Estimation of technical, economic and allocative efficiencies in sugarcane production in South Africa: A case study of Mpumalanga growers

by

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DEDICATIONS

This dissertation is dedicated to my wonderful family: my husband Isaac and my three beloved sons, Phiwo, Ingi and Bandi. Thank you for your patience while I was doing my studies. Also, thank you for being part of my life.

A special dedication to my late sister Gcinaphi: I am sure that she would have loved to share this moment with me. Thank you for being my sister. Also, heartfelt thanks are forwarded to my mother for taking care of my boys while I was still studying.

A dedication to all my friends and colleagues for the words of encouragement and support you have given me towards the completion of this project.

May the Almighty Lord God richly bless you and I love you all.

DECLARATION

I declare that the thesis hereby submitted in partial fulfilment for the requirement of the degree Master of Science (Agricultural Economics) at the University of Pretoria has not been submitted by me for any other degree at any other institution.

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DATE: **...**

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ABSTRACT

There have been a number of support initiatives rendered to the small-scale sugarcane farmers in Mpumalanga but the sugarcane production there has remained low. This raised some questions on the efficient use of available resources and the fruitfulness of the Producer Development Initiatives (PDIs). Justification for further assistance to the small-scale farmers requires empirical evidence of efficient resource use. This study employed the stochastic frontier production function to calculate the technical, allocative and cost efficiency. This study provides insight into three issues: the levels of technical, economic and allocative efficiencies of small-scale sugarcane farmers; the relationship between efficiency level and various farm/farmer specific factors; and implications of policy and strategies for improving small-scale sugarcane production.

The technical, allocative and economic efficiencies of small-scale sugarcane farming were estimated in order to identify the potential increase in production without incurring additional costs. The study used data obtained from a field survey covering 231 small-scale sugarcane farmers in the Nkomazi region for the 2009/2010

sugarcane production season. According to the stochastic frontier production function using the Cobb-Douglas model, labour, herbicides and fertilizer showed significant positive effects on sugarcane production. The results also indicated that the small-scale sugarcane farmers suffer from considerable lack technical, allocative and cost efficiency. The mean technical, allocative and cost efficiency estimates are 68.5%, 61.5% and 41.8% respectively. A Tobit regression was used to analyse the impact of the farm/farmer characteristics on efficiency. The impact analysis revealed that age, level of education and gender are significant determinants of technical efficiency. On the other hand, level of education, off-farm income, land size and experience are significant determinants of allocative efficiency. In so far as cost efficiency is concerned, the significant determinants are level of education, land size and experience in sugarcane farming.

The findings of the study justify the need for improved agricultural partnerships between the sugar mills and the sugarcane farmers. An example of such collaboration would be if millers were to not only give credit to the farmers, but also give technical guidance to small producers in return for the delivery of a specific quantity and quality of cane at a stipulated time. The collective efforts of these farmers and millers, once harmoniously co-ordinated, can enhance production efficiency and economic prosperity.

Also, appropriate policy formulation and implementation is an effective instrument to improvement in farm efficiency and productivity which promotes overall growth of the economy. Therefore, there is need for all stakeholders (both private and public sector) to make combined efforts to remove the bottlenecks that have constrained effective policy implementation in, and its accrued benefits to, South African agriculture.

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LIST OF ACRONYMS

AAF	Akwandze Agricultural Finance
AE	Allocative Efficiency
CE	Cost Efficiency
CRTS	Constant Returns to Scale
DEA	Data Envelope Analysis
DRTS	Decreasing Returns to Scale
GDP	Gross Domestic Product
IRTS	Increasing Returns to Scale
MLE	Maximum Likelihood Estimates
OLS	Ordinary Least Squares
PDIs	Producer Development Initiatives
PF	Production Frontier
SACGA	South African Cane growers Association
SASA	South African Sugar Association
SACU	South African Customs Union
SPF	Stochastic Production Frontier
TE	Technical Efficiency
Tsb	Transvaal Sugar Board
VAT	Value Added Tax

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND TO THE STUDY

The rural areas of South Africa are characterised by high levels of poverty. Approximately 70% of the poor reside in rural areas (Strategic Plan for South African Agriculture, 2001) and are dependent on agriculture for their livelihoods. Income for this group of people is constrained owing to the fact that the rural economy is not vibrant enough to provide for self-employment opportunities. The major cause for this is the policies which were implemented in the past. On the other hand, natural risks, such as climate variability, high production costs and uncoordinated policies, have in the past contributed to suboptimal growth and investment in the agricultural sector. Therefore, in order for rural areas to develop and expand opportunities for wages and self-employment, a foundation that would support greater earning and spending power is required (Strategic Plan for South African Agriculture, 2001).

Sugarcane is an important crop in South Africa, grown in KwaZulu-Natal (KZN), Mpumalanga and some parts of the Eastern Cape. The South African Sugar Association (SASA) indicates that the sugar industry generates an annual estimated income of R8 billion (SASA, 2010). The nominal Gross Domestic Product (GDP) estimate for the industry in 2009 was R2 400 billion (Stats SA, 2010). Therefore, the industry contributes between 0.5% and 0.7% to the national GDP. As a result of this, the industry makes an important contribution to the national economy. It also accounts for 6.88% of total agricultural exports (within the South African Customs Union – SACU), a decline from 11.7% in 1996, which could indicate that the exports declined because of a decline in production.

Furthermore, the industry directly employs about 77 000 workers, and indirectly employs about 350 000 workers, which represents a significant percentage of the total agricultural workforce in South Africa. The industry provides direct employment in sugarcane production and processing, and indirect employment in numerous support industries (such as input suppliers). More than 2% of South Africa's population is dependent on the sugar industry.

It can therefore be argued that sugar mills and sugarcane farms play an important role in the economic survival of their surrounding rural communities and towns. A number of independent studies such as Maloa (2001) have found that milling towns and sugar farming areas have lower levels of unemployment and higher per capita income than the average small towns and farming areas in South Africa. These studies also found that the level of service in these areas is much higher, largely as a result of direct contributions by the industry or partnerships with government.

Given the importance of the sugar industry in South Africa, it is worrying that it seems to be shrinking. Area under sugarcane production decreased from 429 thousand ha in 2000/2001 to 382 thousand ha in the year 2009/2010. Production also decreased from 23 million tons to 16 million tons during the same period (DAFF, 2011; SASA, 2011). The average yield of cane harvested also declined from 73.95 tons/ha in 2000/2001 to 67.67 tons/ha in 2009/2010 (SASA, 2011). In contrast to this, the nominal producer price has been showing an increase year-on-year, which should serve as an incentive for the sugarcane farmers to increase their production. It is therefore expected that other factors are driving the production and area contraction in the industry. A significant reason quoted by Sibiya and Hurley (undated), were lower productivity caused by poor education and limited skilled labour.

The above phenomenon is also evident in small scale production of sugar. According to Tregurtha and Vink (2008), a large number of small-scale agricultural producers have traditionally been involved in the sugar industry as cane growers. Records show that their number has declined over the past 10 years with the result that the small-scale farmers' share of the industry declined from a high of 18.4% in 1997/98 to the current level of 10% (Tregurtha & Vink, 2008). It is also indicated that the yield of the small-scale farmers, as a percentage of average industry yields, are declining. Other causes of the declining performance in sugarcane production are inadequate use of available and recommended technologies, high input costs and an unstable global economy. Poor infrastructure, inadequate and poor market information, and high levels of technical inefficiencies on the farmers' side also account for low productivity.

The above evidence is in stark contrast with the sugar industry's impressive increased participation in the producer development initiatives (PDI) since 1999. According to the Cane Growers Association, the number of sugarcane farmers registered for the PDI has increased from 152 in 1999 to 358 in 2006, and the number is still increasing.

In addition to the PDI, the industry has a variety of education and training initiatives that are geographically widespread across the sugarcane-growing areas (SASA, 2007). The industry is one of the industries where small-scale farmers are participating in the mainstream.

SASA (2010) indicates that there are more than 33 700 small-scale growers, accounting for about 8.4% of the total annual crop. SASA (2010) further argues that the sugar industry has a long history of promoting and supporting small-scale farmers on tribal land (communal land).

Mentorship programmes focusing on business skills and grower support extension services are conducted to support sugarcane growing activities. The industry also provides technical skills training and accounts and financial management workshops for new and emerging sugarcane growers. Regional economic advisors, grower support service officers, special Value Added Tax (VAT) and diesel dispensations are also made available to the small-scale growers.

Through the South African Sugarcane Growers Association (SCGA), SASA has strengthened its regional economic service to provide local-level support to new medium-scale black sugarcane growers who have entered the industry. Similar support is given to the beneficiaries of the Government's land reform programme. The milling companies provide extension services in support of the sugarcane-growing operations of the small, medium and large-scale black farmers. SASA also provides in-field training to small-scale sugarcane farmers and offers certified courses in sugarcane agriculture and provides technology transfer and extension.

Through the financial bodies established by the sugarcane mills, small-scale sugarcane farmers are able to access funds to purchase production inputs such as fertilizer, seed sugarcane, herbicides and ripeners.

The aim of these support measures is to encourage increased production in the sugarcane sub-sector. However, the production of sugarcane has been fluctuating over the past years, to some extent owing to policy constraints and climate and weather conditions. Other causes of the declining performance in sugarcane production are inadequate use of available and recommended technologies, high input costs and an unstable global economy. As mentioned above, poor infrastructure inadequate and poor market information and high levels of technical inefficiencies on the farmers' side also account for low productivity.

The high (per unit) cost of production, attributable to high costs of inputs, can be reduced through increasing the farm outputs as a result of improving technical efficiency. This therefore implies that the current levels of technical efficiency have to be quantified in order to approximate the production losses that might be caused by inefficiencies owing to differences in farmers' management practices and socio-economic characteristics.

Causes of the declining yields might be poor institutional arrangements. This could include poor policies governing the production and marketing of sugarcane. This could lead to the farmers being reluctant to put more effort into the production of sugarcane. However, such causes are out of the control of the small-scale sugarcane farmers. This, therefore, means that prominence will be given to the causes that are within the control of the small-scale sugarcane farmers which include the efficient use of production inputs to produce maximum output. It is therefore important to evaluate whether the yields are declining because small-scale farmers are technically inefficient in their input use. As a result, there is a need to quantitatively evaluate the efficiency levels of the small-scale sugarcane farmers, with the goal of finding ways to improve efficiency, if inefficiencies are identified.

1.2 PROBLEM STATEMENT

It has long been recognised that in order to improve agricultural production and productivity, scarce resources have to be efficiently used. Bravo-Ureta and Evenson (1994) suggest that improving smallholder farmer productivity is vital for economic growth because there is more equitable income distribution through employment creation. Furthermore, Hayami and Ruttan (1985), Kuznets (1996) and Seligson (1982) have indicated that farm productivity could be increased if new production technologies can be adopted. Bravo-Ureta and Pinheiro (1993) have highlighted the point that only efficient farmers are able to realise productivity gains. It is also argued that technically efficient farmers are able to achieve maximum levels of output with the minimum level of inputs. Over the past decade, however, smallholder sugarcane farmers did not seem to be enjoying productivity gains despite the existing technology and support. This implies that the agricultural support provided by the sugar industry and other stakeholders, to small-scale sugarcane farmers, does not seem to be bearing the desired outcomes. Interestingly, despite the various support programmes to the small-scale sugarcane farmers, productivity seems stagnant. As mentioned earlier, this can possibly be attributed, in part, to the fact that SASA (2010) indicates that the total sugarcane crop area has decreased from 394.8 million hectares in 1995/6 to 391.5 million hectares in 2009/10. Additionally, the yield of harvested sugarcane decreased from 69.9 tons/ha in 1996/7 to 67.7 tons/ha in 2009/10. The effect of the support provided by the industry to the sugarcane farmers is therefore unknown. Following the line of thought of the discussion above, this study aims to quantify the level of productivity and possibly identify areas where productivity and efficiency can be improved.

Similar studies was done by by Amani (2005) in Tanzania and show that small-scale farmer productivity is suffering owing to the fact that most small-scale farmers do not practice high-yield farming methods (Amani, 2004). Ahmad, Ghulam and Iqbal (2002) add that the low productivity of small-scale farmers is caused by poor management factors (inefficiency gaps). Therefore, to accomplish sustained growth in sugarcane production, efficiency and productivity have to be increased. This can be achieved by understanding the determinants of small-scale farmer efficiency.

Locally, there is currently no empirical evidence on the level of efficiency of small-scale sugarcane farmers. Accordingly, policy formulations have been hampered by the lack of empirical studies at farm level. It is important to establish whether the causes of slow growth in productivity are due to small-scale farmer inefficiency and if so, to what extent. Providing an indication of the current farm-level efficiency and factors that hold back small-scale farmers from increasing their production is crucial. This means an understanding of the relationship between efficiency and farm-specific factors should be acquired. This information can ultimately be used to guide policymakers to make sound policy decisions towards the empowerment of small-scale farmers. In short, the aim of the study is to bridge the gap between efficiency and the practical aspects of small-scale sugarcane production in South Africa. This gap is currently attributable to insufficient knowledge on small scale farmer efficiency in the South African sugar industry.

1.3 PURPOSE STATEMENT

The purpose of this study is to estimate the technical, economic, and allocative efficiency of sugarcane production in South Africa, with special reference to the Mpumalanga Province. If inefficiencies are prevalent, this study further aims to identify possible causes for the inefficiencies and suggest solutions, in the form of policy recommendations. With declining hectares and yields, as mentioned in the section above, improved efficiency can provide an opportunity for small-scale farmers to increase returns and market share.

On a similar note, the profitability of a farming enterprise is also determined by how farmers allocate their resources in response to price incentive. This means that allocative efficiency also forms part of the formula for improving productivity gains using the available technology. If both technical and allocative efficiencies are met by the production entity, then it is said to be economically efficient.

In light of the above argument, it becomes important to identify whether technically and allocatively efficient farms are also economically efficient.

1.4 RESEARCH OBJECTIVES

The main objective of the study is to estimate the technical, economic and allocative efficiency of the sugarcane farmers in the Mpumalanga Province. The specific objectives of the study are to:

- Determine the levels of technical, efficiency levels among small-scale sugarcane farmers in the Mpumalanga Province.
- Determine economic efficiency levels among small-scale sugarcane farmers in the Mpumalanga Province.
- Determine allocative efficiency levels among small-scale sugarcane farmers in the Mpumalanga Province.
- Examine the relationship between technical, economic and allocative efficiency levels and various farm/farmer specific factors and thereby identify possible causes for inefficiencies.
- Make policy recommendations for improving small-scale sugarcane production and considering the implications thereof.

1.5 STATEMENT OF HYPOTHESES

For meaningful results, the research was guided by the following null hypotheses:

- ***H_0*:** Small-scale sugarcane farmers are fully efficient and there is no room for growth in efficiency. This implies that there are no inefficiencies among the smallholder sugarcane producers.
- ***H_0*:** Socio-economic and demographic variables have no significant influence on the efficiency of the small-scale sugarcane farmers. This implies that the farm/farmer characteristics have no effect on the inefficiency of the sugarcane farmers in the study area.

1.6 IMPORTANCE AND BENEFITS OF THE STUDY

This study has both practical and theoretical significance. Practically, by knowing the small-scale farmers' level of efficiency, information for economic policy formulation can be obtained. Furthermore, from the microeconomic point of view, identifying the factors that may improve profitability of the farms is important. The information obtained from this study can be used to devise strategies/policies to make small-scale sugarcane farms become more efficient and consequently more profitable.

The study is also important owing to the fact that sugarcane production is decreasing, which creates the perception that PDIs do not bear fruit. This study could, however, serve as a starting point/bench mark for future studies on efficiencies in the region to see whether there is an improvement in efficiencies as a result of the PDIs.

In terms of theoretical benefits, the study intends to expand the literature on the technical performance of small-scale sugarcane farmers in Mpumalanga. To the knowledge of the author, there is no study on the technical efficiency of small-scale sugarcane farmers published in South Africa. The results of the study could help fill this gap.

1.7 DEFINITION OF KEY TERMS

In this section, the definitions of terms that are used in the study are provided. These definitions are based on the works of various authors.

- **Technical efficiency:** A situation whereby a firm adopts an output-expanding or an input-conserving approach (Kumbhakar & Lovell, 2000). In simple terms, technical efficiency is defined as the ratio of the observed to maximum feasible output, given the production technology and the observed input use.

- **Allocation efficiency (AE): W**hen a firm uses inputs in amounts that minimise the production costs at given input prices while maintaining or increasing output.

- **Economic efficiency (EE):** The product of allocation (allocative) and technical efficiency (Farrell, 1957).

- **Cost efficiency (CE):** A situation whereby a firm is economically efficient if it produces a given quantity of output at the possible minimum cost at a given state of technology (such a firm has to be technically and allocatively efficient).

- **Return to scale (RTS):** A method used to classify the relationship between inputs and outputs. The returns to scale can either be increasing (IRTS), decreasing (DRTS) or constant (CRTS) depending on whether the proportion of output increases/decrease with a more/less amount as increases in inputs. For multiple inputs, RTS can be defined as the change in outputs when all inputs change in an equal proportion (Farrell, 1957).

- **Production frontier (PF):** The minimum input used to produce a given level of output.

1.8 ORGANISATION OF THE STUDY

The rest of the study is organised into six chapters. Chapter 2 presents a detailed overview of empirical and theoretical issues with regard to technical, allocative and economic efficiency. This chapter also gives a review of empirical studies on efficiency in the agricultural sector. The review of the literature will help guide which method will be suitable for the analysis. Chapter 3 gives the analytical framework and empirical specifications for the approach that will be used in the study. The study area, sampling procedures, data and socioeconomic characteristics of the sampled small-scale farmers are outlined in Chapter 4. Chapter 5 gives the discussion of the findings of the study and Chapter 6 provides the summary of the research problem, the study approach, main findings and the policy implications, limitations of the study and the recommendations for further research.

CHAPTER 2

LITERATURE REVIEW ON EFFICIENCY, MEASUREMENT AND EMPIRICAL APPLICATIONS

2.1 INTRODUCTION

This chapter gives a review of empirical studies on the measurement of efficiency in the field of agriculture. It is intended to provide a proper understanding of the specific area of research and to assist the researcher in establishing a clear framework to be employed for the analysis in this study. Based on the literature reviewed, the possible methods that can be used for the study will be identified. There is a large amount of empirical and theoretical literature in the field of efficiency measurement. This review will focus specifically on studies in the agricultural sector.

2.2 The concept of efficiency and frontier models

The technical relationship in which inputs are transformed into output can be defined as the production function (Battese & Coelli, 1992). It can also be defined as the maximum output that can be produced from a given set of inputs. The maximum output attainable in a production process is what gives rise to certain concerns in economic theory which includes efficiency with which economic agents produce such outputs. To measure this efficiency, a production function is derived which depicts the maximum output as a function of input set. On a similar note, Coelli *et al*., (2005) indicated that the cost frontier function depicts the minimum cost as a function of input prices and output. The term efficiency is a relative measure of a firm's ability to utilise inputs in a production process in comparison to other firms in the same industry. It is relative in the sense that comparisons are made relative to the best performing firm in the same industry. In economics and other fields, a firm's efficiency can be viewed in terms of technical efficiency, allocative efficiency and economic efficiency.

A technically efficient firm is one which produces maximum quantity of output from a given set of inputs. Allocative efficiency is the ability of the firm to use inputs in optimal proportions given their respective prices and production technology (Coelli *et al*., 2005). Knowledge of the production frontier is necessary when one needs to calculate the firm's different efficiencies. A production frontier indicates the maximum outputs given a set of inputs ad existing production technology. A cost frontier describes the minimum costs given output levels, input prices and production technology. This means that that given the knowledge of the production frontier and the actual input-output levels of any firm, efficiency can be measured.

The discussion on the measurement of productivity and efficiency originated from papers by Koopmans (1951) and Debreu (1951). Farrell (1957) extended the works of Debreu and Koopmans to measure productivity and efficiency. Farrell (1957) demonstrated efficiency measurement using the input oriented approach where a firm used two inputs, capital (K) and labour (L) to produce output (Y). Farrell's work on the measurement of efficiency is shown in the figure below. He made an assumption that a firm producing a single output (Q) from two inputs (K, L) under constant returns to scale (CRS), and has prior knowledge of an efficient production function. Under the CRS assumption, SS' represents an isoquant of various input combinations that are used in the production of one unit of output. Point P represents input combination (K, L) used in the production of a unit of output. Point Q represents an efficient input combination which is in the same factor as P. This means that for a firm operating at point P, $TE = OQ/OP$. If the price ratio is defined by the line AA', then $AE = OR/OQ$. The distance RQ represents the reduction in the cost of production that would occur if production was done using an allocatively efficient technique. Economic efficiency is the product of TE and AE which on the graph is given by OR/OP. This is the simplest way of determining a firm's efficiency based on the assumption that there is constant returns to scale and that factors of production are known

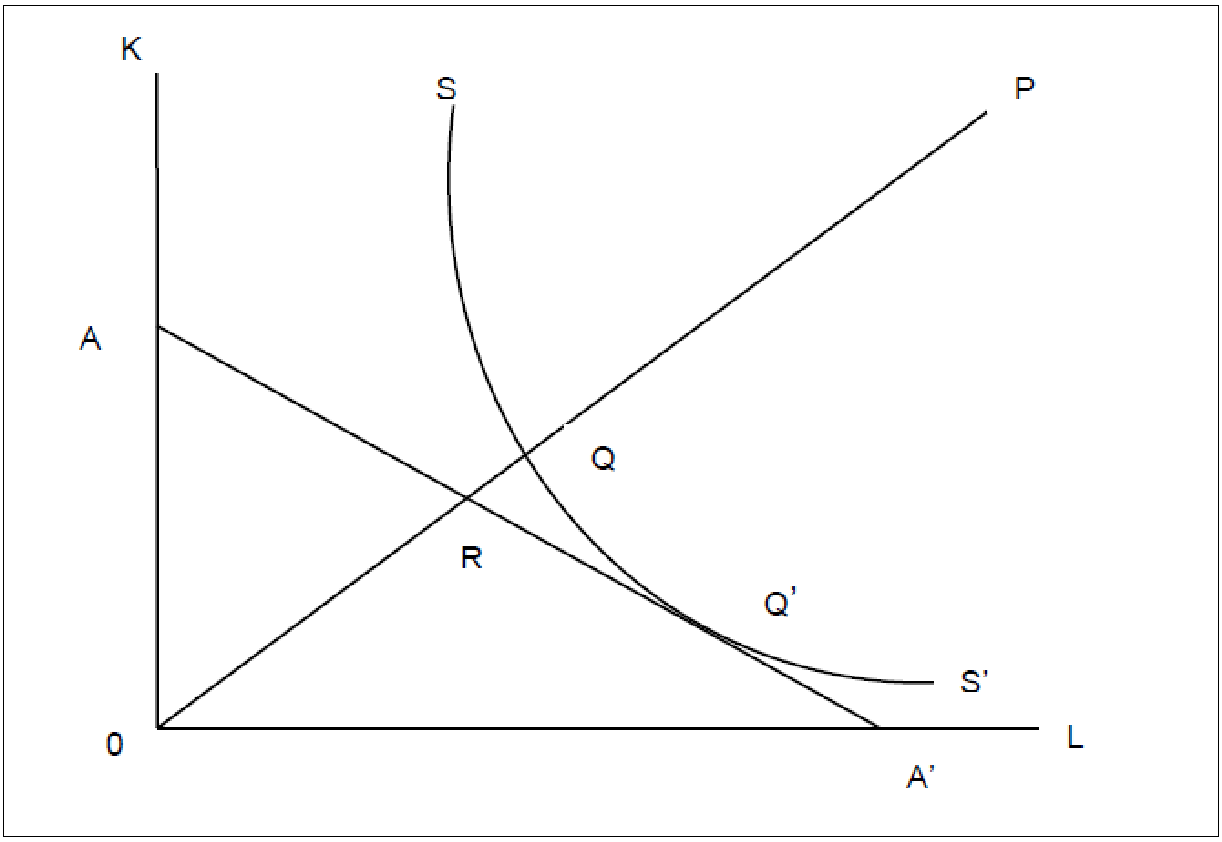

Figure 2.1: Measurement of AE, TE and EE using a two input case isoquant under the constant returns to scale

Two main categories of efficiency measurements have been discussed in literature namely; the average production functions and the frontier approach. The production function approach measures efficiency by first constructing average productivity of inputs and then constructing an efficiency index. Pitt and Lee, 1981 indicated that this method was unsatisfactory because production functions were incapable of providing information on efficiency as they attributed differences from the estimated function to symmetric random disturbances. Aigner, Lovell and Schmidt (1977) added that such functions are seen as average functions because they estimate the mean and not the maximum output. The disadvantages of the production function approach led to the development of a new method with better and well founded conceptual basis for measuring efficiency- the frontier approach. To date this is the method which has been widely used. The frontier approach to efficiency measurement can be divided into parametric and non-parametric. The non parametric approach describes frontier models which are robust with respect to the particular functional form and distribution assumptions, and is usually deterministic in nature. Deterministic production frontier models are those with output which is bounded from above by a non stochastic frontier. Such frontiers have a disadvantage of not accounting for the possible influence of measurement errors and other statistical noise upon the shape and positioning of the estimated frontier. According to Aye (2010) the parametric frontier approach involves specification of a functional form for the production technology as well as making assumptions about the distribution of the error terms. When compared to the non-parametric approach, the parametric approach has an advantage owing to its ability to express frontier technology in simple mathematical form as well as the ability to encompass non-constant returns to scale. The major flaw of the parametric approach is that sometimes unwarranted functional/structures may be imposed on the frontier. And when this is the case, it imposes a limitation on the number of observations that can be technically efficient. The parametric approach is divided into deterministic and stochastic frontiers. The parametric deterministic approach is further divided into the statistical and 1non-statistical methods.

2.3 Stochastic Frontier and efficiency measurement

With deterministic frontiers, all variations in firm performance are attributable to variations in firm efficiency. This tends to neglect the fact that there are other factors which may affect efficiency. The general SFPF was proposed by Aigner, et al. (1977). Since then there has been considerable research and studies that have been conducted to extend and apply the model (Battese and Coelli, 1995). Aigner *et al.* (1977) discovered and resolved problems that were observed in Farrell (1957). A more satisfactory conceptual basis was used through the inclusion of an efficiency component in the error term of the estimated production function. They presented the model as follows:

$$y_i = f(x_i; \beta) + \varepsilon_i \quad (2.1)$$

Where;

$$\varepsilon_i = v_i - u_i \quad (2.2)$$

ε_i is the disturbance or error term, the vector v_i are random variables which are assumed to be normally, identically and independently distributed between mean zero and variance $\boldsymbol{\sigma^2}$ i.e. $v_i \sim NiiD\ (0, \sigma_v^2)$, while vector u_i is the error component which is assumed to be independent of v_i and that u_i are non-negative random variables (truncated at zero from below) which are assumed to account for the technical inefficiency in production such that $u_i \sim NiiD\ (0, \sigma_u^2)$.

Based on the distribution assumption of the disturbance term, Aigner *et al* (1977) indicated that equation (2.1) can be estimated using the likelihood technique. The equation (2.1) is known as the stochastic frontier production function. The stochastic frontier production function postulates the existence of technical inefficiencies in production for firms involved in producing a particular output (Battese & Coelli, 1995). This implies that frontier functions provide the basis for defining efficient performance as their primary objective is to search for evidence of inefficiency. Battese and Coelli (1995) mentioned that with the stochastic frontier production function, input use efficiency among smallholder farmers can be determined and based on the results an intervention can be identified to ensure that such inefficiencies are corrected.

The use of the frontier model has increased due to several reasons. Frontier is consistent with the theory of optimising behaviour; and that deviations from a frontier have a neutral interpretation as a measure of the efficiency with which economic units pursue their technical and behavioural objectives (Bauer, 1990). The use of frontier has increased also due to the fact that information about the structure of the frontier and about the relative efficiency of economic units has many policy applications (Bauer, 1990).

With the Stochastic Frontier Analysis, parameters used in efficiency analysis are estimated using the maximum likelihood method. Battese and Corra (1977) indicated that from a given data, the production frontier is estimated using the likelihood function and the parameter estimates derived from the normal equations obtained by partial derivatives of the likelihood function. The variance parameters estimated using the maximum likelihood and used in efficiency analysis are:

$$\sigma^2 = \sigma_u^2 + \sigma_v^2, \gamma = \frac{\sigma_v^2}{\sigma^2} \text{ and } 0 \leq \gamma\ 1. \qquad (2.3)$$

If $\gamma \rightarrow 0 \Longrightarrow \sigma_u^2 \rightarrow 0$ and $\sigma_v^2 \rightarrow \sigma^2$. This means that the symmetric error term v_i predominates the composed error term, and that the farm output differs from the frontier output due to measurement error and other external factors of production. If $\gamma \rightarrow 1 \Longrightarrow \sigma_v^2 \rightarrow 0$ and $\sigma_u^2 \rightarrow \sigma^2$, it means that the asymmetric non-negative error term u_i is predominant error in the composed error and the difference between the farm output and the frontier output is attributable to differences in technical efficiency. In this case, technical efficiency is measured as:

$$TE = E\left(e^{ui}/u_i\right) = \left\{\frac{1-\emptyset[\mu_i^*/\sigma_i^*]}{1-\emptyset(-\mu_i^*/\sigma_i^*)}\right\} e^{\left(-\mu_i^*+\frac{1}{2}\sigma_i^{*2}\right)} \qquad (2.4)$$

Where:

$\boldsymbol{\mu_i^*} = \frac{\mu\sigma_v^2 - u_i\sigma_u^2}{\sigma_u^2+\sigma_v^2}, \boldsymbol{\sigma_i^{*2}} \equiv \frac{\sigma_u^2\sigma_v^2}{\sigma_u^2+\sigma_v^2}$ and $\emptyset(-\mu_i^*/\sigma_i^*)$ or $\emptyset[\sigma_i^* - \mu_i^*/\sigma_i^*]$ represent the cumulative distribution function.

The mean technical efficiency in this case is given represented by:

$$\overline{TE} = E\left(e^{ui}/u_i\right) = \left\{\frac{1-\emptyset[\sigma^*-(\mu^*/\sigma^*)]}{1-\emptyset(-\mu^*/\sigma^*)}\right\} e^{\left(-\mu^*+\frac{1}{2}\sigma^{*2}\right)} \qquad (2.5)$$

2.4 Duality in efficiency analysis

The duality concept is used in cost and profit functions. It is normally used where it is impossible to estimate the cost functions. Aye (2010) indicated that this impossibility is caused by the fact that inputs among firms do not vary resulting in symmetric deviations from the cost-minimizing behaviour in an industry. From the production frontier, it is possible to change the sign of an inefficient error component of the SFPF into a stochastic cost frontier model. The resultant dual cost frontier model takes the following form:

$$c_i = c_i(w_i, y_i, \delta)\exp(v_i + u_i) \quad (2.6)$$

Where, c is the minimum cost of the i[th] firm, $c_i(w_i, y_i, \delta)\exp(v_i + u_i)$, is the stochastic cost frontier, w_i is the vector of input prices of the i[th] firm, y_i is the output of the i[th] firm and δ is a vector of unknown parameters which are functions of parameters in the production function. The vector v_i are random variables which are assumed to be normally, identically and independently distributed between mean zero and variance $\boldsymbol{\sigma^2}$ i.e. $v_i \sim NiiD\,(0, \sigma_v^2)$, and independent of u_i which are non-negative random variables assumed to account for the cost of inefficiency in production. This means that u_i defines how far above the cost frontier the firm can operate, and if AE is assumed it represents the cost of technical efficiency.

Coelli (1995b) forwarded three reasons which justify the use of alternative dual forms of production technology. The first reason is that behavioural objectives such as cost minimization can be reflected by dual forms; secondly, multiple inputs can be accounted for. Lastly, to simultaneously predict both technical and allocative efficiencies. The decision to estimate either the production or cost frontier lies in the exogeneity assumptions. This means that the estimation of a production frontier whenever inputs are exogenous and a cost frontier whenever output is exogenous (Schmidt, 1986). Schmidt and Lovell (1979) suggested a Maximum Likelihood Method for estimating a Cobb-Douglas cost frontier with (k-1) factor demand equations. The equations were specified as follows:

$$lny_i = A + \sum \alpha_i\, lnx_{ij} + v_i - u_i \quad (2.7)$$

$$lnx_{i1} - lnx_{ij} = lnp_{ij} - lnp_{1i} - ln\alpha_1 - ln\alpha_j + \varepsilon_{ij} \quad (2.8)$$

$$lnc_i = k + \frac{1}{r} lny_i + \sum_{j=1}^{k} \frac{\alpha_j}{r} lnp_{ij} - \frac{1}{r}(v_i - u_i) + (E_i - ln\, r) \quad (2.9)$$

Equation (2.9) is the production function whilst equation () is a set f first order conditions and equation (2.10) is the cost function. $\boldsymbol{y_i}$ is the output of the i[th] firm, $x's$ are inputs, $p's$ are input prices and $\boldsymbol{\varepsilon_{ij}}$ represents allocative efficiency. $r = \sum_{j=1}^{k} \alpha$ the returns to scale . E_t is given as a function of $\varepsilon's$ and the parameters. He cost of technical inefficiency therefore given as $\frac{1}{r}u_i$, whilst the cost of AE is $(E_i - \ln r)$.

$$E_i = \sum_{j=2}^{k} \frac{\alpha_j}{r} ln\varepsilon_{ij} + ln\left[\alpha_1 + \sum_{j=2}^{n} \alpha_j e^{\varepsilon ij}\right] \qquad (2.10)$$

Two major weaknesses were identified to be associated with this approach (Schmidt and Lovell (1979). Firstly, it is usually not easy to estimate a cost frontier due to uniform input prices to firms in the same industry. Secondly, the approach is inly applicable to self dual functional forms like the Cobb-Douglas, and do not apply to functional forms like the translog.

2.5 Efficiency decomposition

Production functions such as the Cobb-Douglas production frontier exhibit self-dual characteristics. This implies that it is easier to understand the behaviour of an alternative form. From a production frontier, it is only possible to estimate the technical efficiency of the firm and the economic and allocative efficiencies can be obtained if that particular frontier is self-dual. Thus, from a logarithmic self dual Cobb-Douglas production frontier of the form:

$$lny_i = A + \beta_i lnx_i + \varepsilon_i \qquad (2.11)$$

Where $A = ln\beta_0$, y_i, x_i and the parameter β_i are as defined above. The composed error term (ε_i) is obtained by subtracting predicted output from observed output as follows:

$$\varepsilon_i = y_i - \hat{y}_i \qquad (2.12)$$

Using the maximum likelihood method parameters of the stochastic frontier production function are estimated, and by subtracting v_i from both sides of equation (2.11), to get;

$$y_i^* = y_i - v_i = A + \beta_i lnx_i - u_i \qquad (2.13)$$

Where $\boldsymbol{y_i^*}$ is the observed output of the i[th] firm adjusted for statistical noise captured by $\boldsymbol{u_i}$. Using the equation (), technically efficient input vector $\boldsymbol{x_i^T}$ for a given level of $\boldsymbol{y_i^*}$ is obtained by solving simultaneously equation () and input ratios, $\frac{\boldsymbol{x_i}}{\boldsymbol{x_k}} = \boldsymbol{p_k}(\boldsymbol{k} > 1)$, where $\boldsymbol{p_k}$ is the observed input ratio. The duality assumption states that the corresponding dual cost frontier can be expressed as:

$$C_i = h(W_i, Y_i^*; \delta) \tag{2.14}$$

where C_i is the cost minimum of the i th firm associated with output, Y_i^*, W_i is a vector of input prices of the i th firm and δ is a vector of parameters which are functions of the parameters in the production function. The economically efficient (cost minimising) input vector, X_i^E, is derived by using Shepherd's Lemma and then substituting the firm's input prices and adjusted output quantities into the system of demand equations:

$$\frac{\partial c}{\partial w_i} = x_{ji} = x(w_i, y_i^*, \delta) \tag{2.15}$$

Hence, from the given technically and economically efficient input packages the actual cost of observed input levels by their respective prices as $\mathrm{w_t x_t}$ in the case of technical efficiency (TE) and $w_e x_e$ in the case of economic efficiency (EE) can be calculated, therefore:

$$TE = \frac{(\mathrm{w_t x_t})}{\sum(\mathrm{w_t x_t})} \tag{2.16}$$

On the same note,

$$EE = \frac{(w_e x_e)}{\sum(w_e x_e)} \tag{2.17}$$

Since $EE = TE * AE$, it implies that $AE = \frac{EE}{TE}$, then

$$AE = \left[\frac{(w_e x_e)}{\sum(w_e x_e)}\right] / \left[\frac{(w_t x_t)}{\sum(w_t x_t)}\right] \tag{2.18}$$

2.6 Sugarcane production efficiency studies

The studies highlighted in this section analysed the technical efficiency of sugarcane production using the SFPF. Only one study used the DEA. The objective of this section is to highlight the advantages of the SFPF method and to identify factors that impact on production efficiency, specifically regarding sugar production studies.

Msuya (2007) analysed the technical efficiency of sugarcane and the factors affecting the efficiency of 140 outgrower and non-outgrower farmers in Turiani Division, Mvomero District, Morogoro Region, Tanzania. The technical efficiency was estimated using the Cobb-Douglas production frontier, assumed to have a truncated normal distribution. The results of the estimation showed that there were significant positive relationships between age, education, and experience with technical efficiency.

The stochastic production frontier was employed by Hanna (2006) to estimate technical efficiency at the plot level. The ethnical efficiency among a cross section of sugarcane growing farmers was estimated by Hanna (2006) using the stochastic production function. The results revealed that education, land area, discharge of tube wells and distance of plots from water sources were the causes identified in explaining inefficiency. The results also showed that the estimated technical efficiency scores are highest on plots where water is sourced from a privately owned tube well, followed by plots serviced by partnered tube wells, and lowest on plots where water is bought.

The technical efficiency of small scale sugarcane farmers of Swaziland was investigated by Dlamini, et al, (2010) using stochastic frontier production functions for Vuvulane scheme and Big Bend individual farmers. The stochastic production frontier function model of the Cobb-Douglas type incorporates a model for the technical inefficiency effects. Farm-level cross-sectional data were collected from 40 sugarcane schemes and 35 individual sugarcane farmers. The results revealed some technical efficiency levels of the sample farmers that are varied widely. For the Vuvulane sugarcane farmers, efficiency ranges from 37.5 to 99.9% with a mean of 73.6%, while for the Big Bend sugarcane farmers it ranges from 71 to 94.4%, with a mean value of about 86%. The sugarcane farmers at Vuvulane over-utilised land. Thus, an appropriate amount of land utilisation could increase the sugarcane production for Vuvulane sugarcane farmers. For both groups of farmers, the technical inefficiency decreased with increased farm size, education and age of the sugarcane farmer, but increased when small scale sugarcane farmers engaged in off-farm income earning activities.

Babalola *et al*. (2009) assessed the efficiency differential in industrial sugarcane production in Jigawa state, among farming households benefiting from government intervention through the Millennium Village Commission Programme (MVCP) and those who were not. A stochastic frontier production function model (SFPFM) was used to determine and compare the technical efficiency in sugarcane production among the MVCP farmers and non-MVCP farmers. The result of the analysis showed that the coefficients for farm-size, hired labour, quantity of sugarcane stem-cuttings planted, quantity of fertilizer, volume of pesticide and irrigation water used for sugarcane production were all significant factors for sugarcane production by the MVCP farmers, while for non MVCP farmers, the coefficients for farm size, hired labour, quantity of sugarcane stem-cuttings planted and quantity of fertilizer used were the significant factors for the sugarcane production. The result further indicated that non-MVCP farmers were more technically efficient than MVCP farmers (mean technical efficiency of 0.70 and 0.60 respectively). Sources of inefficiency were traced to membership of associations, ecological zones and varietal differences (for the MVCP farmers) and farming experience, contact with the extension service, levels of education, access to credit, membership of organisations, participation in programmes and cropping density (for the non-MVCP farmers). Cost and benefit analysis showed that more benefits accrued to the farmers supported by the MVCP.

Ojo *et al*. (2009) examined the productivity and production efficiency among 100 small-scale irrigation sugarcane farmers in Niger State, Nigeria, using a stochastic translog frontier function. The Stochastic translog frontier production function was used to represent the production frontier of the small scale irrigated sugarcane farms.

The results showed a return to scale of 3.51, indicating an increasing return to scale and that small-scale irrigated sugarcane production in the area was in stage I of the production region. The study also showed that the levels of technical efficiency ranged from 82.58% to 99.24% with mean of 95.39%, which suggests that average irrigated sugarcane output falls 5% short of the maximum possible level. From the results obtained, although farmers were generally relatively efficient, they still have room to increase the efficiency in their farming activities at about 5% efficiency gap. The results further showed that farmers' educational level, years of farming experience and access to extension service significantly influenced the farmers' efficiency positively.

Padilla-Fernandez and Nuthall (2009) attempted to identify the sources of input use inefficiency in sugarcane production in the Central Negros area, Philippines. A non-parametric Data Envelopment Analysis was used to determine the relative technical, scale and overall technical efficiencies of individual farms which use the same type of inputs and produce the same output (cane). Under a specification of variable returns to scale, the mean technical, scale and overall technical efficiency indices were estimated to be 0.7580, 0.9884 and 0.7298, respectively. The results showed that the major source of overall inefficiencies appears to be technical inefficiency, rather than scale effect. Input use differences between the technically efficient and inefficient farms are highly significant in terms of area, seeds and labour inputs. There was no significant difference in the use of fertilizer and power inputs. For many farms, labour is the most binding constraint, followed by land and power inputs, while seeds and NPK fertilizer are not binding. This paper also provides evidence that the overall technical efficiency of sugarcane farmers in Central Negros is positively related to farmers' age and experience, access to credit, nitrogen fertilizer application, soil type and farm size.

2.7 SUMMARY OF FINDINGS

From the reviewed literature, it is evident that the most used methods of measuring efficiency are the SFPF and the DEA. However, the advantages associated with the SFPF (its ability to deal with statistical noise) make it a widely used method to determine efficiency, such that a majority of studies analysing the technical efficiency of sugarcane production used this method. This advantage also makes the SFPF the most used approach in analysing the efficiency of agricultural production.

Although the focus has been on studies concerned with sugar production, it is acknowledged that the studies differ significantly from one another in terms of location, climatic conditions, etc. The variables identified do, however, serve as a starting point for the decision on which factors to analyse as determinants of sugar production efficiency. In order to improve the understanding of each of these variables, literature beyond sugar production studies have been taken into account. This serves as a further substation of the variables analysed in this study and are discussed below.

2.8 DETERMINANTS OF EFFICIENCY

The reviewed studies highlighted the following factors as important determinants of efficiency in sugar production:

- Farmers' age
- Farmers' education
- Access to extension
- Access to credit
- Agro-ecological zones
- Land holding size
- Number of plots owned
- Farmers' family size
- Gender
- Tenancy
- Market access
- Farmers' access to improved technologies, such as fertilizer, agrochemicals, tractors and improved seeds, either through the market or public policy interventions which have been associated with technical efficiency.

Studies conducted by Amos (2007); Ahmad, Ghulam & Iqbal (2002); Kibaara (2005); Tchale and Sauer (2007); and Basnayake and Gunaratne (2002) have discovered that farmers' age and education, access to extension, access to credit, family size, tenancy, and farmers' access to fertilizer, agrochemicals, tractors and improved seeds varieties have a positive effect on technical efficiency.

Although studies by Amos (2007), Raghbendra, Nagarajan and Prasanna (2005), and Barnes (2008) found the relationship between land holding size and efficiency to be positive, a clear-cut conclusion on the influence of this variable on efficiency has not been reached, as discussed in Kalaitzadonakes *et al*., (1992). On the other hand, influence of the number of plots on efficiency has been reported by Raghbendra *et al*., (2005) to be negative. This implies that land fragmentation (as measured by number of plots) has a negative impact on yields. Meanwhile, Parikh and Shah (1994) have added that the value of farm assets and the degree of land fragmentation determine the variations of technical efficiency in the North-West Frontier Province of Pakistan.

Solis *et al*. (2009) discovered that non-owners are more efficient than owners. This result contradicts the commonly held idea that, *ceteris paribus*, land ownership reduces risk and, consequently, should enhance expected returns and encourage farmers to invest in more productive technologies (Gebremedhin and Swinton, 2003). However, several empirical studies have reported a negative association between land ownership and farm efficiency (Byiringiro and Reardon, 1996; Binam *et al*., 2003; Deininger *et al*., 2004). Nevertheless, this result is consistent with the fact that non-owners have added cash outflow requirements to cover land rental and this could act as an incentive to be more efficient. The relation between efficiency and farm size has received the most attention in the literature (Britton and Hill, 1975; Pasour, 1981; Abate, 1995; Piesse, 1996; Adesina and Djato, 1996; and Tadesse and Krishnamoorthy, 1996). Yet, there is no consensus among the available studies on the age-old debate of efficiency differences in the small versus large-scale farm (Tadesse and Krishnamoorthy, 1996; Kalirajan and Flinn, 1983; Lingard, Castillo and Jayasuriya, 1983).

There are conflicting results on the influence of socio-economic variables, such as gender. Tchale and Sauer (2007) point out that, while some studies (in Lesotho) report that gender of the farmer has no significant influence on efficiency, other studies found that gender plays an important role. Gender presents positive and statistically significant effects on TE, suggesting that male-headed households are more efficient than their female counterparts. Gonzalez (2004) contends that lower levels of efficiency among female headed households could stem from gender inequities in rural Latin America, where women have more difficult access to land, capital and other financial services. The gender difference could also stem from unmeasured outputs generated by females in the household. Generally, female household-heads are not only in charge of their family business but they are also responsible for taking care of basic household needs (child rearing and care, cooking, cleaning, etc.). These activities are difficult to quantify but they do compete for women's time and effort.

According to Skarstein (2005), R&AWG (2005) and Msuya (2007), producer associations are very important in transforming the agricultural sector into one with high productivity and high quality output. While referring to Tanzania, Skarstein (2005:359) stresses that, if the agriculture sector is to be transformed, producer associations (in form of farmers' cooperatives) are needed first and foremost to give the smallholders bargaining power in the input, output and credit markets. Msuya (2007) and R&AWG (2005) went a step further and showed that integrated producer schemes are more suited than cooperatives in assisting smallholder farmers to address most of the constraints they face, including low production and productivity

Battese, Malik & Gill (1996) and Hallam and Machado (1996) considered the age of the primary decision-maker, the maximum years of formal schooling for members of the household, and the ratio of adult males to the household size, as explanatory variables to the inefficiencies of production of wheat farmers in the four districts of Pakistan. They found that in one district, age and schooling of farmers are significantly related to the efficient production of wheat. They contest that human capital enables farmers to improve on resource utilisation, thus achieving higher productivity. Parikh and Shah (1994) have suggested that younger farmers are most likely to operate efficiently.

Presented in Figure 2.2 is a conceptual proposed paradigm which shows that the independent variables on the left of the diagram exert a certain influence directly or indirectly on the criterion variable. Each arrow in the figure represents a presumed path of influence.

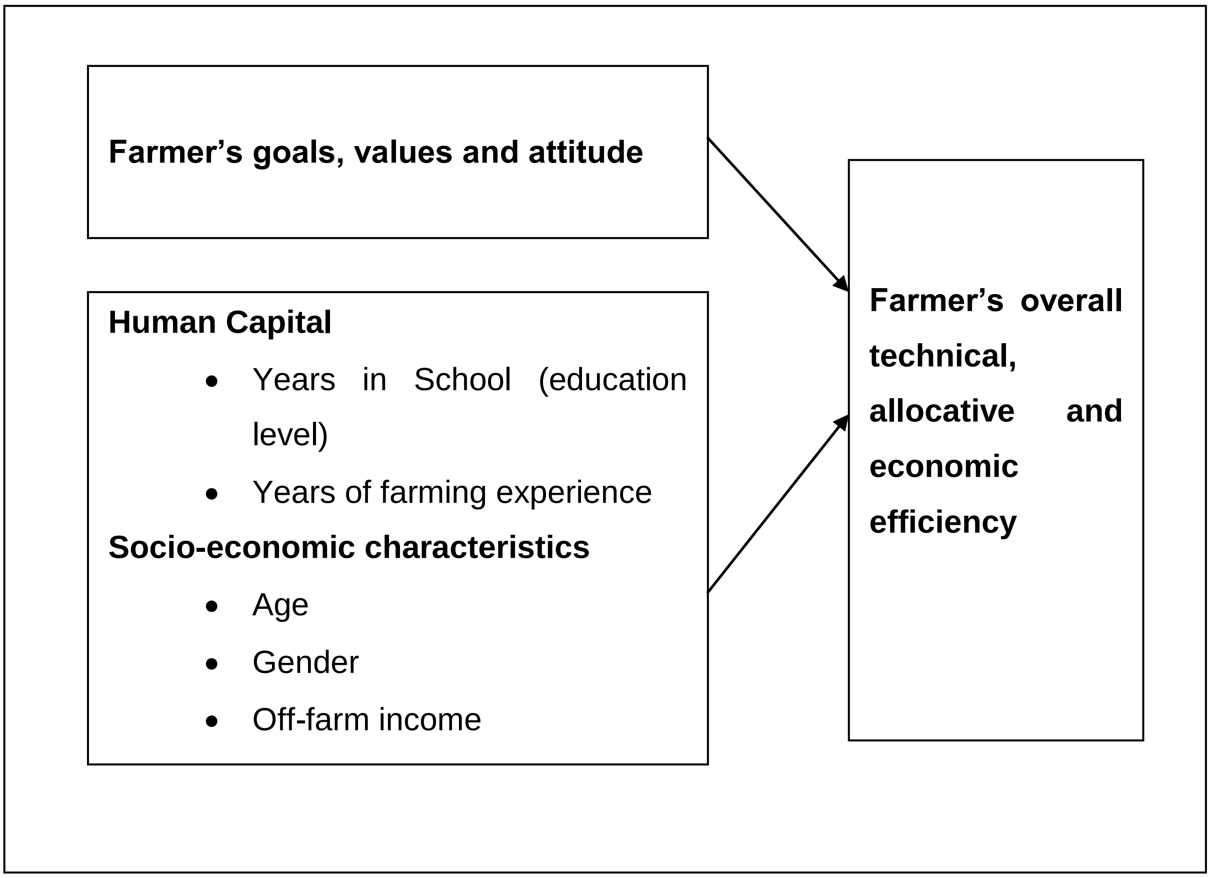

Figure 2.2: A schematic paradigm showing the associations of farmer's goals, values, attitudes, some selected-efficiency variables and farmer's production efficiency levels.

Source: Adapted from Padilla-Fernandez and Nuthall, 2009)

2.9 SUMMARY

The variables discussed in this section serve as substantiation for the model developed in equation 3.16. This model does not include all the above mentioned variables. For example, farmers' access to market and access to extension services are not included in the model. It is left out owing to the fact that all sugarcane smallholder farmers have access to market and extension services, in the study area. Also, the farm environment factors and adoption of technology factors are also not included. However, all other variables important in addressing sources of productivity variability among smallholder farmers are included.

CHAPTER 3

ANALYTICAL FRAMEWORK AND EMPIRICAL SPECIFICATIONS

3.1 INTRODUCTION

The method of analysis that is used in this study is the SFPF. From the literature review in the previous chapter, it is apparent that parametric and non-parametric approaches can be used to measure production efficiency. The econometric estimation of the production or cost functions falls under the parametric approaches. These approaches involve the estimation of the production frontier or curve which represents the maximum feasible output for the different input levels, given the technology that is being used. The technologies represented are single-output. The production functions can take several functional forms, ranging from the translog to the restrictive Cobb-Douglas, and can be estimated econometrically. The cost functions, profit functions and the revenue functions, like the production functions, can also be estimated econometrically. The imposition of an explicit functional form and distributional assumption on the error terms is one of the major drawbacks of the parametric approach.

On the other hand, there is no imposition of restrictions on the technology in so far as the non-parametric approach is concerned. This means that the non-parametric approach is less prone to misspecifications. The most commonly used non-parametric approach is the data envelopment analysis (DEA). Given the fact that many studies have used the different approaches for different reasons, the approach that is of interest in this study is the parametric stochastic frontier production function.

The SPF is capable of capturing measurement error and other statistical noise influencing the shape and position of the production frontier. Since agricultural production is largely influenced by exogenous shocks, the SPF is a better technique to use to measure technical efficiency. The technique takes into account the assumption that farmers may produce outside the frontier, not only because of measurement errors, statistical noise or any non-systematic influence, but also because they experience some technical inefficiency. It is in this regard that in the next section the analytical framework of the parametric stochastic frontier is presented. Section 3.3 later specifies and describes the empirical model used in this study.

3.2 ANALYTICAL FRAMEWORK

3.2.1 The production frontier and efficiency decomposition

The production technology is conventionally represented by the production function. Bravo-Ureta and Rieger (1991) developed a procedure or model for decomposing the cost efficiency into its technical and allocative components from the production frontiers. This helped to overcome the problem of solving for the cost function directly when there are little or no variations in the prices among the sampled firms. This methodology involves the use of the observed input ratio, the level of output for each firm adjusted for statistical noise, and the parameters of the stochastic frontier production function (SFPF). The parameters of the SFPF are used to derive the cost function. To illustrate the approach, the stochastic frontier production function can be given as:

$$Y_i = f(X_i;\beta) + \varepsilon_i \qquad (3.1)$$

$$\varepsilon_i = v_i - u_i \qquad (3.2)$$

where ε_i is the composite error term. The components v_i and u_i are assumed to be independent of each other, where v_i is the two-sided normally distributed random error and u_i is the one-sided efficiency component with a half normal distribution. Y_i is the observed output of the i th firm, X_i is the input vector of the i th firm and β is the unknown parameters to be estimated.

The composite error term (ε_i) is obtained by subtracting the predicted output from the observed output:

$$\varepsilon_i = Y_i - \hat{\mathbf{Y}}_i \qquad (3.3)$$

The maximum likelihood method is used to estimate the parameters of the SFPF. Subtracting v_i from both sides of equation (3.2) gives:

$$Y_i^* = Y_i - v_i = f(X_i;\beta) - u_i \qquad (3.4)$$

where Y_i^* is the observed output of the i th firm adjusted for statistical noise captured by v_i. From equation (3.4), the technically efficient input vector, X_i^T, for a given level of Y_i^* is derived by solving simultaneously equation (3.4) and the input ration, $X_1/X_t = \rho_k (k > 1)$, where ρ_k is the ratio of the observed inputs.

Assuming that the production function is a self-dual function like the Cobb-Douglas production function, the corresponding dual cost frontier can be derived and written in a general form as:

$$C_i = h(W_i, Y_i^*;\delta) \qquad (3.5)$$

where C_i is the cost minimum of the i th firm associated with output, Y_i^*, W_i is a vector of input prices of the i th firm and δ is a vector of parameters which are functions of the parameters in the production function. The economically efficient (cost minimising) input vector, X_i^E, is derived by using Shephard's Lemma and then substituting the firm's input prices and adjusted output quantities into the system of demand equations:

$$\frac{\partial C_i}{\partial W_i} = X_i^E(W_i, Y_i^*;\delta) \qquad (3.6)$$

For a given level of output, the technically efficient, economically efficient and actual costs of production are given by $W_i X_i^T$, $W_i X_i^E$ and $W_i X_i$ respectively. The above cost measures are then used to do the bias calculation of the technical and economic (cost) efficient indices for the i th firm as follows:

$$TE_i = \frac{W_i X_i^T}{W_i X_i} \qquad (3.7)$$

and

$$EE_i = \frac{W_i X_i^E}{W_i X_i} \qquad (3.8)$$

The allocative efficiency can be calculated based on Farrell's methodology which states that the economic efficiency (EE) is divided by the technical efficiency (TE) to get allocative efficiency:

$$AE_i = \frac{W_i X_i^E}{W_i X_i^T} \qquad (3.9)$$

The method of Bravo-Ureta and Rieger (1991) was followed to avoid the problem of estimating the cost frontier directly. However, the method has been criticised because the output-oriented approach is used to estimate the parameters of the frontier, whereas the input-oriented approach is used to derive the technical efficiency. The method gives technical efficiency scores that are different from those obtained from the maximum likelihood estimation of the SFPF in equation (3.1), which is output-oriented, unless firms are operating under constant returns to scale.

3.3 EMPIRICAL MODEL

3.3.1 The parametric stochastic frontier production function (SFPF)

The Cobb-Douglas model for this study is specified as follows:

$$\ln Y_i = \delta + \sum_{j=1}^{4} \beta_j \ln X_{ji} + v_i - u_i \qquad (3.10)$$

Where Y_i is the observed sugarcane output for the i th farmer and X_{ji} is the j th input quantity for the i th farmer, namely land, labour, fertilizer and herbicides. $\ln\Box$ represents the natural logarithm of the associated variables, and δ's and β 's are parameters to be estimated.

Given the vector of input prices for the i th farm (W_{ji}), parameter estimates of the stochastic frontier production function (β) in equation (3.10), and the input oriented adjusted output level Y_i^* in equation (3.4), the corresponding Cobb-Douglas dual cost frontier is derived and written as:

$$\ln C_i = b_0 + \sum_{j=1}^{4} b_j \ln W_{ji} + \emptyset \ln Y_i^* \qquad (3.11)$$

By using Shephard's Lemma, the cost minimising (economically efficient) input vector, X_i^c , is derived by substituting the firm's input prices and adjusted output quantity into the system of demand equations, which is given as follows:

$$\frac{\partial C_i}{\partial W_i} = X_i^c = b_j W_j^{-1} Y_i^* \qquad (3.12)$$

For a given level of output, the corresponding technical efficient, cost efficient and actual costs of production are equal to $W_i X_i^T$, $W_i X_i^c$, and $W_i X_i$, respectively. These three cost measures are then used as the basis for calculating the technical and cost efficiency scores for the i th farm as follows:

$$TE_i = \frac{W_i X_i^T}{W_i X_i} \qquad (3.13)$$

and

$$CE_i = \frac{W_i X_i^C}{W_i X_i} \qquad (3.14)$$

The allocative efficiency can be calculated based on Farrell's methodology which states that the cost efficiency (CE) is divided by the technical efficiency (TE) to get allocative efficiency:

$$AE_i = \frac{W_i X_i^C}{W_i X_i^T} \qquad (3.15)$$

The computer program, FRONTIER version 4.1 (Coelli, 1996a), is used to estimate the model. The program gives the maximum likelihood estimates for the parameters of the model, as well as the technical efficiency scores, whereas the allocative and cost efficiency scores were computed using a program that was written and implemented in STATA version 10.0.

3.3.2 Hypothesis testing

The generalised likelihood-ratio test statistic is used to test the various null hypotheses for the parameters in the frontier production function and in the inefficiency models. The test statistic is defined by:

$$\lambda = -2 \{\log [L (H_0) - \log [L (H_1)]\},$$

Where L (H_0) and L (H_1) represent the likelihood function values under the null (H_0) and the alternative hypotheses (H_1), respectively. The first hypothesis ($H_10: \gamma = \delta_10 = \delta_11 = \cdots \delta_14 = 0$) is to test whether farmers are technically efficient and there is no room for improved efficiency growth (if there are any technical inefficiency effects in the model). The $\delta's$ represent the parameters in the production function. The second hypothesis $[(H]_0: \alpha_1 = \cdots = \alpha_6 = 0)$ is to test whether the farm/farmer level variables effect farm level technical efficiencies. The $\alpha's$ represent the parameters of the farm/farmer variables.

3.3.3 Determinants of inefficiency

As has already been mentioned earlier, the CE is composed of the TE and AE. This implies that the cost inefficiency arises as a result of the combination of both the technical and allocative inefficiencies. For policy implications, the factors that cause these inefficiencies need to be identified through investigation of the relation between the calculated TE, AE and the farm/farmer specific variables. Thereafter, the association between the farm/farmer specific variables can then be established.

The AE and TE models were estimated as follows:

$$EFFICIENCY = f(AGE, EDUCATION, OFFFARMINC, LANDSIZE, EXP) \quad (3.16)$$

where: *EFFICIENCY* is the natural logarithm of farm-level AE, TE or EE. The variables included in equation (3.16) are dummy variables. The variables are defined as follows: *AGE* is equal to one for those ages less than 40 and zero otherwise; *EDUCATION* level is equal to one if the small-scale farmer has five or more years of schooling and zero otherwise; *OFFFARMINC* is equal to one for farmers with sources of off-farm income and zero otherwise; *LANDSIZE* is equal to one for farmers with less than 5 hectares of land and zero otherwise; and *EXPERIENCE* is one for farmers with more than 10 years' sugarcane farming experience and zero otherwise.

The model in equation (3.16) was estimated using the Tobit procedure. This is due to the fact that the efficiency values are bound between 0 and 100 (Greene, 1991). In a Probit model the variable of theoretical interest is unobserved: what is observed is a dummy variable, y , which takes on a value of 1 if y_i * is greater than 0, and 0 if otherwise (Olagunju et al, (2007). In contrast, Splett, et al, (1994) devised what became known as the Tobit (Tobin's probit) or censored normal regression model for situations in which y is observed for values greater than 0 but is not observed (that is censored) for values of zero or less.

3.4 SUMMARY

Chapter 3 has discussed the method that is used in the study. The first section discussed the analytical framework on how the production frontier can be specified and decomposed into efficiency. The second section discussed the empirical model specification (SFPF) and the farm/farmer specific variables that are included in the model. The section further explained how the cost function can be used to as a basis for calculating the technical efficiency, allocative and economic efficiency. The last section discussed the inefficiency model and the variables that are included.

The next chapter describes the study area, the survey design and data collection methods, as well as the socio-economic characteristics of the sample households.

CHAPTER 4

STUDY AREA, SURVEY DESIGN AND SOCIO-ECONOMIC CHARACTERISTICS OF THE SAMPLE HOUSEHOLDS

4.1 INTRODUCTION

The purpose of this chapter is to give a description of the study area, the research design and the socio-economic characteristics of the sampled sugarcane small-scale farmers. The next subsection provides a brief description of the study area. The survey design is outlined in the third subsection. The data types, sources and methods of collection are presented in subsection four. The subsection 5 provides a description of the variables used for estimation of the selected model. Subsection 6 describes the socio-economic characteristics of the sample small-scale sugarcane farmers.

4.2 THE STUDY AREA

The Nkomazi region was selected to undertake the study because it is the major sugarcane producing area in the Mpumalanga Province. The study area is situated in the Mpumalanga Province, towards the north-east of South Africa. It is bordered by Mozambique and Swaziland to the east and Gauteng Province to the west. On the northern part, it is bordered by Limpopo. Sugarcane production mainly takes place in the areas in-between the Mananga border, Komati border and in some areas towards Nelspruit (mainly in the Lowveld region of the Mpumalanga Province).

The Nkomazi region covers an area of 3 500 km^2. The area has been described to be among the areas with the highest agricultural potential in South Africa. Its resources comprise a unique combination of soil, climate and water. The climate is temperate in winter and hot and humid in summer. The soils are fertile and well suited for sugarcane farming.

Figure 4.1: Location of the study area

Source: http://www.tsb.co.za/the_company/the_area/location/

4.3 SURVEY DESIGN AND SAMPLING PROCEDURE

The research implemented both survey (primary) and secondary data. A secondary research approach involves the collection of information or data from existing sources, for example yearly reports (such as Mill Group Data). In the case of this research, information was gathered from company records indicating sugar yields for the different small-scale growers. The secondary research constitutes the bulk of the data collected.

A survey research approach is defined by Saunders, Lewis and Thornhill (2007) as research that involves the collection of information from a sizeable population. That said, Leedy and Ormrod (2005) define a survey research as research that acquires information about experiences, opinions, attitudes and characteristics through tabulations and analyses the respondents' responses to a given set of questions. As such, this study used a structured questionnaire with closed questions which generated numeric data from willing participants only (Leedy & Ormrod, 2005).

The designed questionnaire was pre-tested with farmers in the one of the sugarcane growing areas to check if it was suited for the research objectives and to minimise biases. The information collected through the questionnaire included:

- Household characteristics, such as gender, age, level of education and the number of years in the sugarcane farming business (years of experience in sugarcane farming);
- The number of hired and family labour involved in sugarcane farming per season;
- Information on technical issues, such as area planted to sugarcane, and amounts of fertilizer and herbicides used;
- The quantity of sugarcane harvested.

Before the sample size is determined, it is of utmost importance to note the number of sugarcane farmers in the Mpumalanga. According to Table 4.1, the Mpumalanga Province has a total of 1 423 sugarcane farmers, with 179 large-scale farmers and 1 242 small-scale growers. The Komati area has a total of 936 sugarcane farmers with 83 large-scale farmers and 852 small-scale farmers. The Malelane area has 96 large-scale farmers and 390 small-scale farmers.

Table 4.1: Number of cane growers in the Mpumalanga Province (2010/2011 season)

Mill area	Large-scale farmers	Small-scale farmers	Total
Komati	83	852	936
Malelane	96	390	487
Total	**179**	**1 242**	**1 423**

Source: SASA, 2011

There is a wide range of sampling techniques that can be used. These include systematic sampling, random sampling, clustered sampling, stratified sampling and multi-staged sampling. According to Acharaya and Barbier (2000), the sample selection method depends on the objectives of the study, size of the population in the area on which the study is focused, and the information available before the survey takes place. Since there is only one group of small-scale sugarcane farmers in the Nkomazi region, the sampling method chosen for this study was the simple random sampling.

This is against the background that the total number of small-scale sugarcane farmers in the Nkomazi region is 852. Simple random sampling involves selecting a sample out of the total population such that each farmer has an equal chance of being selected into the sample. Using a 95% confidence level and a 5% confidence interval, the sample size required is 297 in extent. This sample size was also based on the fact that it will give a true representation of the population of small-scale farmers in the Nkomazi region. The procedure for selecting the small-scale farmers using the random selecting criteria was to:

- Obtain from the mill a list of grower codes for small-scale sugarcane farmers under the Nkomazi region;
- Print the list and tear it into strips, each identifying an individual;
- Fold the strips and place them into a box and shuffle them around;
- Randomly pick the names of 297 small-scale farmers from the box.

After the random sampling of the small-scale farmers, the researcher had the grower codes for the farmers to be included in the study. The researcher then compiled a list of all the small-scale sugarcane farmers who were requested to take part in the survey (based on the random sampled list). After that, letters were written to the grower code owners requesting them to take part in the survey and the letters were given to the extension officer of the area to hand over to the farmers.

4.4 DATA COLLECTION

As mentioned above, both primary and secondary data sources were used to gather the required information. A field survey method was conducted to obtain the primary data used in this study owing to the unavailability of farm records for the small-scale sugarcane farmers. Structured questionnaires were used in group meetings with farmers. This was done because of time and financial constraints associated with the study. To prepare the questionnaire, the procedure used by Msuya and Ashomongo (2005); and Dlamini, Rugambisa and Belete (2010) was used. The questions were formulated in such a way that they provided enough information on the inputs and out-variables, as well as household characteristics. This was done to enable the estimation of efficiency of the small-scale sugarcane farmers and the determinants of inefficiency.

In order to answer the objectives of the study, data was collected on the quantities and prices of inputs and sugarcane output. The inputs for which both quantity and price data were collected were land planted to sugarcane, hired labour, fertilizer and herbicides. Socio-economic characteristics, such as level of education, farmer experience, age, farm size, access to extension services, access to credit, to name a few, were also determined. Additional data was collected on the constraints faced by the small-scale sugarcane farmers.

The primary data was collected through the use of questionnaires which were administered to each group of small-scale sugarcane farmers on a given day. The questions were read by the researcher and the respondents were allowed to fill in their questionnaires with answers to the relevant questions. This procedure was followed until all the farmers had been interviewed.

Secondary data was also obtained to supplement the primary data. Data from Tsb Sugar Mill and Akwandze Agricultural Finance (AAF) was requested. The data was on sugarcane crop area, production, yield, sucrose content and prices. Information on the services offered by the mill to the small-scale sugarcane farmers was obtained as well.

4.5 VARIABLE DESCRIPTION

This section provides the description of the variables used for the analysis. The means and standard deviations of all variables used in the estimation of the frontier model, which include the output quantity and input quantities and their prices, are also presented.

Table 4.2: Description of variables used in the study

Variables	Description
Production (PROD)	The quantity of sugarcane produced during the 2009/2010 season, expressed in tons
Land (LAND)	The amount of land in hectares planted with sugarcane by a farmer in the period under investigation
Labour (LABOUR)	The amount of hired and family labour used by the farmer, measured in man-days
Fertilizer (FERT)	The amount of chemical fertilizer, measured in kilograms.
Herbicides (HERB)	The quantity of herbicides used by the farmer, measured in litres.
W_{LAND}	The price the farmer would pay to rent a hectare of land.
W_{FERT}	The price of chemical fertilizer per kilogram
W_{HERB}	The price of. herbicide per litre
W_{LABOUR}	The price of labour per man-day

Source: Survey Results, 2011

The summary of statistics of inputs and output used in the estimation of the frontier function and the technical efficiency is provided in Table 4.3. The input prices used to compute the cost and allocative efficiency is also provided in the same table. The average production of sugarcane in the study is 420.9 tons. The farm size ranges between 3.5 and 12.2 hectares, with an average of 7.3 hectares. On average, the farmers applied 727.3kg of fertilizer, which translates to 99.6kg/ha. The use of fertilizer varies, depending on recommendations from the soil tests. On average, the sugarcane farmers applied 58.1 litres of herbicides and used 281.4 man-days of labour per year.

Table 4.3: Summary of statistics of variables used in the parametric stochastic frontier function

Variables	Mean	Standard deviation	Minimum	Maximum
PROD (tons)	420.9	173.278	67.7	872.7
LAND (ha)	7.3	1.013	3.5	12.2
FERT (kg)	727.3	133.89	250.0	1150.0
HERB (litres)	58.1	17.6889	13.0	157.8
LABOUR(man-day)	281.4	84.441	64.8	756.4
W_{LAND}	3218.79			
W_{FERT}	44.14			
W_{HERB}	23.98			
W_{LABOUR}	49.15			

Source: Survey Results, 2011

4.6 HOUSEHOLD AND FARM CHARACTERISTICS OF STUDY SAMPLE

4.6.1 Age, gender and education level of household head

The decision-making process is significantly influenced by the age of the household head. Hussain (1989) has concluded that older farmers are more risk averse to new technologies than younger farmers, hence younger farmers are known to be risk takers, that is, they like exploring new avenues and taking chances. On the other hand, according to the author's opinion, older farmers are considered to be more experienced as they have been around for a longer time. According to Table 4.4, the average age of the small-scale sugarcane farmers was 46 years: the majority of the farmers were aged between 41–50 years.

Table 4.4: Age of household heads

Age range	Frequency (n=231)	Percentage (percent)
<30	0	0
30-40	71	30.7
41-50	89	38.5
51-60	54	23.4
>60	17	7.4
Average age	46.7(8.8)	

Source: Survey Results, 2011 (Number in parentheses represent the standard deviation)

According to the results in Table 4.5, out of the 231 small-scale sugarcane farm owners interviewed, 80.1% were male and 19.9% were female. Additionally, the education level of the farmer is important as it plays a major role in the technology adoption level of the farmers. The results indicate that a majority (59.3%) of the small-scale sugarcane farmers are literate and only 40.7% of them are illiterate. About 13% of the farmers have reached tertiary education level.

Table 4.5: Gender and education levels of household heads

Variables		Frequency (n=231)	Percentage (percent)
Gender:	Male	185	80.1
	Female	46	19.9
Education Level:	No formal	94	40.7
	Primary	78	33.8
	Secondary	46	19.9
	Tertiary	13	5.6

Source: Survey Results, 2011

The years of experience of the farmer are very important when it comes to knowledge on factors that can improve the productivity of the farm. As indicated in Table 4.6, the majority (37.7%) of the small-scale sugarcane farmers have between 1–5 years experience. This could be attributed to the fact that some children have inherited the sugarcane farms from their parents, hence the low level of experience. Only one farmer was found to have more than 20 years' experience in the sugarcane production business.

Table 4.6: Number of years of experience

Years experience	Frequency (n=213)	Percentage (percent)
<1	0	0
1 – 5	87	37.7
6 – 10	83	35.9
11- 20	60	26.0
>20	1	0.4
Average	8.1 (4.5)	

Source: Survey Results, 2011 (Number in parenthesis is the standard deviation)

4.6.2 Household size

Family labour plays an important part in the success of a small-scale farming enterprise in that the farmer does not need to spend too much money on labour costs. The sugarcane farming enterprise is labour intensive after harvesting owing to the ratoon maintenance exercise. As recorded in Table 4.7, from the sugarcane farmers interviewed, the average household size was 9 members.

Table 4.7: Household sizes

Variable	Number	Percentage
Adult members	3.4	37.4
Children	5.2	62.6
Average household size	8.6 (3.3)	

Source: Survey Results, 2011

4.6.3 Major Sources of Income

According to the results obtained from the study (as indicated in Table 4.8), the sample households in the study get their income from different sources, other than sugarcane production. The majority of households depend on agricultural activities for their source of income, which means that farmers produce sugarcane and also engage in other agricultural activities. The results show that more than 60% of the farmers interviewed depend on agriculture for their livelihood (including sugarcane production). It is also evident that 5.6% of the farmers also depend on off-farm employment as their major source of income, with sugarcane production being a secondary source of income.

Table 4.8 also shows that the average income from sugarcane production and other agricultural activities was R18 045.18 and R680.23 per harvest respectively. Child grants and pensions also contribute to the income of the small-scale sugarcane farmers. About 29% of the small-scale sugarcane farmers benefited from child grants and pension payments. This is possible, given the fact that there were a number of small-scale sugarcane farmers who indicated that they were aged more than 60 years and this entitles them to pension (old age grant).

Table 4.8: Major sources of income

Sources of income	Frequency (n=231)	Percentage (percent)
Sugarcane production	53	22.9
Sugarcane production and other agricultural activities	96	41.6
Off-farm employment	13	5.6
Other (child grant and pension)	69	29.9
Average income from sugarcane (R)	R18 045.18	
Average income from agric sources (R)	R680.23	

Source: Survey Results, 2011

Table 4.9 depicts the asset ownership (apart from land) of the sampled households. The results show that all respondents own a house or home. The results also indicate that a majority (49%) of the farmers owned either a tractor or tractor-drawn implements, as is expected of farmers. About 35% of the farmers own a vehicle of some kind and 16% have access to telephone or cell phone services.

Table 4.9: Asset ownership

Type of asset	Frequency (n=231)	Percentage (percent)
Vehicle ownership	81	35
Tractor and implements	113	49
Telephone or cell phone services	37	16

Source: Survey Results, 2011

4.6.4 Type of irrigation systems

There are four different types of irrigation systems that are used in sugarcane production. These include flood irrigation, centre pivot, drip irrigation and sprinkler irrigation. The type of irrigation used by a farmer determines the level of productivity of that particular farm, as well as the possibility of water saving. The sprinkler and flood irrigation systems are known to waste water. On the other hand, the drip irrigation is regarded as the most efficient in that it saves water (water only goes where needed).

According to Table 4.10, there are no farmers who use the centre pivot and flood irrigation systems. A majority (54.5%) of the small-scale sugarcane farmers use the sprinkler irrigation system and only 45.5% uses the drip irrigation system.

Table 4.10: Types of irrigation systems

Type of irrigation	Frequency (n=231)	Percentage (percent)
Flood irrigation	0	0
Centre pivot	0	0
Drip irrigation	105	45.5
Sprinkler irrigation	126	54.5

Source: Survey Results, 2011

4.6.5 Management practices

In order for the farmer to make sound decisions, control production and productivity of the sugarcane, record keeping becomes a very important tool. According to Table 4.11, approximately 16.5% of the small-scale sugarcane farmers practised record keeping and a majority (83.5%) of them do not keep records. The reason they gave for not keeping records was that AAF has records of every transaction that happens on the farm. Additionally, a majority of those farmers who do keep records are those that have formal off-farm employment and the reason they gave was that they want to make sure that everything is done the right way so that they do not incur losses.

Table.4.11: Record keeping

Record keeping	Frequency (n=231)	Percentage (percent)
Yes	38	16.5
No	143	83.5

Source: Survey Results, 2011

4.6.6 Access to services

Table 4.12 provides information on the access to services by the small-scale sugarcane farmers. These services play a vital role in the improvement of agricultural productivity of the small-scale sugarcane farmers. If these services are not properly accessed by the farmer, production will be affected.

4.6.6.1 Access to credit

The survey results indicate that all the small-scale sugarcane farmers have access to credit. This is a true reflection of what is currently happening in the sugar industry. All farmers access their production credit from AAF which provides different types of credit, ranging from establishment loans to ratoon maintenance loans. This fund provides the loans to the farmers on agreement that the repayment will be done when the product is sold at the mill. This is when the loan is repaid and the extra cash given to the farmer as farm income.

4.6.6.2 Access to extension services

The provision of extension services to the small-scale sugarcane farmers is done by the Tsb Sugar Limited's extension department. There are extension officers who mainly specialise in assisting the small-scale sugarcane farmers with solutions to daily sugarcane husbandry problems. Notwithstanding this, about 64% of the small-scale sugarcane farmers claim that they do not have access to extension services and only 36% acknowledge having extension services rendered to them.

4.6.6.3 Management support

A Tsb subsidiary company, Shubombo, was established in 2007 in order to assist the sugarcane farmers with the management of their sugarcane farms. Among other things, the company focuses on providing expertise on agricultural requirements, business development and management skills to sugarcane farmers, and not only small-scale farmers. Interestingly, a majority (60%) of the sampled small-scale farmers indicated that they do not receive any management support from the company. Only 40% of the small-scale sugarcane farmers indicated that they receive management support from the company.

Overall, the results are an indication that the company does provide some support to the small-scale sugarcane farmers. However, there is an indication that there is a possibility that the farmers need to be more involved in considering the form of assistance that they require.

From the results it was also gathered that the small-scale farmers are given assistance in the form of agronomic services. In this case the agronomy department of Tsb Sugar Company perform water and soil analysis on the farmers' fields. This helps the farmers to know the status of their fields so as to know which types of fertilizers to apply and at what rates. According to Table.4.12, a majority of the farmers indicated that they do receive the services of the agronomy department of the company.

Table 4.12: Services accessed by the small-scale sugarcane farmers

Services		Frequency (n=231)	Percentage (percent)
Access to credit	Yes No	231 0	100 0
Extension services	Yes No	83 148	35.9 64.1
Management support	Yes No	92 139	40 60
Transport services	Yes No	231 0	100 0
Accounting services	Yes No	53 178	23 77
Water quality	Yes No	51 180	22 78
Soil analysis	Yes No	113 118	49 51
Soil profiles	Yes No	122 109	53 47

Source: Survey Results, 2011

4.6.7 Constraints Experienced by Small-Scale Sugarcane Farmers

The problems experienced by the small-scale sugarcane farmers can disturb their performance and productivity. If these problems were to be identified, programmes that might help improve the productivity could be put in place. The small-scale sugarcane farmers who participated in the analysis were asked to identify major problems they are faced with. Several problems were identified and were ranked in order of importance.

The problems identified are presented in Table 4.13. According to the results, the most important problems were low production levels, poor marketing conditions, cost of finance and high operational costs. The production levels of the small-scale sugarcane farmers are most vital for the profitability of the business. In sugarcane production, the farmer has to get high yields if he or she is to cover the costs of production. The results indicated that a majority of the survey respondents view low production levels as a major constraint in the sugarcane business.

Similarly, poor marketing conditions are not good for any business. With regards to sugar cane, prices are determined based on a recoverable value (RV) system which is negotiated between the producers and the millers and administered by the South

African Sugar Association. The recoverable value is determined by factors such as cane quality and % sucrose in cane. According to Table 4.14, the sugarcane farmers (67.5%) view such an arrangement as a constraint on the performance of the sugarcane business because they have to rely on the mills determine the quality of their cane. Whether or not this is in fact a constraint is debatable, and it is advocated that small scale farmers should (in some cases) just be better informed about the pricing system.

The cost of finance was also viewed as a very important constraint on the profitability of the sugarcane business. In most instances the sugarcane business is 100 percent debt-financed and the farmers indicated that they feel the impact of the finance charges. From a personal interview with the AAF staff, there was an indication that farmers are charged 14% interest on money borrowed. However, they indicated that if the farmer was a member of AAF, then the farmer will be charged 12% interest. About 73.1% of the sampled small-scale sugarcane farmers indicated that the cost of capital is a very important constraint on their sugarcane operations.

The major operational costs of a sugarcane business are in labour, fertilizer, electricity, harvesting and haulage. According to Table 4.13, high operational costs were viewed as a very important constraint on the production of sugarcane.

Table 4.13: Constraints in sugarcane farming as viewed by the respondents

Constraint	Very important		Important		Less important	
	Frequency	percent	Frequency	percent	Frequency	percent
Transport problems	26	11.4	45	19.6	160	69
Cost of finance	169	73.1	34	14.9	28	12
Poor marketing conditions	156	67.5	27	11.7	48	20.8
Poor management	127	55	34	14.5	70	30.5
Low production levels	175	76.1	35	15.3	21	8.6
High operational costs	192	83.2	23	10	16	6.8
Social cohesion	67	29.3	138	60	26	11

Source: Survey Results, 2011

4.7 SUMMARY

From the results above, it is apparent that the small-scale sugarcane farmers have access to a number of important services as rendered by the Tsb Sugar Company. For example, all the sugarcane farmers have access to credit facilities as offered by AAF. However, the farmers are faced with a number of challenges which need to be addressed. A majority of the farmers felt that the costs of production and operational costs (ratoon maintenance costs) are very high despite the fact that they are granted credit to purchase it. This can have a negative impact on the productivity of the sugarcane crop. Some farmers revealed that the marketing conditions are poor in the sense that they can only sell to the local sugar mill who are price takers. Accordingly, there is need to cushion the farmers from the high production and operational costs.

The results and discussions follow in the next chapter.

CHAPTER 5

RESULTS AND DISCUSSIONS

5.1 ECONOMETRIC ANALYSIS

5.1.1 Hypothesis testing

The generalised likelihood-ratio test statistic is used to test the various null hypotheses for the parameters in the frontier production function and in the inefficiency models. The test statistic is defined in Chapter 4 and is applied as follows:

The first hypothesis to be tested is that farmers are technically efficient and there is no room for improved efficiency growth (Is there are any technical inefficiency effects in the model ?), that is, $H_0: \gamma = \delta_0 = \delta_1 = \cdots \delta_4 = 0$

The null hypothesis is rejected as the γ parameter is 0.867 and significant at 1 per cent probability level. This means that about 87 % of the variation in the sugarcane output produced is caused by inefficiency.

The second hypothesis to be tested is whether the farm level variables, as identified in Chapter 4, affect farm level technical efficiencies, that is, $H_0: \alpha_1 = \cdots = \alpha_6 = 0$. This hypothesis is rejected on grounds that variables in the inefficiency model have a collective significant contribution in explaining technical inefficiency of the small-scale sugarcane farmers. The result of the likelihood ratio test (LR=69.33) is a confirmation that the small-scale sugarcane farmers' variable and low productivity is the result of the variance in farm management. This reflects how efficiently the farmer can use available resources.

5.1.2 Production frontier and technical efficiency estimates

The results of the Maximum Likelihood (ML) and ordinary least square (OLS) of the Cobb-Douglas SFPF are presented in Table 5.1. The input coefficients in the two models are positive as expected and significant at the 1 per cent level, except for the intercept and the coefficient of land. This means that these inputs contribute to increased output. The sum of the coefficients is 1.652, indicating increasing returns to scale. The largest contributor to the small-scale sugarcane farmers' production is labour, which has an elasticity of 0.365. This means that a 10% increase in labour supply will increase output by 3.65%. This is an expected result with the case of sugarcane because all the activities are done manually, except for irrigation even though this does need labour for changing the sprinkler positions. Contrary to the general view of Basnayake and Gunaratne (2002), land is not significant in the production of sugarcane which implies that the size of land does not matter. This implies that other factors are at play when it comes to land utilisation, for example, proper management can help the farmer achieve more production, even on a small piece of land.

The other large contributors to small-scale sugarcane production are the herbicides and fertilizers, which both have an elasticity of 0.31, implying that a 10% increase in the amount of fertilizer and herbicides applied will raise output by 3.1%.

The value of the parameter γ , is 0.98 and is significant at 1 per cent level, implying that 98% of the variation in output is attributable to inefficiency. This means that the technical, economic and allocative inefficiency effects are significant in the stochastic frontier production function.

Table 5.1: Parameter estimates of the Cobb-Douglas production frontier

Variable	OLS Estimates		ML Estimates	
	Coefficient	Standard error	Coefficient	Standard error
lnIntercept	-0.895	0.571	0.606	0.562
ln(LABOUR)	0.391***	0.069	0.365***	0.056
ln(HERB)	0.286***	0.103	0.309***	0.088
ln(FERT)	0.286***	0.085	0.309***	0.078
ln(LAND)	0.084	0.087	0.063	0.082
Adjusted R^2	0.841	-	-	-
γ	-	-	0.9893***	0.614
σ^2	-	-	0.897	0.790
M	-	-	-1.736	2.214
Log-Likelihood	-	-279.72	-259.67	-
LR-Test	-	-	-	69.33

Source: Survey Results, 2011

*****Significant at 1 percent probability level.**

- **Technical efficiency scores**

As indicated in equation 3.1, the observed output (Y_i) of the *i*th firm is a function of the input vector (X_i) of the ith firm and the unknown parameters ($\beta's$) to be estimated and the error term (ε_i) .

From equation 3.1, equations 3.2 and 3.3 were obtained and used to calculate the technically efficient input combination, given the fact that $TE_i = \frac{W_i X_i^T}{W_i X_i}$, with W_i , X_i^T , and X_i as explained in Chapter 3. The results generated are presented in Table 5.2.

From the results, it is evident that the technical efficiency scores range from 55.4 to 80.3, with a mean of 68.3%. The presence of technical inefficiency indicates potential output gains without increasing input use. This means that if the small-scale farmers were to operate on the frontier, they would achieve a cost saving of 24.8%. On the other hand, if the average small-scale farmer in the sample was to achieve the TE level of its most efficient fellow farmer, then the average small-scale farmer could realise a 14.9% cost saving, that is, ($1 - [68.3/80.3]$). A similar calculation for the most technically inefficient small-scale farmer shows that a cost saving of 31.0% (that is, ($1 - [55.4/80.3]$). None of the respondents had a technical efficiency of 100 per cent. The implication of this is that there is room for improvement in sugarcane production in the study area with the available technology and given sets or resources.

Table 5.2: Frequency distribution of the technical efficiency score for the small-scale sugarcane farmers

Technical efficiency (percentage)	TE(Frequency)
100	0
90 – 100	0
80 – 90	0
70 – 80	51
60 – 70	179
50 – 60	1
40 – 60	0
<40	0
Mean (percent)	68.3
Minimum (percent)	55.4
Maximum (percent)	80.3
Std Deviation	0.0299

Source: Survey Results 2011

- **Economic efficiency (EE) and allocative efficiency (AE)**

Given the self-dual nature of the Cobb-Douglas production function, the corresponding dual cost frontier can be derived from the form $C_i = h(W_i, Y_i^*; \delta)$, parameters as explained in Chapter 3.

Given the vector of input prices for the i th farm (W_{ji}), parameter estimates of the stochastic frontier production function (β) in equation (3.10), and the input oriented adjusted output level Y_i^* in equation (3.4), the corresponding Cobb-Douglas dual cost frontier is derived and written as:

$$lnCi = 0.677695 + 0.348948 \ln W_{LAND} + 0.295411 \ln W_{FERT} + 0.295411 \ln W_{HERB} + 0.0609229 \ln W_{LABOUR} + 0.9560229 \ln Y^*$$

where C is the cost of production for the i th farmer. W_{LAND} is the average rental price of land per hectare, estimated at R3218.79. W_{FERT} is the average price of fertilizer per kg, estimated at R44.14. W_{HERB} is the price of herbicide per litre, estimated at R23.98. W_{LABOUR} is the average price of labour per day, estimated at R49.15.

In light of the above, these two equations were used to derive the AE and EE:

$$TE_i = \frac{W_i X_i^T}{W_i X_i} \tag{5.2}$$

And

$$CE_i = \frac{W_i X_i^C}{W_i X_i} \tag{5.3}$$

With the parameters as explained in Chapter 3.

The average allocative efficiency is 61.5% with a minimum of 15.6% and a maximum of 83.2%. This indicates that there is still room to improve allocative efficiency of the small-scale sugarcane farmers by 38.5%, if they operate on the frontier. This also suggests that if the average small-scale sugarcane farmer were to achieve the allocative efficiency level of his or her most efficient fellow farmer, the average household could achieve a cost saving of 26.1%, while the least efficient small-scale farmer could achieve a cost saving of 81.3%. On a similar note, none of the respondents had an allocative efficiency of 100%. This means that the small-scale farmers could assign the resources to their best alternative uses and prices, as well as allow them to execute their allocative functions through input use.

The cost efficiency of the small-scale sugarcane farmers ranges from 11.4% to 53.6%, with a mean of 41.8%. This gives room for cost efficiency improvement by 58.2% if the small-scale farmers were to operate on the frontier. This suggests that the average farmers could gain economic efficiency of 77.9% and the least efficient farmer could gain economic efficiency of 78.7%. This demonstrates the available potential that the small-scale sugarcane farmers in the study area can exploit to enhance the productivity and profitability through the use of available technology and resources.

Table 5.3: Frequency distribution of economic (CE) and allocative efficiency score for the small-scale sugarcane farmers from the SFA

Efficiency (Percentage)	CE (Frequency)	AE (Frequency)
100	0	0
90 – 100	0	0
80 – 90	0	3
70 – 80	0	51
60 – 70	0	86
50 – 60	20	54
40 – 60	135	23
<40	76	14
Mean (percent)	41.8	61.5
Minimum (percent)	11.4	55.4
Maximum (percent)	53.6	83.2
Std Deviation	0.0784	0.1252

Source: Survey Results, 2011

5.1.3 Determinants of efficiency among the small-scale sugarcane farmers

As has been mentioned earlier, the EE is composed of the TE and AE. This implies that economic efficiency arises as a result of the combination of both the technical and allocative efficiencies. For policy implications, the factors that cause these efficiencies need to be identified through the investigation of the relation between the calculated TE, AE and the farm/farmer specific variables. Thereafter, the association between the farm/farmer specific variables can then be established.

It is should be noted that in the efficiency model (Table 5.3), variables are included as efficiency variables; thus a positive coefficient means an increase in efficiency and a positive effect on productivity.

The AE and TE models were estimated as follows:

$$EFFICIENCY = f(AGE, GENDER, EDUCATION, OFFFARMINC, LANDSIZE, EXP) \quad (5.2)$$

The model in equation (5.2) was estimated using the Tobit procedure. This is because the efficiency values are bound between 0 and 100 (Greene, 1991). According to the results obtained as presented in Table 5.3, all the variables have positive signs but some are not significant. *EDUCATION* level has a positive and significant impact on all three efficiencies (TE, AE and EE). Thus, as years spent in school increase, this results in increased technical, allocative and economic efficiency.

Education's contribution to productivity has been attributed to worker and allocative effects (Welch-effect). The worker effect refers to technical efficiency which implies that a more educated farmer has ability to achieve higher output from a given bundle of inputs. The allocative effect refers to allocative efficiency which means the ability of the educated to obtain, analyse and understand economically useful information about inputs, production practices and commodity mix, which enhances their ability to make optimal decisions with regard to input use and product mix. In short, the farmers' managerial capabilities are more sharpened, the higher the level of education.

Amos (2007) also found that education has a positive relationship with the adoption of new technologies and advisory services which results in improved efficiency. This result is in line with other studies (Belbase and Grabowski, 1985; Kalirajan and Shand, 1989) which found a positive relationship between years of schooling and farm efficiency. Hyuha (2006) also supports the results on the level of education. Thus improving education level of farmers in the Nkomazi region can result in increased production efficiency. However, these findings disagree with the findings of Page and John (1984) and Wang et al. (1996) studies. The findings from these studies were that the relationship between technical efficiency and education is negative.

On the other hand, *LANDSIZE* has a positive and highly significant impact on AE and EE only. The significant relationship implies that the sugarcane farmer can achieve better optimal combination of factors of production on larger plots than on smaller plots. Increasing population pressure will continue to magnify the problem of land fragmentation with implications for efficient production and maximisation of sugarcane production.

Likewise, *EXPERIENCE* has a positive and highly significant impact on EE and AE. This implies that an increase in the duration of the farmer's involvement in sugarcane production increases the productivity of his or her crop. The level of farming experience helps explain scale efficiency. This suggests that management skill aspects, such as the optimal timing of operations, are important. Extension education also becomes more effective if targeted to experienced farmers rather than less-experienced ones. The findings of Padilla *et al.* (2001) confirm that experience is positively related to efficiency.

AGE has a positive and significant impact on the level of TE. The results suggest that farmers under the age of forty years have the highest levels of technical efficiency. Khan and Saeed (2011) have argued that younger farmers are more technically efficient than older farmers, indicating that as younger farmers become more educated, they become more efficient. Beniam *et al*. (2004) assume that the older a farmer gets, the more experienced he or she will be. It is argued that older farmers appear to be more efficient than younger farmers because of their good managerial skills, which they have learnt over time. Then again, whether the efficiency goes to the older or the younger farmers depends on the type of crop being cultivated and which age group is more interested in that crop. Given the importance and significance of land, labour, capital and other resources in farm production, it could be argued that young households are deficient in resources and might not be able to apply inputs or implement certain agronomic practices sufficiently quickly. As timely application of inputs and implementation of management is expected to enhance efficiency, young farmers may find this challenging. These results are in line with the findings obtained by Kalirajan & Shand (1989), Kalirajan and Flinn (1983) and Belbase and Grabowski (1985). Hussain (1989) concluded that older farmers are more risk averse to new technologies than younger farmers.

In addition, the results indicated that the farmers' participation in *OFF-FARM* employment negatively and significantly affects allocative efficiency. As far as the impact of off-farm employment on technical efficiency is concerned, the literature offers mixed results. Some argue that off-farm labour supply curtails farming efficiency (Abdulai & Huffman, 1998). Others contend that the additional income generated by other household members, who engage in off-farm employment, can more than compensate for the constraints caused by reduced farm labour availability. For instance, Pascaul (2004) indicates that lack of finance from off-farm income to purchase seeds seriously hampers farmers' efficiency levels. Tesfay *et al.*, (2005) also found a positive impact of off-farm employment on technical efficiency. It may also be hypothesised that managerial input may be withdrawn from farming activities with increased participation of the educated in off-farm activities, which leads to lower efficiency. Abdulai and Eberlin (2001) found higher inefficiency of production with the involvement of the household in off-farm activities. In any case, the effect of off-farm occupation on production efficiency may not be determined beforehand. In this study, involvement in off-farm activity, though insignificant, was found to have positive signs in reducing inefficiency. This implies that a farmer does not spend the much needed time on his or her farm and thus production inputs may be incorrectly used at times. Padilla *et al*. (2001) also support the result of off-farm employment by concluding that if the farmer spends more time in his or her off-farm duties, the more he or she becomes inefficient.

Table 5.4: Tobit model results for the impact of farm/farmer characteristics on efficiency

Variable	TE	AE	CE
Intercept	4.326*** (0.024)	3.627*** (0.313)	2.364*** (0.318)
Age	0.0712** (0.063)	-0.411 (0.0411)	-0.034 (0.0121)
Education level	0.602* (0.182)	0.659* (0.452)	0.801** (0.432)
Off-farm income	0.008 (0.009)	-0.034* (0.042)	-0.064 (0.052)
Land size	0.051 (0.022)	0.543*** (0.101)	0.623*** (0.106)
Years experience	0.030 (0.025)	0.321*** (0.211)	0.380** (0.217)
Gender	0.001*** (0.001)	0.002 (0.00)	0.002 (0.00)
Log-likelihood	38.5	-26.5	-33.8

Source: Survey Results, 2011

Number in parenthesis is the standard deviation

Notes: ***Significant at 1 percent level; **Significant at 5percent level; *significant at 10 percent level

5.2 SUMMARY

It can be gathered from the technical efficiency analysis results that the small-scale sugarcane farmers are not fully efficient. The hypothesis that the small-scale sugarcane farmers are fully efficient and there is no room for efficient growth is rejected. The results also reveal that socio-economic characteristics and demographic variables of the small-scale sugarcane farmers have a significant influence on their level of efficiency. This means that the hypothesis that socio-economic and demographic variables have no significant influence on the efficiency of the small-scale sugarcane farmers is rejected. The factors which have an impact on the efficiency of the small-scale sugarcane farmers are age, level of education, land size and years of experience in sugarcane farming. The significance of the latter hypothesis is that it shows that small scale farmers could possibly benefit from specific programs aimed at groups with certain characteristics. For example, younger farmers, which is shown to be less risk averse could possible benefit from programs with more experimental technologies or female farmers could benefit from a program which enables them to address constraints specific to female decision making in farming.

CHAPTER 6

SUMMARY, CONCLUSIONS AND POLICY IMPLICATIONS

This chapter summarises the results of the study. The summary and conclusions on the results obtained are provided and their policy implications are given. The study recognises a number of limitations and accordingly recommendations for further research are provided.

6.1 SUMMARY AND CONCLUSIONS

Despite a number of support initiatives (such as provision of production credit and extension services) rendered to the small-scale sugarcane farmers, sugarcane production efficiency of small scale farmers still have room for vast improvements. This raised some questions on the efficient use of available resources. For justification on providing further assistance to the small-scale farmers, empirical evidence was needed. The study was undertaken to estimate the technical, allocative and economic efficiencies of small-scale sugarcane farmers in the Nkomazi Region of the Mpumalanga Province, South Africa.

A limited number of studies in South Africa have dealt with allocative, technical and economic efficiency concurrently. The majority of the studies, done outside South Africa, used the parametric stochastic frontier production function and data envelopment analysis. However, others did a comparison of both the SFPF and the DEA.

This study used the stochastic frontier production function to decompose the cost efficiency into technical and allocative components. This involved an imposition of input-oriented framework on the output-oriented stochastic frontier production function results. As mentioned, there are a limited number of studies in South Africa that have dealt with technical, allocative and economic efficiency simultaneously. The study provides answers to three objectives:

- To determine the levels of technical, economic and allocative efficiencies of small-scale sugarcane farmers.
- To examine the relationship between efficiency level and various farm/farmer specific factors.
- To consider implications for policy and strategies for improving small-scale sugarcane production.

The study used data obtained from a survey for the 2009/2010 sugarcane production season. The study area was the Nkomazi region. A simple random sampling technique was used to select the respondents. A total of 297 small-scale sugarcane farmers were selected for interviewing. However, only 231 questionnaires were used for the analysis because 66 were not compatible (the small-scale farmers could not answer all the questions). Data was collected on their production activities and socio-economic characteristics.

Results from the SFPF indicated that the small-scale sugarcane farmers suffer from considerable technical, allocative and cost inefficiencies. The mean technical, allocative and cost efficiency estimates are 68.5, 61.5 and 41.8 per cent respectively. This implies that there is a possibility of raising small-scale farmer sugarcane production by 58.2 per cent through overall efficiency improvement. Additionally, a Tobit regression was used to analyse the impact of the farm/farmer characteristics on efficiency. The impact analysis revealed that age, level of education and gender are significant determinants of technical efficiency. On the other hand, level of education, off-farm income, land size and experience are significant determinants of allocative efficiency. In so far as cost efficiency is concerned; the significant determinants are level of education, land size and experience in sugarcane farming.

6.2 POLICY IMPLICATIONS

Despite the number of agricultural initiatives which have been put in place to support small-scale sugarcane farmers in the Mpumalanga Province, small-scale sugarcane farmers have remained inefficient. Examples of Producer Development Initiatives are the establishment of Shubombo of Tsb to provide farm management services to the small-scale sugarcane farmers and other Tsb stakeholders, and Akwandze Agricultural Finance to provide production credits to sugarcane farmers. The provision of agronomic services by Tsb to help farmers deal with technical problems on their sugarcane farms is another initiative to help sugarcane farmers increase productivity. However, the productivity of these sugarcane farmers remains low.

Based on the results presented in this study, the resources available to the small-scale sugarcane farmers are not efficiently used, such as the available land, the use of fertilizers, labour, herbicides and inadequate formal education. The statistical analysis of the study revealed that the farmers are faced with the challenges of high production input and operational costs. This means that even where credit support is available to the farmers; it may not be enough to cover all the basic costs. For example, a farmer is given credit, based on the value of his or her sugarcane crop harvest. If the production input and operational costs are higher than the credit he or she qualified for, it means that less will be applied in terms of the production inputs. This calls for improved agricultural partnerships between the sugar mills and the sugarcane farmers. Millers could not only give credit to the farmers but also technical guidance to small producers in return for the delivery of a specific quantity and quality of cane at a stipulated time. The collective efforts of these farmers and millers, once harmoniously co-ordinated, can enhance production efficiency and economic prosperity.

The positive and significant impact of education level implies that policies to provide for adequate basic education programmes (Adult Based Education and Training – ABET) among the small-scale sugarcane farmers need urgent attention. The role of education cannot be overstressed as it enhances the small-scale farmers' skills and understanding of difficult production techniques. Education's contribution to productivity has been attributed to worker and allocative effects (Welch). The worker effect refers to technical efficiency which implies that a more educated farmer has the ability to achieve higher output from a given bundle of inputs. The allocative effect refers to allocative efficiency which means the ability of the educated to obtain, analyse and understand economically useful information about inputs, production practices and commodity mix, which in turn enhances their ability to make optimal decisions with regard to input use and product mix.

Where small-scale farmers are illiterate, the effects can be seen on the decisions they may take regarding production techniques. This can include over-utilisation or under-utilisation of the production resources. A review of agricultural policy with regard to renewed public and private support to refurbish the agricultural extension system is needed. The quality and adequacy of extension services in South Africa need to be upgraded. Proper training needs to be provided for extension workers in order to enhance effective delivery of innovation messages to farmers. In short, additional efforts should be devoted to upgrade the skills and knowledge of the extension workers, as well as to ensuring the timely dissemination of production information to the growers. It goes without saying that proper monitoring and evaluation systems should be in place to ensure that policies are implemented correctly.

Since farm size has positively impacted on efficiency, increases in the size of the farms must receive priority. The farm area is currently being squeezed as a result of increasing population pressure which requires farm land to establish residential properties. This implies that cooperative or corporate farming could be one of the ways in which productive efficiency can be increased. These developments should be given more priority by the Government. Policy makers should also give attention to consolidation of holdings. If more effort is put towards these developments, the existing small-scale farming could blossom. In turn, the flow of capital to agriculture could be improved and pave the way to modern production technologies on a massive scale.

Appropriate policy formulation and implementation is an effective instrument for improvement in farm efficiency and productivity which promotes overall growth of the economy. Accordingly, there is need for all stakeholders (both private and public sector) to partner in order to make combined efforts to remove the bottlenecks that have constrained effective policy implementation and its accrued benefits in the South African agriculture. Recognition and reward for small-scale farmers who achieve defined objectives and levels of excellence in farm production can serve as a booster to increase sugarcane production and agricultural production in general.

In conclusion, an effective instrument for improvement in farm efficiency and productivity is the formulation and implementation of proper policies. This implies that complementary policies, which will include land expansion, investment in education and improved extension systems, must form part of the strategy to improve farm efficiency.

6.3 LIMITATIONS OF THE STUDY AND AREAS FOR FUTURE RESEARCH

The empirical results of this study should be interpreted with some caution, in consideration of the following. One limitation was the limited amount and quality of the production data. The fact that farmers were asked to provide information on events which took place a year before the time of interview might mean that some farmers provide incorrect information. For example, some could not remember the date, place of purchase, and prices of farm inputs; and the frequency of attending field days, meetings and seminars.

The study was conducted on the small-scale sugarcane farming in the Nkomazi region, yet there are other regions that produce sugarcane in the province or in the country, hence the findings might not be a representation of the entire small-scale sugarcane production. This was because of time, budgetary and data constraints. Therefore, it is recommended that a similar study be conducted in all the other small-scale sugarcane growing areas and provinces.

Furthermore, the study only selected a few of the farm/farmer characteristics and perceptions (on the constraints they face and support they get from the sugar mill) that might have an impact on the efficiency of the small-scale sugarcane farmers. Owing to data constraints, the researcher was not able to cover all farm/farmer related variables. An extension to include all other farm/farmer variables is recommended in order to compare how they impact on the efficiency of the small-scale sugarcane farmers. For example, the membership of the small-scale farmers in farmers' organisations has been excluded because there are too many of them (input provision, water). A study which will analyse the effect of the type of producer organisation on the efficiency of the farmers is therefore needed. An extension of the study to analyse the efficiency of large-scale sugarcane farmers is also recommended. This will help identify whether the large-scale sugarcane farmers obtain high yields because they are efficient in input use or whether it is because they enjoy economies of scale. This will help identify key factors that enable large-scale farmers to receive high yields, which can serve as a recommendation for increasing the productivity of the small-scale farmers.

The study considered only the SFPF model. Given the developments in the statistical DEA models, an extension of this work using DEA models can add to the technical efficiency literature, and also help to compare the findings with the ones for the SFPF.

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APPENDIX 1: QUESTIONNAIRE

RESEARCH QUESTIONNAIRE FOR SMALL-SCALE SUGARCANE PRODUCTION IN THE MPUMALANGA PROVINCE OF SOUTH AFRICA

Please carefully read and complete the questionnaire. The information you will provide will be treated with confidentiality. This questionnaire should be completed for the 2009/2010 production season.

Name of interviewer:

Date :

Grower Code	
Interviewee	
Address/area/location	
Contact number	

A. HOUSEHOLD CHARACTERISTICS

1. Age of farmer…………………………..(years).

2. Gender of farmer………………………

3. Marital status…………………………..

4. Highest level of education: ☐

1=primary school 2= metric 3= tertiary certificate 4= tertiary diploma 5= degree, 6=other(specify)……………………

5. Total number of years of formal education (if any) ....years

6. How long have you been involved in the sugarcane farming business?............................(years).
7. Are you a member of a farmers' association? Yes ☐ No ☐
8. Are you currently working elsewhere other than on the farm? Yes ☐ No ☐
9. What is your household size including yourself? Please specify below:

Household member	**Number**
Adult member (above 18 years)	
Children (below 18 years)	
Total household size	

A. LAND AND LABOUR UTILIZATION

1. How much land do you own?.........................(hectares)
2. How much labour do you use for the sugarcane business per season?

Family labour……………….(man days).
Hired labour…………………(man days).

3. .
4. How much land is grown with sugarcane?...............................(ha)

B. FARMING OPERATIONS

1. How much area of land did you use for sugarcane cultivation the last farming season?........ha
2. Please provide the following information regarding your irrigation.

Source of water[i]	
Type of irrigation[ii]	

[i]Code: 1= rain fed, 2= irrigated

[ii]Code: 1= drip system, 2= flood system, 3= sprinkler, 4= centre pivot, 5= micro jet, 6= other (specify)………………………………………..

3. What production inputs do you use?

Type of input	Quantity (kg or L)	Costs/unit	Provider (Source)
fertilizer			
Pesticides			
Herbicides			
Ripeners			
Other (specify)			

4. Which farm assets do you own?

Asset[i]	Size/Number	Date acquired/built	Source of income[ii]
Tractor			
Plough			
Disc			
Irrigation pump			
Lorry/LDV			
Other (specify)			

[i]Code; 1= tractor, 2= plough/disc, 4=irrigation pump, 5=other (specify)…………………………………………………..

[ii]Code: 1=equity, 2=loan, 3= other (specify)………………………………………………………………………….

C. FARM INCOME AND EXPENDITURE

1. What is your approximate total annual farm income for the household?

Source of farm income	Price/unit(R)	Number of units
Sugarcane production		
Livestock production		
Crop production		

2. What are your other sources of income?

Other income	Amount (R)
Income from employment	
Child support grant	
Remittances:	
Old age grant	
Pension	

3. What is your approximate total annual farm expenditure?

Expenditure	**Cost/unit**	**Number of units**
Labour		
Fertilizer		
Chemicals (pesticides and herbicides)		
Chemical Ripeners		
Irrigation		
Transport		
Other (specify)		

D. SERVICES ACCESSED BY THE SMALL-SCALE SUGARCANE FARMER

	Yes	**No**
Access to credit		
Access to extension services		
Management support		
Transport services		
Accounting services		
Water quality testing		
Soil analysis		
Soil profiles		

E. PROBLEMS ECNOUNTERED IN SUGARCANE FARMING

In general, what are the main problems encountered in sugarcane production? Please rank them in the order of their importance, starting with the most important to you.

1.
2.
3.
4
5.
6.
7.
8.
9.
10.

Thank you!