

**COLLEGE OF LAW AND MANAGEMENT STUDIES
SCHOOL OF ACCOUNTING, ECONOMICS AND FINANCE
WESTVILLE CAMPUS**



**UNIVERSITY OF
KWAZULU-NATAL**

**INYUVESI
YAKWAZULU-NATALI**

PhD. RESEARCH WORK

**MATERIAL FLOW COST ACCOUNTING PRACTICES AND RESOURCE
EFFICIENCIES IN SOUTH AFRICAN SUGAR INDUSTRY**

By

**Mishelle Doorasamy
(Student Number: 962085866)**

Supervisor: Dr Bruce Rhodes

DECLARATION

I, Mishelle Doorasamy, declare that:

1. The research reported in this thesis, except where otherwise indicated, is my original research;
2. This thesis has not been submitted for any degree or examination at any other university;
3. This thesis does not contain other persons' data, pictures, graphs or other information, unless specifically acknowledged as being sourced from other persons;
4. This thesis does not contain other persons' writing, unless specifically acknowledged as being sourced from other researchers. Where other written sources have been quoted, then:
 - a. Their words have been re-written, but the general information attributed to them has been referenced;
 - b. Where their exact words have been used, then their writing has been placed in italics and inside quotation marks and referenced;
5. Where I have reproduced a publication of which I am author, co-author, or editor, I have indicated in detail which part of the publication was actually written by myself alone and have fully referenced such publication; and
6. This thesis does not contain text, graphics or tables copied and pasted from the Internet, unless specifically acknowledged, and the source is detailed in the thesis and in the references' section.

Signed...M.Doorasamy

Date...19/08/2019.....

DEDICATION

This thesis is dedicated to my husband and son, Ivan and Kyle Doorasamy, for their unwavering support and understanding.

ACKNOWLEDGEMENTS

I would like to express my sincerest gratitude and appreciation to the following persons without whom the completion of this research study would not have been possible:

Firstly, my gratitude goes to the Almighty God and the ancient of days by whose power and strength I have been able to complete this PhD thesis. His favour over me has granted me the ability and strength to accomplish my goals and endeavours;

My special appreciation is extended to my indefatigable supervisor, Dr Bruce Rhodes, for his invaluable advice, assistance, guidance, constructive criticism and overall contribution to this project;

I must not fail to also thank my dear husband, Mr. Ivan Doorasamy, for his continuous support, encouragement and motivation for me to persist during the difficult times. His moral support was my source of inspiration during the course of this study;

The role of my son, Kyle Doorasamy, in making a heroic achievement of this magnitude cannot be over emphasised. I sincerely appreciate his patience, understanding and support within the duration of this study;

A research of this type would not have been possible without source of data. Hence, I am greatly indebted to Sugar Milling Research Institute (SMRI) and South African Sugar Association (SASA) for their continuous support in the supply of data and the industry information in the course of this study;

Immense gratitude goes to Mr. Stanley Munsamy, General Manager of Gledhow Mill and Alasdair Harris, Maidstone mill, for providing me with the information required; and

My sincere thanks to all members of staff of University of KwaZulu-Natal for their scholarly support particularly during presentations at the School of Accounting, Economics and Finance for their support and encouragement during my study, particularly Professor Harold Ngalawa, Acting Dean of Research and Higher Degrees.

ABSTRACT

Given the backdrop of inefficiencies and declining productivity in the South African sugar industry, this study examined material flow cost accounting (MFCA) as a decision-making toolkit for improving resource efficiency in the industry. This was considered with three distinct objectives, namely: to establish which factors determine the quality of sucrose in sugarcane production; to demonstrate the potential environmental and economic benefits of cleaner production processes and technologies in the sugar milling industry, and to examine the effectiveness of adopting the MFCA framework approach as a decision-making tool in the supply chain to improve overall performance of the sugar industry. Data were collected from a panel of the six sugar milling firms that are operating in the South African sugar milling industry. For the first and second objectives, the panel auto regressive distributive lag (P-ARDL) estimating technique was adopted while models from literature were employed to assess the efficiency of the implementation of MFCA as an important alternative to the conventional accounting process in the third objective. A system generalized method of moments (GMM) estimation technique was also used to estimate the impact of sucrose content on profitability. As well, a random effect regression model was employed to examine the relationship between material flow cost accounting and resource efficiency. Besides the aforementioned methods, detailed conceptual issues relating to cleaner production were identified and addressed. Taking the sugar cane industry in South Africa as the study focus, an alternative measure that enhances the quality of sugar, particularly that of sucrose, was investigated. Findings from the study revealed that certain factors, such as transportation and loading delay, not only contribute to losses in sucrose, but also affect the farmers' yields due to increase in deterioration of cane sugar. Specifically, the result of objective one revealed that, both in the short- and long- runs, most of the variables investigated have the tendency of increasing the sucrose level in sugar cane while an increase in other variables would decrease sucrose level altogether. However, the impact of soil water content (100mm) appears not to be statistically significant on sucrose production in the short- and long-runs. Of special interest is stalk growth (of sugar cane) and average temperature, as their values are more significantly germane as regards to the quantity of sucrose obtained for sugar cane processing in South Africa. The study further used a structural equation model to examine the relationship between cleaner production and firm performance, which was measured by environmental, operational and financial performance. The hypothesis tested supported that cleaner production had a positive and

significant influence on the environmental, operational and financial performance of the firms in the sugar industry. Results from the last two objectives of the study provide evidence to support the conclusion that the effective MFCA implementation process supports increased efficiency in the sugar cane industry as well as cleaner production. The study also found that sucrose content has a positive and significant impact on the profitability of the firms. As well, the evidence showed that material flow cost accounting has a positive relationship with resource efficiency. This study, therefore, recommends the proficient use of MFCA among the South African industries as they possess the quality of classifying product cost from waste cost, hence, improving profitability and organizational efficiency. The contribution of this study lies in the researcher's capability to model the MFCA process for minimizing the applicable costs of the sugar industry for optimal performance.

TABLE OF CONTENTS

DECLARATION	ii
DEDICATION	iii
ACKNOWLEDGEMENTS	iv
ABSTRACT	v
LIST OF FIGURES	xii
LIST OF ABBREVIATIONS	xv
DISSEMINATION OF THESIS	xvi
CHAPTER 1	1
INTRODUCTION	1
1.1 Introduction	1
1.2 Statement of the Problem	8
1.3 Research Aim	10
1.4 Research questions	10
1.5 Specific Research Objectives	10
a. Scope of the Study	11
b. Significance of the Study	11
c. Research Contribution	12
d. Organisation of the study	13
CHAPTER 2	14
CONCEPTUAL ISSUES AND LITERATURE REVIEW	14
2.1 Introduction	14
2.2 Historical Background of Sugar Cane	14
2.2.1 Pattern of Cultivation and Uses	16
2.2.2 Cane Ethanol/Energy Cane	18
2.2.3 Sugar Cane as Food	18
2.2.4 Ribbon Cane Syrup	18
2.2.5 Pattern of Cultivation	19
2.2.6 Environmental Pollution of Sugar Cane Production	20
2.2.7 Preventive Effect of Cleaner Production	21
2.2.8 The Role of MFCA in industry	23
2.2.9 By-Products of Sugar Production and the Environmental Impact of CO ₂	25

2.4 SUMMARY	27
CHAPTER 3	28
COMPARING THE DIFFERENT YIELDS OF SUGAR CANE.....	28
3.1 Introduction.....	28
3.2 Empirical Literature Review.....	31
3.3 Method	33
3.3.1 Data Source.....	33
3.3.2 Test stationary.....	33
3.4 Principal Component Analysis.....	37
3.5 Summary	40
CHAPTER 4	42
4.1 Introduction.....	42
4.2 The Sucrose Cycle in Sugar Cane.....	45
4.3 Problem Statement	49
4.4 Objectives of the chapter.....	51
4.5 Theoretical Foundation	51
4.5.1 Theoretical Framework on the factors that influence Sucrose Content	51
4.5.2 Theoretical Framework on Sucrose Content and Firm Performance	54
4.6 Empirical Literature	56
4.6.1 Factors influencing sucrose quality in sugar cane.....	56
4.6.2 Empirical Literature on Sucrose Level and Firm Performance.....	60
4.7 Method	62
4.7.1 Sources of Data	62
4.7.2 Model Specification for the factors that influence sucrose level	63
4.7.3 Definition of variables	66
4.7.4 Justification of Estimating Techniques	67
4.7.5 Estimation model on the impact of sucrose quality on the profitability	67
4.7.6 Estimation Technique and Model	67
4.7.7 Estimation Model.....	68
4.7.8 Explanation of the Variables.....	69
4.8 Results and Discussion.....	70
4.8.1 Unit Root Test Result.....	70
4.8.2 Result and Discussion on the Panel ARDL Regression Model	72
4.8.3 Interpretation.....	73

4.8.4	Inferences, Comparison with Previous Empirical Studies and Discussion of Findings	74
4.8.5	Testing for Serial Correlation	74
4.8.6	To Measure the Strength of the Panel ARDL Regression Analysis Model	76
4.8.7	Panel ARDL Error Correction <i>Model</i>	76
4.8.8	Test for Heteroskedasticity	77
4.7.9	Stability Test	78
4.8.10	Normality test.....	78
4.8.11	Short-Run Causality Tests among the Determinants of Sucrose Quality	80
4.8.12	Summary	81
4.9	Results and Discussion on the Impact of Sucrose Content on the Profitability of Firms	81
4.9.1	Summary Statistics.....	82
	Table 4.9: Summary Statistics	82
4.9.2	Correlation Matrix	83
4.9.3	Unit Root Tests	83
4.9.4	The Regression Results	84
4.9.5	Summary of Chapter	88
CHAPTER 5	89
ENVIRONMENTAL AND ECONOMIC BENEFITS OF CLEANER SUGAR PRODUCTION	89
5.1	Introduction.....	89
5.2	Objectives of the chapter.....	95
5.3	Conceptual issues in Cleaner Production.....	95
5.4	Literature Review on the Cleaner Production.....	96
5.4.1	Theoretical Literature.....	96
5.4.2	Empirical Literature	103
5.4.3	Conceptual Framework.....	109
5.4.4	Hypotheses Development	111
5.4.4.1	The influence of cleaner production (CP) on Environmental Performance (EP).....	111
5.4.4.2	The influence of cleaner production (CP) on Operational Performance (OP).....	111
5.4.4.3	The influence of cleaner production (CP) on Financial Performance (FP).....	112
5.5	Methodological Approach on the influence of Cleaner Production on Performance	113
5.5.1	Data Collection	114
5.5.2	Validity and Reliability of the Instrument	117
5.5.3	Data, Analysis and Method.....	117
5.6	Results and Discussion	118

5.6.1	Reliability and Validity of the Test Instruments	119
5.6.2	Internal Consistency and Reliability	119
5.6.3	Exploratory Factor Analysis	119
5.6.4	Structural Equation Model	121
5.6.5	Confirmatory Factor Analysis.....	122
5.6.6	Structural Model	125
5.5.2	Methods on the Model Development for a Cleaner Production	130
5.5.1	Questionnaires for Sugar Cane Production	135
5.7	Summary	136
CHAPTER 6		138
MFCA EFFECTIVENESS IN SUGARCANE PRODUCTION		138
6.1	Introduction.....	138
6.2	The statement of problem	142
6.3	Historical Background	144
6.4	MFCA and Resource Efficiency or Waste Reduction/Management	144
6.5	Theoretical Framework.....	148
6.6	Material Flow Cost Accounting and Resources Efficiency or Waste Reduction	150
6.6.1	Prior studies on Material Flow Cost Accounting and Resources Efficiency	150
6.6.2	Method.....	154
6.6.3	Estimation Model.....	154
6.6.4	Results and Discussion.....	157
6.6.4.1	Descriptive Analysis	157
6.6.4.2	Multicollinearity Test.....	158
6.6.4.3	The impact of MFCA on Resource Efficiency (Cost of Waste)	158
6.6.4.4	The impact of MFCA on resource Efficiency (Quantity of Waste).....	162
6.7	Development of MFCA system outputs in the context of the sugar cane milling industry ..	166
6.7.1	Empirical studies on the Adoption or application of MFCA in an Organisation.....	166
6.7	Decision making power of MFCA as a tool.....	172
6.8	Material Flow Cost Accounting (MFCA) Model.....	180
6.9	Conclusion and Recommendation	182

Chapter 7.....	182
SUMMARY, CONCLUSION AND RECOMMENDATIONS.....	183
7.1 Summary.....	183
7.2 Policy Implications.....	188
7.3 Policy Recommendations.....	189
7.4 Limitation of the Study.....	191
7.5 Further Study area.....	191
References.....	192

LIST OF FIGURES

Figure 1 South Africa Cane Harvested Vs. Sucrose Losses	4
Figure 2: Cane Harvested and Sucrose Losses	5
Figure 2.1: Conceptual Framework	26
Figure 3: Percentage of Sucrose as compared to other sugar cane yields	40
Figure 4: Extended sugar season.....	44
Figure 5: The sugar cane sucrose cycle	Error! Bookmark not defined.
Figure 6: Akaike Information Criterion (Top 20 models)	75
Figure 7: Stability Test.....	78
Figure 8: Normality tests	79
Figure 9: Summary of Cleaner Production definitions as adopted from Kauna University of Industry, and Economics Technology Lithuania	Error! Bookmark not defined.
Figure 10: Adopted methodological Model (ACME) on Cleaner Production....	Error! Bookmark not defined.
Figure 11: Adopted methodological Model (ACME) on Cleaner Production....	Error! Bookmark not defined.
Figure 12: The declining Trend of Sucrose in South African sugar cane season	Error! Bookmark not defined.
Figure 13: Classification of production Process	Error! Bookmark not defined.
Figure 14: Material Flow Model.....	Error! Bookmark not defined.
Figure 15: The role of MFCA in an organization	Error! Bookmark not defined.
Figure 16: Existing MFCA Framework.....	Error! Bookmark not defined.
Figure 17: Adjusted MFCA framework for improved process waste-reduction decisions ...	Error! Bookmark not defined.
Figure 18: Process flow diagram of sugar industry	Error! Bookmark not defined.
Figure 19: Model of material flow cost accounting.....	Error! Bookmark not defined.

LIST OF TABLES

Table 2.1: List of tables showing the ranking of world largest producer of sugarcane in the world	16
Table 2.2: Top World Sugar Cane Exporting and Importing Countries.....	17
Table 3.1: Results from Augmented Dickey Fuller, Phillip Peron and Dickey Fuller Tests for Unit Root	34
Table 3.2: The result of correlation Matrix on the series Suc (dependent variable), LOGTS;LOGTC and YP Tons	34
Table 3.3: The result of Summary Statistics on the series SUC (dependent variable), LOGTS;LOGTC and YP Tons	35
Table 3.4: The result of the principal component analysis on the series: Suc (Dependent variable), LOGTS; LOGTC and YP Tons	38
Table 4.1: South African Sugar Cane Varieties and their Characteristics.....	47
Table 4.2: Results from Panel Unit Root Test.....	71
Table 4.3: Results from Results from Panel ARDL model	Error! Bookmark not defined.
Table 4.4: Serial Correlation.....	74
Table 4.5: ECM Analysis.....	76
Table 4.6: Bound Testing.....	77
Table 4.7: Heteroskedasticity Test: Breusch-Pagan-Godfrey.....	77
Table 4.8: Short-Run Causality Tests.....	80
Table 4.9: Summary Statistics	83
Table 4.10: Correlation Matrix	83
Table 4.11: Results of the Unit Root tests???	84
Table 4.12: Regression Results.....	85

Table 5.1: Instrument Items	116
Table 5.2: Exploratory Factor Analysis Results	120
Table 5.3: Confirmatory Factor Analysis Results.....	123
Table 5.4: Discriminant Validity Analysis	125
Table 5.5: Adjustment Index of the Proposed Model.....	126
Table 5.6: Results of Hypothesis Testing	127
Table 5.7: Adopted methodological Model (ACME) on Cleaner Production	130
Table 6.1 Variable Definitions.....	156
Table 6.2: Descriptive Data	157
Table 6.3: Correlation Matrix and VIF Results	158
Table 6.4: The impact of MFCA on Resource Efficiency (Cost of Waste).....	159
Table 6.5: The impact of MFCA on resource Efficiency (Quantity of Waste)	162

LIST OF ABBREVIATIONS

ABBREVIATIONS	DEFINITION OF TERMS
ACCA	Association of Chartered Accountants
AIC	Akaike Information Criterion
AVTM	Average Temperature
CO ₂	Carbon Dioxide
CP	Cleaner Production
EMA	Environmental Management Accounting
Ecref	Evaporation - reference sugar cane
Fao	Evaporation - reference grass
GHS	Green House Gas
Grow	Stalk growth - reference sugar cane
ISO	International Standard Organisation
MFCA	Material Flow Cost Accounting
ND	Not Dated
FPE	Final prediction error
P-ARDL	Panel Error Correction Model

DISSEMINATION OF THESIS

Published Paper

- Doorasamy, M. and Rhodes, B. (2017). South African Sucrose Quality in Sugar: Determinants and its Empirical Implications. *Journal of Economics and Behavioural Studies*, 9(5).
- Doorasamy, M. and Rhodes, B. (2017). Effectiveness of MFCA as a tool to improving sucrose quality in sugar production *Environmental Economics*, 8(3).
- Doorasamy, M. (2018). An Empirical Investigation of the Declining Sucrose Content in South African Sugar Cane. *Journal of Economics and Behavioural Studies*,

Paper under Review

- Environmental and Economic Benefits of Cleaner Production Processes in the South African Sugar Milling Industry.

CHAPTER 1

INTRODUCTION

1.1 Introduction

Resource scarcity, rising prices of raw materials, pollution and economic downturn are factors that have placed organizations alike under pressure to improve their production processes to achieve increased efficiency. By this, the aims and objectives of ‘Sustainable Development Goal 2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture and SDG 12: Responsible Consumption and Production, will be achieved. The SDGs are a collection of seventeen (17) global goals set by the United Nations General Assembly in the year 2015 for the year 2030 (Hak et al., 2016). Key to the attainment of the SDGs is to make information available and understandable such that progress can be tracked. Among the SDGs, the second goal has received much attention because of its implication to the survival of humankind (Rasul, 2016). The second goal of the SDGs addresses SDG 12; it seeks to ensure efficient use of resources that can reduce the negative impact of economic activities on the environment. The goals focus on delinking economic growth to the use of resources and ensuring that hazardous wastes and chemicals are effectively managed to minimize their impact on the environment and human lives (Akenji & Bengtsson, 2014).

The staircase to SDG 12 means that organizations need a paradigm shift from not only reducing industrial wastes, but also to crafting means of minimizing costs generally if they must remain in production and be profitable. Like every other industry, the sugar industry faces these challenges, exacerbated by the impact of environmental issues like droughts which compel industry to implement an urgent mechanism for cost efficiency strategies. Furthermore, the industry should avail its contribution to the host economies, thereby guaranteeing its survival. The international standard (ISO) 14051 of 2011 recognized material flow cost accounting (MFCA) as a technique that is appraised for highlighting processes within an organization that increases costs in terms of consumption and wastages of resources. MFCA is characterised a different way of management accounting that focuses on the identification and differentiation of cost related to products and material losses which aims to improve the efficient use of resources (Dunuwila, Rodrigo & Goto, 2018).

Among other techniques, MFCA is a formidable tool for revitalising the ailing industries (Bennett, Schaltegger and Zvezdov, 2011). The adaptation of MFCA to reviving the currently ailing sugar industry in South Africa is, hence, the preoccupation of this study. The sustainability of the sugar industry is critical towards the attainment of the second Sustainable Development Goal 2, which aims to eradicate hunger in the world by the year 2030. According to Rasul (2016), tackling hunger cannot be achieved by simply increasing food production. The author explained that hunger can be contained through sustainable food production, and thus, there is the need to adopt the right technology and procedures to provide food. By employing MFCA, resources which van Zyl (2012) claim are being used one and half times more than their replacement will be used effectively.

The importance of raw sugar manufacture to an economy has been established in many studies. For instance, sugar cane is ranked first among plant commodities in many countries (National Institute of Food and Agriculture, 2016). The sugar industry in South Africa has made an important impact on the country's economy, contributing to labour employment, industrial and agricultural investments, linkages with suppliers, and support for customers and other industries. This industry acts as a catalyst to economic development and local employment creation in the rural areas. Direct employment in the sugar production process includes various skills ranging from agricultural scientists to farm labourers. Currently, there are approximately about 79000 direct jobs and 350000 indirect jobs derived through sugar industry activity (SASA, 2017). Sugar cane is the second-largest South African field crop by gross value, surpassed only by maize. This industry also contributes to the employment of approximately 113009 (direct, indirect and induced) jobs in South Africa and economic growth of the country (Kwenda, 2015) through its contribution of between 0.5 and 0.7 percent of national Gross Domestic Product (GDP) (SASA Industry Directory, 2012-2013). The industry is responsible for generating an annual average direct income of approximately R12 billion (SASA, 2013).

The continued realisation of the above economic importance of the sugar industry in the South African economy is now been threatened as South African sugar mills are finding it increasingly challenging to maximize the recovery of sucrose from sugar cane. For this purpose, sugar mills are often situated as close as possible to the supply source of the cane. The viability of the financial activity of these important capital investments rely on a sustainable supply of sugar

cane from the various supply mill area. The recent persistent drought has increased the challenges faced by the industry, as certain sugar mills have remained closed for extended periods of the 2015-2016 planting season due to lack of sugar cane around the milling area. These closures have brought negative impacts on the livelihoods of people employed directly or indirectly by the industry, specifically among the dwellers in the rural areas where few employment opportunities are now available. As earlier stated, this is a major concern to stakeholders because it threatens the attainment of the SDG 2, which aims to eradicate poverty by the year 2030.

Meanwhile, on the world stage, fluctuating commodity prices, imports and development of sugar substitutes and sweetness enhancers, among others, put sugar industries under tremendous pressure to increase the process efficiencies and diversify their product portfolio to keep this industry competitive (National Institute of Food and Agriculture, 2016). In the face of these ongoing issues, sugar production in developing countries, and particularly South Africa, has grown very slowly over the past decade. Consequently, demand has outgrown supply as global sugar consumption in developing countries continue to expand due to population growth, rising incomes and dietary patterns (Nyberg, 2011). The 2016 GAIN Report of the annual demand and supply of sugar in South Africa estimated a decrease of 3% in sugar cane crop which translates to 2% decrease in sugar production in 2016/2017 periods. Although the report states that the country is still able to satisfy local consumption and a few exports, the loss in production meant lost revenue that would have impacted the overall well being of the economy. Thus, while drought may be natural and hardly controlled, efforts at reducing other wastes and inefficiencies that are controllable through possible adaptation of MFCA should be worth investigating.

In the South African economy, the sugar cane industry makes a fundamental contribution which is ascribed to its industrial and agricultural investments, high employment, foreign exchange earnings, as well as its affiliations with support industries, major suppliers and customers. It should, however, be noted that, in recent years, especially in the past decade, the sugar cane industry in South Africa has been struggling to break even as it barely survives tighter profit margins, mainly caused by stagnancy and declining yields, coupled with rising input costs. It should be further noted that the prevalence of Eldana¹ in the coastal regions has necessitated

¹ A sugar cane borer pest in Africa, which is of the Pyralidea family.

the shortening of cutting cycles by the growers, contributing negatively to the quality of cane delivered as well as yields (BFAP, 2015).

As noted above, drought conditions have been another major contributing factor to the decline in yields. Such a decline (Figures 1 and 2) was especially experienced during the 2014/ 2015 season, when a remarkable drop in the levels of rainfall was experienced. The 2015 drought year remained unforgettable as the driest year in a 103-year rainfall history (SASA, 2016).

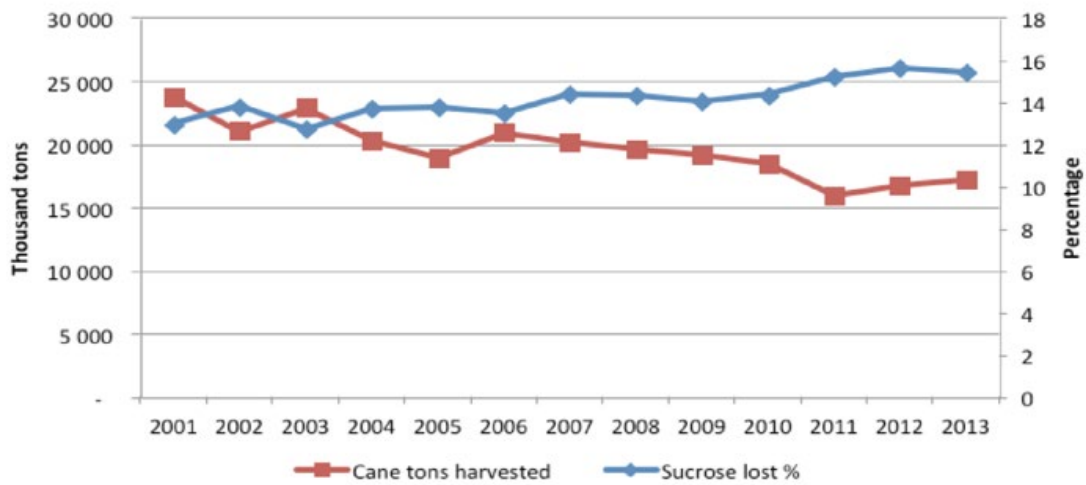


Figure 1.1: South Africa Cane Harvested Vs. Sucrose Losses

Source: SASA (2016)

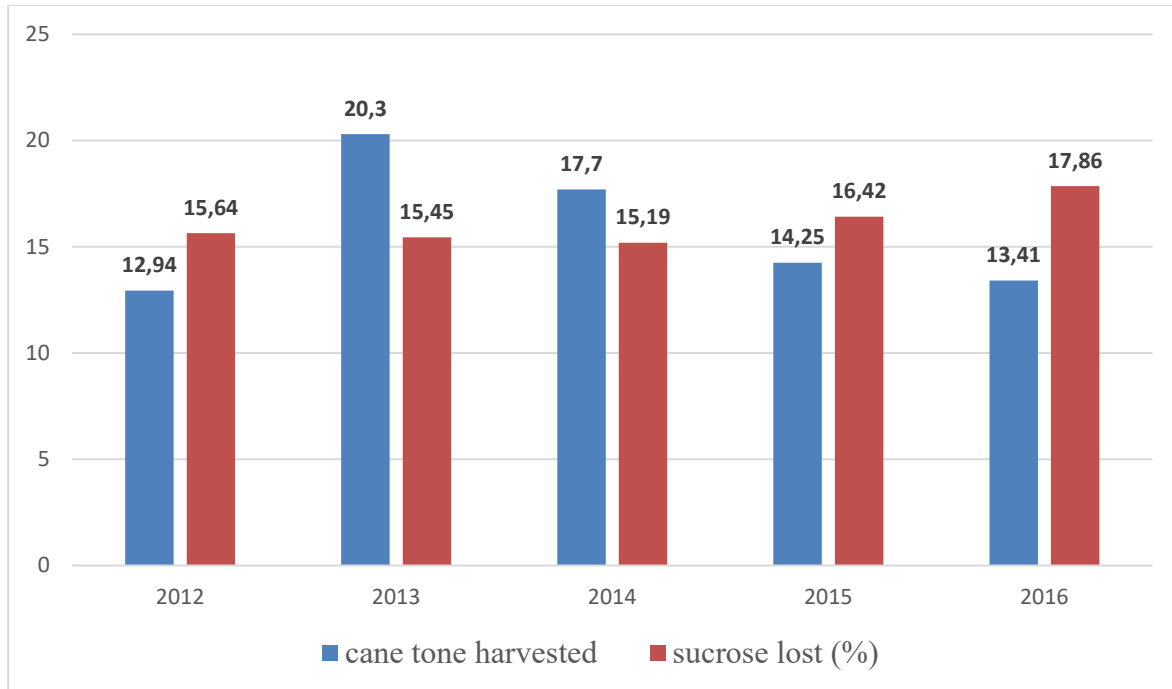


Figure 1.2: Cane Harvested and Sucrose Losses

Source: Author's construction from data collected

The drought has severely impacted on the total yield levels and, consequently, the total cane production eventually dropped to 14.25 million tons in 2015, when compared to 20.3 million tons in 2013 and 17.7 million tons in 2014, respectively (BFAP, 2015). Notably, sucrose losses are increasing, as shown in Figures 1 and 2 above, with a steady increase since 2003; however, cane tons harvested are declining in the same period.

Six companies own the 14 sugar mills operating in South Africa. For the approximate 36 weeks of the year between April and December, the mills operate constantly. However, it is interesting to note that the recent drought occurred at a period when a large number of mills are struggling with the lowering of profit margins for the past several years and consequent lower throughput. Presently in South Africa, while energy costs have been increasing, the supply of energy remains unreliable, thereby aggravating the existing pressure already bedeviling the sugar cane industry. This industrial pressure has led the sugar cane industry participants to seek alternative means of offsetting the high cost of operations.

There is a rising concern in the persistent decline in the quality content of sugar cane product in the recent years with the peak declining period in the 2015/2016 season. This period has been plagued with severe droughts; the tonnes of cane harvested in a season were extremely low with a decline of 16% in the 2014/15 and 2013/14 seasons, respectively. These unfavourable conditions severely resulted in two of the industry's factories not being able to operate, namely, Umzimkulu and Darnall in the KwaZulu-Natal (KZN) province, while most of the other factories operated below the average industry productive capacity. The quality of cane sugar also suffered a deteriorating trend from that season, especially in terms of mixed juice purity and the percentage of the total recoverable value of cane. The overall time efficiency also declined considerably due to the percentage of lost time experienced and the marginal increase in no-cane stops, along the same 2014/15 season. Furthermore, extraction and boiling house recoveries declined while undetermined losses considerably increased (Smith, David, Madho and Achary, 2016).

Another dimension of inefficiency in the industry stems from environmental concerns due to increasing industrial waste that characterize the industry. During the 70's and 80's, the main approach to environmental policy was to treat and filter harmful substances. Accordingly, instruments were developed to explore the costs of filter and treatment technologies. Since then, it has become evident that companies have realized that environmental protection can be more effectively and economically realized by implementing integrated technologies aimed at avoiding or, at least, reducing harmful substances through the reduction of material flows (Orbach and Liedtke, 1998).

Many companies in South Africa are not using the latest technologies and state of the art processes in the reduction of waste. This has a major impact on their environmental performance and profitability as higher levels of pollution require more expensive pollution abatement equipment. South Africa is committed to cleaner production and encourages all organisations to adopt cleaner production to ensure a sustainable future (South African Cleaner Production Centre, 2013).

Many companies are not aware that the adoption of cleaner production can result in immense savings (Schaltegger *et al.*, 2010). This means a company can cut cost by using less resources to produce the same output whilst contributing to environmental protection targets.

Conventional management accounting (CMA) techniques distort and misrepresent environmental issues. Managers are unaware of the impact on profit and loss accounts and the balance sheet impact of environment-related activities. They are missing out on opportunities to reduce costs and improve business practices (ACCA Think Ahead, 2015).

'If Management Accounting as a discipline is to contribute to improving the environmental performance of organizations, then it has to change. Environmental Management Accounting (EMA) is an attempt to integrate best practices of management accounting with best practices in environmental management' (ACCA Think Ahead, 2015:1).

Currently, the implementation of cleaner production is lagging. Moreover, low levels of EMA adoption have been reported. EMA will demonstrate where cleaner technologies can be used. Previous studies recommend that companies should consider restructuring their conventional costing system and adopt an EMA system (Schaltegger *et al.*, 2010). An EMA system requires commitment from the environmental manager, cost accountant, senior managers, and staff to ensure the successful implementation of the system.

Material flow cost accounting (MFCA), a tool of EMA, highlights processes that consume large amounts of resources and generate larger amounts of waste (Bennett, Schaltegger and Zvezdov, 2011). MFCA was officially declared an ISO 14051 in 2011 (International standard ISO 14051, 2011). MFCA enables the identification of value-added loss as a result of material losses (Schmidt and Nakajima, 2013). A good example of this would be the sugar cane industry in South Africa, especially as this industry needs to improve resource efficiency because the industry has reported poor performance in the last few seasons (Smith, Davis, Madho and Achary, 2016). The sugar industry is one of the biggest agricultural industries in South Africa, and, hence, plays an important role in the upliftment of the rural areas (Kwenda, 2015). This industry is, however, showing signs of decline; hence, there is an urgent need for change. Sugar manufacturing is a well-established industry with traditional technologies (Padayachee, 2010) and is also known to be one of the most productive species in terms of its conversion of solar energy to potential chemical energy (Ramjeawon, 2008).

The culmination of the foregoing challenges presupposed new production techniques that could enhance the efficiency of the system for increased output. The main objective of this thesis is

to explore ways to achieve new production techniques through the MFCA. The subsequent parts of this chapter deal with the statement of the problem, detailed research objectives and questions, scope of the study, study significance and the organization of this thesis.

1.2 Statement of the Problem

The South African sugar milling industry is facing operational challenges. Since 2013, the changing economic conditions of the sugarcane business from the drought have had an impact on the economy and the industry as follows: R1.9 billion estimated loss in gross revenue to growers; 34% drop in cane production in the dry-land areas, a 26% drop in cane available to the industry compared to the production in a typical year; a decrease of 4% in real net operating income; a 1.7% decline in estimated total number of workers; and a negative impact on the rural economy. Similarly, undetermined losses across 95% of the sugar mills are higher than the expected average. The sugar industry performed poorly in terms of cane harvested, which decreased by 16% in 2014/2015 and 26% in 2013/2014. Furthermore, the industry performed dismally, as evidenced by the downward trend on boiler house recoveries (BHR), whereby the lowest average values in the last ten seasons have been reported (South African Cane Growers' Association, 2016).

In finding solutions to the challenges faced by the South African sugar milling industry, there was a need to identify the major causes of these challenges. First, inefficiency in operation, which causes high factory losses, is cited as the major cause which has. According to the 2016 reports of the National Institute of Food and Agriculture (NIFA, 2016), the South African sugar milling industry is relatively more inefficient compared to their international sugar mills counterparts; given their higher sucrose losses in filter cake, molasses and bagasse. Hence, the South African sugar milling industry is currently operating below the international efficiency benchmarks according to the same report. It is important to note that the efficiency of sugar extracted is largely affected by the quality of the cane (Smith *et al.*, 2016). However, what seems to be ignored in all of the figures and data reported is that the quality of cane depends on the time delay between 'Cut to crush'. Research suggests that the time lag between harvesting and crushing results in a reduced crushing rate, loss of recoverable sugar and inferior sugar quality. This has a significant negative impact on the entire milling operations; causing losses

throughout production (Mahadevaiah and Dezfuly, 2013). Hence, commercial sugar becomes more expensive because of the higher manufacturing costs.

Expectedly, the improvement in the production and operational efficiency has been professed as the main cure to the ailing sugar milling industry. What is known is that these firms have employed some production and operational methods to improve their efficiency. As part of their sustainable business practice, many industries have adopted End-of-pipe technology. However, this approach is only a temporary measure and does not address the cause of the problem. It is critical that companies look at ways to achieve sustainable competitive advantage by improving production and investing in cleaner technologies (Radonjic and Tominc, 2007).

Meanwhile, the International Standards of Organisation (ISO 14051), also known as MFCA, is a strategy that has been implemented in other industries to address their challenges and improve both environmental and economic performances. Some researchers have examined the extent to which firms adopt or practice MFCA (Maher, 2007; Chaltegger *et al.*, 2010; Fakoya, 2014; and Harvey, 2016) whilst others examined the benefits and challenges of adopting MFCA (Mishelle & Garbharran, 2015; Kasemset, Chernsumornchai & Pala-ud, 2015; and Dunuwila, Rodrigo & Goto, 2018). All these studies adopted a case study approach, focusing on a single firm. What is missing is how MFCA can be used to improve efficiency and effectiveness. MFCA is based on the theory that firms are profit maximisers, at the same time environmentalists. The MFCA theory postulates that firms can improve their environmental and financial performance through an application of a costing system that highlights processes that consume resources and generate waste.

Thus, the application of MFCA result to high productivity, waste reduction, cost savings and higher profitability. The question that remains unknown is whether the MFCA theory can be applied in the sugar cane industry in South Africa to improve their environmental and economic performance. This study thus intends to solve a practical problem by investigating the use of MFCA in South Africa's sugar industry to improve resource efficiency, productivity and performance of firms. This study contributes to the extant literature on the application of MFCA in enhancing productivity in the South African sugar industry.

1.3 Research Aim

The study aims to investigate the use of MFCA in South Africa's sugar industry to improve resource efficiency, productivity and performance of firms. This aim will be resolved with the following relevant research questions and specific research objectives.

1.4 Research questions

In conducting this study, these research questions are set:

1. What are the factors that cause the declining of sucrose content in South African sugar cane?
2. What are the factors that influence the quality of sucrose in the production of sugar cane in South Africa?
3. What are the potential environmental and economic benefits of the application of cleaner production processes and technologies in the sugar milling industry?
4. What is the efficacy of the MFCA framework as a decision-making tool in enhancing the performance of firms in the South African sugar industry?

1.5 Specific Research Objectives

The specific objectives for the study are to:

1. Conduct an empirical investigation of the declining sucrose content in South African sugar cane;
2. Determine the factors which influence the quality of sucrose in sugar cane production;
3. Ascertain the potential environmental and economic benefits of the application of cleaner production processes and technologies in the sugar milling industry; and
4. Measure the efficacy of the MFCA framework as a decision-making tool in enhancing the performance of the South African sugar industry.

a. Scope of the Study

The study's focus is on the South African sugar milling industry. The fourteen firms that this study focused on are Amatikul, Darnell, Eston, Felixton, Gledhow, Komati, Maidston, Malelane, Noodsbe, Pongola, Sezela, Ucl, Umfolozi and Umzimku.

b. Significance of the Study: Sugar Industry Contribution to Socio-Economic and Environmental Development

Economic contributions of the South African sugar industry are quite significant, given its agricultural and industrial investment, foreign exchange earnings, its high employment and linkages with major suppliers, support industries and customers. It is a diverse industry involved in the industrial factory production of raw and refined sugar, syrups and a range of by-products (SASA Industry Directory, 2012-2013). The significance of this study includes, but is not limited to, the following: upliftment of the sugar industry; reduction of carbon emissions and other environmental hazards, such as industrial wastes and waste to landfill, that are caused by inefficient production; improvement of production efficiency of mills, profitability and international competitiveness of sugar manufacturing; development of a model to assist the industry to include the supply chain in MFCA; identification of how quality impacts loss of sucrose throughout the production process; creation of awareness of the benefits of cleaner production and resource efficiency; and employment creation, especially at the local level.

A profitable industry with growth prospects means more jobs. Sugar is an export commodity and improving the output of sugar could mean greater exports and global competitiveness. Creation of new value-added products through bio-refinery is a long-term goal. MFCA will assist in curbing inefficiencies and identifying waste that could be used for bio-refinery projects. Compliance with ISO 14001/ ISO 14051 and sustainability targets is an added benefit of this study.

c. Research Contribution

This study contributes to the extant literature on the application of MFCA in enhancing productivity in the South African sugar industry. Although there are many studies on the application of MFCA in various contexts, the use of MFCA to improve resource efficiency in the South African sugar industry remains unknown. The present study significantly contributes to the growing literature in three different perspectives.

First, a modern dynamic econometric approach is employed to estimate the sucrose content in sugar cane through the use of a Cobb-Douglas production model previously unseen in literature. This model has established the fact that, given quantity control in the explanatory variables, outcome quantity of sucrose expected in cane sugar could be determined. This concept is of great importance to policy makers in the Department of Agriculture in South Africa. This is the first study integrating variables available from SASA to determine possible improvements in sucrose production of sugar cane. Evidence is found to support a negative and positive relationship between sucrose and certain explanatory variables.

Second, in terms of objective two, the study will contribute new knowledge to the extant world-wide literature. To some extent, the study has been able to adopt and apply South African data to develop MFCA accounting principles which hitherto had not been attempted. Again, the study will adopt MFCA models to classify the cost of finished products from residual cost. The implications of this study to policy application rest solely on the need for maximization of profitability in industries resulting from adequate waste reduction management skills.

Third, from this study's third objective, the author noted that certain factors, such as transportation and loading delay, contribute to losses in sucrose which not only affect the farmers' yield but increase the deterioration of cane sugar. Hence, minimization modelling through appropriation of an objective function is to be developed to control transportation cost and supply of sugar cane to the mills.

d. Organisation of the study

This thesis consists of seven chapters. Chapter 1 lays the foundation of the study by providing the requisite motivation, study rationale in terms of the problem being addressed, the research objectives, as well as the study contribution. Chapter 2 contains the main conceptual and empirical reviews of literature on the sugar industry. The conceptual review provides background and historical issues on the sugar cane industry, particularly as it relates to the South African experience. The literature reviews focus on the relevant studies in MFCA, in general, and the sugar industry, in particular. This thesis is also made up of chapters 3, 4, 5 and 6, respectively. In each of these chapters, reviews of literature, research methods and empirical analyses are included. For want of generality, chapter 3 empirically determines those factors that impact on the quality of sucrose in the South African sugar industry. Chapter 4 explores the environmental and economic benefits of cleaner production processes in the South African sugar milling industry, while chapter 5 investigates reasons for the declining sucrose contents in sugar cane. Chapter 6 assesses the effectiveness of MFCA as a tool to improve sucrose quality in sugar-cane production processes, and, lastly, chapter 7 provides a summary, conclusion and relevant recommendations. Also included in this chapter are the limitations of this study which provide a basis for future work.

CHAPTER 2

CONCEPTUAL ISSUES AND LITERATURE REVIEW

2.1 Introduction

The previous chapter discussed the motivation of the study and provided background information on the research topic. It presented the statement of the problem, research aim, questions and objectives. The previous chapter also highlighted the significance and contributions of the study. This chapter discusses the conceptual issues and reviews the literature relating to MFCA and the sugar industry. The conceptual issues cover the background of the sugar production industry and describe its various components, including situating MFCA, in the sugar industry. The literature review focuses on the sugar industry and the use of MFCA to lay the requisite foundation for the empirical analysis in the subsequent chapters.

2.2 Historical Background of Sugar Cane

In a study of this nature, it is important to explore the history of sugar cane to gain knowledge of how the product has evolved. The origin of the cane sugar plant has been dated back to the earliest emerging civilizations which flourished long before the Christian dispensation. However, the actual sugar extraction acquired from sugar cane was never developed until early 600AD. Before this, sugar cane was known only for chewing, and its juice for drinking (Shrivastava, Srivastava, Solomon, Sawnani and Shukla, 2011). Southeast Asia and South Asia have been historically known as the home origin of sugar cane with the oldest historical information on record as crystallized sugar about 5 000 years ago. This product was introduced to Northern Africa and Europe around 800 AD. Significantly, sugar cane was one of the early crops imported to America. By the 7th century, production of sugar through the growing of sugar cane was introduced to China, while it was introduced by the Arabs to Egypt, Mesopotamia, Spain and North Africa as crystallized sugar at the dawn of the 8th century. From there, it was later taken to South and Central America, and, finally, brought to the Caribbean islands by Christopher Columbus (Shrivastava, Srivastava, Solomon, Sawnani and Shukla, 2011).

Cane sugar is a special perennial grass which flourishes adequately in frost-free warm temperate and tropical areas. Mainly, this product grows in temperate and tropical climates, having been known as one of the most outstanding photosynthesizers and vegetative plants across the globe. The plant needs plenty of sunlight, high temperatures and large quantities of water (ranging in the averages of 1 500 mm of rain per annum, otherwise it would certainly require irrigation for its growth), good drainage and fertile soils. The average life cycle of the crop is 10 to 24 months; however, this can be four times extended or even more by further ratoon² cropping. For most plant crops, sugar cane is mostly harvested after about a year to 18 months, or within a year for ratoon crops. Due to modern technology, the growing cycle may be considerably shorter, particularly in fully mechanized cultivation areas, such as US and Australia, where the average life cycle of the cane plant prior to harvesting period is nine months after the emergence of spring, and seven to eight months for ratoon crops. Generally, harvesting is carried out in the dry season, especially when the stalks are rich, giving the maximum amount of sucrose (Dahlia *et al.*, 2009).

Until recently, about 50% of the cane sugar production has not enjoyed mechanised plantation, processing and harvesting, especially in the less developed countries. According to the Economic and Social Department of the Food and Agricultural Organization of United Nations statistics, Brazil, India and China are today the world highest producers of cane sugar in terms of tonnage and acreage, accounting for about 65% of world output alone. Only about 5% of the global production is grown in Africa, and typically East Africa produces 30% of this production. South Africa is the largest sugar cane producer in the sub-Saharan Africa region, followed by Sudan, Kenya, Swaziland, Mozambique and Cameroon. Again, from the perspective of global yields, among the eight top countries of the world, six sub-Saharan African countries are represented, with Peru taking the highest yields (135 ton/ha) while Egypt and Senegal follow (Sharpe and Peter, 1998).

As the growing of sugar cane evolves, a special specie, *Saccharum*, a unique specie, having a range of six to thirty-seven species of sugar cane, has been discovered and grown across the globe. This specie belongs to the family of sugar cane of Poaceae among the tribe of Andropogoneae, which is a native of warm temperate in tropical regions. This special form of species has some peculiar features which include stout, jointed, and fibrous stalks known to be highly rich in cane sugar and

² Ratoon is the shoot from which sugar cane is grown (Davis, Gillaspie, Harris & Lawson, 1980).

by measurement and grows in the range of two to six meters. However, an interbred variety is the major type of species found in major countries of the world, cross bred by the farmers so as to meet with the high commercial demands of cane (Lai, 1993).

2.2.1 Pattern of Cultivation and Uses

Records reveal that there are about 200 countries all over the world that are involved in the growing of sugar cane to produce a global total of about 1324.6 million tons. Brazil and India have consistently featured as the world’s largest producers of sugar cane. For example, Brazil was the world's largest producer of sugar cane in the year 2015 with a production of 739267 metric tons followed by India with a production of 441200 metric tons, as shown in Table 1.1. Sugar cane usage has a very wide coverage, ranging from the production of sugar to that of ethanol, usually extracted from molasses for fuel, falernum, soda, rum and cachaça (popularly known as the national spirit of Brazil). The remains of the sugar cane plant after crushing is known as bagasse and can be burned to generate heat needed for electricity in mills.

Table 2.1: Ranking of world’s largest producers of sugarcane

Countries	Production (Thousand Metric Tons)
Brazil	739267
India	341200
China	125536
Thailand	100095
Pakistan	63750
Mexico	61182
Colombia	34876
Indonesia	33700
Philippine	31874
United States	27906
World	1877105

Source: Food and Agricultural Organization of United Nations: Economic and Social Department; The Statistical Division (2015).

As shown above, Brazil, the largest producer of sugar cane, uses it mainly for sugar production as well as supplying the required ethanol needed in the production of ethanol-gasoline blends (gasohol) for powering automobile and transportation. Sugar cane is particularly sold as jiggery in India, primarily for consumption as sweeteners in tea and coffee. It is often refined into sugar and also used for the production of alcoholic beverages (Yadav and Solomon, 2006).

Table 1.2 gives a list of top countries that export and import sugar cane. For example, Brazil was the top exporting country of sugar cane in 2016/2017 with an export of 28.50 thousand tons while the Indonesia and China were the top two importing countries with imports of 4.92 and 4.60 thousand tons respectively.

Table 2.1: Top World Sugar Cane Exporting and Importing Countries

WORLD EXPORTING AND IMPORTING COUNTRIES, 2016/2017			
(Thousand Tons, White sugar equivalent)			
Exporting Countries	Amount	Importing Countries	Amount
Brazil	28.50	Indonesia	4.92
Thailand	7.02	China	4.60
Australia	4.00	USA	2.94
India	2.13	EU	2.94
Guatemala	1.98	Bangladesh	2.10
EU	1.51	Algeria	2.10
Mexico	1.29	Malaysia	1.89
Cuba	1.09	Nigeria	1.82
Ukraine	0.81	South Korea	1.76
Colombia	0.70	Saudi Arabia	1.62

Source: United States Department of Agriculture (2018)

2.2.2 Cane Ethanol/Energy Cane

Cane ethanol is generally obtained as a by-product of sugar processing mills. Since its use can be extended as a source of fuel, mostly as a renewable biofuel, an alternative to gasoline, its usage has gained wide acceptance as a fuel for cars in Brazil and is gradually becoming a more suitable option, because of its energy efficiency, compared to gasoline. Currently, in Brazil, an average of 75 tons per hectare of raw sugar cane are produced annually. The sugar cane in Brazil is transferred for processing to the factory by burning and cropping, where 77% of the mass of the raw cane undergoes transformation. In a single year, one hectare of sugar cane produces 4 000 litres of ethanol (excluding further input of energy since the produced bagasse is above the required amount to distil the final output). This excludes the required energy used in transportation and tilling. Hence, in comparison, the solar energy-to-ethanol conversion efficiency is 0.13% (Nyberg, 2012).

2.2.3 Sugar Cane as Food

Among the sugar growing nations, there are numerous popular dishes and foods derived from sugar. These include direct raw sugar cane cubes or consumption of cylinders, whose bagasse is spat out after the juice is sucked. The sugar cane cylinders or cubes are prepared by first peeling out the hard outer layers from the washed raw canes and then cutting them into small cylinders or cubes for chewing. Sugar cane is also used in the production of rum, particularly in the Caribbean. The squeezed sugar from cane is usually fermented and distilled to make the rum. For many years, sugar cane syrup was the conventional sweetener used in soft drinks, however, in recent times, it has been greatly substituted (especially in US) with the less expensive high-fructose corn syrup, though some people considered it not tasting quite alike when compared with the sugar it displaced (Zargaaran et al., 2016)

2.2.4 Ribbon Cane Syrup

Ribbon cane is a subtropical varietal that was once widely grown in southern United States and as far north as coastal North Carolina. The juice was extracted with horse or mule-powered crushers; it was boiled, like maple syrup, in a flat pan, and then used in the syrup to form sweetener for other foods. It is not a commercial crop nowadays, but a few growers try to keep alive the old traditions and find ready sales for their product. Most sugar cane production in the United States occurs in Florida and Louisiana, and to a lesser extent in Hawaii and Texas.

2.2.5 Pattern of Cultivation

The cultivation of sugar cane requires a tropical climatic condition, with an average range of 600-800 mm (24 in) of moisture annually. When comparing the plant kingdom, sugar cane is one of the most effective photosynthesizers as it has the capacity of converting an average of 2% of incident solar energy into biomass. In prime growing regions, such as Brazil, Peru, Australia, Colombia, Cuba, Ecuador and Hawaii, sugar cane has the capacity of producing 20 kg per square meter when exposed to direct sunlight. The cultivation of sugar cane is more of cuttings, though there are some types of cane that produce seeds. The most common method of reproduction in the recent times is stems cuttings (Uriarte *et al.*, 2009). For the planting of sugar cane, each cutting requires at least one bud to germinate, often planted by hand. One stand of sugar cane could be harvested many times once planted because ratoons come after each harvest as new stalks. Normally, a lesser yield is experienced after each successive harvest; hence, replanting is eventually required as decline in yields increases. Agricultural practice determines the number of harvests of cane, but they range between two and ten harvests in-between plantings (Department of Agriculture, Forestry and Fisheries, 2014).

Sugar cane harvesting is done mechanically or manually. More than half of the world's production of sugar cane is harvested manually, particularly among the developing countries (Meyer and Fenwick, 2003). The field is first set on fire in order to burn dry dead leaves and kill any dangerous snakes hiding among the crops while the water-rich stalks are left intact and roots are kept unharmed. Cutting of the standing cane takes place with machetes or cane knives, just above the ground. An experienced skilled harvester could cut up to 500 kg of sugar cane per hour. This compares to harvesting machinery that can get up to 100 tonnes of sugar cane per hour. However, such harvested sugar cane requires rapid transportation to the processing plant; otherwise it starts losing its sugar quality content as damages to the sugar cane, due to mechanical harvesting, might accelerate its decay. Sugar cane is cultivated in most parts of the world during some particular months of the year; a period called 'safra', the Portuguese word for harvest. The only place in the world where there is no 'safra', and, therefore, sugar cane is cultivated and produced all year-round is Colombia in South America.

2.2.6 Environmental Pollution of Sugar Cane Production

Sugar cane production is synonymous with environmental pollution. Important ecological areas are often damaged by the effluents that flow into the water from sugar cane processing; soil is easily eroded, nutrients are leached from the topsoil, and production can only be maintained over time with increasing reliance on fertilizers (Harvey, 2016). More so, sugar mills produce wastewater, emissions, solid waste, flue gases, soot, ash, ammonia and other substances that have a negative impact on the environment. Ultimately, sugar milling causes pollution, industrial waste and soil erosion and degradation (Harvey, 2016). Cane burning is potentially hazardous and impacts negatively on the community. It has also been shown that there is increased pressure on environmental compliance from the marketplace as the majority of key industrial customers in the sugar industry measure their potential suppliers on environmental practices (Padayachee, 2010). Padayachee (2010) further concurred that the implementation of an environmental management system (EMS) is fast becoming a necessity for the industry. The EMS has proved to be an important tool in managing environmental risks, reduction in waste and legislative compliance in addition to demonstrating the company's commitment to environmental management to various stakeholders. There is a general consensus that there is improvement of environmental standards within the industry, but at a very slow pace (Maher, 2003).

The environmental pressures associated with sugar cane production in South Africa are similar to those of other sugar industries globally (Maher, 2010). The negative impact of sugar processing worldwide includes water availability and contamination, cane burning, noise, odours, discharge from the mill, reduction in soil quality, use of fertilisers, herbicides and pesticides, waste management, and lack of bio-diversity. Cane burning has been identified as an area of most concern to the industry (Maher, 2007). Due to the negative environmental impact, legislation has been used to promote environmental safety. Areas addressed in such legislation are related to soil and water conservation, atmospheric pollution and practices that might affect the health and safety of labourers (Maher and Schulz, 2003). Government intervention is needed to ensure regulatory compliance. Other legislation that will affect the sugar cane industry in general include governments taking measures to limit emissions of carbon dioxide and other greenhouse gases

through the auspices of the Kyoto Protocol³, an agreement between countries that they will cut back on carbon emissions. Other methods include putting taxes on carbon emissions or higher taxes on gasoline to force people and companies to conserve energy and reduce pollution (National Geographic Society, 2015).

2.2.7 Preventive Effect of Cleaner Production

It is apparent from the foregoing that sugar production contributes significantly to environmental pollution. Much of the pollution has been attributed to increased waste in the industry and, although Fakoya and van der Poll (2012) generally linked wastes to economic growth, the resulting environmental hazard and declining productivity in the industry require a revolution from the status quo. Besides, strict legislation, market pressure, and decreasing profit margins have increased the need for organizations to reduce their waste and raw material inputs to ensure future sustainability and legislative compliance. The convention has been to filter and treat potentially environmentally harmful substances, an approach which has been less effective in terms of both costs and pollution reduction. According to Orbach and Liedtke (1998), the modern way is adopting the system of integrated technologies, which has been found not to be in use by many companies in South Africa. This has its attendant effects on both industrial output and the environment; hence, the need for the adoption of cleaner production for a more sustainable future (South African Cleaner Production Centre, 2013).

External reporting and internal management of environmental issues have gained prominence in recent times, particularly with the advent of international standardization of various focus areas of environmental management which includes the most recently established ISO 14051 (2011). Environmental pressures on external reporting from an accounting perspective include the disclosure of environmental costs in a financial report, production of separate environmental accounts and the exclusion of non-product output costs (cost of wasted material that do not form part of the final product) from production costs. This raises the question as to whether or not non-product output costs are being calculated and subtracted from production costs. Notwithstanding

³ The Kyoto Protocol is an international treaty that aims at reducing the use of greenhouse gases which have been implicated in causing climate change. The treaty to which South Africa is a signatory was signed in Kyoto, Japan, in December 1997 and entered into force in February 2005. Include in-text reference

the importance of external reporting, it is important to note that internal management of environmental issues and reporting need be addressed first before external reporting.

Conventional management accounting (CMA) systems are inadequate to deal with environmental costs (non-product output costs), which are typically allocated to general overhead accounts. Consequently, managers are unaware of the true magnitude of their environmental costs because they are not reflected as part of production costs. These negative externalities⁴ pose the danger of stunting the potential of the industry as stakeholders perceive them as being environmentally irresponsible, and the consequence may be low growth. They have no information with which to manage non-product output costs and thus no incentive to reduce these costs (ACCA Think Ahead, 2015). Hence, production costs are overestimated due to the inclusion of non-product output costs. In order to address this problem, the environmental management accounting system (EMAS) must be used to accurately track and trace environmental costs of products or processes that are responsible for these costs, providing managers with information needed to manage environmental costs which can be used in strategic decision making (Christ and Burritt, 2013).

Most companies are using inefficient processes and technologies that are obsolete relative to state-of-the-art processes. This results in higher production costs, which, in turn, affect their profitability and competitiveness (Schaltegger *et al.*, 2010). Boiler setups can be so obsolete that they cannot utilise the bagasse which could be used as a resource for other processes. In addition, the inefficient incineration at sugar mills causes unnecessary CO₂ emissions. Potential opportunities for savings are not easily identified by companies because of inadequate data collection and monitoring systems. The importance of considering non-product output costs during decision making on cleaner production options have also been established in several business cases (METI, 2011). However, there is gap in academic knowledge on the role and importance of EMA in identifying inefficient production processes. Superior environmental and economic performance is achievable by benchmarking environmental costs (Ferreira, Moulang and Hendro, 2010; Burritt, Herzig and Tadeo, 2009; Christ and Burritt, 2013; Schaltegger *et al.*, 2010; Thant and Charmondusit, 2010; Chiu and Leung, 2002; Va'n, 2012).

⁴ Negative externalities represent a wide variety of costs which are not normally included in prices and charges. These could be from diffuse pollution sources (Gujarati, 2009).

South Africa's commitment to cleaner production led to the formation of the UNIDO National Cleaner Production Centre (NCPC-SA) (South African Cleaner Production Centre, 2013). This organisation plays an important role in assisting industries to adopt cleaner production and improve resource efficiency (Delano, 2013; South African Cleaner Production Centre, 2013). Cleaner production is perceived by management as a costly strategy with no financial returns to the company in the short-term. Information needed to estimate the potential for cleaner production savings was facilitated by making use of material flow analysis (Christ and Burritt, 2013).

In South Africa, higher energy and raw material prices are incentivising cleaner production to become more applied rather than waste treatment or waste disposal (National Cleaner Production Strategy, 2004; Lakhani, 2007).

2.2.8 The Role of MFCA in industry

MFCA is an essential part for a company aiming to achieve resource efficiency (Schmidt and Nakajima, 2013). As with EMA, MFCA is currently an unregulated activity; hence, it is up to the individual organization to determine the practices that are most appropriate to their operations. Case-based research has revealed that MFCA provides a means to identify areas of inefficiency relating to material quantities and costs, and, by so doing, makes visible the potential for cost reductions and eco-efficient outcomes (Schmidt and Nakajima, 2013). Few organizations avail themselves to the practice. The MFCA literature is largely driven by action-based case studies in which experienced academics have played a leading role in facilitating the implementation process.

In South Africa, MFCA is not widely known in many manufacturing industries. Fakoya and van der Poll (2013) conducted a feasibility study on the combination system of enterprise resource planning (ERP) and MFCA waste-reduction decisions in a brewery company. The findings indicated that the waste information could be shared with other parties enabling more effective procedures in decision making on waste reduction plans (Kasemset, Chernsupornchai and Palaud, 2015).

Reinvestment is needed to ensure future sustainability of the agricultural sector. This is a concern for both millers and growers who consistently face lower margins. There are basically eight steps involved in the sugar milling process which include cane preparation, sucrose extraction, raw juice

clarification, filtration, evaporation, syrup clarification, crystallization and centrifugal separation, respectively. Sucrose loss is experienced at each of the stages mentioned above; therefore, it is essential to review the major vulnerabilities of sucrose loss throughout the process (Kwenda, 2015). The adapted MFCA framework will assist in identifying sucrose loss in both monetary and physical units and also enable managers to identify possible causes of significant losses. MFCA will also be extended to include sucrose loss due to delays from 'harvest to crush'. This area has been researched using scientific, chemical and mathematical modeling (Hyrsova, Vagner and Palasek, 2011). However, an accounting dimension such as MFCA has not yet been explored to assess the loss of sucrose and its knock-on effect on the milling process in both physical and monetary terms. This is a key area that needs investigation for potential economic benefits through improved resource efficiency that will benefit the South African sugar milling industry resulting in 'value-added production'. This research, therefore, attempts to extend the MFCA approach to the entire supply chain to ensure a win-win situation for both cane growers and the milling industry simultaneously.

Current industry average burn-to-crush delay is over 72 hours, resulting in significant losses of recoverable sugar due to deterioration in cane quality. The reason for these losses could possibly be a result of poor management practices. It is important that growers gain an understanding of what delays can cost so that there is an incentive to minimise this delay in an effort to maximise returns, as far as possible (Ducasse, 2013). The average sucrose loss due to cane deterioration has been estimated at 10% of the sucrose that could be delivered to the factory. In South Africa, this could represent a loss of up to 250 000 tons of saleable sugar, approximately valued at R1.6 billion per year at current prices. The microbial action taking place in the cane is a cause for the large proportion of this loss, and also the problems experienced in processing cane (SMRI, 2014/2015).

Levels of MFCA knowledge within organizations in South Africa prior to the involvement of this type of research remain unknown. In the absence of academic guidance, extant knowledge within an organization and management group is important when assessing the potential benefits of MFCA, as it is expected to influence the decision to implement. Despite the tangible benefits of MFCA, if stakeholders are not familiar with this research, the sum of these benefits is likely to remain unnoticed. Also, uptake by business is going slowly against the notion of strong competition drive of economic performance (Christ, Roger and Burritt, 2016). This study aims at addressing this issue by creating awareness of the potential benefits of adopting the MFCA

approach as a decision-making tool for all role players to increase resource efficiency in the sugar manufacturing industry.

2.2.9 By-Products of Sugar Production and the Environmental Impact of CO₂

A special feature of the sugar industry is the fact that the sugar cane plant produces its own potential source of energy from sugar production in the form of bagasse (Ramjeawon, 2008). Electricity is generated from bagasse production for agricultural and transportation use but contributes to the net CO₂ emission from fossil fuels, given that all carbon from sugar cane is recyclable. Combustion of fossil fuels releases carbon dioxide (CO₂), which is a major contributor to greenhouse gases (GHG) in the atmosphere. There is strong evidence that the build-up of GHGs is the primary cause of global warming that has become a serious concern in recent decades (The National Academy of Sciences, 2016). Climate change is not just a national concern as all countries are similarly affected by the substantial increase in CO₂ emissions worldwide. Individuals and organisations are encouraged to use fossil fuels in the most efficient and environmentally responsible way to ensure the sustainability of the earth's resources.

“Addressing the issue of sustainable resources in a nation that gets about 81% of its total energy from oil, coal, and natural gas is a formidable goal, but one that we must pursue vigorously” (The National Academy of Sciences, 2016: 1).

2.3 CONCEPTUAL FRAMEWORK

Figure 2 shows the essential idea behind MFCA and how it can be applied to achieve resource efficiency and improve environmental performance among sugar cane milling firms. It can be found that the main aim of every sugar cane milling firm is to obtain sugar which is high in quality. The quality of sugar is therefore affected by the sucrose content. The model continues with the recognitions that a number of factors affect the sucrose content in sugar canes and sugar. In addition, there are various causes of low content of sucrose in sugar cane. With the application of MFCA, it is expected that the firms will obtain better information on the causes of low sucrose content and the factors that affect the sucrose content.

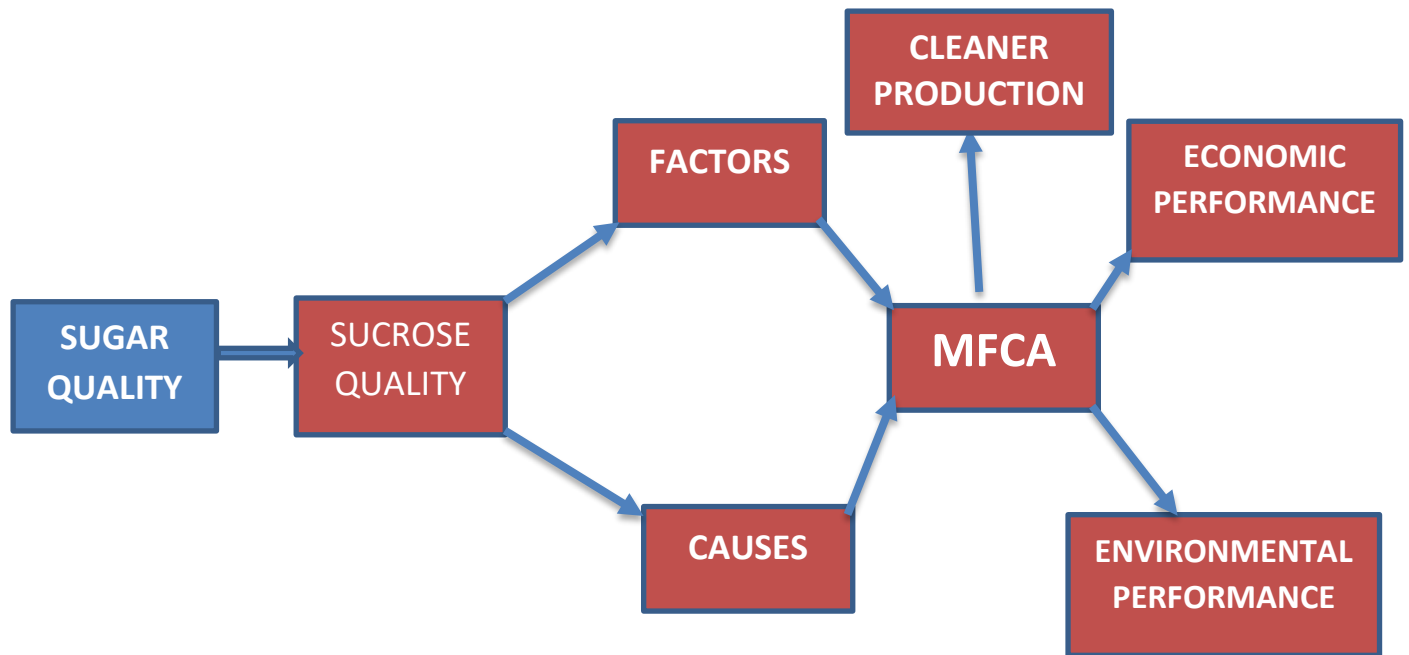


Figure 2.1: Conceptual Framework

In classic cost accounting all costs would only be allocated to the product as cost unit. In MFCA the material costs are divided between the product and the residual materials, depending on where the materials end up. In addition, system costs that can be generated in companies by storage, processing or transport are added. These are also divided between products and residual materials on the basis of suitable key indicators. This allocation can—but need not—be carried out on the basis of physical quantities.

Figure 2.1 further indicates that MFCA can be used to improve the financial performance of the sugar milling firms. Here, with MFCA, the costs of the material losses can now provide indications for improvement measures. Potentials for reducing costs exist in particular in avoiding material losses. The monetary savings are distinctly higher than if only the direct costs of waste disposal are assessed for the residual materials. This would reflect in the financial performance of the firms. Similarly, Figure 2.1 shows that MFCA can be used to improve the environmental performance of the sugar production firms. This means, for example, that the amortization periods for investment to reduce residual material quantities are shorter and open up greater scope for measures in quality or environmental management.

The conceptual framework encapsulates the four objectives of the study. First, the conceptual framework shows sugar quality is determined by the quality of the sucrose in the sugar cane. As well, it can be obtained from the framework that the declining content of sucrose level can be caused by any factors. In addition, the framework shows that MFCA can be an effective tool to ensure effective sugar cane production and hence increase the content of sucrose in sugar cane. This can be achieved through a cleaner production process. Finally, a firm can use MFCA framework as a decision-making tool to enhance its performance, both economically and environmentally.

2.4 SUMMARY

This chapter provides an insight into the extant literature on sugar cane production. The first part reviewed the basic concepts of sugarcane production *cum* the historical antecedent of the industry. The second part explored literature on what has been done in the past with the objective of identifying gaps that require empirical investigation. While empirical literature in the sugar cane industry is scarce in South Africa, no one has investigated the adaptation of MFCA to resolving the mammoth need for efficiency in the sugar industry from the growing of the main raw material, i.e., sugar cane, to the milling in the factories, including the environmental issues. Thus, this study seeks to make a contribution by extending the literature in this area. These identified gaps are addressed in the subsequent chapters by exploring various ways to improve the quality of sugar production without increasing the cost of production.

The next chapter is based on literature that compares the different yields of sugar cane.

CHAPTER 3

COMPARING THE DIFFERENT YIELDS OF SUGAR CANE

3.1 Introduction

Using principal component analysis, this chapter aimed at investigating the declining sucrose levels in South African sugar cane. The agricultural production of sugar cane has been one of the major sources of income to the South African economy. Sucrose has been classified in the analysis of Brix percentage of sugar cane juice as one of the most important parameters of sugar composition, due to its usefulness, among the components in sugar cane which are needed for farmers to generate income within the economy. However, since 2014, data indicate that the sucrose content has declined and is still ongoing, representing a great loss to the farmers. To investigate this trend, this study has regressed the sucrose percentage in cane as a dependent variable against the ratio in tons of cane to 1 ton of sugar, tons of cane crushed, tons of sugar made, and yield per hectare of harvested cane.

The study used correlation matrices, summary statistics and principal component analysis as tools in carrying out its investigation. From the regression result, the proportional composition value of sucrose which stands at 0.6059 - the highest compared to others in the model - indicates that it is an essential component in the chain of sugar production. However, when the maximum value of sucrose (14.24) is compared with its minimum (12.92), a remarkable decline is observed. Since a remarkable difference is also observed when the mean value of 13.55 is compared with the standard deviation value of 0.378318, the study can conclude that the percentage level of sucrose is low compared to other explanatory variables. This finding typically signifies a decline in the value of sucrose when compared with other variables under investigation.

Dated back to the 1970's, the deterioration of sucrose content in cane under South African conditions has been investigated (Wood, 1973). Similarly, Robillard, Vawda and Lionnet

(1990) have indicated that, for the deterioration of whole stalk sugar cane, ethanol could be adopted as a chemical index. Ethanol extract concentrations are now being adopted at the industrial level in the monitoring of cane delays. However, one essential part which appears not to have been covered concerns the application of the concentration of ethanol to evaluate the quantity of losses in sucrose as a result of the post-harvest deterioration process. It is important to note that, apart from the aspect of sugar recovery, as a result of lower purities at the factory, the destruction of sucrose in the stalk represents a direct loss to the farmer who delivers the cane (Robillard, Vawda and Lionnet, 1990).

Among the raw materials rich in sucrose that produce sugar all over the world, sugar extraction from sugar cane makes up 70% (Butterfield *et al.*, 2001). Due to its ability and peculiarity in the phenomenal dry matter production, it is also being adopted as a bioenergy crop. In fact, the crop is gaining great significance in the biofuel industry (Chohan *et al.*, 2014). Again, as a result of the consistent increase in population, the demand for bio-energy, sucrose and white sugar is increasing day by day. Due to low production, however, the present production of sucrose requirement is not enough to meet the increasing demand needed for man's consumption (Cheema and Mahmood, 2005). Low sugar yields, low sucrose, low rate of adoption of the available varieties of high yielding sugar cane are some of the limiting factors of sugar cane yield productions, amongst others (Chohan *et al.*, 2007; Ong'ala, Mwanga and Nuani, 2016).

Again, in terms of annual global sucrose and cane production, current global production is in the average of 1 450 million tons of cane from 22 million hectares worldwide, thus making sugar cane the world's primary sugar crop. Brazil and India are currently the two major sugar cane producing countries in the world, with the global production accounting for about 60%, in addition to its impact in the food industry, while South Africa is the highest cane producing country in Africa (Department of Agriculture, Forestry and Fisheries, 2014). For instance, Brazil dedicates 48% of her sugar cane production capacity to the production of ethanol, while 52% is allocated to meeting the sugar production requirements in the country, whereas, in Asia, nations such as China, India, Philippines, Thailand and Pakistan have already taken biofuel crop for ethanol production as the main output. It is expected that such a production capacity will be able to meet the fuel mixture requirements. For instance, among other fuel requirements, these

countries have been able to adopt an ethanol-gasoline blend of 10 to 90% (Chakwauya, Beyene and Chikwamba, 2009).

According to a study done by Netafim (2018), more than a hundred countries under temperate tropical and sub-tropical conditions grow sugar cane (retrieved from the internet <http://www.netafim.co.za> on 18/07/2018). This is because sugar cane, whose yield is affected significantly by temperature, is a crop of tropical climates, relative humidity and solar radiation. Likewise, the grand growth period favours stalk development; the relative humidity ranges between 55 – 85%, while the optimum mean daily temperature range is 14 to 35°C. The optimal solar radiation requirement is 18 – 36 MJ/m² (total annual: 6350 MJ/m²). With daylight in the range of 10 – 14 hours, stalk growth increases.

With special attention to the South African sugar industry, the industry produces an approximate 2.3 million tons of sugar-rich in sucrose annually (South Sugar Institute Directory, 2014), 75% of which is marketed and sold within the Southern African Customs Union (SACU), and the remaining 25% in other parts of Africa, the USA and Asia. South Africa has, thus, continued to rank among the top fifteen sugar-producing countries in the world.

However, a consistent decline in production has been observed over the past two decades peaking in the recent past planting season, with various factors speculated as being responsible. Some of those factors are: weakening yields and a reduction in the sugar-cane production area according to the Bureau for Food and Agricultural Policy (BFAP) in South sugar Institute Directory (2014); rising input costs and a lack of cohesion and economies of scale (South sugar Institute Directory, 2014; Stainbank, 2011); and a growing culture of minimum reinvestment into farm infrastructure (especially among commercial farmers) due to the threat of land claims, poor soil health and replanting (South Sugar Institute Directory, 2014; Harris, 2016).

There is an ongoing debate in the literature on the possible reasons for the decline in sucrose ratio to overall sugar cane. This chapter aims to investigate the veracity of the purported decline of sucrose in the South African sugar industry, and then propose suggestive corrective measures to the current low level of sucrose in sugar cane.

3.2 Empirical Literature Review

There are some studies that have investigated the factors that causes sucrose level in sugar cane to decrease. Different methods have been adopted to conduct such studies which also resulted to the production of different or conflicting results. First, Ftwi, Mekbib and Abraha (2016) adopted principal component analysis to assess the inter-relationships among traits considered and the phenotypic nexus among 49 sugar cane genotypes. The demonstrated cluster analysis indicated that the 49 sugar cane genotypes under investigation were highly different for Pol in juice and were clustered into nine groups, as indicated by millable stalk population (ha-1), the cane yield (tons ha-1m-1), number of tillers (ha-1) and purity percentage. It was noted that the relationship among sugar cane genotypes was not dependent on geographic origin, indicating a variation in the large proportion of the complete genetic which was retained within the origin groups. Where active genetic exchange was found, millable stalk diameter and millable stalk height had been seen to be greatly associated with sugar yield while there is a weak correlation between sugar yield and quality traits.

On the other hand, multiple regression analysis and path indicated that recoverable sucrose percentage (%), cane yield, and Pol impact closely to the variability of sugar yield; these traits are vital for high sugar yield and may be put into consideration in sugar cane breeding programmes. More importantly, millable stalk population and millable stalk height through Brix and cane yield, purity, Pol, together with the number of internodes via recoverable sucrose % had large indirect impacts on sugar yield, indicating that such traits could be given consideration during sugar yield high selection. Generally, adequate and similar information was provided following the adoption of cluster, linear discriminant, principal component, multiple regression analyses and path coefficient. The adoption of multivariate analyses led to positive results, and the outcomes of the study were highly adequate for offering concrete recommendations.

Again, Zhou (2014) gathered data from the variety testing final stage estimated by adopting the SAS mixed method to analyse cultivar least square means. The objectives of the research were to investigate which trends determine genetic gains for sucrose content, cane yield, and sugar

yield for cultivars that germinates in the sandy and humid soils of the Midlands region, so as also determine the characteristics of the cultivar and the soil types. Quality over time and trends in yield were examined by adopting simple linear regression analysis. There were significant and consistent increases in cane sugar yield with year of release, implying remarkable achievement in the genetic gains. When comparing sugar yield and higher cane with that of older cultivars, the currently released cultivars produced more significantly, showing that there will be significantly increased profitability through the adoption of new cultivars. Gains in sucrose content were limited, showing the necessity to promote breeding for sucrose content. The negative association between sucrose content and cane yield was found by the use of principal component analysis, implying that the main variables that grouped the cultivars exist. Specifically, cultivars generating low-level sucrose content (for instance N31) appear not to be suitable for the humid soils, while cultivars generating low cane yield (for instance, N37) appear not to be suitable for planting in the sandy soils. Consequently, breeding cultivars generating high cane yield for the sandy soils and high sucrose content for the humid soils would increase genetic gains for sugar yield. Hence, increasing the planted area to current cultivars is expected to enhance sugar yield by 7-20%.

Sugar yield is obtained from cane yield and sucrose content (Terzi *et al.*, 2009) and, therefore, cane yield and sucrose content and their interaction are important parameters for developing superior genotypes (Zhu *et al.*, 2000; Chohan *et al.*, 2007). Several reports clarify the relationship between cane yield components and cane yield and cane quality traits. For example, Ahmed *et al.* (2010) reported positive correlation between cane yield and its components (number of millable stalks/m², millable stalk height internodes/stalk and single weight) but negative association with millable stalk diameter, Pol in juice and purity. Similarly, Tyagi and Lai (2007) reported that the weight of millable stalks contributed a high direct effect on cane yield followed by millable stalk, height, number and thickness. Ei-Shafi and Ismail (2006) used a multiple regression model and reported that the main contributors for sugar yield were cane yield, sugar recovery percentage and millable stalk diameter.

Generally, the results of different studies showed discrepancies to the level of sugar yield and cane yield. However, there is a dearth of empirical studies on the causes of declining content of

sucrose level in sugar canes in South Africa. This phenomenon necessitates successive studies to be conducted to determine the relationship and association of the traits to increase the efficiency of selection. The novelty of this study lies in its adoption of a more robust method. While previous studies mostly used primary data through questionnaire and interview, this study used and modified Zhou (2014) and Ong'ala, Mwanga and Nuani (2016) model to examine factors that cause the declining content in sugar cane in South Africa.

3.3 Method

To ascertain the decline of sucrose in the production process through the cleaner production strategies in the sugar milling industry, the model used below is adapted and built upon from the work of Zhou (2014) and Ong'ala, Mwanga and Nuani (2016).

This section seeks to establish with empirical evidence that there is a consistent decline of sucrose in the sugar cane production in South Africa in recent years. The stages shall include; data source, stationarity test, descriptive statistics, correlation matrix and principal component analysis.

3.3.1 Data Source

Data on sucrose percentage in cane (Suc); tons of cane to 1 ton of sugar (LOGTS); implies tons of cane crushed (LOGTC); tons of sugar made (YP); yields per hectare of harvested cane (tons) are adopted to enable one to establish these facts which were on SASA statistical Bulletin for the 2016/2017 season.

3.3.2 Test stationary

Tests for unit root for all the variables in the data set were conducted to determine the form of model to adopt. This process has been achieved by testing the unit root with three method alternatives offered by robust versions of the augmented Dickey Fuller, Phillip Peron and Dickey Fuller tests, the results of which are shown in Table 3.1.

Table 2.1: Results from Augmented Dickey Fuller, Phillip Peron and Dickey Fuller Tests for Unit Root

Augmented Dickey Fuller			Phillip Peron			
Variables	Order of Integration	P-Value	Order of Integration	P-Value	Order of Integration	P-Value
SUC	I(0)	0.0077***	I(0)	0.0048	I(0)	0.0008***
LOGTS	I(1)	0.0043***	I (1)	0.0002***	I(1)	0.0020***
LOGT_C	I(1)	0.0229**	I(1)	0.0000***	I(1)	0.0134**
Y_P	I(1)	0.0360**	I(1)	0.0000***	I(1)	0.0134**
TONS	I(0)	0.0066**	I(0)	0.0027***	I(0)	0.0006***

Source: Author's Computation 2018

***, ** and * represent statistical significance at 1%, 5%, and 10%, respectively.

The study showed the integration order for all variables in the first differences and levels it tested for the presence of unit roots. Several approaches were engaged to compare, test and validate the findings in the results so as to further ascertain consistency. Results from Table 3.1 showed that none of the variables is of I(2). LOGTS, LOGTC, and YP have a unit root and are thus integrated at I (1), thereby becoming stationary at 1% level of significance. However, yields per hectare of harvested cane (tons) and sucrose percentage in cane are all devoid of unit root, and, thus, integrated at I(0). This unit root test offers a mixed outcome because part of the variables was found stationary at order one while others were stationary at levels. Table 3.2 replicates the result of the correlation matrix in the variables adopted in the panel model.

Table 3.2: The result of correlation Matrix on the series Suc (dependent variable), LOGTS; LOGTC and YP Tons

Ordinary correlations					
	SUC	LOGTS	LOGT_C	Y_P	TONS
SUC	1.000000				
LOGTS	0.037980	1.000000			
LOGT_C	-0.170939	0.976405	1.000000		
Y_P	-0.074525	0.841162	0.853532	1.000000	
TONS	-0.837841	-0.530342	-0.334820	-0.314510	1.000000

Source: Author’s computation 2018

Note: Suc implies sucrose percentage in cane; LOGTS implies tons of cane to 1 ton of sugar; LOGTC implies tons of cane crushed; YP implies tons of sugar made; tons imply yields per hectare of harvested cane.

From the information supplied in Table 3.2 and taking sucrose as the dependent variable, the variables exhibit different forms of relationship with one another within the model. The study particularly gives special attention to the noticeable relationship between sucrose and the other independent variables, as indicated in the table. Suc maintains a positive but weak relationship with LOGTS, whereas, from Table 3.2, it is clear that Suc reflects an inverse relationship with all other variables, respectively. In terms of weak association, all other variables have a weak correlation with Suc except tons, which exhibit a high correlation. This is an interesting result as it indicates that some of the variables under investigation do have a multicollinearity problem. For instance, the correlation between LOGTS_C and LOGTS ($r = 0.976405$); Y_P and LOGTS ($r = 0.841162$) and TONS and SUC ($r = -0.837841$) were above the recommended level of 0.60. However, it was considered significant to maintain all the variables in the study, given the individual contribution and the importance of the issues to the understanding of each construct; hence the results are reliable.

Table 3.3: The result of Summary Statistics on the SUC (dependent variable), LOGTS; LOGTC and YP Tons

	SUC	LOGTS	LOGT_C	Y_P	TONS
Mean	13.55353	14.62045	16.77559	64.92529	8.633529
Median	13.68000	14.63489	16.79734	65.14000	8.530000
Maximum	14.24000	14.83179	16.98839	73.95000	9.170000
Minimum	12.92000	14.30249	16.51428	54.36000	8.330000
Std. Dev.	0.378318	0.139621	0.125383	4.577430	0.279149
Skewness	-0.129136	-0.578284	-0.367312	-0.274145	0.770162
Kurtosis	2.410539	2.917479	2.600903	3.472520	2.250200
Jarque-Bera	0.293369	0.952325	0.495089	0.371094	2.078816
Probability	0.863566	0.621162	0.780715	0.830650	0.353664
Sum	230.4100	248.5477	285.1851	1103.730	146.7700
Sum Sq. Dev.	2.289988	0.311902	0.251534	335.2458	1.246788
Observations	17	17	17	17	17

Source: Author's Computation, 2018

Note: Suc implies sucrose percentage in cane; LOGTS implies tons of cane to 1 ton of sugar; LOGTC implies tons of cane crushed; YP implies tons of sugar made; tons imply yields per hectare of harvested cane

Table 3.3 above reports the summary statistics results for all variables. The mean result of every variable is given in the second row. In the third and fourth rows, the value of maximum and the minimum are shown, and standard deviations are reported in row five. As for the case of sucrose percentage in cane which is the study's dependent variable, the study compared the maximum value (14.24) with its minimum value (12.92). Again, the mean value of 13.55 was compared with the value 0.378 of the standard deviation. The study concluded that the amount of sucrose

percentage in relationship to another explanatory variable is significantly lower, and this typically signifies a decline in the value of sucrose.

A further comparative look of tons of cane to 1 ton of sugar shows that the maximum value 14.83179 is closer to the mean than the minimum value 14.30249. Moreover, the standard deviation, which is a good measure of dispersal, has a low value of 0.139621. This claim is further supported and strongly confirmed by the value of the standard deviation which is closer to the mean. This indicates that there is a considerable gap between the expected sucrose percentage and that of tons of cane to 1 ton of sugar. This result is supported substantially by the existing prior expectations in the South African sugar producing company which concurred that the value of sucrose is declining.

The same trend of events is obtainable for tons of cane crushed (LOGTC); tons of sugar made (YP); and yields per hectare of harvested cane (tons). The maximum values are all closer to the mean than the minimum. Hence, there is a clear indication that the value of sucrose percentage is significantly low in comparison with other values under investigation. However, the study takes a further step by examining principal component analysis.

3.4 Principal Component Analysis

The principal component analysis (PCA) is one powerful statistical method widely applied to classify phenotypic traits in crop germplasm into groups based on similarities (Rukundo *et al.*, 2015). The purpose of the principal component analysis is to find the best low-dimensional representation of the variation in a multivariate data set. One can carry out a principal component analysis to investigate whether one can capture most of the variations between samples using a smaller number of new variables (principal components), where each of these new variables is a linear combination of all or some of the traits. PCA reduces the original variables into a new set of uncorrelated variables known as principal components (PCs). These PCs clarify the connections between traits and divide the total variance of the original traits into a small number of uncorrelated new variables (Wiley and Lieberman, 2011). The PCA allows visual

differentiation among entries and identify possible associations (Mohammadi and Prasanna, 2003) by providing a two-dimensional scatter plot consisting of individual entries.

Table 3.4 showcases the result of the principal component analysis.

Table 3.4: The result of the principal component analysis on the series

Principal Components Analysis					
Eigenvalues: (Sum = 5, Average = 1)					
				Cumulative	Cumulative
Number	Value	Difference	Proportion	Value	Proportion
1	3.029429	1.292057	0.6059	3.029429	0.6059
2	1.737372	1.529287	0.3475	4.766801	0.9534
3	0.208085	0.182983	0.0416	4.974886	0.9950
4	0.025102	0.025090	0.0050	4.999988	1.0000
5	1.17E-05	---	0.0000	5.000000	1.0000
Eigenvectors (loadings):					
Variable	PC 1	PC 2	PC 3	PC 4	PC 5
SUC	0.092412	-0.741012	0.222217	0.626867	0.004312
LOGTS	0.563876	0.082381	-0.343466	0.130955	0.734942
LOGT_C	0.536581	0.241349	-0.338337	0.330641	-0.655772
Y_P	0.510731	0.196959	0.825873	-0.135203	-0.003877
TONS	-0.353184	0.589128	0.190034	0.679916	0.172600

Source: Author's computation

The basic phenomenon in the principal component analysis rests in its ability to adopt a statistical procedure to operate through orthogonal transformation to convert a set of observations of possibly correlated variables into a set of values of linearly uncorrelated variables called principal components. This study uses this underlying principle to examine and to compare the declining level of sucrose percentage in cane. The value 0.092412 for sucrose percentage in cane, when compared with other values, has shown a consistent decline under the

eigenvectors (loading). However, the proportional composition of 0.6059 of sucrose is the highest particularly as one compares this value with others in the model, indicating it is principally an essential component in the chain of sugar production.

The result of the statistical analysis has clearly shown the importance of sucrose in the production of sugar cane, but at a declining state. The implication of this declining and yet essential product generates the question of why the decline? In answering this question, Harris (2016) argued that the decline in the sucrose yield in the average from 11%-38% across the South African geographic and climatic zones is more than what can be attributed to the reduction in climatic potential (South Sugar Institute Directory 2014). Harris (2016) substantiated that one of the major factors responsible for this bulk of reduction is the sugar cane production area originated from the segment of small-scale growers that witnessed a reduction for the period from 2001 to 2014 in area in the order of 47 000 Ha. Again, rising costs of input, a lack of economies of scale and cohesion from the grower's group appear to be important contributing factors to the decline in sucrose yield in South Africa (South Sugar Institute Directory, 2014; Stainbank, 2011). In addition, the ever available and the ongoing South African real threat of land claims has triggered the general opinions, particularly among large-scale commercial farmers, of minimum replanting and soil health, reinvestment into farm infrastructure, as these factors have considerably contributed to the prolonged passage of sucrose yield decline in the industry (South Sugar Institute Directory 2014).

The decline in sucrose is presented graphically in Figure 3.1.

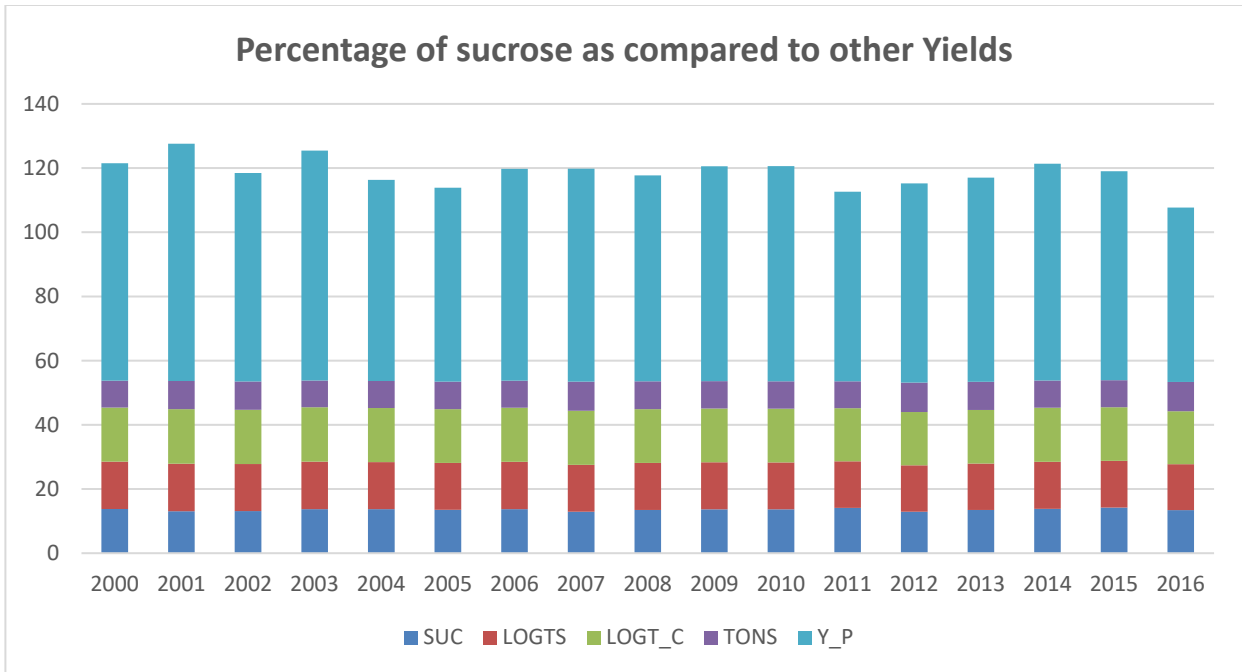


Figure 3.1: Percentage of Sucrose as compared to other sugar cane yields

Source: Author's Computation 2018

In ascending order, they are tons of cane to 1 ton of sugar; tons of cane crushed; tons of sugar made and yields per hectare of harvested cane.

3.5 Summary

This chapter set out to investigate whether there is an existence of decline of sucrose in the cane sugar in the South African sugar industry. Using data from SASA, the study compared the principal component analysis result with summary statistics and correlation matrices. The results clearly indicate that a low sucrose level exists when compared with other components of sugar cane. The implication is that sucrose does not grow in proportion with other components of sugar cane. South African sugar cane growers suffer from the decline as farmers are paid in terms of the quantity of sucrose in the sugar cane. The findings negated the result of Ahmed *et al.* (2010), but corroborate the findings of Barnes, Meyer and Schmidt (2000). Given the outcome of this chapter, the following chapter considers ways of improving the quality of sugar sucrose by investigating the issues that drive the quality of sucrose in the country.

The section that follows is an empirical investigation on the determinants of sucrose content in South Africa. In addition, the impact of sucrose content on financial performance is also examined in the chapter that follows. Data on sucrose percentage in cane (Suc); tons of cane to 1 ton of sugar (LOGTS); tons of cane crushed (LOGTC); tons of sugar made (YP); yields per hectare of harvested cane (tons) are adopted to enable the establishment of these facts.

CHAPTER 4

DETERMINANTS OF SUGAR SUCROSE QUALITY AND FIRM PERFORMANCE

4.1 Introduction

Having established the extent of the decline in the quality of sugar sucrose in South Africa, this chapter explores the factors that determine the quality of sucrose in the South African sugar cane production process to inform policies on improvement. The chapter also investigates the impact of sucrose quality on the performance of the sugar milling firms. The performance of the firms is defined by both return on assets and return on equity. Though South Africa is the 15th largest producer of sugar cane in the world and the highest in Africa, a decline has been observed in the production of high-quality sugar in the country.

This chapter adopts the auto regressive distributive lags (ARDL) technique to analyse sugar cane production using panel data from 1980 to 2016 in South Africa. Ten variables were tested, including average temperature, stalk growth, evaporation, and soil water content (100mm). The findings revealed that, on both in the short and long run, some of the variables investigated have the tendency of increasing the sucrose level in sugar cane while an increase in other variables would decrease the sucrose level altogether. However, the impact of soil water content (100mm) appears not to be statistically significant on sucrose production in the regression model in the short- and long-runs. Of special interest are stalk growth and average temperature, as their values are more significantly germane in terms of the quantity of sucrose obtained during sugar cane processing in South Africa.

Raw sugar cane juice is made of a highly complex system of molecular, colloidal and suspended sugars and non-sugars, and its quality is measured by the proportion between these two classes of components. The major interest of a sugar cane miller is the amount of sugar that can be produced per ton of cane crushed. It is this part which is an asset to the miller, since everything else is a liability. The smaller the amount of cane that is crushed for each ton of sugar produced,

and the lower the level of impurities, the easier it is for the miller to crystallize sugar from the juice.

Sugar cane processing has made a wide range of contributions to the South African economy. Foremost, as has been earlier stated, is the high revenue that the sugar cane industry generates. Secondly, approximately 77 000 jobs are generated through direct employment in the production and processing of sugar cane, and another 350 000 in other related-support industries. In addition, there are approximately 35 300 registered cane growers. Approximately one million people, more than 2% of South Africa's population, depend on the sugar industry for a living. Furthermore, the sugar industry has provided educational support to the economy. The Sugar Industry Trust Fund for Education (SITFE), which was launched in 1965 as a private sector initiative, has to date, provided bursaries to more than 10 000 students, supported tertiary institutions and school building projects, and worked towards the improvement of overall education standards in conjunction with community-based educational authorities (SASA Directory, 2013).

South African sugar mills' main focus is to optimally extract sugar from sugar cane (Eggleston, 2010). Introduction of diffusion over the years, as a preferred method of sugar cane extraction, has, to an extent, improved the rate of sucrose extraction (Rein, 1999). The length of the South African milling session is usually nine months, starting in April and ending in December (Moor and Wynne, 2001). Rein (2007) and Eggleston (2010) posited that about 98% of extractions from sucrose is obtained in South African sugar mills. However, Wynne and Groom (2003) objected, arguing that the 98% extraction rate cannot always be the case. Rather, it is the length of the milling session in South Africa that determines the sucrose content recorded for a particular season at a mill. Their findings indicate that there is a bell-shaped path that appears typical in the South Africa season to the sugar cane sucrose content curve, the month of July being the usual peak. Throughout the season, sugar cane quality differs since the quality is influenced by factors such as the sugar cane cultivar grown, weather, pre- or post- harvest delay, and the age of the crop. At the starting and ending periods of the milling season, the recovery rate of sucrose is always lower, majorly as a result of cane quality fluctuations throughout the season and wet weather during harvesting (Kwenda, 2015). The duration of the season is determined by the amount of recoverable sucrose in the sugar cane plant. In the period from

about the middle of March to the middle of December, the sucrose content is sufficient to allow for commercially viable extraction. Although the sucrose content tapers off at either end of the harvesting season, the total sugar content is still sufficient to allow for profitable bioethanol production (Tongaat Hulett, 2012).

Figure 4.1 shows that the extension of the sugar season is associated with additional sugar cane to be processed.

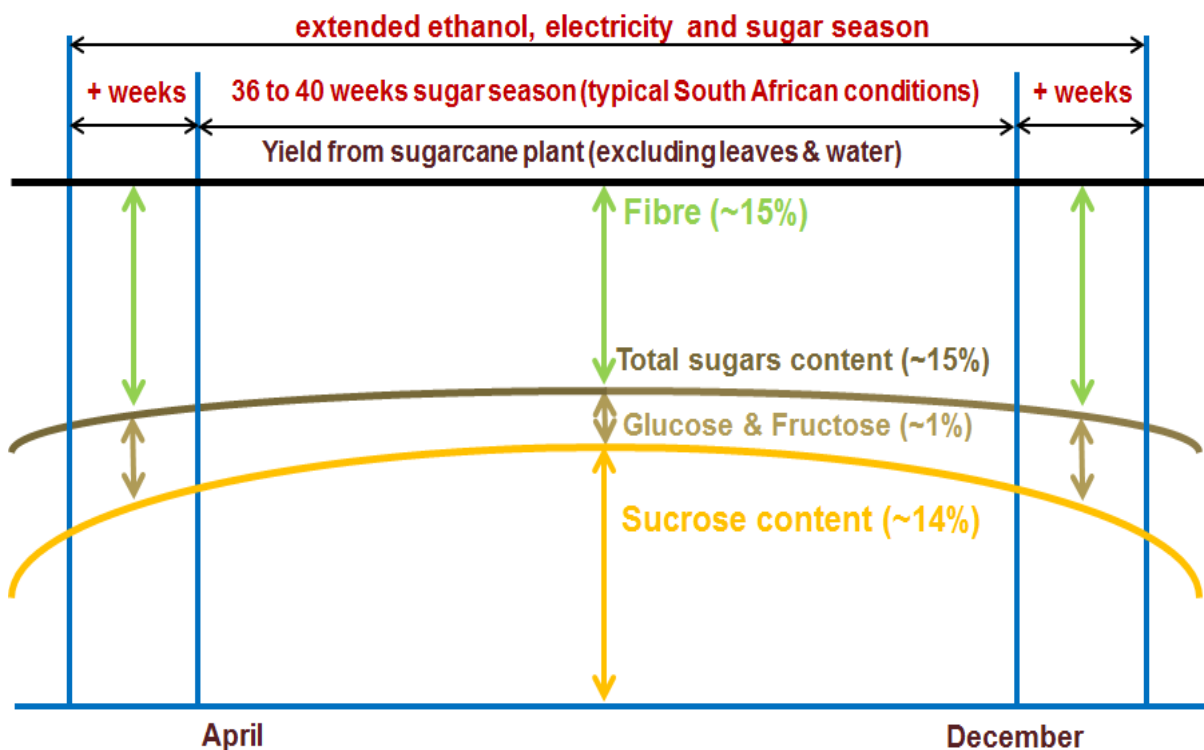


Figure 4.1: Extended sugar season

Source: Tongaat Hulett (2012)

The processing of additional sugar cane requires a further expansion of the area under sugar cane by about 12.5%. This expansion is only feasible in combination with bioethanol production and access to bioethanol markets.

One major reason for the concern over the decline in the sucrose level in sugar cane is its economic impact. The South African sugar cane industry is a diverse one involving both the agricultural cultivation processes, as well as the industrial production of sugars, syrups and a

range of by-products. It is a significant part of the country's agricultural economy with an average sugar output of 2.2 million tons per season (second only to maize) and is mostly centred in KwaZulu-Natal. About 60% of this sugar is marketed in the Southern African Customs Union (SACU), and in combination with the world export market, contributes around R8 billion per annum to the South African economy and about R2.5 billion per annum to export earnings for the country. The average value of sugar cane production is R5.1 billion per annum, which is 17.4% of the total gross value of the annual field crop production in South Africa. The industry supports 79000 direct job and another 270000 indirect job opportunities. It is estimated to provide sustainable livelihoods to about 1 million people (Tongaat Hulett, 2012).

As has been discussed, a declining level of sucrose in sugar cane affects the quality of sugar produced. This, in the opinion of Kwenda (2015), adversely affects the financial performance of a firm. Kwenda (2015) justified this claim, arguing that the major factors that contribute to a high sugar recovery rate are high sucrose and purity, and low fibre and level of non-sugars. The quantity and nature of non-sugars contained in the sugar cane are particularly important, as they have an impact on processing and refining costs. Sucrose content is, therefore, an all-important economic factor (Meyer and Wood, 2001). In fact, Mason et al. (2014) observed that the days when sugar cane was paid in terms of a cane tonnage basis are long past. At present, one often hears that experimental results and even field yields should be given in tons of sucrose per acre or tons of sucrose per acre per unit time. It therefore posited that the quality of sucrose in sugar affects the performance of a firm in terms of increased sales/demand and decreased production cost.

4.2 The Sucrose Cycle in Sugar Cane

Sucrose is produced in sugar cane leaves (the "production site") through photosynthesis and transported to the stem (the "storage site") via the phloem. It is then either stored or converted to glucose and fructose, which are used to provide the energy required for new growth. Although new growth reduces the sucrose content in the stem, it is most important, since it allows the plant ("factory") to increase both its sucrose production and storage sites (Bull, 2000). After the new growth phase, the cane undergoes the maturation stage where all fructose, glucose and other soluble carbons are reconverted to sucrose for storage (Whittaker and Botha,

1997). It is worthy of note that, even with optimal maturation conditions, a low yield cannot be overcome if the new growth stage was not efficient and led to the poor (low yield) or excessive (low sucrose, but high fibre) cane growth. Scientists have made significant efforts to discover ways in which the growth process can be understood and manipulated to lead to high-sucrose cane yields, but with very little success. In addition, factors, like climate and water availability, which also affect the efficiency of this stage, are out of the farmer's control. However, one thing that can be done to ensure high-sucrose produce is to ensure proper and adequate crop nutrition (Wang *et al.*, 2013).

Table 4.1 highlights the South African sugar cane varieties and their characteristics.

Table 4.1: South African Sugar Cane Varieties and their Characteristics

Variety	Parentage	Origin	Year of Release	Cane yield and RV (sucrose content)	Disease Susceptibility	Recommended Harvesting Practices	Recommended Planting Conditions	Ratooning, water stress recovery and response to ripeners	Other remarks
NCo376	Co421 x Co312	Coimbatore (India) & SASRI, South Africa	1955	Generally high yield and RV.	Susceptible to mosaic and smut.	Annual harvesting to be done at mid-late season.	Widely planted along the coast, not permitted in the Midlands or Northern Irrigated regions	Good ratooning ability, good water stress recovery and response to ripeners.	
CP66/1043	CP52/1 x CP57/614	Canal Point, Florida, USA	1987	High RV, low yield.	Resistant to mosaic and smut. Susceptible to eldana and yellow leaf syndrome. May lodge severely.	To be harvested in the first few weeks of the milling season.	Well-irrigated soils.	Generally poor ratooning ability and water stress recovery.	Requires excellent growing conditions. Profitable for farmers far away from the mill.
N12	NCo376 x Co331		1979	High RV.	Resistant to eldana and brown rust. Susceptible to mosaic.	Must be harvested older than 18 months.	Variety of soils in rain-fed regions. Relatively poor performance on humic soils and on frost pockets.	Good ratooning ability.	Hardy variety which performs well in a variety of conditions.
N14	N7 x MP	SASRI, South Africa	1980	Low RV, high yield.	Resistant to lodging. Susceptible to eldana, highly susceptible to RSD with high spread rate and losses.	Annual harvesting at mid-late season. Do not harvest after mid-October. Poor cane yields after mid-August.	Not suitable for weak, shallow, or poorly-drained soils.	Poor water stress recovery, poor response to ripeners (Fusilade and Gallant), no response to Ethephon.	Requires high application of N and K fertilizers. Should not be planted too far away from the mill.
N16	NCo376 x Co331		1982	High RV, high yield.	Susceptible to eldana, smut, tawny, and brown rust.	Long cycle harvesting (more than 15 months old).	Humic soils in the Midlands and Hinterland. Usable in frost	Poor water stress recovery.	Shows rapid stalk elongation and a high population of erect stalks,

							pockets. Performs poorly on shallow and sandy soils.		leading to generally good payloads.
N17	NCo376 x CB38/22	SASRI, South Africa	1984	Moderate-high RV, low-moderate yield		Annually along the coast. Must be harvested in summer (mid-late season).	Well-drained soils (sandy to sandy clay loams and heavy clay). Best results have been obtained on the North Coast and Zululand.	Poor ratooning ability in winter.	
N19	NCo376 x CB40/35	SASRI, South Africa.	1986 (North) / 1989 (South)	Very high RV, low	Susceptible to mosaic.	Annual harvesting.	Performs well on a range of soils (good alluvium, dolerite, Vryheid sediments) with proper irrigation.		Requires favourable rain-fed conditions to reach its potential of very high RV.
N21	CB38/22 x N52/214	SASRI, South Africa.	1989	Moderate RV, high yield	Resistant to eldana. Susceptible to lodging with late (16 – 20) month harvesting.	Harvest at 14 – 15 months if planted in Spring, and at 16 – 20 months if planted in Autumn.	Performs well on a range of soils (NGS Ordinary, Dwyka, tillite, granites), preferably on soils with above 12% clay content.	Good water stress resistance.	This variety actually performs better under stressed conditions and when eldana levels are high.
N22	70E0469 x N52/219	SASRI, South Africa.	1991	High RV, low-moderate cane yield.		Harvest early to mid-season. Poor results in the late season.	Only in high-potential soils with proper irrigation.	Poor water stress resistance.	Very suitable for mechanical harvesting due to its erect nature. RV content is highest early in the season.

Source: Author's review, 2018

It can be observed from Table 4.1 that there are various factors that determine the quality of sucrose and other components in sugar cane. These factors include correct selection of varieties, topping height, harvesting practices, harvest to crush delays, occurrences of diseases and/or pest infestation, fertiliser management practices, use of chemical ripeners and soil type. Fertilizer management practices can have a direct impact on the chemical quality of the sugar cane juice produced, not only as regards to the sucrose content, but also on non-sucrose parameters (such as gums, starch, phenols and ash) which can determine the amount of sugar recovered in the processing stream (Wood, 1982). The limited research available highlights the following factors responsible for sugar loss during the processing of sugar cane: method of storage and harvesting, cane variety; whether the cane is cut whole stock or billeted; and the level of cane contamination during cutting and storage. These attributes differ by country (Lamsal, 2013).

4.3 Problem Statement

Customer demand for high-quality sugar puts pressure on harvester operators and growers to focus on delivering sugar cane with high-quality content. However, this could be detrimental to the maintenance of sucrose quality, as it can lead to them pushing machine harvesters beyond their capacity, resulting in increased losses in sugar and sucrose. The imbalance between quality maintenance and the quest to meet customers' demand is a major challenge to cane growers in South Africa. Policy makers argue that certain harvesting practices, such as lower pour rate and lower ground speed, can help limit cane loss and soil damage during harvesting. However, such practices significantly increase the cost of harvesting. A high-quality cane will have a higher commercial cane sugar (CCS), improving grower returns, but, at current harvesting prices, it is difficult to produce high-quality cane economically. The importance of understanding the factors that determine sucrose quality is shown by the priority of sucrose content among other components of sugar cane, as has been earlier discussed.

The inability to effectively manage the economic pressure from various cane growing stages spanning plantation through harvesting results in short billets, high cleaning losses and excess

stool damage. This, in turn, leads to a lower quality product being delivered. There have been various activities and strategies put in place to improve the sucrose level in sugar cane. In doing so, a lot of resources have been consumed. However, there appears to be no or little success in the improvement in the sucrose level in sugar cane (Eggleston, 2010). One important thing that has been neglected over the years is the identification of the factors that affect the sucrose level in sugar cane. The identification of these factors can help with policy and strategic formulation aimed at improving the sucrose level in sugar cane. Elsewhere, Eggleston (2010); Albert and Orgeron (2012); Zhou M.M. (2014) and Watanabe, Nakabaru, Taira, Ueno and Kawamitsu (2016) found that the sucrose level in sugar cane is affected by the weather condition, the extraction procedure, the sugar cane and the length of milling session. These findings present major steps towards the improvement of sucrose level in sugar cane. In the South African context, there is a dearth of literature on the factors that affect the sucrose level in sugar cane. Since the context in South Africa is different, the firms are cautious in the applicability of these findings. There is thus the need to investigate the factors that influence the sucrose levels in sugar canes in South Africa. Addressing this major challenge is a major gap in the literature, which this study investigates.

Another important issue attached to sucrose quality is its impact on performance. There have been some studies that have examined the effect of sucrose quality on operational efficiency (Mason et al., 2014). These authors argued that the quality of sucrose helps reduce crushing and milling time as well as reducing machine breakdowns. However, how the quality of sucrose reflects on the economic performance of the firms remains underexplored in literature, especially in South Africa, which is the largest producer of sugar cane and sugar in Africa. The question which remains unanswered is: must firms commit extra resources to increasing the quality of sucrose and how does this affect profitability? This creates a gap in literature on the impact of sucrose quality on economic performance. This study thus attempts to fill the gap by investigating the impact of sucrose quality on the profitability of sugar production firms in South Africa. The major contribution of this study, in addition to those clarified earlier is that it explicates the latent structure of two major constructs in contemporary business: sucrose quality and firm performance, that have been major concerns to both practitioners and researchers.

4.4 Objectives of the chapter

The broad objective of this chapter is to determine the relationship between sucrose and the factors that determine its quality.

The specific objectives are to:

1. Identify which factors determine sucrose quality in the South African sugar cane growing industry; and
2. Investigate the extent to which sucrose quality/content influence the profitability of sugar production firms in South Africa.

4.5 Theoretical Foundation

4.5.1 Theoretical Framework on the factors that influence Sucrose Content

The study is guided by the theoretical foundation of the Cobb-Douglas production function as a means of establishing the factors that determine the quality of sucrose in the South African sugar cane milling industry. The Cobb-Douglas production theory dates back to the seminal works of Cobb and Douglas (1928). Cobb and Douglas (1928) econometrically were the first to estimate the aggregate production function. The Cobb-Douglas production function is the most popular theoretical and empirical analysis for productivity and growth, and recently its association with firm performance or value. Though, formulated about a century ago, Felipe and Adams (2005) contend that the parameters used to estimate the aggregate production function, is germane to the contemporary work of productivity, technological change, growth and labour. The authors maintained that the significant theoretical hypothesis like potential output, demand and technical change are still based on the Cobb-Douglas production theory. The Cobb-Douglas production theory postulates that there is a linear relationship between productivity on side and labour and capital on the other side (Kosztowniak, 2014). The Cobb-

Douglas production theory supports the existence of aggregate production function, an addition to the validity of marginal productivity theory of distribution.

The basic idea behind the Cobb-Douglas production theory is that aggregate production or quality of production is affected by many factors such as the labour and capital available to a firm. Though purely related to theoretical economics, this idea has been adopted in many studies that relates to production, productivity and performance. Bowles (1970) and Buchanan (1976) expanded the scope of the production function to incorporate linkages in the industry production possibilities of output and input, but with other possible factors which are often influenced by technical relationships with a profit maximisation motive.

In this study and consistent with the position of Felipe and Adams (2005), it is argued that the Cobb-Douglas production function can reproduce the income accounting identity that distributes value added between labour and profits. The Cobb-Douglas production function is a functional relationship in which output in country i at time t . These values are constantly determined by available technology. The Cobb-Douglas model thus shows constant returns to scale. This means that doubling the usage of capital and labour will also double output. A departure from the Cobb-Douglas production function emerges as one considers the education production function where some measures of output are determined by variables influencing them. The study attempts to adopt such variables used in literature, though not yet used in the South African context, where output is represented by Sucrose variables *and input* represent the set of capital and labour inputs in the production function. This is consistent with Bowles (1970).

The theoretical background behind sucrose formation can be traced to Buchanan (1976), who found, in his simple time regression analysis, an inverse relationship between sucrose, harvestable components and water-related contents. In addition, Rein (2007) and Meyer *et al.* (2013) posited that evaporation forms the heart of a sugar mill and is also the determining factor of the factory's steam economy. According to this argument, raw juice, which contains about 0.5% suspended solids, is heated up to near-boiling point and sent off to the evaporation system (Jorge *et al.*, 2010). Evaporation involves the removal of water from sugar cane juice with the aim of attaining a solid concentration of about 60 - 65° Brix and an invert sugar

composition of about 3.5 - 4.5%. Juice concentration is reduced to a value just under the saturation point, after which crystallisation is initiated. This is done to get a cane juice concentrate with as little steam consumption, sucrose loss and colour formation as possible (Kwenda, 2015). Kwenda (2015) further postulates that a number of factors affect the efficiency of diffusers in the process of sucrose formation, such as cane preparation and residence time, imbibition and percolation rates, the number of diffuser stages, flooding and temperature. These factors should be taken into consideration and monitored if high sucrose extraction efficiency levels are to be maintained.

Similarly, an impact factor which needs to be considered in the overall sugar production process is the environmental effects of sugar cane production processes. The choice of technologies applied in agronomic and agro-processing practices largely determines the environmental impact of the production process. The major environmental effects are air pollution from pre-harvest sugar cane burning (to facilitate cutting), water pollution, and soil erosion and compaction. Soil degradation through erosion and compaction happens as a result of intense mechanization (traffic of heavy machinery) and failure to implement best cultivation management practices and has a negative impact on sugar cane yields (Martinelli and Filoso, 2008). Compaction worsens erosion problems because it reduces soil porosity, decreasing water infiltration and increasing runoff (Martinelli and Filoso, 2008). Soil degradation majorly occurs during periods such as land conversion, replanting of yields, and the time gap between crop harvesting and the next canopy closure. During these periods, the soil is left bare and is thus subjected to the erosive forces of rain and wind. Even the necessary conversion of natural, wild vegetation and extensive pastoral land into sugar cane fields increase the risk of soil degradation. For example, in São Paulo, in a study conducted in 2001, a sharp rise in erosion rates (2 Mg/ha.year to 30 Mg/ha.year) was observed between pastures and other natural vegetation and sugar cane fields. Such high rates of soil erosion cause sediment deposition into water reservoirs, wetlands, streams and rivers (Sparovek and Schnug, 2001).

According to Kwenda (2015), the sugar cane milling process basically comprises eight steps: cane preparation; sucrose extraction; raw juice clarification; filtration; evaporation; syrup

clarification; crystallization; and centrifugal separation. Sucrose loss is experienced at each of these stages. It is, therefore, essential to review the major vulnerabilities of the product (sucrose) throughout the process, since the sugar cane industry is a complex system that requires efficient risk management capabilities.

Watanabe *et al.* (2016) carried out a study focused on the nutrients present in sugar cane juice with the aim of identifying the key factors affecting sugar cane quality. They collected sugar cane samples between 2013 and 2015 from all sugar cane mills in Japan to examine the relationships between juice nutrients and sucrose concentration. Their analysis of the collected juice showed that potassium (K⁺) and chloride (Cl⁻) were most abundant in the juice, and that they both had a negative correlation with sucrose concentration. In addition, they found that the production area had a significant impact on the respective concentrations of potassium and chloride, with those having higher K⁺ and Cl⁻ concentrations showing low sucrose concentration.

4.5.2 Theoretical Framework on Sucrose Content and Firm Performance

The study uses product-quality assimilation theory to explain the impact of sucrose content on the financial performance of firms in the sugar cane industry in South Africa. The product-quality assimilation theory is grounded on the dissonance theory proposed by Festinger (1957). The theory posits that consumers make perceptive assessments between expectations about the product and the perceived product performance or quality. This view of the consumer post-usage evaluation was introduced into the customer satisfaction literature in the form of assimilation theory. According to Sodeyfi (2016), consumers seek to avoid dissonance by adjusting perceptions about a given product to bring it more in line with expectations.

This demonstrates the motivation, order, or ideology behind the way consumers acquire more goods and services in great amounts because of the choice of needs and wants encompassing product safety, customer satisfaction and customer loyalty (Chaudha, Jain, Singh, & Mishra, 2011; Harper & Porter, 2011; Suchánek, Richter & Králová, 2014). This means that customers would buy more of a particular product that is of a higher quality and increases their satisfaction. The improved product quality would therefore increase the market share, sales

and revenue acquisition for a business (Shah, 2014). This means that firms can improve their performance by using a process approach or consistent operation techniques to improve product quality and customer satisfaction, which would translate into the meeting of revenue targets. Customer satisfaction is the sense of contentment that consumers experience when comparing their introductory expectations with the actual quality of the acquired product (Krivobokova, 2009).

Product quality is the life-support of quality control and it ensures that consumers are able to buy high-quality products or services with long-lasting reliability (Jahanshahi et al. 2011: Jabbour, et al., 2015)). Product quality attains improved processes that produce a safe uniform output of products. Suchánek, Richter and Králová (2014) thus argued that there is a direct relationship between product quality and a firm's market share. This is because, customers become satisfied when products satisfy their needs and wants, and they would be willing to buy such products again, even at a higher price, thus increasing the revenue of a firm. Hence, Han and Hyun (2015) and Verhoef and Lemon (2013) contend that quality products motivates customer satisfaction and hence, influence the higher lifetime value of a firm.

In addition, a quality product is also linked to reduced costs. This is because the quality product requires less advertising, distribution, and storage costs because they would have a higher demand. Sodeyfi (2016) thus contends that higher quality products give rise to higher demand, encourages prompt payment and reduces discounts offered to customers. All these are consistent with an improved performance of firms. The postulation of this study is that sugar with a high sucrose content influences a range of organisation variables such as customer satisfaction, repetitive purchase, decreased production cost and decreased advertisement. This study further argues that decreased waste and its associated costs will ultimately increase the financial performance of the firms.

4.6 Empirical Literature

4.6.1 Factors influencing sucrose quality in sugar cane

Direct studies on the factors that influence the sucrose level in sugar cane dearth and limited. However, some authors have done related studies on this subject matter. Aina, Ajijola, Ibrahim, Musa and Bappah (2015), investigated factors influencing sugar cane production and its profitability among the Moro Local Government Area of Kwara State farmers (central Nigeria), taking a random sample of 80 sugar cane farmers. Questionnaires were collected between 2010 and 2011 and the analysis of the results was carried out by adopting descriptive statistics, multiple regression functions and farm budgets. The study showed that male farmers (65%) were in the majority and most of the respondents were within the age group 31 – 40 years (70%). About 75% of the farmers investigated had more than 10 years of farming experience. The study showed that the production of sugar cane in the area under investigation was profitable and worthwhile as the profitability margin was in the average net farm income of about ₦27100.21/ha, indicating that for every naira expended on investment, a return of about ₦1.88 is expected. The most significant determining factors in the production of sugar cane in the area under investigation were sugar cane sett⁵ and farm size; these variables were found to be significant at 5% and 1% level of significance, respectively. The study recommended that more funds are needed to facilitate an improved quantity of sugar cane production by farmers for an increase in effective system productivity. The study also recommended that farmers should be assisted and linked with credit service providers, such as insurance companies, financial institutions and other private community money lenders. The limitation of this study was that none of the factors investigated had any effect on the quality of sucrose and other sugar cane contents.

In another study, Buchanan (1976) analysed the statistical trends in cane quality and yields over 25 seasons. He showed that, though there was a higher cost of production and a decrease in cane quality as a result of increased cane yields, the higher amount of recovered sugar

⁵ Stem cutting or section of sugarcane stalk for vegetative propagation

(exclusive of factory performance) and its consequent increase in returns more than compensated for reduced quality. He further showed evidence of the possible economical advantage to be gained in certain circumstances from the processing of tops (excluding leaves). To further investigate this evidence, he adopted time series simple regression analysis, and concluded that, from the statistical trends in cane quality and yield, there is economic support for the reduction in cane quality, provided yields continue to increase. Summarily, he recommended that cane quality alone should not be maximised at the expense of yield.

In a related study, Deressa, Hassan and Poonyth (2005) examined the significant impact of temperature on the quality of sugar cane production. They used a Ricardian model that captured farmers' adaptation to analyse the impact of climate change on South African sugar cane production under irrigation and dryland conditions. Their study was based on time series data for the period 1977 to 1998, pooled over 11 districts. Results showed that climate change has a significant nonlinear impact on net revenue per hectare of sugar cane in South Africa, with higher sensitivity to future increases in temperature than precipitation. In addition, they discovered that irrigation was not an effective strategy towards mitigating the negative effects of climate change on sugar cane production in South Africa. They concluded by suggesting that focusing on technologies and management regimes is a more effective approach towards adapting to climate change in sugar cane production.

In India, extensive research was conducted on energy and food security and the economics of sugar cane bioethanol. . Gunatilake and Abeygunawardena (2011) examined the feasibility economics of sugar cane bioethanol in India as they prioritized competing policy on food security as a pre-eminent issue while adopting net present value in the method of estimation. The estimation was separately conducted for sugar cane juice and molasses-based bioethanol. This study showed that there is no form of competition between molasses ethanol and agricultural resources. The findings also indicate that the 2010 price of oil and molasses-based bioethanol have been found to be economically feasible. The estimation again shows that it will be difficult to achieve 20% blending of bioethanol without negatively affecting Indian food production at the current productivity level. Moreover, since social benefits derived are not as much as the cost of production of sugar cane bioethanol, the adoption of sugar cane bioethanol option is not economical (Gunatilake and Abeygunawardena, 2011). In an attempt

to improve social welfare without compromise, molasses, a by-product of manufactured sugar, which can support up to 5% blending on bioethanol, was employed. Believing that, in the country, first-generation bioethanol is limited in scope, the ambition of the Indian government is to provide energy security that could depend on bioethanol technologies in this second-generation development, and this needs a lot of improvements to become viable commercially. Therefore, the promotion of bioethanol in India requires that it should be treated with a degree of caution because of its possible impact on the food and the industrial sector.

The study conducted by Guilleman, Gal, Meyer and Schmidt (2003) is premised on the Sezela mill supply area. It examined the possibility for profitable improvement on the mill area by adjusting harvest schedule and cane supply to account for cane quality trends in the sub-region. The recoverable value of sugar (RV) from supplied raw canes were estimated from the delivery data of supplied sugar canes to the Sezela mill between the years 2000 and 2001. Some sub-areas that were likely to have common cane quality patterns all through the year were delimited along these same periods using weather data. New curves for the RV of sugar distribution were developed for these areas using the cane quality database. Furthermore, multiple cane supply scenarios from these sub-areas were evaluated using a spreadsheet model developed in the course of the project.

There were different start and end dates for each scenario represented in each sub-area for cane delivery; the rates of delivery also differed during the harvest window. The findings indicated that the total RV production could be improved by 1-5% by structuring the mill supply area into identical zones and adjusting allocation according to variations found in the cane quality. In addition, findings also indicated that all cane growers, both coastal and inland, could increase their revenues under the tested scenarios. The authors extensively discussed the serious consequences of the new restructuring for allocation delivery among growers within harvest operations and a sub-area together with the cane payment system, particularly at farm level.

Gal and Requis (2002) studied the management of cane harvested at the small-scale grower level with the Sezela mill located in the southern coast of KwaZulu-Natal province as a case study. While adopting a descriptive approach to analyse available data, the initial assumption

was confirmed by this study which hypothesized that the poor performances of contractors are the cause of most of the recorded delivery concerns which the growers encounter at the small-scale level. The study noted that conflicts frequently arose between concerned stakeholders with respect to irregular deliveries, which are as a result of the unreliability of the contractors on issues affecting both their loading output and daily availability. These conflicts, as noted by the study, result in three major constraints: the problem of cash at the starting point of the season; inefficient planning capacity during the season; and lack of existing formal contracts between the growers and contractors, that is, lack of appropriate principles of bookkeeping.

The Sezela mill neither controls nor owns a large share of the farms in South Africa. Hansen, Barnes and Lyne (2002) conducted sensitivity analysis and built a simulation model to reduce and investigate the delays in the South African delivery systems and sugar cane harvest. Their findings indicate that a system integration which comprises the transport, harvest and mill process may result in a significant decline in delay, cost and times. The simulation method was developed by Le Gal, Masson, Bezuidenhout and Lagrange (2009) to investigate the contribution of an improved harvest of sugar cane mechanization. Lejars, Le Gal, Auzoux (2008) also built a simulation model to study the impact of decision-making that has been centralized among the various stakeholders of harvesters, sugar cane growers, millers and haulers, among industries in South Africa versus decentralized decision-making. Again, McDonald, Dube and Bezuidenhout (2008) pioneered another simulation model to operate on the transportation, sugar cane harvesting, together with mill-yard activities for a mill supply area.

In general, the factors influencing the quality of extracted sucrose and other related content include transportation, terrain, capital, labour, rainfall and distribution to the milling stations. From the findings of the literature, which have been conducted on products such as sugar cane and other primary products across the globe, it appears that there are diverse views on the concept of applying Material Flow Cost Accounting (MFCA) as a decision-making toolkit for improving resource efficiency of sugar cane and what determines quality of sucrose seems to vary from country to country. Generally, the results of different studies showed discrepancies to the level of sugar yield and cane yield. Unfortunately, the factors that determine this quality

of sucrose and other related content in sugar cane have not been extensively explored in the South African industry, and the controversies raised in other studies regarding this issue are yet to be empirically resolved for the South African sugar cane processing industries. Thus, a considerable gap exists in the literature which needs to be filled.

4.6.2 Empirical Literature on Sucrose Level and Firm Performance

One of the earliest works carried on sugar cane extraction is that of Buchanan (1976) who conducted a study on the impact of sugar cane quality on the performance of the processing factory. The study presented an analysis of statistical trends in cane quality and yields for a period of 25 seasons. The study showed that increased returns as a result of increased sugar yields (exclusively with respect to factory performance) more than offset the cost of producing and processing the increased yield in spite of the decreased quality of cane. The study concluded that, provided the statistical trend of increasing yield continues, the accompanying decline in cane quality is justified on an economic basis.

Similarly, Sambuo (2015) premised his study on the fact that the scarcity of resources has constantly caused what is produced to be consumed. His work showed that a tremendous increase in the rate of sugar production in Tanzania led to the rise of sugar consumption in the country. The study analysed the relationship between the quantity of sugar produced (SGP) and sugar consumed (SGC) in Tanzania covering a period of 1977 to 2014. A series of data were collected from economic survey data of Tanzania in 2012 and the Sugar Board of Tanzania (SBT) in 2015. The objective of the study was to identify the drivers of demand for sugar production and consumption in Tanzania. The focus was to analyse whether there is direction causality from SGP to SGC, from SGC to SGP, bilateral causality, or they are independent of each other. The Granger causality analysis was used, and the order of integration employed in the vector autoregressive (VAR) was estimated by the seemingly unrelated technique (SUR). The findings indicated that there was a two-way causality of sugar produced and consumed in Tanzania by 2014. Therefore, in order to improve the livelihood of rural farmers, the government should spend a large amount of money expanding local industries and providing subsidy on farm inputs and production facility that could have an income multiplier effect for local sugar cane producers. Interventions should be on the sugar

import tariffs and duties. The current low import tariffs adversely affect the domestic demand for locally produced sugar because the price of imported sugar is much lower. Moreover, more investors should be invited to invest on sugar cane production because the demand is still high.

Furthermore, there was another argument put forward by Patlolla, (2010) that the production of sugar cane in India is adopted to manufacture three sweetening agents such as khandsari, gur and sugar. It is required that sugar processors for cane should comply with a floor price while the producers of khandsari and gur were exempted from the floor price. Hence, any impacts of the choice of sugar processor in the method of procurement, particularly on the incentives that confront farmers, would depend on the anticipated price of cane among those unregulated competing markets. Private sugar processors are commonly used as an unusual form of vertical integration in Andhra Pradesh (AP) India. Instead of conventional pre-planting contracts, permits were issued to choose cane growers a few weeks ahead of harvest..

Another hypothesis was also put forward that a low-cost way of procuring high-quality cane is a function of the probability of the permit system (permits that specify the amount of cane to be delivered during a narrow period) and it is a principal motivation factor supporting the choice of sugar processors (Kwenda, 2015). Hence, the author built up an AP cane procurement market model which integrates the floor price policy which is applicable for the processing of sugar cane; this model compares processor profits under the probabilistic *ex ante* production contracts and *ex post* permit system. The model suggests that both the profits from unit cane purchase and the quality of cane acquired appear larger, particularly when the processor makes use of *ex post* permits. The resultant gains emerge at the expense of the higher cost of cultivation which the farmers incurred. Hence, the researcher went further to confirm and test the theoretical model predictions by adopting household survey data conducted in 2008.

Similarly, Zeddies (2006) considered the competitive nature of the Thailand sugar industry. Thailand ranks third among the major sugar cane exporters in the world market. This position is next to Brazil and Australia, and this achievement has a great impact on Thailand's GDP growth and national income. Hence, in Thailand, among the major economic sectors and indicators, sugar cane production plays an important role. The main objectives of Zeddies

research work were to examine the competitive nature of the Thailand sugar industry, the returns and costs between sugar cane and its competing crops. Interviews and field surveys were conducted with the individual stakeholders of the sugar cane producing industry. To support the research, more secondary data were reviewed. Both secondary and primary data informed the data source adopted in the study. The sales of sugar rely on the market channel and the type of sugar; this ranges from 14 Baht/kg to 18 Baht/kg. For sugar cane that is bought from farmers, it takes an average distance of 53.33 km to transport it to the final industry for processing. The nearer the sugar cane fields are to the industry, the better is the competitive nature of the sugar industry.

4.7 Method

This section discusses the techniques used to estimate the factors that affect the quality of sucrose level in sugar cane and the effects of sucrose quality of firm performance.

4.7.1 Sources of Data

Two set of data were used for the analysis. These are, data on sucrose quality or content and the financial data. Data spanning the period between 1980 and 2017 on *Avtm*, *Drn60*, *Ecref*, *Fao*, *Grow*, *Harvest*, *Rain*, *Sr100*, *Swc100* and *TT16* are sourced from the South Africa Sugar Research Institute (SASRI) website, while data on sucrose content in sugar were sourced from South Africa Sugar industry directorate 2016/2017 version.

The data on sucrose content in sugar were sourced from South Africa Sugar industry directorate 2016/2017 version. As well, the data on the financial performance of the firms were sourced from the both the annual reports of the firms and iress. There were six major sugar producing firms in South Africa. All the six firms were used for the study. The data from 1986 to 2017 were used for the study. This resulted to one hundred and eighty panel datasets. However, due to missing data for some of the firms for some years, one hundred and sixty-seven panel data sets were used for the study.

4.7.2 Model Specification for the factors that influence sucrose level

The method in this paper is built on the theoretical foundation of the Cobb-Douglas production function as a means of establishing the factors that determine the quality of sucrose in the South African sugar cane milling industry. Many studies that examined the factors that influence the quality of a product adopted the Cobb-Douglas production model (Kotulič & Pavelková, 2014). In addition, studies such as Martinelli and Filoso (2008); Watanabe *et al.* (2016) and Jia *et al.* (2016) have specifically used the Cobb-Douglas production model to investigate the factors that affect either sugar cane production or the sucrose quality in sugar cane. Further, Jia *et al.* (2016) argued that the function is capable of estimating the economic output of certain inputs, or requirement of certain inputs. The Cobb-Douglas production model has therefore formed as the regression model in studies that examines the factors that influence the quality of a product.

The Cobb-Douglas production function is a functional relationship in which output in country i at time t takes the following form:

$$Y_t = AL_t^\beta K_t^\alpha \quad (1)$$

Where Y_t is the total output production at time t , A is the total factor productivity, L_t is the labour input (the total number of person-hours worked in a particular time), K_t is capital input, and β and α are the output elasticity of capital and labour, respectively. These values are constantly determined by available technology.

If $\beta + \alpha = 1$, the Cobb-Douglas model shows constant returns to scale. This means that doubling the usage of capital (K_t) and labour (L_t) will also double output (Y_t). If $\beta + \alpha > 1$, it shows increasing returns to scale, and if $\beta + \alpha < 1$, it shows diminishing returns to scale.

On the other hand, an equivalent is a linear function of the natural logarithms of the three variables in equation (1), which can be given as:

$$\log(Y_t) = \log(A) + \beta \log(L_t) + \alpha \log(K_t) \quad (2)$$

According to Pavelescu (2014), Cobb-Douglas production model can easily be expanded to accommodate more variables. Authors have justified the use of Cobb-Douglas production

function in similar studies because the model is very effective, provided the various variables (inputs) are provided in the model. Similarly, Cook and Zhu (2014) observed that the major advantage of the Cobb-Douglas production model is that it shows diminishing marginal returns (short-run effect) and can also be used to estimate returns to (long run effect) more appropriately.

Bowles (1970); Buchanan (1976); Kamruzzaman and Hasanuzzaman (2007); Nazir, Jariko and Junejo (2013); Jia et al. (2016); expanded the scope of the Cobb-Douglas production function to incorporate linkages in the industry production possibilities of output and input, but with other possible factors which are often influenced by technical relationships with a profit maximisation motive.

A departure from the Cobb-Douglas production function emerges as one considers the education production function where some measures of output are determined by variables influencing them. The study attempts to adopt such variables used in literature, though not yet used in the South African context, taking the forms in Equations (1) and (2) above, where: Output Y_t is represented by Sucrose variables $Sucr_t$, and K_t and L_t represent the set of capital and labour inputs in the production function. This is consistent with Bowles (1970). Motivated by earlier studies, this study thus adopted the Cobb-Douglas production model and included variables such as: *Sucrose*, *Avtm*, *Drn60*, *Ecref*, *Fao*, *Grow*, *Harvest*, *Rain*, *Sr100*, *Swc100* and *TT16*. This leads to the study's model specification.

These variables had earlier been identified, either individually or collectively as the major factors affecting sugar cane production or sucrose quality in sugar cane in other jurisdictions. Given that *Avtm*, *Drn60*, *Ecref*, *Fao*, *Grow*, *Harvest*, *Rain*, *Sr100*, *Swc100* and *TT16* would bear multiplicative relationship as inputs, we have:

$$Sucrose = f(Avtm, Drn60, Ecref, Fao, Grow, Harvest, Rain, Sr100, Swc100, TT16) \quad (3)$$

At a panel data level, the linear relationship in the above equation yields:

$$\ln \text{Sucrose}_t = \ln \alpha_1 \text{Avtm}_{i,t} + \ln \alpha_2 \text{Drn60}_{i,t} + \ln \alpha_3 \text{Ecref}_{i,t} + \ln \alpha_4 \text{Fao}_{i,t} + \ln \alpha_5 \text{Grow}_{i,t} + \ln \alpha_6 \text{Harvest}_{i,t} + \ln \alpha_7 \text{Rain}_{i,t} + \ln \alpha_8 \text{Sr100}_{i,t} + \ln \alpha_9 \text{Swc100}_{i,t} + \ln \alpha_{10} \text{TT16}_{i,t} + \mu_t \quad (4)$$

Equation (4) leads to the ARDL model specification as follows:

The model in ARDL format;

$$\begin{aligned} \Delta \text{Sucrose}_t = & c_0 + \sum_{j=1}^n \beta_{1j} \Delta \text{RSucrose}_{it-j} + \sum_{j=1}^n \beta_{2j} \Delta \text{Avtm}_{it-j} + \sum_{j=1}^n \beta_{3j} \Delta \text{Drn60}_{it-j} + \sum_{j=1}^n \beta_{4j} \Delta \text{Ecref}_{it-j} + \sum_{j=1}^n \beta_{5j} \Delta \text{Fao}_{it-j} \\ & + \sum_{j=1}^n \beta_{6j} \Delta \text{Grow}_{it-j} + \sigma_1 \text{Harvest}_{it-1} + \sigma_2 \text{Rain}_{it-1} + \sigma_3 \text{Sr100}_{it-1} + \sigma_4 \text{Swc100}_{it-1} + \sigma_5 \text{TT16}_{it-1} + U_t \dots \dots (5) \end{aligned}$$

Where: $\ln \text{Sucrose}_t$ is the content of sucrose which is the dependent variable, and Avtm , Drn60 , Ecref , Fao , Grow , Harvest , Rain , Sr100 , Swc100 , and TT16 are the explanatory variables.

$\ln A$ is assumed to be constant, while μ_t is the part of the rate of growth of enrolment that cannot be explained by the growth of Avtm , Drn60 , Ecref , Fao , Grow , Harvest , Rain , Sr100 , Swc100 and TT16 .

$\alpha_1 - \alpha_{10}$ are partial elasticities of the respective variables.

μ_t , α_{t1} , α_{t2} , α_{t3} , α_{t4} , α_{t10} are constants to be measured and must be positively signed according to a priori expectations.

The long run ARDL model (ECM) is also provided below.

$$\begin{aligned} \Delta \text{Sucrose}_t = & c_0 + \sum_{j=1}^n \beta_{1j} \Delta \text{RSucrose}_{it-j} + \sum_{j=1}^n \beta_{2j} \Delta \text{Avtm}_{it-j} + \sum_{j=1}^n \beta_{3j} \Delta \text{Drn60}_{it-j} + \sum_{j=1}^n \beta_{4j} \Delta \text{Ecref}_{it-j} + \sum_{j=1}^n \beta_{5j} \Delta \text{Fao}_{it-j} \\ & + \sum_{j=1}^n \beta_{6j} \Delta \text{Grow}_{it-j} + \sigma_1 \text{Harvest}_{it-1} + \sigma_2 \text{Rain}_{it-1} + \sigma_3 \text{Sr100}_{it-1} + \sigma_4 \text{Swc100}_{it-1} + \sigma_5 \text{TT16}_{it-1} + \lambda \text{ECM}_{it-j} + U_t \dots \dots (6) \end{aligned}$$

Where all the variables remain same and $\lambda \text{ECM}_{it-j}$ is error correction model that is used to estimate the long run relationships.

In line with Equation (5) and (6) above, five steps are involved in carrying out a panel ARDL analysis: the ARDL unit root testing, the ARDL regression, ARDL Error Correction Model (ECM), diagnostic test, and analysis and interpretation of results.

4.7.3 Definition of variables

The variables used in the study are defined as follows:

- (i) Average Temperature (AVTM): This is the sum of maximum temperature and minimum temperature divided by two to form the average temperature for the fourteen milling firms in South Africa;
- (ii) Deep Drainage at 60mm (Drn60): This is the average soil water that percolates beyond the root zone (deep percolation) for a soil with a total available moisture of 60 mm;
- (iii) Evaporation: reference sugar cane (Ecref): This averages the water loss through evaporation from the soil surface and transpiration from a fully canopied unstressed sugar cane crop;
- (iv) Evaporation - reference grass (Fao): This is a composition of all references on water loss through evaporation from the soil surface and transpiration from unstressed short green grass;
- (v) Stalk growth - reference sugar cane (Grow): This averages the total fresh cane growth of a full canopy unstressed sugar cane crop estimated as a function of incident solar radiation or crop water use, whichever is more limiting;
- (vi) Harvestable days – mechanically (Harvest): This is an average of mechanically harvestable days, determined from soil water content in the top 30 mm layer;
- (vii) Rain: This is the average annual rainfall for all the mills within the cultivated period;
- (viii) Runoff – 100mm (Sr100): This accounts for the average surface runoff (water flow) as a result of the soil being saturated with water for a soil with a total available moisture of 100 mm;
- (ix) Soil Water Content - 100 mm (Swc100): This comprises the averages of plant available soil water content calculated for rainfed conditions for soil with a total available moisture (TAM) of 100 mm and with a full canopy cane crop growing on it; and
- (x) Thermal time 16°C (TT16): This is the average cumulative value of the mean daily temperature minus a threshold/base temperature of 16°C, below which the rate of sugar cane development or growth is taken as zero.

4.7.4 Justification of Estimating Techniques

This takes into account the existence of unit roots and/or co-integration associated with the data to determine the appropriate method. To achieve this method, Giles (2013) itemised three conditions that pose a challenge to the data and subsequently determine the choice of the method used:

- (i) If all variables are non-stationary at levels (i.e. $I(0)$), Ordinary Least Square (OLS) model is simply appropriate. This is the case of stationarity;
- (ii) If all variables are non-stationary at levels, but are all stationary at $I(1)$, then it is advisable to use VECM as it is a simpler model (Johansen Cointegration Approach).
- (iii) If some variables are stationary at levels $I(0)$ and some are $I(1)$, or when some variables are fractionally integrated leading to some complexity, the autoregressive distributive lag (ARDL) is most appropriate (Chudik and Pesaran, 2013).

4.7.5 Estimation model on the impact of sucrose quality on the profitability

This section discusses the estimation technique used to investigate the impact of sucrose level on the profitability of the sugar milling firms. . It specifically presents the estimation model and the variables used in the model.

4.7.6 Estimation Technique and Model

The study draws on the advantages of panel data analysis and thus employs a dynamic estimation technique called the Generalised Method of Moments (GMM). The panel data involves the use of observations on cross-sections of units over many periods. Panel data thus has both time series and cross-sectional data. This feature of panel data makes it superior compared to time series and cross-sectional data in many ways. Panel data contains a more productive data of high degree of variability, reduces the challenges associated with collinearity among the explanatory variables and thus enhances the efficiency of the

estimation (Baltagi, 2008). In addition, panel data postulates that firms are heterogeneous , which permits researchers to control for unobservable heterogeneity, thus allowing the elimination of biases emanating from the presence of individual effects (Brooks, 2008). Another positive thing about the use of panel data is that it allows researchers to analyse the adjustment process of the explained variable in response to variations in the values of the independent variable. These show that panel data enables researchers to handle the problem of omitted variables associated with results of regression.

The Generalised Method of Moments (GMM) is an estimation technique that has many advantages. Specifically, GMM can solve the problem of omitted variable bias, errors in measurement and endogeneity of regressors (Baltagi, 2008). As a result of the endogeneity problem with panel data, Arellano and Bond (1991) suggested the use of instrumental variables (IV) to assume the generalised methods of moments (GMM) of corresponding moment conditions, called difference GMM. GMM can eliminate the individual fixed effects by first differencing regression equations. The GMM then consider the lagged variable as a corresponding instrumental variable of endogenous variables in the difference equation (Bond et al., 2001).

4.7.7 Estimation Model

By using the generalised methods of moments (GMM) estimation technique, the study estimates the impact of sucrose content on the profitability of the sugar milling firms. The model provided below, which is adopted from Zhang and Pan (2009), is used for the estimation. In this model, two variables have been used to measure the performance of the profitability of the firms. These variables are: return on assets (ROA) and return on equity (ROE). The model has however been modified to accommodate for sucrose contents. The model is thus provided in models 7 and 8 below.

$$\begin{aligned}
 ROA_{i,t} = & \beta_0 + \beta_1 Sucrose_{i,t} + \beta_2 ROA_{i,t-1} + \beta_3 Size_{i,t} + \beta_4 Risk_{i,t} \\
 & + \varepsilon_{i,t} \dots \dots \dots \dots \dots \dots
 \end{aligned}
 \tag{7}$$

$$\begin{aligned}
 ROE_{i,t} = & \beta_0 + \beta_1 Sucrose_{i,t} + \beta_2 ROE_{i,t-1} + \beta_3 Size_{i,t-1} + \beta_4 Risk_{i,t} \\
 & + \varepsilon_{i,t} \dots \dots \dots \dots \dots \dots
 \end{aligned}
 \tag{8}$$

Where ROA_{it} is the return on assets of the firms at time t , ROE_{it} is the return on equity at time t , $sucrose$ is sucrose content at time t , measured by the percentage of sucrose in a gram of sugar, ROA_{it-1} is the lagged return on assets, ROE_{it-1} is the lagged return on equity, $Size_{it}$ is the size of the firms at time t , measured by the log of total assets, $Risk_{it}$ is the leverage of the firms at time t , measured by the total debt to equity ratio and ϵ_{it} is the random error term.

4.7.8 Explanation of the Variables

Dependent Variables: In literature, many metrics have been used to measure the profitability of firms. These performance variables include r =net profit margin, gross profit margin, return on assets, return on equity, earnings per share, operating profit, net profit, economic value added, residual income, etc. However, Huang and Pan (2016) assert that the variables that have been widely used to measure a firm's performance include return on assets, return on equity and net profit margin. In this study, both return on assets (ROA) and return on equity (ROE) have been used as the measures of profitability of the firms. These performance measurement metrics have been used frequently in earlier studies (e.g. Maina and Ishmail, 2014; Suardi and Noor, 2015; Awais et al., 2016; Huang and Pan, 2016; Kanwal et al., 2017). Consequently, both return on assets and return on equity are the dependent variables of the regression model.

Independent Variable: Sucrose content is the main variable of interest in the regression model. The content or quality of sucrose is argued to affect the performance of firms. According to Buchanan (1976), sucrose content or quality has an impact on the performance of the processing factory. Similarly, Sambuo (2015) observed that a tremendous increase in the rate of sugar production in Tanzania led to the rise of sugar consumption in the country and hence increase in the performance of sugar milling firms. Premised on these studies, the study expects that the sucrose content in sugar cane would have an impact on the profitability of the firms. The sucrose content is measured by the percentage of sucrose in a gram of sugar.

Control Variables: Apart from sucrose level, many other factors influence the performance of firms. Overlooking these variables lead to an omitted variable bias and would consequently

lead to endogeneity problems. To address the potential of omitted variable bias, the study introduced some control variables that can potentially affect the performance of the firms. The size (log of total assets) and risk (leverage) were therefore introduced as control variables.

4.8 Results and Discussion

The estimating technique employed is the panel autoregressive distributed lag (ARDL) approach of Chudik and Pesaran (2013), with the aim of testing for the existence of long- and short-run relationships between sucrose content in sugar cane and the variables that determine it. The choice of the ARDL method for this study is based on the following features:

- When long-run and short-run dynamics are to be estimated, the ARDL model offers the most recent valuable method (Giles, 2013);
- The ARDL model is appropriate with a mixture of $I(0)$ and $I(1)$ data. This means that this approach can be applied to sequences, whether they are $I(0)$, $I(1)$, or mutually cointegrated, irrespective of their order of integration, but not $I(2)$ (Katircioglu, 2009);
- Variables can assume different lag-lengths as they enter the model, and ARDL can accommodate up to six variables (Giles, 2013);
- The short-run and long-run of the model are estimated simultaneously (Dritsakis, 2011); and
- ARDL is appropriate for both large and small sample sizes (Rafindadi and Yosuf, 2013).

In line with the above justification for chosen method, this chapter employed the panel ARDL method, which is consistent with Chudik and Pesaran (2013), to estimate the sucrose content in South African sugar cane. Faridi and Murtaza (2013), among others, have employed panel? ARDL while using the Cobb-Douglas production function.

4.8.1 Unit Root Test Result

Unit root testing on the panel series macro-variables was first carried out on the sample. This was done to avoid the possibility of having spurious regression results since most macro-economic time-series usually have unit roots and the error of regressing non-stationary series

on each other that could result in inaccurate/invalid regression. The general form of the unit root test is stated as follows.

$$Y_t = D_t + Z_t + U_t$$

Where: D_t is the deterministic component; Z_t is the stochastic component and U_t is the stationary error term.

In testing for the presence of unit roots (stationarity), this study employed a robust version of the Augmented Dickey-Fuller test (ADF) proposed by Dickey Fuller; Phillip Peron and Hadri unit root tests. This study employed the three approaches to examine test the presence of unit root. These approaches were adopted to validate the consistency of the results (Moon and Perron, 2004). The results revealed that all the variables are stationary at levels or stationary at first difference under the three methods, namely: ADF-Fisher Chi Square; Hadri; and Phillip Peron Unit root-test. The p-values were tested at 1%, 5% and 10%, respectively, as shown in Tables 4.2. The unit root result was accepted since there is consistency and the estimating technique adopted can incorporate $I(0)$ in the regression analysis.

Table 4.2: Panel Unit Root Tests

Test	ADF _a	PP _a	Hadri _b
Level	474.78**	536.27**	17.72**
Difference		903.96**	21.98**

Source: Author's Estimation, 2019

NOTE: The probabilities of panel unit root test are computed assuming asymptotic; Subscript 'a' tests the hypothesis of the presence of the individual unit root process; and Subscript 'b' tests the hypothesis of no unit root in the common unit root process. ** denote the rejection of the null hypothesis at the one (1) percent significance level.

Table 4.2 presents the unit root tests results under three different methods. The results show that all the variables are stationary at level. These different methods were employed to validate the results of one another.

4.8.2 Result and Discussion on the Panel ARDL Regression Model

This section reports results from the panel ARDL regression analysis done on the South African sugar cane milling industry. The popularised ARDL estimating technique, as proposed by Pesaran and Pesaran (2010), was adopted with one lag. Table 4.3 below presents the result of the panel ARDL estimated regression. According to the estimates from the panel regression, a high level of sucrose content is obtainable in both the long- and short-runs, as most variables that determine sucrose content in sugar-cane are statistically significant at a 5% level, except soil water content - 100 mm (Swc100), which is insignificant. It is evident that the variables under investigation tend to improve the sucrose content in the South Africa sugar cane industry, if appropriate attention is given to their behaviour.

Table 4.3: Results from Panel ARDL model

Dependent Variable: SUCROSE				
Method: Panel ARDL				
Sample: 1980-2016				
Model selection method: Akaike info criterion (AIC)				
Selected Model: ARDL (1, 1, 1, 1, 1, 1, 1, 1, 1, 1)				
Short-run Cointegrating Form				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(SUCROSE(-1))	0.415227	0.037154	11.175707	0.0015
D(SRO100)	-0.008469	0.000482	-17.568617	0.0004
D(SRO100(-1))	0.015909	0.000747	21.307105	0.0002
D(RAIN)	0.007401	0.000327	22.631870	0.0002
D(RAIN(-1))	-0.012874	0.000485	-26.565897	0.0001
D(HARVEST)	0.060107	0.002072	29.013529	0.0001

D(HARVEST(-1))	-0.093860	0.003658	-25.657408	0.0001
D(GROW)	38.239732	1.283654	29.789752	0.0001
D(GROW(-1))	24.367272	0.955758	25.495238	0.0001
D(FAO)	-31.06625	1.148737	-27.043840	0.0001
D(FAO(-1))	4.278805	0.508227	8.419079	0.0035
D(ECREF)	8.063441	0.383741	21.012710	0.0002
D(ECREF(-1))	-8.814526	0.334510	-26.350540	0.0001
D(DRN60)	0.001318	0.000368	3.578049	0.0373
D(AVTM)	-5.570829	0.207804	-26.808064	0.0001
D(AVTM(-1))	-1.577333	0.136116	-11.588165	0.0014
D(SWC100)	-0.002789	0.002855	-0.976830	0.4007
D(SWC100(-1))	-0.061940	0.003197	-19.374341	0.0003
D(TT16)	0.024974	0.000851	29.334098	0.0001
D(TT16(-1))	0.010655	0.000511	20.865465	0.0002
Long Run Coefficients				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
SRO100	-0.004502	0.001384	-3.253732	0.0474
RAIN	0.005088	0.000588	8.648131	0.0033
HARVEST	0.051463	0.005617	9.162409	0.0027
GROW	11.570062	1.308137	8.844686	0.0030
FAO	-17.54530	2.100031	-8.354785	0.0036
ECREF	6.843537	1.087776	6.291309	0.0081
DRN60	0.005439	0.001577	3.448763	0.0410
AVTM	-3.894437	0.348141	-11.186389	0.0015
SWC100	0.017636	0.010036	1.757219	0.1771
TT16	0.016084	0.001021	15.757655	0.0006
C	68.369306	6.301726	10.849299	0.0017

Source: Author's estimation 2018

4.8.3 Interpretation

A total of ten variables (among the variables that show a tendency to influence sucrose quality) entered the ARDL regression model, as indicated in Table 4.5. The results show that the variables have a high tendency to improve the sucrose content in sugar cane both in the long- and short-runs. This tendency can be attributed to the fact that all variables exhibit significant relationships except soil water content - 100 mm (Swc100). The coefficient signs of these variables are important, as they give further details about the impact of these variables on the dependent variable. For instance, a 1% increase in the runoff – 100mm (Sr100) will cause sugar cane sucrose content to decrease by 0.8% in the short-run and by 0.5% in the long-run. However, the reverse is the case in the previous season, where a 1% increase in the runoff – 100mm causes a 1.5% increase in sucrose content. Similarly, a 1% increase in rainfall will increase sucrose by 0.7% in the short-run and 5.1% in the long-run. Likewise, a mechanically

harvestable day has the possibility of improving the sucrose content. There could be 6.0% and 5.1% increments in the sucrose content in the short- and long- runs, respectively, as a result of a 1-day increase in the harvestable day.

In summary, the study found consistency in the results obtained both in the short- and long-runs. For instance, Growth, Ecref, Drn and TT16 values would increase the sucrose quality with a 1% increase in the variables' coefficients. This is also true in the long-run. However, the study revealed a reverse relationship among Fao, Ecref lag, Avtm, and its lag. An increase in these variables would decrease the sucrose content in sugar cane by the coefficient value level.

4.8.4 Inferences, Comparison with Previous Empirical Studies and Discussion of Findings

The results indicate a negative relationship between sucrose content and evaporation – reference grass (Fao), evaporation – reference sugar cane (Ecref) and the lag of Ecref, and average temperature (AVTM) and its lag, which is contrary to *a priori* expectation and existing theory. They support the findings of Buchanan (1976) who found, in his simple time regression analysis, an inverse relationship between sucrose, harvestable components and water-related contents. Deressa, Hassan and Poonyth (2005) also noted that precipitation and temperature negatively and significantly affect sugar cane production in South Africa. The adoption of regression analysis to determine the impact of these explanatory variables on sucrose has not been exploited much in literature. However, results have shown how sucrose could be increased in the production of sugar cane, given the consideration of the available variables under investigation. The component proportions that will lead to an incremental increase of sucrose in sugar cane have been identified.

4.8.5 Testing for Serial Correlation

Table 4.6 shows the serial correlation test for the analysis conducted.

Table 4.4: Serial Correlation

Breusch-Godfrey Serial Correlation LM Test			
F-statistic	1.243341	Prob. F(2,1)	0.5355
Obs*R-squared	24.96180	Prob. Chi-Square(2)	0.0000

Source: Author's Computation 2018

The correlation test is applied to the following hypotheses:

H_0 : There is no serial correlation among the paired independent variables and the dependent variable; and

H_1 : There is a serial correlation among the paired independent variables and the dependent variable.

Decision rule: Accept null hypothesis (H_0) when p-value is greater than 5%.

Reject null hypothesis (H_0) when p-value is less than 5%.

The results from serial correlation are shown in Table 4.4. The probability value in the table indicates that the F-statistics p-value is greater than 5%. Therefore, we fail to reject the null hypothesis, and we reject the alternative hypothesis, implying that there is no serial correlation in the model.

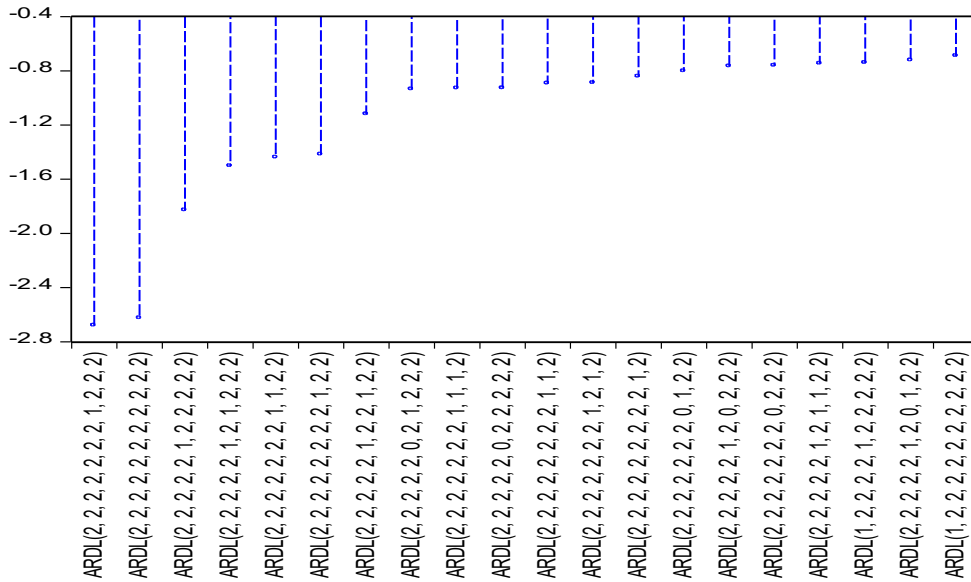


Figure 4.1: Akaike Information Criterion (Top 20 models)

Source: Author's estimation 2018

4.8.6 To Measure the Strength of the Panel ARDL Regression Analysis Model

The study requires determining the long-run and short-run relationships as well as the strength of the Akaike information criterion (AIC) model selection summary on other models (the Hannan-Quinn criterion and Schwarz criterion) in the regression model. A criteria graph has been employed to determine the top twenty (20) different series-ARDL models. The benchmark for the model analysed shows “that a lower value of the AIC, behaves better in the model”. From Figure 6, the first ARDL (1, 1, 1, 2, 2, 2, 2) model seems to be mostly preferred over others, since it provides the lowest possible value (-.94) in the Akaike information criterion. The ARDL (1, 1, 0, 2, 2, 2, 2) model appears to be the next with a -0.89 value as shown in Figure 5.

4.8.7 Panel ARDL Error Correction Model

In Table 4.5, the error correction model (ECM) analysis is used to investigate the short-run and long-run dynamics of the model.

Table 4.5: ECM Analysis

Variable	Coefficient	Std. Error	t-Statistic	Prob.
CointEq(-1)	-2.258148	0.074588	-30.274923	0.0001

Source: Author’s estimation 2018

The ECM coefficient reveals the speed of adjustment – how slowly or quickly the variables are expected to return to equilibrium. The negatively-signed coefficient of the ECM established an existing disequilibrium in the past, but the system is getting adjusted in the right direction. An ECM value of -2.258 suggests that there is a speed of adjustment from the short-run deviation to the long-run equilibrium of those factors that determine the sucrose variables.

Furthermore, it is noted that long-run equilibrium can be attained since the ECM is statistically significant at 5%. This study's findings support the result of Bannerjee *et al.* (1998) and Rabbi (2011), who argued that a strong significant ECM value establishes proof of the existence of a stable long-run association. The findings of this study further show that there will be convergence (steady-state) of the system and the attainment of a high rate of sucrose in sugar is expected in the long-run.

Table 3.6: Bound Testing

Null Hypothesis: No long-run Relationships exist

Test Statistic	Value	K
F-Statistic	16.36734	10
Critical Value Bounds		
Significance	I0 Bound	I1 Bound
10%	1.76	2.77
5%	1.98	3.04
2.5%	2.18	3.28
1%	2.41	3.61

Source: Author's estimation 2018

The bound test was done to further establish the long-run relationship among these variables. It is traditional that the value of F -statistics must be higher than both the lower and higher values of the upper bound. As indicated in Table 4.6 above, the value of 16.36734 is higher than 3.61 and 2.41. This finding further establishes the fact that there exists a long-run relationship among the variables in question.

4.8.8 Test for Heteroskedasticity

Table 4.7: Heteroskedasticity Test: Breusch-Pagan-Godfrey

F-statistic	1.264954	Prob. F(31,3)	0.4916
Obs*R-squared	32.51265	Prob. Chi-Square(31)	0.3922
Scaled explained SS	0.447050	Prob. Chi-Square(31)	1.0000

Source: Author's estimation 2018

The test for heteroskedasticity was carried out on the regression analysis where it is expected that the variance of the error term be constant for all levels of observation. If this assumption

is violated, then a heteroskedasticity problem sets in. This study used the Breusch-Pagan-Godfrey test to confirm the existence of heteroskedasticity. The rule of thumb here is that three probability values must not be significant. As indicated in Table 4.7 above, this condition was met in this study's results, meaning that no heteroskedasticity exists in the model.

4.7.9 Stability Test

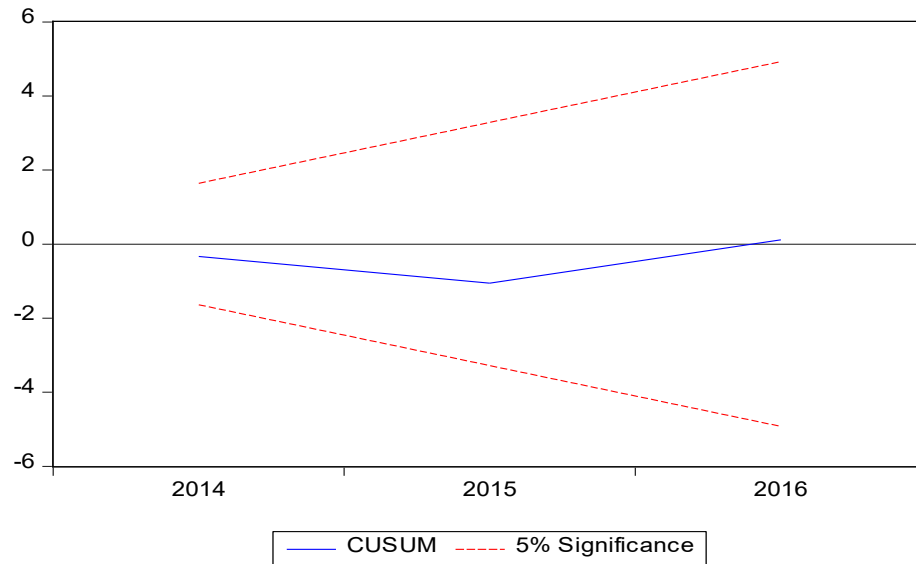


Figure 6: Stability Test

Source: Author's estimation 2018

Furthermore, a stability test was carried out on the recursive residual, using the Cusum procedure at the 5% level of significance. If the blue line shown in Figure 7 falls between the two red lines, it means that the regression is stable, and further confirms that there is a long-run relationship.

4.8.10 Normality test

The Normality Test was conducted on this study's regression analysis with the results in Figure 4.2.

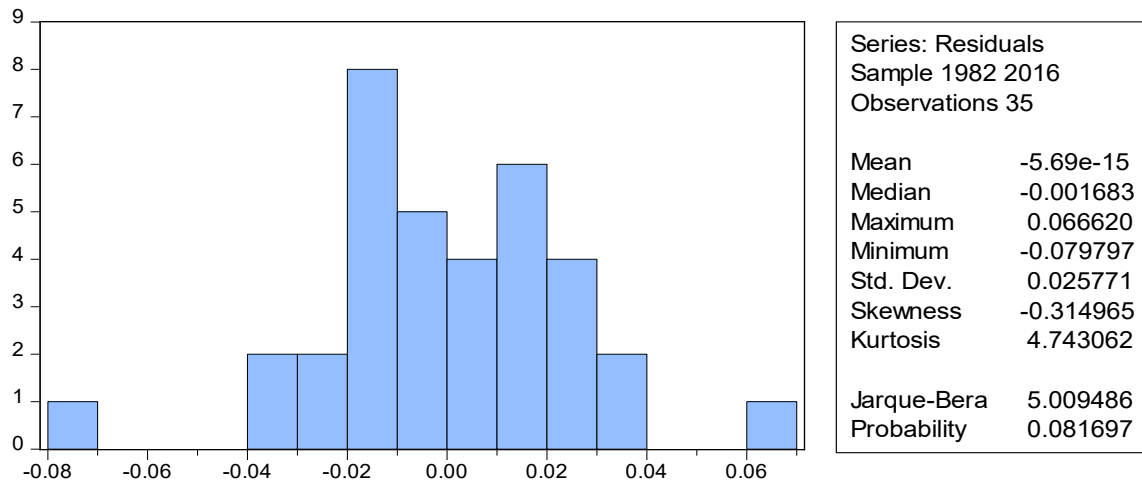


Figure 4.2: Normality tests

Source: Author's Estimation 2018

For a normal distribution, the Kurtosis should be skewed around 3.0. If $K > 3$, it implies excess height, i.e., a height above average. This study's Kurtosis value of 4.7 fits in by approximation and revealed that the model is normally distributed.

Jarque-Bera: J-Bera is a perfect test for normality. It is a combination of both Skewness and Kurtosis. The normal standard or decision rule is: If $J-B < 5.99$, H_0 is accepted (i.e., there is normality). If $J-B > 5.99$, reject H_0 is rejected (i.e., there is no normality). Again, with a Jarque Bera value of 5.009, one does not reject H_0 , meaning that there is normality.

4.8.11 Short-Run Causality Tests among the Determinants of Sucrose Quality

Table 8: Short-Run Causality Tests

EQUATION: P-ARDL, H₀=C(1)=C(2)=0			
Statistics	VALUE	DF	PROBABILITY
F -statistics	17.96141	(2, 3)	0.0214
EQUATION: P-ARDL, H₀=C(2)=C(3)=0			
Statistics	VALUE	DF	PROBABILITY
F -statistics	10.73110	(2, 3)	0.0429
EQUATION: P-ARDL, H₀= C(3)=C(4)=0			
Statistics	VALUE	DF	PROBABILITY
F -statistics	1.512483	(2, 3)	0.3514
EQUATION: P-ARDL, H₀=C(4)=C(5)=0			
Statistics	VALUE	DF	PROBABILITY
F -statistics	21.99715	(2, 3)	0.0161
EQUATION: P-ARDL, H₀= C(5)=C(6)=0			
Statistics	VALUE	DF	PROBABILITY
F -statistics	37.66610	(2, 3)	0.0075
EQUATION: P-ARDL, H₀= C(6)=C(7)=0			
Statistics	VALUE	DF	PROBABILITY
F -statistics	59.50756	(2, 3)	0.0039
EQUATION: P-ARDL, H₀= C(7)=C(8)=0			
Statistics	VALUE	DF	PROBABILITY
F -statistics	53.33957	(2, 3)	0.0045
EQUATION: P-ARDL, H₀= C(8)=C(9)=0			
Statistics	VALUE	DF	PROBABILITY
F -statistics	13.30528	(2, 3)	0.0322

Source: Author's calculation 2018

The study further considered the possibility of two variables jointly impacting on the short-run increase in sucrose quality. In the Wald test model: C1= Avtm; C2=Drn60; C3=Ecref; C4= Fao; C5=Grow; C6=Harvest; C7=Rain; C8=Sro100; C9=Tt16; C10=Swc100. The results indicate that all the pairs of variables could jointly impact on the sucrose level in the short-run, except for the pair of C(4) and C(5), namely, evaporation – reference grass and stalk growth – reference sugar cane, whose p-values are not significant. This implies that both variables cannot jointly cause sucrose to increase in the short-run.

4.8.12 Summary

The results above clearly show that nine out of the ten variables under investigation have the tendencies of improving the quality of sucrose in sugar cane in the South African industry. However, the results are mixed as some variables have the tendencies of improving it, for instance: Growth, Ecref, Drn and TT16 values have a positive impact on sucrose production while, on the other hand, Fao, Ecref lag, Avtm, and its lag have the tendency of decreasing sucrose in sugar cane.

Again, from the outcome result of diagnostic checks, the study establishes that the results are robust, reliable and consistent. The study's hypothesis that some variables can have a significant positive impact in improving sucrose production in South African sugar cane industry has been established. The findings from this study are supported both empirically and theoretically in the literature. This chapter significantly contributes to the growing literature in three different perspectives. First, the study employed the most recent dynamic econometric approach in determining sucrose content in sugar cane using a Cobb-Douglas production model. This approach has enabled the researcher to establish that, given quantity control in the explanatory variables, the outcome quantity of sucrose expected in cane sugar could be determined. This concept is of great importance to policymakers in the Department of Agriculture in South Africa. To the best of the researcher's knowledge, this is the first study integrating variables found on the SASA website to determine possible improvement in sucrose production of sugar cane. Despite some limitations of the data, evidence was provided to show the different relationships of the selected explanatory variables with sucrose quality. The next chapter proceeds to consider the economic and environmental impact of sugar production, given an improved sucrose quality.

4.9 Results and Discussion on the Impact of Sucrose Content on the Profitability of Firms

This section presents the results on the impact of sucrose content on the profitability of the sugar milling firms in South Africa. This section also presents the results of the summary statistics of the variables. In addition, the correlation matrix among the results is presented to

establish the existence of collinearity among the independent variables or otherwise. In addition, the regression results of the two models are presented and discussed in this section.

4.9.1 Summary Statistics

The summary statistics of the variables are presented in Table 4.9.

Table 4.9: Summary Statistics

	Mean	Standard Deviation	Maximum	Minimum
ROA (percentage)	9.62	2.553	45.75	-2.73
ROE	16.85	7.971	89.89	-4.68
Sucrose (percentage)	13.72	1.638	11.58	14.81
Size (billions of Rands)	12.79	6.922	29.12	0.82
Risk (percentage)	69.03	12.95	81.82	19.27

Source: Author's Estimation, 2019

Table 4.9 shows a summary of the descriptive statistics of the variables used. The results show that the average return on assets was 9.62%, suggesting a relatively low performance. The minimum and maximum ROA were -2.73% and 45.75%, respectively. The standard deviation of 2.333 shows that there were variations in the ROA among the firms. Similarly, the average return on equity of the firms was 16.85%, which indicates a relatively good performance. In addition, the standard deviation was 7.971, suggesting the return on equity among the firms were relatively dissimilar and varied. The average sucrose level of the firms was 13.72% while the minimum and maximum sucrose levels were 11.58% and 14.81% respectively. With respect to the average size of the firms, it was found that the average size (total assets) of the firms was R12.79 billion whilst the minimum and maximum size/total assets were R0.82 billion and R29.12 billion respectively. Lastly, the average risk level (leverage) of the firms was 69.03%.

4.9.2 Correlation Matrix

A Pearson correlation analysis among the independent variables was performed prior to the estimation of the impact of sucrose content on the performance of the firms.. This was done to ascertain whether there was any collinearity. The results are presented in Table 4.10.

Table 4.10: Correlation Matrix

	ROA	ROE	Sucrose	Size	Risk
ROA	1.0000				
ROE	0.5322	1.0000			
Sucrose	0.5376*	0.5911**	1.0000		
Size	0.4529**	0.1185*	0.0537	1.0000	
Risk	-0.1371**	-0.1073**	0.0254	0.3842**	1.0000

Source: Author's Estimation, 2019

* Statistically significant at 10%

** Statistically significant at 5%

The results presented in Table 4.10 shows that the correlation among the independent variables was weak. Apart from the correlation between return on assets and the size of the firms ($r = 0.4529$), the correlation coefficient among the other variables were below 0.400, suggesting a weak disclosure. According to Hair et al. (2009), a correlation coefficient of less than 0.50 poses no problem with multicollinearity, and thus, there is no issue of multicollinearity among the independent variables.

4.9.3 Unit Root Tests

Table 4.11 presents the results of the unit tests of the variables in both models.

Table 4.11: Results of the Unit Root tests

Variables	RETURNS ON ASSETS				RETURN ON EQUITY			
	ADF _a	PP _a	IPS _a	Hadri _b	ADF _a	PP _a	IPS _a	Hadri _b
Level	413.51**	521.93**	-3.924**	16.21**	431.41**	642.77**	-5.9425**	18.04**
Difference		818.14**		16.77**		915.72**		23.81**

Source: Author's Estimation, 2019

NOTE: The probabilities of panel unit root test are computed assuming asymptotic; Subscript 'a' tests the hypothesis of the presence of the individual unit root process; and Subscript 'b' tests the hypothesis of no unit root in the common unit root process. ** denote the rejection of the null hypothesis at the one (1) percent significance level.

Here, four different unit root tests are performed. These include PP Fisher, ADF Fisher, IPS and Hadri. The three-unit root tests, PP Fisher, ADF Fisher; IPS test for the existence of individuals unit root process in series whilst the Hadri test does not have unit roots in the common unit root process. The results presented in Table 4.11 shows the absence unit root in levels for both series (ROA and ROE). The Hadri and PP tests also show show no unit root at first difference. Similarly, both the IPS and ADF tests reject the hypothesis of the presence of unit root in both levels and the first difference. These results indicate that a stationary process produces the series. . Thus, the GMM approach is appropriate for model estimation.

4.9.4 The Regression Results

The study estimated the impact of sucrose content on the profitability of the sugar milling firms in South Africa. Two performance variables return on assets and return on equity were used as measures of profitability. The study thus regressed both dependent variables separately for equations (7) and (8). Sucrose content measured by the Brix percentage in sugar was used as the independent variable. Other control variables included size of the firms, the lag of the dependent variables and the leverage of the firms. The results of the regression are presented in Table 4.12. The results present the coefficient of the various variables as well as the t-statistics in parentheses.

Table 4.12: Regression Results

	Model 1	Model 2
	ROA	ROE
Constant	0.212*** (3.241)	0.242* (1.647)
Sucrose _{it}	0.216*** (3.874)	0.208*** (2.441)
ROA _{it-1}	0.171** (02.832)	-
ROE _{it-1}		0.216 (1.194)
Size _{it}	0.119* (1.505)	0.0921 (1.903)
Risk _{it}	-0.106 (3.084)	0.0935 (2.497)
AR (2)	0.573	0.524
Hansen P-value	0.558	0.492
Wald X2 (12)	6241.17	5846.88
Prob > X2	0.000	0.000

Source: Author's Estimation, 2019.

Notes: * Significant at the 10% level, ** Significant at the 5% level and *** Significant at the 1% level.

The dynamic panel data regression results are provided in Table 4.12. Two tests were conducted for the presence of serial correlation in the model whilst Hansen Tests were used to test for the validity of the model. The result of the second-order serial correlation (AR 2) shows that both estimation models have no second-order serial correlation because the p-value of both models are insignificant and thus we are unable to reject the null hypothesis of the absence of second-order correlation in the models. Similarly, the Hansen tests show that the p-values of both models are insignificant, and therefore, we are unable to reject the null hypothesis.

The results show the coefficient of β_1 (0.216) for model 1 is positive and significant ($p < 0.01$) at 1%. This means that there is a positive relationship between sucrose content and return on assets. Thus when the sucrose level increases, the return of the assets is expected also to increase, ceteris paribus. In addition, the coefficient of β_1 (0.208) for model 2 is positive and

significant ($p < 0.01$). This suggests that the sucrose content in sugarcane has a positive and significant impact on the return on equity of the firms. The results mean that an increase in the sucrose content is expected to increase the return on equity for firms.

These results confirm the observation that a sugar cane with a high percentage of sucrose will reflect on the sucrose content of the final sugar produced. The higher quality sugar will thus reflect in the higher demand of the sugar and eventually increase the profit level of the firms.

Similarly, the result is plausible in the sense that the milling of sugar with a high percentage of sucrose requires less cost because its effect on equipment is minimal as well as requiring less time for production. In addition, since Albert and Orgeron (2012) argue that the quality of sucrose helps reduce crushing and milling time as well as reducing machine breakdowns, a high sucrose content would be beneficial to a firm.

These results are not surprising because the major interest of a sugar cane miller is the amount of sugar that can be produced per ton of cane crushed. It is this part, which is an asset to the miller since everything else is a liability. The smaller the amount of cane that is crushed for each ton of sugar produced, and the lower the level of impurities. This makes it easier for the miller to crystallize sugar from the juice, and the resultant effect is an increase in the quantity of sugar produced. Based on the argument of Gal and Requis (2002), which is further supported by Aina et al. (2015), a sugar cane with a higher sucrose content provides the highest quantity of sugar. These claims are justified because the major factors that contribute to a high sugar recovery rate are high sucrose and purity, and low fibre and level of non-sugars. The quantity and nature of non-sugars contained in the sugar cane are particularly important, as they have an impact on processing and refining costs. Sucrose content is, therefore, an all-important economic factor (Meyer and Wood, 2001).

In fact, the days when sugar cane was paid in terms of a cane tonnage basis are long past. At present, one often hears that experimental results and even field yields should be given in tons of sucrose per acre or tons of sucrose per acre per unit time. It is true that high sucrose content comes with extra cultivation cost and purchasing prices, however, the increased returns as a result of increased sugar yields (exclusively with respect to factory performance) more than offset the cost of producing and processing the increased yield. All these factors would

eventually result in a higher sugar quality, higher demand, and lower production cost and therefore, a higher profit.

The results also indicate a positive relationship between the size of the firms and both ROA and ROE. These results suggest that the ROA and ROE of a firm are affected by the size (total assets) of the firms. Specifically, the results indicate that when the size of the firm is increased, the ROA and ROE of the firms also increases accordingly. These results are however, significant at 10%. Indeed, these results are least surprising because a firm with bigger assets stands the chance of expanding their operations and investing in profitable activities. This suggests that larger firms would have the extra capital that they can utilise to improve their performance.

Finally, the study examined whether the risk level (leverage) of the firms had an influence on their ROA and ROE. The results show an insignificant and negative relationship between the risk level of a firm and the ROA and ROE. This shows that a highly geared firm impacts negatively on their ROA and ROE. These results show that the firms might be highly geared and lacked flexibility in operation. This would restrict them to take advantage of new investment opportunities and thus impeding their performance.

In addition, the results suggest that the lagged value of ROA impacts positively on the ROA of the succeeding year. The result is also statistically significant at 5%. Similarly, the lagged value of return on equity also impacts positively on the ROE of the succeeding year. This is an indication that the ROA and ROE of a particular year are affected by the ROA and ROE of the previous year respectively. The positive coefficients mean that an increase in a ROA and ROE of a particular year would increase the ROA and ROE of the succeeding year. These findings confirm the findings of previous authors such as Suchanek et al. (2014); Jabbour, et al. (2015) and Sodeyfi (2016) who found that product quality has a significant impact on the performance of firms.

4.9.5 Summary of Chapter

As has been shown, the sucrose content of sugar cane is influenced by many factors. The results have shown that Growth, Ecref, Drn and TT16 values have a positive impact on sucrose production. This means that an increase in these factors would result in an increase in the sucrose content. Similarly, the results show that Fao, Ecref lag, Avtm, and its lag have the tendency of decreasing sucrose in sugar cane. The implication of this study is that the firms can increase the sucrose content of sugar if time and resources are spent on these factors and how to control them.

In addition, the evidence shows that sucrose content also has a positive impact on both ROA and ROE. The implication of these findings is that the sugar milling firms can improve their performance when they increase the sucrose content in their sugar cane and sugar. Though increasing the sucrose content would result in extra cost, the extra revenue and benefits would more than offset the extra cost. Achieving this would require that the firms understand the various factors that influence the sucrose content and putting in place measures to handle them effectively.

Given, the sugar industry provides 79000 direct jobs and offers another 270000 indirect job opportunities (SASA, 2017), it is important that the various stakeholders in the sugar industry find ways of eliminating the controllable factors that affect sucrose content. This will have the direct consequence of increasing the sugar quality and quantity and eventually increasing the financial performance of the firms.

The next chapter investigates the determinants of sucrose quality and the empirical implication in South Africa. The chapter further examines the environmental, operational and financial influence of clean cane production in South Africa.

CHAPTER 5

ENVIRONMENTAL AND ECONOMIC BENEFITS OF CLEANER SUGAR PRODUCTION

5.1 Introduction

Having investigated the determinants of sucrose quality and the empirical implication in South Africa, this chapter seeks to assess the economics and environmental benefits of clean cane production in South Africa. The objectives of the study were to examine the benefit of cleaner production process in the South African milling industry as well as to develop a framework for optimisation principles that minimises production cost among South African milling industry. The detailed conceptual issues relating to cleaner production were identified and addressed in this study. Taking the sugar cane industry in South Africa as the focus, alternative measures that enhance the quality of sugar, particularly that of sucrose, were investigated. The study noted that certain factors, such as transportation and loading delay, contribute to losses in sucrose which not only affect the farmer's yields but increase deteriorations of cane sugar. Hence, minimization modelling through appropriation of an objective function was developed to control for transportation cost, supply of sugar cane to the mill, and transport means to carry sugar cane harvested by machine from the source to the desired destination. The correct application of this model in the South Africa sugar cane industry would enhance the quality of sucrose production and improve the farmer's welfare as well as the profitability margin.

The production of sugar cane in South Africa is one of the most important means of foreign exchange earnings and has contributed importantly to the GDP growth of the economy. The industry has, however, noted a declining trend in the cane quality, particularly in the sucrose extractions in recent years. The implication of this decline of sucrose quality to the sugar cane industry, particularly to the South African economy, is the adverse effect this decline has on profitability, employment opportunities, its contribution to GDP growth, general economic performance, improved standard of living and a decline in income (SASA, 2016).

The promotion of cleaner production among industries is specifically of great importance as it enhances an improved performance of environments and the quality of productivity within

the organizational settings, alongside with the supply chains, and the society at large. The concept of cleaner production covers every facet of production and human activities; hence, the ability to understand which factors determine the improvement of cleaner production's promotion. To a great extent, cleaner production in the literature has engaged the effects of some specific factors, such as process innovations and the adoption of international standards, particularly as they serve as a regulatory body, as well as the friendly environments with a well-developed cultural framework on the cleaner production. Process innovations are ways through which sucrose and by-products of sugar cane are converted into value-added products. Particularly, product innovation impacts on cleaner production in the following areas: minimisation of energy; pollution prevention; and material reduction (Dangelico and Pujari, 2010).

Conceptually, the United Nations Environmental Programme (UNEP) defined cleaner production (CP) as an integrated and preventative strategy by which pollution and wastes are reduced throughout the entire production cycle. In CP, every decision is considered, particularly actions and activities connected with enhancing better performance of environments through a remarkable decline in the negative effects on the environment. According to Ortolano *et al.* (1999), it is not just all about activities impacting on the pollution control in a production process; the objectives of CP are to appropriate resources more effectively, lower the total amount of less desired outputs and improve returns in monetary terms through the reduction of energy and material consumption.

In recent times, the strategy adopted in enhancing CP has increasingly become a fundamental approach since the United Nations Conference on environment and development was held in 1992. 'The cleaner production strategy' in China introduced a modern policy framework for industrial development and environmental protection (Wang, 1999). A remarkable number of enterprises among the Chinese have accepted the application of 'this cleaner production strategy' to improve and measure the organisational production processes, and this process has substantially achieved a remarkable decline in environmental pollution. However, despite this outstanding achievement, it was noted that only at the starting point of a long journey of pollution reduction and prevention in China that CP was tolerated. Many constraints, such as lack of awareness, regulatory impediments, technological hurdles, financial resources, and

organisational constraints, worked against the policy (Wang, 1999), prompting the strict enforcement of regulations.

Promoting CP in organisations is essential for enhancing environmental performance not only to the sugar cane industries but also to the wider communities along their supply chains. It is also important to note that having a good knowledge of the factors affecting CP improves the promotion of good sanitation. For example, high water consumption, generation of liquid effluent with high organic content and generation of large amounts of sludge and other solid wastes are common environmental problems in food processing sectors, including sugar cane mills. To solve these problems, water usage can be cut down drastically through in-house recirculation, liquid and solid wastes re-used and high organic wastewater treated by biological digestion. Cleaner production can be impacted in this way by the following measures: material reduction; and energy minimisation together with pollution prevention. These green production processes not only reduce water, energy and material needs, but also generate less waste (Dangelico and Pujari, 2010; Chowdary and George, 2012; Li and Lamblin, 2016).

However, to adopt CP, capital investment will be required. Since the 1980s, various approaches to reduce the industrial environmental impact have been developed. Most of these approaches are a response to the command-control legislation developed in the 1970s in the industrialized world. Central in the command-control legislative approach is the environmental permit. The permit 'commanded' the industry to what levels the production of wastes and emissions were acceptable, and how environmental protection was to be organized within the firm to realize these levels. The environmental protection agencies were supposed to be in control if industries were not complying with the content of the permits.

The command-control approach started to be criticized for a number of reasons. First, industrialists claimed that legislators were insufficiently capable of prescribing what protective measures they should apply. Second, the permit system was very complex, as environmental legislation became more diversified and specialized to deal with various environmental media, such as air, water and waste separately; every media was asking for a separate permit. Third, only a small percentage of permits was effectively controlled and updated. Industry responded by developing various systems and approaches that were

“market-based” and “self-regulatory”. The ISO management systems are probably the best-known response and the world industries’ implemented systems for regulation following the ISO-framework. Other approaches developed in the 1980s and 1990s are “Cleaner Production” (Schaltegger, Bennett, Burritt and Jasch, 2010).

Cost-benefit analysis (CBA), as a tool for CP, is a systematic approach aimed at analysing the weaknesses as well as the strengths among alternatives in a given activity, transactions, or project investments. This technique is often adopted in literature to determine options that offer the best approach to achieving benefits of cost minimization (Quah and Haldane, 2007). Again, CBA is conceptually explaining a systematic process of comparing and calculating costs and benefits of a decision and policy with particular regard to a given project. Cost-benefit analysis is often used by organizations to appraise the desirability of a given policy. It is an analysis of the expected balance of benefits and costs, including an account of foregone alternatives and the *status quo*. CBA helps predict whether the benefits of a policy outweigh its costs, and by how much relative to other alternatives, so that one can rank alternate policies in terms of the cost-benefit ratio. Generally, accurate cost-benefit analysis identifies choices that increase welfare from a utilitarian perspective. Assuming an accurate CBA, changing the status quo by implementing the alternative with the lowest cost-benefit ratio can improve Pareto efficiency. While CBA can offer a well-educated estimate of the best alternative, perfect appraisal of all present and future costs and benefits is difficult, and perfection in terms of economic efficiency and social welfare is not guaranteed.

From the broad perspective of CBA, two important features on the aim of CBA can be identified: it attempts to investigate if a decision on investment is soundly justified and this can be verified through an appropriate feasibility study; and CBA further provides information as to whether its costs outweigh benefits, and to what extent. Again, it offers a basis for a comparison of projects, and this process involves the comparison of total expected costs of each option against their total expected benefits (Quah and Haldane, 2007).

In most developing economies and particularly South Africa, an increase in industrial activity, such as demand for electricity and transportation, results in poor air quality and emissions which have become major issues of concern (Stringer, 2010). Rising raw material prices and higher energy costs are making the need for cleaner production to grow in importance and

relevance. CP focuses on enhanced productivity and reduced effects of wastes, which are the results of the new design over the life of products, processes and services (National cleaner production strategy 2004; Lakhani, 2007). The amount of waste to landfill capacity is increasing steadily.

There is a strong link between CBA and CP, though not distinct from cost-effectiveness analysis. In CBA, costs and benefits that flow over time are articulated in monetary terms and then adjusted to net present values using a discount rate. Most organisations are still using less efficient technologies and processes that are outdated rather than adopting state-of-the-art processes which could result in a reduction in the costs of production, which can contribute to their competitiveness and profitability (Schaltegger *et al.*, 2010).

Closely related, but slightly different, formal techniques include cost-effectiveness analysis, cost-utility analysis, risk-benefit analysis, economic impact analysis, fiscal impact analysis, and social return on investment (SROI) analysis.

Although CP has been confirmed to enhance efficiency, it has, however, not yet been well-developed within the production process. The commitment to CP by the South African government has brought about the formation of the National Cleaner Production Centre (NCPC) (Trusler, and Mzoboshe, 2011). At the international level, there is the United Nations Industrial Development Organization (UNIDO). The task of the NCPC-SA partnership is to give greater access to the required industrial support to help firms implement cleaner production which requires investment in cleaner technologies. The need to improve this section of the production process was established at the cleaner production conference, the event held at Gauteng in June 2013 (Delano, 2013). Cleaner production and resource efficiency (CPRE) were eventually integrated into NCPC-SA centres' services. Resource efficiency and cleaner production include energy life cycle assessments, efficiency, as well as environmental accounting (South African Cleaner Production Centre, 2013).

As shown from numerous case studies, most companies are not currently aware of how to implement the EMA concept; hence, they were not able to enjoy the opportunities and privileges in the implementation of EMA. Since the approach is recent and appears new to most organisations, fundamentally, there is a clear need for a more structured guide on how

to operate the new management accounting practices and integrate information relating to the environment. Environmental support groups, particularly governments, and other regulatory organizational bodies, are expected to encourage and promote the adoption of EMA in various organisations. The implementation of EMA remains a concern among most organisations in South Africa as most of these companies are reluctant to accept the implementation of new systemic approaches unless such approaches are enforced by law through a legislative or regulatory requirement (Doorasamy, 2014).

There is a general consensus in the literature that this emerging challenge in the sugar industry is caused by limited access to modern technological services in developing economies. This limitation indicates that such societies are far from industrialization. The need for efficient utilization of resources is crucial sustainable growth in the sugar industry. However, since the issue of cleaner production and its related cost and benefit analysis is in the embryonic stage, little studies have attempted to provide evidence on this area. Besides, the stakeholders demand that a framework be developed for optimisation principles that minimises production cost in the South African milling industry. With these gaps identified, this chapter provides evidence on the benefits of cleaner production and further offer a suggestive solution to this current decline in the sugar industry. The real contribution of this chapter lies in its adoption of alternative measures of cleaner production by including all the components of ISO 141001, which to date have not been collectively tested.

5.1.2 Contribution of the Chapter

This study makes three contributions to literature. First, instead of focusing on a single aspect of performance measurement, the chapter attempts to compare various performance measurements: Environmental; operational and financial. This provides a broader view of the impact of cleaner production to a firm, instead of focusing on a single performance metric, which has been the case for previous studies. In addition, the chapter complements existing literature, which has mainly concentrated in the developed world and other continents, which has different operating and environmental conditions. Another contribution lies in its adoption of alternative measures of cleaner production by including all the components of ISO 141001, which to date have not been collectively tested.

5.2 Objectives of the chapter

The objectives of this chapter are:

1. Investigate the influence of cleaner production on the performance of South African sugar industry; and
2. Develop a framework for optimisation principles that minimises production cost in the South African sugar industry.

5.3 Conceptual issues in Cleaner Production

There are numerous competing definitions connected to cleaner production. These have been influenced by the pollution prevention principles in the 1980s, such as, *inter alia*, cleaner technologies, pollution prevention, waste prevention, low-and non-waste technologies and waste minimization. Hence, in 1989, UNEP first prioritized cleaner production to the frontline. CP was then seen as the persistent adoption of an integrated preventative environmental strategy required for products, processes, and services in order to minimise environmental and human risks. Ever since the introduction of this term, cleaner production has grown over time and there were numerous variations in its conceptual definitions.

Cleaner production has been conceptually defined as a preventive form of environmental protection and as a company-specific initiative which was intended to minimise emissions and waste while output of production is maximized. As part of the process of adopting CP, a company attempts to recognize available options of minimizing emissions and waste out of industrial processes through source reduction strategies by analysing the material flows and energy in the organisation. The organisational and technological improvements assist to suggest preferred alternative in the adoption of energy and materials, in other to avoid waste, gaseous emissions waste and, water generation, as well as waste of heat and noise.

The concept of cleaner production was developed as a programme of UNIDO (United Nations Industrial Development Organization) and UNEP (United Nations Environmental Programme) at the preparation of the Rio Summit under the leadership of Jacqueline Aloisi de Larderel, the former Assistant Executive Director of UNEP. The primary aim of the CP programme was to reduce the impact of industrial waste on the environment.

Again, CP is an organisational preventative measure introduced by the management of the organisation to manage the environmental effects of business products and processes. CP adopts technological changes, resources, processes or practices to reduce environmental risk, waste, and health-related risks; adopts resources and energy more effectively; enhances business competitiveness and profitability; and improves the effectiveness of the production process. Hence, regardless of size or type, CP is applicable to all businesses.

CP is a process that is on-going, and applicable to production processes; services or products could be expanded to cover the entire product's lifecycle or service. Some cleaner production techniques include changes in input materials, technology, operating practices, product design, waste use, packaging and maintenance.

CP relates to other conceptual sustainability, such as environmental sound, technologies eco-efficiency, green procurement, life cycle assessment and zero emissions. The success of cleaner production requires the inputs of staff, staff participation and awareness together with senior management support.

5.4 Literature Review on the Cleaner Production

The theoretical and empirical evidence of the economic and environmental benefits of sugar production in literature are reviewed in this section with particular emphasis on South Africa.

5.4.1 Theoretical Literature

Innovation theory is adopted in this section to harness the various explanations in a framework of theoretical analysis and has its foundation rooted in the work of Dieleman (2007);

Rosenberg (1982) and Nelson and Winter (1982). This study offered an explanation for the adoption of innovation theory as this theory guides to focus in more detail on the change process towards cleaner production in the dimensions of technological advancement. Innovation theory is a rich field where a group of theories provides the prospect of integrating the theoretical framework that was previously discussed. These theories are presented in Figure 5.1.

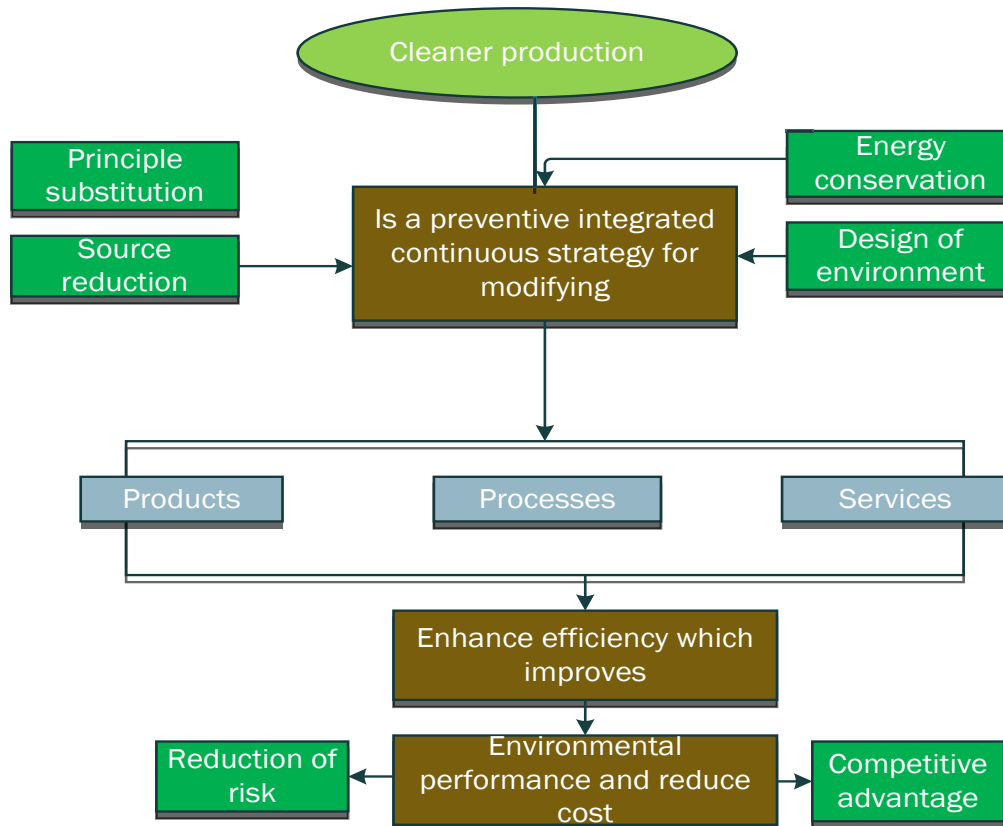


Figure 5.1: Summary of Cleaner Production definitions as adopted from Kauna University of Industry, and Economics Technology Lithuania

This study presents four perspectives to this innovation theory. There are subtle variations on their views of the innovation process as well as slightly different explanations. However, these theories could be said to complement each other, where the focus of the innovation process in organizations differ on each perspective.

Perspective 1: Cleaner Production as a change and learning process in organizations

Perspective 1 exhibits and demonstrates the implementation process of innovations in existing production processes. This model type was built on the pioneering work of Rosenberg (1982) with his book titled *Exploring the black box and inside the Black Box*. When considering innovation theory, these works could be considered as milestones (particularly when issues relating to technology are raised, but this depends on the inherent natures of the innovations). This theory, by contrast, indicates that innovations are at the starting point and far from being perfect; hence, it will require various modifications and adaptations. The innovation success greatly relies on the degree by which these innovations are integrated successfully into the existing company. Rosenberg (1982) adopted two identities to analyse the processes that were required to tailor and integrate innovations: “learning by using”; and “learning by doing”. The former is a means to integrate new technology in the existing production process while the latter is improving and changes existing in the production processes.

Rosenberg (1982) argued that innovation is a process of continuous learning, having special emphasis on both the “process” as well as “learning”. It takes time for modifications of extant procedures and technologies inside organizations to take hold. Changes could never be assumed as immediately “accomplished”. What is required are experiments that could proffer solutions to questions such as: Are these innovations performing as anticipated? Are there additional modifications that could allow innovation to function as expected in the extant process of production, in the set-out procedures for the workforce, performing with the innovation anywhere else? Only by adopting current technologies could the company learn the method of adopting the expected innovation in the fullest capacity and be classed as a successful adventure.

Rosenberg further argued that it is impossible practically to obtain solutions to most of the challenging questions when they are only on the drawing table. However, through experimentation, the integration of innovation takes place and that’s how companies get to learn more on how to adopt the technology. This process captures the essence of learning by doing or adopting the technology. Neglecting this process of learning is akin to considering an organization from the perspective of a black box; hence, a fundamental innovation aspect

is overlooked in the learning process. A challenge was put forward by Rosenberg to consultants of companies who were advised to invest in cleaner technologies, particularly new technologies, without a support process of implementation. Innovation could be seen as a process under which different parts of a company require to learn through their participation in the process of change.

There is a strong correlation between the work of Rosenberg and clean production (CP). As earlier identified, CP is a concept by which process and product modifications are the results of feasibility studies, assessments, implementation and experimentations. A demonstration project of CP leads to the processes of experimental search within an organization and concludes with a list of potentially feasible alternatives. Normally, it is left to the organizations to implement the alternative. These CP projects normally begin with a process within the organizations with the representatives making assessments. In the process where assessments are conducted, the specific challenges confronting an organization are recognized. In the next stage, the developed projects are discussed with the various organizations' representatives with the expectations of effecting different alternatives for change. Consequently, a proportional part of the chosen alternatives is studied and evaluated for implementation. Feasibility studies and experimentations are seen as an important aspect of a good CP project.

As this method is applied, it may appear as if the projects recognise the significance of the process of learning within the organization; to some extent, they actually do. However, most of the time, the crucial roles of the real process of implementations are not integrated into these CP projects; the reasons given do not necessarily mean the absence of resources or lack of commitment. However, the argument is that implementations are a learning and change process that must be carefully handled and introduced early in the cleaner production project.

Second Perspective: Cleaner Production is hindered by the framework of pollution control institutions

This perspective concurred with the extensive studies conducted by Dosi (1982). He carried out a study on evolutionary economic innovation and the significant importance of institutions in the innovation process. Nelson and Winter (1982) introduced a theory on the evolution of economic change and offered an explanation on how the development of innovations along certain technological trajectories could be established within technological regimes. Dosi

(1982) further expanded the general ideas of “technological trajectory” towards the direction of encompassing technology, the paradigm and institutions, as he viewed these concepts as one basic concept. Lundvall (1988) harnessed the “institutional trajectories concept” which centred on the contributions of institutions in societies.

Paradigms’ and trajectories’ regimes are built within the framework of some technological applications or solutions which could have become referential and standard. Normally, innovations are expected to focus on technological improvement. Certain explanations are reported on the fewer rate of implementation referred to in the cleaner production of an institutional environment. Bruijn De, Coenen and Lulofs (1996) advocated for more partnership and environmental friendship collaborations in CP while, in the same vein, Stone (2004) noted that lack of an adequate institutional framework to stimulate and facilitate cleaner production in an organization could hamper the goal of the organisation. Dieleman (1999) and Hofman (2003), as they considered more intimately at cleaner production, recognised the presence of a high level of pollution control regime. Controlling pollution operates in a situation where the standard adopted method in handling industrial pollutions are expected to adopt treatment in the end-of-pipe technology and where the majority among the institutions have been restricted in the standard method of handling emissions and waste. From the conclusion made by Dieleman (1999), most CP projects, in reality, have shown that a pollution-controlled regime exists. A situation when a demonstration project could recognise many options for CP is evidence that organizations failed to appropriate extant opportunities coming from pollution prevention. They appear limited to pollution prevention strategy in as much as solutions for emissions and waste are closely phrased in terms of treatment technologies and end-of-pipe activity. The greatest attainment and credit of most CP projects is that, through this strategy, the industrialists’ minds are opened. The introduction of CP projects allows them to foresee possible alternative approaches. The achievement of most pollution prevention demonstration projects is cumulated here: they show the feasibility and possibilities of the often-overlooked preventive approach.

It is worthy of note that CP projects identify the control dynamics of pollution regimes. This simply indicates that their actions need to be complemented within the organisation with a minimum of two additional activities: the first one requires the majority of the stakeholders in an organization for the given project; while the second work deals with the organisation and

its stakeholders over a given period of time. A regime does not only occur within the organisations but, rather, it should as well be located in the environment of the companies. There are possible factors that determine implementation options as restricted by the cleaner production continuation in organisations which are lacking most of the time. For instance, the lack of support from the environment could be counter-productive. Consultants, suppliers of new technologies, research organizations, governments and education are all partners in the search and identification of solutions to problems in the environment. In the situation where these partners receive training in the control of pollution rather than the prevention of pollution, they would prescribe and sometimes advise organisations to invest in treatment technology. Many contemporary CP projects are working more intimately with the appropriate stakeholders to engage them towards change to CP. Summarily, when CP projects fail to recognise the dynamics of trajectories and pollution control regimes, it is an indication that the impact of one CP project is limited in time and in scope.

Third Perspective: Cleaner Production functioning in the capacity of innovation-diffusion process

The work of Rogers (1995) forms the foundation upon which the third perspective is drawn. The novelty of his work caught across the period of 1962 and 1995 when he majored most of his research work on hundreds of innovation processes. Rogers' results revealed that most of the identified processes followed a pattern of a S-curve. It begins with a slow rate of innovative diffusion. After a while, the process of the innovative diffusion increases and the diffusion rate and adoption slow down again in a subsequent phase. The event follows a process such that, in the beginning, a small group of innovators gets involved in new practices or new technologies, which is immediately accompanied by sets of early adopters that are still small but slightly bigger. In reality, an innovation spreads at the time most people begin to adopt it. A distinction was made by Rogers between a late majority and an early group, but with slightly different characteristics between the two groups. It is of utmost importance that the moment the two sets of groups choose to adopt an idea of innovation; it becomes generally acceptable to the whole society or a group. Finally, another set emerges as a "laggards" group; this fails to adopt the innovation for a long time. The idea of separate waste collection is an example of innovation that follows this type of pattern which is adopted with keen interest by only a small

group and then, as time goes on, it gets collectively accepted by larger groups. However, some individuals continue to decline to adopt the new idea of waste separation despite its general acceptability and particularly now that it has become a new community standard to a certain extent.

Rogers failed to apply innovation as a search process, unless in areas discussed by other scholars in this article. Hence, Rogers is not concerned with the explanation of the diffusion rate and its acceptability by focusing at the features of the search process. Rogers rather gave more consideration to the effects of agent dynamics in the process of innovative diffusion. Mass media, government, heroes like singers, consultants, or football players, all, can function as change agents. However, more particularly, Rogers singled out mass media as being an important agent as they play a key role in many processes of innovation activity. Targeted and continued information, as a whole, is highly significant in allowing a majority to accept an innovation.

Roger's work is hardly ever used to offer an explanation to the implementation rate in cleaner production. However, it potentially contains some interesting insights. The pattern of diffusion of cleaner production that is "normal" or quite archetypical is the first observation based on the innovative diffusion of the body of knowledge. There are no reasons to assume that the case for CP should be different when almost all innovations follow the same pattern. It looks reasonable to imagine that the first generation CP projects are closely linked to the group of the early adopters. The main task now is to reach the majority group based on Roger's assumption, and this indicates adopting the right change agent(s) that could increase the diffusion rate in CP.

It makes sense to assume that these agents of change need to have a certain legitimacy and authority. In stimulating cleaner production, it is important to note that legislators, branch organizations and particularly governments, could play a significant role, not only by ways of acting as a participator in CP projects, but also as protagonists and as change agents in the various approaches to CP. As argued by Boonsc, Baas, Bouma, Groene and Le Blansch, (2000), CP has remained mainly a bottom-up approach until now for organisations based on the demonstration of the execution of projects. In these projects, the assumption is that, as a result of the inherent CP's positive features, the diffusion process might follow. This

assumption does not appear to be true; however, the impact of appropriate agents of change might be required to elevate CP to the next level of diffusion.

Fourth Perspective: Cleaner Production as a process of developing modern networks for socio-technical activities

The fourth perspective is deduced from the empirical work of the sociologists Callon (1987), Latour (1987), Bijker and Law (1992). In this perspective, the fundamental assumptions are the concepts of the construction of social technology. The challenges are emanating from the assumptions of this concept centre on the technological determinism under which people are required to acquaint themselves with progress in the technological programme that is inevitable and autonomous. The studies in the fourth perspective emphasizes on the socio-technology concept.

5.4.2 Empirical Literature

There are several studies exploring factors that contribute to cleaner production (CP); however, only a few studies examine these contributing factors simultaneously. These factors in the literature were used in this study as factors through an effective conceptual framework, represented in their leaner production. In addition, ISO14001 certification is the key factor included in the framework, eco-innovation of process and product, government regulations and industrial, as well as environmentally friendly culture.

Studies exist on the application of part of ISO14001 certification in cleaner production. In China, nine main Chinese pharmaceutical organisations in Tianjin, were adopted in an organisational case study by Li and Lamblin (2016) to investigate the contribution of the key factors on CP. The investigation indicates that organisations with the certification of ISO14001 have the great tendencies of being one step ahead of their competitors; for CP to be active, ISO14001 certification could not be the only determining factor leading to the efficiency of those manufacturing companies. There are innovations of green processes, not just product innovation, which impact directly on CP. An environmentally friendly culture particularly impacts on cleaner production's promotion. It is required that the industry should encourage and build an environmentally friendly culture and process-oriented innovations to

be more effective in the long-run objective of CP. Hence, the study offers insight for a case study based on environmental sustainability researchers, cleaner production and the strategic direction for manufacturing organisations to achieve environmental sustainability and cleaner production.

Mwakasonda, Cowan and Visagie (2006) noted that, currently, the mining industry in South Africa is disposing an average of 10 million tons of ultra-fine of coal annually. Once this coal is disposed, the sulphur involving ultra-fines constitutes numerous problems in the South African natural environment. The Water Research Commission initiated a programme to evaluate the adoption of CP within the mining organisation. A research study was conducted to ascertain if the CP approach would be appropriate to identify opportunities to decline this waste of coal, as well as to investigate the most feasible of these opportunities. To effectively perform this task, an assessment critically affecting the role of CP was carried out in three coalfield case study collieries within the South African Witbank area. Sampling with mass-balancing, accompanied by laboratory tests characterisation together with site surveys, was applied to analyse the quality, quantity and the sources of the three collieries in the ultra-fine coal site. Reference here

To generate the CP options, brainstorming sessions, literature reviews, and interviews were concurrently adopted. An economic, technical and environmental feasibility assessment was prepared and engaged for each option, to investigate the most appreciable and viable interventions for implementation. Through the assessment, numerous opportunities were provided. The quantity of disposed coal can be reduced in the three collieries, by preventing coarser coal from being castoff with the ultra-fine coal, particularly by an average of 24% in a case. To reduce the tendencies for wastages, improving the top size crusher could decline the coal amount that is milled to less than 150 μ m. The outcome from the assessments suggested that workable CP opportunities to decline ultra-fine coal wastage was found in the investigated sites, while their feasibility is on a specific colliery. Hence, these authors linked the benefits from finances in the proposed options with that of CP as being a reliable approach in handling environmental problems.

In his paper, Dieleman (2007) argued and proposed a new model in the concept of cleaner production as a means of stimulation. Categorically, the first section sketched out the cleaner production's historical development. It was shown that the method gained much popularity in the nineties, and the outcome brought optimistic assurance that CP would soon become a common practice within industry. The findings of evaluation studies on CP in USA, Europe, New Zealand and Australia were presented in the second section. The outcome showed that the rate of CP's implementation was much slower than expected in the nineties. Various innovation theories were addressed in section three. All the three sections assist to offer explanations as to why the implementation rate is much slower than expected, as they point at slightly varied aspects of innovation in cleaner production. Various theories were combined together in section four. This study further offers an explanation on how processes in organisations tend to interrelate with the arrangement among the institutions outside the organisation, such as education and legislation. Based on the theories' combination, it was established to institute social experiments to enhance CP. The social experiments could be seen as a third-generation model to enhance CP. The first generation is the demonstration projects while the regional network-based approach could be regarded as the second generation. The general goal in the social experiment is not to narrow down the implementation of CP, but rather to challenge operators of CP more significantly with the outcomes of cleaner production for their mode of operation and standards. It incorporates the concept of social change to generate a friendlier and more comfortable cleaner production with socio-technical network.

Still on the adequacy of sugar cane supply at the mills for optimal production, Narayanamoorthy (2005) conducted a study on the economics of drip irrigation in sugar cane cultivation with a study case of a farmer from Tamil Nadu in India. The study showed that sugar cane cultivation requires intensive water-supply as most of those predominantly grown in various parts of India had only a growth rate of about 1.81% per annum. The consequence of a lower growth rate of sugar cane is the shortage of raw material at the mills. The surface method of irrigation continues to be the major source of water supply for sugar cane cultivation through efficiency in the use of water consistently remains very low (35-40 per cent) due to distribution losses and substantial evaporation. Narayanamoorthy's (2005) study revealed that few research studies covered the gap in literature on how best to respond to some

certain fundamental questions regarding water needed for sugar cane plantation when farm-level data are adopted. Some of the identified questions include: What informed the viability of investment in drip technology? Is the benefit-cost ratio margin in the adoption of drip investment worthwhile? To what extent can the adopted technology save annual water needed for sugar cane production? Are productivity gains observable and commensurate? Will any problem emerge with operation in the application of the system at the field level?

It is noted that some research studies have been able to respond to some of these concerns through the use of experimental data or the use of actual farm-level data to estimate benefit-cost ratios (BCR) and net present worth (NPW). For example, the study of Sivagangai in Tamil Nadu used the instrumentality of the discounted cash flow technique in sugar cane cultivation (Shanmugam, Rajendran and Suresh, 2012). The study indicated clearly that the method of dripping irrigation possesses some advantages over the conventional irrigation method for the cultivation of sugar cane. The gains in productivity as a result of the method of dripping irrigation process was found to be 54% (30 tonnes/acre), and water preserved as a result of drip method irrigation (DMI) increased to about 58%, which is an advantage over the long-existing flooding irrigation method. Due to the dramatic reduction in water and electricity consumption during well water lifting, the farmer saved an average of 1 260 kilowatts per acre (kwh/acre). In addition to these benefits, the farmer was able to save cultivation cost to the amount of about Rs. 3,450/acre, most especially in the operational areas, such as cost of irrigation (other costs together with labour). The viability in the economy of drip investment in the cultivation of sugar cane through the discounted cash flow analysis indicated that drip investment in the cultivation of sugar cane is highly viable economically. The DMI has, therefore, been shown to be more economically viable in sugar cane cultivation compared to the conventional surface irrigation methods.

In Brazil, Lamsal, Jones and Thomas (2011) developed a model capable of handling sugar cane harvest's logistics problem. They integrated a series of valid inequalities into the model, particularly, for the lifting of the lower bound as well as introduction of heuristics for solving an initial feasible solution. The effectiveness of the inequalities and heuristics was demonstrated through computational results. Furthermore, rather than single locations, they explored the possibility of permitting trucks to operate multiple locations in order to

demonstrate the value of permitting the harvest speed to differ. Barnes, Meyer, and Schmidt, (2000) offered an alternative method of reducing the delay in the harvest to crush of sugar cane. Losses in sucrose and deterioration of cane quality and other sugar cane components are due to the long-time delay between harvesting and the crushing. Data were collected from the Sezela mill area using the simulation model. Well-developed strategies for reducing harvest-to-crush delays, such as implementation of harvesting groups and altered burning and delivery schedules, were adopted. Major sources of data collection came from hauler and extension growers and personnel. Furthermore, interviews with mill personnel using surveys of transport systems and harvesting were used in the area. Detailed data on the Sezela mill yard operations were derived from a previous simulation model and additional time studies that were performed. The results of the experimental runs performed with this model indicated that the longest delays between harvesting and crushing of sugar cane occur when the burnt cane is waiting to be cut, the time taken for the movement of the loaded canes to reach the mill yard stores and the delays in the mill yard stockpiles. These delays arose from the differences in harvesting, delivery and milling cycles. The major drawback of the model was the time taken for the runs.

Harris (2016) investigated the post-harvest deterioration in the South African sugar-cane supply chain where temperature and burnt harvest to crush time are seen as two major determinants of sugar-cane deterioration. The study undertook analytical work on the Maidstone mill where various delivery data were gathered for the 2015/16 season and robust correlations were derived from a spreadsheet-based model for regression analysis. The result indicated that, if a 12-hour reduction for the current 2016/17 season could be achieved, R9 694 352 would be saved as a result of the combined efforts in the reduction of losses incurred from post-harvest deterioration and mill extraction improvement and recovery in the boiling house. Singh (2013) took Uttar Pradesh and four districts as a focal point to analyse economies of sugar-cane base farming because this product is a very important cash crop with domineering impacts in the farming system. Data collection was sourced mainly from both primary and secondary sources. The suggestion spanning from the outcome of the research has shown that simultaneous planting of two heterogeneous products, such as wheat and sugar-cane, would reduce cultivation cost where attention is to be given to yields, production and technology of plantation.

Hessa, Sumbergb, Biggsc, Georgescud, Haro-Monteagudoa, Jewitte, Ozdoganf, Marshallg, Thenkabailh, Daccachei, Marinj and Knoxa (2016) noted that the sugar cane area is increasing speedily in response to bioethanol growing demands as well as sugar demand for human consumption globally. Sugar cane is a crop with a specific significant positive, negative socio-economic and environmental impact. The investigation of these authors has a direct focus on Sub-Saharan Africa (SSA), a region critically known for its continued growth, as a result of her great production capacity, proximity, European markets and low cost of production. Through information from key stake-holders; informants, workshops and research-industry output, the researcher jointly investigated the effects of sugar cane development on air quality, soil, water, food security, and employment, particularly on human health. The outcome of their findings indicated that, generally, sugar cane production is neither unsustainable nor sustainable, explicitly bad nor good.

The effects of sugar cane production on the society and environment are a function of the world-wide sugar political economy, quality of the scheme, local context, farm management and nature of the production system. Drawing from the climatic change threats together with the upcoming changes in the trade nexus with the European Union, currently, policies on agricultural development are driving international and national interest on sugar cane investment in the SSA, with growth to play a fundamental role in the region's sustainable development. The research outcome, by the researcher's expectation, is to assist and guide policymakers and other researchers with new information and insights on the environmental situations and social effects associated with production technologies, alternative sugar economy models and qualities of management.

The foregone discussion provides insightful information on the application of cleaner technology in production. What is obvious is that there are various cleaner production principles. These principles and components have been consolidated into the ISO14001 certification. In addition, earlier studies that examined the cleaner production among firms by using the ISO14001 certification did not use all the principles of the ISO14001 certification. This does not tell the whole story about how firms apply cleaner production and its resultant cost and benefits. This chapter thus departs from previous studies by applying the entire components of the ISO14001, which to date have only been partially tested, especially in the

sugar milling industry. In addition, the study provides a broader view of the impact of cleaner production on a firm, instead of focusing on a single performance metric, which has been the case for previous studies.

This study is particularly important in South Africa because as Mbohwa (2013) noted, the South African sugar manufacturing industry produces electricity, sugar as well as raw materials for the production of ethanol and other related by-products. The electricity cogeneration in the sugar industry is structured to accommodate energy security as well as the elimination of greenhouse gas emissions. Thermal and electrical energy are the two kinds of primary energy adopted for the processing of sugar-related products. This study acknowledges energy management as the best practice required to enhance the cogeneration processes and its efficiency. To generate electricity, the application of energy efficiency and conservation measures is paramount in the development of the sugar industry for the country's own usage as well as the upward transmission to the national grid. The study further noted that money is saved while the reduction of coal consumption is enhanced through an effective application of more energy-efficient practices. Technological and equipment improvements, together with advancement in process design that is required to enhance the efficiency of factory energy, were identified. Again, the chapter discusses further the cogent roles played by bio-energy together with its potentials in the South African sugar industry with a view to advising the government on policymaking as well as informing decision-makers appropriately.

5.4.3 Conceptual Framework

From the literature reviewed, it can be observed that cleaner production influences a firm in many ways. The consensus from literature is that a firm stands to benefit from cleaner production in terms of improvement in environmental performance, operational or competency performance and financial or economic performance. Based on this, Figure 5.1 is presented to show the relationship between cleaner production and environmental performance, operational performance, and financial or economic performance.

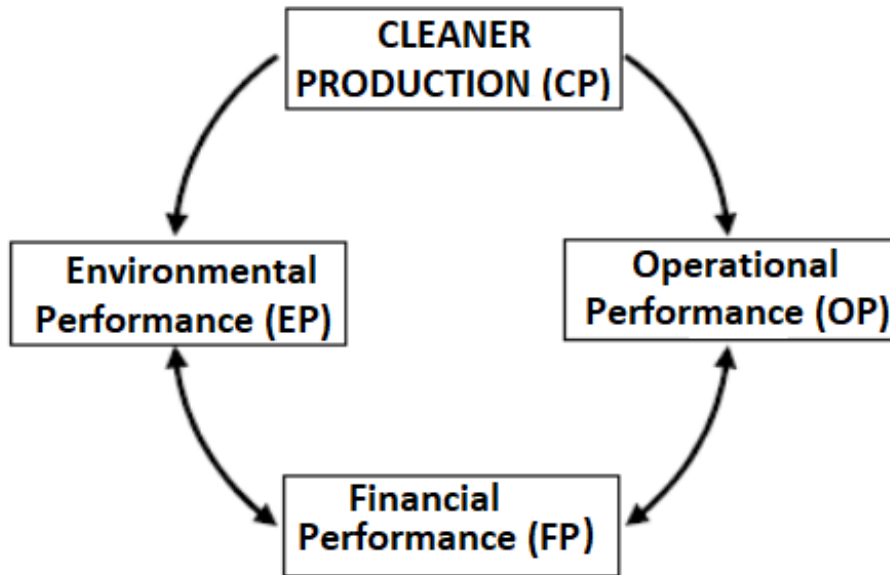


Figure 5.1: Conceptual Framework on the Significance of Cleaner Production

Source: Severo et al (2015)

The framework presented in Figure 5.1 postulates that the implementation of cleaner production would have a positive influence on the performance of the firms in the sugar industry. Specifically, the diagram explains that cleaner production can influence the environmental, operational and financial or economic performance of the firms in the sugar industry. These performance elements were the basis for providing sustainable cleaner production (Severo et al., 2015). It is therefore expected that a successful implementation of a cleaner production would influence these performance elements. This is reflected on the fact that the implementation of cleaner production through a detailed strategy would offer a direct impact on the level of environmental and operational performance, which would eventually translate into the improvement in the financial performance of firms, as illustrated in Figure 5.1. It is therefore expected that the adoption of cleaner production will offer immense benefit to the sugar industry and sugar cane firms in South Africa.

5.4.4 Hypotheses Development

5.4.4.1 The influence of cleaner production (CP) on Environmental Performance (EP)

Firms operate in a community, and therefore, their activities affect the environment and the citizens. As a result, the environmental performance of firms has been under scrutiny in severe times, where firms that do not perform well environmentally are penalised through fines and product boycott. Consequently, firms are continually looking for ways of improving their environmental performance. Similarly, sustainable production has a significant role in the contemporary manufacturing and production model where social and environmental performance have become precedence in the sustainability paradigm. Severo et al. (2015) argued that firms become more competitive when they have high innovation capacity and are able to consistently demonstrate the culture of continuous improvement. Severo et al. (2015) maintained that this would bring better environmental and social performance, thereby improving their overall sustainability performance.

Studies have found that the adoption of cleaner production can decrease the consumption of raw materials (Przychodzen & Przychodzen, 2015). In addition, there is evidence that cleaner production reduces the release of carbon dioxide created from the reaction of the raw material processes (Barbieri et al., 2010). Similarly, Cheng et al. (2014) reported that the adoption of cleaner production increases internal recycling and consequently reducing the environmental impact of wastes. From these studies, it is evident that the adoption of cleaner production would have a positive influence on the environmental performance of a firm. Based on the foregone discussion, the following hypothesis is formulated.

H1: Cleaner production (CP) has a positive influence on the environmental performance of firms in the sugar and sugar cane industry.

5.4.4.2 The influence of cleaner production (CP) on Operational Performance (OP)

Literature suggests that cleaner production has enabled firms to improve their operational performance significantly. This is as a result of the quest for the improvement in quality and efficiency. This has resulted in the training of staff as well as the procurement of effective equipment that are environmentally friendly. Through this effective integration between employees and equipment in the cleaner production process, it has allowed firms to improve

operational efficiency at optimal conditions (Zeng et al., 2010). The commitment of firms to improve and amend operational process motivates them to emphasis on the reduction of raw materials, reduction of waste, use of renewable energy and materials through cleaner technologies (Marchi, 2012). This enables the firms to respond quickly to changes occurring in the market and acts as market movers in exploring new opportunities. These would result in the improvement of their operational performance. Empirically, Zeng et al. (2010) provided evidence that cleaner production had a positive influence on the operational performance of Chinese manufacturing firms. Severo et al. (2017) also found that cleaner production had a positive influence on the operational performance of metal mechanic firms in Brazil. Based on the above discussion, it is therefore hypothesised that:

H2: Cleaner production (CP) has a positive influence on the operational performance of firms in the sugar and sugar cane industry.

5.4.4.3 The influence of cleaner production (CP) on Financial Performance (FP)

The awareness and development of cleaner production in recent times by firms suggests that cleaner production has a significant influence on the financial performance of firms (Przychodzen & Przychodzen, 2015). The authors maintained that firms benefit immensely from the adoption of cleaner production, especially in their manufacturing operation system because continuous implementation of cleaner production will make firms economically viable through the elements found in cleaner production: recycling of materials to enable better control of resources; use of modern technologies to ensure efficiency in production and reduction in waste and pollution. This will eventually allow the cost of production to be minimised, in addition to helping to enhance financial performance. The implementation of cleaner production through a detailed strategy would offer a direct impact on the level of environmental and operational performance, which would eventually translate into the improvement in the financial performance of firms. In fact, studies such as Zeng et al. (2010); Barbieri et al. (2010); Cheng et al. (2014); Severo et al. (2015) and Severo et al. (2017) provided evidence to support that cleaner production has a positive influence on the financial performance of firms. The foregone discussion leads to the formulation of the following hypothesis.

H3: Cleaner production (CP) has a positive influence on the financial performance of firms in the sugar and sugar cane industry.

5.5 Methodological Approach on the influence of Cleaner Production on Performance

In this study, a descriptive research approach was adopted through the use of primary data. A primary data is a data collected by the researcher from the first-hand source using such methods like interviews, questionnaires, observations and experiments (Creswell, 2014). The population of the study comprised the operational managers and production supervisors of all sugar milling factories in South Africa. In addition, the field managers of all the large-scale cane growers in South Africa as at November 2018. There was a total of fourteen (14) sugar mills and 1231 large-scale cane growers in South Africa. The sample size comprised of all the 14 sugar milling firms and two hundred and ninety-three (293) large-scale cane growers. All the milling firms were chosen for the study, considering their relatively small number. The production/operation managers and production supervisors were chosen for the study. One hundred and eighteen (118) respondents were obtained from this category of the population. Thus, a sample size of four hundred and eleven (411) was considered.

This sample size was of the large-scale cane growers was chosen based on the guidelines of Krejcie and Morgan (1790). The authors provided a guideline for choosing a sample size from a population and based on the guideline, a population of 1231 requires a sample size of 293. The sample was chosen using a simple random sampling technique. The basic principle of a systematic sampling technique is probability sampling method where each member from a large population falling on a specific periodic interval (*ith* number) was selected (Saunders, Lewis and Thornhill, 2007). Here, the names of the respondents were obtained from the websites of the South African Sugar Association (SASA) South African Cane Growers Association (SACGA). The firms that were on the interval or multiples of four were then selected. This means that the firms on the *first, fourth, eighth, twelfth*, and so on, that appeared in alphabetical order on the list were selected.

5.5.1 Data Collection

In this study, a questionnaire was used to collect the data. According to Creswell (2013), questionnaire allows respondents to tell their story in their own language, providing the researcher with rich descriptive details of the phenomenon. This provided a more appropriate judgement on the perceived usefulness of cleaner production (CP) to the sugar milling firms in South Africa. The questionnaire was developed after an extensive literature review, where the various benefits or usefulness of cleaner production in the context of manufacturing industry were identified (Marchi, 2012; Cheng et al., 2014; Severo et al., 2015). The literature showed that cleaner production achieves two main objectives: to improve operational performance and ensure environmental sustainability. As a result, the study was conducted to examine whether cleaner production has been beneficial to the sugar production firms in the context of the stated latent variables.

The questionnaire presented in Table 5.1 was used to collect the data. The questionnaire consisted of four (3) sections. All the sections contained structured statements with options of several responses based on a Likert scale. Section one (1) collected information on the extent of adoption of cleaner production in the sugar industry. Five (5) response items were developed in this section to examine how the firms have adopted cleaner production. Section two (2) also related to how cleaner production has also influenced the environmental performance of the firms. In this section, five (5) response items were developed. In section three (3), the effect of cleaner production on operational performance was also examined, where six (6) response items were also developed. Finally, section four examined the extent to which cleaner production influence the financial performance of the firms. Here, three (3) response items were provided.

The questions were weighted on a 5-point scale rated from 1 to 5 as follows. Strongly Agree (5), Agree (4), Uncertain/Undecided (3), Disagree (2) and Strongly Disagree (1). These asked the respondents to indicate the extent to which they agreed or disagreed with the statements. Likert scale normally has five or seven categories to show strengths of agreement or disagreement (Saunders et al., 2007). Yin (2013) thus asserts that the multiple-item scales such as the Likert scale are popular for three reasons. First, many items have the potential to capture a broad concept than a single question. Second, the employment of many items can

assist in illustrating finer distinctions items. In addition, if any of the question is misunderstood by a respondent and only one question is asked, that response will not be appropriately interpreted.

The questionnaires were electronically administered (email and Google docs form). The Likert scale questionnaire was accompanied by an introductory statement explaining the questionnaires and the purpose of the study. Respondents were given two weeks to complete the questionnaire on the Likert scale. This was considered long enough, as they also have their workload and deadlines. The researcher reminded the respondents three days before the deadline for submitting their questionnaires. However, the data collection took one month and two weeks. Once the respondent completed, the questionnaire examined them for completeness. Out of the 411 questionnaires sent, three hundred and eighty-six (386) were returned. In addition, fourteen (14) questionnaire were incomplete and thus were deemed invalid and excluded from the study. This brought a total valid questionnaire to three hundred and seventy-two (372), which is considered high for structural equation modelling (SEM) (Severo et al., 2015).

Table 5.1: Instrument Items

CODE	OBSERVABLE VARIABLES	LATENT VARIABLES
CP 1	The firm implements sustainability policy on the environment and society in development processes	CLEANER PRODUCTION
CP 2	The firm implements sustainability policy on product development	
CP 3	The firm adopts sustainability policies that improve the welfare of employees, society and the environment	
CP 4	The firm uses renewable energy	
CP 5	The firm strictly enforce rules on cleaner production	
EP 1	CP decreases water consumption	ENVIRONMENTAL PERFORMANCE
EP 2	CP reduces the environmental impact of the operation	
EP 3	CP decreases energy consumption	
EP 4	CP decreases the consumption of raw materials	
ESP5	CP decreases waste emission	
OP 1	CP reduces the cost of production	OPERATIONAL PERFORMANCE
OP 2	CP increases the quality of sugar produced	
OP 3	CP increases production capacity	
OP 4	CP improves the health and safety of workers	
OP 5	CP reduces machine breakdowns	
FP 1	CP has increased profitability	FINANCIAL/ECONOMIC PERFORMANCE
FP 2	CP has increased return on capital employed	
FP 3	CP has increased return on equity	

Adopted from Severo et al. (2015)

5.5.2 Validity and Reliability of the Instrument

To ensure that the data and results of this study are valid, the study ensured that a rigorous research design, consistent with previous studies, was adopted. In addition, the data collection instruments were checked by the supervisor and independent individuals with considerable knowledge of the topic and research. Their views were incorporated appropriately. In addition, pre-testing of the questionnaire was conducted with a sample of twenty (20) small scale cane growers. The pilot study was necessary to determine the validity of the instruments and to enable the researcher to determine whether the respondents understood the question.

In addition, the Alpha validity of the items in the questionnaire was determined through the calculation of a Cronbach Alpha. Cronbach's alpha estimates internal consistency by determining how well all the items on the assessment relate both to one another and to the total test (Kline, 2015). Cronbach's coefficient alpha is a popular reliability test that is used to establish the internal consistency of a multi-item measurement (Creswell, 2013). A reliability coefficient of less than 0.50 is unacceptable; between 0.5 and 0.60 is regarded as significant, between 0.70 and 0.80 is regarded as good and above 0.80 considered as excellent. The Cronbach Alpha calculated was 0.81 thus emphasizing the validity of the questionnaire.

5.5.3 Data, Analysis and Method

The structural equation model (SEM) technique was adopted to analyse the data. A structural equation model is a data analysis technique that employs many techniques in a set of methodological procedures for statistical analysis (Hayes, Motoya & Rockwood, 2017). Byrne (2016) asserts that the structural equation model permits simultaneous dependency relationships tests and the measurement of the intensity of these relationships. Kline (2015) recommends that the least number of observations for a structural equation model should be 200. In this study, the total observations or respondents was 372, which is above the 200 recommended respondents by Kline (2015). The statistical analysis of the data was performed using IBM SPSS Statistics software (version 25). In addition, the structural equation analysis method was done using IBM SPSS Amos software (version 25). Both exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) methods were used for the study.

An exploratory factor analysis (EFA) was used to confirm of the proposed model (Figure 5.1) while a confirmatory factor analysis (CFA) was used to measure the relationship between the variables in each construct. The exploratory factor analysis method was used to examine: the factor loadings, where the accepted value is greater than or equal to 0.5 (Kline, 2015); Bartlett test of sphericity and Kaiser-Meyrer-Olkin (KMO), which measured the adequacy of the sample with a value of more than 0.5 deemed adequate (Byrne, 2016); and communality test, which measured the factor loadings, which recommends a value of not less than 0.5 (Hayes, Motoya & Rockwood, 2017).

In the confirmatory factor analysis process, variance analysis was conducted through an average variance extracted (AVE), as recommended by Kline (2015). The average variance extracted explains the total variance of each observable variable within the construct evaluation process. This average variance extracted was employed to evaluate the discriminant validity analysis as well as the convergent validity (CV). The discriminant validity (DV) measures the variance in the observed variable that is influenced by the latent variable which has recommended values of not more than 0.8 (Keith, 2014). The discriminant validity is employed to examine whether the constructs in the model measures what they are purported to measure, or they measure different constructs (Briere et al., 2017). In addition, the convergent validity examines the direct relationships between the latent variables and further confirms whether the variables in each construct are mutually consistent (Byrne, 2013).

5.6 Results and Discussion

This section presents the results on the Cronbach's Alpha, exploratory factor analysis, confirmatory factor analysis and the structural model on the influence on cleaner production on the performance of the sugar industry. The Cronbach's alpha, exploratory factor analysis and the confirmatory factor analysis measure the reliability and validity of the test instruments while the structural model examines whether a relationship exists among the constructs.

5.6.1 Reliability and Validity of the Test Instruments

Consistent with earlier studies (Zeng et al., 2010; Severo et al., 2017 and Briere et al., 2017), the test instruments were first validated through the use of Cronbach's alpha, exploratory factor analysis and confirmatory factor analysis. The results on the Cronbach's alpha and exploratory factor analysis are presented in Table 5.2. Table 5.3 and 5.4 also presents the results of the confirmatory factor analysis and the structural model.

5.6.2 Internal Consistency and Reliability

The Cronbach's alpha statistics utilised to examine the level of satisfaction of the internal consistency of the observable variables that arose from the exploratory factor analysis. The results indicated that all the constructs: cleaner production; environmental performance; operational performance and financial performance had Cronbach's alpha ranging from 0.734 and 0.901. These values are above 0.70 and are considered by Kline (2015) as satisfactory. As a result, the reliability of the estimates of all the latent variables were satisfactory. The 15 test items were therefore used to measure the four latent constructs in the structural equation model.

5.6.3 Exploratory Factor Analysis

In line with the principles of structural equation modelling, an exploratory factor analysis was conducted to investigate whether the individual observable variables would load on their respective latent constructed, as claimed. Fifteen (15) tests items were consequently submitted to exploratory factor analysis. The results are presented in Table 5.2.

Table 5.2: Exploratory Factor Analysis Results

CODE	TEST ITEM VARIABLES	FACTORS			
		1	2	3	4
CP 1	The firm implements sustainability policy on the environment and society in development processes	.767			
CP 2	The firm implements sustainability policy on product development	.635			
CP 3	The firm adopts sustainability policies that improve the welfare of employees, society and the environment	.567			
CP 4	The firm uses renewable energy	.783			
EP 1	CP decreases water consumption		.635		
E9 2	CP reduces the environmental impact of the operation		.708		
EP 3	CP decreases energy consumption		.664		
EP 5	CP decreases waste emission		.618		
OP 1	CP reduces the cost of production			.858	
OP 3	CP increases production capacity			.693	
OP 4	CP improves the health and safety of workers			.759	
OP 5	CP reduces machine breakdowns			.609	
FP 1	CP has increased profitability				.762
FP 2	CP has increased return on capital employed				.574
FP 3	CP has increased return on equity				.507
Cronbach Alpha		.867	.901	.873	.734
Eigenvalues		9.54	2.88	1.93	1.74
Percentage of Variance Explained		46.74	13.86	9.31	7.87
Percentage of Total Variance Explained = 64.83					
KMO = 0.895; Bartlett's Test of Sphericity: $X^2 = 4382.227$; $df = 317$; $p = 0.000$					

Source: Author's Estimation (2019)

Table 5.2 presents the results on whether the individual observable variables would load on their respective latent constructed, as proposed. First, the adequacy of the sample size for successful factor analysis was checked by using Kaiser-Meyer-Olkin (KMO) measure of sample adequacy. The KMO results show that the coefficient of the sampling adequacy is 0.895, higher than the recommended value of 0.60. This suggests that the sample size is admissible for exploratory factor analysis. In addition, the results indicate that Chi-square of the Bartlett's Test of Sphericity ($X^2 = 4382.227$) was statistically significant at $p < 0.001$, which demonstrates that the exploratory factor analysis is appropriate (Zeng et al., 2010 and Severo et al., 2017).

From the results presented in Table 5.2, it can be observed that the factor analysis through the maximum likelihood factoring Promax rotation method provided four separate latent constructs. To obtain the significant factor loading, the tests items that loaded less than 0.4 were discarded. Fifteen (15) test items were therefore retained. The eigenvalues of all the four constructs were also higher than one (1) whilst all four constructs explained the total variance up to 64.83%, suggesting almost two-thirds (more than half) of the variance in the studied variables is explained by these constructs. To further support the discriminant validity, the results show that the loadings of the observable variables on their individual constructs were more than the cross-loadings on any other constructs. These results on the reliability and validity of the instruments make a strong case for the appropriateness of the use of structural equation model to study the relationship between cleaner production and the performance of the firms in the sugar industry.

5.6.4 Structural Equation Model

The section uses the structural equation model to test the proposed hypotheses in the study. In structural equation modelling, Kline (2015) suggested a two-stage approach is undertaken. The measurement model was first conducted through confirmatory factor analysis. The structural model is then conducted to examine the relationships among the constructs.

5.6.5 Confirmatory Factor Analysis

A confirmatory factor analysis was conducted with IBM SPSS Amos 25 with the maximum likelihood method. This was conducted to confirm the results obtained from the exploratory factor analysis as well as to examine the discriminant and convergent validity of the observable variables in the study. The model was first cleansed such that the construct validity and better fitness of the model would be achieved. This was through the elimination of standardised residual estimates of pairs of measured items that were above 2.58 from the model. These residual estimates of pairs suggest a greater level of error in the model specification (Keith, 2014; Hair et al., 2017). In addition, tests items with standardised factor loadings of less than 0.50 were discarded such that convergent validity would be achieved (Zeng et al., 2010). As a result, two test items were deleted from the analysis. The result of the confirmatory factor analysis is thus presented in Table 5.3.

Table 5.3: Confirmatory Factor Analysis Results

Constructs and Test Items	Composite Reliability (CR)	Average Variance Explained (AVE)	Standardised Loadings	t-value
Cleaner Production	.837	.525		
CP 1			.725	10.176
CP 2			.808	16.943
CP 3			.764	- a
CP 4			.731	12.367
Environmental Performance	.746	.647		
EP 1			.718	13.254
E9 2			.743	15.368
EP 5			.721	- a
Operational Performance	.884	.621		
OP 1			.747	- a
OP 3			.662	11.419
OP 4			.895	17.916
OP 5			.826	16.935
Financial Performance	.795	.594		
FP 1			.814	15.84
FP 2			.782	- a
FP 3			.771	13.325

Source: Author's Estimation (2019)

Notes: a = path parameter was set to 1, therefore no t-values were estimated; All loadings are significant at 0.001 level.

From Table 5.3, the results on the confirmatory factor analysis shows that fourteen (14) test items were loaded on their individual constructs. It can be observed that the standardised factor loadings were all statistically significant, with values ranging from 0.662 to 0.896, validating a test for construct validity (Severo et al., 2017; Briere et al., 2017). Though, the Chi-square statistics ($X^2 = 235.751$, $df = 92$, $p < 0.001$) failed to support the model, the other fit

satisfactorily measured the tolerable estimates in the confirmatory factor analysis. For instance, the Normed Chi-square statistic was 2.311, which is less than 3, suggesting a better fit of the model (Hair et al., 2010).

The Root Mean Residual (RMR) and Goodness-of-Fit Index (GFI) were 0.032 and 0.911, which suggests a good fit of the model, respectively. The Standardised Root Mean Square Residual and Root Mean Square Error of Approximation were 0.042 and 0.061, which are much lower than the proposed cut-off of 0.08 (Severo et al., 2017). Finally, the Comparative Fit Index (CFI), Tucker-Lewis Index (TLI), Normed Fit Index (NFI) and Incremental Fit Index (IFI) were 0.933, 0.918, 0.931 and 0.906 respectively. These estimates suggest that the model fitted well with the data and thus offered an acceptable solution for the measurement model (Hair et al., 2010).

The table further shows the composite reliability, and average variance extracted results of the constructs of the model. The composite reliability measures the level of internal consistency reliability of the observed variables. The composite reliability tests provided the following results: cleaner production (0.837); environmental performance (0.746); operational performance (0.884) and financial performance (0.795). These coefficients are higher than the acceptable value of 0.70, which is recommended by researchers (Keith, 2014; Hair et al., 2017). The results from the average variance explained to show that the constructs obtained estimates ranging from 0.525 to 0.642. These estimates are higher than the acceptable threshold of 0.50, thus confirming the good convergent validity of the constructs in the measurement model (Schumacker, 2017).

The discriminant validity statistics results of the constructs in the model are also presented in Table 5.4. It can be ascertained from the discriminant validity statistics results that the squared root of the average variance explained were much higher than the squared correlation estimates correlation estimates between a construct and any other constructs. This demonstrates that the latent constructs: cleaner production; environmental performance; operational performance and financial performance are reliable and valid constructs in the model. This corroborates with the expectation of obtaining a correlation between the constructs less than the average variance explained, suggesting that the observable variables are consistent in their measurement.

Table 5.4: Discriminant Validity Analysis

Constructs	CP	EP	OP	FP
Cleaner Production	.725**			
Environmental Performance	.373	.804**		
Operational Performance	.295	.382	.788**	
Financial Performance	.416	.501	.343	.771**

Source: Author's Estimation (2019)

Note: ** = AVEs' Square Root and off-diagonal estimates is the squared inter-construct estimates

5.6.6 Structural Model

The structural model is presented in Figure 5.2 whilst Table 5.6 presents the summary results on the relationship between cleaner production and performance of the firms in the sugar industry. Specifically, the results test the hypothesis formulated on whether cleaner production influence three performance constructs: environmental performance; operational performance and financial performance. In addition, Table 5.5 presents the results regarding the strength of the proposed model.

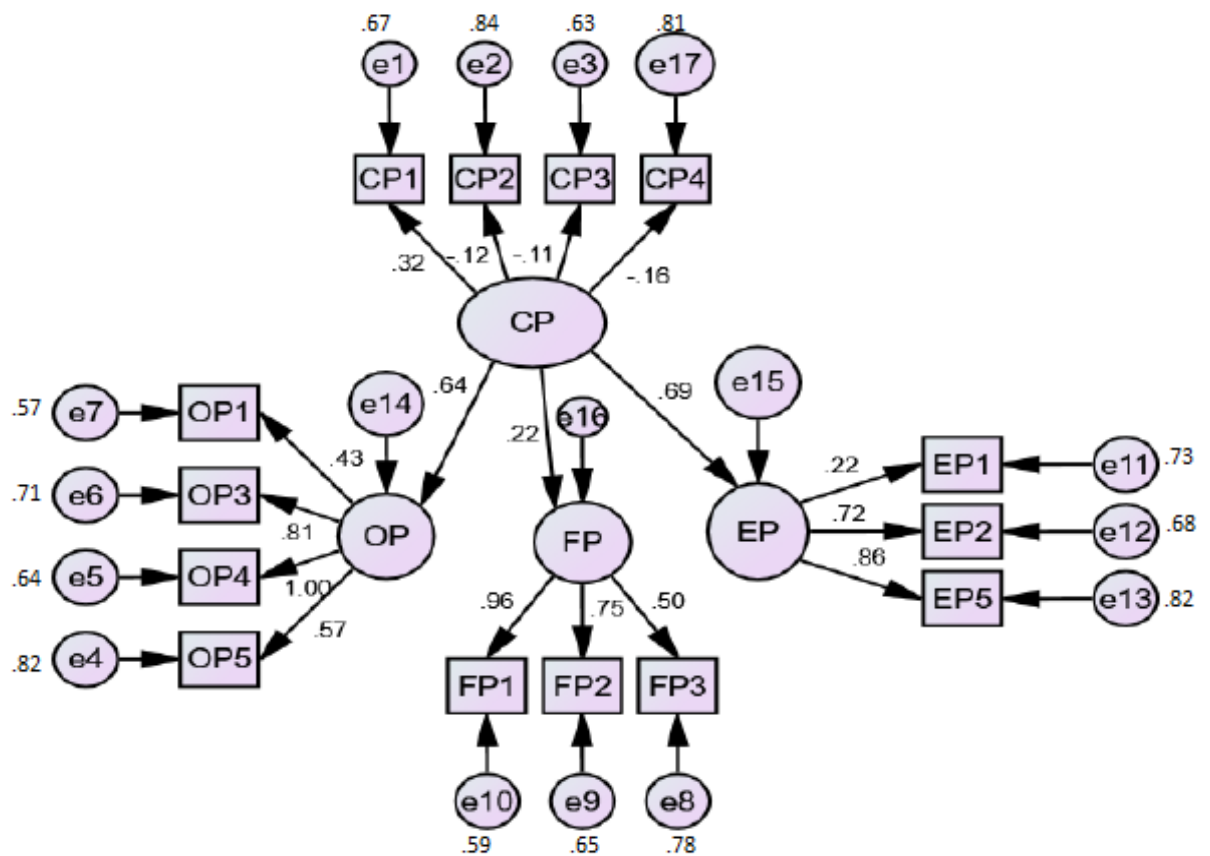


Figure 5.2: Path Coefficients in the Structural Equation Model
 Source: Author's Estimation (2019)

Table 5.5: Adjustment Index of the Proposed Model




	Final model
Chi-square (X)	3174.75
DF	563.64
X/df	5.633
P	0.000
CFI	0.936
NFI	0.943
GFI	0.914
AGFI	0.873
IFI	0.868
RMSEA	0.0547

Source: Author's Estimation (2019)

The structural model was used to test the statistical significance of the hypothesis formulated for the study. Here, environmental performance; operational performance and financial performance are the dependent variables, whilst cleaner production is the independent variable. Though the Chi-square ($X^2 = 3174.75$; $df = 563.64$; $p = 0.001$) did not improve and thus was unable to support the model, the other measurement of fit tests provided satisfactory solution to the path estimates in the model; $X^2/df = 2.084$; $GFI = 0.914$; $RMR = 0.041$; $IFI = 0.868$; $TLI = 0.943$; $CFI = 0.936$; $RMSEA = 0.054$; $AGFI = 0.873$. These results suggest that the model has satisfactory goodness of fit and thus, a structural equation model can provide a good explanation to the results. In addition, these results demonstrate a good match of the analysis and the measurement model, which further supports the hypotheses H1, H2 and H3. In addition, this supports the evidence of the presence of a relationship between cleaner production and the three performance measurement metrics: environmental performance; operational performance and financial performance, which emerged as a key finding in this study.

The final model results presented in Table 5.6 shows statistically significant results between the independent variable (cleaner production) and the dependent variables (environmental performance; operational performance and financial performance).

Table 5.6: Results of Hypothesis Testing

Hypotheses	Path/Structural Relationship	Standardised Coefficient	t-value	p-value	Result
H1	CP  Environmental Performance	0.69	14.653	0.000	Support
H2	CP  Operational Performance	0.64	7.385	0.000	Support
H3	CP  Financial Performance	0.22	4.037	0.003	Support

Source: Author's Estimation (2019)

The results of the structural model show that all the path estimates are significant at $p < 0.001$. The results further show that cleaner production ($\beta = 0.69$; $t = 14.653$; $p = 0.000$) is statistically and positively related to environmental sustainability performance. In addition, it can be observed from Table 5.6 that a positive and significant relationship exists between cleaner production ($\beta = 64$; $t = 7.385$; $p = 0.000$) and the operational performance. Similarly, the results indicate that cleaner production ($\beta = 22$; $t = 4.037$; $p = 0.003$) has a positive and significant influence on the financial performance of the firms in the sugar industry. Consequently, these results support the confirmation of the hypotheses H1, H2 and H3 that: cleaner production has a significant influence on environmental performance; operational performance and financial performance.

The results on the positive influence of cleaner production on environmental sustainability performance can be explained by the fact that the firms operating in the sugar industry are under pressure to be responsible to the environment and the community where they operate. As a result, these firms have adopted modern technologies and process in the activities which eventually reduces the negative environmental impact of their activities. These firms continually look for new ways of improving their environmental performance. In addition, the increasing use of recycled materials by the firms has reduced waste and pollution considerably. Since recycling and waste reduction is a key component of cleaner production, it is not surprising that the adoption of cleaner production has contributed to the environmental performance of these firms. Through recycling, these firms are expected to change waste into new products and materials and potentially reducing waste and negative environmental impact. This result aligns with the findings of earlier studies such Barbieri et al. (2010); Cheng et al. (2014); and Przychodzen and Przychodzen (2015) who found that the adoption of cleaner production would have a positive influence on the environmental performance of a firm. Based on the foregone discussion, the following hypothesis is formulated.

The results show that cleaner production has enabled sugar and sugar cane firms to improve their operational performance significantly. This may be the result of the quest for the improvement in quality and efficiency. This might have resulted in the training of staff as well as the procurement of effective equipment that are environmentally friendly. Through this effective integration between employees and equipment in the cleaner production process, it

has allowed firms to improve operational efficiency at optimal conditions. The commitment of firms to improve and amend operational process would motivate them to emphasis on the reduction of raw materials, reduction of waste, use of renewable energy and materials through cleaner technologies. This would, in the end, enable the firms to respond quickly to changes occurring in the market and acts as market movers in exploring new opportunities and contribute to the improvement of their operational performance. This finding confirms the findings of Zeng et al. (2010) and Severo et al. (2017) who provided evidence that cleaner production had a positive influence on the operational performance of Chinese manufacturing firms and metal mechanic firms in Brazil respectively.

The result further shows that cleaner production has a positive and significant influence on the financial performance of sugar and sugar cane firms in South Africa. This result is not surprising because the sugar and sugar cane firms can benefit enormously from the adoption of cleaner production, especially in their manufacturing operation system since continuous implementation of cleaner production will make firms economically viable through the elements found in cleaner production: recycling of materials to enable better control of resources; use of modern technologies to ensure efficiency in production and reduction in waste and pollution. This will eventually allow the cost of production to be minimised, in addition to helping to enhance financial performance. In addition, the implementation of cleaner production through a detailed strategy would offer a direct impact on the level of environmental and operational performance, which would eventually translate into the improvement in the financial performance of the sugar and sugar cane firms. The results agree with the findings of Zeng et al. (2010); Barbieri et al. (2010); Cheng et al. (2014); Severo et al. (2015) and Severo et al. (2017) who provided evidence to support that cleaner production has a positive influence the financial performance of firms.

The study has provided evidence that the sugar and sugar cane firms in South Africa benefit from cleaner production in terms of improvement in environmental performance, operational or competency performance and financial or economic performance. This is plausible because these performance elements were the basis of providing sustainable cleaner production (Severo et al., 2015). It is therefore not surprising that a successful implementation of a cleaner production would influence these performance elements. This is reflected on the fact that the

implementation of cleaner production through a detailed strategy would offer a direct impact on the level of environmental and operational performance, which would eventually translate into the improvement in the financial performance of sugar and sugar cane firms in South Africa.

5.5.2 Methods on the Model Development for a Cleaner Production in South Sugar Cane Industry

This section addresses the methodological issues on how cleaner production could be achieved in the South African sugar cane industry, as modelled by United Nation Environment Programme (ND). The adopted methodologies are classified into two. The starting point in the process of achieving cleaner production is the recognition of the need. The procedure for achieving cleaner production, as pioneered in the adopted methodological model (ACME) (Dieleman, 2007), is summarized and shown in Table 5.7 below. Following the recognition of the need are planning and organization; assessment of the project, feasibility analytical study and implementation through effective organizational planning resulting from the management commitment, organized project team, the identification of barriers and setting out of achievable objectives.

Table 5.7: Adopted methodological Model (ACME) on Cleaner Production

CP Method	
Planning and organization	<ul style="list-style-type: none"> • Obtain management commitment • Organize project team • Identify barriers and solutions • Set objectives • Pre-assessment
Assessment	<ul style="list-style-type: none"> • Identify sources (WHEN) • Analyze causes (WHY) • Generate possible options (HOW)
Feasibility analysis	<ul style="list-style-type: none"> • Evaluate options on technical, environmental and economic basis • Select best options
Implementation	<ul style="list-style-type: none"> • Option implementation • Monitoring and evaluation • Sustain and continue

Source: Dieleman (2007)

CP calls for an organised approach, to overcome barriers, and to ensure a successful implementation. Four basic steps are linked with CP assessment and can be classified as follows:

i. Organisation and Planning: these require management commitment in order to assess and identify focussed areas. However, sometimes, limited assessment focus is necessary for each assessment application, for instance, a raw material group, water, energy or a section within the factory;

ii. Assessment: This stage is made up of a more effective analysis of inflow of material together with material balances within each stage in the manufacturing process. Most waste sources generated are shown through control measures of reality versus theory. These stages are: (1) To identify and analyse causes (why?); (2) to identify sources (where?); and (3) to generate possible options (how?).

iii. Feasibility Analysis: this involves screening of technical, economic and environmental options) in order to select and prioritise best options; and

iv. Implementation option: This process involves evaluation, monitoring, continuity and sustainability.

Listed below are nine steps towards actualizing the sugar cane CP in the South African industry. The effective application of these steps would result in the overall reduction of material losses through waste. The stages include:

- (1) CP project start-up: this is the conception stage. Ideas at this stage are low and subject to critical scrutiny;
- (2) Project organization: this stage requires the development of a suitable sugar cane model that will have the capacity of running the cleaner production to reduce waste in the overall estimation;
- (3) CP option: the modelling system offers alternative options that generate the best alternatives. The model must be tested through programming in simulation packages to enjoy the best result;
- (4) Feasibility analysis: once the model is run, the analysis is evaluated to obtain results that key into the organizational goal of sugar cane CP;

- (5) Report assessment: this stage is crucial in the CP transformation as errors are bound to occur if reports are wrongly assessed. Here, there are two possible errors which could threaten the effective operation of sugar cane cleaner production achievement:
- (1) Type A errors: these are errors that should be dropped because they are injurious to the overall effective operation of sugar cane cleaner production, if they are accidentally allowed into the system. Type A errors have been committed; and
 - (2) Type B errors: these are errors of dropping important information that could have been useful in achieving sugar cane cleaner production objectives. Both errors are expected to be avoided.
- (6) Project implementation: this is project execution level which has to do with a higher-level involvement of management skills. The proper application of a model to real-life situation is required here;
- (7) Progress measurement: this is the level where the goal is compared with achievement in the process of project execution, where the actual is measured against the standard. It is commonly referred to as the appraisal level of project execution;
- (8) Final reporting: reporting is systematic as each stage of the sugar cane CP is evaluated and feedback is collated to be submitted to top management for further decision making; and
- (9) Top management review: this is the stage where achievement is translated into organizational policy. Guidelines from the policy become an organizational rule to be followed.

5.6.2 Proposed Model on the factors accounting for the decline of sucrose sugar level

What follows is an empirical investigation examining the claim of the declining quantity and quality of sucrose in sugar cane. As we have seen, parts of the literature argue that, in recent years, sucrose percentage has been falling in South Africa (Harris, 2016). Data on sucrose percentage in cane (Suc); tons of cane to 1 ton of sugar (LOGTS); tons of cane crushed (LOGTC); tons of sugar made (YP); yields per hectare of harvested cane (tons) are adopted to enable the establishment of these facts.

This section addresses the mathematical modelling of the minimization method as developed by López-Milán, Esteban and Plà, Lluís (2015). Here, the objective function is sought to minimize waste and maximize sugar content particularly in the sucrose producing industry.

The decision variables are represented by $X_{i,j,k,l,m}$,

where:

i represents the origin. Here in this model, $i=1$ to $i=A$ (sugar cane fields);

k represents the transportation means (various road transportation means) $k=1$ to $k=K$;

j represents the destination $j=1$ (sugar mill);

l represents the cutting system (as a group of harvesting machines). Here, $l=1$ to $l=L$; and

m represents the time of the day. Here $m=1$ to $m=H$ where $H \leq 24$.

Objective Function

$$\text{Minimize: } \sum_{i=1}^A \sum_{k=1}^K \sum_{l=1}^L \sum_{m=1}^H C_{ijklm} * X_{ijklm} \quad (1)$$

It is assumed from the foregoing that all fields have equal opportunities.

C_{ijklm} = the transportation cost of the sugar cane relating to the distance and the transportation means used in each case, where

$$C_{ijklm} = C_k * d_{ij} \quad (2)$$

where:

C_k = cost related to transport k ; and

d_{ij} = distance between origin, i and destination j ($j=1$).

Subject to the following constraints:

(1) The supply of sugarcane to the sugar mill.

M_{\max} = Maximum cane to be cut

M_{\min} = Minimum cane to be cut

$$\sum_{i=1}^A \sum_{k=1}^K \sum_{l=1}^L \sum_{m=1}^H * X_{ijklm} \leq M_{\max} \quad (3)$$

$$\sum_{i=1}^A \sum_{k=1}^K \sum_{l=1}^L \sum_{m=1}^H * X_{ijklm} \geq M_{\min} \quad (4)$$

This is built to avoid the problem of overflow;

(2) Maximum Processing capacity

$SMax_m$ = Maximum cane the mill can process

$SMin_m$ = Minimum cane quantity to be transported

$$\sum_{i=1}^A \sum_{k=1}^K \sum_{l=1}^L \sum_{m=1}^H * X_{iklm} \leq SMax_m \quad M=1, 2, 3, 4, \dots, H \quad (5)$$

$$SMin_m \leq SMax_m$$

$$\sum_{i=1}^A \sum_{k=1}^K \sum_{l=1}^L \sum_{m=1}^H * X_{iklm} \geq SMin_m \quad M=1, 2, 3, 4, \dots, H \quad (6); \text{ and}$$

(3) To consider the transport capacity by road

$$\sum_{i=1}^A \sum_{l=1}^L CR_{ilk} * X_{iklm} \leq TM_k \quad (7)$$

Here; $m=1, 2, \dots, H$

$k=1, 2, \dots, K$

CR_{ilk} = Transport need (in hours) to carry sugarcane harvested by machine l , from origin i to destination $j=l$ by road transport k .

TM_k = The number of carriage means of type k available per hour

$$CR_{ilk} = \frac{D_{il} * \left(\frac{1}{VL_k} + \frac{1}{V_k} \right) + T_{kl}}{C_{ck}} \quad (8)$$

D_{il} = Distances from origin I to destination

VL_k = Speed of the carriage means, k , with load.

V_k = Speed of the carriage means, k , without load

T = Waiting time of carriage means, k , with cutting system l

CC_k = Loading capacity of carriage means, k .

The model developed above seeks to explore an alternative option that provides controls for the transportation cost, delivery delay and overflow of resources of cane sugar. The model provides controls for transport need (in hours) to carry sugar cane harvested by machine 1, from origin i to destination j by road transport k . Achieving this through equation 8 would reduce the problem of an overflow of the raw material of cane sugar, which is the root cause of deterioration resulting in the loss of sucrose. It also provides controls for transportation cost and offers proximity of transportation that fastens delivery, thereby reducing wastages. The questions that follow shall assist in the implementation of model 8.

5.5.1 Questionnaires for Sugar Cane Production

The following questions comprise the questionnaire for sugar cane production:

- (1) How many fields of sugar cane farms serve raw materials to the company?
- (2) What is the transportation means of loading cane from the source to the factory?
- (3) What is the destination type of cane sugar? (Storage or direct to the mill)
- (4) What is the cutting system type? (Manual or machine)
- (5) Which hour of the day are they cut? What is the length of an hour per day?
- (6) Have the fields equal opportunities, or are there varieties of sugar cane?
- (7) What is the transportation cost per distance covered?
- (8) What is the maximum cut of cane sugar per day?
- (9) What is the minimum cut of cane sugar per day?
- (10) What is the maximum cane the mill can process per day?
- (11) What is the minimum cane the mill can process per day?
- (12) What is the transport capacity per load?
- (13) What is the transport need (in hours) to carry sugarcane harvested by machine 1, from origin i to destination $j=1$ by road transport k ?
- (14) What is the number of carriage means of type k available per hour?
- (15) What is the distance from origin I to the destination?

- (16) What is the speed of the carriage means, k , with load?
- (17) What is the speed of the carriage means, k , without load?
- (18) What is the waiting time of carriage means, k , with the cutting system?
- (19) What is the loading capacity of carriage means?

5.7 Summary

This chapter investigated the benefits of cleaner production from the perspective of South African sugar cane industrial production unit. The study investigated the influence of cleaner production from the perspective of a South African sugar cane industrial production unit. The objectives are to investigate the influence of cleaner production on the environmental, operational and financial performance of the South African sugar cane industry as well as to develop a framework for optimisation principles that minimises production cost in the South African milling industry. The detailed conceptual issues relating to cleaner production were identified and addressed.

The study has provided evidence that the sugar and sugar cane firms in South Africa benefit from cleaner production in terms of improvement in environmental performance, operational or competency performance and financial or economic performance. This is plausible because these performance elements were the basis of providing sustainable cleaner production. This shows that the successful implementation of a cleaner production would influence these performance elements. This is reflected on the fact that the implementation of cleaner production through a detailed strategy would offer a direct impact on the level of environmental and operational performance, which would eventually translate into the improvement in the financial performance of sugar and sugar cane firms in South Africa.

Taking the sugar cane industry in South Africa as the study focus, an alternative measure that enhances the quality of sugar, particularly that of sucrose was investigated. The study noted that certain factors, such as transportation and loading delay, contribute to losses in sucrose

which not only affects the farmers' yields but also increases the deterioration of cane sugar. Hence, minimization modelling through appropriation of the objective function was developed to control transportation cost, the supply of sugar cane to the mill, and transport needs to carry sugar cane harvested by machine from the origin to the destination by road transport. The correct application of this model in the South African sugar cane industry would enhance the quality of sucrose production and improve the farmers' welfare and profitability margins. In the next chapter, the MFCA model in South African sugar production is discussed to further consolidate efforts at enhancing efficient production and environmental sustainability for increased industry productivity.

CHAPTER 6

MFCA EFFECTIVENESS IN SUGARCANE PRODUCTION

6.1 Introduction

Previous chapters provided evidence to show that improving the processes of sugar production has economic and environmental benefits for the South African economy. In this chapter, the MFCA is modelled for adaptation to the production processes of the South African sugar cane industry for improved efficiency in output and environmental friendliness. The chapter further examines the relationship between material flow cost accounting and resource efficiency. Sugar production in South Africa is one of the major foreign exchange earnings and constitutes an important contributor to GDP growth of South Africa. It is argued that sucrose content, one of the significant components of sugar cane, has been on a declining trajectory in recent years.

Inefficiency in sugar production has been cited as one of the major challenges facing sugar production (Stainbank, 2011). There is an incidence of high wastage costs in sugar production especially in South Africa (Schmidt and Nakajima, 2013). This study further offers MFCA as a valuable tool since it supports the managerial decision-making process by making it possible to visualize and quantify material losses. The hypothetical question here is: can MFCA as a tool to increase organizational profitability? The study adopts models from literature to assess the efficiency of MFCA as an important alternative to the conventional accounting process. In this study, production cost has been classified into four categories, namely: system cost; energy cost; material flow cost; and residual cost. To assess the efficiency of this accounting skill, data from the South African Sugar Cane milling industry has been adopted to establish the claim in this study and, finally, this study has been able to implement the process involved in the use of MFCA. This study, therefore, recommends the proficient use of MFCA in organizations among the South African industries as it possesses the quality of classifying product cost from waste cost and, hence, improving profitability and organizational efficiency.

The South African sugar cane industry, which contributes close to R8 billion yearly to its economy and approximately R2.5 billion to yearly export earnings, is second only to maize production as a major part of the agricultural sector and is mostly centred in KwaZulu-Natal. It contributes 17.4% of the total gross value of annual field crop production in South Africa. Furthermore, the sugarcane industry provides 270000 indirect job opportunities, in addition to the 79,000 jobs directly related to sugarcane production. In fact, it is estimated to provide sustainable livelihoods to a total of about 1 million individuals (Forestry and Fishery, 2011).

The South African sugar industry produces approximately 2.3 million tons of sugar annually (South Sugar Institute Directory 2014), 75% of which is marketed and sold within the Southern African Customs Union (SACU), and the remaining 25% in other parts of Africa, the USA and Asia. It has thus continued to rank among the top fifteen sugar-producing countries in the world.

However, a consistent decline in production has been observed over the past two decades peaking in the recent past planting season, with various factors speculated as being responsible. Some of those factors are weakening yields and a reduction in the sugarcane production area according to the Bureau for Food and Agricultural Policy (BFAP) in South Sugar Institute Directory (2014); rising input costs and a lack of cohesion and economies of scale (South sugar Institute Directory, 2014; Stainbank, 2011); a growing culture of minimum reinvestment into farm infrastructure (especially among commercial farmers) due to the threat of land claims, poor soil health and replanting (South Sugar Institute Directory, 2014; Harris, 2016).

Figure 10 below indicates the declining trend in the large-scale production of sugarcane production and particularly sucrose yields.

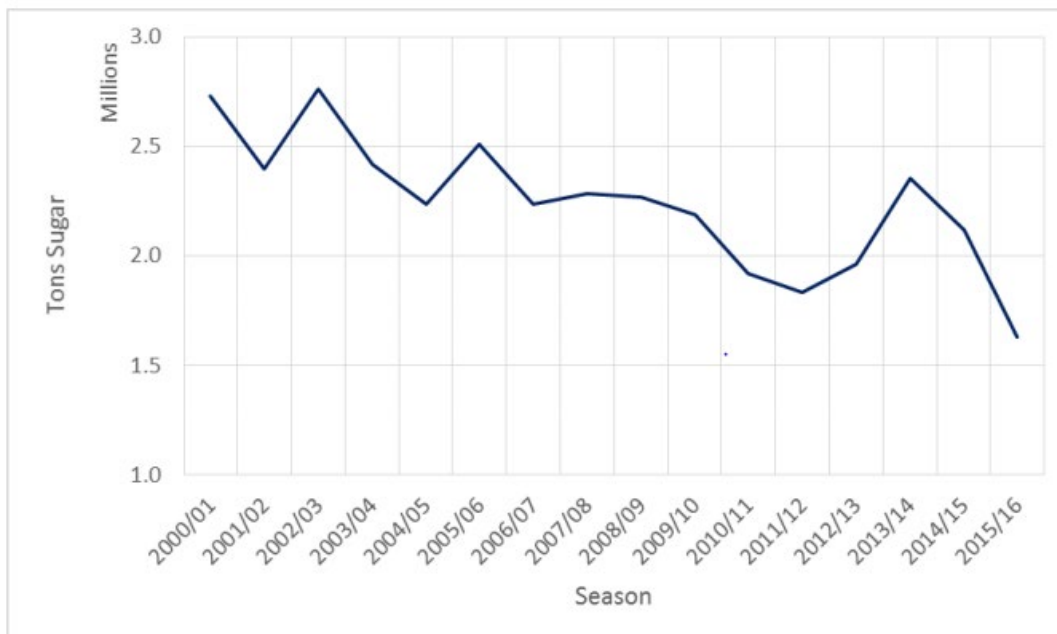


Figure 10: The declining Trend of Sucrose in South African sugar cane season

Source: Adopted from Harris (2016)

In addition to the general decline in sugar cane production due to the factors discussed, its international cost competitiveness has been on the rise. Unfavourable weather conditions experienced over the past decade have led to a significant increase in energy-associated input costs, with the situation being aggravated by the falling international sugar prices. These factors led to a reduction in sugar cane processing, leading to unutilized processing capacity and leaving non-sugars in unprocessed forms.

The quality of sugar cane juice is indicated by the ratio of sugars to non-sugars contained in it, where the higher the amount of sugar, the better for the sugar cane miller. The lower the amount of cane and level of impurities for each ton of cane crushed, the easier it is to crystallize sugar from the juice. The most important factors contributing to the high recovery of sugar are high sucrose, high purity, low fibre and low level of non-sugars. The level and nature of non-sugars are of great importance, as they have a direct impact on the cost of sugar processing and refinement.

Following the declining trend in the large-scale production of sugarcane and particularly sucrose yields, this study considers the adoption of a material cost reduction accounting framework as an alternative to maintaining a competitive edge in the market share of sugar cane in the international market. The study's argument in support of MFCA is based upon the weaknesses associated with the conventional accounting principles in accounting for material wastage.

According to Schaltegger *et al.* (2010), MFCA is an EMA tool which can be used to reduce both environmental impact and cost, as well as improve organizations' business productivity by reducing waste and its associated cost. In addition, it measures the flow of raw materials in both physical and monetary units. The cost categories related to MFCA are material, energy, system and waste management costs (Schmidt and Nakajima, 2013).

Schmidt and Nakajima (2013) were one of the first accountants to find weaknesses in conventional cost accounting models, major among which is the fact that they do not provide sufficient required data. While conventional cost accounting (CCA) systems trace and interpret monetary value flows as product cost, thus focusing on the cost figures for each product in each process, MFCA focusses on mass balances in each process. In general, companies rather than focusing on the material losses generated from a process, focus on the input materials and the quantity and/or quality of products. MFCA, on the other hand, takes into cognizance and measures input materials, output and non-product output (material losses), evaluating them in fiscal terms. It, therefore, performs better than traditional cost accounting models which provide insufficient information about the internal use of materials in manufacturing and resulting material losses and is more suitable for appraising alternative processes and technologies which can lead to more efficient material and energy utilization (Sygulla *et al.*, 2011). According to Sygulla *et al.* (2011), MFCA has been mainly implemented in practice in Japan, where it is seen as the new 'Kaizen' for many Japanese companies and is promoted by the Japanese Ministry of Economy, Trade and Industry. It is also being implemented in Germany, though still at a low rate.

6.2 The statement of problem

The continued decline in the sucrose quality of sugar cane and the general fall in sugar cane profitability in the South African sugar industry is of great concern to policymakers. Not only does this ugly event pose a challenge to the major revenue generation to the South African economy, but also threatens the existence of cane production on the African continent, as South Africa is the leading producer of cane and possesses the most industrialized sugar cane production system. Policymakers have, however, hypothesized that having an alternative to the cost-reduction strategy on the material losses can salvage this critical situation.

Consequently, this study sets out to develop an alternative MFCA measure as a best accounting practice which, if well appropriated, has a great chance of improving the quality and production of sugar cane in South Africa. The argument about the efficiency of resources, particularly relating to the waste-reduction process, is not only an issue of concern for environmentalists, scientists, activists and environmental analysts, but also for management accountants. In an attempt to contribute to waste reduction from various directions, experts in the field of management accounting developed MFCA to offer both non-financial and financial waste information to support waste-reduction decisions by managers. It is believed that the adoption of this tool would be of immense benefit to the sugar cane industry in South Africa.

Previous studies provided evidence that firms that applied material flow cost accounting could benefit from more efficient use of resources. For instance, Jasch (2009) found that, after the adoption of material flow cost accounting, Brewery Murau was able to save \$186,000 in the year 2006 through reduction of waste cost, thus emphasising that material flow cost accounting affect resource efficiency. In a case study on a medium-sized brewery in Vietnam, Shaltegger et al. (2012) found that material flow cost accounting could improve the efficient use of resources while Ulhasanah and Goto (2012) found that material flow cost accounting reduced loss by 14% in an Indonesian firm. The authors found that MFCA could provide accurate and more information that helped management to reduce waste and cost. Key

characteristics of these studies are that they all used a single firm as a case study. Furthermore, these studies did not use robust statistical analysis to establish the relationship between material flow cost accounting and resource efficiency or waste, rather adopting a more descriptive and exploratory research approach. Thus, the results have limitations because they relate to a specific firm and also based on the perception of the implementers. Hence their applicability to the general case is limited.

This chapter departs from previous studies by adopting a robust statistical method to examine the relationship between material flow cost accounting and resource efficiency. This chapter contributes to the literature by using a robust statistical method to provide evidence on the relationship between material flow cost accounting and resource efficiency.

This chapter also focuses on MFCA. It identifies the importance of MFCA information for the optimization of production processes and material flow management tools. The objective is to present MFCA system outputs in the context of the sugar cane milling industry and indicate the importance of acquisition of data from the MFCA system for the optimization of cane milling processes. In addition, the contribution of this chapter lies in the fact that it will help future researchers to use the developed model to examine the importance of MFCA information for the optimization of production processes.

6.2.1 Objectives of the chapter

The following are the objectives of the chapter.

1. To establish the relationship between MFCA and resource efficiency
2. To develop an MFCA system outputs in the context of the sugar cane milling industry and indicate the importance of the acquisition of data from the MFCA system for the optimization of cane milling processes.

6.3 Historical Background

In Japan, the MFCA method was first applied in 2000 and soon became widespread under the name material flow cost accounting. The first MFCA case studies, such as the one at the firm Nitto Denko, were funded by the Japanese Ministry of Trade and Industry (METI), which subsequently recommended further application of the idea. METI has continued to finance projects aimed at further developing the method and application context of MFCA, while numerous other independent studies have been published. Today, over 300 companies in Japan have experience with MFCA.

In the year 2007, Japan suggested that an MFCA norm be developed within the ISO 14000 family with the aim of setting out and standardizing general principles and frameworks for MFCA to support more widespread adoption of the method and, thus, contribute to more efficient worldwide resource handling in companies. It was to involve the education of representatives or consultants of small and medium-sized companies about the MFCA and its inherent advantages - the simplicity of its basic concept and its scalability. It was, however, not to be developed into a certifiable process, as it generally only addresses proprietary and private in-company details and processes. Several countries, such as Brazil, the United Kingdom, Finland, Malaysia, Mexico and South Africa as well as Japan and Germany, were involved in drawing up the ISO norm which was adopted and published in 2011 as ISO 14051 (Schmidt and Nakajima, 2013).

6.4 MFCA and Resource Efficiency or Waste Reduction/Management

Material flow cost accounting (MFCA) is one of the tools in environmental management accounting that is used to reduce the environmental impact of a firm as well as reducing cost. Again, material flow cost accounting is a tool employed by firms in decision making to improve business productivity through the reduction of waste (Granlund & Lukka, 2017). Specifically, material flow cost accounting helps measure the flow of raw materials, both in monetary and physical units. These cost categories, according to Schmidt and Nakajima (2013) include; material cost, system cost, energy cost, and generation cost. As a result of the

potential benefits of material flow cost accounting, many firms have started its adoption, especially in Japan, to reduce wastes and improve the efficient use of resources (Schmidt & Nakajima, 2013). Schaltegger et al. (2012) thus observed that decreased material input and material cost is a result of a decreased waste generation, which eventually results in improved efficiency. This suggests that the two main aim of material flow cost accounting is waste reduction and resource efficiency. However, Alawattage et al. (2017) contend that waste reduction and resource efficiency are the same since by reducing waste means using resources efficiently and effectively. Material losses or wastes that emanates from production processes are regarded as an inseparable part of material flows (Granlund & Lukka, 2017). These wastes are environmentally and economically undesirable. Therefore, the emphasis of material flow cost accounting is to identify areas of cost savings through the reduction in material consumption and wastes generation.

From the foregone discussion, it means that waste reduction is an important management activity that promotes effective utilisation of resources. Waste results in a huge cost to a firm or organisation in relation to input costs and recycling cost. Recycling mostly demands incurring huge expenses on input acquisition and energy cost during the conversion of the waste for eventual usage. In addition, Smith and Ball (2012) noted that waste costs include the amount incurred on the input material and the associated conversion costs. As a result, waste reduction is a logical way of defining efficient use of resources because it ensures higher outputs and avoids recycling and disposal expenses.

The use of material flow cost accounting will therefore help a firm to record material and financial flows in a production process, thereby making clear any inefficiency in the production process, by using the physical and financial information (Bartelmus, 2009). Since material flow cost accounting tracks the costs and quantities of materials, processes, wastes generation and waste recycling, it helps management appreciate the sources and causes of wastes generation. This enables the managers to take decisions at the right time to plug these wastes sources, and eventually ensuring efficient use of resources. Consequently, there is the need for firms and organisations to adopt material flow cost accounting to help the firm in three ways; increase environmental performance, increase environmental accountability and

ensure informed environmental and waste reduction decisions. The need for material flow cost accounting in a firm is presented in Figure 6.1 below.

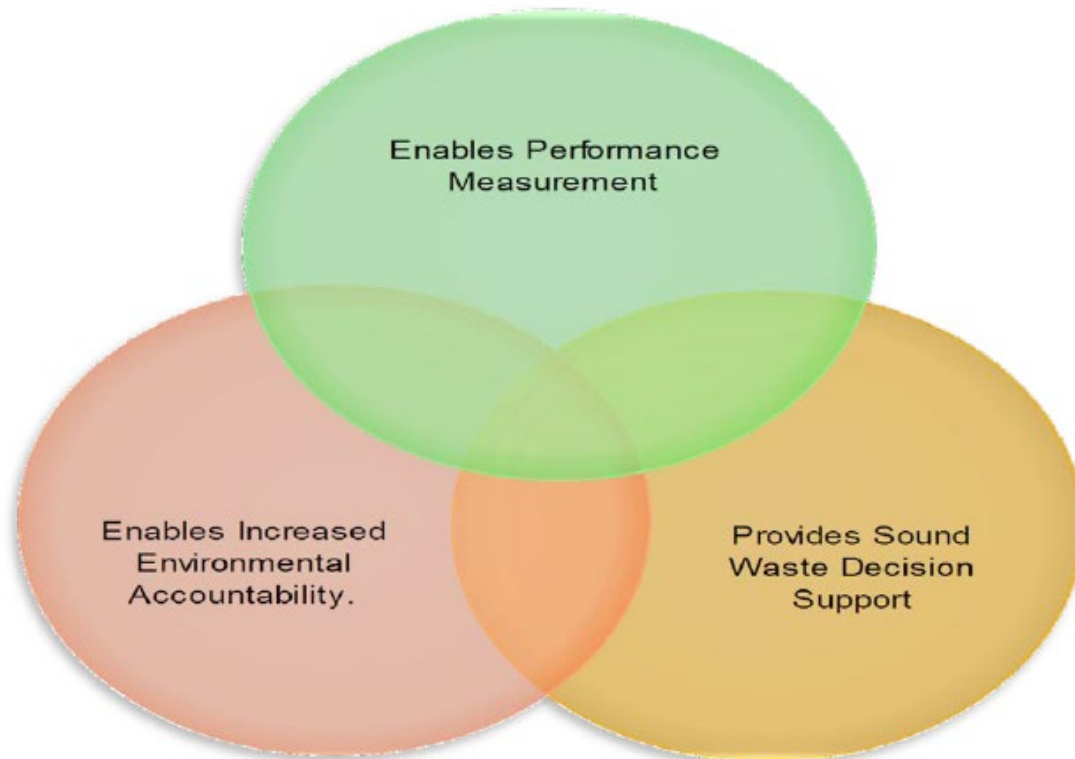


Figure 6.1: Benefits from adopting Material Flow Cost Accounting in a firm

Source: Fakoya (2014)

It can be observed from Figure 6.1 that material flow cost accounting has three main potential benefits to a firm. First, it facilitates performance measurement. According to Bartelmus (2009), the challenge of measuring the utility of economy of economic goods and amalgamating it is more obvious and efficient for environmental services, which mostly are not determined by market forces. Alawattage et al. (2017) thus argue that material flow cost accounting can alternatively be used as a valuable tool to measure and internalise results of environmental performance and improvements in waste reduction. Schmidt and Nakajima (2013) similarly argue that material flow cost accounting can offer the required information on the financial and physical process waste that creates environmental performance measurement. Given material flow cost accounting aims to reduce waste in the production

process, the need to ascertain, measure, and allocate costs to processes that generate wastes and assisting production managers to improve environmental performance and make waste reduction decision makes the adoption of material flow cost accounting very significant.

Similarly, the disclosure of information on the environmental impact of a firm is noted as one of the main objectives of material flow cost accounting. As a result, information on waste collected through material flow cost accounting mirrors this important responsibility (Schaltegger et al., 2012). Kokubu et al. (2009) concur that the provision of this information through material flow cost accounting promotes a firm's accountability to the community. In addition, material flow cost accounting enables the provision of relevant financial and non-financial information on waste to decisions on support reduction. According to Alawattage et al. (2017), such information should indeed be relevant to both internal and external stakeholders. Firms can therefore improve their accountability responsibilities through the adoption of material flow cost accounting in its external reports. As such, the information generated through material flow cost accounting can help provide support for effective waste reduction or resource efficiency decisions.

Additionally, material flow cost accounting can help provide sound waste reduction decision support. This is because Schaltegger et al. (2012) contend that several firms are unable to consider the full array of environmental costs in their decision making. The authors further assert that material flow cost accounting can help firms to attain improved environmental performance. Mostly, firms are not aware of the loss incurred on waste and waste recycling because such wastes are reused and at times can be sold for a fee. However, processing costs like labour, fuel, depreciation, materials and utilities on waste are difficult to identify and are mostly not included in the environmental costs used in waste reduction decisions (Schmidt & Nakajima, 2013). Since not all of these costs can be captured by the current material flow cost accounting framework, it is necessary to develop a framework to provide a more detailed or comprehensive waste information system to improve resource efficiency.

6.5 Theoretical Framework

This study is conducted within the framework of the contingency theory. The contingency theory postulates that cost information system must be structured in a flexible way such that the environmental and organizational structure that confronts the firm are accommodated (Riahi-Belkaoui, 2002). Similarly, Christ and Burritt (2015) contend that management and cost accounting information systems must adjust to the precise needs of an organisation. In light of this, Ferreira and Otley (2009) and Granlund and Lukka (2017) argue that management and cost accounting information systems should be framed within an adaptive framework. This means that every cost and management accounting system adopted by a firm must consider various factors that affect the organisation or the firm. Contingency theory therefore accounts for the environment, organisational characteristics and the styles of managerial decision making. Other authors such as Drury (2008), Nguyen (2018) and Granlund and Lukka (2017) also concur that contingency theory approach to cost and management accounting is founded on the premise that no universally accepted accounting system is suitable to every organisation in every situation. Contingency theory therefore endeavours to find areas of traditional management accounting systems that are related to specific defined situations and to establish a suitable matching like the environmental impact and resource utilisation.

The contingency theory permits the adjustment of cost and management accounting systems to adequately take care of the specific factors that affects the operations of a firm or an organisation. Thus, by using the material flow cost accounting system, there is the opportunity for a firm or an organisation to address the contingent operational pressures of the sugar milling firms such as waste generation or resource efficiency and increase organisational performance. Contingency theory was drawn principally from the ecological approach of a firm (Sisaye, 2001; Alawattage et al., 2017). The author further explained that ecological approach examines how the environment, technology and organisational characteristics affect organisational decision and performance. The environmental characteristics involve the community where a firm operates, the weather condition and the government and other regulations. Technological factors also comprise of the extent to which a firm adopt

technology in its operations. Similarly, the organisational specific actors include the experience of management and employees, management style and the rate at which assets are replaced or repaired. All these factors would have effects on the type would affect the type of cost and management accounting system a firm decides to adopt. In addition, these factors would have effects on resource efficiency.

According to Yagi and Kokubu (2018), a strategy is a process through which a firm uses its resources to make the best of its environmental opportunities and consequently reduce its potential threats from the environment. The contingency theory therefore broadens the scope of strategic and management control by highlighting the balance between external environmental factors and organisational internal resources. From the foregone discussion, contingency theory was chosen for the study since it is linked to the adoption and effectiveness of cost and management accounting system within a firm and it can be employed to examine and offer light into the link between business strategy, management accounting system and resource efficiency or waste management.

As has been pointed out earlier, a high rate of the implementation of MFCA among Japanese companies has been observed, to reduce material losses rather than recycling wastes. They have found out that reducing material input and its resulting cost eventually leads to improved processing efficiency and reduced waste treatment costs since it results in reduced waste. These two key activities, in turn, lead to a reduced environmental footprint of the manufacturing process.

Furthermore, the MFCA does not only provide data in physical and monetary units, but also shows the individual value of material flows (Maceno et al., 2018). Material costs are a key component of material flow costs because they represent an important cost item in manufacturing companies. Material flows are reconstructed and analysed within a quantity centre to identify what part of input materials resulted in products, and which ones flowed out as material losses/waste. The MFCA also monitors the cost associated with all energy sources used within a quantity centre, known as energy cost (Schmidt, Gotze & Sygula, 2015; Alawattage et al., 2017). Products and material losses are also allocated system costs, which are defined as all costs incurred when handling material flows within a company (e.g., personnel costs, etc.). Each material flow within a company (whether relating to products, raw

materials, material losses, or works in progress) may be treated as a carrier of system costs. Output flows are always allocated system costs which are retransferred to subsequent flows and material stock. Waste disposal costs must also be allocated to material losses incurred by a quantity centre.

Fakoya (2015) assert that to measure the usefulness environmental or material flow cost accounting system, it demands that one first measure the performance of an organisation. Guenther et al. (2017) also contend that even though, the prime aim of allocating environmental cost, especially waste costs to processes is perhaps economic, such allocations would help firms to find or identify best options of waste reduction and achieve resource efficiency. This study thus examines the relationship between a cost accounting system such as material flow cost accounting and resources efficiency or waste reduction. It thus seems rational for a firm with a high waste cost to adopt material flow cost accounting that permits the control of its waste cost. Granlund and Lukka (2017) thus stressed that contingency theory postulates that a linking strategy and management control systems ensures organisational effectiveness. As such, it can be put forward that, it is reasonable for the management of sugar-producing firms to adopt material flow cost accounting that helps in the management of contingencies, especially wastes.

6.6 Material Flow Cost Accounting and Resources Efficiency or Waste Reduction

6.6.1 Prior studies on Material Flow Cost Accounting and Resources Efficiency

The cost of waste can be classified into two main parts. Ahluwalia and Nema (2009) categorised these cost as those linked to waste generation and the cost of disposal and management of the waste. Ahluwalia and Nema (2009) further stated that some waste costs are mostly hidden in raw material costs in the form of wasted products, conversion cost of non-product outputs, cost of treating waste, waste recycling cost, lost time and cost of cleaning production line as a result of waste. According to Fakoya (2014), some of these costs are mostly not avoidable and are included in production cost. This made costing of waste a difficult task. As a result, Fakoya (2014) developed a comprehensive way of accounting for waste cost in production. The author thus proposed that waste cost can better be measured by the use of material flow cost accounting that will provide better information on how materials

are used. The results of the adoption of material flow cost accounting are the reduction in waste costs and continuingly ensuring effective use of resources. As a result, many studies have been conducted to examine how material flow cost accounting can be used to reduce waste and ensuring resource efficiency.

One of the prominent studies that examined the impact of material flow cost accounting was Jasch (2009), who examined the effect of material flow cost accounting on resource efficiency. Jasch (2009) used a case study approach to analyse data from Brewery Murau. Specifically, the author used the material flow cost accounting framework to highlight areas in the operation of the firm that needed improvements. Jasch (2009) found that, after the adoption of material flow cost accounting, Brewery Murau was able to save \$186,000 in the year 2006 through reduction of waste cost, thus emphasising that material flow cost accounting affect resource efficiency. Similarly, Shaltegger et al. (2012) conducted a case study to examine how the use of material flow cost accounting could improve the efficient use of resources in a medium-sized brewery in Vietnam. The authors found that the use of material flow cost accounting helped the firm to significantly reduce waste cost.

In South Africa, Doorasamy and Garbharran (2015) analysed the effectiveness of adopting the MFCA approach to highlight non-product output costs and assist managers in their strategic decision-making processes about implementing cleaner production processes. The paper was based on a case study of a paper manufacturing company in KwaZulu-Natal, South Africa, which provides evidence that MFCA's technique highlights the value of non-product output costs to enable managers to assess the financial and environmental benefits of adopting CP techniques and technologies. It has been concluded by Doorasamy and Garbharran (2015) that the company should integrate MFCA with the current EMS system to ensure efficient use of resources and their future sustainability.

Hyršlová, Vágner and Palásek (2011) also presented an application of the MFCA within the manufacturing plant of Lasselsberger, the largest manufacturer of ceramic tiles in the Czech Republic. Their study showed the importance of data acquired from the MFCA system as well as its application to optimizing manufacturing processes under specific conditions for a company's manufacturing plant. Their findings confirmed the uniqueness and advantage of the MFCA, in that it monitors materials' flow and the costs associated with a product and

material losses, thus ensuring efficient use of resources. In Indonesia, Ulhasanah and Goto (2012), how material flow cost accounting could be used to ensure sustainable cement production. With the application of material flow cost accounting, the authors reporting that loss cost reduced by 14%. In a related study, Huang et al. (2019) examined the effectiveness of material flow cost accounting in waste reduction. The results of the study showed that material flow cost accounting constitutes a valuable management tool at reducing waste in production.

Doorasamy (2015) conducted a study which examined the role of MFCA in identifying waste (non-product output) and its effect on an organization's profitability. This was done by examining multiple case studies which demonstrate MFCA as an important environmental management tool for ensuring organizational sustainability. The studies also showed that there is inadequate information/education in many organizations about MFCA, and, as such, they are not able to enjoy the benefits of adopting the MFCA. The author concluded that MFCA increases the transparency of environmental costs, allowing managers to identify saving opportunities which can be gained through adopting CP techniques or technologies and make informed investment decisions. Since this concept is new to many industries, the author suggested that more structured guidelines relating to the adaptation of current management accounting practices to include environment-sensitive practices need to be set out and communicated to them.

To demonstrate that the number of trucks could be reduced to avoid excessive supply, Prichanont, Prichanont, and Buransri (2005) adopted discrete-event simulation to examine how MFCA could be helpful. They found that the escalating cost of transportation is due to not having an extensive truck waiting time at the mill and effective cane delivery truck utilization. Simulations showed that up to 600 of the current 1 000 trucks could be eliminated while the needs of the mills remain unchanged statistically. Nakafima et al. (2014) used material flow cost accounting to identify the wastes and material losses in production. The author found that material flow cost accounting helped identify losses that could be handled directly at the production line and the material losses. The authors concluded that material flow cost accounting could provide information on the types and causes of losses in production so that management could put in strategies to either eliminate or reduce them.

Other studies also used exploratory studies to identify the benefits of the adoption of material flow cost accounting. These authors identified several benefits of material flow cost accounting. For instance, Sulong, Sulaiman and Norhayati (2015); Chompu-Inwai et al. (2015) and Yagi and Kokubu (2018) observed that material flow cost accounting could be beneficial to a firm in the following ways: proper understanding and identification of inefficient areas, reduction in direct material cost, reduction in cost of waste in production, reduction in disposal cost and accuracy in product costing. Similarly, Kokubu and Tachikawa (2013), Fakoya (2015); Rieckhof, Bergmann and Guenther (2015) and Nguyen (2018) opined that material flow cost accounting could be utilised to prove daily activities in the production process to enhance resource efficiency, provide better costing technique, ensure reduction in waste and reduce production and environmental cost.

It can be observed from the above studies that material flow cost accounting could influence the efficient use of resources. However, these studies did not use robust statistical analysis to establish the relationship between material flow cost accounting and resource efficiency or waste, which makes their findings not robust. Most of these studies adopted a descriptive and exploratory research approach. Thus, the results have limitations because they relate to a specific firm and also based on the perception of the implementers. This is understandable, though, because the concept of material flow cost accounting is still developing, and there was the need to first use these study approaches in establishing its significance. Moving forward, there is a need to establish the real impact of material flow cost accounting, using robust econometric or statistical methods. There is however a dearth of empirical studies which employed robust statistical methods to examine the impact of material flow cost accounting on resource efficiency or waste reduction. This leaves a gap in literature on material flow cost accounting, and this study intends to use a robust statistical method to examine the relationship between material flow cost accounting and resource efficiency. This study contributes to literature by using a robust statistical method to provide evidence on the relationship between material flow cost accounting and resource efficiency.

6.6.2 Method

This section discusses the method adopted to examine the relationship between material flow cost accounting and resource efficiency. Data were sourced from the records of the sugar milling firms. The annual reports and other records, especially those on production, spanning the period between 1980 and 2017 were used. There were six major sugar-producing firms in South Africa, and all six were used. The data from 1980 to 2017 were used for the study. This resulted in one hundred and eighty panel datasets. However, due to missing data for some of the firms for some years, one hundred and sixty-seven panel data sets were used.

6.6.3 Estimation Model

As indicated earlier, the main aim of material flow cost accounting is the reduction of waste and production of information for a proper cost and management accounting system. Again, material flow cost accounting is a tool employed by firms in decision making to improve business productivity through the reduction of waste (Granlund & Lukka, 2017). However, Sulong, Sulaiman and Norhayati (2015) observed that the reduction in waste in the production process is an indication of how efficient resources are used. Similarly, Schaltegger et al. (2012) reported that decreased material input and material cost is a result of a decreased waste generation, which eventually results in improved efficiency.

According to Ahluwalia and Nema (2009), material flow cost accounting results in more efficient use of resources. Ahluwalia and Nema (2009) further noted that resource efficiency in production can be classified into two categories. These resource efficiency categories are reductions in cost linked to waste generation, particularly the reduction in the quantity of waste generated. These cost categories, according to Schmidt and Nakajima (2013) include; material cost, system cost, energy cost, and generation cost.

Ahluwalia and Nema (2009) further stated that some waste costs are mostly hidden in raw material costs in the form of wasted products, conversion cost of non-product outputs, cost of treating waste, waste recycling cost, lost time and cost of cleaning production line as a result of waste. According to Fakoya (2014), some of these costs are mostly not avoidable and are included in production cost. This made costing of waste a difficult task. As a result, Fakoya

(2014) developed a comprehensive way of accounting for waste cost in production. The author thus proposed that waste cost can better be measured by the use of material flow cost accounting that will provide better information on how materials are used. The results of the adoption of material flow cost accounting is the reduction in waste costs and continuingly ensuring effective use of resources. Consequently, the study used two variables for resource efficiency. These variables are the cost of waste and the quantity of waste generated.

The preceding discussion suggests that material flow cost accounting can result in efficiency in the use of resources. However, Smith and Ball (2012) argued that waste in production is a product of many factors of which material flow cost accounting is one. Smith and Ball (2012) argued that factors such as the level of technology, age of machines, and the maintenance culture of a firm influence the level of waste generated in production. Smith and Ball (2012) posited that the technology adopted by a firm influences the waste generated because modern technologies have the ability to reduce waste in production. Similarly, Schmidt and Nakajima (2013) argued that a firm with older machines and poor maintenance culture is likely to experience machine breakdowns, and this will result in an increment in the level of waste generated. These observations are corroborated by Alawattage et al. (2017) who also argued production waste is caused by the technology adopted by a firm, the age of the firm and the nature of machines used in production. From the foregone, to establish the relationship between material flow cost accounting and resource efficiency, the following estimation models are used.

$$\text{WasteCost}_{it} = \beta_0 + \beta_1\text{MFCA}_{it} + \beta_2\text{AgeM}_{it} + \beta_3\text{MM}_{it} + \beta_4\text{TechInv}_{it} + \epsilon_{it} \dots \quad (1)$$

$$\text{WasteQty}_{it} = \beta_0 + \beta_1\text{MFCA}_{it} + \beta_2\text{AgeM}_{it} + \beta_3\text{MM}_{it} + \beta_4\text{TechInv}_{it} + \epsilon_{it} \dots \quad (2)$$

The variables in the models are explained in the Table 4.6 below.

Table 6.1 Variable Definitions

Variables	Definition
$WasteCost_{it}$	Cost of Waste at time t . This is measured by the ratio of waste cost to the total cost of production.
$WasteQty_{it}$	Quantity of waste generated at time t . The is measured by the ratio of the quantity of waste generated to the total production quantity.
$MFCA_{it}$	The adoption of material flow cost accounting at time t . Dummy variables are used for this measurement, where zero (0) represented the non-adoption of material flow cost accounting method in a particular year, and one (1) represented the adoption of material flow cost accounting method in a year.
$AgeM_{it}$	Age of machine at time t . This is measured by the age of the machines used for production.
MM_{it}	Maintenance level of the machine at time t . This represents the number of machine maintenance in a year.
$TechInv_{it}$	Investment in Technology integration at time t . This represents the natural logarithm of the amount spent on technological improvement in production in a particular year.
β_0	Constant of the equation
$\beta_1, \beta_2, \dots \beta_5$	The coefficients of the variables
ϵ_{it}	The stochastic error term at time t

6.6.4 Results and Discussion

6.6.4.1 Descriptive Analysis

Table 6.2 presents the descriptive statistics of the variables used for the study.

Table 6.2: Descriptive Data

	Mean	Standard Deviation	Maximum	Minimum
WasteCost (percentage)	9.52	8.926	16.76	6.82
WasteQty (percentage)	12.85	7.825	16.28	8.57
AgeM	6	3.6272	9	1
MM (R'000000')	2.21	1.067	4.837	1.00
TechInv (R'000000')	63.943	37.323	83.942	5.4738

Source: Author's Estimation (2019)

From table 6.2, it can be observed that the average value for the WasteCost (ratio of waste cost to the total cost of production) was 9.52%, meaning waste cost constituted more than 9.52 percent of the total cost of production of the firms. In addition, the average WasteQty (ratio of the quantity of waste generated to the total production quantity) of the firms was 12.85%, with a maximum and minimum values of 16.28% and 8.57% respectively. With a standard deviation of 7.825, it suggests that there is a wide difference among the firms concerning the quantity of waste generated in production. The average AgeM (age of machines) of the firms was also 6, suggesting the machines used for production averaged 6 years old while the average MM (number of machine maintenance) of the machines of the firms was 2.21. Similarly, the average TechInv (amount spent on technological improvement in production in a particular year) is R63.94 million.

6.6.4.2 Multicollinearity Test

To check for multicollinearity among the independent variables, a Pearson correlation analysis was performed. The results are presented in Table 6.3.

Table 6.3: Correlation Matrix and VIF Results

	WasteCost	WasteQty	MFCA	AgeM	MM	Tech	VIF
WasteCost	1.00						1.135
WasteQty	0.793***	1.00					1.017
MFCA	-0.247***	-0.285***	1.00				1.031
AgeM	0.106**	0.246**	0.074*	1.00			1.104
MM	-0.364**	-0.517**	0.272*	0.214**	1.00		1.017
TechInv	-0.153**	-0.264**	0.081	0.063*	-0.085*	1.00	1.186

Source: Author's Estimation (2019)

*** = $p < 0.01$; ** = $P < 0.05$ and * = $p < 0.10$

As shown in Table 6.3, the correlation among the variable was not strong. Except for the correlation between WasteCost and WasteQty ($r = 0.793$) and MM and WasteQty ($r = -0.517$), the correlations coefficient among the variables were less than 0.4. The correlation between WasteCost and WasteQty pose no statistical challenge because both variables are dependent variables. According to Thompson et al. (2017), a multicollinearity exists if the correlation between two variables is above 0.75. Based on the results, it can be concluded that no serious correlation problem exists among the independent variables. Confirming this claim, the variance inflation factors (VIF) shown in Table 6.3 suggests that there is no problem of multicollinearity among the variables.

6.6.4.3 The impact of MFCA on Resource Efficiency (Cost of Waste)

The result on the impact of material flow cost accounting on resource efficiency, measured by the cost of waste is presented in Table 6.5. The Hausman Test results ($p = 0.3187$) presented in Table 6.5 suggests the results are insignificant, and thus, the null hypothesis is not rejected.

As a result, a Random Effect model was used for the estimation. The coefficients and the t-statistics (presented in parenthesis) are presented in Table 6.4.

Table 6.4: The impact of MFCA on Resource Efficiency (Cost of Waste)

	Random Effect	Fixed Effect
Constant	21.51 (2.721)	19.94 (3.182)
MFCA	-0.1943** (1.827)	-0.1683** (1.525)
AgeM	0.1824** (1.983)	0.1869** (1.896)
MM	-0.1697* (2.024)	-0.1738* (2.183)
TechInv	-0.9242*** (2.536)	-0.1859*** (2.064)
R ²	0.6532	0.6241
Adjusted R ²	0.5785	0.5539
F-stats	65.37***	63.81***
Hausman Test		
Chi-square	3.862	
d.f.	2	
p-value	0.3187	

Source: Author's Estimation (2019)

*** = $p < 0.01$; ** = $P < 0.05$ and * = $p < 0.10$

The results from the random effect model presented in Table 6.4 show that material flow cost accounting has a negative impact on the cost of waste of sugar milling firms. This means that the adoption of material flow cost accounting contributes to a decline in the cost of waste in production. Here, the coefficient of -0.1943, which suggests that the adoption of material flow cost accounting can result in a 19.43% decrease in the cost of waste in production when the other variables remain unchanged. In addition, the result is significant at 5%. This result is not surprising because material flow cost accounting could provide management of the sugar production firms with enough information on the causes and sources of waste. This would eventually permit the sugar-producing firms to generate relevant and reliable data for effective

decision-taking on waste. This will result in increased efficiency in production through capital investment.

This result can also be explained by the fact that material flow cost accounting could help the sugar-producing firms to accurately evaluate production process cost and reduce waste costs by adjusting changes to production processes. The sugar-producing firms that adopted material flow cost accounting could have reduced cost of waste because it might have provided them a framework to effectively trace in the production process where material inputs, work in progress and defective products would occur such that corrective actions would be taken. This is attainable because material flow cost accounting is a tool employed by firms in decision making to improve business productivity through the reduction of waste

This result is consistent with that of Kokobu et al. (2009), who found that many firms and organisations in Japan improved their resource efficiency by adopting material flow cost accounting. Similarly, the result confirms the findings of earlier studies such as Jasch (2009); Kokubu and Tachikawa (2013); Nakafima et al. (2014); Sulong, Sulaiman and Norhayati (2015); Chompu-Inwai et al. (2015) and Guenther (2015) and Nguyen (2018) who all provided evidence to support that material flow cost accounting can result in a reduction in waste costs. Consequently, the sugar production firms can reduce waste cost significantly if they fully adopt material flow cost accounting.

The results further show that the age of machines or plants (AgeM) of the firms is positively related to the cost of waste in production. The coefficient of AgeM is 0.1824, suggesting an increase in the age of the assets increases the cost of waste in production up to 18.24%, when the other variables remain unchanged. Also, this result is significant at 5%. The result suggests that as the machines used for production grow in age, its efficiency and effectiveness decreases, thus producing more waste. The result can be explained by the fact that new machines are efficient at converting the sugar cane to sugar without generating much waste. This result was expected because, in the production process, old machines or plants are prone to breakdowns and functioning abnormally. These machine breakdowns will eventually result in some of the sugar canes getting spoilt, especially when there are no appropriate storage facilities for the raw materials and the work in progress.

It can further be ascertained from the results that machine maintenance (MM) has a negative and significant relationship with the cost of waste in production. Here, the results mean that an increase in the maintenance of the machines or plants would result in a decrease in the cost of waste in the sugar production process. This result is reasonable because machines wear and tear as they are used or grow in age. This reduces their efficiencies and is subject to developing faults regularly. It therefore becomes necessary that the machines are serviced or maintained regularly for them to function well. Thus, machines that are not maintained or serviced regularly and appropriately will underperform, and this will affect the production process. The result of under-serviced or under-maintained machines is machine breakdowns and breakdown in the production process. This will, in turn, lead to some of the sugar canes going waste, and thus increasing the cost of waste. These findings agree with that of Smith and Ball (2012), who observed that factors such as the age of machines and the maintenance culture of a firm influence the level and cost of waste generated in production.

The impact of investment in technology (TechInv) on the waste cost in sugar production is also negative, suggesting that an improvement in technological investment will result in a decline in the waste cost. Table 6.5 shows that the coefficient of TechInv is -0.1924, which indicates that a percentage point increase in the investment in technology would result in a 19.24% decrease in the cost of waste. This is consistent with the idea that firms invest in technology to improve production and efficiency. Here, an improvement in technology would result in a decrease in the time of production, waste in production, and machine breakdowns.

Similarly, technological investment is normally made to achieve a specific purpose, of which resource efficiency is the prime reason. It therefore stands to reason that firms would not invest in technology if it would not result in more efficient use of resources and reduction in cost. This result confirms the findings Schmidt and Nakajima (2013) who reported that a firm with older machines and poor maintenance culture is likely to experience machine breakdowns and this will result in an increment in the level of waste generated. In addition, this finding is corroborated by Alawattage et al. (2017) who noted production waste is caused by the technology adopted by a firm, the age of the firm and the nature of machines used in production.

The results further show that the R^2 and adjusted R^2 of the model are 0.6532 and 0.5785 respectively. The R^2 of 0.6532 suggests that the variations in the dependent variables can be explained by the independent variables up to 65.32 percent. In addition, it can be observed that the probability of the F-statistic is significantly at 0.01, suggesting the fitness of the model.

6.6.4.4 The impact of MFCA on resource Efficiency (Quantity of Waste)

The previous section examined the relationship between material flow cost accounting and resource efficiency, measured by waste cost. This section also presents the results on the impact of material flow cost accounting on resource efficiency, measured by the quantity of waste. As well, the Hausman Test results ($p = 0.2993$) presented in Table 6.5 suggests the results are insignificant, and thus, the null hypothesis is not rejected. As a result, a Random Effect model was used for the estimation. The coefficients and the t-statistics (presented in parenthesis) are presented in Table 6.5.

Table 6.5: The impact of MFCA on resource Efficiency (Quantity of Waste)

	Random Effect	Fixed Effect
Constant	19.27 (2.811)	21.17 (3.182)
MFCA	-0.1857** (1.925)	-0.1758* (1.089)
AgeM	0.1694**(2.146)	0.1763*(1.937)
MM	-0.1874** (19.75)	-0.1781** (2.096)
Tech	-0.1174** (2.851)	-0.1059*** (1.926)
R^2	0.6395	0.6113
Adjusted R^2	0.5681	0.5454
F-stats	59.86***	62.64***
Hausman Test		
Chi-square	3.091	
d.f.	2	
p-value	0.2993	

Source: Author's Estimation (2019)

*** = $p < 0.01$; ** = $P < 0.05$ and * = $p < 0.10$

Table 6.5 presents the results on the impact of material flow cost accounting on the quantity of waste generated in the sugar production process. The results show that material flow cost accounting has a negative relationship with the quantity of waste generated by the sugar milling firms. The coefficient of -0.1857, suggests that the adoption of material flow cost accounting can result in a 18.57 percent decrease in the quantity of waste in the sugar production process, *ceteris paribus*. The result is significant at 5%. Similar to the results on waste costs; this result is not surprising because material flow cost accounting could provide management of the sugar production firms with enough information on the causes and sources of waste. This would, in turn, help the sugar-producing firms to generate relevant and reliable data for effective decision-taking on waste. This is expected to result in increased efficiency in production through capital investment.

The results further show that the age of machines or plants (AgeM) of the sugar milling firms has a positive and significant (at 5%) on the quantity of waste generated in sugar production. The coefficient of AgeM is 0.1694, suggesting an increase in the age of the assets results in an increase in the quantity of waste by up to 16.94%, *ceteris paribus* and is significant at 5%. Here again, the result suggests that as the machines used for production grow in age, its efficiency and effectiveness decreases, thus producing more waste. The result can also be explained by the fact that new machines are efficient at converting the sugar cane to sugar without generating much waste. This result was expected because, in the production process, old machines or plants are prone to breakdowns and functioning abnormally. These machine breakdowns will eventually result in some of the sugar canes getting spoiled, especially when there are no appropriate storage facilities for the raw materials and the work in progress.

The results further show that machine maintenance (MM) has a negative and significant relationship with the quantity of waste generated in sugar production. The results suggest that an increase in the maintenance of the machines would result in a decrease in the quantity of waste generated in sugar production. This result is reasonable because of the wear and tear on machinery. This reduces their efficiencies and is subject to developing faults regularly. It therefore becomes necessary that the machines are serviced or maintained more regularly for them to function well. Thus, machines that are not maintained or serviced regularly will

negatively affect the production process and lead to some of the sugar cane going waste, and thus increasing the quantity of waste.

The impact of investment in technology (TechInv) on the quantity of waste generated in sugar production is also negative, suggesting that an improvement in technological investment will result in a decline in the quantity of waste generated in sugar production. Table 6.5 shows that the coefficient of TechInv is -0.1924, which indicates that a percentage point increase in the investment in technology would result in a 19.24% decrease in the quantity of waste generated in sugar production. This is consistent with the idea that firms invest in technology to improve production and efficiency. Here, an improvement in technology would result in a decrease in the time of production, waste in production, and machine breakdowns. Similarly, technological investment is normally made to achieve a specific purpose, of which resource efficiency is the prime reason. It therefore stands to reason that firms would not invest in technology if it would not result in more efficient use of resources and reduction in the quantity of waste generated in sugar production. This result confirms the findings Schmidt and Nakajima (2013) who reported that a firm with older machines and poor maintenance culture is likely to experience machine breakdowns and this will result in an increment in the level of waste generated. Also, this finding is corroborated by Alawattage et al. (2017) who noted production waste is caused by the technology adopted by a firm, the age of the firm and the nature of machines used in production. These findings are also consistent with Smith and Ball (2012) who observed that factors such as the age of machines and the maintenance culture of a firm influence the level of waste generated in the production

Lastly, the results further show that the R^2 and the adjusted R^2 of the model are 0.6395 and 0.5686, respectively. The F-statistic is significant at the 1% level, suggesting the good fitness of the model.

The results reported above clearly show that material flow cost accounting has a negative and significant impact on both waste cost and quantity of waste generated. This result can be explained by the reason provided for the waste cost because material flow cost accounting could help the sugar-producing firms to accurately evaluate the production process and reduce waste by adjusting changes to production processes. The sugar-producing firms that adopted

material flow cost accounting could have reduced waste in production because it might have provided them a framework to effectively trace in the production process where material inputs, work in progress and defective products would occur such that corrective actions would be taken. This is attainable because material flow cost accounting is a tool employed by firms in decision making to improve business productivity through the reduction of waste.

It must be stated that waste reduction is an important management activity that promotes effective utilisation of resources. Thus, waste results in a huge cost to a firm or organisation in relation to input costs and recycling cost. Material flow cost accounting can therefore be employed by the sugar milling firms as a tool in decision making to improve business productivity through the reduction of waste. Specifically, material flow cost accounting would help measure the flow of raw materials, both in monetary and physical units. Therefore, the emphasis of material flow cost accounting is to identify areas of cost savings through the reduction in material consumption and wastes generation.

Similarly, since material flow cost accounting tracks the costs and quantities of materials, processes, wastes generation and waste recycling, it helps management appreciate the sources and causes of waste generation. This would enable the managers of the sugar milling firms to decide at the right time to plug these wastes sources, and eventually ensuring more efficient use of resources. Additionally, material flow cost accounting can help provide sound waste reduction decision support to the sugar production firm in South Africa. These results are consistent with that of Kokobu et al. (2009), who found that many firms and organisations in Japan improved their resource efficiency by adopting material flow cost accounting. Similarly, the result confirms the findings of earlier studies such as Jasch (2009); Kokobu and Tachikawa (2013); Nakafima et al. (2014); Sulong, Sulaiman and Norhayati (2015); Chompu-Inwai et al. (2015) and Guenther (2015) and Nguyen (2018) who all provided evidence to support that material flow cost accounting can result in a more efficient use of resources.

6.7 Development of MFCA system outputs in the context of the sugar cane milling industry

6.7.1 Empirical studies on the Adoption or application of MFCA in an Organisation

Over the years, controversies have surrounded the concept of the material flow of products, such as sugar and other related primary products, as to the efficient methods of attaining best cost reductions in products without a trade-off of quality extractions (Schmidt & Nakajima, 2013). In terms of seeking a more efficient production of sugar, both in ensuring better cost management and less stress on the environment, MFCA application has been adjudged a useful technique. Given its proposed potential to support an eco-friendlier production that could improve transparency in the concept of material losses in the cause of industrial production, Doorasamy (2015) studied its possible application on the sugar cane industry of South Africa. Employing both empirical and theoretical approaches, the author investigated the adaptability of MFCA as a powerful instrument and method of analysing the economic impact and environmental management adopted in industries. The study noted that environmental impacts could be reduced by companies and would promote efficiency in daily business activities through the efficient use of this tool. The study was built on a theoretical framework with a special interest in explaining the nature of the relationship between environmental and economic performance through the application of the EMA concept in a business environment. Two lines of research were followed in this empirical study: the hypothesized relationships in the theoretical models were empirically tested through the adoption of instrumental studies, and the study conducted descriptive statistics aimed at investigating the factors that determine the EMA adoption. The study evaluated the contribution of MFCA in product output (waste) together with its role in achieving an organization's profitability. Numerous case studies that ascertained MFCA as a vital environmental management accounting tool for ensuring future organizational sustainability were reviewed.

Hyršlová, Vágner and Palásek (2011) presented an application of the MFCA within the manufacturing plant of Lasselsberger, the largest manufacturer of ceramic tiles in the Czech Republic. Their study showed the importance of data acquired from the MFCA system as well as its application to optimizing manufacturing processes under specific conditions for a company's manufacturing plant. Their findings confirmed the uniqueness and advantage of

the MFCA, in that it monitors materials' flow and the costs associated with a product and material losses. The data acquired during this process enable management to identify and propose measures which can lead to more effective production and lower the volume of material losses. The advantages of the MFCA over traditional approaches can be classified into two:

- Economic: Its primary focus is on material flows and all associated costs; and
- Environmental: By focusing on the reduction of waste through the reduction of unnecessary input, MFCA leads to a lower and better environmental performance by companies.

METI (2010) classified MFCA as being highly appraised and rapidly disseminated as a powerful method to simultaneously realize “reduced environmental impacts” and “improved business efficiency” by increasing transparency of material losses. MFCA is acknowledged as one of the environmental management accounting tools, which contributes to making both the environment and economies compatible. The paper discusses MFCA as a potential approach to reveal the quantitative and monetary effects in the frame of material flow management. It gives an introduction to its basic ideas, identifies methodical shortcomings and presents two enhancements for improvement: the explicit regard of energy (loss) flows; and a procedure for a more detailed analysis and forecast of system costs. METI (2010) argues that the adoption of MFCA could be extended to data envelopment analysis (DEA) as it is one of the most frequently used analytical tools to appraise productive unit efficiency performance, based on inputs and outputs. This method of analysis has been adopted for benchmarking and performance evaluation. Ultimately, an organization employs this tool of analysis in its productive units and would want to optimally utilize all the resources in the production process, so that outputs are maximised from a given set of inputs.

In a related study, the Productivity Institute (2013) identified the MFCA concept of categorising wastes as material losses resulting from the manufacturing processes and, therefore, are an integral aspect of the manufacturing costs. The institute argued that production costs could be substantially reduced with less industrial waste, thereby saving cost or disposal and waste recycling. Consequently, production can become more environmentally

friendly, resulting in improved competitiveness and enhance the manufacturing processes. A brown sugar product manufacturer in Japan applied the MFCA concept to each stage of the production processes beginning from production to the final packaging (METI, 2010). There were four kinds of identified material losses; these emanated from excessive packaging, packaging materials for raw sugar, products dropped, and 'off-specification' brown sugar that was preserved for later re-use. The industry noted that off-specification products controlled about 5% of the overall products. Even though the difference was preserved for later 're-use', the truth of the matter is that losses, such as energy consumption and system costs, were produced during the process of manufacturing. It was again found that the off-specification products did not only lead to a lesser output but added to labour costs as there was an increase in the on-going night shift duty for the shop floor personnel. The contribution of another 5% of the overall products, which also dropped brown sugar bits, suggested losses as earlier mentioned. Another uncovered loss from packaging material for raw sugar is the packaging process and excessive packaging, which hurts the environment.

Fakoya (2014) applied the MFCA framework's basic principle as a case study area in the reduction of waste processing decision making in the beer brewing industry in South Africa. The author adjusted and adopted the existing MFCA framework with the objective of supporting and improving the process of waste-reduction decision making among the managers in the brewery industry in South Africa. The lack of adequate ability to supply the required process in waste information could probably reduce organizations' efforts to achieve and implement expected waste-reduction strategies. The study focused on the exploratory multiple case study approach through the adoption of a pilot study and an in-depth interview in two brewery industries, namely, a large brewery and a micro-brewery to achieve the objectives of the study. The result indicated that, even though the adoption of technology appears fundamentally essential to control process waste in the brewery industry, there is a limitation of an adequate accounting tool in both organizations that impacts on waste-capturing management. Again, it is important for companies to integrate an accounting tool that is relevant in aiding the control of waste-related information that can enhance waste-reduction decisions. The author concluded with the recommendation of the application of an MFCA framework adjusted programme that would reflect a more robust approach for information synthesis to enhance waste-reduction decisions.

Christ and Burritt (2013) submitted a review of existing literatures on MFCA with the intention of developing a research idea that could offer a basis for the development of the future of the MFCA tool. Issues were raised on the lack of adequate theories behind MFCA: low ability in the application of the practiced tool and lack of required skill and knowledge; and inadequate surveys, statistical research and interview methods to complement the case studies. Other issues raised include the limitation of logical proof in the applicability of the tools beyond different firm sizes and manufacturing inhibiting their implementation for performance enhancement. An intention to recognize the promising opportunity for research and the scope of application in the organization, together with an expansion of strategy for investigations, are then itemized.

The MFCA was developed as an approach for improving resource efficiency in manufacturing companies by adopting the distribution of the various costs in the flows to products and residual materials. The trend development of MFCA has been further traced to its efficient present-day application (Schmidt and Nakajima, 2013). As has been, few studies have been conducted on a global scale on the issues around the factors that determine the quality of sucrose in sugar cane (Albert, 2012; and Zhou, 2014). However, there seems to be not much similarity among these various works conducted on sugar cane product across countries. These differences can be attributed to the fact that industrial operational structures differ across countries and quite a handful of such studies have been undertaken in developed countries with little use of MFCA as a decision-making toolkit for improving resource efficiency (Mishelle & Garbharran, 2015; Kasemset, Chernsumornchai & Pala-ud, 2015; and Dunuwila, Rodrigo & Goto, 2018). The reason might relate to the general interest of individual researchers in areas where much knowledge has been explored. Empirical research considering the application of MFCA in the sugar industry is quite scanty and, where available was analysed on a descriptive basis, limiting its applicability. Such limitations make this study apt and worth undertaking, especially in South Africa. This paper argues that just as MFCA first achieved practical relevance and large-scale application in Japan, even to the point of being converted into an ISO standard, it can also be successfully applied within the South African context, particularly in the sugar can industry, with remarkable results.

The next section addresses various methodological approaches through the implementation of models and MFCA's principles in classifying production and waste cost.

6.7.2 Methodological Approach on the development of an MFCA system outputs

The foundation of these model frameworks is built upon the works of Fakoye (2014); and Hysrlova, Vagner and Palasek (2011). Figure 6.1 below indicates the fundamental issues behind MFCA. In conventional cost accounting, every cost could be apportioned to an individual product and regarded as unit cost. The material cost in the MFCA classification is appropriately divided between the residual or waste and the actual product; this, however, depends on ending points of the material used. Again, company system costs, such as transport, processing, and storage, can be generated and distributed between the wastes or the residuals and the main product based on the appropriate indicator's key.

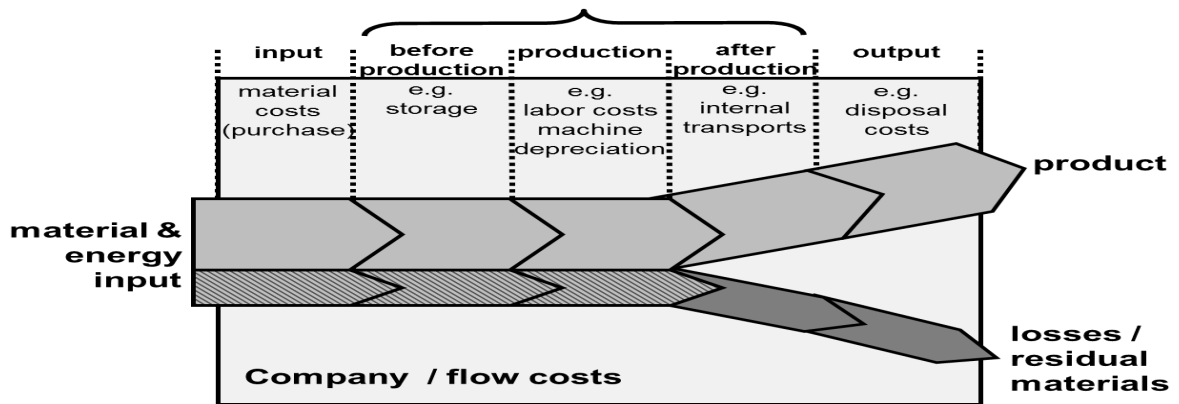


Figure 6.1: Classification of the production process

Source: Author's Extraction, 2018

From Figure 11 above, through the asymmetry in the cost of material losses, provision for an improved measure can be made. From this method of analysis, the possibility of cost reduction can lead to avoidance of material losses. Savings in terms of monetary value are higher in comparison to when the production process of the direct cost of residual or waste disposal is obtained. It, therefore, indicates, for instance, the chosen periods of amortization available for

investment reduction in wastages are shorter and the larger scope is open for environmental management or quality measurement.

The production of sugar cane in South Africa, as shown in Figure 6.2 is a step-by-step process taking effects from plantation to the final harvesting.

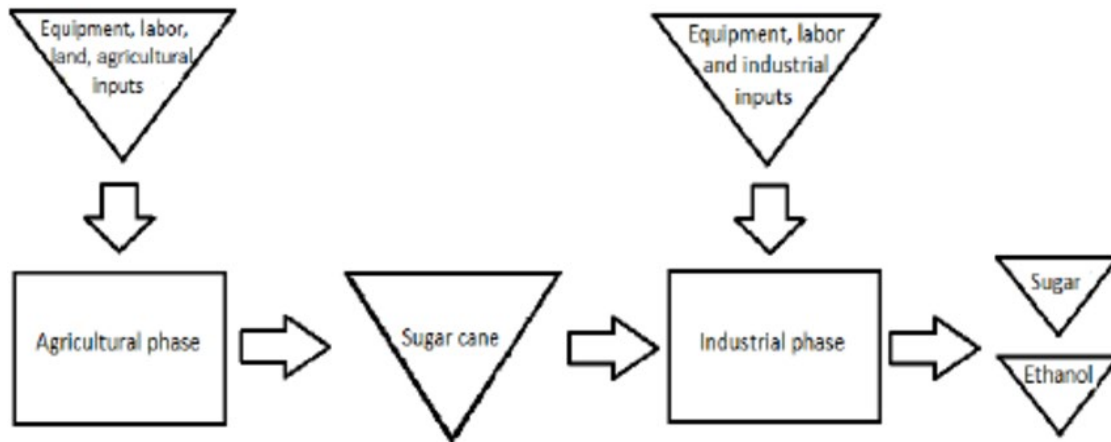


Figure 6.2: Production process of Sugar cane Extraction to the product

Source: Author's Extraction, 2018

There are currently more than 26000 sugar cane growers in South Africa (Department of Agriculture, Forestry and Fishery, 2014). It is most likely that sugar cane grows in almost all classes of soil; it, however, requires fertile, humid and well-drained soils. A most suitable soil type must be about 100 to 150 cm deep with good drainage. With a pH ranging from 6.0 to 7.7, it can grow and thrive well in deep, well-drained soils of medium fertility of sandy loam soil textures. However, the optimum soil pH value is in the average of 6.5, but considerably, sugar cane can tolerate this degree of soil alkalinity and acidity. Sugar cane is produced and processed with the inputs of equipment, labour, land and other related inputs. From the industrial phase, three categories of sugar output are acquired, i.e., sugar (X), ethanol (Y) and baggase (Z). Figure 6.3 illustrates how losses are identified during the three parts of production.

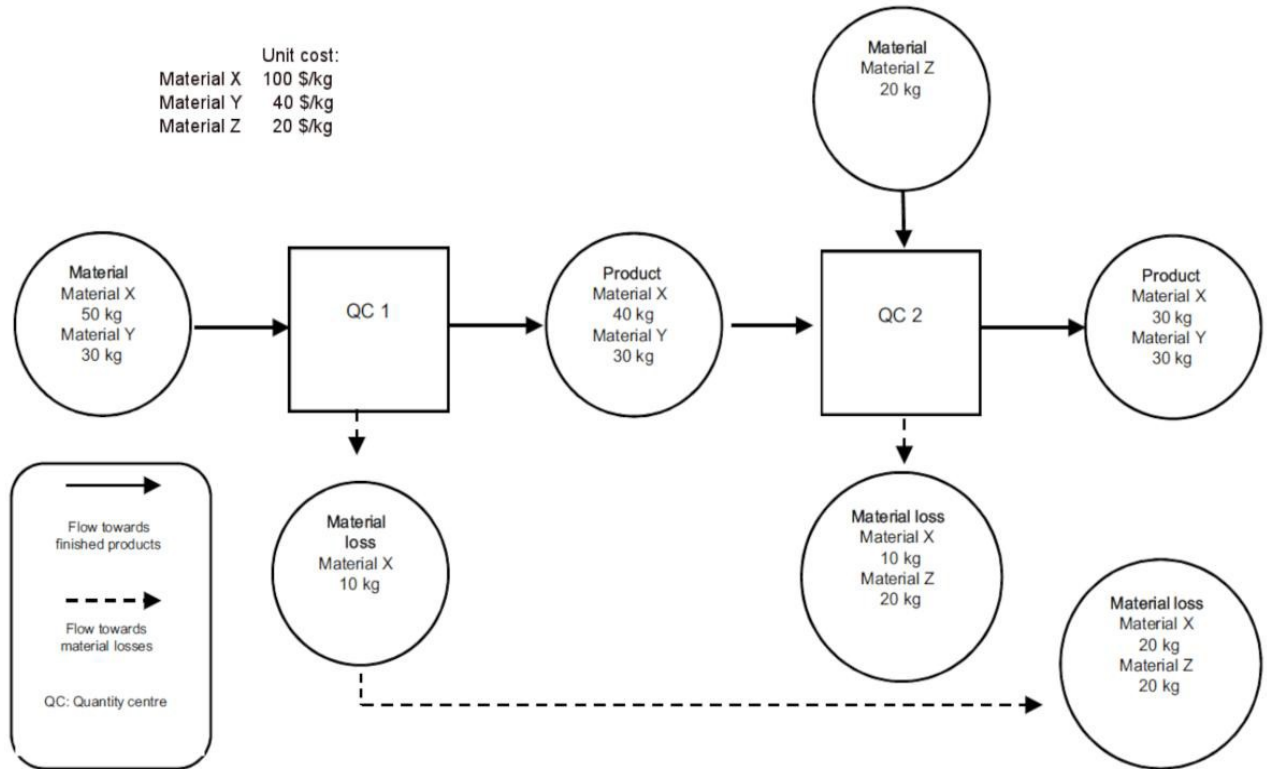


Figure 6.3: Material Flow Model

Source: Adopted from Hyrslova, Vagner and Palasek (2011)

Figure 6.3 models a simple material flow in the materials X, Y, and Z representing sugar, ethanol and baggages, respectively. However, possible cane varieties result in yielding various levels of sucrose in kilograms. The direction of arrows indicates a flow directed towards both the finished product and material losses. The application of the material flow model results in the material losses of 10kg and 20kg from quantity control (QC1 and QC2).

6.7 Decision-making power of MFCA as a tool

MFCA enables the miller and farmer to estimate losses from materials from the harvesting period to the manufacturing period. The losses in the material include per day loss in sucrose (Harris, 2016). The organization experiences economic losses resulting in a material loss in terms of farmers' income and revenue due to the systemic recoverable value indicating that sugar cane quality through sucrose component is a factor that determines the quality as well

as farmers' returns. The content of sucrose quantity in sugar determines the per ton quantity of cane required to be crushed in the sugar manufacturing firm. Hence, the efficiency of production can be improved by sourcing cane that is of high quality in sucrose content. MFCA identifies, both in monetary and physical terms, the importance of sucrose loss in the milling industry. Adopting this methodology to detect losses of material enhances millers'/farmers' diligence and, therefore, motivate them to control the 'time-lag' of cut to crush by ensuring that the sucrose content cane taken to the mill is of high quality. It assists the management to possibly consider the value chain of the determining factors causing losses in sucrose among farmers and millers. It guides to determine the appropriate theoretical framework of MFCA and to adopt a relevant model to either reject or accept the application of the MFCA theoretical framework.

This section focuses on the role of MFCA on information transmission. Figure 14 shows that, for the internal decision-making process to be efficiently managed in the organization, the appropriate skills in managing material and energy efficiency that bring about an observable reduction in residual cost is required as it can be finally seen in the column of material losses of 770€.

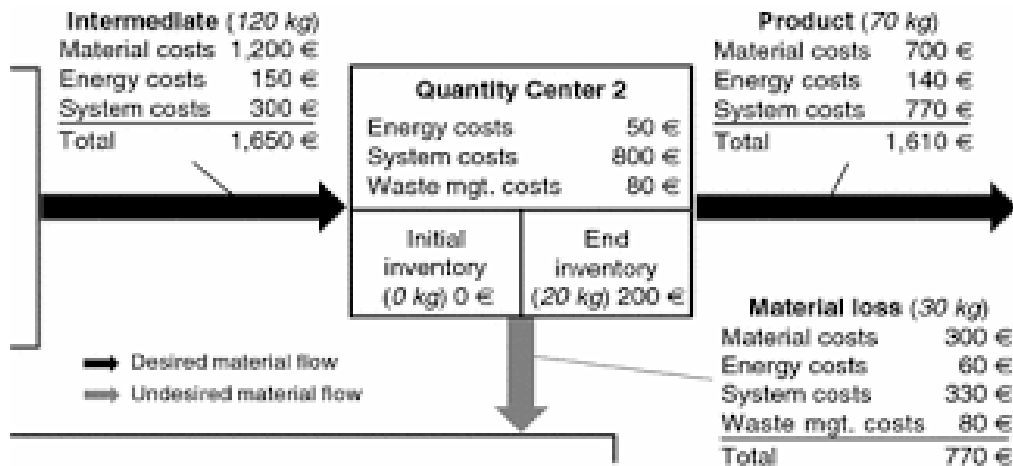


Figure 6.4: The role of MFCA in an organization

Source: Christ and Burritt (2016)

The peculiarity of the MFCA framework is, therefore, expected to apportion costs to various stages of the production process; this process is otherwise called the MFCA framework as, indicated in Figure 6.5 below.

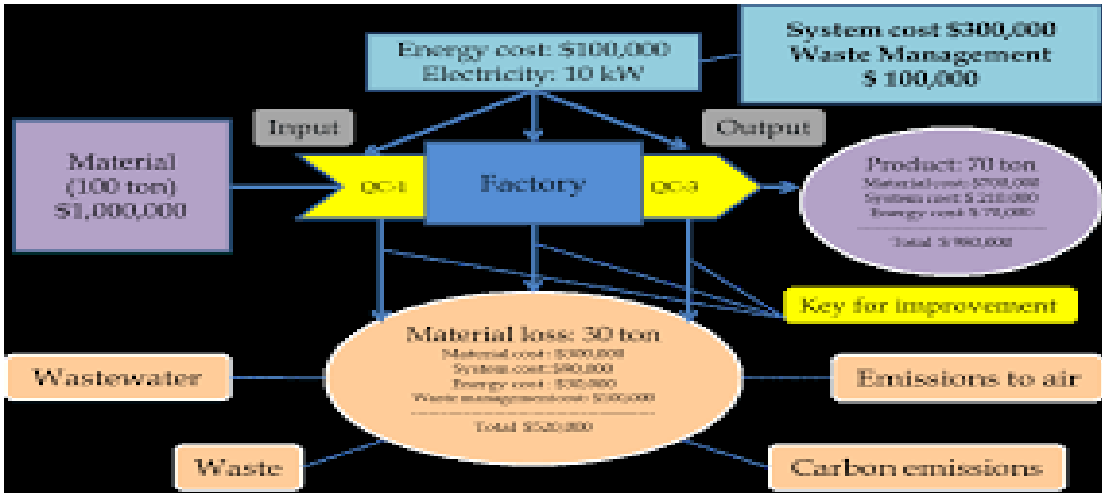


Figure 6.5: Existing MFCA Framework

Source: Author's Extraction (2018)

For simplicity, MFCA groups various costs into material costs, energy costs, system cost and waste treatment costs (METI, 2007). The 30 tons of waste resulting from sugar production is substantive enough to appreciate the impact of MFCA in an organization. This aggregate sugar production cost is recorded in dollar values because this organization (Illovo Sugar Limited) is a US-based company in South Africa. The components of waste products in this model include water-waste, emission-to-air waste and carbon. The implications of this waste to final production are numerous. Apart from the fact that it has a significant impact on the final pricing, environmental/social costs are taken into consideration based on Pareto optimality. This is further specified according to METI (2007) as:

- Cost of material, which includes input and auxiliary materials costs such as solvents, detergents and catalysts;
- Systems costs, such as labour, overhead and other depreciation charges;

- Energy costs, including electricity, utility, fuel and other related energy costs; and
- Treatment costs on waste are the incurred costs in the process of conversion of waste to an acceptable international accounting standard before it is allowed to flow the environment.

Table 6.6: Compilation of MFCA Approach

Material Cost	Environmental Cost Accounting	Cost on wastage	Material Flow Cost Accounting
Cost of Material during production, e.g., Packaging			2,003,400
Cost of material during wastages		18,000	250,060
System Cost			74,300
Material Losses incurred before system cost		6080	18,020
Material Losses incurred after system cost		7500	17,000
Cost incurred on waste	20,320	3,400	12,500

Source: Author's computation, data adopted from SASA (2016)

Table 6.6 differentiates environmental accounting from material cost accounting and shows that MFCA gives attention to more details than the conventional cost accounting. It is clear from Table 17 that conventional accounting considers only the final possible cost on waste incurred in the process of production. However, material flow cost accounting is more detailed in each process of production. Hence, the total cost incurred on waste could be identified and treated accordingly to reflect on prices. It simply indicates that only in material flow cost accounting can true prices on the product can be found.

In Table 6.7, the cost of material losses is identified for the two production periods. In the study's example, the losses are R1015.45 for production period one and 1202.54 for production period two.

Table 6.7: Cost Report from South Milling Industry for the years 2015/2016 and 2016/2017, respectively

	2015/2016					2016/2017				
	Material cost	Energy Cost	System cost	Waste Mgt Cost	Total	Material cost	Energy Cost	System cost	Waste Mgt Cost	Total
Manpower cost in CR	10279	12,751	44,917	679	68,626	10,694	13,657	49,094	734.45	74,179.45
Process cost in CR	553	391	67	10.11	1021.1	682	484	148	131.4	1445.4
Season Maintenance	640	2048	5686	83.74	8457.74	735	1,632	6657	90.24	9114.24
Off-crop Maintenance	430	6754	18468	184.86	25836.86	506	5129	14,890	205.25	20,730.25
Other expenses	106	308	5360	57.74	5831.74	110	281	3729	41.20	41.20
Products	XXX					408,987 Tons				408,987
Material losses				1015.45					1202.54	1202.54

Source: Author's Computation (2017) and data from SASA (2016)

The losses are estimated on a pro-rata basis from the system, material and energy costs of the company. If material losses are apportioned appropriately, these costs would be saved, thereby increasing organizational profitability. However, in real-life practice, only the R1 015.45 and R1 202.54 are perceived as waste disposal costs emanating from the cost of material losses. At any rate, if the company has the full knowledge of the complete costs differently separated from material waste from technical efficiency measures, the order of reduction in the material

losses would improve the company's worth. This analysis is the advantage of MFCA. A further step is to establish the procedure or analysis of possible residual or waste cost.

Procedure and Analysis: Given that x and y are the inputs of material involved in the production process to produce the finished good of sucrose in the sugar cane (SC) processing as proxied by c and d and given that balances in mass resulting from the differences is ϵ , then, from the MFCA perspective, waste created in process X could be mathematically derived such that:

$$(\epsilon) = (x+y) - (c-d) \quad (1)$$

Accordingly, the streams of waste from the South African sugar industry could be expressed (per MFCA) as:

$$E \text{ (in } R) = \epsilon(Q) * [(x(Q) * Rx + y(Q) * Ry + CC) / [x(Q) + y(Q)]] \quad (2)$$

Where:

E denotes streams of waste such as bagasse;

(Q) implies the equivalent physical quantities of sucrose and other useful quantities from sugar cane;

R represents rates per physical unit;

and,

CC (cost of conversion) = $\sum RQ_i * Ri$. This cost includes the four classifications of cost according to the model in Figure 15.

Where RQ_i = quantity of i^{th} resource.

Figure 6.6 depicts an augmented MFCA procedure from the perspective of total material and energy losses. This further breaks down to absorb total labour losses, cost of returns in production and the treatment in waste disposal.

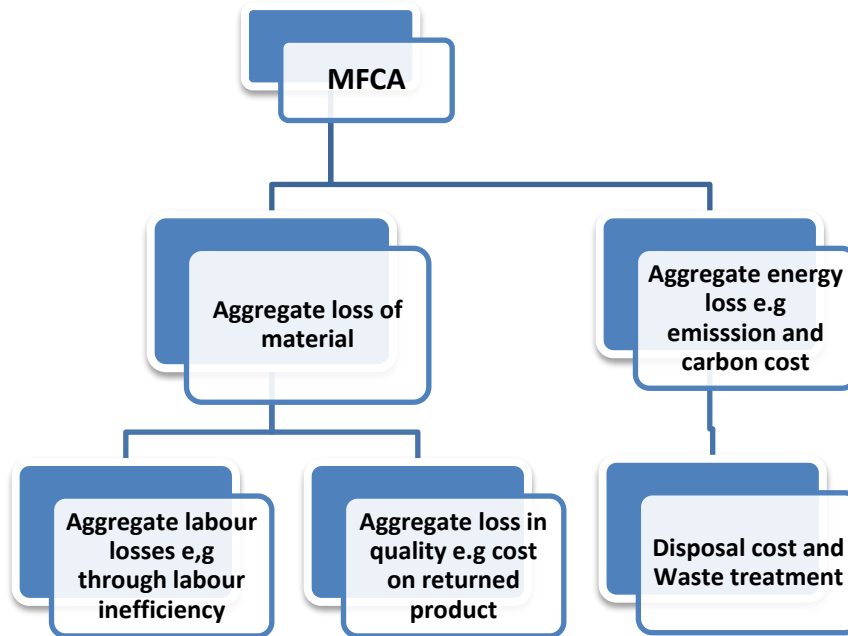


Figure 6.6: Adjusted MFCA framework for improved process waste-reduction decisions

Source: Augmented from Fakoya (2014)

What makes MFCA unique is not the summation process, but the procedure and process involving the scaling up of costs in each of the processes as well as proportionately loading the value on the outputs; hence, the model described in equation (2) could aid the control of incoming inputs of material systematically to finished products, such that waste cost is separated from the overall product. Figure 6.6 above indicates the MFCA adjustment process to establish the current MFCA quantitative analysis for an improved waste-reduction process and decision-making paradigm for a cane milling plant.

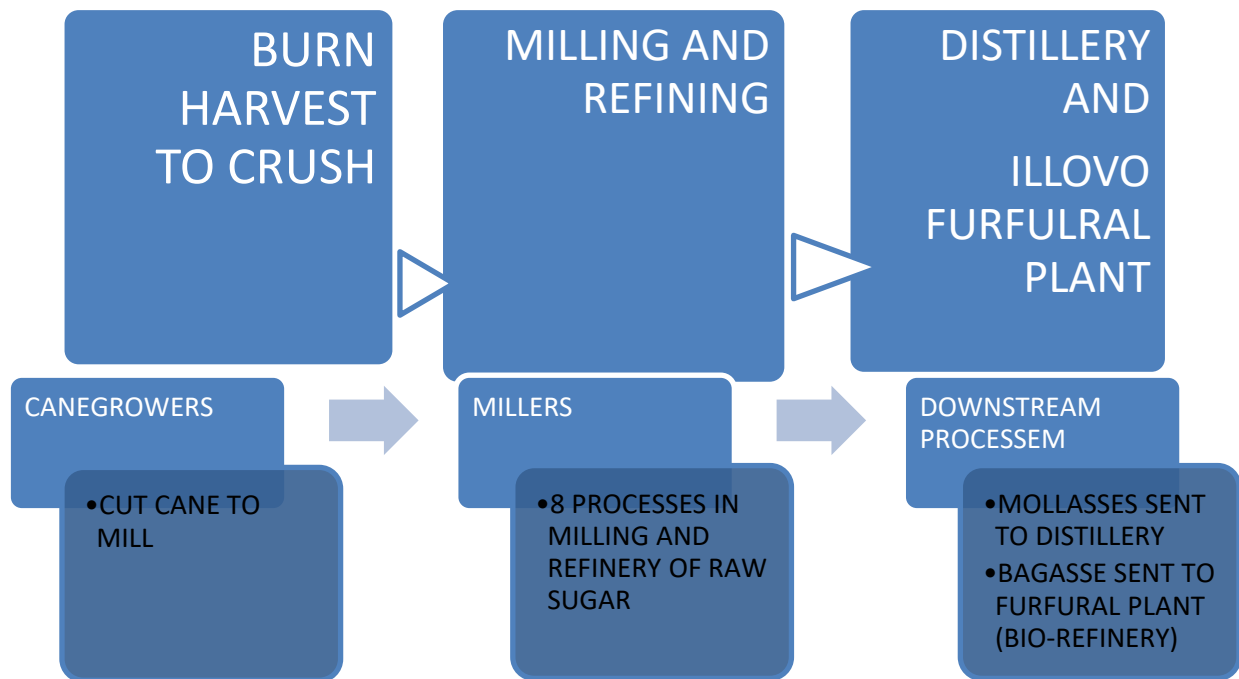


Figure 6.7: Process flow diagram of sugar industry

Source: Augmented from Fakoya (2014)

The model summarises the sugar production process from the farmers to the final milling process at the industry. Waste in the production process needs to be acknowledged and accounted for. Waste from various stages are itemised as follows:

Cane grower stage: The farmer’s wastage cost may include payment for idle time, excess fertilizers used, excess manpower charges, delay in the harvesting periods, etc.

Milling and refining of raw materials: Wastes in the production process include the mediation between labour versus capital intensity, harvest to crush delay, packaging and branding, poor transportation network, etc.

6.8 Material Flow Cost Accounting (MFCA) Model

Figure 6.8 illustrates schematically how EMA can be applied to measure the physical and monetary unit flows of material in the manufacturing process and to identify the accurate cost of waste and emissions, leading to substantial cost reductions.

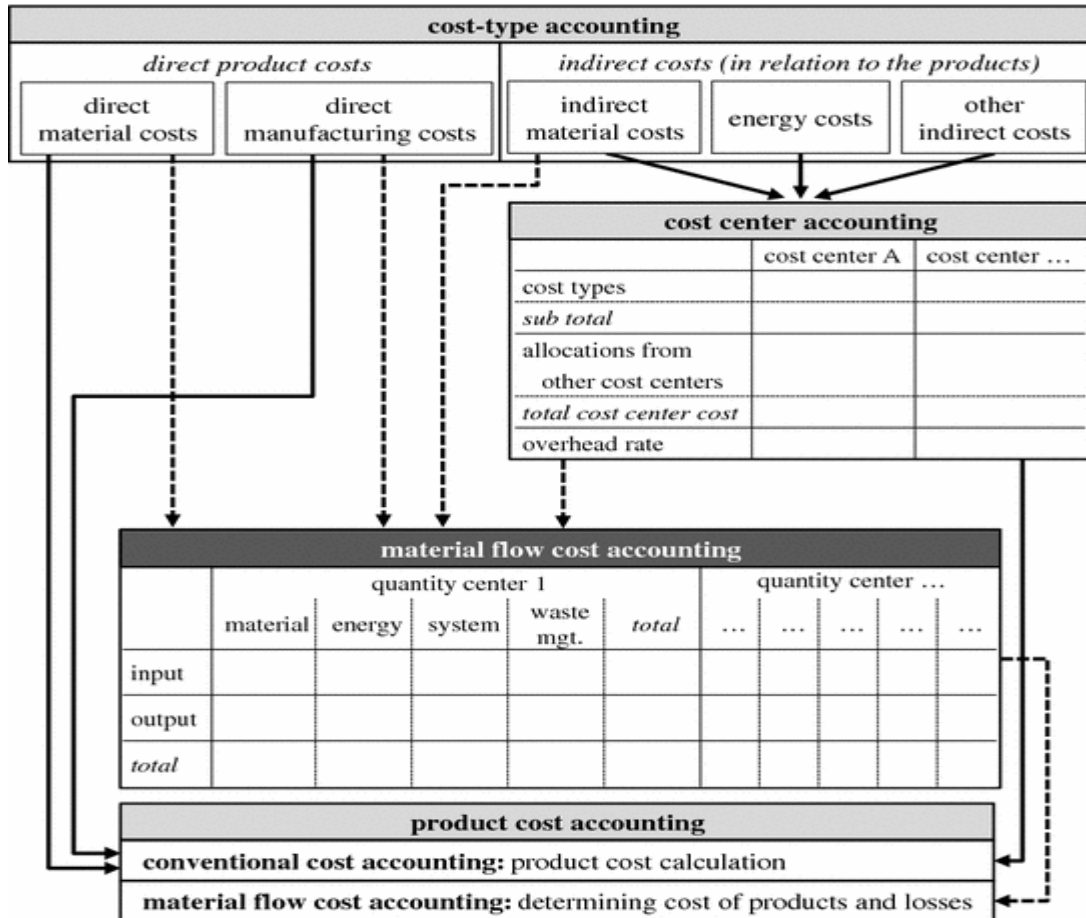


Figure 6.8: Comparative difference between conventional and material flow cost accounting

Source: Author's Extraction (2018).

The study further researched the standard format by which direct cost and indirect cost could be disaggregated from the cost of production, taking into consideration the conventional pattern and the material flow cost accounting pattern. The direct cost is made up of material

cost and manufacturing cost while the indirect cost is made up energy cost, certain aspects of material cost and miscellaneous expenses in the process of production.

Figure 6.9 showcases the comparative improvement that EMA has over the conventional accounting system.

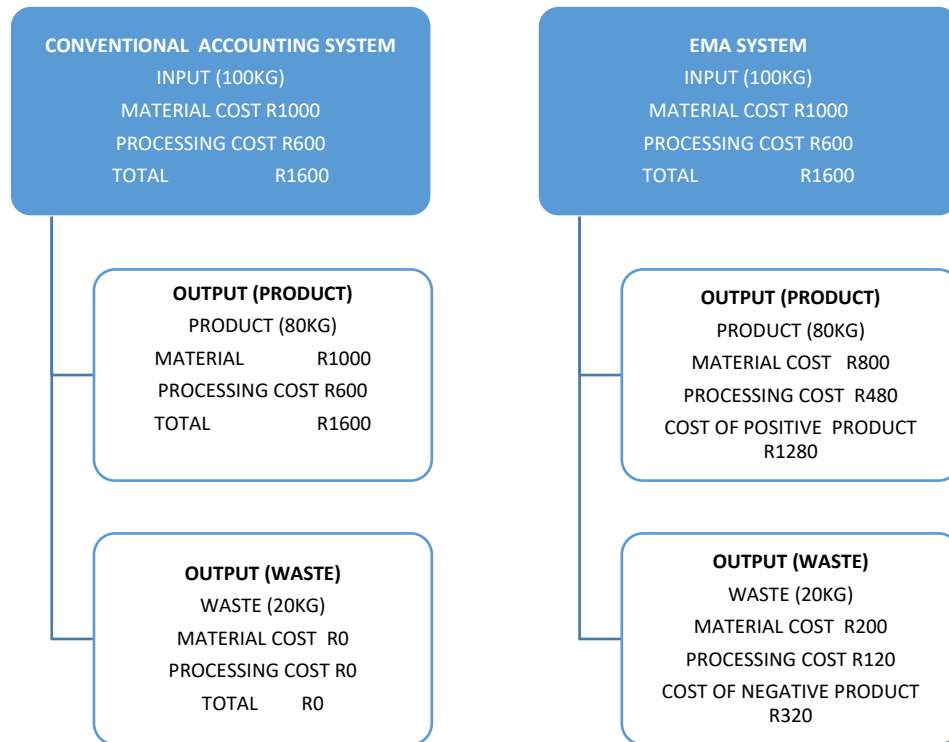


Figure 19: Model of Material Flow Cost Accounting

Source: Doorasamy (2014) (METI, 2007)

Both the conventional accounting system and EMA consider production cost, as indicated at the output level. However, a deviation emerged as conventional accounting failed to account for the 20kg waste and, hence, the R320 acknowledged in EMA leading to the apportioning of cost of the negative product; processing and material cost could not be accounted for in conventional accounting. Consequently, prices of the product under conventional accounting will be unnecessarily higher, whereas, under EMA, prices are apportioned accordingly.

The EMA model was first developed in Germany in 1999. Thereafter, it was modified by the Ministry of Economic, Trade and Industry of Japan 2007. MFCA, a tool of EMA, has been introduced to the sugar milling industry to identify viable options to improve resource and process efficiency (Schmidt and Nakajima, 2013). The MFCA approach, in Figure 19, is used to measure non-product output costs, which are the largest cost category in environmental costs (Jasch, 2009). Pollution costs extend far beyond just waste disposal and treatment costs, where, for instance, non-product output costs must be included as part of pollution costs and environmental costs.

6.9 Conclusion and Recommendation

The effectiveness of MFCA, as a tool for improving sucrose quality in sugarcane production, has been established. The study has been able to identify the major limitations inherent in conventional accounting methods. The study's research question; 'Can MFCA as a tool increase organizational profitability?' has also been verified. However, the study has adopted data from the South African Sugar Association (SASA, 2016) to adequately classify production cost appropriately for the South African sugar cane industry. The study has contributed to extant world-wide literature in some sense; it has been able to adopt and apply data from the South African database to develop MFCA principles which, before now, have not been done in literature. Again, the study has been able to adopt MFCA models to classify the cost of finished products from residual cost. The implications of this study to policy application rest solely on the need for maximization of profitability in industries resulting from adequate waste reduction management skills. The MFCA skill has not been integrated into the curriculum in South African schools; however, it is expedient that special considerations be given to the development of this area of the accounting system.

Chapter 7

SUMMARY, CONCLUSION AND RECOMMENDATIONS

7.1 Summary

This study investigated material flow cost accounting (MFCA) as a decision-making toolkit for improving the resource efficiency of the South African sugar industry. Sugar cane in South Africa is the second largest field crop by gross value, surpassed only by maize. This industry also contributes to the employment of approximately 113 009 (direct, indirect and induced) jobs in South Africa.

However, in recent years, a consistent decline in production, particularly sucrose, has been observed, peaking in the recent past planting season with various factors speculated as being responsible. Some of those factors are weakening yields and a reduction in areas allocated to sugarcane production according to the Bureau for Food and Agricultural Policy (BFAP); rising input costs and a lack of cohesion and economies of scale; a growing culture of minimum reinvestment into farm infrastructure (especially among commercial farmers) due to the threat of land claims, poor soil health, and replanting.

The study contributed to the literature, firstly by assessing the possible factors responsible for sugar cane yields with special interest in sucrose with the aim of offering solutions. It examines the effectiveness of adopting the MFCA approach as a decision-making tool in the supply chain to improve the overall performance of the sugar industry. The evidence of the study showed that organisational profits could be improved with the effective implementation of MFCA. This study, for the first time in the South African context, built MFCA accounting principles using South African data; hence, this the findings of this study were a major addition to literature in this domain. Furthermore, the study demonstrated the potential environmental and economic benefits of cleaner production processes and technologies in the sugar milling industry, given the age-long widespread consensus that the agricultural sector in South Africa plays a fundamental role in addressing employment and economic development both to individuals and to the nation at large.

The relevance of MFCA, as a decision-making toolkit for improving the resource efficiency of the South African sugar industry, has been addressed by previous studies. The findings

from these studies concurred that a policy framework that seeks to promote sucrose improvement from cane sugar would enhance the promotion of the sugar cane product in South Africa.

However, the efficiency required for the framework policy in promoting sucrose improvement depends on the effectiveness of the transmission mechanism that is impacted by the composition, structure, vulnerability and the interplay of the independent variables that determine its quality. Most findings concur that species of cane differ across countries and the level of cane quality are likely to impact on the percentage of sucrose extractions, particularly as the demand for sugar and its use increases over time. The study therefore examined the application of MFCA in the sugar cane industry in South Africa.

A system generalized method of moments (GMM) estimation technique was also used to estimate the impact of sucrose content on profitability. As well, a random effect regression model was employed to examine the relationship between material flow cost accounting and resource efficiency. Besides the aforementioned methods, detailed conceptual issues relating to cleaner production were identified and addressed. Taking the sugar cane industry in South Africa as the study focus, an alternative measure that enhances the quality of sugar, particularly that of sucrose, was investigated. The study further used a structural equation model to examine the relationship between cleaner production and firm performance, measured by environmental; operational and financial performance.

The first major objective of the study was to examine the factors responsible for sucrose quality in sugar cane in South Africa. This objective uses panel data estimation to identify factors that are responsible for sucrose quality in South Africa. Through the implementation of the production function, Bowle's (1970) production framework model was introduced and was found appropriate as this study's model estimating technique. The P-ARDL regression identified average temperature, deep drainage at 60mm, evaporation, stalk growth, harvestable days' soil water contents, rain, run-off and thermal time as the main factors that influence the quality and quantity of sugar sucrose in South Africa both in the short- and long-run. This technique provides a robust indication of what must be done to increase the productivity of sucrose and how MFCA could be deployed for better efficiency.

The second objective was to conduct an empirical investigation of the declining sucrose content in South African sugar cane through the application of principal component analysis. Sucrose has been classified in the analysis of sugar cane juice as one of the most *important* parameters of sugar composition, due to its usefulness among the components in sugar cane which are needed for farmers to generate income within the economy. This study revealed a declining sucrose content, which began in 2014, and is still ongoing, representing a great loss to the farmers. This finding provides a plausible ground for the adoption and implementation of material MFCA besides the argument for the environmental. These findings show that the Cobb-Douglass production theory does not adequately explain the factors that affect the production of sugar cane.

The second major objective was to investigate the extent to which sucrose quality/content influence the profitability of sugar production firms in South Africa. The study revealed that the sucrose content in a sugar cane had a positive effect on both the return on assets and return on equity of the sugar cane production firms. These results confirm that a sugar cane with a high percentage of sucrose will reflect on the sucrose content of the final sugar produced. The higher quality sugar will thus reflect in the higher demand of the sugar and eventually increase the profit level of the firms. The result is plausible in the sense that the milling of sugar with a high percentage of sucrose requires less cost because its effect on equipment is minimal as well as requiring less time for production. The implication of these findings is that the sugar milling firms can improve their performance when they increase the sucrose content in their sugar cane and sugar. Though increasing the sucrose content would result in extra cost, the extra revenue and benefits would more than offset the extra cost. Achieving this would require that the firms understand the various factors that influence the sucrose content and putting in place measures to handle them effectively. This result is consistent with the product-quality assimilation theory, which states that high-quality products attract more customers, less selling and distribution cost, and higher profits.

The third objective examined the influence of cleaner production on the performance of the firms in the sugar cane industry. A descriptive research approach was adopted through the use of primary data. A questionnaire was used to collect the data. The questionnaires were

electronically administered (email and Google docs form). Structural equation model (SEM) technique was adopted to analyse the data. Both exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) methods were used for the study. The results of the structural model show that all the path estimates were significant. The results further show that cleaner production was statistically and positively related to environmental sustainability performance. Also, the evidence showed a positive and significant relationship between cleaner production and operational performance. Similarly, the results indicate that cleaner production had a positive and significant influence on the financial performance of the firms in the sugar industry. Consequently, these results support the confirmation of the hypotheses H1, H2 and H3 that: cleaner production has a significant influence on environmental performance; operational performance and financial performance. It is therefore concluded that there is the presence of a relationship between cleaner production and the three performance measurement metrics: environmental performance; operational performance and financial performance, which emerged as a key finding in this study. Besides, this result suggests that innovation theory explains the adoption of cleaner production by the firms.

The third broad objective of the study was to further conduct a cost-benefit analysis for a cleaner production process in the South African milling industry as well as to develop a framework for optimisation principles that minimise production cost in the South African milling industry. The detailed conceptual issues relating to cleaner production were identified and addressed in this study. Taking sugar cane industry in South Africa as a study focus, an alternative measure that enhances the quality of sugar, particularly that of sucrose, was investigated. The study noted that certain factors, such as transportation and loading delay, contributed to losses in sucrose, which not only affect the farmers' yields but increase deterioration of cane sugar. Hence, minimization modelling, through the appropriation of the objective function, was developed to control for transportation cost, the supply of sugar cane to the mill, and transport needs to carry the sugar cane harvested by machine from the origin to the destination by road transport. The correct application of this model in the South African sugar cane industry would enhance the quality of sucrose production and improve the farmers' welfare and the profitability margin.

The study further examined the impact of MFCA on waste cost and waste quantity. Data were sourced from the records of the sugar milling firms. The annual reports and other records, especially those on production, spanning the period between 1980 and 2017 were used. There were six major sugar-producing firms in South Africa, and all six were used. The data from 1980 to 2017 were used for the study. A Random Effect model was used for the estimation. The evidence showed that material flow cost accounting has a negative and significant impact on both waste cost and quantity of waste generated. The sugar-producing firms that adopted material flow cost accounting could reduce waste in production because it might have provided them a framework to effectively trace in the production process where material inputs, work in progress and defective products would occur such that corrective actions would be taken, thus confirming that contingency theory influences the adoption of MFCA among the firms. This is attainable because material flow cost accounting is a tool employed by firms in decision making to improve business productivity through the reduction of waste.

Finally, the study examined the effectiveness of adopting the MFCA framework approach as a decision-making tool in the supply chain to improve the overall performance of the sugar industry. The study's research question was: Can MFCA as tool increase organizational profitability? To answer this question, the study adopted models from literature to assess the efficiency of MFCA as an important alternative to the conventional accounting process. In this study, production cost was classified into four categories, namely: system cost, energy cost, material flow cost, and residual cost. Assessing the efficiency of this accounting skill, data from South African sugar cane milling industry were adopted to establish the claim that this study has been able to implement the process involved in the use of MFCA, in some sense. The model summarised the sugar production process from the farmers to the final milling process in the industry. Hence, waste in the production process needs to be acknowledged and accounted for. Waste from various stages are itemised as follows: Cane grower stage: The farmers wastage cost may include payment for idle time, excess fertilizers used, excess manpower charges, delay in the harvesting periods, etc., and Milling and refining of 'raw materials: Wastes in the production process include the mediation between labour versus capital intensity, harvest to crush delay, packaging and branding, and poor transportation network. Consequently, it is concluded that the MFCA framework is an effective decision-making tool that can enhance the performance of sugar production firms in South Africa.

7.2 Policy Implications

In identifying the factors that determine the appropriate sucrose content that maximises sugar cane production, the findings from this study significantly contribute to the growing literature in three different perspectives. First, the most recent dynamic econometric approach in determining the sucrose content in sugar cane was introduced using the Cobb-Douglas production model, which, before now, has not been used by any researcher. This model has established that, given quantity control in the explanatory variables, the outcome quantity of sucrose expected in cane sugar could be determined. This concept is of great importance to policymakers in the Department of Agriculture in South Africa. This is the first study integrating variables found in the SASA website to determine the possible improvement in sucrose production of sugar cane. Finally, the evidence is provided to support a negative and positive relationship between sucrose and the explanatory variables, respectively. Particularly, the results indicate a negative relationship between sucrose content and evaporation – reference grass (Fao), evaporation – reference sugar cane (Ecref) and the lag of Ecref, and average temperature (AVTM) and its lag, which are contrary to prior expectation and existing theory. The study's findings support the findings of Buchanan (1976) who found in his simple time series regression analysis an inverse relationship between sucrose, harvestable components and water-related contents. Also, precipitation and temperature negatively and significantly affect sugar cane production in South Africa. The adoption of regression analysis to determine the impact of these explanatory variables on sucrose has not been exploited much in literature. However, results have shown how sucrose could be increased in the production of sugar cane, given the consideration of the available variables under investigation. The component proportions that will lead to increment have been identified. For instance: a 1% increase in the runoff – 100mm causes a 1.5% increase in sucrose content. Similarly, both in the short- and long-runs, a 1% increase in rainfall will increase sucrose by 0.7% in the short-run and 5.1% in the long-run. Similarly, a mechanically harvestable day has the possibility of improving sucrose content. There could be 6.0% and 5.1% increments in sucrose content in the short- and long-runs, respectively, as a result of a 1-day increase in the harvestable day.

The implications of this study's objective two to policy application rest solely on the need for the maximization of profitability in industries resulting from adequate waste reduction management skills. The MFCA skill has not been integrated into the curriculum in the South African higher education institutions; however, it is expedient that special considerations be devoted to the development of this area of the accounting system. The implication of the study's objective three to policy implication is that the correct application of the developed model in the South Africa sugar cane industry would enhance the quality of sucrose production and improve the farmers' welfare and the profitability margin.

7.3 Policy Recommendations

Based on the findings of the conducted study, urgent policy action is imperative to improve the current declining state of sugar cane production and particularly sucrose. Hence, the under-listed recommendations, emanating from this study, are proposed:

- (1) An ideal agricultural policy that would promote mechanically generated sucrose enhances sugar cane without increasing the unemployment rate since the enlargement of sugar cane plantations is urgently required. The persistent declining state of sucrose content, as indicated in Figure 1, is worrisome and calls for a complete investigation of the appropriate species, as identified in Table 1, to cope with the severity of drought and unfavourable weather without compromising productivity;
- (2) The results of the study have shown how sucrose could be increased in the production of sugar cane, given the consideration of the available variables under investigation. The component proportions that will lead to increments have been identified. For instance, a 1% increase in the runoff – 100mm causes a 1.5% increase in sucrose content. Similarly, in both the short- and long-runs, a 1% increase in rainfall will increase sucrose by 0.7% in the short-run and 5.1% in the long-run. Similarly, a mechanically harvestable day has the possibility of improving sucrose content. There could be 6.0% and 5.1% increments in sucrose content in the short- and long-runs, respectively, as a result of a 1-day increase in the harvestable day. Hence, an

alternative to rainfall is required. An extension of farmland to cover riversides to increase access to irrigation at low cost is urgently needed;

- (3) MFCA skill has not been integrated into the curriculum in the South African higher education, more especially as an important module in Management Accounting and Finance. The study has been able to categorize and separate production costs from waste costs. This classification would reduce overcrowding of cost and true profitability ratio on products could be ascertained;
- (4) Taking the sugar cane industry in South Africa as a study focus, this study has essentially implored econometric measures to explain the sucrose declining state in the production of sugar. The implication of this declining and yet essential product generates the possible question as to why the decline? Hence, attention should be drawn to this statistical proportionality as this will help direct the management to prioritize the reduction of delays that lead to the deterioration of sucrose;
- (5) Transportation delay reduces the quality of sucrose in sugar cane, which results in losses and a decline in profits for farmers. Minimization modelling through the appropriation of the objective function was developed to control for transportation cost, supply sugar cane to the mill, and provide transport to carry sugar cane harvested by machine from the origin to destination by road transport. The correct application of this model in the South African sugar cane industry would enhance the quality of sucrose production and improve the farmers' welfare and the profitability margins; and
- (6) The model developed with attached assumptions would enhance the workability of the model. Each of the sugar cane producing industries should engage the programmers as the right application would ensure control for transportation delay, queuing problems and promote just-in-time arrival of sugar and the departure of sugar from the off-loaded trucks.

7.4 Limitation of the Study

All research work has limitations, especially with data availability. While the inclusion of more variables in the analysis of factors that determine the quality of sugar cane could have made this study a more robust one, the non-availability of data is a severe limitation. Extant literature is also very limited in this area, accounting for the paucity of theories and empirical findings on which the study could be modelled.

7.5 Further Study area

This study is particularly keen on data availability to implement the model we proposed in Chapter 5 on the economic and environmental benefits of sugar production. Studies investigating the impact of an increased time lag between ‘Cut-to-Crush’ on non-product output and production efficiency of the sugar mill are encouraged, as they will further provide a clearer picture to the overall contributors of efficiency in the industry.

References

- ACCA Think Ahead. (2015). Environmental Management Accounting. Online. Available: <http://www.accaglobal.com/an/en/student/exam-support-resources> (Accessed 21 October 2015). Environmental Management Accounting in South Africa. Status, challenges and implementation framework. D. Tech. Tshwane University of Technology.
- Aina, O.S., Ajijola, S., Ibrahim, I., Musa I.A. and Bappah, T.M. (2015). Economics analysis of sugarcane (*saccharum officinarum*) production in Moro Local Government Area of Kwara State, Nigeria. *International Research Journal of Plant Science* (ISSN: 2141-5447), 6(1):1-6, DOI: <http://dx.doi.org/10.14303/irjps.2012.079>.
- Akenji, L., & Bengtsson, M. (2014). Making sustainable consumption and production the core of sustainable development goals. *Sustainability*, 6(2), 513-529.
- Alawattage, C., Wickramasinghe, D., & Uddin, S. (2017). Theorising management accounting practices in Less Developed Countries. *The Routledge Companion to Performance Management and Control*, 285-305.
- Albert J. Orgeron, (2012). *Sugarcane Growth, Sucrose Content, and Yield Response to the Ripeners Glyphosate and Trinexapac-Ethyl*.
- Baas, L. (2007). Integrated Environmental and Economic Performance Assessments for Strategic Planning and Policy Analysis in Paper Manufacturing. *Journal of Cleaner Production*, 15:1205-1216.
- Banerjee, A., Dolado, J. and Mestre, R. (1998). Error-correction mechanism tests for cointegration in a single-equation framework. *Journal of time series analysis*, 19(3): 267-283.
- Barbieri, J.C., Vasconcelos, I.F.G., Andreassi, T., Vasconcelos, F.V., 2010. Innovation and sustainability: new models and propositions. *RAE* 50 (2), 146e154.
- Barnes, A., Meyer, E. and Schmidt, E. (2000). Evaluation of methods to reduce harvest-to-crush delays using a simulation model, *Proc S Afr Sug Technol Ass*, 74

- Baxter, P. and Jack, S. (2008). Qualitative Case Study Methodology: Study Design and Implementation for Novice Researchers. *The Qualitative Report*, 13 (4): 544-559. Online. Available: <http://www.nova.edu/ssss/QR/QR13-4/baxter.pdf>.
- Bennett, M., Schaltegger, S. and Zvezdov, D. (2011). Environmental management accounting. *Review of Management Accounting Research*, S: 53-84.
- Bennett, M., Schaltegger, S. and Zvezdov, D. (2013). *Exploring Corporate Practices in Management Accounting for Sustainability* (online), 1-56. Available: <http://www.icaew.com/academic>.
- Bijker, W. and Law, J. (Eds.) (1992). *Shaping Technology / Building Society: Studies in Sociotechnical Change*. Cambridge, MA: MIT Press.
- Boons, F., Baas, L., Bouma, J., De Groene, A. and Le Blansch, K. (2000). *The Changing Nature of Business*. Utrecht: International Books.
- Bowles, S. (1970). *Towards an educational production function Education, income, and human capital* (pp. 11-70): NBER.
- Bras, B., Realff, M. and Carmichael, C. (2004). Integrated Environment and Economic Performance Assessment for Strategic Planning and Policy Analysis in Paper Manufacturing. CPBIS project – B-4: 5-7, *final project report to CPBIS*.
- Brennan, N. (1998). *Accounting research: a practical guide*. Oak Tree Press. Online. Available: <http://hdl.handle.net/10197/2924>
- Briere, J., Runtz, M., Eadie, E., Bigras, N., & Godbout, N. (2017). Disengaged parenting: Structural equation modeling with child abuse, insecure attachment, and adult symptomatology. *Child abuse & neglect*, 67, 260-270.
- Bruijn de, T.J.N.M., Coenen, F.H.J.M. and Lulofs, K.R.D. (1996). Pollution Prevention Projects in the Netherlands. *Journal of Cleaner Production*, 4: 41-53.
- Buchanan, E. J. (1976). The effect of cane quality on factory performance - how important is it? Proceedings of The South African Sugar Technologists' Association.

- Bureau for Food and Agricultural Policy (2015). BFAP Baseline Agricultural Outlook 2015 – 2024.
- Burritt, R. L., Herzig, C. and Tadeo, B. D. (2009). Environmental Management Accounting for Cleaner Production: the case of a Phillipine rice mill. *Journal of Cleaner Production*, 17:431-439.
- Butterfield, M., D’Hont, A. and Berding, N. (2001). The sugarcane genome: a synthesis of current understanding, and lessons for breeding and biotechnology. *Proc. Soc. Afr. Sugarcane Technol. Ass.*, 75: 1-5.
- Byrne, B. M. (2016). *Structural equation modeling with AMOS: Basic concepts, applications, and programming*. Routledge.
- Callon, M. (1987). Society in the Making: The study of technology as a tool for sociological analyses. In: *The Social Construction of Technological Systems* (W.E. Bijker, Th.P. Hughes and T. Pinch, Eds.). Cambridge Mass: MIT-Press 1987, pp. 83-103.
- Chaudha, A., Jain, R., Singh, A., & Mishra, P. (2011). Integration of Kano's Model into quality function deployment (QFD). *International Journal of Advanced Manufacturing Technology*, 53 (5-8), 689-698.
- Cheema, I.A. and Mahmood, T. (2005). Efficacy of different herbicides to control weeds in spring planted sugarcane. *Pak. Sugar J.*, 20(5): 5-8.
- Cheng, C.C.J., Yang, C-l., Sheu, C., 2014. The link between eco-innovation and business performance: a Taiwanese industry context. *J. Clean. Prod.* 64, 81e90.
- Chiu, S. Y. and Leung, R. (2002). Clean and sustainable production. *Quality Management and European standards (EMAS)*:10.
- Chohan, M., Panhwar, R.N., Memon, M.A., Unar, G.S. and Mari, A.H. (2007). Performance of new sugarcane varieties for cane yield and quality under different agro-climatic conditions of Sindh. *Pak. J. Sci. Res.*, 59: 28-33.
- Chohan, M.U.A., Talpur, S., Junejo, G.S., Unar, R.N. and B. P.A. (2014). Selection and evaluation of the diverse sugarcane genotypes in 4th stage. *The J. Anim. Plant Scis.*, 24(1), 197-203.

- Chowdary, B.V. and George, D. (2012). Improvement of manufacturing operations at a pharmaceutical company, a lean manufacturing approach. *J. Manuf. Tech. Manag.*, 23(1), 56-75.
- Christ, L. K. and Burritt, R. L. (2013). Environmental management accounting: the significance of contingent variables for adoption. *Journal of Cleaner Production*, 41:163-173 (online). Available: <http://elsevier.com/locate/jelepro>
- Christ, L. K. and Burritt, R. L. (2016). Environmental management accounting: the significance of contingent variables for adoption. *Journal of Cleaner Production*, 41:163-173 (online). Available: <http://elsevier.com/locate/jelepro>
- Chudik, A., and Pesaran, M. (2013). Large Panel Data Models with Cross-Sectional Dependence: a Survey. *CAFE Research Paper*. (13):15.
- Cockburn, J. J., Coetzee, H. C., Van den Berg, Conlong, D. E and Witthöft, J. (2014). Exploring the role of sugarcane in small-scale farmers' livelihoods in the Noodsberg area, Kwazulu-Natal, South Africa. *South African Journal of Agricultural Extension Online version* ISSN 2413-3221.
- Creswell, J. W., 2013. *Qualitative inquiry and research design: Choosing among five approaches* (3rd ed). Thousand Oaks, CA: Sage
- Dahlia; *et al.* (2009). Consumer Preference for Indigenous Vegetables. World Agroforestry Centre.
- Dangelico, R.M. and Pujari, D. (2010). Mainstreaming green product innovation: why and how companies integrate environmental sustainability. *J. Bus. Ethics*, 95: 471-486.
- Davis, M. J., Gillaspie, A. G., Harris, R. W., & Lawson, R. H. (1980). Ratoon stunting disease of sugarcane: Isolation of the causal bacterium. *Science*, 210(4476), 1365-1367.
- Delano, R. (2013). Valued platform to illustrate impact and profitability of RECP program. *Cleaner Production Conference* (online). Available <http://www.energyforecastonline.co.za/articles/cleaner-production-conference>

- Department of Agriculture, Forestry and Fisheries (2014) *Sugarcane Production Guidelines*.
- Deressa, T., Hassan, R., and Poonyth, D. (2005). Measuring the impact of climate change on South African agriculture: the case of sugarcane growing regions. *Agrekon*, 44(4): 524-542.
- Diaz, J.A. and Perez, H.G. (2000). Simulation and optimization of sugar cane transportation in harvest season. *Winter Simulation Conference*, 2:1114–1117.
- Dieleman, H. (2007). Cleaner Production and Innovation Theory: Social Experiences as a new model to engage in Cleaner Production. *Rev. Int. Contam. Ambient*, 23 (2): 79-94.
- Doorasamy, M. (2014). Using Environmental Management Accounting to identify the benefits of cleaner production in a paper and pulp manufacturing company in KwaZulu-Natal: A case study. Masters' thesis. Durban University of Technology.
- Doorasamy, M. (2015). Theoretical developments in environmental management accounting and the role and importance of material flow cost accounting. *Environmental Economics*, 6(3):
- Dosi, G. (1982). Technological paradigms and technological trajectories: a suggested interpretation of the determinants and directions of technical change. *Research Policy*, 11: 147-162.
- Dritsakis, N. (2011). Demand for Money in Hungary: An ARDL Approach. *Review of Economics and Finance*, 5:1-28.
- Ducasse, G. (2013). Farming for RV. Impact of Harvest-to-Crush Delay on Cane Revenue. The Newsletter of the South African Cane Growers' Association.
- Eggleston, G. (2010). *Sustainability of the sugar and sugar-ethanol industries*. American Chemical Society, Washington DC, USA.
- Fakoya, M. B. (2014a). An adjusted material flow cost accounting framework for process waste-reduction decisions in the South African Brewery Industry, PhD thesis at the University of Pretoria.

- Fakoya, M. B. and Margaretha van der Poll, H. (2013). Integrating ERP and MFCA systems for improved waste-reduction decisions in a brewery in South Africa. *Journal of Cleaner Production*, 40: 136-140.
- Fakoya, M.B. (2014b). Adopting material flow cost accounting model for improved waste-reduction decisions in a micro-brewery. *Environment Development and Sustainability* (online). Available: <https://www.researchgate.net/publication/267238085>.
- Faridi, M. Z. and Murtaza, G. (2014). *Disaggregate Energy Consumption, Agricultural Output and Economic growth in Pakistan: An ARDL Modelling Approach to Co-integration*.
- Ferenhof, H. A., Vignochi, L., Selig, P. M., Lezana, A. G. R. and Campos, L. M. S. (2014). Environmental management systems in small and medium-sized enterprises: an analysis and systematic review. *Journal of Cleaner Production* (online), 74:44-53. Available: <http://www.elsevier.com/locate/jclepro>
- Ferreira, A., Moulang, C. and Hendro, B. (2010). Environmental management accounting and innovation: an exploratory analysis. *Audit and Accounting Journal*, 23:920-948.
- Festinger, L. (1957). *A Theory of Cognitive Dissonance*. Stanford, CA: Stanford University Press. Harper, S. C., & Porter, T. W. (2011). Innovate or Die. *Industrial Engineer*, 43(9), 34-39.
- Fore, S. and Mbohwa, G. T. (2010). Cleaner production for environmental conscious manufacturing in the foundry industry. *Journal of Engineering Design Technology* (online), 8(3):314-333. Available: <http://dutlib.dut.ac.za:2057/docview/1012253156>
- Frondel, M., Horbach, J. and Rennings, K. 2004. *End-of-Pipe or Cleaner Production? An Empirical Comparison of Environmental Innovation Decisions Across OECD Countries*. ZEW Discussion papers, No. 04-82 (online). Available: <http://hdl.handle.net/10419/24090>
- Ftwi, Mekbib and Abraha (2016). Multivariate analysis of sugar yield contributing traits in Sugarcane (*Saccharum officinarum*, L), in Ethiopia. *African Journal of Plant Science*, 10(8):145- 156.

- Giles, D. (2013). ARDL Models-Part II-Bounds Tests. *Econometrics Beat*, 19.
- Granlund, M., & Lukka, K. (2017). Investigating highly established research paradigms: Reviving contextuality in contingency theory based management accounting research. *Critical Perspectives on Accounting*, 45, 63-80.
- Guilleman, E., Gal, P., Meyer and Schmidt, E. (2003). Assessing the Potential for Improving Mill Area Profitability by Modifying Cane Supply and Harvest Scheduling: A South African Study. *Proc S Afr Sug Technol Ass*, (7).
- Gujarati, D. N. (2009). Basic econometrics. Tata McGraw-Hill Education.
- Gunatilake, H. and Abeygunawardena, P. (2011). Energy Security, Food Security and the Economics of Sugar Cane Bioethanol in India. African Development Bank Working Paper Series.
- Hair Jr, J. F., Babin, B. J., & Krey, N. (2017). Covariance-based structural equation modelling in the Journal of Advertising: Review and recommendations. *Journal of Advertising*, 46(1), 163-177.
- Hák, T., Janoušková, S., & Moldan, B. (2016). Sustainable Development Goals: A need for relevant indicators. *Ecological Indicators*, 60, 565-573.
- Han, H., & Hyun, S. S. (2015). Customer retention in the medical tourism industry: Impact of quality, satisfaction, trust, and price reasonableness. *Tourism Management*, 46, 20-29.
- Hansen, A.C., Barnes, A.J. and Lyne, P.W.L. (2002). Simulation modelling of sugarcane harvest-to-mill delivery systems. *Trans. Am. Soc. Agric. Eng*, 45, 531–538.
- Harris, A. (2016). Determining the cost of post-harvest deterioration in a South African Sugarcane supply chain. M.Sc. thesis at the Cranfield University.
- Harvey, M. (nd). World Wildlife Fund-WWF. Sugarcane. Online. Available: <http://www.worldwildlife.org/industries/sugarcane> (Accessed 25 July 2016).
- Hayes, A. F., Montoya, A. K., & Rockwood, N. J. (2017). The analysis of mechanisms and their contingencies: PROCESS versus structural equation modeling. *Australasian Marketing Journal (AMJ)*, 25(1), 76-81.

- Hessa, T.M., Sumbergb, J., Biggsc, T., Georgescud, M., Haro-Monteagudoa, D., Jewitte, G., Ozdoganf, M., Marshallg M., Thenkabilh, P., Daccachei, A., Marinj, F. and Knoxa, J.W. (2016). A sweet deal? Sugarcane, water and agricultural transformation in Sub-Saharan Africa. *Global Environmental Change*, 39(2016): 181–194.
- Hofman, P.S. (2003). Embedding “Radical” Innovations in Society. Background Report to the CondEcol Project based on Experience from the Netherlands. Program for Research and Documentation for a Sustainable Society (ProSus). Centre for Development and the Environment, University of Oslo.
- Hussain, M.F., Anwar, S. and Hussain, Z. (2006). Economics of Sugarcane Production in Pakistan: A Price Risk Analysis. *International Research Journal of Finance and Economics*, ISSN 1450-2887 (4), Euro Journals Publishing, Inc. <http://www.eurojournals.com/finance.htm>
- Hyršlová, J., Vágner, M. and Palásek, J. (2011). Material Flow Cost Accounting (MFCA) – tool for the optimization of corporate production processes. *Business, Management and Education*, 9(1): 5–18. doi:10.3846/bme.2011.01.
- International Standard ISO 14051 First Edition (2011). Reference No. ISO 14051: 2011 (E) (online). Available: <https://www.iso.org>
- Jahanshahi, A. A., Gashti, M. A. H., Mirdamadi, S. A., Nawaser, K., & Khaksar, S. M. S. (2011). Study the effects of customer service and product quality on customer satisfaction and loyalty. *International Journal of Humanities and Social Science*, 1(7), 253-260.
- Japanese Industrial Standards committee. (2007). *International standardization committee for Environmental Management Accounting*. Preliminary proposal for the International Standardization of Material Flow – Based Environmental Management Accounting for ISO TC 207: 1-3, 10-11.
- Jasch, C. (2009). Environmental and Material Flow Cost Accounting Principles and Procedures. *Journal of Industrial Ecology*. Springer science and Business Media: Berlin, 25 (2):832-834.

- Jonall, P. (2008). *Environmental Management Accounting (EMA), Management Accounting including Environmental Management: 2*.
- Jorge, L.M.M., Righetto, AR., Polli, PA., Santos, O.A.A. and MacielFilho, R. 2010. Simulation and analysis of a sugarcane juice evaporation system. *Journal of Food Engineering*, 99, 351-359.
- Kasemset, C., Chernsupornchai, J. and Pala-ud, W. (2015). Application of MFCA in waste reduction: case study on a small textile factory in Thailand. *Journal of Cleaner Production*, 108: 1342-1351. Online. Available: <https://www.elsevier.com/locate/jclepro>
- Katircioglu, S. T. (2009). Revisiting the tourism-led-growth hypothesis for Turkey using the bounds test and Johansen approach for cointegration. *Tourism Management*, 30(1): 17-20.
- Keith, T. Z. (2014). *Multiple regression and beyond: An introduction to multiple regression and structural equation modeling*. Routledge.
- Kline, R. B. (2015). *Principles and practice of structural equation modeling*. Guilford publications.
- Krejcie, R. V. & Morgan, W. M. (1970). Determining Sample Size for Research Activities. *Educational and Psychological Measurement*, 30, 607-610.
- Krivobokova, O. V. (2009). Evaluating Customer Satisfaction as an Aspect of Quality Management. Proceedings of World Academy of Science. *Engineering & Technology*, 53(1), 565-568.
- Kwenda, P.R. 2015. *A Review of the Sugar Milling Process in South Africa and How it Influences the Length of the Milling Season*. MSc Bio-resources Systems. University of KwaZulu-Natal, School of Engineering.
- Lai, W. (1993). *Indentured labor, Caribbean sugar: Chinese and Indian migrants to the British West Indies, 1838–1918*. ISBN 978-0-8018-7746-9

- Lakhani, M. (2007). The need for Clean Production and Product Re-design. *Journal of Cleaner Production*, 15 (13): 1391-1394.
- Lamsal, K., Jones, P. and Thomas, B. (2011). *Sugarcane Harvest Logistic in Brazil*. IOWA Research online. Tippie College of Business Publication.
- Latour B. (1987). *Science in Action. How to Follow Scientists and Engineers through Society*. Cambridge MA: Harvard University Press.
- Lejars, C., Le Gal, P.-Y. and Auzoux, S. (2008). A decision support approach for cane supply Management within a sugar mill area. *Comput. Electron. Agric.*, 60:239–249.
- Li, X. and Hamblin, D. (2016). Factors impacting on cleaner production: case studies of Chinese pharmaceutical manufacturers in Tianjin, China. *Journal of Cleaner Production*, 131: 121-132.
- Lopez, M. E., Miquel, F.S. and Pla-Aragones, L.M. (2006). Sugar cane transportation in Cuba, a case study. *European Journal of Operational Research*, 174(1):374–386.
- López-Milán, Esteban & Plà, Lluís. (2015). *Optimization of the Supply Chain Management of Sugarcane in Cuba*. 224. 107-127. 10.1007/978-1-4939-2483-7_5.
- Lundvall, B.A. (Ed.) (1988). *National systems of innovation; towards a theory of innovation and interactive learning*. London: Pinter Publishers.
- Magwaza, L.S. and Opara U.L. (2015). Analytical methods for determination of sugars and sweetness of horticultural products—A review. *Scientia Horticulturae*, ELSEVIER (184): 179–192.
- Mahadevaiah, M. and Dezfily, A. (2013). Studies on effective flocculants on stale sugarcane juice settling. *International Journal of Recent Scientific Research*, 4 (2): 151-153. Online. Available: <http://www.recentscientific.com>
- Maher, G. W. (2015). Environmental Pressures, Challenges and Strategy for the Sugar Grower in South Africa—*An Overview*. *South African Sugar Association Experiment Station*. Mount Edgecombe, South Africa.

- Maher, G. W., & Schulz, L. (2003). An environmental management system for sugarcane in the Noodsberg area of South Africa. *Proc S Afr Sug Technol Ass*, 77:189-195.
- Maher, G.W. 2003. An Environment Management System for Sugarcane in the Noodsberg Area of South Africa. *Proc.Int.Soc.Sugar Cane Technol*, 7:189–199.
- Maher, G.W. 2007. SuSFarMS Environmental Management System: An Extension Tool for implementing Better Management Practices in Sugarcane. *Proc. Int. Soc. Sugar Cane Technol*, 26:498-503.
- Maher, G.W. 2010. Report on Profit, People and Planet. How does the South African Sugar Industry React? *Proc. Int. Soc. Sugar Cane Technol*, 27:1–6.
- Marchi, V., 2012. Environmental innovation and R&D cooperation: empirical evidence from Spanish manufacturing firms. *Res. Policy* 41, 614e623.
- Martinelli, L.A. and Filoso, S. (2008). Expansion of sugarcane ethanol production in Brazil: environmental and social challenges. *Ecological Applications*, 18: 885-898.
- Mbohwa, C. (2013). Energy management in the South African Sugar Industry. Proceedings of the World Congress on Engineering. Vol I, WCE, London, U.K.
- McDonald, B. C., Dube, E. and Bezuidenhout, C. N. (2008). TranSwarm: A sugarcane transport simulation model based on behavioural logistics. In Proceedings of the South African Sugar Technologists' Association, 81: 434–438.
- Mendes, L. (2012). Clean Technologies and Environmental Management: A Study on a Small Dairy Industry in Brazil. *Resources and Environment* (online), 2(3):100-106. Available: <http://journal.sapub.org/re> .
- METI Ministry of Economy, Trade and Industry (2007). *Guide for Material Flow Cost Accounting*. Japan: Environmental Industries Office: Environmental Policy Division.

- METI Ministry of Economy, Trade and Industry (2010). *Guide for Material Flow Cost Accounting*. Japan: Environmental Industries Office: Environmental Policy Division.
- Meyer and Wood, (2001). The Effects of Soil Fertility and Nutrition on Sugarcane Quality: A Review. South African Sugar Association Experiment Station, South Africa.
- Meyer, E. & Fenwick, L. J. (2003). Manual sugarcane cutter performances in the southern Africa region. In *The South African Sugar Technologists' Association*: 150–157. Durban.
- Meyer, J., Rein, P., Turner, P. and Mathias, K. (2013). *Good management practices for the cane sugar industry*. Germany
- Ministry of Economy, Trade and Industry (2010). *Environmental Management Accounting Workbook*. Tokyo, Ministry of Economy, Trade and Industry Japan.
- Ministry of Economy, Trade and Industry of Japan (METI). (2007). *Environmental Management Accounting (Material Flow Cost Accounting: MFCA)* (online). Available: <http://www.meti.go.jp/policy/eco-business> .
- Ministry of Economy, Trade and Industry of Japan (METI). (2010). *Environmental Management Accounting: MFCA Case Examples*; METI: Tokyo, Japan.
- Mishelle, D. and Garbharran, H.L. (2015). The effectiveness of using material flow cost accounting (MFCA) to identify non-product output costs. *Environmental Economics*, 6(2):
- Mohammadi, S. and Prasanna, B. (2003). Analysis of genetic diversity in crop plants salient statistical tools and considerations. *Crop. Sci.*, 43(4): 1235-1248.
- Moon, H. R. and Perron, B. (2004). Testing for a unit root in panels with dynamic factors. *Journal of econometrics*, 122(1): 81-126.
- Moor, G.M. and Wynne, A.T. 2001. Economic maximisation of grower and miller sugar cane profits: Optimising the length of milling season at South African sugar factories. *Proceedings of the International Society of Sugar Cane Technologists*, 24:245-249.

- Mwakasonda, S., Cowan, B. and Visagie, E (2006). Energy policies for sustainable development in South Africa. Energy Research Centre, University of Cape Town. https://www.iaea.org/OurWork/ST/NE/Pess/assets/South_Africa_Report
- Nakajima, M. (2009). Evolution of Material Flow Cost Accounting (MFCA) Characteristics on Development of MFCA Companies and Significance of Relevance of MFCA. *Kansai University Review of Business and Commerce*, 1-20.
- Narayanamoorthy, (2005). Economics of Drip Irrigation in Sugar Cane Cultivation: Case Study of a Farmer in Tamil Nadu, *Ind. Jn. of Agri. Econ*, 60 (2):.
- National Academy of Sciences. (2016). What you need to know about Energy, Environmental Impact. The National Academies of Sciences Engineering Medicine (online). Available: <http://needtoknow.nas.edu/energy/energy-costs/environmental>
- National Cleaner Production Strategy. Draft 2. (2004). The Government of the Republic of South Africa.
- National Institute of Food and Agriculture. (2016). Investigation of methodologies for the enhancement of manufacturing operations in the production of raw sugar and bio-based products from sugarcane and dedicated energy crops. *CRIS - Project report*. Louisiana State University. Online. Available: <http://portal.nifa.usda.gov/web/crisprojectpages/1005244>.
- Nelson, R.R. and Winter S.G. (1982). *An evolutionary theory of economic change*. Cambridge, Massachusetts: Belknap Press of Harvard University Press.
- Neves, M. F., Trombin, V.G. and Consoli, M.A. (2010). Measurement of Sugar Cane Cain in Brazil, *International Food and Agribusiness Management Review*, 13 (3):.
- Nyberg, J. (2011). Sugar International Market Profile: Background Paper for the Competitive Commercial Agriculture in Sub-Saharan Africa (CCAA) Study. Washington DC: World Bank, 8, 257994-1215457178567.

- Nyberg, J. (2012). *Sugar-based ethanol: International market profile*. Rome: Food and Agriculture Organization.
- Nyberg, J. (nd). *Sugar International Market Profile. Markets and Trade Division. Food and Agriculture Organization of the United Nations*.
- O'Reilly, G. (1998). The South African Sugar Industry. *Int Sug J*, 100: 266-268.
- Ong'ala, J. Mwanga, D. and Nuani, F. (2016). On the Use of Principal Component Analysis in Sugarcane Clone Selection. *Journal of the Indian Society of Agricultural Statistics*, 70(1): 33-39.
- Orbach, T. and Liedtke, C. (1998). Eco-Management Accounting in Germany. Concepts and practical implementation. Final Report of Project, '*Management Accounting and Environmental Management: Towards the Sustainable Enterprise*'.
- Ortolano, L. Cushing, K. K. and Warren, K. A. (1999). Cleaner production in China. *Environ. Impact Ass. Rev.*, 19: 432-436.
- P.Y. Le Gal, J. Le Masson, C. N. Bezuidenhout, and L. F. Lagrange (2009). Coupled modelling of sugarcane supply planning and logistics as a management tool. *Computers and Electronics in Agriculture*, 68: 168–177.
- Padayachee, N. (2010). Environmental challenges facing the sugar manufacturing industry. *Proc S Afr Sug Technol Ass*, 83:365-372.
- Patlolla, S. (2010). Managing Quantity, Quality and Timing in Cane Sugar Production: *Ex Post* Marketing Permits or *Ex Ante* Production Contracts? Selected Paper prepared for presentation at the Agricultural & Applied Economics Association's 2010 AAEA, CAES & WAEA Joint Annual Meeting, Denver, Colorado.
- Pesaran, B. and Pesaran, M. H. (2010). *Time series econometrics using Microfit 5.0: A user's manual*: Oxford University Press, Inc.
- Peter Griffee (2000). "Saccharum Officinarum". Food and Agriculture Organization of the United Nations.

- Plinio, Mario and Nastari. (1983). The role of sugar cane in Brazil's history and economy
- Pons, M., Bikfalvi, A., Llach, J. and Palcic, I. (2013). Exploring the impact of energy efficiency technologies on manufacturing firm performance. *Journal of Cleaner Production* (online), 52:134-144. Available: <http://elsevier.com/locate/jclepro>
- Prichanont, K., Prichanont, S. and Buransri, N. (2005). *Improvement guidelines for sugar cane delivery systems*. In 35th International Conference on Computers and Industrial Engineering, pages 1585–1590.
- Primrose Magama and Khuthadzo Mugodo, (2015). *Biogas production potential for South African sugar cane industry*. The Arc-Institute of Agricultural Engineering and Salome Modiselle, Economic Analysis Unit, Arc-Agricultural
- Promoting sustainable use of industrial materials. (2013). *Pulp and Paper industry material* (online). Available: <http://industrialresourcescouncil.org/material/pulpandpaperindustrymaterials/t>
- Przychodzen, J., Przychodzen, W., 2015. Relationships between eco-innovation and financial performance: evidence from publicly traded companies in Poland and Hungary. *J. Clean. Prod.* 90, 253e263.
- Qian, W. and Burritt, R. (2008). The Development of Environmental Management Accounting: An Institutional View. In: Schaltegger, S., Bennett, M., Burritt, R. and Jasch, C. eds. *Environmental Management Accounting for Cleaner Production*. Netherlands: Springer., 233-248. Available: http://dx.doi.org/10.1007/978-1-4020-8913-8_12.
- Qu, S. Q. and Dumay, J. 2011. The qualitative research interview. *Qualitative Research in Accounting and Management*, 8 (3): 238-264.
- Quah, E. and Haldane, J. B. S. (2007). *Cost-benefit analysis*. Routledge.
- Quinlan, C. (2011). *Business Research Methods*. Hampshire United Kingdom: Thoman Rennie, South Western Cengage learning.

- Rabbi, F. 2011. *Effectiveness of Monetary Policy in Pakistan: Empirical Evidences based on Bound Test Approach*.
- Radonjič, G. and Tominc, P. (2007). The role of environmental management system on introduction of new technologies in the metal and chemical/paper/plastics industries. *Journal of Cleaner Production*, 15 (15): 1482-1493.
- Rafindadi, A. A. and Yosuf, Z. (2013). *An application of panel ardl in analysing the dynamics of financial development and economic growth in 38 sub-saharan african continents*. Paper presented at the Proceeding-Kuala Lumpur International Business, Economics and Law Conference.
- Ramjeawon, T. (2008). Life cycle assessment of electricity generation from bagasse in Mauritius. *Journal of Cleaner Production*, 16: 1727-1734. Online. Available: <http://www.sciencedirect.com>.
- Rasul, G. (2016). Managing the food, water, and energy nexus for achieving the Sustainable Development Goals in South Asia. *Environmental Development*, 18, 14-25.
- Rees, B. (2015). *Evaluation of Systems to Harvest, Process and Transport Sugarcane Biomass*. *Bio-resources Engineering*, School of Engineering, University of KwaZulu-Natal, Pietermaritzburg South Africa.
- Rein, P. 2007. *Cane sugar engineering*. Berlin, Germany: Verlag Dr. Albert Bartens.
- Roberts, S. (2017). *The fundamentals of sucrose accumulation in sugarcane*. Retrieved from <http://www.fertilizer.co.za/public-relations/news/2017/239-the-fundamentals-of-sucrose-accumulation-in-sugarcane>.
- Robillard A., Vawda and Lionnet, G. R. E., (1990). The Measurement of Losses Associated with Cane deterioration. *Proceedings of the South African Sugar Technologists' Association*, Sugar Milling Research Institute, Durban.
- Rogers, E.M. (1995). *Diffusion of innovation*. 4th edition. New York: The Free Press.

- Rosenberg, N. (1982). *Inside the Black Box: Technology and Economics*. Cambridge: Cambridge University Press.
- Rukundo, P., Hussein, S., Mark, L. and Daphrose, G. (2015). Application of principal component analysis to yield and yield related traits to identify sweet potato breeding parents. *Tropical Agric. (Trinidad)*, 92(1).
- Sambuo, D. (2015). Causality Analysis of Sugar Production and Consumption in Tanzania. *Journal for Studies in Management and Planning* Available at e-ISSN: 2395-0463, (01)10 <http://internationaljournalofresearch.org/index.php/JSMaP>
- SASA (2013) Durban, South Africa. Available from: [<http://www.sasa.org.za/HomePage1.aspx>].
- SASA Industry Directory (2012-2013). *The South African Sugar Industry Directory*. www.sasa.org.za
- SASA, (2016). *South African Sugar Industry Directory 2016/2017*. Available at <http://www.sasa.org.za/Files/Sugar%20Industry%20Directory%202016.pdf>
- SASA, (2016). *The South African Sugar Industry and Potential Expansion of its Product Chain*. Available at <http://pmg-assets.s3-website-eu-west-1.amazonaws.com/150513SASA.pdf>
- Saunders, M., Lewis, P. and Thornhill, A. (2007). *Research Methods for Business Students*. 7th ed. England: Pearson Education Limited.
- Schaltegger, S., Bennett, M., Burritt, R. L. and Jasch, C. (2010). *Eco-efficiency in industry and science. Environmental Management Accounting for Cleaner Production*. 5th edition. UK: Springer Science and Business Media.
- Schmidt, M. and Nakajima, M. (2013). Material Flow Cost Accounting as an Approach to Improve Resource Efficiency in Manufacturing Companies, 2(3): 358-369; doi:10.3390/resources2030358.

- Schumacker, R. E. (2017). *Interaction and nonlinear effects in structural equation modeling*. Routledge.
- Severo, E.A., Guimaraes, J.C.F. and Dorion, E.C.H. (2017). Cleaner production and environmental management as sustainable product innovation antecedents: A survey in Brazilian industries. *Journal of Cleaner Production*, 142, 87-97
- Severo, E.A., Guimaraes, J.C.F., Dorion, E.C.H., Nodari, C.H., 2015. Cleaner production, environmental sustainability and organizational performance: an empirical study in the Brazilian metal-mechanic industry. *J. Clean. Prod.* 96, 118e125.
- Shah, A. (2014). Internal marketing's effects on employee satisfaction, productivity, product quality, consumer satisfaction and firm performance. *American Journal of Management*, 14(4), 33.
- Shanmugam, S., Rajendran, K. and Suresh, K. (2012). Traditional uses of medicinal plants among the rural people in Sivagangai district of Tamil Nadu, Southern India. *Asian Pacific. Journal of Tropical Biomedicine*, 2(1): S429-S434.
- Sharpe and Peter (1998). *Sugar Cane: Past and Present*. Southern Illinois University. Retrieved 2012-04-02.
- Shrivastava, A.K., Srivastava, A.K., Solomon, A., Sawnani, A. and Shukla, S.P. (2011). Sugarcane Cultivation and sugar Industry in India: Historical Perspectives. *Sugar Tech*, 13(4):266-247.
- Sikuka, W. (2016). *GAIN Report*. Global Agricultural Information Network. USDA Foreign Agricultural Service.
- Singh, G. (2013). Empirical Study on Economics of Sugarcane Cultivation and processing-based farming in Uttar Pradesh. *Sky Journal of Agricultural Research*, 2(1). 7-19.
- Smith, G. T., Davis, S.B., Madho, S. and Achary, M. (2016). Ninety-First Annual Review of the Milling Season in Southern Africa (2015/16). *Proc S Afr Sug Technol Ass*, 89: 21-51.

- Sodeyfi, S. (2016). Review of literature on the nexus of financial leverage, product quality, & business conditions. *Journal of Economic & Management Perspectives*, 10(2), 146-150.
- South Africa. (2004). *National Cleaner Production Strategy*. Draft 2. Pretoria: Government printer (online). Available: <http://unep.or.jp/ietc/knowledge>.
- South African Cane Growers' Association (CANEGROWERS). (2016). Large-Scale Grower Cost Survey. *Cost of Growing Cane in the 2014/2015 Season*. Cost Book.
- South African National Cleaner Production centre. (2013). *Case study in good organization management and governance practices* (online). Available <http://unido.org/cp>.
- South African Sugar Association (2016). *Monthly Report*. SASA, October. Durban.
- South African Sugar Association Industry Directory 2012/2013
- South African Sugar Association Industry Directory 2016/2017
- South African sugar directory, (2014). *Tongaat Hulett Limited - Integrated Annual Report*. Durban.
- South African sugar directory, (2014). *Understanding the factors that have impacted on cane production in the South African sugar industry*. Pretoria.
- Sparovek, G. and Schnug, E. (2001). Temporal Erosion-Induced Soil Degradation and Yield Loss. *Soil Sci Soc Am J*, 65: 1479-1486.
- Stainbank, G. (2011). *Value Migration in the South African Sugar Industry*. University of Cape Town.
- Stone, L. (Ed.) (2004). *Resource Stewardship and Waste Minimization; towards a sustainable New Zealand University of Canterbury*. Christchurch New Zealand: Centre for Advanced Engineering.

- Stringer, L. (2010). *The Green Workplace- Sustainable strategies that benefit employees, the environment, and the bottom line*. Paperback edition. New York: Palgrave Macmillan.
- Suchánek, P., Richter, J., & Králová, M. (2014). Customer satisfaction, product quality and performance of companies. *Review of economic perspectives*, 14(4), 329-344.
- Sugar Milling Research Institute NPC annual report 2014-2015
- Supsomboon, S. and Yosnuat, J. (2004). A stochastic model for optimal order quantity for sugarcane factory with uncertainties. In *Proceedings of the Fifth Asia Pacific Industrial Engineering and Management Systems Conference*, pp. 21, 2.1–21.2.11.
- Sygulla, R., Bierer, A. and Gotze, U. 2011. Material Flow Cost Accounting – Proposals for Improving the Evaluation of Monetary Effects of Resource Savings Process Designs. *44th Conference on Manufacturing Systems (online)*. Wisconsin, USA. Available: https://tu-chemnitz.de/wirtschaft/bwl3/DownloadAllgemeinOffen/44thCIRP_MFCA.pdf
- Thant, M. M. and Charmondusit, K. (2010). Eco-efficiency assessment of pulp and paper industry in Myanmar. *Clean Technology Environmental Policy*, 12:427-439.
- The National Geographic society. (2015). *Air pollution facts, Air pollution effects, Air pollution solution* (online). Available: <http://environment.nationalgeographic.com/environment/global-warming>
- Thompson, C. G., Kim, R. S., Aloe, A. M., & Becker, B. J. (2017). Extracting the variance inflation factor and other multicollinearity diagnostics from typical regression results. *Basic and Applied Social Psychology*, 39(2), 81-90.
- Tominaga, T.T., Cássaro, F.A.M., Bacchi, O.O.S., Reichardt, K., Oliveira, J.C.M. and Timm, L.C. (2002). Variability of soil water content and bulk density in a sugarcane "eld. *Australian Journal of Soil Research*. 40: 605-614.
- Tongaat, H. (2012). *Bioenergy Potential of Sugarcane*. Province of Kwazulu- Natal: Provincial Planning Commission.

- Trusler, G. and Mzoboshe, S. (2011). *The Introduction of Cleaner Production Technologies in the South African Mining Industry* (No. 1553/1, p. 11). WRC report.
- UNEP (ND). *Introduction to cleaner production: concepts and practice*. Institute of environmental Engineering
<http://www.un.org/esa/sustdev/sdissues/technology/cleanerproduction.pdf>
- Uriarte, M., Yackulic, C. B., Cooper, T., Flynn, D., Cortes, M., Crk, T. and Sircely, J. (2009). Expansion of sugarcane production in São Paulo, Brazil: implications for fire occurrence and respiratory health. *Agriculture, ecosystems & environment*, 132(1-2): 48-56.
- V'an, H. (2012). Environmental benefits and its statement in Environmental Management Accounting. Ph.D. University of Szeged
- Verhoef, P. C., & Lemon, K. C. (2013). Successful customer value management: Key lessons and emerging trends. *European Management Journal*, 31, 1–15.
- Wang, J. (1999). China's national cleaner production strategy. *Environ. Impact Assess. Rev.* 19: 437-456.
- Watanabe K., Nakabaru M., Taira E., Ueno M. and Kawamitsu, Y. (2016). Relationship between nutrients and sucrose concentrations in sugarcane juice and use of juice analysis for nutrient diagnosis in Japan. *Agronomy and crop Ecology*.
<http://dx.doi.org/10.1080/1343943X.2015.1128106s>
- Welman, C., Kruger, F. and Mitchell, B. *Research Methodology*. 3rd edition. Cape Town: Oxford University Press Southern Africa.
- Wiley, E. and Lieberman, B. (2011). *Phylogenetics: Theory and Practice of Phylogenetic Systematics*. John Wiley and Sons, New York. Vol. 10(8), pp. 145-156, August 2016
 DOI: 10.5897/AJPS2016.1419, Article Number: 66A6F5659493 ISSN 1996-0824.
- Wood, R. A. (1973). Varietal differences in the rate of deterioration of whole stalk sugar cane. *Proc S Afr Sug Technol Ass*, 47: 133-137.

- Wood, R.A. (1982). Nutrition and cane quality. *S Afr Sug Agron Ass.*
- Wynne, A.T. and Groom, G. 2003. Technical parameters used to measure and monitor length of milling season in the South African sugar industry. *Proceedings of the South African Sugar Technologists' Association*, Durban, South Africa 77: 63-76.
- Yadav, R. L. and Solomon, S. (2006). Potential of developing sugarcane by-product based industries in India. *Sugar Tech*, 8(2-3): 104-111.
- Yin, R. K. (2009). *Case Study Research Design and Methods*. 4th edition. Los Angeles: Sage Publications, Inc.
- Yin, R. K. (2010). *Qualitative research from start to finish*. New York: Guilford Press.
- Yin, R. K. (2013). *Case study research: Design and methods*. Sage publications.
- Zargaraan, A., Kamaliroosta, L., Yaghoubi, A. S. and Mirmoghtadaie, L. (2016). Effect of Substitution of Sugar by High Fructose Corn Syrup on the Physicochemical Properties of Bakery and Dairy Products: A Review. *Nutrition and Food Sciences Research*, 3(4): 3-11.
- Zeddies J. (2006). *The Competitiveness of the Sugar Industry in Thailand*. University of Hohenheim Stuttgart, Germany
- Zeng, S.X., Meng, X.H., Yin, H.T., Tamb, C.M., Sun, L., 2010. Impact of cleaner production on business performance. *J. Clean. Prod.* 18, 975e983.
- Zhang, C., & Pan, F. (2009). The impacts of customer satisfaction on profitability: a study of state-owned enterprises in China. *Service Science*, 1(1), 22-30.
- Zhou M.M. (2014). Cultivar Genetic Gains for Sugarcane Yield, Sucrose Content and Sugar Yield in the Midlands Region Breeding Programmes. *Proc S Afr Sug Technol Ass.*) 87, 419–431.
- Zikmund, G. W. (2004). *Business Research Methods*. 7th edition. United States of America: Thomson South-Western.

