ANALYSIS OF THE EFFICIENCY LEVELS OF THE MANUFACTURING SECTOR IN ZIMBABWE

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ANALYSIS OF THE EFFICIENCY LEVELS OF THE MANUFACTURING SECTOR IN ZIMBABWE

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Declaration

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This submission is the results of my own independent work/investigation, except where otherwise stated. Other sources are acknowledged giving explicit references.

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Abstract

Identifying the best level of efficiency within firms and determining efficiency drivers and barriers is the main issues in efficiency theory, as the use of efficiency scores is believed to have an important influence when crafting efficiency models in the manufacturing sector of an economy. Using input-output data from developed economies and blend it with financial ratios will salvage decimation in any sectors of the economy. This study analysed the efficiency levels of the manufacturing sector in Zimbabwe. The manufacturing sector is one of the most significant pillars of the economy due to its contribution to the Gross Domestic Product (GDP), export earnings, employment levels and investment opportunities. The two efficiency orientations namely Output-Orientation and Input-Orientation were considered to determine the barriers and the drivers of efficiency in Zimbabwe's manufacturing sector. The underpinnings of the efficiency measurement was guided by Duality theory and approaches to efficiency measurement, namely the production function approach and the cost function approach. Applying both descriptive and non-parametric Data Enveloping Analysis (DEA) statistics, and a hybrid of cross sectional and longitudinal quantitative surveys, primary data from questionnaires, and secondary data from the Zimbabwe Stock Exchange financial statements, were utilized. The sample size used was 21 firms from each of the 10 manufacturing sub-sectors. Using the primary and secondary data, the study, in addition, the study calculated the efficiency scores for each firm in the 10 manufacturing sub-sectors, average efficiency score for each sub-sector and the overall efficiency score for the Zimbabwe's manufacturing sector. This allowed for firm efficiency comparison and sectorial efficiency. The sectors were analysed under the assumptions of constant returns to scale (CRS) and variable returns to scale (VRS) in line with the study objectives. Using Output-Orientation and Input-Orientation there was certainty that inefficiencies in Zimbabwe's manufacturing sector is a result of both input excesses and output shortfalls, the slacks-based measure was be used. This slacks-based measure was able to identify and assign the magnitudes of barriers and drivers of efficiency in each sub-sector and the whole manufacturing sector in Zimbabwe. The input variable which is a major driver of efficiency in the manufacturing sector is costs of material, both under CRS and VRS. The output variable which is a major driver of efficiency in the manufacturing sector is the sales, both under CRS and VRS. The input variable which is a major barrier to efficiency in the manufacturing sector is cost of services, both under CRS and VRS. The output variable which is a major barrier to efficiency in the manufacturing sector is the level of value-addition in manufactured products, both under CRS and VRS. The study found that average efficiency score for Zimbabwe's manufacturing sector is 67.1% under CRS and 80.2% under VRS. It can be deduced that 34.9% of DMU in the whole manufacturing sector are efficient under CRS and assuming VRS, 52.5% are efficient. Combining the DEA results will better inform the government on sectorial and national policies to effect and prepare the best efficient model which will favour Gross Domestic Product (GDP), export earnings, employment levels and investment opportunities. These efficiency results can be used by management and government as an assessment tool to rank firms' efficiency performance based on sector-by-sector, input-by-input and output-by-output. Given that efficiency ratios obtained differs from the financial ratios from financial statements, this study offered hybrid disclosure of efficiency ratio and conventional financial ratio as a solution to decimation of the Zimbabwe's manufacturing sector tracking.

Dedication

I dedicate my dissertation work to my family and many friends, both in the academic and outside the academic fields. A special feeling of gratitude to Harry and Mary, whose words of encouragement and push for tenacity pre-occupied my thoughts. My brothers, Michael and Christopher, have never left my side and are very special. I also dedicate this dissertation to my many friends and researchers who have supported me throughout the process.

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List of acronyms and abbreviations

BCC	Banker, Charnes and Cooper
CEO	Chief Executive Officer
CRS	Constant Return to Scale
CU	Capacity Utilization
CZI	Confederation of Zimbabwe Industries
DC	Developing Countries
DE	Dynamic Efficiency
DEA	Data Enveloping Analysis
DMU	Decision Making Unit
DRS	Decreasing Return to Scale
EC	European Commission
EE	Economic Efficiency
ESAP	Economic Structural adjustment Programme
EU	European Union
FDI	Foreign Direct Investment
FPT	Flexible Production Technologies
FRA	Financial Ratio Analysis
GDP	Gross Domestic Product
GLS	Generalised Least Squares
GMM	Generalized Method of Moments
GNP	Gross National Product
IDP	Industrial Development Policy
ILO	International Labour Organisation

IRS	Increasing Return to Scale
NC	Numerically Controlled
NRZ	National Railways of Zimbabwe
OLS	Ordinary Least Squares
OTE	Overall Technical Efficiency
PBT	Profit Before Tax
PCA	Principal Component Analysis
RBZ	Reserve Bank of Zimbabwe
ROA	Return on Assets
RPED	Regional Program on Enterprise Development
SEK	Swedish Kronar
SFA	Stochastic Frontier Analysis
SME	Small to Medium Enterprise
SSA	Sub-Saharan African
STERP	Short Term Emergency Recovery Programme
TE	Technical Efficiency
TFP	Total Factor Productivity
UNDP	United Nations Development Programme
US	United States
VAT	Value Added Tax
VRS	Variable Return to Scale
XE	X-efficiency
ZEPARU	Zimbabwe Economic Policy Analysis and Research Unit
ZIA	Zimbabwe Investment Authority

ZIMSTAT	Zimbabwe National Statistics Agency
ZISCO	Zimbabwe Steel Company
ZNCC	Zimbabwe National Chamber of Commerce
CCR	Charnes, Cooper and Rhodes
NEC	Non-parametric Envelopment Curve
ZIMRA	Zimbabwe Revenue Authority
ZSE	Zimbabwe Stock Exchange

List of Tables

Table 1.1: Common Constraints **2**

Table 2.1:Total World Production of Crude Steel **36**

Table 2.2: African Steel Production in thousand metric tonnes **36**

Table 2.3: Mineral Output for 2013 expected to surpass 2012 production **38**

Table 2.4: Zimbabwe's Metals and minerals prices forecast **39**

Table 2.5: Sales of Chemicals and petroleum products **40**

Table 2.6: Projected Index of the chemicals and petroleum output **42**

Table 2.7: Productivity of the US Transport and Transport equipment sector **46**

Table 2.8: Share of Paper Printing and Publishing sector in US manufacturing **49**

Table 2.9: Percentage contributions to turnover, value addition and employment in the EU **51**

Table 2.10: Main constraints facing textile businesses in Zimbabwe **55**

Table 2.11: Number of footwear establishments in Ethiopia **61**

Table 2.12: Number of footwear workers in Ethiopia **62**

Table 2.13: Barriers of capacity utilisation in the Ethiopian footwear industry **63**

Table 3.1: Drivers of efficiency **98**

Table 4.1: Research population and sample **146**

Table 6.1: CRS Beverages and Tobacco Efficiency scores..160

Table 6.2: CRS Beverages and Tobacco Efficiency Score Analysis 162

Table 6.3: CRS Beverages and Tobacco Benchmarking Analysis 163

Table 6.4: VRS Beverages and Tobacco Efficiency scores...164

Table 6.5: VRS Beverages and Tobacco Efficiency Score Analysis 166

Table 6.6: VRS Beverages and Tobacco Benchmarking Analysis 167

Table 6.7: CRS Chemical and Petroleum Products Efficiency scores 169

Table 6.8: CRS Chemical and Petroleum Products Efficiency Score Analysis.............170

Table 6.9: CRS Chemical and Petroleum Products Benchmarking Analysis...............171

Table 6.10: VRS Chemical and Petroleum Products Efficiency scores 173

Table 6.11: VRS Chemical and Petroleum Products Efficiency Score Analysis...........174

Table 6.12: VRS Chemical and Petroleum Products Benchmarking Analysis.............175

Table 6.13: Clothing and Footwear Efficiency scores of the CRS CCR Input-Oriented 177

Table 6.14: CRS Clothing and Footwear Efficiency Analysis 179

Table 6.15: CRS Clothing and Footwear Benchmarking Analysis 180

Table 6.16: VRS Clothing and Footwear Efficiency Scores..181

Table 6.17: VRS Clothing and Footwear Efficiency Score Analysis...............................182

Table 6.18: Clothing and Footwear Benchmarking Analysis 183

Table 6.19: CCR Foodstuffs Efficiency scores 185

Table 6.20: CRS Foodstuffs Efficiency Analysis 186

Table 6.21: CRS Foodstuffs Benchmarking Analysis.. 187

Table 6.22: VRS Foodstuffs Efficiency Scores 189

Table 6.23: VRS Foodstuffs Efficiency Score Analysis 190

Table 6.24: VRS Foodstuffs Benchmarking Analysis.. 191

Table 6.25: CRS Metals Efficiency scores 193

Table 6.26: CRS Metals Efficiency Score Analysis.. 194

Table 6.27: CRS Metals Benchmarking Analysis 195

Table 6.28: VRS Metals Efficiency scores 197

Table 6.29: VRS Metals Efficiency Score Analysis.. 198

Table 6.30: VRS Metals Benchmarking Analysis 199

Table 6.31: CCR Non-Metallic Minerals Efficiency scores 201

Table 6.32: CRS Non-Metallic Minerals Efficiency score Analysis 203

Table 6.33: CRS Non-Metallic Minerals Benchmarking Analysis................................. 204

Table 6.34: VRS Non-Metallic Minerals Efficiency scores 205

Table 6.35: VRS Non-Metallic Minerals Efficiency Scores Analysis 207

Table 6.36: VRS Non-Metallic Minerals Benchmarking Analysis..................................208

Table 6.37: CRS Paper Printing and Publishing Efficiency scores................................209

Table 6.38: Paper Printing and Publishing Efficiency Analysis.....................................211

Table 6.39: CRS Paper Printing and Publishing Benchmarking Analysis 212

Table 6.40: VRS Paper Printing and Publishing Efficiency scores................................213

Table 6.41: VRS Paper Printing and Publishing Efficiency 215

Table 6.42: VRS Paper Printing and Publishing Benchmarking Analysis 216

Table 6.43: CRS Textiles Efficiency scores...218

Table 6.44: CRS Textiles Efficiency Analysis...219

Table 6.45: CRS Textiles Benchmarking Analysis 220

Table 6.46: VRS Textiles Efficiency scores...222

Table 6.47: VRS Textiles Efficiency Analysis...223

Table 6.48: VRS Textiles Benchmarking Analysis 224

Table 6.49: CRS Transport and Transport Equipment Efficiency scores 226

Table 6.50: CRS Transport and Transport Equipment Efficiency Analysis 227

Table 6.51: CRS Transport and Transport Equipment Benchmarking Analysis.........228

Table 6.52: VRS Transport and Transport Equipment Efficiency scores 230

Table 6.53: VRS Transport and Transport Equipment Efficiency Analysis 231

Table 6.54: VRS Transport and Transport Equipment Benchmarking Analysis......232

Table 6.55: CRS Wood and Furniture Efficiency scores 234

Table 6.56: CRS Wood and Furniture Efficiency Analysis 236

Table 6.57: CRS Wood and Furniture Benchmarking Analysis 237

Table 6.58: VRS Wood and Furniture Efficiency scores 238

Table 6.59: VRS Wood and Furniture Efficiency Analysis 240

Table 6.60: VRS Wood and Furniture Benchmarking Analysis 241

Table 8.1: Comparative Analysis of Efficiency scores..303

Table 8.2: Comparative Analysis of the Major Efficiency drivers...............................304

Table 8.3: Comparative Analysis of Major Efficiency barriers 306

Table 9.1: Country comparison 329

Table 9.2: AFDIS Financial Performance 330

Table 9.3: Battery Manufacturing and Distribution 332

Table 9.4: ART Paper...333

Table of Contents

Contents

Declaration ...... **iii**

Abstract ...... **iv**

Dedication ...... **vi**

Acknowledgements ...... **vii**

List of acronyms and abbreviations ...... **ix**

List of Tables ...... **xii**

Table of Contents ...... **xvii**

CHAPTER ONE **1**

INTRODUCTION AND BACKGROUND TO STUDY **1**

1.1 Introduction 1

1.2 Background to the study 4

1.3 Research problem 7

1.4 Aims and objectives of the study 10

1.4.1 Aims of the study 10

1.4.2 Objectives of the study 11

1.5 Research questions 11

1.6 Significance of the study 12

1.7 Research methodology 15

1.7.1 Research design 15
1.7.2 Target population..17
1.7.3 Sampling method..17
1.7.4 Measuring instruments 19
1.7.5 Data collection..21
1.7.6 Data analysis..21
1.7.7 Anonymity and confidentiality..22
1.7.8 Validity and reliability..22
1.7.9 Ethical consideration 23
1.8 Assumptions..23
1.9 Delimitations of the study 24
1.10 Limitations 24
1.11 Definition of terms 25
1.11.1 Efficiency..25
1.11.2 Efficiency score 26
1.11.3 Technical efficiency (TE)..26
1.11.4 Manufacturing sector..26
1.11.5 Data enveloping analysis..27
1.11.6 Decision-making unit 27
1.11.7 Capacity utilisation..28
1.12 Organisation of chapters..28
1.12.1 Chapter One: Introduction to the research problem 29
1.12.2 Chapter Two: Manufacturing sector in Zimbabwe..29
1.12.3 Chapter Three: Theories and models of efficiency 29
1.12.4 Chapter Four: Research methodology 29
1.12.5 Chapter Five: Data presentation procedures..30
1.12.6 Chapter Six: Measuring efficiency in Zimbabwe's manufacturing sector 30

1.12.7 Chapter Seven: Drivers and barriers of efficiency in Zimbabwe's manufacturing sector....30
1.12.8 Chapter Eight: Recommended efficiency models in Zimbabwe's manufacturing sector....30
1.12.9 Chapter Nine: Interpretation and discussion of results....31
1.12.10 Chapter Ten: Conclusions and recommendations....31
1.13 Conclusion....31
THE MANUFACTURING SECTOR IN ZIMBABWE....32
2.1 Introduction....32
2.2 Overview of the Zimbabwean manufacturing sector....32
2.3 Review on the evolution of the Zimbabwean manufacturing sector....33
2.3.1 Metals sector....35
2.3.2 Chemicals and petroleum products sector....40
2.3.3 Non-Metallic minerals sector....43
2.3.4 Transport and transport equipment sector....46
2.3.5 Paper Printing and publishing sector....48
2.3.6 Foodstuff sector....50
2.3.7 Textile sector....54
2.3.8 Beverages and Tobacco sector....58
2.3.9 Clothing and Footwear sector....60
2.3.10 Wood and Furniture sector....65
2.4 Conclusion....67
CHAPTER THREE....69
THEORIES AND MODELS OF EFFICIENCY....69
3.1 Introduction....69

3.2 Conceptualising theory on efficiency....70
3.2.1 Types of efficiency....71
3.2.2 Duality theory....78
3.2.3 Input-output efficiency measurement....83
3.3 Slacks-based measure....86
3.4 Methodologies of efficiency measurement....86
3.4.1 Simple regression....87
3.4.2 Stochastic Frontier (SF) Analysis....90
3.4.3 Index Numbers/ Ratio analysis....91
3.4.4 Data Enveloping Analysis (DEA)....92
3.5 Empirical studies....97
3.6 Drivers of efficiency in the manufacturing sector....97
3.7 Barriers to achieving efficiency in the manufacturing sector....101
3.8 Limitations of the financial ratio measure of efficiency....104
3.9 Efficiency in the manufacturing sector....107
3.9.1 Non-African experiences on efficiency in the manufacturing sector....109
3.9.2 African experiences on efficiency in the manufacturing sector....114
3.10 Recommended efficiency models....124
3.11 Summary....125
CHAPTER FOUR....127
METHODOLOGY....127
4.1 Introduction....127
4.2 Research design....127
4.3 DEA models....128
4.3.1 The Charnes, Cooper and Rhodes (CCR) Models....129

4.3.2 The Banker, Charnes and Cooper Model (BCC), (1984) 131

4.4 Pre-conditions For The Application of DEA 133

4.4.1 Positivity Axiom...134

4.4.2 Isotonicity Axiom...134

4.4.3 Homogeneity of DMUs Axiom 134

4.4.4 Number of DMUs Axiom..135

4.5 Mathematical Formulation of the DEA...135

4.5.1 The Input-Oriented Constant Returns to Scale Formulation 136

4.5.2 The Input-Oriented Variable Returns-to-Scale (VRS) Formulation 139

4.5.3 Economies of Scales in DEA...140

4.6 Justification of variables in the estimated empirical model 140

4.6.1 Input Variables 141

4.6.2 Output Variables...143

4.7 Target population 144

4.8 Sample size..145

4.9 Data Sources..147

4.10 Data collection tools and procedures 148

4.11 Data analysis 150

4.12 Delimitation..150

4.13 Research limitations..151

4.14 Validity and Reliability...151

4.15 Anonymity and confidentiality...152

4.16 Ethical considerations 152

4.17 Conclusion..153

CHAPTER FIVE 154

DATA PRESENTATION PROCEDURES 154

5.1 Introduction 154

5.2 Areas of Efficiency...155

5.2.1 Orientation 155

5.2.3 Data Enveloping Analysis (DEA) Stages 157

5.3 Results presentation procedures' summary...158

5.4 Conclusion...159

CHAPTER SIX 160

MEASURING EFFICIENCY IN ZIMBABWE'S MANUFACTURING SECTOR.....160

6.1 Introduction 160

6.2 Beverages and Tobacco manufacturing efficiency scores 160

6.2.1 CRS Beverages and Tobacco 160

6.2.2 VRS Beverages and Tobacco 164

6.3 Chemical and Petroleum Products manufacturing efficiency scores 168

6.3.1 CRS Chemical and Petroleum Products 168

6.3.2 VRS Chemical and Petroleum Products...173

6.4 Clothing and Footwear manufacturing efficiency scores...177

6.4.1 CRS Clothing and Footwear...177

6.4.2 VRS Clothing and Footwear...181

6.5 Foodstuffs manufacturing efficiency scores 185

6.5.1 CRS Foodstuffs...185

6.5.2 VRS Foodstuffs 189

6.6 Metals manufacturing efficiency scores...193

6.6.1 CRS Metals...193

5.8.2 VRS Metals...197

6.7 Non-Metallic Minerals manufacturing efficiency scores..201

6.7.1 CRS Non-Metallic Minerals..201
5.9.2 VRS Non-Metallic Minerals..205
6.8 Paper Printing and Publishing manufacturing efficiency scores.................................209
6.8.1 CRS Paper Printing and Publishing...209
6.8.2 VRS Paper Printing and Publishing...213
6.9 Textiles manufacturing efficiency scores...217
6.9.1 CRS Textiles...217
6.9.2 VRS Textiles...222
6.10 Transport and Transport Equipment manufacturing efficiency scores......................226
6.10.1 CRS Transport and Transport Equipment 226
6.10.2 VRS Transport and Transport Equipment..230
6.11 Wood and Furniture manufacturing efficiency scores..234
6.11.1 CRS Wood and Furniture 234
6.11.2 VRS Wood and Furniture..238
5.15 Conclusion..242

CHAPTER SEVEN...243

DRIVERS AND BARRIERS OF EFFICIENCY IN ZIMBABWE'S MANUFACTURING SECTOR 243

7.1 Introduction 243
7.2 Slacks analysis in the Beverages and Tobacco 243
7.2.1 CRS Beverages and Tobacco Slack Analysis...244
7.2.2 VRS Beverages and Tobacco Slack Analysis 246
7.3 Slacks analysis in the Chemicals and Petroleum 249
7.3.1 CRS Chemicals and Petroleum Products Slack Analysis.....................................250
7.3.2 VRS Chemicals and Petroleum Products Slack Analysis 252

7.4 Slacks analysis in the Clothing and Footwear....255
7.4.1 CRS Clothing and Footwear Slack Analysis....255
7.4.2 VRS Clothing and Footwear Slack Analysis....258
7.5 Slacks analysis in the Foodstuffs....261
7.5.1 CRS Foodstuffs Slack Analysis....261
7.5.2 VRS Foodstuffs Slack Analysis....264
7.6 Slacks analysis in the Metals....267
7.6.1 CRS Metals Slack Analysis....267
7.6.2 VRS Metals Slack Analysis....270
7.7 Slacks analysis in the Non-Metallic Minerals....272
7.7.1 CRS Non-Metallic Minerals Slack Analysis....273
7.7.2 VRS Non-Metallic Minerals Slack Analysis....276
7.8 Slacks analysis in the Paper Printing and Publishing....278
7.8.1 CRS Paper Printing and Publishing Slack Analysis....279
7.8.2 VRS Paper Printing and Publishing Slack Analysis....281
7.9 Slacks analysis in the Textiles....284
7.9.1 CRS Textiles Slack Analysis....285
7.9.2 VRS Textiles Slack Analysis....287
7.10 Slacks in the Transport and Transport Equipment....290
7.10.1 CRS Transport and Transport Equipment Slack Analysis....290
7.10.2 VRS Transport and Transport Equipment Slack Analysis....293
7.11 Slacks analysis in the Wood and Furniture....296
7.11.1 CRS Wood and Furniture Slack Analysis....296
7.11.2 VRS Wood and Furniture Slack Analysis....299
7.12 Conclusion....302
CHAPTER EIGHT....303

RECOMMENDED EFFICIENCY MODELS IN THE ZIMBABWE'S MANUFACTURING SECTOR 303

8.1 Introduction 303

8.2 Recommended efficiency model using efficiency scores 303

8.3 Recommended efficiency model using major efficiency drivers 304

8.4 Recommended efficiency model using major efficiency drivers 305

8.5 Conclusion 306

CHAPTER NINE 307

INTERPRETATION AND DISCUSSION OF RESULTS 307

9.1 Introduction 307

SECTION A: QUANTITATIVE ANALYSIS 308

9.2 Beverages and Tobacco Quantitative Analysis 308

9.3 Chemical and Petroleum Products Quantitative Analysis 311

9.4 Clothing and Footwear Quantitative Analysis 313

9.5 Foodstuffs Quantitative Analysis 315

9.6 Metals Quantitative Analysis 317

9.7 Non-Metallic Minerals Quantitative Analysis 319

9.8 Paper Printing and Publishing Quantitative Analysis 321

9.9 Textiles Quantitative Analysis 323

9.10 Transport and Transport Equipment Quantitative Analysis 325

9.11 Wood and Furniture Quantitative Analysis 326

9.12 Comparative discussion of the ten manufacturing sub-sectors in Zimbabwe 328

9.13 Documental Analysis 330

SECTION B: Qualitative analysis..334

9.14 ZIMSTAT qualitative analysis..335

9.15 ZNCC qualitative analysis 337

9.16 ZIA qualitative analysis 338

9.17 CZI/ Buy Zimbabwe/Ministry of Industry and Trade qualitative analysis 338

9.18 Conclusion...339

CHAPTER TEN...340

CONCLUSIONS AND RECOMMENDATIONS...340

10.1 Introduction 340

10.2 Summary of the study 340

10.3 Key findings, conclusions and implications...342

10.3.1 Beverages and Tobacco manufacturing sub-sector under CRS and VRS 343

10.3.2 Chemical and Petroleum Products sub-sector under CRS and VRS 344

10.3.3 Clothing and Footwear sub-sector under CRS and VRS....................................346

10.3.4 Foodstuffs sub-sector under CRS and VRS 347

10.3.5 Metals sub-sector under CRS and VRS...348

10.3.6 Non-Metallic Minerals sub-sector under CRS and VRS....................................349

10.3.7 Paper Printing and Publishing sub-sector under CRS and VRS.........................351

10.3.8 Textiles sub-sector under CRS and VRS...352

10.3.9 Transport and Transport Equipment sub-sector under CRS and VRS 353

10.3.10 Wood and Furniture sub-sector under CRS and VRS 354

10.3.11 Overall Manufacturing sector under CRS and VRS...356

10.4 Recommendations of the study 357

10.4.1 To government and policy makers 357

10.4.2 To the Management of manufacturing firms..358

10.5 Areas of further research 358

10.6 Conclusion 359

References 360

APPENDIX A: LETTER OF INFORMATION AND CONSENT FOR RESEARCH INSTRUMENTS AT ZIMSTAT 370

APPENDIX B: LETTER OF PERMISSION GRANTED 372

APPENDIX C: GATEKEEPERS LETTER 373

CHAPTER ONE

INTRODUCTION AND BACKGROUND TO STUDY

1.1 Introduction

The study focuses on the manufacturing sector in Zimbabwe which according to Kanyenze, Kondo, Chitambara and Martens (2011: 482)was one of the most significant pillars of the economy due to its contribution to the Gross Domestic Product (GDP), export earnings, employment levels and investment opportunities. The United Nations Development Programme (UNDP) (2008: 125) and a survey report by the Confederation of Zimbabwe Industries (CZI) (2008: 4) concluded that the manufacturing sector was the mainstay of Zimbabwe's economy. Despite the great contribution of Zimbabwe's manufacturing sector to the economy, its efficiency has been on the decline (Gumbe and Kaseke 2010: 5).An analysis of the reasons for this decline is provided in the following paragraphs.

Manufacturing companies in Zimbabwe are confronted with challenges which include challenges faced in the manufacturing plant and business challenges. Challenges experienced at the plant include the use of old equipment; an erratic supply of electricity; an erratic supply of water; raw material supply; lack of investment in research and development; lack of specialized skills; and shortages of spare parts for machinery. Business challenges include low demand for some products, high labour costs, lack of working capital, high utility bills, liquidity challenges in the market and competition from imports (Zimwara and Mbohwa 2015: 155).

In addition, a survey conducted by the CZI (2015:6) revealed that the five most problematic infrastructural factors are power cuts and shortages; poor road infrastructure; inefficient rail networks within the country; water shortages and poor transport infrastructure for access to ports(CZI 2015: 6).It can be noted that a regular trend seems to be developing with regard to the leading factors affecting the manufacturing industry, thereby limiting its capacity. The major capacity constraints have remained unchanged over the last four years,which possibly explains why capacity utilization has been on a downward trend since 2011. The major issues being raised continue to recur and some are yet to be addressed.

Moreover, as can be noted in Tables 1.1 and 1.2, common constraints that respondents to identify as inhibiting capacity over the years are premised around low demand, working capital constraints, outdated machinery, competition from imports, the current environment, high cost of doing business and theunreliable service provision of utilities. In 2015, 28.4 % of all respondents reported low aggregate demand as the major inhibitor to capacity, followed by capital-related issues. This can be attributed to increasing company closure,leading to an increase in unemployment and under-employment which affects aggregate demand as consumers have less disposable income to spend (CZI 2015:13).

Table 1.1: Common Constraints

Common Constraints	**2011**	**2012**	**2013**	**2014**	**2015**
Low product demand	18%	13.3%	17.6%	28.8%	28.4%
Raw material	13%	5.3%	5.9%	6.2%	6.9%
Energy	7%	9.9%	8.6%	3.8%	6.4%
Lack of working capital	17%	32%	40.2%	26.5%	18%
Outdated machinery	8%	11.4%	9.8%	7.3%	12.3%
General cost of production	-	8%	5.2%	6.2%	8.5%

Source: Adapted from CZI surveys (2011;2012; 2013;2014;2015).

Kanyenze, Kondo, Chitambara and Martens (2011: 482) noted that the major manufacturing sector constraint has been a lack of working capital. This was also catalysed by capital outflows as a result of Zimbabwe being a risky investment destination. Foreign currency challenges and poor monetary policies also affect working capital availability. CZI (2013: 15) confirmed that low product demand was also identified as a major constraint in the time frame under consideration. It is no doubt that imported products reduced the demand for local goods. Other constraints not captured in The tablefrom CZI (2014:14) arelack of a skilled manpower, an uncompetitive export market, import competition, labour costs and machine breakdowns.

Further more, large and small firms alike identify input supply including availability, quality and cost as a leading obstacle to developing an efficient manufacturing sector inAfrican countries. Mzumara (2012: 20)argued that poor management of the fiscal policy contributed most to the poor performance of the Zimbabwean economy. Zimbabwe had its lowestinflation in 1980, at 7%. This clearly shows that at independence, the economy was very strong. The period 1980-1990 shows that inflation was generally below 20%. In 1991,inflation was 48% and in 1992,40%. This can be explained by the drought experienced in 1992. In 1998 inflation picked up to 48% from 20%. This increase can be attributed to cash grants awarded in 1997 to war veterans and the effects began to be experienced from that year. In 1999 inflation further increased to 56.9% with Zimbabwe’s participation in the Democratic Republic of Congo war (Mzumara 2012: 26).

Continuing on this downward spiral, in 2001 inflation jumped to three digits as the crisis began to worsen due to the unplanned land reform which began as land invasions in 2000. Moreover, in 2006 inflation reached four digits and in 2007, it hit five digits and then went to ten digits in 2008. It can be argued that actual inflation could have been much higher than the official figures. In 2009, inflation was tamed with theadoption of multi-currency.The general decline in economic activity due to the landreform, sanctions, poor economic policies and other factors resulted in closure of manycompanies and the retrenchment of many workers as capacity utilisation dwindled to the lowest levels. Company closures and retrenchment also led to the exodus of both skilled and unskilled labour to South Africa and other countries.

Therefore, it can be noted from the aforementioned discussionthat the macroeconomic factors had an impact in Zimbabwe’s manufacturing sector, especially before the dollarization era (pre-2009). However, the decimation has continued to date. This suggests that even though the macroeconomic environment is still unfavourable,manyof the inefficiencies also have to do with internal factors.

This introductory chapter outlines a brief background to the study, followed by an explanation of the statement of the research problem, the aim of the study, research questions, research objectives and significance of the study. The chapter also posits a dialogue on the scope and limitations of the study. At the end of this chapter, a brief discussion on definitions of key terms will be undertaken, followed by an outline of the organisation of the thesis.

1.2Background to the study

The manufacturing sector plays a pivotal role in both developing and developed economies.Manufacturing has historically been the driver of economic growth, structural change, and catch-up in world developments. Special opportunities for reaping economies of scale; engaging in technological progress and learning; profiting from spill-overs to other sectors; and providing job opportunities for variously skilled levels of labour are well placed in the manufacturing sector. In developing economies, the manufacturing sector is a source of raising living standards, civilisation and economic development, whereas in developed economies, manufactured goods are indicative of innovation and competitiveness.

It has been propounded that the share of the manufacturing sector in global output amounts to about 16%, whilst Zimbabwe's manufacturing share toGDP is about 13-15% (CZI 2011: 3). Developed countries have sixty-two million jobs in their manufacturing sector on average and their service sector obtains 30-55% of their jobs from the manufacturing sector (McKinsey Global Institute 2012: 8). CZI (2009: 4) stated that, in Zimbabwe, 15% of formal employment is in the manufacturing sector, when the economy is at its peak. The McKinsey Global Institute (2012: 6) further found out that manufactured goods make up 70% of global trade. In the same vein, the Reserve Bank of Zimbabwe (RBZ) (2009: 9) posits that Zimbabwe's manufacturing sector contributes 37% to exports when it is at its peak.

Furthermore, the McKinsey Global Institute (2010: 1-2) points out that developing countries continue to drive global growth in the demand for manufactured goods, yet they can use efficiency scores to benchmark a competitive position and therefore, to meet their own demand for manufactured goods. Currently, manufacturing firms listed on the stock exchange have only a mandate to publish their financial statements as a communication of their performance. These statements have a limited scope on efficiency measure and status. These financial statements do not reveal the inputs or outputs which are on the efficient frontier. Only the overall performance of the Decision Making Unit (DMU) is narrated. Davies, Kumar and Sha (2012: 102) aptly contend that the manufacturing sector can promote the economic growth of a country and increase global trade.The European Commision (2012:1-2) showed that increased global participation is evident in emerging economies like China, Brazil, India and South Africa, which are steadily catching up with developed countries.Manufacturing workers in open economies received pay rates 3 to 9 times greater than those in closed economies, depending on the region. Helpman (2014: 1-14) suggested that a Chilean worker in a sector open to trade and investment gains an average €1,100 more per year than a worker in a relatively closed sector. Manufacturing firms contributing to global trade are mostly the ones producing at the efficiency frontier as their products' prices will be lowly marked.

Additionally, the manufacturing sector supports other sectors such as the mining and agriculture sectors through backward and forward linkages (CZI 2007: 6). However, despite the evidence that the manufacturing sector is paramount to global economic growth, efficiency in the Zimbabwean manufacturing sector has not been adequately analysed.This, therefore, makes the current study pertinent. Results from this study, when implemented, can be used to assist DMUs in Zimbabwe's manufacturing sector to aspire towards an efficiency frontier which will allow them to produce enough for local demand cheaply and compete in the global trade of manufactured goods. Much needed foreign currency will be earned, employment opportunities increased and the economic linkages with other sectors enhanced, which are some of the benefits.

Besada and Moyo (2008: 12) and the United Nations Development Programme (UNDP) (2010: 6) concur that Zimbabwe had a well-developed manufacturing sector in Sub- Saharan

Africa up to the late 1990s. Zimbabwe`s manufacturing sector has traditionally been a key driver of regional economic growth, GDP, export receipts and employment in Zimbabwe. The sector produced diversified products ranging from foodstuffs to steel products consisting of some 1260 separate units producing 7000 different products as alluded to by Kanyenze*et al.*(2011: 482). The CZI (2013: 9) indicated that from the 1980s up to the late 1990s, the manufacturing sector experienced growth in terms of production, capacity utilisation and contribution to employment. However, the World Economic Forum's 2005 Global Competitiveness Report ranked Zimbabwe amongst the countries with the worst macro-economic environments (Lopez-Claros and Schaw 2005). It was number 109 out of 117 countries polled. Zimbabwe's economy declined by more than 40% of its real GDP since 1997 and exports have fallen by a proportion of more than half. Foreign direct investment has dropped from USD 444 million in 1998 to USD 9 million in 2004. Industry officials say more than 400 firms have closed between the years 2000-2012, leaving over 90% of people unemployed and capacity utilisation declined to below 40% (CZI 2013: 18).

The World Bank (2010: 4) indicated that the contribution of the manufacturing sector to exports declined significantly in Zimbabwe, with the sector now exporting fewer types of goods than before the 1990s. The World Bank (2012: 24-27) showed that the performance of the manufacturing sector in Zimbabwe has been falling, with capacity utilisation declining to 10% in 2011 from 60% in 1996. According to the UNDP (2010: 5), the once vibrant Zimbabwean manufacturing sector in the Africa of the 1990s is experiencing a sharp decline in its contribution to economic growth, employment, performance and exports when compared to other sectors. The low performance of the manufacturing sector has negatively affected efforts to revive the economy of Zimbabwe after a period of decline. In view of the massive contribution of the manufacturing sector to the economy in general, the decline in the efficiency of manufacturing firms has remained one of the major challenges to the recovery of the Zimbabwean economy.

The Zimbabwean manufacturing sector has therefore been characterised by massive de-industrialisation, firm closures, downsizing and falls in capacity utilisation by 5.3% between 2012 and 2013 (CZI 2013: 8). Furthermore, only four of seventy manufacturing firms listed on the stock exchange are performing above 50% capacity (CZI 2013: 15). The Zimbabwe

Stock Exchange (2011: 7) reported that firms in the manufacturing sector have shown variations in their performance, with the foodstuff and metal product firms performing well, while clothing and footwear; metals and metal products; and transport and equipment firms performing dismally. A number of firms failed to open up for years after the stabilisation of the economy (CZI 2013: 8), leading to a decline in the performance of the manufacturing sector operating in the same business environment. Several factors can be attributed to the decline in manufacturing output, but an important factor to consider is the level of efficiency. The level of efficiency can be effectively measured by a robust non-parametric study which has not been done in Zimbabwe. These challenges justify this study, as analysing and disclosing the efficiency scores to determine inefficient firms can open avenues that could make them imitate the firms with government agreed uponefficiency scores.

1.3 Research problem

Despite the significant contribution that the manufacturing sector can make to the Zimbabwean economy, the efficiency of firms in the sector has been on the decline (Bond 1998: 31-40 and CZI 2013: 10-13).Manufactured exports declined progressively from US$853.3 million in 2001 to US$210.3 million by 2008(Kanyenze, Kondo, Chitambara and Martens 2011: 143). Against the backdrop of the overall economic slowdown, the results of the CZI (2013:2) reveal slackening economic activity as overall capacity utilizationhas continued declining from 44.9% in 2012 to 39.6% in 2013. Large efficiency variations still exist in the sector and performance has not improved significantly (UNDP 2010; Kanyenze*et al.* 2011: 482). Although the economy has stabilized and started to grow in the dollarized era, the efficiency and contribution of the manufacturing sector has not improved. Marongwe (2010: 24) attested that capacity utilization of manufacturing firms has remained below 40%, despite the stabilization of the economy after 2008. A number of firms remain closed and a number of former workers remain unemployed (CZI 2013: 8). The CZI (2013: 5) indicates that capacity utilisation of the manufacturing sector continues to drop as firms are now operating on average between 10-48%, which is a decline from 60% in the 1990s. Kanyenze*et al*. (2011: 482) argue that restoration of performance of the manufacturing sector has remained as one of the key priorities of the Government of Zimbabwe in the post-dollarized period. Manufacturing will be the epicentre of any stabilisation programme. There are three interventions that quickly come to the fore and these are elucidated below.

Firstly, in a bid to restore the performance of the manufacturing sector Short Term Emergency Recovery Programme (STERP) was introduced. In this regard, the expected outcome of STERP is to ensure that the current industrial capacity utilisation is increased from low levels of around 10% to over 60% in the next six months (STERP 2009: 51). According to the Zimbabwean Government (2009b:9),STERP was aimed at growth-driven recovery; restoration of the value of the domestic currency and its stability; and increasing capacity utilization in all sectors of the economy.

Secondly, it is also noteworthy that Zimbabwe was not spared the adverse impact of economic misalignment and inefficiencies despite the existence of a framework that sought to steer the manufacturing sector to value-added growth for domestic and export market for manufactured goods. Thus, the Ministry of Industry and Commerce in a practical vein intended to address these changes and challenges drew up the Industrial Development Policy (IDP) Framework 2012 - 2016 which replaces the one that expired in December 2010, to serve as a solid blue-print for Zimbabwe's industrial growth and revival. The IDP itself envisages transforming Zimbabwe from a producer of primary goods into a producer of processed, value-added goods for both the domestic and export market through the promotion of efficiencyin the manufacturing sector. The overall objective of the policy is to restore the manufacturing sector's contribution to GDP of Zimbabwe from the current 15% to 30%, and its contribution to exports from 26% to 50% by 2016 (Industrial Development Policy 2012-2016 (2012: 52).

Thirdly, the National Trade Policy emphasizes, the Zimbabwean government's commitment to boost efficiency in the manufacturing sector. This is evident in that one of the objectives of the National Trade Policy 2012-2016(2012: 6) was to promote the enhanced value-addition of primary commodities in all sectors of the economy, thereby restoring the manufacturing sector's contribution to export earnings from16% in 2011 to 50% by 2016. The continued decline in the efficiency of the manufacturing sector has become a serious concern for the sector, other related sectors and the government. Challenges of closed firms and low performance of the firms in the manufacturing sector have created the need for research studies focusing on how the efficiency of the sector can be improved.

Capacity utilisation was at its peak in 1996. Thereafter, there has been swings of a falling economy. Increase in capacity utilisation for the years 2009 and 2013 can be attributed to dollarization and bumper harvest and not to outtright efficiency of the manufacturing firms.

Given the struggling manufacturing sector in Zimbabwe, there is a critical need to plan how to allocate the available resources efficiently in order to maximize the returns from investment in the sector. An analysis of the CZI reports from 2007 to 2014 reveals that the major challenge relating to the manufacturing sector is inefficiency in the utilization of the existing resources in the sector, rather than availability of these resources. There has been inefficient use of existing industrial infrastructure, energy, water and landuse especially arable land.Zimbabwe boasts of abundant skilled and unskilled labour, but this resource has been inefficiently utilised. Consequently, this calls for a thorough investigation of the efficiency levels of the Zimbabwe's manufacturing sector. An analysis is also required to determine why some firms are closing, some are struggling and few are still surviving and subsequently losing manufacturing sector efficiency, despite operating in the same economic environment.

The McKinsey Global Institute (2012: 3) insightfully argues that inefficiencies in the manufacturing sector is a problem as it slows down agricultural transformation, a panacea to improving living standards in developing countries like Zimbabwe. The same institute also contends that as long as they remain inefficient, developing economies will continue to siphon scarce resources for the exchange of highly valued manufactured goods from the United States of America, China and South Africa. Therefore, improving manufacturing efficiency will reduce imports of manufactured goods, increase employment and improve competitiveness. Since 60% of the manufacturing firms in Zimbabwe face competition (CZI 2012: 6), being efficient will improve firm survival.

The Data Enveloping Analysis (DEA) characteristic used in this model to consider more than one input and output at a time is useful in order to obtain numerical values for comparison. A multidimensional evaluation of different efficiency aspects is established by the careful selection of the inputs and outputs. Inspection of more than one aspect eliminated the possible errors that could be caused by the selection of only one input and output, or even the use of financial ratios. Moreover, the results were enriched with the additional analysis of input excesses and output shortfalls by expanding the study to cover the factors lying beneath the inefficiencies. Within these, DEA is a suitable tool to make performance evaluations and to compare the performances of industries, enabling decision makers to better analyze the situation (Saricam and Erdumlu 2012: 528).Therefore, in light of the problems in Zimbabwe's manufacturing sector, this study uses DEA to help alleviate the problem of how the manufacturing efficiency framework can be used to salvage declining manufacturing output in Zimbabwe.

1.4 Aims and objectives of the study

The main aim in the study of analysing how efficiency can be used to salvage the decimation of Zimbabwe's manufacturing sector is explained. This will be followed by a narration of the sub-objectives specific to meeting the main aim.

1.4.1 Aims of the study

This study aims to investigate and analyse how the manufacturing efficiency framework can be used to salvage the declining manufacturing output in Zimbabwe. Besides providing possible options for improving the efficiency of the manufacturing sector, the study also attempts to extend the existing knowledge of efficiency models by recommending sectorial efficiency levels generated from Data Enveloping Analysis (DEA) scores. Financial ratios are currently a standard way of measuring corporate efficiency, which use historical values and not the real input-output relationship (frontier). The use of these accounting-based financial ratios to measure firm performance has been criticized by Cummins and Weiss (2013: 795). For instance, accounting data ignores the current market value of manufacturing firms and does not include economic value-maximizing behaviour (Avkiran 2011: 323). Additionally, these financial ratios do not consider the input - output mix and its value does not compare firms across the sector (Fethi and Pasiouras 2010: 189). However, this study recommends a harmonised disclosure of efficiency ratios to augment traditional financial ratios. By legislating this type of disclosure and undertaking surveillance on the minimum accepted sector efficiency scores, the falling manufacturing output in Zimbabwe could possibly be salvaged. Therefore in summary, the aim of the study isto analyse the efficiency levels of the manufacturing sector in Zimbabwe.

1.4.2 Objectives of the study

The study objectives of the study are:

i. To determine the drivers of efficiency in Zimbabwe's manufacturing sector;

ii. To compare financial ratios with efficiency ratios in the input-output model in order to identify the levels and kinds of inefficiencies in Zimbabwe's manufacturing sector.

iii. To measure efficiency in Zimbabwe's manufacturing sector using the production plans of the efficiency scores.

iv. To identify the barriers to achieving efficiency levels in Zimbabwe's manufacturing sector; and

v. To develop an efficiency model that will recommend an efficient input-output use in Zimbabwe's manufacturing sector.

1.5 Research questions

This study addressed the following research questions:

i. What are the major drivers of efficiency in Zimbabwe's manufacturing sector?

ii. How do financial ratios compare with input-output efficiency ratios in explaining inefficiencies in Zimbabwe's manufacturing sector?

iii. How is efficiency measured and which scores are efficient in the manufacturing sector in Zimbabwe?

iv. What are the barriers to achieving efficiency in Zimbabwe's manufacturing sector?

v. How can an efficient model on efficiency be developed, which can recommend an efficient input- output use in Zimbabwe's manufacturing sector?

1.6 Significance of the study

The significance of this study hinges on the fact that previous research in the efficiencyof firms has been confined mainly to developed countries.Such examples include the United Kingdom, Sweden and Germany whose sectorial efficiency studies have continued to place Europe and Western countries competitively in manufacturing globally. By exploiting a large macroeconomic and input/output data-set with sectoral information, Wan and Morgan (2017: 2) and Su and Yao(2017: 47) found that in the middle-income stage, the manufacturing sector tends to pull along all other sectors, including the services sector. Therefore, a decline in the growth rate of the manufacturing sector will negatively affect the growth of all other sectors in both the short and the long-runs. They also investigated the possible mechanisms as to why manufacturing is central to development in a middle-income economy. The researchers found that a larger share of manufacturing not only raises the gross private saving ratio, but also accelerates the pace of technological accumulation. This suggests that manufacturing sector efficiency is still the key engine of economic growth for middle-income economies.There is limited research ondeveloping countries, particularly in Africa, regarding efficiency measurement and improvement using non-parametric approaches. Therefore, this study provides an invaluable contribution to how the efficiency of themanufacturing sector in Zimbabwe can be improved.The non-parametric method used to identify the drivers of efficiency on the performance of the manufacturing sector in Zimbabwe will be used to propose guidelines for disclosure of firm efficiency scores together with accounting ratios, as the analysis can assist in salvaging declining manufacturing output in Zimbabwe. If the declining manufacturing output is salvaged, then Zimbabwe will attain a steady economic growth.

The most distinct difference of this study is its proposal to use efficiency scores together with accounting ratios, rather than accounting ratios alone, in measuring performance of firms.The use of these accounting-based financial ratios to measure performance has been criticized for several reasons. The data used to construct accounting ratios do not consider the objective current market value of the DMU and does not represent economic value-maximizing behaviour. Additionally, the prices of outputs and its inputs are left out in the computation of these financial ratios, while the selection of the weights of financial ratios is subjective. Due to these difficulties, an informed conclusion is that efficient frontier approaches are the best estimators of firm efficiency and subsequent performance if one is to compare with traditional financial ratios. Hon, Tuck and Yu (2011: 19)claim that the frontier approach offers an overall objective numerical score and ranking, as well as an efficiency proxy together with the economic optimization mechanism. It is worth mentioning that the frontier analysis suffers from the same drawback mentioned earlier for the financial ratios. Namely, they rely on accounting data and not on market values. However, it is believed that the efficiency proxies of the frontier approach are better measures of DMU performance (Halkos and Salamouris 2004: 203).Traditional financial ratio analysis does not allow for objectively combining independent evaluations into a single performance score and it is difficult to use for comparative purposes. Paradi, Rouatt and Zhu (2011: 99) found that a DMU might have strong results for some ratios but show poorly in others, making it difficult to judge whether the DMU is, on average or on some other basis, efficient or not. Simply aggregating these results together can give a misleading indicator of performance or worse, hide under-performing business components within the overall.

Further to explaining the weaknesses of using financial ratios alone, it can be noted that analysis of the manufacturing sector can be done in two ways: by use of traditional financial ratio analysis (FRA) or by frontier analysis methods such as data envelopment analysis (DEA). Kumbirai and Webb (2010: 30) argue that financial ratios enable one to identify unique firm strengths and weaknesses, which in itself informsfirm profitability, liquidity and credit quality. FRA is popular for a number of reasons: it is easy to calculate and interpret; and it allows comparisons to be made between firms using benchmarks or the average of the industry sector. On the other hand, a number of studies (Zhu,2000: 105; Ho and Zhu 2004: 425; Yu and Chang 2014: 15) argue that the usefulness of FRA to estimate and predict firm efficiency has failed because of the univariate nature of ratio analysis, which presents major limitations in assessing firm performance. It is concluded that a single ratio fails to provide a complete set of information of a firm over the breadth of its activities, and there is no criterion for selecting a ratio that is appropriate for all interested parties. Therefore, a lack of an objective standard for selecting the ratios would cause instability and fail to satisfy all stakeholders. Findings show that financial ratios can only be an appropriate method when firms manage a single input to generate a single output. FRA does not provide sufficient information when considering the effects of economies of scale and estimation of overall efficiency measures. However, performance evaluation of organizations such as manufacturing firms is more complex with multi inputs and outputs which cover all aspects of the firm. For these reasons, DEA was introduced as an alternative approach for assessing the performance of such firms (Cooper, Seiford and Tone 2000: 7; Yu and Chang 2014: 212). Charnes, Cooper and Rhodes (1978: 429) for the first time introduced an efficiency measurement technique which is known as DEA. It has proven to be an essential tool because it measures relative efficiencies by using multi-inputs and multi-outputs. Its essential tools and strength might be borrowed to salvage a fallen manufacturing sector in Zimbabwe.

Having been drained thousands of dollars from the fiscal funds over the years, coupled with an opportunity cost on corporation tax, the economy may improve in terms of capacity utilization, productivity and growth of GDP once the manufacturing sector in Zimbabwe begins to operate with guidance from efficient scores.The economy may also benefit from efficiently operating firms, which will earn the confidence of both investors and lenders, thereby increasing access to capital and financial markets. Since the manufacturing sector links to other sectors,such as agriculture, it can facilitate growth in these sectors. The manufacturing sector has always had strong linkages with the agricultural sector, with agriculture sourcing from it over half of its intermediate goods such as insecticides, stock feeds and fertilizer, while nearly half of agricultural produce is supplied to the manufacturing sector (Magure 2012: 68). This in turn results in increased GDP, export earnings, employment levels and investment opportunities (Kaminski and Ng 2013: 3).

The Government of Zimbabwe will benefit from the study as it is a direct enquiry into national interest and is in line with its plans of turning around the manufacturing sector. As a major regulator, the government will be equipped to correct the inefficiencies and decimation in the manufacturing sector through a dossier of efficiency strategies that will be recommended by the research. Most importantly, the Government is expected to benefit from increased investment inflows from investors, which will be unlocked once efficient practices are adopted and firms perform to expectations.

The researcher also proposes that the apex bodies that control the licensing, regulation and supervision of firms in the manufacturing sector, including policy formulation, monitoring and evaluation, can make informed decisions on the basis of the findings of the study. Existing and potential investors and managers should also benefit from this study as they would be able to make decisions informed by efficiency ratios.

Furthermore, this study may add value to knowledge creation by demonstrating the similarities, consistencies and differences of this research with the current principles, beliefs, ideologies, concepts, theories, and/or models put forward by various scholars and researchers.The study, additionally, makes a significant contribution to the growing body of research on efficiency in general and in the manufacturing sector in particular. Emanating from the envisaged publications, the findings may also be used as a source of reference for other researchers. Academic researchers may use the study findings to stimulate further research in the area of efficiency.

1.7 Research methodology

The research methodology explains how the research is carried out. It gives a clear blueprint of how valid data will be collected, the data research instruments employed and the data collection procedures and data analysis procedures followed.

1.7.1 Research design

Research design emphasizes techniques for organizing a research process to achieve maximum control over factors that may interfere with the validity of the findings (Bechhofer and Paterson 2012: 167). Polit and Beck (2013:7) define a research design as "*the researcher's overall process for answering the research question or testing the research hypothesis*". In brief, research design must, at least, include; (a) a clear statement of the research problem; (b) procedures and techniques to be used for gathering information; (c) the population to be studied; and (d) methods to be used in processing and analysing data

(Khotari 2011: 32). There are many documented research design categories and none is agreed to be the best (Corbin and Strauss 2014: 8). This study will utilise the mixed method research design.

A mixed method research design is useful to capture the best of both the quantitative and qualitative approaches (Creswell 2013: 20). It is suitable for generalizing the findings to a population and developing a detailed view of the meaning of a phenomenon or concept. According to Creswell (2013: 18), a quantitative approach is one in which the researcher primarily uses post-positivist claims for developing knowledge from cause and effect thinking which is reduced to specific variables. Quantitative research design is an excellent way of finalizing results and proving or disproving a hypothesis (Khotari 2011: 32). The questionnaire was used for the quantitative research methodology to approve or disapprove the hypothesised causes of inefficiency in the manufacturing sector in Zimbabwe. It answered the objective claims of the "what" and "how" research questions in this study. The Data Enveloping Analysis (DEA) statistical and computational techniques provided the efficiency ratios. Qualitative research is an exploratory method were the researcher is immersed in the collection and analysis of the data (Corbin and Strauss 2014: 4). The researcher used interviews for the qualitative research methodology, where in-depth interpretation on the causes of inefficiencies in the Zimbabwean manufacturing sector were gleaned. The interviewees are experts in the manufacturing sector in Zimbabwe.

A mixed method design gives the smallest error and is supposed to be the best design in many investigations. It is a design that minimises bias and maximises the reliability of the data collected, yielding maximal information. This provides an opportunity for considering many different aspects of the efficiency problem in Zimbabwe and, is therefore considered to be the most appropriate and efficient design. According to Bechhofer and Paterson (2012: 167), the fundamental principle of mixed research involves combining quantitative and qualitative methods, approaches and concepts that have complementary strengths and non-overlapping weaknesses.

1.7.2 Target population

Manufacturing firms in Zimbabwe comprise the research population. These are large manufacturing firms which have operated for the past ten years and provide the data necessary for efficiency decisions in Zimbabwe's manufacturing sector. The number of large manufacturing firms in Zimbabwe has dropped to around six hundred and fifty (CZI 2014: 8). Probability sampling was used to select the 210 firms which constituted the target population. A random sampling design was used to randomly select 21 firms in each of the ten categories. The clusters are homogenous subdivisions based on geographic area, so that all manufacturing firms in Zimbabwe are represented. Practical considerations of time and cost underpinned the selection of the 210 manufacturing firms based on random sampling.

1.7.3 Sampling method

Stratified sampling was used to place the firms into different manufacturing categories: foodstuffs (10.7%); beverages and tobacco (21.3%); textiles (3.9%); clothing and footwear (4%); wood and furniture (8%); paper printing and publishing (11.2%); chemicals and petroleum products (3.9%); metals (23.3%); non-metallic minerals (7%); and transport and transport equipment (6.7%) (Zimbabwe National Statistics Agency(ZIMSTAT) 2010: 3). Probability sampling wasutilised where each manufacturing sector category is represented by the randomly selected twenty- one firms. The 210 members who were given the structured questionnaire were randomly selected from each of the ten categories. The sample was representative, since all manufacturing sector categories were represented.

It is statistically known that large numbers of inputs and outputs compared to the number of DMUs may reduce the discriminatory power of DEA and subsequently, the results. Therefore, Cook, Tone and Zhu, (2014: 4) suggested that by "rule of thumb", the number of DMUs be at least twice the number of inputs and outputs combined (Cook, Tone and Zhu 2014: 4). Banker and Natarajan (2011: 273),on the other hand, state that the number of DMUs should be at least three times the number of inputs and outputs combined. However, according to Williams (2014: 245), such a rule is neither imperative nor does it have a statistical basis, but rather is often imposed for convenience. In that sense, the size of the sample or the number of DMUs under evaluation may be immaterial (Cook, Tone and Zhu 2014: 3). Based on recommendations by Banker and Natarajan (2011: 273), seven variables made up of two outputs and five inputs were used, which justifies that each of the ten sectors must have twenty- one firms (7 variables x 3 times= 21 DMUs).

The ten different categories in the manufacturing sector and the five Apex Boards, namely the Ministry of Industry and Trade, CZI, Zimbabwe National Chamber of Commerce (ZNCC), Zimbabwe Investment Authority (ZIA) and ZIMSTAT were the targeted population for the interviews. Purposive sampling identified the twenty Chief Executive Officers (CEOs) from the sampled firms and the five CEOs from the Apex Boards for the in-depth interviews. Two (one outstanding and one failing) firms from each manufacturing sector category, totalling twenty-five,were purposively selected using the extreme or deviant case approach and the other five members each came from the five Apex Boards.The total number interviewed was twenty-five. Siegle (2011: 6-28) indicates that extreme or deviant cases allow learning from highly unusual manifestations of the phenomenon of interest, such as outstanding firms and notable failing firms. Mixed or purposeful caseswereused to purposively select Chief Executive Officers from the Apex Boards to ensure representation of all manufacturing firms. The combination or mixed purposeful case ensures triangulation, flexibility, meets multiple interests and the needs of the research (Seidman 2013: 3).

As a result of massive closure of manufacturing firms in Zimbabwe in recent times, 2010-2015, the targeted population included firms which have managed to operate for the past decade. This enabled benchmarking and analysis of efficiency drivers. The sample is representative as all sectors were considered. The sample was large enough to provide valid results according to how the DEA works.

Using the rule of thumb, the questionnaire sample was representative as it exceeded 5% of the population. Baker and Edwards (2012: 856) conclude that there is no concrete guidelines on the sample size for interviews. Richards and Morse (2012: 1) and Creswell (2013: 10) suggest that interviews be at least 20-30 interviewees. Purposive sampling is justified for interviewees in this study as Cohen *et al.* (2011: 15) suggested that it accessed ‘knowledgeable people’ by virtue of their professional roles, work experience and leadership roles.

1.7.4 Measuring instruments

This study will utilise questionnaires, interviews and documental analysis as measuring instruments. These instruments will be used to gather the valid data necessary to meet the objectives of the study. The measuring instruments will collect triangulated data that will be used to analyse efficiency in Zimbabwe’s manufacturing sector.

1.7.4.1Questionnaire

A pre-validated closed-ended questionnaire from ZIMSTAT was used as a guide. The main body of the questionnaire is divided according to the research objectives. The questionnaire was pre-tested (during the drafting stage) amongst manufacturing firms with less than five years in operation. Pre-testing increased the reliability, validity and practicability of the questionnaire (Cohen *et al.*, 2011: 15). As pointed out by Saunders *et al.* (2009: 67), the purpose of the pre-test was to refine the questionnaire so that respondents had no difficulty in answering the questions. The results of the pre-test study guided the researcher on the elimination and modification of some of the questions.Questionnaires weredelivered directly to the two hundred and ten firms, comprising twenty- one firms randomly selected from each category, and collected by the researcher after more than four working weeks.

1.7.4.2 Interviews

Interviews provide the researcher with an opportunity to probe answers where explanations and further responses are required (Robinson 2014: 25). In-depth interviews with two key informants, each from two firms representing each of the ten categories and one member from the five Apex Boards, were conducted. The researcher took respondents out of a group for a one-on-one encounter where there was no influence of others. The technique was characterized by extensive probing and open-ended questions posed to the twenty-five interviewees. In-depth interviews also encouragedthe capturing of respondents' perceptions in their own words, a very desirable strategy in qualitative data collection (Robinson 2014: 25). Such a structured interview where "*the interviewer puts a collection of questions from a previously compiled questionnaire, known as an interview schedule, to a respondent face to face and record the latter's responses*" (Corbin and Strauss 2014: 2) is advantageous as it can capture the respondents' illustrations. The information received was used to triangulate the data gathered from the questionnaires (Faux 2010: 100-111) and this was incorporated into the analysis and discussion section of the research.

1.7.4.3 Document review

According Smith and Street (2005: 401), document analysis plays an important role in providing a description of the manufacturing sector over time. This segment of the study is designed to focus narrowly on the achievement of pre-determined objectives.

The following documents were accessed in order to triangulate and analyze the efficiency of Zimbabwe's manufacturing sector:

i. Minutes to annual strategic planning meetings;

ii. Policy documents;

iii. Government's reports;

iv. Apex Boards' reports; and

v. Firm's financial statements audited and unaudited.

All the above documents were reviewed in a chronological sequence and analyzed in terms of their relevance to efficiency theories and proposed efficiency disclosure, and as well as their input on the evaluation of their impact on firm efficiency. Analysis of documents often results in unforeseen or unexpected new insights (Saunders *et al.*, 2009: 30-44) and validates qualitative data. The document review instrument is useful when comparing financial ratios with the input-output model in order to identify the kinds of inefficiencies in Zimbabwe's manufacturing sector.

1.7.5 Data collection

After a pilot study, questionnaires were hand-delivered to the targeted respondents. Completed questionnaires were collected on a mutually agreed date after about four working weeks. Two hundred and ten firms comprising twenty-one firms randomly selected from each category were given the questionnaire. Questionnaires weredelivered directly to the respondents and collected by the researcher.

With regard to the interviews, the researcher made appointments with the chosen participants on agreed upon dates, times and venues. In-depth interviews with two key informants, each from two associations representing each of the ten categories and one member from each Apex Board, will be conducted.

The following documents were accessed in order to triangulate and analyze the efficiency of Zimbabwe's manufacturing sector;

i. Minutes to annual strategic planning meetings;

ii. Policy documents;

iii. Government's reports;

iv. Apex Boards' reports; and

v. Firm's financial statements audited and unaudited.

1.7.6 Data analysis

The quantitative data was grouped into input and output variables which were regressed in Stata Version 16, a data enveloping analysis software. This non-parametric methodology was chosen as it is the strongest comparative measure of efficiency among other efficiency measures suitable for the manufacturing sector situations in Zimbabwe. Foremost, it can assess efficiency levels of Decision-Making Units with multiple incomparable units and outputs. Furthermore, it can handle both input minimisation and output maximisation, which are paramount decisions needed in Zimbabwe's manufacturing sector.

Efficiency scores and a descriptive statistical summary will be presented, leading to an understanding of Zimbabwe's manufacturing sector. The collected data from questionnaires and document analysis will be summarized using tables, graphs and figures. Narrative and discourse analysis will be used to deduce meaning from the interviews. Content analysis is a way of categorizing various items of the documents analysed into a number of categories. It is employed where large amounts of qualitative data have to be analysed (Olubukunola 2011:5). Manufacturing sector efficiency findings will be compared to findings from cases in similar operations, using efficiency scores.

1.7.7 Anonymity and confidentiality

Anonymity refers specifically to removing or obscuring the names of participants or research sites, not including information that might lead participants or research sites to be identified. The main way that researchers seek to protect research participants from the accidental breaking of confidentiality is through the process of anonymisation (Babbie 2015: 60). To achieve anonymity, respondents used pseudonyms. Corporate names of manufacturing firms were used when conducting interviews and questionnaire respondents used code names. Confidentiality refers to the management of private information '*that has been communicated in trust of confidence, such that disclosure would or could incur particular prejudice*' (Tilley and Woodthorpe 2011: 200-210). Data will be responsibly stored for five years before being shredded in order to ensure confidentiality. Clearly, anonymity provides a useful tool to help ensure that confidentiality is maintained.

1.7.8 Validity and reliability

Reliability is the degree to which an assessment tool produces stable and consistent results. This is achieved by pilot testing and the use of different research tools. Validity is how well a test measures what it is purported to measure. Reliability and validity enhances the objectivity and credibility of the research (Silverman 2010: 366). The researcher ensured that the evidence provided is corroborated by at least three data sources, namely questionnaires, interviews and document review, which provide validity to the research in terms of triangulation (Trochim 2013: 3). Tolk (2013: 26) points out that qualitative validity can be judged by the criteria of credibility, transferability, dependability and conformability rather than against some external objective standard. Reproducibility in questionnaires is important in order to achieve reliability and validity, which will be attained by administering the same questionnaire to different respondents (Pickard 2012: 3). Conformity was assessed by noting whether the written records, interviews and questionnaires lead to similar conclusions (triangulation). It is often thought that the inferences and conclusions drawn from a single case study cannot be generalized. Silverman (2010: 225) highlights that interviews are validated if interviewees' responses match their experience. Generalizations from this research should be based on the theoretical framework of efficiency applied. To ensure validity, DEA efficiency ratios are compared to the financial ratios.

1.7.9Ethical consideration

The Durban University of Technology ethical requirements are dealt with by adhering to rules regulating higher degrees qualification. In instances where research work of other scholars is used, referencing was done. The written work was subjected to Turnitin anti-plagiarism software, whichdeters plagiarism. According to Silverman (2013: 173), the consent form signed before the research is conducted ensures voluntary participation and ethical governance. Undertakings, disclaimers and questionnaire coding ensuredthe confidentiality and anonymity of participants.

1.8 Assumptions

Large numbers of inputs and outputs compared to the number of DMUs may diminish the discriminatory power of DEA. A suggested 'rule of thumb' is that the number of DMUs be at least twice the number of inputs and outputs combined. The type of inputs and outputs are the relevant ones in the non-parametric model to explain efficiency. The study assumes that the decimation of the manufacturing sector in Zimbabwe is a result of efficiency problems.The panel data methodology used has certain benefits like using the assumption that firms are heterogeneous; more variable with; less co-linearity between variables; more informative data;more degrees of freedom and more efficiency (Raheman, Afza, Qayyum and Bodla 2010: 154)

1.9 Delimitations of the study

The study utilised the manufacturing sector survey data for the post-dollarization period (2009- 2014) for the manufacturing sector in Zimbabwe.The data is representative as it is captured from the ten categories of the manufacturing sector, namelyfoodstuffs; beverages and tobacco; textiles; clothing and footwear; wood and furniture; paper printing and publishing; chemicals and petroleum products; metals; non-metallic minerals; and transport and transport equipment (ZIMSTAT 2010: 3). Data was collected from firms which have been operating for the past ten years (2004-2014) in order to have information for the post- and pre-decimation period in the manufacturing sector. Sectorial efficiency comparisons can therefore be made. Expert information was obtained from the Apex Boards made up of the Ministry of Industry and Trade, CZI, ZNCC, ZIA and ZIMSTAT, as well as associations of the manufacturing sector categories.

1.10 Limitations

The limited database, short time period and selected variables were some of the major limitations of this study. However, future researchers can work on more variables that affect efficiency.

Under the guise of confidentiality, the research did not have access to information on all the variables needed. The researcher was aware of the limitations of the research instrument and carefully keep observation notes, and avoided summarizing information where possible. The research was limited only tomanufacturing sector performance in Zimbabwe for the years 2009-2014.

1.11 Definition of terms

1.11.1 Efficiency

Cummins and Weiss (2013: 795)define efficiency as the use of resources in order to maximize the production of goods and services.Efficiency is evaluated by comparing firms to "*best practice*" efficient frontiers formed by the most efficient firms in the industry.In terms of the *efficiency* of a producer,one has in mind a comparison between observed and optimal values of its output and input. The exercise can involve comparing observed output to maximum potential output obtainable from the input, or comparing observed input to minimum potential input required to produce the output, or some combination of the two. In these two comparisons, the optimum is defined in terms of production possibilities, and efficiency is technical. It is also possible to define the optimum in terms of the behavioural goal of the producer(Charnes, Cooper, Lewin and Seiford 2013: 10). In this event, efficiency is measured by comparing observed and optimum cost, revenue, profit or whatever goal the producer is assumed to pursue, subject to any appropriate constraints on quantities and prices. In these comparisons, the optimum is expressed in value terms and efficiency is economic(Fried, Lovell and Schmidt 2008: 7).

Furthermore, economic efficiency is measured by the global economic performance of the firm, which is its ability to make its operations profitable. Farrell (1951: 120) defined economic efficiency by the product of technical efficiency and the allocative efficiency. According to his example, it appears that a firm cannot be 100% efficient economically if it is not 100% efficient technically,while simultaneously being 100% efficient allocatively. Economic efficiency can be separated into two distinct criteria and is therefore only the result of those two measures(Ouattara 2012: 37).The efficiency of a DMU is defined as the weighted ratio of the outputs (products or outcomes) yielded by the DMU over the inputs - resources used or consumed (Castelli, Pesenti and Ukovich 2010: 207).

1.11.2Efficiency score

Most definitions of an efficient score included the fact that it is a composite measure. The efficiency score refers to an index measure of output frontier per given vector of inputs(Liu, Lu, Lu and Lin 2013: 3).Cummins and Weiss (2013: 795) determined an efficient score to be the ratio of the inputs used by a fully efficient firm with the same output vector to the input usage of that firm. An efficient score is a statistic estimator developed to make it possible to include variables that determine efficiency simultaneously with the variables that determine the production function.Subsequently, it is a composite vector of outputs per given composite vector of inputs in an attempt to identify whether the inputs have been used efficiently or output produced efficiently. Charnes, Cooper and Rhodes (1978: 430) viewed efficiency scores as a fractional programming vector of inputs to a vector of outputs which has a value between zero and one. An outright efficient DMU has an efficient score of one, whilst the zero value shows no efficiency at all.

1.11.3 Technical efficiency (TE)

Technical efficiency (TE) refers to the ability of a DMU to produce the maximum feasible output from a given bundle of inputs, or the minimum feasible amount of inputs to produce a given level of output. The former definition is referred to as output-oriented TE, while the latter definition is referred to as input-oriented TE. These orientations assist in identifying whether the barrier to efficiency is from the input or output side. According to Wei, Chen, Li and Tsai (2011: 2473), an input-oriented model will provide an input-target improvement strategy, whilst an output-oriented model will provide an output-target to improve efficiency.

1.11.4 Manufacturing sector

A sector of the economy responsible for producing a wide range of commodities from food and beverages to chemicals, clothing and different metal products, can be termed the manufacturing sector. A great portion of the manufacturing activities in the HarareMetropolitan area are spread over the following categories: food processing; textiles; clothing and footwear; plastics and metal products; and furniture (Chingwaru2014: 20).The manufacturing sector means any industry, business or establishment operated for the purpose of preparing, producing, making, altering, repairing, finishing, processing, inspecting, handling, assembling, wrapping, bottling or packaging goods, articles or commodities, in whole or in part. This relates to a series of transformationsof value-creating activities required to develop, produce and deliver goods and services to customers after combining a mix of inputs. Key to this definition is a process of transforming inputs into a finished product. Governments typically classify manufacturing by their finished product. Naudé and Szirmai (2012: 9) pointed out that whilst a manufacturing sector is named after finished products of a particular process, they are also an industry where these finished outputs can also be used as intermediate inputs into other finished products. For example, computers are inputs into transportation equipment manufacturing; chemicals are used in agricultural production;and fabricated metals are used in construction, and so on.

1.11.5 Data enveloping analysis

According to Liu, Lu, Lu and Lin (2013: 1), data enveloping analysis (DEA) is a non-parametric productive efficiency measurement method for operations with multiple inputs and multiple outputs. DEA in its current form was first described in Charnes, Cooper and Rhodes (1978: 429)who proposed a novel method that combines and transforms multiple inputs and outputs into a single efficiency composite index.DEA is a "*data-oriented*" approach for evaluating the performance of a set of peer entities called Decision-Making Units (DMUs), which convert multiple inputs into multiple outputs(Cooper, Seiford and Zhu 2011: 1-2).

1.11.6 Decision-making unit

An entity that transforms inputs into outputs through set processes is defined by Cummins and Weiss (2013: 795)as a DMU. Examples could be departments or firms.It is a buyer centre where selection of the most feasible and logical choices of efficient decisions are made from the available options. According to De Brucker, Macharis and Verbeke (2013:123), policy makers in a DMU must be able to forecast the outcome of each option and, based on all inputs utilised, determine which option is the best for that particular situation.Castelli, Pesenti and Ukovich (2010: 210) further noted that another line of research considers DMUs as components of a greater structure which is interested in maximizing its future efficiency by either re-allocating resources or fixing targets to its sub-units. These units should be homogenous, where at least one input is combined to produce at least one output through DMU profit-maximising practices.

1.11.7Capacity utilisation

Capacity utilisation is the percentage of the firm's total possible production capacity that is actually being used.Thus, it refers to the relationship between actual output that is actually produced with the installed equipment, and the potential output which 'could' be produced if capacity is fully used (CZI 2014: 13). It relates to the optimal planning and scheduling of the input resources required to form them into an optimum output without wastage. Guerriero and Guido(2011: 94) described capacity utilisation as the mix that relates to efficient planning of an input vector in the maximisation of the contribution margin, which is the objective function by satisfying the existing capacity limitations and constraints. Specifically, capacity utilization (CU)can be defined as the ratio of actual used (consumed) products to the total availableproducts(Sun 2007: 1508).In addition, capacity utilization refers to the percentage of resources already installed or paid for by firms, such as capital and labour, actually used by corporations and factories to produce goods. This rate tends to move along with the business cycle: increasing during expansions when companies are trying to produce more goods to meet demand, and declining during recessions when demand for goods declines.

1.12 Organisation of chapters

The study is presented in seven chapters as outlined below:

1.12.1 Chapter One: Introduction to the research problem

Chapter Onesets out the underpinnings of the whole study. The reasonit is worth carrying out this research is provided by the objectives and justification of the study. The contribution of this study is clearly shown by the importance of the problem being solved.

1.12.2 Chapter Two: Manufacturing sector in Zimbabwe

An overview of the manufacturing sector in Zimbabwe will be provided using facts and trend analysis. An exploration of the manufacturing sector in Zimbabwe will be conducted to show its decimation and possible drivers. An overview will assist to show that the manufacturing sector in Zimbabwe was once at its peak between 1980 and 2006.

1.12.3Chapter Three: Theories and models of efficiency

Theories and models that explain efficiency are reviewed. Previous studies will be analysed to inform methodology and research gaps. The research will link how the use of efficiency theories and efficiency studies can salvage the decimation of the manufacturing sector in Zimbabwe. A comprehensive discussion and explanation of all key concepts and theories relating to the research questions will be provided. The key concepts and theories include the three types of efficiency: technical efficiency; allocative efficiency (referred to by Farrell (1957: 253) as “price efficiency”); and economic efficiency (referred to by Farrell (1957: 253)as “overall efficiency”). This study will utilise all these two efficiency orientations, namely Output-Orientation and Input-Orientation, will be discussed to determine whether the inefficiency originates from inputs or from outputs. Duality theory and approaches to efficiency measurement will be highlighted as used in other studies.

1.12.4 Chapter Four: Research methodology

This Chapter will focus on how the research was conducted by highlighting methods used in the study.This chapter will offer a justification of the mixed methods research approach used in this investigation. Quantitative and qualitative information will be examined and the choice behind the selection of the design discussed.

1.12.5 Chapter Five: Data presentation procedures

Presentation of visual diagrams will highlight the progression involved in the mixed methods design, as suggested by Creswell and Plano Clark (2007:63). Conceptualising efficiency and assumption in which the results will be presented are explained.

1.12.6 Chapter Six: Measuring efficiency in Zimbabwe's manufacturing sector

Results presented addresses the objective: To measure efficiency in Zimbabwe's manufacturing sector using the production plans of the efficiency scores.

1.12.7 Chapter Seven: Drivers and barriers of efficiency in Zimbabwe's manufacturing sector

Results presented addresses the objectives:

i. To determine the drivers of efficiency in Zimbabwe's manufacturing sector; and
ii. To identify the barriers to achieving efficiency levels in Zimbabwe's manufacturing sector.

1.12.8 Chapter Eight: Recommended efficiency models in Zimbabwe's manufacturing sector

Results presented addresses the objective: To develop an efficiency model that will recommend an efficient input-output use in Zimbabwe's manufacturing sector.

1.12.9Chapter Nine: Interpretation and discussion of results

Interpretations of data will be made using various presentation techniques and discussed in relation to existing literature and objectives.

1.12.10Chapter Ten: Conclusions and recommendations

Chapter 7focuses on the implication of the findings and areas that need further research.The significance of the findings will be explained and linked to the five research questions. Directions for further research will also be discussed.

1.13 Conclusion

The study was motivated by a high unemployment rate of over 80%; large amounts of imports and shrinking exports as alluded to by Chingwaru (2014: 20), with efficiency in the manufacturing sector as the panacea to these economic problems. This chapter provided a background based on the aim of the study. The problem statement argued that despite numerous efforts to improve efficiency in the manufacturing sector in Zimbabwe, decimation in this sector has continued. There are also limited African case studies on the efficiency of the manufacturing sector from which Zimbabwe can learn. This research problem illustrated the inexplicable poor performance of the manufacturing sector in Zimbabwe, given the availability of enabling input factors. The chapter presented the significance of the study for government policy makers, manufacturing sector stakeholders, regulatory authorities and fellow researchers. The methodology used is outlined, paying attention to its usefulness in handling this type of data. The Chapterconcluded by defining key terms and outlining the structure of the thesis.

The next chapter provides acomprehensive analysis of the manufacturing sector in general and Zimbabwe in particular.

CHAPTER TWO

THE MANUFACTURING SECTOR IN ZIMBABWE

2.1 Introduction

The Zimbabwean manufacturing sector is pivotal to the Zimbabwean economy because it provides backward linkages to agriculture and forward linkages to the service sector. Considering the period prior to 2008, the manufacturing industry was considered to be very significant, as it contributed most to the economy's overall GDP.For instance, in 1980 it contributed 22.1% of GDP.However, it slumped to about 7.1 % in 2008. At its crest, the manufacturing sector used to contribute about 42% to export earnings. However, as of 2010, the sector's contribution to GDP and exports was 13% and 27% respectively (CZI 2012:3). The manufacturing sector in Zimbabwe is struggling, with most companies operating below full capacity. As propounded by the Confederation of Zimbabwe Industries (CZI) (2012:5), the industry's capacity utilisation was 18.9 percent in 2009; 57 percent in 2011; 44.9 percent in 2012; and 39.6 percent in 2013. The fall in capacity in 2013 marks a new era of political and economic environments. This chapter provides a comprehensive overview of the sub-sectors distinctive in the Zimbabwe's manufacturing sector.

2.2 Overview of the Zimbabwean manufacturing sector

In order to have an understanding of the manufacturing sector in Zimbabwe today, it is of paramount significance to trace the highlights and patterns of growth of the sector. Davis *et al.* (2012: 5) posited that the downward spiral in the Zimbabwean manufacturing sector began in the period prior to the 1990s, following the twitch of operational alteration as well as earlier the contemporary hyper-inflationary epoch. In the late 1990s, Zimbabwe stood renowned as possessing one of the supreme established sectors of manufacturing inSub-Saharan Africa. The greater part of Zimbabwe's Gross Domestic Product emanated from the manufacturing sector. Also, its production base comprised corporations manufacturing an extensive assortment of merchandise ranging from foodstuff to steel and metals. A customarily sequestered, established pecuniary segment reinforced the progression of the manufacturing sector. Variations in monetary as well as financial procedures, comprising the course of action of upholding an overestimated controlled exchange ratio implemented since 1998 functioned in contradiction to internal manufacturers in support of importations.

The consequent era of hyper-inflation steered an already weakening manufacturingcapacity, leaving behind a tract that is being observed currently. The manufacturing sector currently contributes a smaller amount of less than 15 percent of GDP (CZI 2012: 4). Reversing such a decline is one of the vital intentions of contemporary government policy.Davis *et al.* (2012: 5) noted that the economic as well as regulatory strategies of the government of Zimbabwe in the 1990s, tailed by the hyper-inflationary situation, steered companies to be displaced, with restricted entrance taking place.The majority of those firms that managed to survive and endure in manufacturing commenced their operations not less than 20 years ago.

2.3 Review on the evolution of the Zimbabwean manufacturing sector

Davies, Kumar and Shah (2012:13) traced the background to the Zimbabwean manufacturing sector and propounded that Zimbabwe's manufacturing sector originated fundamentally as a push from the agronomic and mining sectors. It also emerged into a major processor of outputs from the above-mentioned segments, chiefly agronomy. Zimbabwe's internal situation presented a component of ordinary fortification. Following the Second World War, the manufacturing sector was enthused by trade, as well as the outlay strategies of the Federation of Rhodesia and Nyasaland in 1952 to 1962. Before the Federation, the Balance of Payments (BOPs)excesses stimulated by Zambia endorsed capital goods importations by Zimbabwe, whereas labour immigration from Malawi safeguarded an abundant inexpensive workforce. Trade strategy was a federal accountability, and exchange rates stayed fixed to safeguard business that was principally situated in Zimbabwe.

Furthermore, following the Unilateral Declaration of Independence (UDI) in 1965, intercontinental authorizations combined with inland guidelines intended to uphold macroeconomic as well as BOPs, constantly delivered a satisfactory empowering atmosphere. Following the 1980 independence, Zimbabwe continued with success stories in many of its manufacturing sub-sectors. A few years after independence, the government pursued contradictoryand slow-paced economic policiescompared to before independence. Nonetheless, the government relaxedregulation over the budget discrepancy and consequently, an unpredictable macro-economic strategy mix progressively destabilized generally macro-economic stability (Davis 1981:5). The inhibited external interchange locus directed the government to espouse an assortment of procedures envisioned to influence the restriction, although preserving a secure exchange rate. For instance, numerous commodity exchange rates were arrived at and extraneous tradingarrangements for exporters were announced. By the late 1980s,informal openings came under these structures rather than through the official import provision schemes.

After 1997, a number of extra-governmentalregulation actions twisted the feasibility of not only the manufacturing sector, but also other sectors. Macro-economic uncertainty, and ambiguity over property rights, as well as political instability produced a contrary outlay environment which distressed all sectors and its institutional structures. Misguided ratings of energy, as well as other infrastructural facility suppliers, destabilized the practicality of such sectors, principally to the much needed knockon-effects on the rest of the economy, comprising the manufacturing sector. Deteriorating agronomic productivity disadvantaged the stream of raw-materials to numerous manufacturing sub-sectors. Asremarked earlier, the manufacturing sector in Zimbabwe was nurtured from the dispensation of agronomic produces, so this deterioration in deliveries affected the sector’s competitive advantage. The irresponsible scheme of price controls announced in June 2007 had calamitous consequences on manufacturing as well as retailing sectors. The current manufacturing constraints vary from raw materials, institutional challenges, finances, energy, corruption and political instability to world economic challenges. This therefore disturbs the efficiency of the manufacturing sector and its input- output matrix.

2.3.1 Metals sector

Metal production is energy intensive. However, sophisticated energy management systems ensure the efficient use and recovery of energy throughout the steelmaking process for re-use, wherever possible.The World Steel Association Fact Sheet on Energy Use in the Industry (2016: 1) found that energy is one of the major cost drivers of steel production, comprising 20% to 40% of the total cost in some countries. Thus, improvements in energy efficiency result in reduced production costs and thereby, improved efficiency. The energy efficiency of steelmaking facilities vary depending on production route; type of iron ore and coal used; the steel product mix; operation control technology; and material efficiency. Therefore, these are the widely agreed drivers of efficiency in the metal industry.

The steelmaking industry is highly efficient in its use of raw materials with the technology available today. Key contributing factors include high material efficiency rates, by-product recycling and steel recycling. From the data collected by the World Steel Association Fact Sheet onSteel and Raw Materials (2016:20), the metal sector is nearing zero-waste with current material efficiency rates at 97.3%, meaning that 97% of raw materials used on-site are converted to products and by-products that are used or recycled. Recycling and an efficient sustainable supply chain have been noted as the major drivers in the efficiency of the metal manufacturing sector.Steelmakers worldwide look to ensure the sustainability of their supply chains. Many companies have policies and requirements for the safety, environmental and ethical performance of their raw material suppliers. Whenever possible, they work with suppliers to make improvements or corrections in cases of non-compliance.

Table 2.1:Total World Production of Crude Steel

Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Region										
European union	207 386	210 260	198 705	139 436	172 911	177 791	168 589	166 356	169 301	166 115
Other Europe	28 124	30 533	31 621	29 034	33 650	39 079	39 917	38 627	38 374	36 178
North America	131 421	132 618	125 138	83 772	111 562	118 675	121 586	118 978	121 093	110 945
South America	45 269	48 232	47 490	37 776	43 888	48 165	46 379	45 822	45 043	43 899
Africa	18 695	18 675	16 970	15 400	16 624	15 696	15 337	15 963	14 885	13 701
Middle East	15 376	16 452	16 646	17 766	20 000	23 230	24 979	26 967	29 986	29 429
Asia	675 226	758 385	784 090	811 866	918 449	995 457	1 026 801	1 123 646	1 139 667	1 112 872

Source: Adapted from Steel Statistical Yearbook (2016: 1-128)

Asia is the largest producer of metal steel in the world. It hit a record high of 1139667 tonnes in 2014. In the world, the African region produces the least amount of steel. North America and the European Union also have notable amounts of steel metal outputs for the period 2006 to 2015.

Table 2.2: African Steel Production in thousand metric tonnes

Africa Steel statistics										
	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Algeria	1 158	1 278	619	597	662	551	557	417	415	650
D.R Congo, e	30	30	30	30	30	30	30	30	30	30
Egypt	6 045	6 224	6 198	5 541	6 676	6 485	6 627	6 754	6 485	5 506
Ghana	25	25	25	25	25	25	25	25	25	25
Kenya, e	20	20	20	20	20	20	20	20	20	20
Libya	1 151	1 250	1 137	914	825	100	315	712	712	352
Mauritania, e	5	5	5	5	5	5	5	5	5	5
Moroco	314	512	478	499	485	654	539	558	501	516
Nigeria, e	100	100	100	100	100	100	100	100	100	100
South africa	9718	9 098	8 246	7 484	7 617	7 546	6 938	7 162	6 412	6 417
Tunisia	75	80	82	155	150	150	150	150	150	50
Uganda, e	30	30	30	30	30	30	30	30	30	30
Zimbabwe	24	23	<500	<500	<500	<500	<500	<500	<500	<500

e- estimate

Source: Adapted from Steel Statistical Yearbook (2016: 128)

Algeria, Egypt and South Africa are the top metal producers in Africa. In 2006 and 2007, Zimbabwe produced 24 and 23 thousand metric tonnes. Since then, Zimbabwe has failed to produce above 500 tonnes of steel metal.

The metals sector is a sub-sector of the manufacturing sector where metals such as nickel, chrome, copper and platinum are products of the Zimbabwean mining industry. Unfortunately, most of these are exported in their raw state because Zimbabwe does not possess enough machinery and equipment to process such metals into finished goods. The metals sector is sub-divided into eight major categories which consist ofmaterial extraction, metal processing, metal forming, metal fabrication, equipment assembly, distribution of product, retailing, as well as the marketing. Zimbabwe Economic Policy Analysis and Research Unit(ZEPARU) (2011:17) noted that the metals sector could become pivotal to the Zimbabwean economy if supported by sound policies and regulations, as well as the injection of funds for recapitalization.

Despite being regarded as the most vital sub-sector of the manufacturing sector, the metals sector is also said to be not very competitive in the global market. In the period between 2010 and 2012, the sector registered a trade deficit of approximately US$3.3 billion, translating into an average of about US$660 million annually. The trade deficit was mostly attributed to the engineering and metals commodities. Because the engineering goods sub-sector recorded a tremendous deficit of about $8.1 billion, despite a slight trade gain of the metals sector of $ 4.8 billion. According to ZIMSTAT (2010: 6), the resuscitation of the engineering sub-sector and an export-led industrial rejuvenation resulted in the turn-around of the trade deficit. The deficit was somehow spearheaded by the non-operation of major players such as Zimbabwe Steel Company (ZISCO) because they became the major missing link in the chain.

The analysis of Gross Output intermediate consumption and the probable value added for the period 2010-2012 indicated that the metals sector manufactured approximately US$1.9 billion to the gross output and added value of about US$1.1 billion annually. Thus, the overall value added was about 58%, suggesting that the market players that were responsible in value addition were successful. In recent years, processing plants have been developed and there is opportunity for conversion of raw materials into processed or semi-processed products for export. CZI (2016:8-10)propounded that the metals sector of Zimbabwe has the potential to generate approximately 14 billion annually if well recapitalized. For the metals sector to be as successful as projected, an investment of about US$145 billion was found to be adequate.

In 2014, some metal prices, specifically precious metals, remained firm.For instance, the price of gold increased by 7.64% in January that year but the price receded in the fourth month of the same year due to the fall of the USA long-term interest rates, as well as the intensification of geographical risk in Ukraine and Russia. Platinum prices firmed from US$1420.43/ounce (Quarterly Economic Review, RBZ, 2014:11).In January,the metals' price further increased to US$1452.60/ounce. on the back of supply-side concerns precipitated by labor disputes in South Africa, which is the biggest producer of platinum in the world. The diagram below indicates the projected output of metals since 2012 to the end of 2013.

Table 2.3: Mineral Output for 2013 expected to surpass 2012 production

METAL	2012 Actual	2013Jan-June Actual	2013Projections
Gold (kgs)	14 742	6 727.36	17 000
Coal (tones)	1784.763	955086.00	2000.000
Nickel (metric tons)	7899	4887.333	10000
Platinum (kgs)	10524	65499.4	12500
Chrome Ore (tones)	408.475	92073	282000

Palladium(kgs)	8136	5068.54	10000
Diamonds (tones)	12014802	-	16900000

Source: Adapted from BBC and KITCO (2013)

According to the December 2013 parliamentary report, the prices of various metals were projected to decelerate, with the exception of nickel. An approximately 4.2% decrease in the overall metals sector was projected in 2014. The parliament of Zimbabwe suggested that the projected decreases in the metals sector have adverse implications for the overall economy's recovery. The table below indicates the projected metal prices for the period 2013-2016, as presented in the 2016 parliament of Zimbabwe.

Table 2.4: Zimbabwe's Metals and minerals prices forecast

Metals	**Unit**	**2013**	**2014**	**2015**	**2016 (est)**
Gold	**US$/toz**	**1380**	**1360**	**1350**	**1345**
Platinum	**US$/toz**	**1480**	**1450**	**1400**	**1384**
Copper	**US$/ton**	**7100**	**7050**	**7000**	**6980**
Coal	**US$/toz**	**76**	**73**	**73**	**73**
Aluminum	**US$/toz**	**1800**	**1850**	**1900**	**1928**
Iron ore	**US$/toz**	**134**	**135**	**137**	**138**
Nickel	**US$/toz**	**1400**	**1500**	**1600**	**16190**

Source: Adapted from BBC and KITCO (2013)

The highy priced metal mineral is copper during 2013 to 2016. Despite being bulk, coal fetched low prices amongst other minerals.

2.3.2Chemicals and petroleum products sector

The Petroleum and Basic Chemical manufacturing sector had the largest impact on energy consumption and hazardous waste generation, and accounts for 19% and 44% of total impacts for each of these environmental impacts, respectively(Egilmez, Kucukvar and Tatari 2013: 101).

Table 2.5: Sales of Chemicals and petroleum products

	Sales (billion $)	Population (million)	Sales/per head of population ($)
China	956	1 338	714
US	532	309	1 720
Japan	228	127	1 800
Germany	203	82	2 480
South Korea	153	49	3 120
Brazil	114	195	585
France	108	65	1 660
Taiwan	81	23	3 520
Russia	73	142	514
Netherlands	72	17	4 240

Source: Adapted from From Facts and Figures (2011), CEFIC

Most chemicals are sold in China followed by the US for$956 and $532 billion USrespectively. China sells much because of the high population, as signified by lower sales per head as compared to their US counterpart. There is no African country in this top ten list.

The major drivers of efficiency in the Chemical and Petroleum manufacturing sub-sector are economic competitiveness; compressing time to market; reducing infrastructure vulnerability; expanding markets for companies; decreasing the supply chain for communication costs; providing global access for software vendors and reducing duplication effort. Obviously, these are all goals worth striving for but they often prove difficult in a latecomer industry. Industry standards will be necessary to provide the inter-operability amongst third party IT components to achieve integrated operations. As the need for standards inter-operability grows, it will require more co-ordination of standards organizations with a more cross-functional focus, despite some of the barriers mentioned before. However, the early adopted standards have had their own difficulties in implementation. One of the key issues which inhibited the implementation of data standards in the petroleum industry was the piecemeal and inconsistent implementation of the various standards in the industry which, at times, would overlap and be redundant. Even within a particular standard, implementation would be uneven, with various versions of a given standard being used at any given time. This particular problem was discussed in 2011 at an Energistics Conference.

According to the American Petroleum Institute andan Ernst and Young study quoted in Cotton, Grissom, Spalding and Want (2012: 5), the five major oil companies had $765 billion of new investment between 1992 and 2006, compared to net income of $662 billion during the same period. Overally the industry consisting of the 57 largest U.S. oil and natural gas companies, had new investments of $1.25 trillion over the same period, net income of $900 billion and cash flows of $1.77 trillion. To compare revenues, Exxon Mobil, the world's largest publicly traded oil company, reported net income of $9.4 billion for the fourth quarter of 2011, up from $9.25 billion the year before. It posted revenue of $121.6 billion, up 16 percent. Also in the fourth quarter of 2011, ConocoPhillips had revenues of $62.4 billion.

ECOWAS is an African regional grouping participating in the exportation of petroleum. For the period 2010-2014, Torres and van Seters (2016: 11-23) show thatof its total exports to the EU, ECOWAS exported 61% petroleum crude and 6% petroleum oil. Nigeria accounts for 73.5% of total registered ECOWAS exports, primarily as a result of its petroleum exports but also due to its larger economy.

This sub-sector of the manufacturing sector in Zimbabwe sells wide-ranging products comprising pesticides and paints as well as varnishes, fertilizers, pharmaceuticals, soaps and cleansing products, perfumesand cosmetics. Huge possibilities for this sub-sectorexist to expand into the technical application for manufacturing For instance, the production of core extruded products, laminations or woven products, polyvinyl chloride and polyethylene barriers (Zimbabwe Investment Authority 2011:3).

Expansion in chemicals as well as petroleum products is dependent upon settlement of debt by the government to producing companies such as fertilizer manufacturers.Failure by government to settle its debt has crippled operations in the sub-sector. Notwithstanding the debt, Zimphos, which is one of the producers, invested in a new plant as well as machinery with the primary motive of boosting output in the sub-sector. In its survey, CZI (2012:7)indicated that the capacity utilization of chemical and petroleum products was approximately 41.6%, although the whole manufacturing sector is constrained by a wide range of factors such as lack of funding, infrastructural setbacks as well as competition from well-established foreign firms.It was projected that the index was likely to increase from 2012 to 2014, as shown by the table below.

Table 2.6: Projected Index of the chemicals and petroleum output

	Chemical and petroleum products
Weight	**11.5**
2012 *Est.*	**130.4**
2013 *Proj*	**134.2**
2014 Proj	**137.9**

Source: Adapted from ZIMSTAT(2014)

The local market for fertilizers and pesticides offers opportunity for further development to provide additional manufacturing capacity for local demand and export within the region. There is potential to increase production of ethanol and give opportunity to the investor for increased production for new export markets, the introduction of new technology and licence to produce new products. Pharmaceuticals are one of the major components of chemical and petroleum products. The sub-sector's greatest challenge in Zimbabwe is the failure by government to protect local firms that produce some products, for instance pharmaceutical products. This challenge arises against the backdrop of imported chemicals and drugs being exempted for duty, as well as Value Added Tax(VAT) through the Statutory Instrument 220 of 2000.

On the other hand, raw materials by local Zimbabwean manufacturers making the same products attract a duty of about 40 percent and 15% VAT.As a result, high tariffs on such products increase the costs of manufacturing by local firms. Therefore,imported goods will be cheaper compared to locally produced goods. This makes such products cheaper to import than to produce. Consequently, the local manufacturing sector is affected in terms of sales,as is the overall economy. The majority are well catered for with a wide range of local and international brands being manufactured and marketed locally and within the region. However, an opportunity exists for the development of medical products from locally grown, natural raw materials, including the controlled growth of prescribed drugs for the industry. An investor wishing to consider any of these opportunities should, in the first instance, contact the Confederation of Zimbabwe Industries.

2.3.3Non-Metallic minerals sector

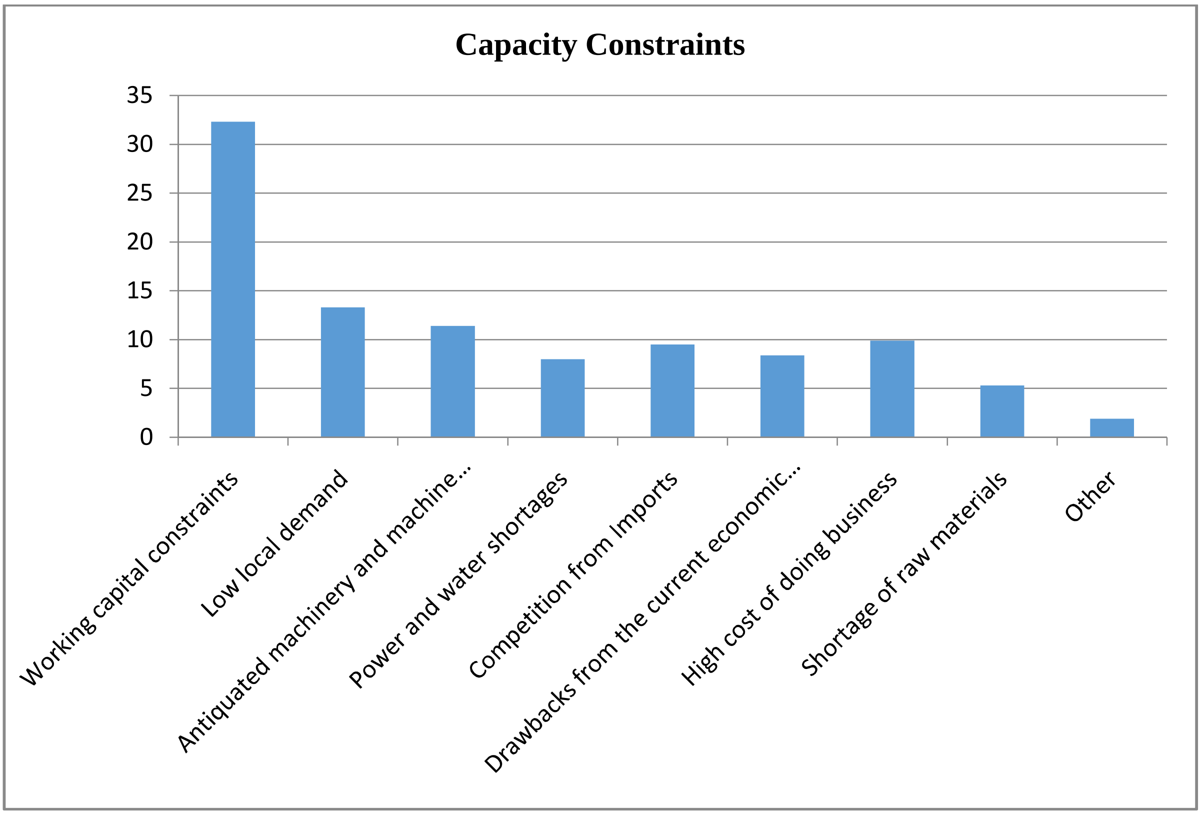
Production of non-metallic minerals includes cement and ceramic products (e.g., tiles, bricks), glass and lime. Based on data reported for 2010 on energy balances by the International Renewable Energy Agency (2015: 70), fossil fuel-based heat demand of the non-metallic minerals sector is estimated at 10 Exajoules (EJ) for 2030. A large share of the sector's heat demand is via direct heat at high-temperature applications (>90%).Aranda-Usón, Ferreira, Mainar-Toledo, Scarpellini and Sastresa(2012: 484) found that in Spain, higher consumption of thermal energy was seen in equipment such as furnaces and dryers, depending on their relative importance to the specific activity. More common items of thermal equipment were regenerative furnaces (powered by combustibles and electricity); unit melter regenerator furnaces (powered by combustibles and electricity - the former being less efficient); melting furnaces (combustible); electrical furnaces; and sintering furnaces (combustible). They further noted that the non-metallic mineral products sector had the highest consumption (24.7%) compared with those observed in the other three sectors analysed (food, drink and tobacco, 9.6%; textile, 4.6%; chemical, 14.7%).

Mineral Commodity Summaries (2016: 3-18) presented that the world's most mined non-metallic minerals are lime (350 million metric tons produced annually); salt (270 million metric tons); and phosphate rock (220 million metric tons). China and India have the largest non-metallic mineral reserves in the world. Because of their strong construction markets and rising food needs, China, India and Brazil are poised for the most growth in the industry. The US non-metallic mineral mining and quarrying industry includes approximately 5,000 establishments (single-location companies and units of multi-location companies) with annual revenue of approximately $28 billion.

Non-metallic minerals have the highest deposits concentrated in the Northern part of Africa. Zimbabwe’s geological environment that dates back to over 300 million years is said to possess a great possibility for hosting a variety of economic minerals and rocks. More than 60 minerals, including metallic as well as non-metallic, have been produced up to 2016 which indicates that the nation is one of the globe’s best known producers of such minerals (Ministry of Industry and Commerce 2011). Non-metallic minerals are also founded in the Zimbabwean manufacturing sector. Non-metallic minerals such as rocks like limestone, dolomite, phosphorite, quartz, mica, clay, silica sand, gemstones, decorative and dimension stones, and construction materials are the common non-metallic minerals in this sub-sector. Dube (2016:3-30) confirmed that the non-metallic sector contributes approximately 23.3% to the total manufacturing sector.

A large area for joint venture investment lies within the oil processing industry where an influx of small-scale indigenous producers would benefit from new technology and the establishment of regional or international marketing organizations. Generally, the milling industry has capacity which could be developed to promote exports into the region. Further opportunity exists in the growing demand for cereals and snack-type products to service not only supermarket requirements but many new franchise outlets. This sector, like all other sub-sectors of the manufacturing sector, is under-performing due to a variety of economic catastrophes that have greatly affected the economy. Figure 3.1 indicates the industrial constraints that have affected the non-metallic sector.

Figure 3.1: Non-Metallic Barriers



Source: Adapted from the annual CZI Manufacturing Sector Survey (2012)

Lack of working capital and low local demand were found to be the major barriers to efficiency in the non-metal industry. The other barriers were inadequate machinery constrained with power shortages and competition from imported non-metal goods.

2.3.4Transport and transport equipment sector

Industries in the Transportation Equipment Manufacturing sub-sector produce equipment for transporting people and goods. Establishments in this sub-sector utilize production processes similar to those of other machinery manufacturing establishments - bending, forming, welding, machining and assembling metal or plastic parts into components and finished products. Productivity of the US Transport and Transport Equipment sub-sector is shown below:

Table 2.7: Productivity of the US Transport and Transport equipment sector

Data series	**2012**	**2013**	**2014**	**2015**
Labor productivity index, output per hour	112.810	115.579	118.647	119.158
Percent change from previous year	3.6	2.5	2.7	0.4
Labor index, total labor hours	88.767	90.890	93.672	96.292
Percent change from previous year	6.8	2.4	3.1	2.8
Output index	100.139	105.049	111.139	114.740
Percent change from previous year	10.7	4.9	5.8	3.2
Unit labor costs index	99.791	99.503	97.259	95.842
Percent change from previous year	-1.5	-0.3	-2.3	-1.5

Source: Adapted from the United States of America's Bureau of Labour Statistics (2017)

The labour productivity index is increasing, showing an improvement in the US Transport and Transport equipment sector's use of labour. Output is also on the rise, showing that the sector is efficient given that its inputs are increasing together with an increase in output.

Transport and transport equipment is one of the major sub-sectors of the Zimbabwean manufacturing sector.During the period of inclusive government, the transport sub-sector was regarded as one of the major sectors that was significantly pivotal towards the enhancement of the manufacturing sector, as well as the overall economy. Manufacturing FactSheet (2012: 1-2), states that the transport and transport equipment constitutes approximately 6.7 % ofthe total manufacturing sector. The transport network comprises of air, rail and road transport. It is the major sub-sectorresponsible for ensuring the link in several sectors of the economy. Since the Zimbabwean manufacturing foundation was largely affected by the long-term financial resources and high cost of available short-term loans, so does the transport cost. The transport sector facilitates economic activities and access to local, regional and international markets. Following the massive downturn of the Zimbabwean economy since 2000, the transport sector was affected. This saw the failure of the National Railways of Zimbabwe (NRZ) to provide rail transport for the carriage of significant raw materials within the country, as well as the region.

Consequently, production/manufacturing of certain products deteriorated since some products that the rail transport used to carry failed to reach their destination. Furthermore, the recent catastrophe facing Air Zimbabwe resulting in its failure to operate adequate planes means that the networking for the required raw materials as well as other required goods was largely affected. The road transport in Zimbabwe is greatly affected by the condition of the roads. The overall condition of Zimbabwean roads was negatively affected by inadequate funding for regular maintenance. The unavailability of proper transport equipment means that the modes of transport are not adequately serviced, resulting in the shortage of transport for both raw materials as well as finished goods to their probable destinations. The transport and transport equipment sector is currently not operating at full capacity due to a lack of adequate funding. The failure of the economy saw the failure of major transport providers, as well as the collapse of car plants. For example, the Willowvale car assembly plant failed to continue operating due to financial hardships.This, implies that transport is imported from other countries, hence the failure of the local transport and transport equipment sub-sector. Transport equipment is important for the manufacture and servicing of the modes of transport. The existence of limited transport equipment such as spare parts means the transport needed to link several sub-sectors is affected, which will also affect the production of vital products in the economy.

2.3.5Paper Printing and publishing sector

The printing industry includes establishments engaged in printing text and images on paper, metal, glass, apparel, and other materials. The publishing industry includes firms that produce and disseminate literature or information through books, newspapers and periodicals. Together, the printing and publishing sector is composed of the following three segments:

- Printing: firms that are engaged in lithographic printing, gravure printing, flexographic printing, screen printing, quick printing, digital printing, manifold business forms printing, books printing, and blankbook looseleaf binders and devices manufacturing.
- Support activities for printing: firms that are engaged in trade-binding and related work, and pre-press services.
- Publishing: firms that publish newspapers, periodicals, books, directory and mailing lists, greeting cards and other materials.

Table 2.8: Share of Paper Printing and Publishing sector in US manufacturing

	2002	2012	2002-2012
Manufacturing labour	36,6	38,3	1,7
Manufacturing intermediate services	19,8	20,7	0,8

Source: **Adapted fromUSDOL, BLS, Occupational Employment Statistics, Commission calculations (2013)**

The paper printing and publishing sector in the US contributed a 36.6% share of the workforce in the manufacturing sector in that country. This figure increased marginally to 38.3% in 2012, signifying a 1.7% increase. This sector, in 2002, contributed 19.8% of its output as intermediate services to the US manufacturing sector. This contribution increased to 20.7% in 2012.

In Zimbabwe, there is the 1975 Act (25:14) that stands to consolidate and amend the law in relation to the printing as well as publication of paper. This refers to books, newspapers, periodicals and other printed publications, as well as the preservation of such papers and publications locally. This Act postulates thatexpressions referring to printing shall be construed as including references to any other means of representing or reproducing words or figures in visible form. In Zimbabwe, there are many companies that engage in the paper printing and publications sub-sector. For instance, institutions like College Press, Mambo Press, Longman and The Herald are good examples of firms in paper printing, as well as publication. For example, the Herald has been in business since 1891 and it has been successfully operating, to some extent, at full capacity. Following the massive economic meltdown in 2008, the paper printing and publications sub-sector was like any other sub-sector that was massively affected and the industry now is not operating up to its expected standard. CZI (2012:14) propounded that this part of the manufacturing sector was greatly affected by industrial melt-down. Paper printing and publishing was severely affected by the absence of long-term finance in technology. The paper printing and publications sub-sector was also affected by the availability of internet in the country.Most people nowadays do not read hard copies, making it practically impossible for the sub-sector to maximize its profits. Considering the fact that the manufacturing sector in Zimbabwe degraded to39% in 2013from 42% in 2011, the paper printing and publication industry was also hugely affected. The CZI (2013:17) noted that instead of improving, they projected the sector to be falling into intensive care. ZIMSTAT (2010: 8) noted that the paper printing and publishing sub-sector contributes about 11.2% of the total manufacturing sector of the country. According to a 2013 report by the Zimbabwe Chamber of Mines,the capacity utilization of paper printing and publishing was approximately 58% in 2011 but fell to about 20% in 2013, an approximately 38% downturn (Ruzivo Trust Manufacturing Factsheets 2010:3).

Some of the factors that led to the decrease in the capacity utilization of paper printing and publishing include high production costs and massive power cuts. Firms that are involved in the printing and publishing of paper propounded that the machinery and equipment they use are out-dated,which makes it more expensive to print paper. The massive power cuts that have been regular in Zimbabwe also affected the paper printing and publishing sector in the country. The Energy and Power Ministry announced in 2015 that the country had to endure power cuts as well as outages because of water shortages in the dam where power is generated. This means that the printing and publishing of paper was greatly affected since printing paper needs electricity.Some of the firms in the sector had to resort to generators but with the exorbitant prices of fuel to power the generators in the years prior to 2016, means productions costs had to double making profit maximization almost an impossible task.

2.3.6Foodstuff sector

Europe’s food and drink industry is world-renowned for combining tradition with diversity to provide safe, high-quality, tasty and affordable food and drink products. It is a key pillar of the European economy and continues to be an engine for growth, despite the current economic situation. According to Eurostat (2012: 4), the food industry brings products to market which cater for both the dietary and ever-changing daily nutritional needs of Europe's 500 million consumers, and increasingly puts environmental considerations at the heart of its business practices. Through constructive dialogue with food chain partners, specifically in the context of the High-Level Forum1 for a Better Functioning Food Supply Chain, FoodDrinkEurope aims to ensure the competitiveness of Europe's food manufacturing industry. The major drivers of efficient manufacturing of food were found to be access to third world markets, as well as opportunities to bring new products and processes to market through research and development and innovation.

Table 2.9: Percentage contributions to turnover, value addition and employment in the EU

	Turnover	**Value Addition**	**Employment**
Food and drink product	16	13,8	14,6
Automobile	10,8	7,1	7,7
Machinery and equipment	8,8	10,7	9,9
Chemicals	7,2	6,6	11,7
Fabricated metal products	6,9	9,8	-
Rubber and plastic products	-	-	5,5
Other	50,3	52,1	50,6

Source: Adapted from Data and Trends of the European Food and Drink Industry (2011)

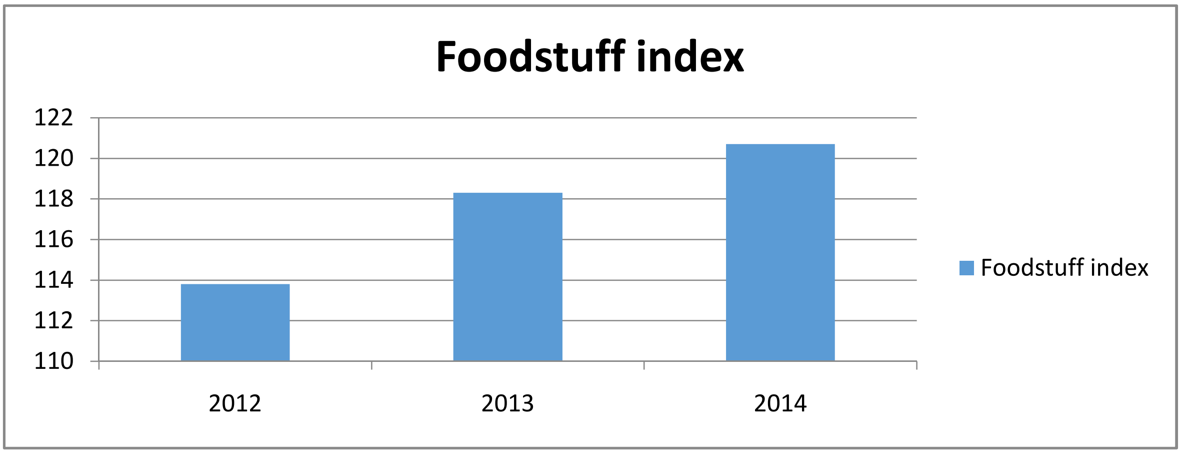
The food and drink industry tops the list in EU in terms of its contribution to turnover (16%), within an estimated turnover of €956 billion per year. It also has the highest rate of employment, totalling 14.6% of the over 4 billion people employed in the EU. In terms of the total value of value added, it contributes 13.8% to the EU manufacturing sector.

Zimbabwe used to be the bread basket of Africa and itused to supply its African counterparts with food and foodstuff. Zimbabwe is an agro-based economy and its manufacturing sector used to operate near full-capacity utilisation. The foodstuff sub-sector relies on the performance of the agricultural sector, which the country is having problems in.Agricultural output has been falling due to factors like drought and high costs of raw materials. Confederation of Zimbabwe industries (2012:7) suggested that foodstuff was operating at 58.2% when average capacity utilization of sub-sectors was 44.9%. This is not impressive because the local foodstuff suffer stiff competition from South African and Zambian imports which make their way through porous borders. Zimbabwe is importing maize, wheat, rice, salt, cooking oil, fruits and vegetables as well as milk and milk products. These imports reduce competitiveness of domestic products and force domestic producers out of their business leading to low GDP and high unemployment rate in the economy. A few firms have recapitalised to boost production of foodstuff products but they have failed to meet the domestic supply gap hence causing a high import bill to the economy.

The government tried ways to create domestic demand by ban of eggs and chicken which are genetically modified but the local production failed to supply adequately leading to smuggling of foodstuff in the country. The foodstuff sub-sector in Zimbabwe has failed to cater for a quarter of the population and the manufacturing sector has been operating below full capacity facing a lot of inefficiencies. With most of Zimbabweans being unemployed their consumption patterns are reduced hence no motive to demand more foodstuff as they do not have income to spend as their disposal income has fallen. Unemployment, inflation and current deflation has caused the sub-sector to become an importer of raw materials and also face high production costs. Less attention has been given on repairing and maintenance of obsolete machinery in the sector, hence, quality of domestic foodstuff is outweighed by foreign products so is the prices.

With a population of 52 million people, South Africa is a food self-sufficient country with most of its food being locally produced. South Africa's foodstuff is made out of local raw materials hence it makes their products cheaper and competitive. South Africa's foodstuff sub-sector has been a major revenue earner for the economy with most of its output being exported to Zimbabwe. South Africa has a lower cost of production as some of the firms are subsidies and have export incentive. More companies are opening in the food sector hence increasing output where excess is exported. South Africa's foodstuff has been much supported by government aid and a rise in consumer spending due to high incomes from the employed workers. South African firms have associations with firms overseas to acquire access to the latest technology and expertise in their respective industries like Simba with Fritosoups (USA) which are in the snack food industry and Robertsons with Bestfoods (USA) are in savoury and soups.

Figure 3.2: Foodstuff Index



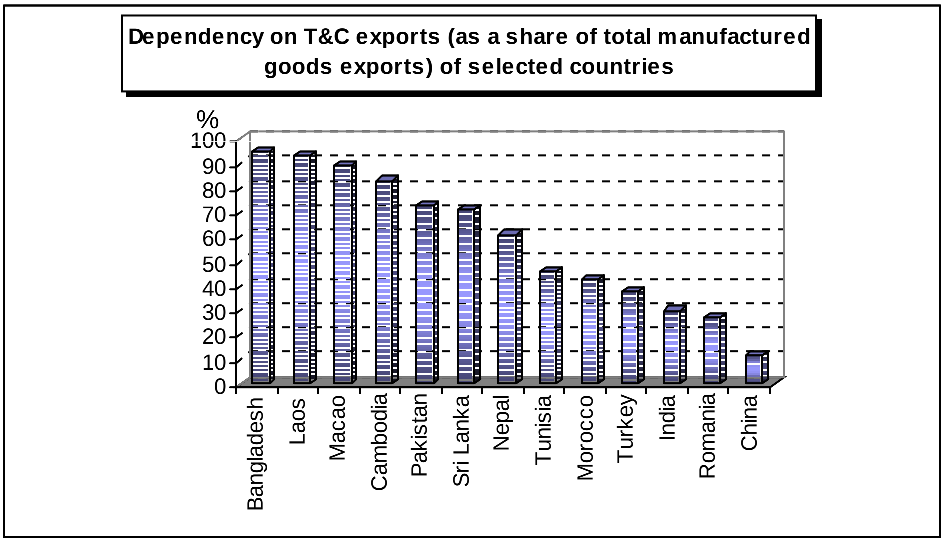
Source : Adapted from CZI (2014)

The diagram above shows that in 2012, the production index of foodstuff was 113.8 and 118.3 in 2013 and 120.7 in 2014, showing an increase in output of 6.9 from 2012 to 2014.

2.3.7Textile sector

The textile sector of Pakistan is large and is a key industrial sector of Pakistan and the world. Memon, Bhutto and Abbas (2012: 13) found that Pakistanitextile firms possess high amounts of fixed assets,which has a negative impact on the performance of the firms. Textile firms in Pakistan are poor in terms of their productive and allocative efficiency. This inefficiency of the textile sector is followed by some serious issues like the severe energy crisis in Pakistan, poor law and order conditions and political instability.Moreover, textile firms in Pakistan are also operating under the optimum level of capital structure and due to this poor selection of capital structure, the financial performance of textile firms is adversely affected. Keeping in mind the importance of this sector, it is suggested that financial analysts and managers should emphasize on optimum level of capital structure and the efficient utilization and allocation of resources. This will help to achieve the targeted level of productive efficiency in the textile sector of Pakistan.

Figure3.3: Dependancy on textile and clothing on exports as a share of exported manufactured goods



Source: Adapted from ComTrade Data (2001)

Some developing countries(DCs) are highly dependent on textiles and clothing exports. This is the case in particular of LDCs and of some Mediterranean countries. The highest share of total industrial goods exports of textile and clothing exports is accounted for by Bangladesh (95%); Laos (93%); Macao (89%); Cambodia (83%); Pakistan (73%); Sri Lanka (7%); Nepal (61 %); Tunisia (46%); Morocco (43%); Turkey (38%); India (30%); and Romania (27%), with China being only 12%.

Table 2.10:Main constraints facing textile businesses in Zimbabwe

1	Shortages of foreign currency, fuels, chemicals and spare parts
2	Inadequate access to raw materials
3	High level of inflation and interest rates
4	A fixed exchange rate system
5	Increased labour market inflexibility
6	Shortages of water and electricity
7	Declining access to healthcare
8	High staff turnover and migration

Source: Adapted from Chiripanhura (2010)

Chiripanhura (2010: 153–175) found that shortages of foreign currency, fuels, chemicals and spare parts in the textile sector are the main barriers in the sector, followed by inadequate raw materials.

Chiripanhura (2010: 172–175), also noted that textile firms in Zimbabwe have enjoyed survival from drivers coming from the implementation of new management techniques that allowed them to increase machine utilisation, continuously improve quality and reduce wastage. He also cited foreign ownership having facilitated the necessary structural changes, as well as enterance to and maintainance of export markets. While there were variations in terms of the implementation and success of the reforms, the changes allowed firms to continuously evolve in line with new economic conditions. It has been shown that technological innovation played a key role in the success of the studied firms. Many of them updated their technologies and also implemented various types of flexibility that increased their efficiency and productivity.

After Economic Structural adjustment Programme (ESAP) of 1991, the manufacturing sector faced de-industrialisation and in 2003, the Zimbabwean government officially launched the Look East Policy to trade and have foreign direct investment (FDI) from Asia, specifically China. The policy aggravated the condition resulting in an influx of cheap, poor quality goods from the East, especially China. The textile industry almost collapsed when major firms like David Whitehead and Modzone Cone Textile closed. Output started to decline, especially manufacturing output overall,instigating a rise in unemployment. After the Look East policy, local textile companies failed to cope with competition and more firms closed down. An estimated 30 000 people became jobless. Government stopped subsidising and opened up the sector to competition. Inefficiency in the sector was also contributed to by the fast-track Land Reform programme of 2000.White commercial farmers were the major players with working capital, expertise and collateral for funding by which they could challenge international products and export their excess.The fast-track Land Reform programme brought raw material availability to the fore as a barrier in the textile manufacturing sub-sector.

The newly appointed black owners of textile firms faced outdated equipment, low domestic demand, constrained funding and cheaper imports. Kanyenze (2006: 23) argued that in 1990, the textile industry employed 24 000. However in 2005 after ESAP and the Land Reform era,employment was 11 522, falling to less than half. He went on to show the rise in imports, which in 2000,2001,2002,2003 were 25 917, 14 743, 20 937 and 43 070 tonnes respectively. Zimbabwe’s textile sub-sector was greatly affected by poor transport and communication infrastructure. The sector needs joint ventures with foreign investors who can bring new technology which is used to produce more at lower cost and fight competition from cheaper imports, but all this is affected by the Indigenisation and Economic Empowerment Policy.

South Africa's textile industry has undergone significant technological developments and has benefited from sophisticated communication and transport infrastructure. When textiles are combined with footwear, leather and clothing,they create 14% of manufacturing employment, representing South Africa's second largest tax revenue earned. It contributed 8% of GDP and created 60 000-80 000 jobs in 2014. The sector is South Africa's third largest employer in manufacturing sector and the eleventh largest exporter of manufactured goods. In the last quarter of 2009, textile and clothing contributed 4.9% of total manufacturing output. From 1994, more than US$1-billion has been spent on upgrading and modernising South Africa's textile, clothing and footwear industries, making it efficient and competitive on the international market. Local demand has risen as development has been taking place with a wide range of services from natural and synthetic fibre production to non-woven, spinning, weaving, tufting, knitting, dyeing and finishing. The South African government has trade agreements with the European Union and the United States. In the case of the USA, textile imports have increased under the Africa Growth and Opportunity Act (AGOA), which has been in place since 2000 and offers tangible incentives for African countries to continue their efforts to open their economies and build free markets.

Figure 3.5: Textile Index in Zimbawe

Source: Adapted fromCZI (2014)

In the textile industry, the production output index was 67.7 in 2012; to 65.3 in 2013 and 62.8 in 2014. This showed a decrease by 4.9 between 2012 and 2014. The fall in textile was directly affected by a decline in cotton output because it is the major input of the sub-sector.

2.3.8 Beverages and Tobacco sector

Food manufacturing accounted for $738.5 billion (12.9 percent) of all U.S. manufacturing shipments in 2012, while beverages and tobacco products accounted for $142.5 billion (2.5 percent). Combined, these industries accounted for $881 billion (15.4 percent), forming the largest single industry within the manufacturing sector (U.S. Department of Commerce, Economics and Statistics Administration 2012: 1).

The report from the International Labour Organisation (ILO) (2011: 1-4) identified the following barriers and drivers in the beverages and tobacco manufacturing sector:

Barriers

- Sustainable food production;
- Uneven industry-retail relations within the food chain;
- Labour productivity and employment security;
- Low skills;
- Occupational health and safety;
- Equality and employment conditions; and
- Policy issues

Drivers

- Promote productive and decent jobs.
- Increase food security and food safety.
- Develop alternatives to tobacco growing and processing.
- Encourage competitive and sustainable production systems.

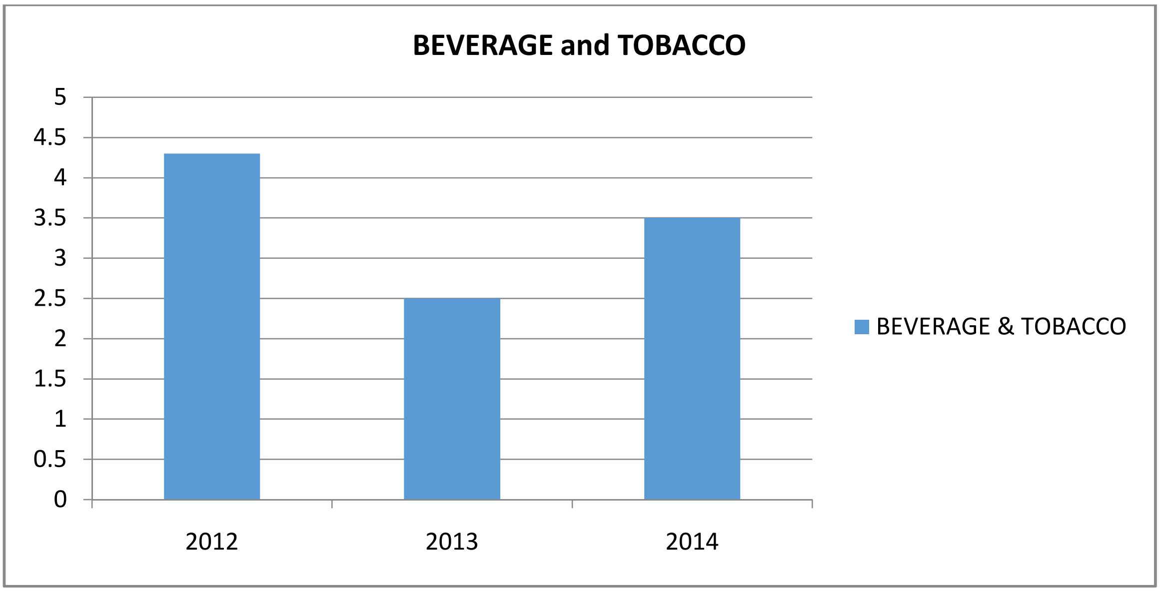
Beverage manufacturing in Zimbabwe consists of businesses that make alcoholic and non-alcoholic beverages. Tobacco businesses produce products like tobacco leaves, cigarettes, re-dry and stem tobacco. With most Zimbabwean farmers being tobacco farmers, the plant has largely attracted a number of players through its higher buying price and demand both locally and abroad. Tobacco as a sub-sector has benefited the manufacturing sector by creating employment to the economy and being one of the biggest revenue as a crop. The tobacco sub-sector has the potential to boost the economy because it is the highest earning exported crop, with demand from China, Japan and Canada. If it was not for the sanctions by the West, tobacco could be the largest employer in the manufacturing sector, followed by beverages. The large number of farmers producing it has reduced its price on the international market. The prices are no longer high due to many countries producing the crop. Tobacco and beverages are the few sub-sectors that manufacturing heavily depends upon as they seem to be the major contributors to GDP.

The beverage industry in Zimbabwe is one of biggest employers with the biggest output in the manufacturing sector. The Zimbabwean economy's tax base has been depending on beverage firms because they have a high domestic demand and consumption is not directly related to income, but taste and preference. The biggest firms in the beverage industry are Delta, Schweppes and Pro-brands. The sector has been of help to the manufacturing sector, but is largely affected by South African, Malawian, Zambian, Mozambican and Botswanian products like Twizza, Dragon and Tambilani. The drinks and other products they produce are affected by the growing demand for ciders which are made in South Africa. These ciders have substituted local beers, drinks and wines. This means a fall in revenue, falls in output, high import bills and falls in capacity utilisation affecting the overall manufacturing sector. The government should help the sector through a free tax of the equipment and machinery used to produce ciders because it is expensive. Furthermore, there should be removal of tariffs on steel cans for packaging purposes.

South African beverages and tobacco are big sub-sectors because their government subsidies them and has trade agreements with European countries, whereby they buy equipment for beverages at a cheaper price and they also export their tobacco at better conditions than

Zimbabwe, which is on sanctions. Beverage is high because South Africans have grants and unemployment benefits, which they mostly spend on drinks, beer, wine and cigarettes.

Figure 3.6: Beverage and Tobacco index in Zimbabwe



Source: Adapted from Zimstat (2015)

Beverage and Tobacco index in 2012 was 91.6 and it dropped to 94.1 in 2013 and in 2014 it rose to 101 as many farmers had increased their efforts and rain had improved.

2.3.9 Clothing and Footwear sector

According to the World Footwear Yearbook in 2015 the worldwide production of footwear reached 23.0 billion pairs, a slight decrease of 0.4% from the previous year. Apart from a decrease registered in 2009 during the financial crisis, this is the first time in decades that footwear production levels declined.

At a continental level, the geographical structure of the industry remains broadly unchanged from previous years. With 87% of world production, Asia is the hub of the footwear industry, with 7 out of the 10 main footwear producers.

At a country level, China is the indisputable leader, producing almost 6 out of every 10 pairs of shoes sold in the world. China's share in world production has increased in a sustained way in the last few decades and peaked in 2013. However, in the last two years the country has lost quota in world production and is back to the share levels of 2010.

Asia continues to increase its lead as the largest footwear-consuming continent, as its share of consumption (53%) almost matches its share of the world population (60%). At a country level, China is the largest footwear market, buying almost one out of every five pairs of shoes sold worldwide. In spite of the decline in 2015, over the last decade the value of the footwear exported worldwide doubled. A major contribution to this movement comes from China, whose footwear exports in 2015 came to just under 10 billion pairs, reducing the country's share of the world total to a still very impressive figure of 69%. Moving in the opposite direction, Vietnam crossed the 1 billion pair threshold and achieved a share of 7% in worldwide exports (World Footwear Yearbook 2011:16).

Successful footwear manufacturing in Africa can be seen in Ethiopia. Footwear manufacturing in Ethiopia can be traced to when Armenian merchants opened two shoe factories in Addis Ababa in the 1930s. These first-comers developed structures and trained workers in this sector.

Table 2.11: Number of footwear establishments in Ethiopia

	Number of establishments	**% of footwear establishments to total manufacturing sector**
2007/8	68	3.52
2008/9	72	3,27
2009/10	83	3,82

Source: Adapted from Central Statistical Authority (2011)

The number of footwear establishments in Ethiopia has been steadily increasing from 68 in 2007/8 to 72 in 2008/9 and 83 in 2009/10. Comparing with rest of the manufacturing sector, the share of the footwear sector to the whole manufacturing sector is marginal above 3%.

Table 2.12: Number of footwear workers in Ethiopia

	Number of workers	**% of footwear workers to total manufacturing sector**
2007/8	4883	3,71
2008/9	5115	3,44
2009/10	5698	3.05

Source: Adopted from Central Statistical Authority (2011)

The footwear absorbs on average above 3% of the workers working in the whole manufacturing sector. For the period 2007 to 2010, workers employed in the footwear has been increasing steadily as shown above.

Birkinesh(2012: 95) observed that capacity utilisation in the Ethiopian footwear industry was below 50% between year 2007 to 2010 and proposed the following as the major barriers:

Table 2.13: Barriers of capacity utilisation in the Ethiopian footwear industry

Barrier	**% Impact**
Raw material	80
Spare parts	70
Lack of market	50
Working capital	100
Machinery breakdown	20
Government rules	20

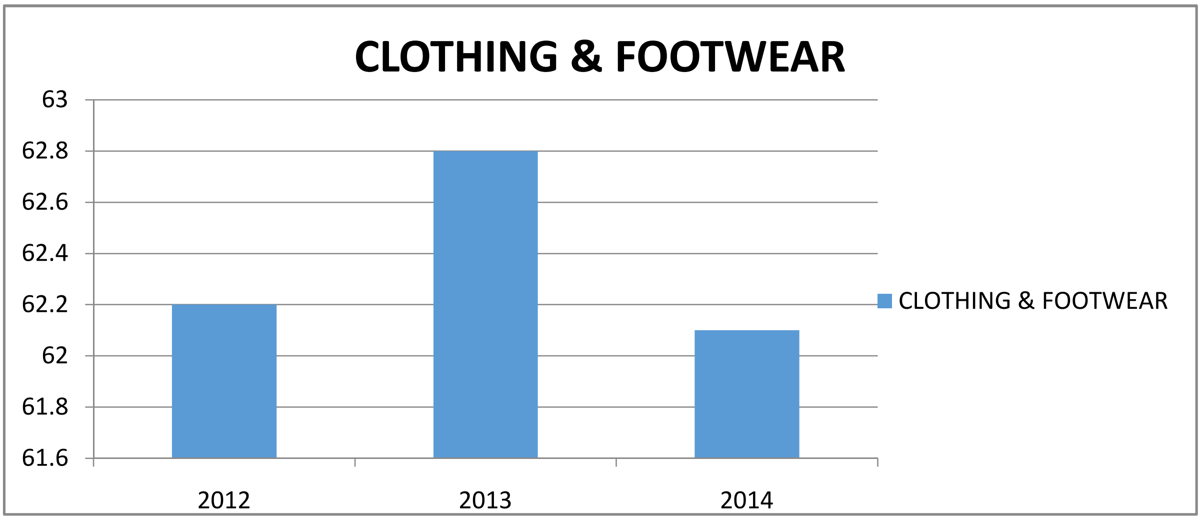
Source: Adapted from Birkinesh (2012)

Working capital was found to be a barrier on efficiency in all footwear firms in Ethiopia followed by raw materials with 80% effect.

The clothing and footwear industry remains constrained by unfair competition from imported subsidised products flooding the domestic market. The Parliament of Zimbabwe (2014: 37) propounded that Zimbabwe registered a marginal growth in 2014, emanating from new investment by one of the big players, BATA Shoe Company. The flooding market is a result of old machinery which lack current design of shoes and hence substituted by imports from South Africa, China, England, and Mozambique. Despite government policies to protect these sub-sectors, imports of clothes and footwear will make their way into the country through porous borders. The Zimbabwean manufacturing sector lacks technology for production which could increase output and reduce cost leading to lower prices. It is very helpful if the companies in the clothing and footwear joint venture with its competitors since they have cheap production methods and domestic companies have the market itself. A change in taste and preferences against the same old brands without innovation has led to a high import bill on the shoes and clothes. Joint ventures could benefit domestic firms to expand their shoe business to foreign markets through companies like Bata, Instep and Tsuro shoemaker. By this, the companies can contribute more to manufacturing output, reduce poverty and imports.

South Africa Information (2013:7) reported that textiles and clothing accounted for about 14% of manufacturing employment and represented South Africa's second largest source of tax revenue. The textile industry was the most cost-effective way of creating jobs. Most of its products are sold as intermediate inputs to the clothing industry (19 percent of total sales) and other sub-sectors. Manufacturers are benefitting from retailers' growing demand for locally made goods as the need for "fast fashion" takes hold. In order to keep up with the latest trends, retailers have to source their products locally to have shorter lead times from design to delivery. This has contributed to the statistics that show as much as 25% to 30% of locally sold clothing is manufactured domestically. In Zimbabwe, manufacturers are not competitive nor innovative enough to catch up with the changes in taste and preference.

Figure 3.10: Clothing and Footwear Index



Source:Adapted from Zimstat (2015)

The diagram above shows trends in the clothing and footwear manufacturing sector. In 2012, the sub-sector had low output with an index of 62.2 and the gap was covered by imports. In 2013, it rose by 0.6 to 62.8 and in 2014, it fell to 62.1 as some companies were closing, facing high cost and experiencing production bottlenecks.

2.3.10 Wood and Furniture sector

Furniture has traditionally been a resource and labour-intensive industry that includes both local craft-based firms and large-volume producers. Mass-producing furniture became a viable manufacturing strategy with the advent of flat-pack or ready-to-assemble designed furniture. This product innovation paved the way for firms to design, manufacture and ship products in large quantities. Firms that mass-produce flat-pack furniture tend to supply products for the low- to medium-price markets. Solid wood furniture manufacturers have retained important niche market segments primarily for high-end, expensive and design-led products. These specialized products tend to be purchased locally, while mass-produced, large-volume products are sold locally and for export.

The Swedish Federation of Wood and Furniture Industry (2016: 1) confirms that the total production of furniture in Sweden was estimated to be 22 billion SEK (Swedish Kronar) in 2015. Exports were 15.8 billion SEK, an increase of 6 percent during 2015, while imports were16,1 billion SEK. According to the latest figures from Statistics Sweden(Statistiska centralbyrån)SCB, the Swedish furniture industry includes 2 262 companies, of which 849 are companies with more than one employee. The total number of employees in the furniture industry is 13 000. Sales in the retail trade of furniture increased by 12 percent to 33,5 billion SEK in 2015 compared to 2014. The total number of employees was 12 000 according to the latest figures from SCB. Approximately 30 000 people are employed in the furniture industry and the total furniture retail trade in Sweden.

The sub-sector continues to benefit from increased activities in the informal and construction sectors. With many construction projects underway, Zimbabwe has seen more people building their houses in new places like Hopely, Stoneridge and Nyatsime. These places in Harare have created demand for the wood and furniture sub-sector output, as their growth has been faster than any other sub-sectors.

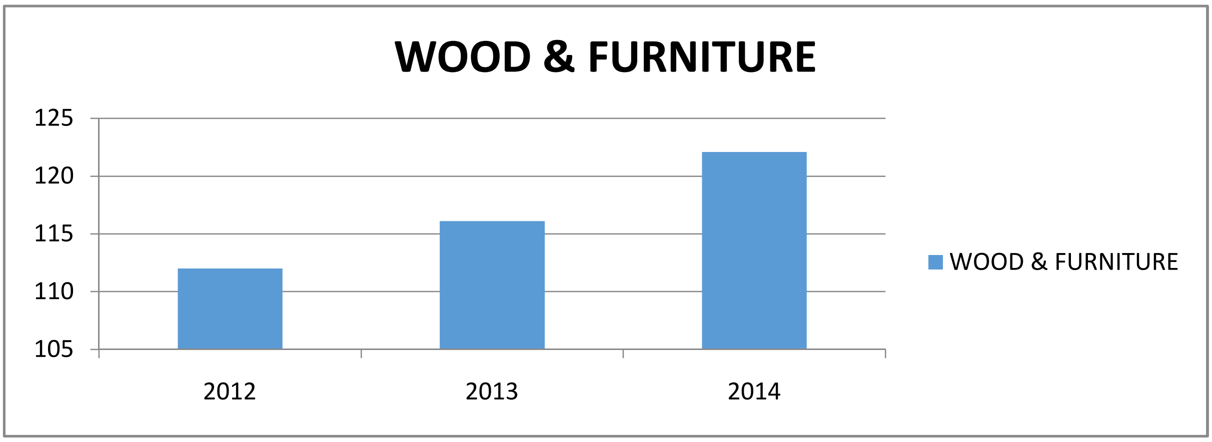
In Zimbabwe, especially Mutare, the sub-sector faces hurdle and risks originating from reduced hectares under plantation due to veld fires. Veld fires have been a major drawback to wood and furniture as the raw material comes from timber. There have been campaigns for Tree plantation day on the 1st Saturday of December every year in an attempt to promote this sector. The wood and furniture industry relies on trees and deforestation affects the output of the sector. Most trees are destroyed by fire at the expense of furniture, which they should be used for.

The Wood and furniture sector is affected by a shortage of electricity which force people to use firewood for cooking and heat. All the timber,used could be useful in the manufacturing sector as they create employment on value addition, which is processing timber to furniture. Furthermore, timber, if cut down, could earn government revenue by exporting to Zambia, Namibia and Botswana who have shown interest in local furniture.

Investment in the manufacturing sector is within sub-sectors such as the timber industry which comprises timber producers, saw millers, timber processors, material manufacturers and timber traders. The sector is one of the most diversified industries and which produces a wide range of products for home, office and garden.These are manufactured from wood, metal and plastic. In Zimbabwe the sub-sector has a few existing big firms who are struggling to survive in the face of problems with finance, technology and development of new markets. Another drawback to Zimbabwe’s wood and furniture manufacturing sub-sector is limited access to information, inadequate business premises, limited access to modern or high-tech machinery and equipment, poor sector integration and challenging market conditions. Kanyenze (2006: 7) argued that the wood and furniture sub-sector’s share of employees by sector was 7.2% in the manufacturing sector.

In South Africa, the furniture manufacturing industry has approximately 2200 registered companies involved in making furniture, bedding and upholstery, and employs approximately 26 400 factory workers. The industry is labour-intensive and contributes about 1% to the manufacturing Gross Domestic Product (GDP) and 1.1% to manufacturing employment. This makes it more attractive to investors and even the government for subsidies and tax holidays. South Africa's furniture products are internationally competitive and based on quality or differentiated designs. South Africa has a furniture manufacturing hub which creates scope and opportunity for small manufacturers to work together to access larger market opportunities.

Figure 3.11: Wood and Furniture Output Index



Source: Adapted from ZIMSTAT (2015)

The Wood and Furniture output index in Zimbabwe was 112.0 as there was low aggregate demand. Its output rose to 116.1 as a result of cheaper building equipment. In 2014, it was 122.1, thus being higher than the previous two years. This was a result of the "Buy Zimbabwe" campaign which promoted local products over imports.

2.4 Conclusion

The manufacturing sector is one of the most powerful sectors in the Zimbabwean economy, but for the past decade it has been facing challenges in its sub-sectors. The metals sub-sector output fell, affecting the GDP and the foreign currency reserve which came through exports. The non-metallic sub-sectorwas faced with high costs of production, which were a result of sanctions, and failed to compete with imports as its output fell. The chemicals sub-sector rose dramatically as it benefited through the "Buy Zimbabwe" campaign and imports were limited, causing a boost in domestic output. In addition, the paper and publishing output, textile, clothing and footwear fell dramatically, reducing the output of the manufacturing sector. It has been noted, that the foodstuff sector's output rose as the government was promoting local brands which were not genetically modified rather than imports. This created output and created employment. Furthermore, the beverage and tobacco sub-sector was decreasing in output due to cheap imports from South Africa and Mozambique. To sum up, reductions in sub-sectors were due to constraints like power shortages, falls in aggregate demand, lack of working capital, competition from imports, high costs of doing business, high costs of raw materials and inadequate machinery. The next chapter presents the theories and models of effeciency.Theoeretical and empirical literature is reviewed in order to give methodological direction to this study. The theoretical literature is grounded on efficiency models and conceptualisation well known in the field of efficiency whilst the empirical literature showed the research gap, evaluation of methodologies applied in other studies and geographically balanced literature on efficiency in the manufacturing sector.

CHAPTER THREE

THEORIES AND MODELS OF EFFICIENCY

3.1 Introduction

Theories and models that explain efficiency are reviewed in this section of the thesis, in an attempt to highlight the theoretical framework as well as the empirical literature derived from both past and recent studies concerning the manufacturing sector. Previous researchwas scrutinized to highlight the research gap. The study examined the benefits of utilising efficiency concepts to retrieve the decimation of the manufacturing sector in Zimbabwe. Consequently, the fundamental concepts and models related to the following questions of the research were explained:

i. What are the major drivers of efficiency in Zimbabwe's manufacturing sector?

ii. How do financial ratios compare with input-output efficiency ratios in explaining inefficiencies in Zimbabwe's manufacturing sector?

iii. How is efficiency measured and which scores are efficient in the manufacturing sector in Zimbabwe?

iv. What are the barriers to achieving efficiency in Zimbabwe's manufacturing sector?

v. How can an efficient model on efficiency be developed which can recommend an efficient input-output use in Zimbabwe's manufacturing sector?

The key concepts and theories include the types of efficiency. The three common types of efficiency: allocative efficiency (referred to by Farrell 1957: 253 as "price efficiency"); economic efficiency (referred to by Farrell 1957: 253 as "overall efficiency") and technical efficiency will be utilised in this study. The other types of efficiency are X-efficiency and dynamic efficiency. The two efficiency orientations namely Output-Orientation and Input-Orientation will be discussed to determine whether the inefficiency originates from inputs or from outputs. Duality theory and approaches to efficiency measurement, namely the production function approach and the cost function approach,will be highlighted as utilised in other efficiency studies. The frontier methodologies used to measure efficiency will be discussed, paying attention to the two broad categories, namely the parametric and non-parametric approaches. The review of empirical literature will be guided by the study objectives, namely:

i. To determine the drivers of efficiency in Zimbabwe's manufacturing sector;
ii. To compare financial ratios with efficiency ratios in the input-output model in order to identify the levels and kinds of inefficiencies in Zimbabwe's manufacturing sector.
iii. To measure efficiency in Zimbabwe's manufacturing sector using production plans of the efficient scores.
iv. To identify the barriers to achieving efficiency levels in Zimbabwe's manufacturing sector; and
v. To develop an efficiency model that will recommend efficient input-output usage in Zimbabwe's manufacturing sector.

3.2 Conceptualising theory on efficiency

This segment of the research chapter examines the numerous notions concerning efficiency as well as its conjectural base. In this section, the types of efficiency will be explained in detail. These economic efficiency types are technical, allocative, X-efficiency and dynamic efficiency. In order to measure efficiency and to analyse efficiency barriers and drivers, the duality and the input-output measures should be evaluated. Furthermore, in order to determine efficiency scores, the frontier methodologies need to be explained. A frontier is the deviation of an observation from the theoretical maximum of an output vector, whereas on the cost vector, it is the theoretical minimum of the mix. The efficiency production frontier allows one to calculate and compare a firm's efficiency to its own benchmark (Pulina, Detotto and Paba 2010: 614). The efficient firm has an efficient score of one, so if any other firm has an efficient score less than one, it has to benchmark its performance to the efficient one.

Maredza (2009: 15) stated that efficiency measurement is derived from the cost or production boundary. The theory of Duality ascertains this relationship between production and costs. The concept of technical efficiency can be defined directly in terms of the production or cost frontier. Frontier can be applied in either case since the function sets are bound on the range of likely observations. For example, production can take place only below or on the frontier. Likewise, costs can be observed above the cost frontier but not below the frontier because it is impossible to achieve costs lower than the minimum input requirements implied by the production frontier. The amounts by which an organization lies below its production frontier or the amount by which it lies above its cost frontier can be regarded as a measure of relative efficiency. The following section explains the types of efficiency.

3.2.1 Types of efficiency

There are many types of economic efficiency, with the common ones being technical, allocative, dynamic and X-efficiency. Economic resources are scarce and therefore should be allocated to cost centres in an efficient manner. Economic efficiency implies that it is impossible to increase one's utility without decreasing someone else's utility for the consumer or producer. Economic efficiency is also referred to as Pareto efficiency, which is determined by efficiency in all types of efficiency. Broadly, it is determined by the combination of the technical efficiency with the allocative efficiency. Ouattara (2012: 37) summed up economic efficiency as concepts of productivity, performance, quality and profit on the one hand, and of the reduction of the total strength employed and of the costs on the other hand. An analysis of various types of efficiency is provided below.

3.2.1.1 Technical efficiency (TE)

Technical efficiency (TE) is effectiveness of input use in producing the maximum output. Within the framework of the manufacturing sector, technical efficiency may then refer to the physical relationship between the resources used (capital, labour and equipment) and some manufacturing sector outcome. Farrell (1957: 15) pioneered most of the work on efficiency measurement. Theefficiency of a firm broadly consists of technical efficiency and allocative efficiency. Farrell's framework of firm efficiency is measured relative to the efficiency of all other firms in the industry, subject toconstraint that all firms are on or below the boundary. The degree to which the actual output of a production unit approaches its maximum is called the technical efficiency of production. A technically efficient unit must operate on its production function, although this condition is not sufficient. Furthermore, a technically inefficient unit may operate beneath its production function, although this condition is not necessary. If the notion of technical efficiency is to have empirical content, it must be based on a proper measure or index (Färe and Lovell 1978: 150).Measuring technical efficiency is to use inputs and output quantity without introducing their prices. Technical efficiency can be decomposed into three components such as scale efficiency (the potential productivity gain from achieving the optimal size of a firm); congestion (increase in some inputs could decrease output); and pure technical efficiency (Khai and Yabe 2011: 136).

2.2.1.2 Allocative efficiency

Maredza (2009: 37) describedallocative efficiency as the ability of an organization to use its inputs in optimal proportionsgiven their respective prices and the production technology. Allocative efficiencyis concerned with choosing between the different technically efficient combinations of inputsused to produce the maximum possible outputs. Taken together, allocative efficiency andtechnical efficiency determine the degree of productive efficiency, also known as total economicefficiency. Thus, if an organization uses its resources both in an allocatively and technically efficient manner,then it can be said to have achieved total economic efficiency (EE).

Allocative efficiency, occasionally known as social efficiency, explains that scarce resources must be utilized in a manner that meets the desires of citizens in a *Pareto-optimal* way, but is not to be puzzled with the model that resources are used to meet the needs as best as possible (Eastaugh 2004: 47). This approach guarantees that the allotment of resources will be correct for the wants and tastes of the people involved, and says nothing about the intelligence or correctness of the choices of these people (Angel 2000: 63). This demonstrates the predicament with what is called the *Pareto-optimal state*. This state, where no one can be made better off without making someone else worse off, is very clearly not the publicly finest circumstance.

Farrell (1957:21), who initiated and articulated work on measuring efficiency, noted that the efficiency of a firm consists of technical efficiency and allocative efficiency. In his framework, Farrell (1957) argued that a business' efficiency can be benchmarkedagainst the competence of all other companies in the business, given the constraint that all firms are on or below the frontier. In the context of healthcare, Tigga and Mishra (2015: 285) defined allocative efficiency as the situation when resources are devoted to the right activities, while technical efficiency is when a given health intervention or health outcome is obtained through few resources.

A production strategy is alleged to be technically efficient if the minimum quantities of inputs are combined to produce maximum output. Technical inefficiency is due to excessive input usage. In the context of manufacturing sub-sectors, technical efficiency may then refer to the physical relationship between the resources used (capital, labour and equipment) and some manufactured output. Allocative efficiency reflects the aptitude of a DMU to utilise its inputs in optimum magnitudes. Therefore, allocative efficiency is apprehensive with selecting amongst the altered technically efficient combinations of inputs used to craft the maximum attainable outputs. Allocative efficiency plus technical efficiency define Pareto efficiency, also referred to as complete economic efficiency. Allocative efficiency in the manufacturing sector DMU is when resources and factors of production are channelled to the right products, while technical efficiency is when manufacturing output is obtained through a few resources, hence cost minimisation. Firms achieve allocative efficiency if they know which product is highly demanded on the market. For example, in the manufacturing sector in Zimbabwe, the motor industry can produce more trucks and family cars because they are in high demand.

2.2.1.3 X-efficiency (XE)

X-efficiency is the term used to describe the minimisation of cost which occurs under conditions of competition.X-efficiencyemerges when technical efficiency is not being achieved due toa lack ofcompetitiveness, hence a lack of incentives to reduce cost. The concept of x-efficiency isaccredited to Leibenstein (1978: 18) who minimised costs under conditions of competition. The concept sometimes applies where there is more or less motivation of management to maximise output.Erkoc (2012: 28) suggested that failure of firms to produce on the efficient frontier is largely caused by inadequate motivation, incomplete contracts, asymmetric information, agency problems and attendant monitoring difficulties. This diverted attention away from traditional production with observable inputs like land and capital. Manufacturing companies' management motivate workers through setting targets that have rewards. For example, in the manufacturing of laptops, a target of 100 per day will receive $1 per day for each worker. X-efficiency occurs when the output of firms from a given amount of input is at its greatest. This kind of efficiency arises when a firm is operating in a highly competitive market where managers are motivated to produce more output. This can be noted in the motor industry in South Africa where there is competition between Mazda, Toyota, Ford, Volkswagen, Renault, BMW, Mercedes Benz and Nissan. X-efficiency in the sector is attained by producing more at low cost, which increases sales and profits.

Contrarily, monopoly business structuresgenerate supernormal profits and have little incentive to get rid of excess labour, resulting in the business`average cost being higher than necessary. Monopolies are protected from competitive forces byentry barriers, thereby allowing for X-efficiency not to occur. However, in a competitive marketscenario, firms are continually under pressure from their rivals to produce at the lowest cost possible. Therefore, X-inefficiency does not occur. The introduction of market or competitive dynamics in healthcare service provision may help achieve efficiency gains.

Frantz (2004: 12) identified X-inefficiency as a situation when costs in excess of the technological minimum is zero. However, the lack of competitive pressure facing these monopoly or duopoly firms is predicted by the XE theory to result in costs being in excess of technologically minimum costs. Hence, the net effect of government regulated public utilities depends upon the relative strength of economies of scale and x-inefficiency.

Carlsson (1972: 13) estimated the effects of competition on x-inefficiency in a small open economy. Using plant data for firms in 26 Swedish manufacturing industriesfor 1968, Carlsson'shypothesis is that a lack of competitive pressure is the main cause of X-inefficiency. Manufacturing firms in the Swedish economy were X-inefficient as many of them were not in a competitive market, causing no worries in reducing cost. There should be competition so that firms reduce cost and wastage in order to remain competitive in the market.

Shen (1973: 13) sought to explain differences in output, capital and labour asa result of firm size, technological diffusion, technological change, input substitution and X-efficiency. His sample was 1947 - 1959 data on 4000 manufacturing plants in Massachusetts. Results have shown that the "best-practice" plants held both higher quantity over labour and capital over labour than other plants of the same size. Shen (1973) demonstrated that X-efficiency raisedoutput over labour more than capital over labour, while increases in the latter are more of the product of technological change. It can be noted from Shen's (1973) study that technology plays a major role in increasing the efficiency of a manufacturing firm in an economy.

2.2.1.4 Dynamic efficiency (DE)

Del Río (2012: 139) posits that dynamic efficiency is where national policy makers enable firm efficiency through technological dimensions. He noted the following integrated perspectives of dynamic efficiency:

- ✓ Technological diversity;
- ✓ Private research, development and demonstration;
- ✓ Learning effect;
- ✓ Technological competition;

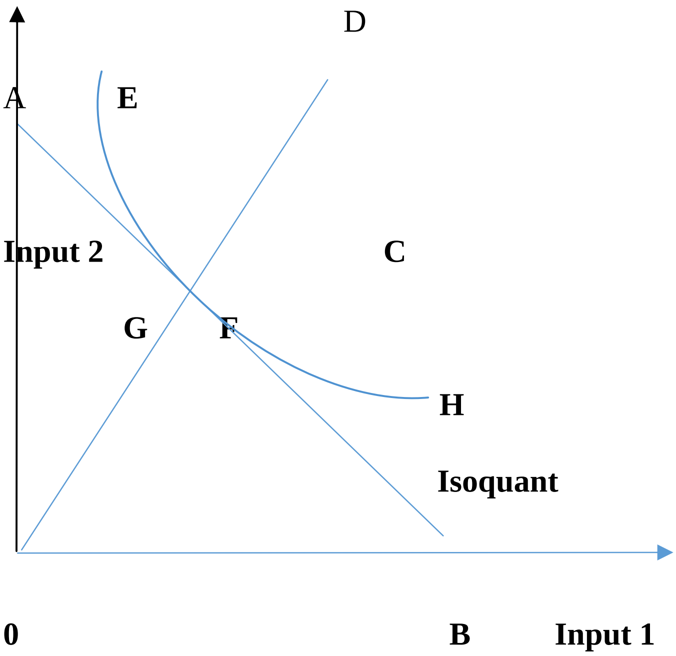
- ✓ Total customer costs, cost containment and
- ✓ Links and interactions between dimensions

Indeed, these perspectives facilitate the implementation of high quality components, as the objective of the investor is not only the minimisation of generation costs, but rather the maximisation of revenues as well.

Dynamic efficiency considers whether firms are likely to develop more efficient techniques overtime. It is therefore necessary for firms to constantly introduce new technology and reduce costsover time. It is a concept that advocates for investment innovation, research and development asvital for efficiency attainment. DE is the ability to adapt quickly and at low cost to changed economic conditions, thereby maintaining output and productivity performance despite 'economic shocks'. It is stimulated by increased competition, which then acts as anincentive for businesses to innovate and adapt. In Zimbabwe, companies like Delta Beverages have been one of the few manufacturing firms that have had dynamic efficiency. The firm has invested more in research and development, which has brought new products such as Super Beer, Shumba and Maheu that have attracted many new customers and boosted the firm's revenue despite the country's economic challenges.

However, Phelps (1961: 638) emphasized in his initial development of the Golden Rule, that a path cannot be judged as dynamically efficient or dynamically inefficient prior to eternity. That is, dynamic efficiency cannot in principle be judged by observing only a particular segment of time. These calculations do allow one to conclude, however, that if the economy behaves in the future as it has in the past, it will be realizing a dynamically efficient equilibrium.Dynamic efficiencyis a model that advocates for outlay modernization, exploration and enlargement as a source of efficiency. This type of efficiency is for growth models and falls outside the analysis of this study. Use of this type of efficiency is constrained in this sectorial study as it uses macroeconomic variables in Zimbabwe like Gross National Product (GNP), investment and national returns.

Figure 2.1: Technical efficient frontier



Source: Adapted from Kanina (2012)

In the diagram above, a manufacturing firm produces its output using a combination of two or more inputs (raw materials and labour). A technically efficient firm is one that is located on the isoquant, that is, on the frontier such as E, F and H. Firms operating at points C and D are technically inefficient. For the manufacturing company operating at point D, the measure of technical efficiency (TE) is given as:

$$TE_{D} = OC \div OD$$

This denotes the ratio of minimal input required to the actual input use, given the input mix used by D. The ratio ED/OD represents the percentage by which all inputs could be reduced without a reduction in output. If the manufacturing firm at point D is to be efficient, it has to relocate itself to point E. Technical efficiency takes values between zero and one, i.e. $0 < TE \leq 1$

Provided input prices, the isocost line **AB** embodies the least cost of creating one unit of productivity. Allocative efficiency emphasises that production happens at the argument where the isoquant line is oblique to the isocost line. According to this definition, business organisations functioning at points **H** and **E** are precisely proficient but allocatively ineffective. Only the company functioning at point **F** is mutually technically as well as allocatively efficient. The Allocative efficiency of manufacturingfirms operating at point **D** is given as:

$\mathbf{AE_{D} = OG \div OE}$

The ratio **GE/OE** represents the percentage reduction in production costs that would occur if production were to occur in the allocatively efficient point: (Coelli 1996: 27) anticipated that pecuniary efficiency is dignified as:

EED =OG ÷ ED

The general efficiency has the benefit that it effortlessly crumbles into technical as well as allocative efficiencies.

(OG÷OD)=(OE÷OD)x(OG÷OE)

that is **EE=TE x AE**

The measures attained characterize input-oriented indicators of efficiency. They are input-oriented as their focus is on the measurement of variations in input use between different manufacturing firms for an unvarying output.

3.2.2 Duality theory

Burgess(1975: 105) discovered that principles of duality enable the investigator to model the technology of a multiple-input-single-output firm or a multiple-input-multiple-output firm either by means of a production function or a cost function. For empirical implementation, both alternatives employ the assumption of competitive market behaviour. According to Lakshmanan (2011: 4), duality theory suggests that one can derive the underlying production function parameters from the cost functions. The same rationale can be used forDMU inputs into a production function or cost function. The costs of output in a firm are determined by the cost of different input factors such as labour, capital and the level of the firm’s output. In a cost function, firms choose the quantities of private inputs in order to minimize the private costs of producing output.

2.2.2.1 The Production function approach

The first empirical treatment of the production function as a frontier is found in the work ofFarrell (1957: 4) and Fieldhouse (1962: 7). A production function can be defined as a process ofphysical transformation in which inputs are combined to generate output. The productionfunction is then interpreted as a purely technical relationship which defines efficienttransformation possibilities, given the set of feasible techniques (technology). In the case ofinefficiency, the production function may be written as an inequality. The production function mostly applies in the manufacturing sector where companies transform raw materials (inputs) to produce output using a given set of technology. Some manufacturing firms are labour-intensive and some are capital-intensive. By being labour intensive, the firm is much more specialised and has a big advantage in labour production as preferred to capital. Capital intensive manufacturing companies are firms that use more capital goods or equipment to produce a product as preferred to labour, all using the production function.

Lewin (1995: 90) asserted that the production function approach is actually a mathematical shorthand expression for expressing an input-output process. Thus, it is the basis for modern growth theory and of growth accounting. This model is always thought of as an approach to explain output consisting of at least two and/or three variables which are not dependant. The traditional two variables procedures comprise only capital stock (K) and labour supply (L). The leading observed action of production utility as a frontier was brought into being in the effort of Farrell (1957:123) and Fieldhouse (1962: 26). The production function may be explained as a procedure of somatic alteration in which involvements are pooled to produce output. The Production function is at that point inferred as a virtuously procedural affiliation which delineates proficient alteration likelihoods, given the set of viable techniques. In the case of inefficiency, the production function can be written as an inequality:

$Y_1 \leq f\,(X_i\,;\,\beta)$.. (1)

Where Y_1 is observed output at establishment *i*

X_i is a vector of inputs

β a vector of parameters which describes the transformation process

f (.) is the production function and has an interpretation of the frontier or Y_{max}

At inefficient operations, potential output Y_{max} will exceed observed performance Y_1 and thus, thetechnical inefficiency implies $Y_1 - Y_{max}$ equals negative. The difference between observed and potential performance can be treated as a residual in the production function, which is equivalent to the technical efficiency ratio. If these residuals are denoted as $\acute{\varepsilon}_i$, then in terms of the production function in [1] above, the technical efficiency ratio can be written as:

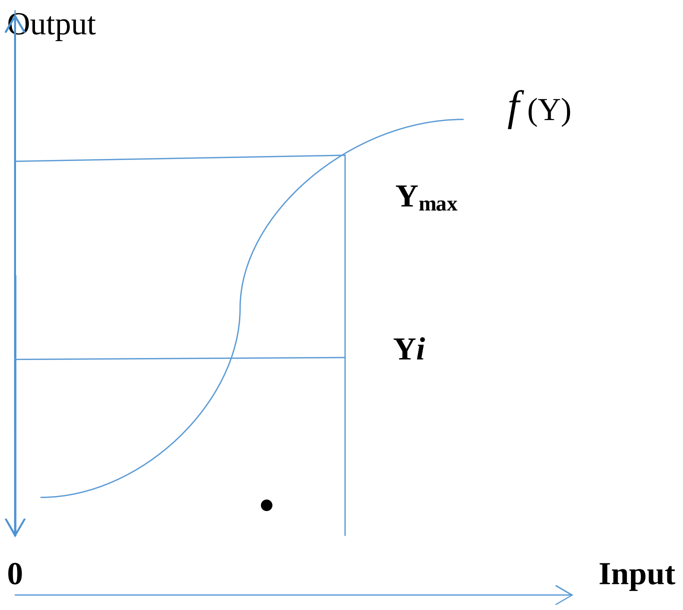
$$\acute{\varepsilon}\mathrm{i} = \frac{Y1}{f\ Xi;\ \beta} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.. (2)$$

$\acute{\varepsilon}_i$ is always non-positive to ensure that observed output cannot exceed potential, that is

$Y_1 > Y_{max}$ is not possible.

Decision Making Unit (DMU[1]) *i* is producing output Y_1, which for input allocation OX is far less than frontier output Y_{max}, as can been seen clearly on the diagram. The difference between actual and potential output, $\acute{\varepsilon}_i$, is negative and hence production at unit *i* is relatively inefficient. The implication is that when the efficiency residual equals 0 the production unit is efficient since actual and potential outputs are equal.

Figure 2.2: Efficiency and the production frontier



Source: Adapted from Ganley (1992)

Any point underneath the production function *f* (Y) is attainable but inefficient. An example of this production mix is **Y*i***and the inefficient part is measured by $\mathbf{Y_{max}} – \mathbf{Y}\boldsymbol{i}$. All the production locus along the function *f* (Y) are efficient.

2.2.2.2 Cost function approach

The theory of duality between cost and production implies that there exists a dual cost functionto the product transformation function in cost/production. A cost function relates the minimized totalcost in a firm to output and factor prices. If excess costs are possible, then the cost function maybe written as an inequality. Manufacturing firms are profit orientated and they are cost minimisers, implying that they try to produce at the lowest cost and if they produce at the lowest cost, they attain higher profits. Cost minimisation attains profit maximisation. The cost function approach leads to X-efficiency, dynamic and productive efficiency. These types of efficiency are related to output and cost, be it for labour, input or capital injected by a manufacturing firm. Firms do not want to expand their plants and equipment, but rather increase output given the same technology and resources.

The duality hypothesis stipulates that for every production, there exists a dualcost function relating to input prices and output. The dual cost function contains allthe information that the production function contains. Binswanger (1974: 34)has shownthat the cost function is more desirable for econometric analysis than the productionfunction, for a variety of reasons. Some of the reasons that prompts this study to use the input approach in the econometric approximation of efficiency in Zimbabwe is supported by the benefits outlined below:

Binswanger (1975: 6)argued thatfor a company, the cost function models the relationship between the firm's costs, output and input prices. The short-run cost function may model the relationship between costs, output, the prices of variable inputs and the level of fixed or quasi-fixed inputs. The cost function helps a firm to compute different types of efficiency which a firm accomplishes when it produces, especially those in the manufacturing sector. Firms sometimes favour the use of the cost function because it has many advantages. One of the advantages is that the cost function summarises all the economically relevant information about the process of converting inputs into outputs. Therefore, the estimated cost function allows the complete description of technology available to a production unit. This means that the manufacturing firm has all economic information used to manufacture their products such as patent fees, tariff fees on importation of raw materials to come up with a total cost and other non-production costs which were used in manufacturing. There is also availability of information and use of technology in the production of the goods in the manufacturing sector, which innovation is used to add to a better method of production which could be cheap.

To elaborate on the cost function approach, Kumbhakar and Lovell (2000: 2) posited that in such regulated industrial sectors as the electric sector, output is usually measured exogenously, as the input prices (competitive markets). In these cases, the use of cost functions is usually preferable. The manufacturing sector in Zimbabwe is unregulated. Therefore, the input approach is desirable. On the other hand, if inputs levels and not output levels, are exogenous, then the inference of a production function seems to be the more natural approach.Therefore, this highlights the principle of duality in production, where the cost function allows estimation when output prices are unavailable or arenot determined in a competitive market. A manufacturing firm which is not aware of output price in the market at the current period can be guided by the cost function method through the duality principle. The cost frontier is the minimum total cost function, which gives the minimum attainable cost for eachlevel of output. This minimum cost helps in setting the price since all firms in the sector face the same costs. The firm can charge a price just slightly above the minimum cost suffered because no firm wants a loss, but rather wants profits (Kumbhakar and Lovell 2000: 2).

The cost function approach is applicable as long as firms are minimizing costs. It does not require the condition of profit maximization because it is a minimising approach. The hitches associated with the cost function approach may also be noted, according to Grosskopf (1993: 34). Firms that inject capital want high return and by so doing, those in management use the cost minimisation method of production. The cost function method does not cater for any profit maximisation method of production because it is a cost minimisation production function.

Binswanger (1974: 4) stated that the cost function approach assumes that all firms are trying to minimize cost. Statistical methods allow oneto accommodate units that are not efficient because of statistical inferences and application of the duality approach in DEA. If the units are not cost minimizing, then the cost function approach is misleading.The cost function approach is also subject to many, if not all, of the usual econometric concerns, from the possibility of simultaneous equations bias to concerns about mis-specification.

3.2.3 Input-output efficiency measurement

This efficiency measurement recognises that from an input-output approach, inefficiency is either as a result of input inefficiencies or output inefficiencies. This approach isolates the origin of the inefficiencies and helps management to formulate the appropriate intervention.

2.2.3.1 Input-oriented measure

An input-orientation approach measures input reductions that are necessary for a production unitto become efficient without a reduction in output (Maredza 2009: 28). Input inefficiencies show the degree to whichinputs must be reduced for the inefficient manufacturing firm to lie on the best practice frontier.Leontief (1941: 1953) developed a unique case of activity analysis which has come to be known as input-output analysis. His work was directed toward constructing a workable model of general equilibrium, efficiency and productivity analysis. Furthermore, it is more closely related to the microeconomic production programming models. This analysis is used to measure the efficiency of an industrial firm whose main business is production. The measurement of the inputs used by the manufacturing sector is the amount of capital injected, the amount of labour used, as well as physical raw materials.

Maredza (2009: 40) suggested that the input-orientation approach measures input reductions that are vital for a production unit to become efficient without a reduction in output. Input inefficiencies show the degree to which inputs must be reduced for the inefficient firms to lie on the best-practice frontier. A firm in manufacturing can use this input-output efficiency measure by reducing unnecessary input which is not of great value to the product and this reduced input should not affect the final output.

Cooper, Seiford and Tone (2000: 7) defined both productivity and efficiency as the ratio between output and input. Lovell (1993: 21) defined the efficiency of a production unit in terms of a comparison between observed and optimal values of its output and input. Resemblance can take the form of the ratio of observed to maximum possible output accessible from the given input, or the ratio of minimum potential to pragmatic input required to produce the given output. This input-oriented measure is easy for measuring the efficiency in a firm given the quantity of input used and the output produced, using the potential and actual outcomes.

In economics, the notion of efficiency is related to the concept of Pareto optimality. An input-output bundle is not Pareto optimal if there remains the opportunity of any net increase in outputs or decrease in inputs. As a result of the strong agricultural sector which is a source of inputs to the manufacturing sector in Zimbabwe, input excesses can be blamed for the decimation of the sector.

2.2.3.2 Output-oriented measure

Maredza (2009: 42) identified output-orientation measures as the expansion of output that is necessary for efficiencyimprovement, holding inputs constant. Output inefficiencies represent the needed increase inoutput for the inefficient organisation to become efficient. An expansion of output that is necessary for efficiency improvement that does not affect inputs in manufacturing is done through adding value to by-products. In furniture manufacturing companies, wood pieces can be used to make shoe racks and cooking sticks, hence output is increased.

Production in manufacturing output is measured in physical quantity using a standardised unit of measurement. Some organisations use an index and others the product quantity measurement unit. For example, cars are measured in units. The quality of these outputs has not been easy to estimate withreasonable precision. The quality of the output can also be seen as some function of the vector ofoutcomes it produces. Furthermore, there has been concern about the lack of differentiation as far as the concept of output and outcome is concerned. It is noted that most researchers pay more attention to outputs than outcomes. Pulina, Detotto and Paba(2010: 614) emphasise that the output-oriented model is employed for planning and strategic objectives. For example, it is employed when decision units need to understand whether an expansion of their capacity is feasible, as long as the existing infrastructure has already been used at its maximum capacity given the level of the inputs (Pulina, Detotto and Paba 2010: 614). The values of capacity utilisation reported by CZI reports may suggest that it is output shortfalls that are affecting efficiency in Zimbabwe’s manufacturing sector.

3.3 Slacks-based measure

If both input reduction and output enhancement are desirable goals in a particular application, then a slacks-based measure may provide the appropriate model structure to capture a DMU's performance measure. Tome (2001: 498) explains a slacks-based measure as a scalar-based measure of determining the efficiency of a DMU in a non-parametric form by considering both the input and output shortfalls. This is therefore a comprehensive measure in input-output efficiency measurement. This means that if there is certainty that inefficiencies in Zimbabwe’s manufacturing sector is a result of both input excesses and output shortfalls, the slacks-based measure will be used. This slacks-based measure will be able to identify and assign the magnitudes of barriers and drivers of efficiency in each sub-sector and the whole manufacturing sector in Zimbabwe. They will also point out the source of the inefficiency that is either from inputs or outputs.

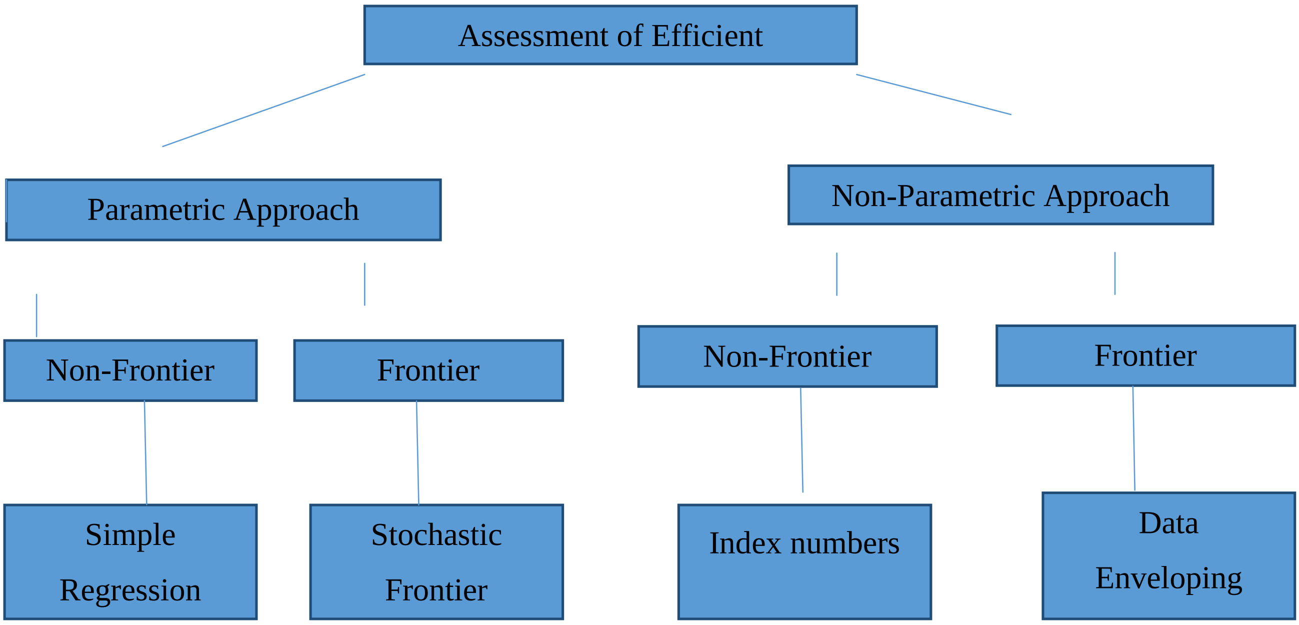
3.4 Methodologies of efficiency measurement

There are two main approaches to estimating relative efficiency across firms namely the parametric approach (more strictly, the statistical approach) and the non-parametric approach. The maindifference between these two approaches is that the former specifies a particular functional formfor the production or cost function, while the latter does not. In fact, the degree of“parameterisation” of the production or cost function can have serious implications in comparativeefficiency analysis, and can be considered to be responsible for the different advantages anddisadvantages that each approach exhibits.

Vaslis(2002: 5) postulates thatthe parametric approach relies on econometric techniques and includes simple regression analysis and Stochastic Frontier Analysis (SFA). Whilst simple regression analysis typicallyseeks to estimate a production or cost function, SFA is an extension of that methodology toestimate the “frontier” of a set of functions with different underlying levels of efficiency.

Non-parametric approaches use mathematical programming techniques. The main non-parametric frontier analysis technique, known as Data Envelopment Analysis (DEA), can be seen as an extension of the simple technique of index numbers.

Figure 2.3: Taxonomy of Efficiency Measurement Techniques



Source: Adapted from Vaslis (2002: 6)

Any efficient study should adopt one of the measurement techniques in the above taxonomy. Choice of efficiency measurement techniques is based on: a). The specification of the (functional) form for the frontier function; b). The presence of noise in the sample data; and the type of data analyzed.

3.4.1 Simple regression

The Econometric Model- Ordinary Least Squares (OLS)

The general form of the simple econometric model is given by:

$$Y_i = {}_0 + {}_1 X_i + u_i \quad i = 1,2,3\ldots n$$

where Y_i - is the i[th] observation on the dependent variable Y

X_i - is the i[th] observation on the independent variable X

n is the number of observations e.g number of firms in a cross-section

$_0$ and $_1$ are the regression coefficients representing the intercept and slope of the regression line. These are unknown and have to be estimated from observed data. The coefficients explain the interpretive power of barriers on drivers in a DMU.

u_i - is the error term or stochastic disturbance term which measures the deviation of each observed Y value from the true regression line. In the above equation, Y_i is the vector of outputs and X_i is the vector of inputs, which are combined in a mix of a DMU. This will illustrate the relative efficiency of a DMU.

This is a non-frontier model used to regress relationships between economic variables, such as the relationship between outputs and inputs in a DMU. However, the simple econometric model is practically inadequate to represent intricacies of most economic systems. The model helps, to present the fundamental ideas of regression analysis as simply as possible.The coefficient of determination r^2 can be obtained, which is a summary measure that indicates how well the estimated regression line fits the data. r^2 measures the proportion or percentage of total variation in the dependent variable that is explained by the regression model. In efficiency cases, it explains variations in efficiency caused by barriers and/or drivers in a DMU.

The main attraction of regression analysis is that it is computationally easy and straightforward. It is part of any statistical package and most spreadsheet software.An additional important advantage is that regression analysis - being a parametric method - provides pragmatic rules that can help in the formulation of a comprehensive strategy for decidingupon competing models of measuring relative efficiency.Moreover, regression analysis can easily estimate the impact of environmental factors on thecompany’s efficiency.

The term environment is used here to describe factors other than outputsthat could influence the efficiency of companies and are assumed to be outside the control of management.

However, OLShas a major potential drawback: residuals in the estimation reflect acombination of relative efficiency; measurement error in the dependent variable (cost); andstatistical noise, rather than only inefficiency. As a result, the final point-estimates of “efficiency”should be discounted before using them in formulating price policies for regulatory purposes.Another limitation of OLS is that they are both subject to theoretical objections. Inparticular, the OLS method does not calculate a cost frontier that corresponds to the theoreticalnotion of a cost function, but a fitted “average” function that provides no direct quantitativeinformation on cost inefficiency in the sample.

Finally, regression analysis is vulnerable to statistical problems, including:

- ✓ lack of “degrees of freedom”, which refer to the difference between the number ofavailable observations and the number of potential explanatory factors. If there are toofew degrees of freedom, this can lead to the problem of having too little information uponwhich to estimate the model; and
- ✓ multicollinearity, which is a term that is used to describe a situation where the explanatoryfactors of the model are highly correlated. In this case, it could be extremely difficult todisentangle the individual influences of the explanatory factors. Therefore theinferential procedure would be problematic.

The OLS is used to find efficiency where the frontier of DMU(s) is a linear function. The function is limited to one output produced from a mix of it least one input. Khai and Yabe 2011)attempted to estimate rice technical efficiency in Vietnam and to identify its determinants using OLS. The analysis estimated the TE level to be 81.6 percent. These results suggest that an increase in output and a decrease in cost could be obtained using available technology. Another study by Raheman, Afza, Qayyum and Bodla (2010: 150) used OLS to test the impact of working capital management on the corporate performance of the manufacturing sector in Pakistan. According to Brandt, Van Biesebroeck and Zhang (2012: 345), regression results with firm-level productivity as a dependent variable on a set of five post-entry dummies was carried out in Chinese industry in order to find the level of efficiency and its barriers. In this Chinese study, the regression showed that export appetite, labour productivity and mobilisation of physical and human capital were the drivers of efficiency.

3.4.2 Stochastic Frontier (SF) Analysis

This is a frontier model which Fare *et al*. (1994) suggested isbest used to estimate cost and production frontiers. In a cost frontier, the units on the frontier are efficient, whereas the units belonging to the area above the frontier are inefficient. Moreover, the area below the frontier is not preferred, since the most costefficient unit is located on the frontier. For reading purposes, frontier models are the standard for efficient scores-the best performing (efficient frontiers) units are equal to one, and the under-performing units (inefficient frontiers) are less than one. Erkoc (2012: 28) concludes that the econometric frontier estimates the performance of the units statistically and measures the difference between the inefficient units and the frontier by the residuals. This is an intuitive approach. However, when assuming that the residuals have two components – noise and inefficiency – the result is the stochastic frontier model. Therefore, the main issue in the econometric frontier model is the decomposition of the error term. The SF model is motivated by the theoretical idea that no economic agent can exceed the ideal frontier and deviations from this extreme represent individual inefficiencies. From Belotti, Daidone,Ilardi and Atella's (2012:14)point of view, this idea has been implemented by specifying a regression model characterized by a composite error term in which the classical idiosyncratic disturbance, aiming at capturing measurement error and any other classicalnoise, is included together with a one-sided disturbance which represents inefficiency.

A very important issue in SF analysis is the inclusion of exogenous variablesin the model which are supposed to affect the distribution of inefficiency. These variables, which usually are neither the inputs nor the outputs of the production process but nonetheless affect the productive unit performance, have been incorporated in a variety of ways: i) they may shift the frontier function and/or the inefficiency distribution; ii) they may scale the frontier function and/or the inefficiency distribution; and iii) they may shift and scale the frontier function and/or the inefficiency distribution. Moreover, Kumbhakar and Lovell (2000) emphasise that, differently from the linear regression model in which the mis-specification of the second moment of the errors distribution determines only efficiency losses, the presence of uncontrolled observable heterogeneity in error term (inefficiency) may affect the inference in SF models.

The stochastic frontier analysis by Shaik, Allen, Edwards and Harris (2012: 14) was used to estimate technical efficiency which extended to examine the market structure, conduct and performance hypothesis for the U.S. trucking industry. The impact of the market structure and conduct variables on performance, that is the technical efficiency measure, reveals that market share, which is often associated with profitability, was negatively and significantly related to technical efficiency for the following commodity categories: (a) refrigerated solids; (b) petroleum products; (c) dump trucks; and (d) agricultural commodities. These results imply that the firms in these commodity categories needed to reduce their market share to become more technically efficient during the study period. In this case, the firms need to identify those customers that are unprofitable and drop them. This will allow the firms to lose market share while improving profitability (or technical efficiency).

3.4.3 Index Numbers/ Ratio analysis

Since the pioneering work of Solow, productivity growth or technical progress has been associated with the time derivative of the production function or some associated function such as the cost function or profit function. González, Díaz, Caamaño and Wilby (2011: 981) concluded that the resulting values of the index can be easily updated whenever new data is available. This means that it can be used to monitor improvements in energy efficiency due to the incorporation of technology, the adoption of policies that are aligned with environmental needs, or just a better use of energetic resources.This formulation is a useful conceptualization, but it is not convenient for the actual measurement of productivity using index numbers. The reason is that index number procedures entail comparisons using discrete data points and therefore require a discrete approximation to the time derivative: DMU ratios are the ultimate example.

Only under very restrictive assumptions is the resulting index invariant to the point of efficiency approximation. It would be desirable to be able to make index number measurements of productivity and the related measurements of input and output, without having to approximate a concept that is specified with respect to continuous time. One approach treats productivity differences as differences in maximum output, conditional on a given level of inputs. This approach leads to output-based productivity indexes. The alternative efficiency approaches treat productivity differences as differences in minimum input requirements conditional on a given level of outputs. This view leads to input-based productivity indexes. Output-and input-based productivity indices differ from each other by a factor that reflects the returns to scale of the production structure. Comparisons based on econometric estimates of the structure of production have often been viewed as being more desirable than index number comparisons. This view is based on the belief that index numbers are consistent only with restricted structures of production. Paradi, Rouatt and Zhu (2011: 100) found that it is a problem to determine the weights to be used in index numbers as they are often not known and discovering under-performing activities due to aggregated numbers are just two of the difficulties of using indices.

3.4.4 Data Enveloping Analysis (DEA)

DEA has been employed by a number of studies in different sectors and in different countries. They are summarized as follows:

Tourism and hospitality

Bell and Morey (1995: 11) adopted DEA to analyze the efficiency of 31 corporate travel departments. The inputs used were the actual levels of expenditure for travel in the form of air, hotel and rental cars; nominal levels of other expenditure; the level of environmental factors, that is ease of negotiating discounts, percentage of legs with commuter flights required; and actual levels of support cost for labor, technology, feesand space. One output used is the level of service provided, which is either excellent or average.

Morey and Dittman (1995: 5) also used DEA with nine inputs and four outputs in order to analyze the efficiency of 54 hotels in the United States. The nine inputs used are room division expenditure; energy costs; salaries; non-salary expenses for property; salaries and related expenses for variable advertising; non-salary expenses for variable advertising; fixed market expenditures; payroll and related expenses for administrative work; and non-salary expenses for administrative work. The four outputs used are total revenue, level of service delivered, market share and the rate of growth.

Anderson, Fok and Scott (2000: 177) employed DEA with their input–output data to analyze the efficiency of 48 hotels in the United States and to estimate the allocative, technical and pure technical levels. The inputs used are full-time equivalent employees; the number of rooms; total gaming-related expenses; total food and beverage expenses; and other expenses. One output used is total revenue, which is generated from rooms, gaming, food and beverages, and other revenues. Their results indicated that the hotel industry was inefficient, with a mean overall efficiency measure of approximately 42%.

Tsaur (2001: 73) employed DEA with seven inputs and six outputs to analyze 53 international tourist hotels in Taiwan during 1996-1998. The seven inputs used were the total operating expenses, the number of employees, the number of guest rooms, the total floor space of the catering division the number of employees in the room division, the number of employees in the catering division, and the catering cost. The six outputs used were total operating revenues, the number of rooms occupied, average daily rate, the average production value per employee in the catering division, total operating revenues of the room division and total operating revenues of the catering division. The results showed that the average operating efficiency score is 0.8733. However, 71.7% of the international tourist hotels in Taiwan present relative inefficiency.

Hwang and Chang (2003: 357) adopted DEA and added the Malmquist productivity index to measure and analyze the managerial performance in 45 Taiwanese hotels in 1998. They also explored the cause of efficiency change during 1994-1998. Their results revealed that the managerial efficiency of Taiwan'sinternational tourist hotels was related to the level of internationalization of the hotels. The research of Chiang, Tsai and Wang (2004: 712)was aimed at using DEA to measure hotel performance under three operational styles of international tourist hotels commonly seen in Taiwan since 2000, namely independently owned and operated, franchise licensed and managed by international hotel operators. The four inputs chosen by the hoteliers were hotel rooms, food and beverage capacity, number of employees, and total cost of the hotel. The three outputs were yielding index; food and beverage revenue; and miscellaneous revenue. They expected their results to provide hoteliers with a basis for constructing strategies and promotion plans. In addition, these results illustrated that not all of Taipei's franchised or managed international tourist hotels performed more efficiently than the independent ones.

Wang, Hung and Shang (2006: 65) employed the four-stage DEA procedure to calculate the pure managerial efficiency of 54 international tourist hotels in Taiwan. They used the following input variables: number of full-time employees, number of guest rooms and total dining area. Outputs variables were room revenue, food and beverage revenue, and other revenue. Their results revealed that there is no significance in pure managerial efficiency due to differences in management style. The pure managerial style of resort hotels is no longer more efficient than that of city hotels. Wang, Hung and Shang (2006: 65)adopted the quality-incorporated Malmquist productivity index and applied data from the Annual Operations Report of International Tourist Hotels from 1992 to 2002 to evaluate productivity in the hotel sector. The study examined productivity changes in 29 hotels as a result of technological changes, efficiency changes or changes in service quality. Four inputs were selected, namely the number of guest rooms, food and beverage capacity, the number of full-time employees and the operating expenses. Five outputs were used, were namely room revenue; food and beverage revenue; miscellaneous revenue; the ratio of housekeeping staff per guest room; and the ratio of food and beverage staff per square meter. Their results showed that the reason for decreased efficiency changes and lowered service quality in Taiwan's hospitality management profession was because it was not viewed as a creditable field. This mentality may be influenced by negative attitudes toward service positions in Chinese culture. In addition, to accommodate peak seasons, a significant number of part-time employees are hired. However, they lack both training and experience, which adversely impacts efficiency and service quality.

Wang, Hung and Shang (2006: 65)used the DEA model to measure the relative cost efficiency of 49 international tourist hotels in Taiwan in 2001. However, they used the single year data to analyze the cost efficiency of international tourist hotels in Taiwan. Four inputs were identified: number of rooms; number of full-time employees in room departments; number of full-time employees in food and beverage departments; and total area of food and beverage departments. Based on the four selected input variables, the input prices in this study were the average wage rate of a full-time employee in the room department; average room rates; average price of food and beverage operations; and average wage rate of full-time employees in the food and beverage department. Results from the Tobit regression indicate that the proportion of foreign individual travelers, online transaction functions and franchising are positively correlated with efficiency in international tourist hotels in Taiwan. However, the number of years a hotel has been operating is not significantly related to any of these efficiency measures.

Financial Sector

Research on bank efficiency is extensive, but there are no studies that focus on banks specialized in private banking and wealth management that go beyond an examination of accounting-based measures like cost-income ratios. Providing a detailed overview of the literature on retail banks is well beyond the scope of this paper, so the researcher restrictsthe review of relevant research to selected articles covering use of the DEA method.

Moreover, comparability with the study at hand is limited when it comes to the definition of bank outputs and inputs in the production process, as these will be specified differently for private banks. Thus, below the researcher outlines how this approach is connected to and deviates from these types of literature with respect to the research focus, the efficiency concepts applied and methodological choices. Most studies select inputs and outputs according to the so-called intermediation approach of bank production, with loans and securities holdings being "produced" using deposits, and labor and capital as the inputs. While much research concentrates on cost and profit efficiency levels in banking, another part of the literature focuses on the technical efficiency of the intermediation process. As reasonable price information necessary to evaluate economic efficiency is not available for all the inputs and outputs in the private banking industry, the researcher mainly refers to the latter strand of research. Casu and Molyneux (2003: 1865)studied the productive efficiency of large banks in France, Germany, Italy, Spain and the United Kingdom for the 1993-1997 period. They report rather low average efficiency scores relative to an efficient frontier, which is shaped by the most efficient banks from all five countries.

Additionally,there seems to have been only little convergence and small improvement in the effieciency of European banks since the creation of the Single Internal Market. Pasiouras (2008: 301) uses data from 95 countries "to provide international evidence on the impact of regulations and supervision approaches on banks". The benchmark for evaluating (in)efficiency is calculated from the pooled data in this paper where Casu and Girardone (2006: 441), who study the connection between efficiency and competition in the banking markets of the European Union (EU 15) between 1997 and 2003, apply national as well as pooled frontiers. All three studies mentioned above report on technical efficiency, which can be broken down into pure technical efficiency and scale efficiency.

Casu and Girardone (2006: 441)for example, report that the "*average overall efficiency score for the EU banking industry over the whole sample period is 76.5 percent, indicating a 23.5 percent average potential reduction in input utilization*". They attribute the observed improvement in efficiency levels during the first half of the 1997–2003 period to cost cutting fostered by deregulation and increased competition, while the subsequent deterioration may stem from the costs imposed by a wave of mergers and acquisitions. There seems to be a (sometimes sizeable) dispersion of observed inefficiency levels across the literature, related to the countries and time periods examined and, of course, the types of banks and how many of them are involved.

Dietrich and Wanzenried (2011: 307) reviewed literature on financial institutions and deduce that inefficiencies of about 20–30% are quite common, and that the level of scale inefficiency is typically small. As do many authors, studies in this category adopt the so-called two-stage approach to explain and draw statistical inferences from the heterogeneity of efficiency scores. Using the measures calculated by DEA in the first stage as the dependent variable, the explanatory second stage applies bank-specific as well as market-level variables to assess the evolution and determinants of efficiency. This two- stage approach using OLS is going to be borrowed and limited to a Stage 1 analysis of efficiency in Zimbabwe's manufacturing sector. Tobit regression is often applied to account for the censored nature of DEA efficiency scores. In this study, the Tobit regression is dropped because the DMU are already homogenous in their sub-sectors of Zimbabwe's manufacturing sector. However, Dietrich and Wanzenried (2011: 307) show that Tobit is not the proper choice for second-stage regressions.

3.5 Empirical studies

The empirical literature review will be guided by the objectives of this study. Authors who contributed to the literature relevant to the objectives will have their studies analysed. The objectives from which sub-headings are drawn are the following;

i. To determine the drivers of efficiency in Zimbabwe's manufacturing sector;
ii. To compare financial ratios with efficiency ratios in the input-output model in order to identify the levels and kinds of inefficiencies in Zimbabwe's manufacturing sector;
iii. To measure efficiency in Zimbabwe's manufacturing sector using production plans of the efficient scores;
iv. To identify the barriers to achieving efficiency levels in Zimbabwe's manufacturing sector; and
v. To develop an efficiency model that will recommend an efficient input-output use in Zimbabwe's manufacturing sector.

3.6 Drivers of efficiency in the manufacturing sector

Various studies have been carried out to explain drivers of efficiency in the manufacturing sector. This section of the study identifies these and analyses them under the following authors:

Terziovski (2010: 892) attempts to explain innovation practices in Australia and how they can affect efficiency and subsequently performance. The study aimed at explaining the drivers of efficiency in 600 manufacturing small to medium enterprises (SMEs) in Australia in the fabricated metal products, basic metal products or tooling and machinery industries. The major drivers of efficiency from a simple regression model of this study are presented below:

Table 3.1: Drivers of efficiency

Driver of efficiency	**Size of impact**
Innovation strategy	37.9%
Formal structure	42.3%
Customer and supplier relationship	-1.1%
Innovation culture	4.8%
Technological capabilities	-1.09%

Source: Adapted from Terziovski (2010)

Table 3.1 shows that an innovation strategy positively drives the efficiency of manufacturing SMEs by 32.9%, followed by the form of the structure with 42.3%. It was found that if these manufacturing SMEs were to formalise their firm structures, efficiency will improve. The above drivers were found to have about 61.6% influence on efficiency, leaving 48.4% of the efficiency being influenced by other drivers not captured in this study. Erkoc (2012: 28) suggested that X-efficiency is largely caused by inadequate motivation, incomplete contracts, asymmetric information, agency problems and attendant monitoring difficulties. A conclusion can be reached that in this study, X-efficiency was measured using a simple OLS regression analysis.

Bunse, Vodicka, Schönsleben, Brülhart and Ernst (2011: 667)utilise the results from an international consortium from Europe (EU, Norway, and Switzerland), Japan, Korea and the

United States and found that many industrial companies still lack appropriate methods to effectively address energy efficiency in production management. Current approaches to integrate energy efficiency performance as a relevant criterion in production management seem to have shortcomings in their comprehensiveness and practicality. The European Commission (EC), with the objective to reduce annual consumption of primary energy by 20% by 2020 for example, estimates an energy saving potential for the manufacturing sector of 25%. This massive study found out that rising energy prices, environmental cost regulations and purchasing behaviour of goods with regard to green efficient products and services were the major drivers of energy efficiency. Since energy efficient manufacturing can have a significant impact on the environmental performance of a product, it can become a significant driver for efficiency and subsequently competitiveness.

In their study, which was initiated by the Swedish Foundry Association, Rohdin, Thollander and Solding (2007: 673), utilised respondents from Swedish foundries who discussed major driving forces for energy efficiency within the sector. Partly based on the results from the workshop and a previous study of the non-energy-intensive industry, and partly based on the scientific theory on the subject, it can be concluded that this will help firms better solve their efficiency barriers. In order to enhance efficiency in Swedish metal manufacturing, the following were the drivers of energy efficiencies in their order of influence:

- Long term strategy
- Management ambition
- Environmental company profile
- Environmental management system and
- Third party financing.

The foundry sector in Sweden found that energy was a major driver in this metal manufacturing industry.

Brandt, Van Biesebroeck and Zhang (2012: 339)found that total factor productivity (TFP) growth for the manufacturing sector in China was much higher due to the massive entry of new firms with above-average productivity levels and growth rates, as well as the exodus of inefficient incumbents. When new firms replace exiting firms, the re-allocation of input factors tend to enhance efficiency. TFP growth coming from improvements in continuing firms (the intensive margin of TFP growth) and through net entry (the extensive margin of TFP growth) was the source of over half of value-added growth in Chinese manufacturing over the 1998–2007 period. TFP's contribution to labour productivity growth is even higher at two-thirds. The rest of the growth in value-added was the result of increases in total capital and labour use in manufacturing, much of which was associated with the entry of new firms. The major drivers were value-added in manufacturing,which grew at more than 22% per annum. Capital accumulation and labour,which was a quality-adjusted input growth, accounted for 5.1% and 4.5% of annual output growth, respectively, or 43% of the total. The remainder, (57%), can be attributed to productivity growth.

Bogetić and Olusi (2013:1) conducted a study to identify the drivers of firm-level productivity in Russia's manufacturing sector. The study estimated total factor productivity (TFP) for Russian manufacturing firms using the Generalized Method of Moments (GMM) model developed in Levinsohn and Petrin (2003: 25) that accounts for endogeneity in productivity functions. This approach recognizes that profit-maximizing firms respond to positive productivity shocks by expanding output via mobilization of additional inputs. By contrast, firms experiencing negative productivity shocks reduce output by reducing the use of inputs. The GMM model is superior in this regard to the alternative OLS functions which yield biased estimates of productivity under these circumstances. Levinsohn and Petrin (2003: 2) assume a Cobb-Douglas production function of the form:

$$Yt=\beta 0+\beta il_t+\beta_k K_t+ \beta m\, Mt+\omega t+\eta_t$$

whereYt is the logarithm of the firm's output, most often measured as gross revenue or value added (measured as gross revenue in this paper); lt and mt are the logarithm of the freely variable inputs labour and the intermediate input (materials); and kt is the logarithm of the state variable capital, examples are fixed assets. The demand for the intermediate input mt is assumed to depend on the firm's state variables kt and ωt. Therefore, the factors of production are assumed to be the drivers of efficiency in this study.

3.7 Barriers to achieving efficiency in the manufacturing sector

The preceding section of this study focused on the drivers of efficiency. This section focuses on barriers to achieving efficiency. Furthermore, the discussion uses sub-headings from different authors who analysed barriers to achieving efficiency.

Rohdin, Thollander and Solding (2007: 672) concluded that energy can be both a driver and a barrier to efficiency. In this study in the Swedish foundry sector in 2007, it was found out that energy was a major barrier to this metal manufacturing industry, apriori. The following were the barriers of energy inefficiencies in their order of influence:

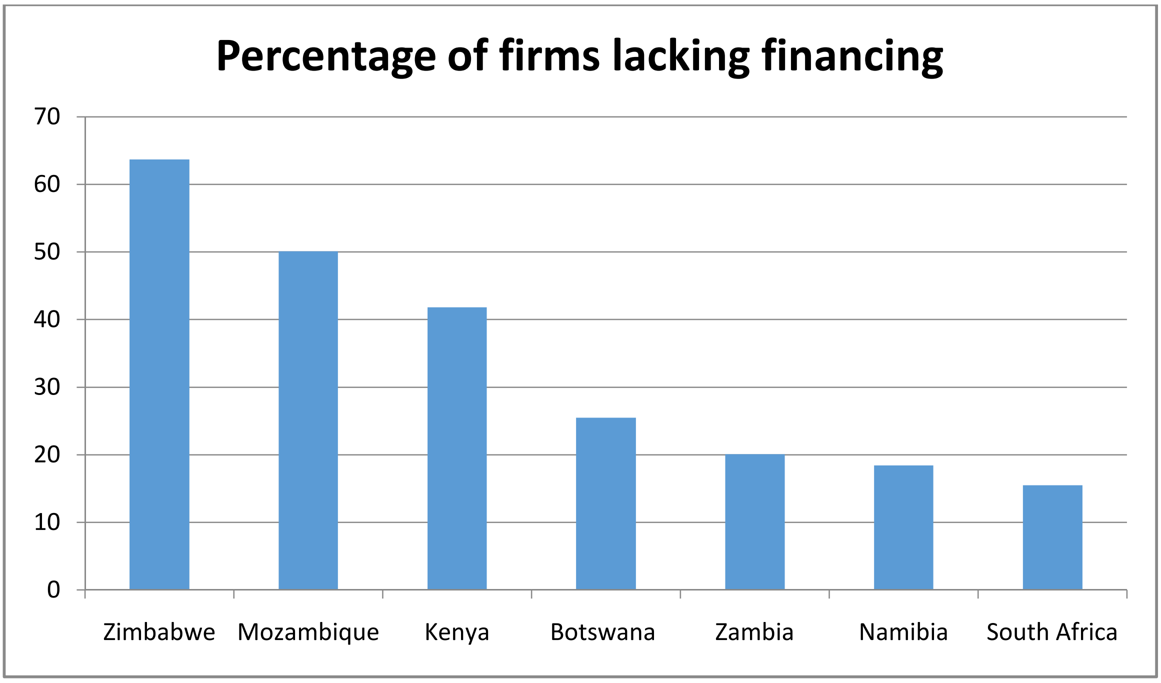
- Access to capital
- Technical risks
- Lack of budget funding
- Information asymmetry
- Other priorities of capital investment
- Poor performance of equipment

Rohdin, Thollander and Solding (2007: 674) recommend that barriers be grouped under economic, behavioural and organisational. This will help firms better overcome these barriers.

Egilmez, Kucukvar and Tatari (2013: 91)used an input-output frontier approach to measure efficiency for the United States (US) manufacturing sectors. It is important to note that approximately 90% of these sectors were found to be inefficient, using a DEA approach. In addition, only 34% of the US manufacturing sector has a higher eco-efficiency score when compared to the US average. On the contrary, 66% of sectors are found to have a lower efficiency score in comparison with the US. average. Based on DEA results, for the Motor Vehicle Body, Trailers and Part manufacturing sector to become 100% efficient, it needs to reduce emissions by 35%; energy use by 31%; hazardous waste by 37%; toxic releases by 38%; and water withdrawals by 32%. For “Leather and Allied Product Manufacturing”, which ranked as second amongst the sectors, to become 100% efficient, it needs to reduce emissions by 73%; energy use by 11%; hazardous waste by 57%; toxic releases by 11%; and water withdrawals by 84%. Analysis of results also show that US manufacturing sectors on average need to decrease emissions by 79%; and EU by 61%to become efficient. It is critical to note that some manufacturing sectors such as “Petroleum and Coal Products Manufacturing”, “Food Manufacturing” and “Motor Vehicle Manufacturing” have a 100% efficiency score based on DEA results. Although these sectors are found to be responsible for high environmental impacts compared to others, these sectors are 100% efficient and did not require any performance improvement values for environmental impact categories. This is attributed to the fact that these manufacturing sectors make significantly higher contributions to the US manufacturing sector’s total economic output, although they have considerable impacts on the environment. DEA ranked these sectors based on their environmental loads and economic value added, simultaneously. Therefore, manufacturing sectors with significant environmental impacts are able to show high eco-efficiency scores. Although these sectors are found to be 100% eco-efficient when considering their economic and environmental performances simultaneously, a supply-chain decomposition analysis is conducted for analyzing the direct and indirect environmental interventions of these major sectors. Value added will be borrowed as an output in this study because it has been shown to influence efficiency.

Davies *et al* (2012: 39) studied re-manufacturing in Zimbabwe, constraints and opportunities in a dollarized economy. The outcomes of their research indicated many factors that act as barriers to maximising efficiency by Zimbabwean firms. Access to finance was regarded as one of the major barriers to maximising efficiency as 64% of businesses in Zimbabwe reported access to finance as a major or severe constraint.This is higher than all comparator countries in the region, as shown in Figure 2.4 below.

Figure 2.4: Rankings of lack of access to finance constraint: Zimbabwe vs. comparators



Source: Adapted from World Bank Enterprise Surveys (2006-2011)

In the World Bank Enterprise Survey of 2006-2011, Zmbabwe had the highest number of firms constrained by a lack of finance in order to operate efficiently. Half the firms in Mozambique are also inefficient because they lack financing. In Southern Africa, South Africa is one of the countries whose firms are not struggling to obtain finance in order to operate efiiciently.

Davies *et al* (2012: 39) further note that in the late 1990s, annual cement demand in Zimbabwe was around 1.2 million tons. This declined to around 100 000 tons in 2008. Since early 2009, when the economy adopted the US dollar as its primary currency, demand rose to 600 000 tons up to the 2010 financial year. Demand is being driven primarily by retailers and concrete product manufacturers for supply to private housing projects. Zimbabwean operations ran at around 50 percent capacity utilisation for the year. Operations were affected by extensive electricity load shedding and a longer-than-anticipated shutdown to install a new clinker cooler at the Colleen Bawn factory. The new cooler, essential to remove a significant bottleneck in the plant, was installed over four months, beginning in April 2010. This was longer than planned and, as a result, the stock built up in advance was inadequate to keep the market supplied. The product was imported from the Slurry factory in South Africa but this proved ineffective due to a rail strike. This means that shortages and loss of sales, combined with additional costs of importing the product, are efficiency barriers which result in lower sales volumes.

Furthermore, Muranda (2003: 102) studied relationships between firm characteristics and export constraints in SME exporters. The outcomes of the study indicated that uncompetitive prices have also been a result of tight competition in foreign markets. Exporters report strong competition from other exporters targeting similar markets, mainly as a result of different product standards; unknown brands or labels; and low value-addition. Sixty percent of manufacturers in this study reported that they either export own manufacturers brands or unbranded products. However, in circumstances where exporters are targeting other developing markets as destinations, there has been considerable success in market penetration. Such success has not been forthcoming in developed markets where buyers are exposed to a wider range of foreign products also seeking to establish themselves. Products with well-publicised brand names or labels therefore stand a better chance. Un-labelled exports cannot earn the exporter a market reputation as much as the branded product. Profitably pricing the unknown brand or the unbranded product is quite difficult, hence the inefficient prices.

3.8 Limitations of the financial ratio measure of efficiency

Despite the much celebrated use of financial ratios in evaluating performance, this study argues otherwise. This study points out that the financial ratio fails to explain the composite performance of the firm, which can be easily done by efficiency scores. The use and limitations of the financial ratios as a measure of performance will be analysed under the writings of different authors.

Gallizo, Jiménez and Salvador (2002: 185) posit that **t**he analysis of financial ratios has traditionally been usedto measure the financial situation of a DMU through a comparisonof its ratios with those of other DMUs operatingin the same sector. Using such information, it is possible to forecast bankruptcies and to take decisions on whether ornot to grant loans or to carry out auditing evaluations. Allthese aspects make it interesting to characterise the dynamiceconomic process of such ratios as each one has a specific criterion it measures. Efficiency scores provides a composite measure of efficiency of any given DMU. Financial ratios do not adjust to the sensitivity of thefirm's exogenous factors that have an industry-wide impact. The Bayesian and non-parametric approach absorb the shocks in efficiency measurement. It was also noted that many ratios are related amongst themselves and very possibly, demonstrate very similar behaviour.

Öcal, Oral, Erdis and Vural (2007: 385) found that industry financial analysis is a means to provide abasis for government to undertake corrective actionand requires analysing a vast amount of data collectedfrom financial statements of various companies withinthe industry.Financial statements like balance sheets and income accounts provide a vast amount of data related to thefinancial state of a company. These data, are then simplified through financial ratio analysis in order tounderstand and analyse the company's performance and financial state. However, most ratios by themselves are not highly meaningful unless they are compared to some standard, such as industry trends or yearlytrends.Industry financial ratios not only allow comparison ofa company's financial performance with its rivals withinthe same industry, but also allow comparison of theindustry itself over time. However, there is a vast number of financial ratios that may be used duringcomparisons and some are more important than others for different industries. This raises the issue ofclassifying financial ratios by reducing redundancies and multicolinearity. In the Turkish construction industry, the deficiency of financial ratios was enhanced by factor analysis. Factor analysis is a statistical method based on the correlation analysis of multi-variables. The purposeis to reduce multiple variables to a lesser number ofunderlying factors that are measured by the variables. In itself factor analysis is a regression model. Factor analysis was applied to financial data collected from Turkish construction companies. Fiveindependent factors were identified and these appeared to measure capital structure and profitability; profit margin and growth; activity efficiency;liquidity; and assetsstructure of companies. These proved to be sensitive to economic changes in the country. It was proven thatcontinuous analysis of these five factors would providesufficient information related to both the relative stateof the industry with respect to time and the relative stateof any construction company with respect to their rivals.

Yalcin, Bayrakdaroglu and Kahraman (2012: 350-364) concluded that financial ratios provide useful quantitative financial informationto both investors and analysts so that they can evaluate theoperations of a company and analyze its position within a sectorover time. In this context, this study advocates a fuzzy model proposalfor the financial performance evaluation of the seven Turkishmanufacturing sectors whose effective and productive performanceis measured by using both traditional and modern financialratios. The non-parametric can also be utilised with inputs and outputs being extracted from the ratios. This will be handy as the evaluative ratios will be multi-dimensional in its measure for performance.

Lack of empirical evidence on working capital management and its impact on the firm's performance in the case of manufacturing sector of Pakistan incentivised the study by Raheman, Afza, Qayyum and Bodla (2010: 156). Empirical literature in Pakistan on workingcapital measures on a sectoral basis lacks the empirical evidence and regression analysis. Therefore, this study added value by estimating the relationship between working capital management and firm performancefor a large sample of 204 manufacturing firms listed on the Karachi Stock Exchange during 1998-2007. This evaluation is limited to working capital efficiency alone and does not consider the state of performance of the whole firm.

Worthington (1998: 97) shows that financial ratios are not enough in their sense and therefore the DEA is sued to investigate theefficiency of thirty listed Australian gold producers and explorers during 1993 to 1994. It extends empirical work in this area in at least two ways. Firstly, and as far as the author isaware, it represents the first attempt to apply the data envelopment analysis approach to the financial statementsof listed Australian companies (other than banks). The evidence provided suggests that, on average, there was alow variation in technical and scale efficiency amongst listed Australian gold producers during the period inquestion. Secondly, the study analyses in detail the posited linkage between financial and productive performance,using a variety of statistical techniques. The results indicate that financial ratios, whilst in themselves usefulindicators of firm performance, may be supplemented by multiple-input, multiple-output technologies. This isespecially the case where the presence of exogenous factors and scale effects may compromise the resultsobtained from traditional parametric analysis. Moreover, by specifically focusing on the input and output slacksmeasured using DEA, the present study offers insights into specific aspects of managerial behaviour than can be improved, rather than merely addressing the summary efficiency score. This is a robust measure of efficiency and performance of DMU.

Mermon and Tahir (2012: 12) studied efficiency/performance analysis of manufacturing companies in Pakistan. The objective of their study was to examine the performance/efficiency of fourteen manufacturing companies in Pakistan using financial accounting ratios. The study asserted that a business entity has to be efficient in order to perform and stay in business. The variables used were: expenses; sales; profit before tax;total assets; and return on assets. Descriptive statistics of the accounting variables were employed. The study concluded that ENGRO company, being the largest company by total assets over 3 years (2006, 2007, 2008) spent more, making low sales, having less Profit Before Tax (PBT) and Return on Assets (ROA) than the other thirteen smaller companies. For example, FCC being the second largest company by assets showed high sales, high PBT and ROA during the five-year period (2006-2010). The study concluded that higher expenses incurred in highlighted companies are a result of Expense Preference Behaviour Theory and low productivity growth. The researchers suggested that the manufacturing sector of Pakistan suffered barriers fromthe slow growth of investment, output and exports, allocative, technical and X-inefficiencies, poor quality of products and low levels of research and development activities, resulting in slow growth rates of productivity. This made Pakistani products incompetent in the world market.

3.9 Efficiency in the manufacturing sector

The magnitude of the significance of manufacturing sector efficiency cannot be over-emphasized. Manufacturing sector efficiency affects the performance of the economy through two different channels: by meansof positive output changes in the manufacturing sector itself, and through effects on the manufacturing sector. Manufacturing sector outputis responsible for a large proportion of the overall output of an economy since it has many sub-sectors.

Thefunctioning of the manufacturing sector affects productivity in the private sector through changes in taxes. Tax affects prices directly as it causes prices to rise, making the final products expensive. Hence, productivity falls as demand is reduced due to high costs and high prices. Manufacturing sector expenditure has been low as the government removed subsidies. These subsidies reduced economic growth because GDP fell. Manufacturing sub-sectors' contributions are very important as they help to make decisions of where firms need to channel resources. The major inefficiencies faced by manufacturing firms are production bottlenecks and political problems.

Maredza (2009: 50) found that measuring an organization's efficiency is about the relationship between the outputs it produces and the inputs it uses. An efficient organization would be one that produces the maximum possible outputs given its inputs, or one that produces a certain level of output with the minimum amount of inputs. The process of measuring an organization's efficiency involves three stages. Firstly, its inputs and outputs need to be defined and measured. Secondly, there is need to define the set of feasible input-output combinations, that is the production efficiency frontier. However, the researcher must answer the question: what outputs could be achieved for any given set of inputs? Finally,the organization's actual input-output combinations are compared with the set of feasible input-output combinations.

These stages are relatively not so complicated in the case of private organisations operating incompetitive markets. Even when organisations involve multiple inputs and outputs, prices areusually available for aggregating these operations and, therefore, efficiency can be easily estimated (Maredza 2009: 51). Apart from difficulties in measuring inputs and outputs, thereare a number of methodological issues relating to the estimation of efficiency in the manufacturing sector. Some of themost important choices concern the determination of output weights; modelling the productionprocess; controlling for environmental constraints; and allowing for dynamic effects (Smith and Street 2005: 14).

Non-African countries' experiences will be reviewed using studies conducted in these countries. In order to provide a comparative lesson, an African perspective of efficiency in the manufacturing sector will also be provided.

3.9.1 Non-African experiences on efficiency in the manufacturing sector

The following authors carried out insightful studies on efficiency in countries outside Africa. Review of such literature will also show a learning curve and reference case studies.

Faria, Fenn and Bruce (2001: 2) studied production technologies and technical efficiency in the Portuguese manufacturing industry. This study aimed at testing whether a given type of process innovation, namely flexible production technologies (FPTs), contributes to increased firm efficiency.The objective of the study was two-fold. Firstly, it aimed at providing measures of the technical efficiency of Portuguese manufacturing firms by estimating a stochastic frontier production function. Secondly, it aimed at investigating the impact of the new FPTs on technical inefficiencies. In particular, the study investigated the impact of eight different types of flexible productiontechnology adopted by Portuguese manufacturing firms. The study opined that firms face a wide range of options about their investments in technologies and innovations. Thus, in the 1980s, flexible production technologies (FPTs) emerged as potentially viable technologies for competing in industries that were traditionally characterised by high-volume repetition manufacturing, but which have more recently been subjected to greater competition and environmental volatility. The new FPTs were thus designed to provide firms with the capability of changing levels of production, as well as producing a larger variety of products in the face of frequent demand variations, at minimumcost.

In order to come up with results, the researchers employed the stochastic frontier analysis where inefficiency was measured as the deviation of the output of the productive unit from an idealised frontier function computed for the whole industry. As such, efficiency of a production unit was given by a comparison between observed and optimal values of its output or inputs. Furthermore, efficiency was said to be technical when the optimum is defined in terms of production possibilities or allocative when theoptimum is defined in terms of the behavioural goal of the production unit. Therefore, their study extended the literature that defines the performance of firms as a function of the state of technology and economic efficiency. The data used in the study were from the Indinova survey, which was conducted by the Portuguese Ministry of Industry in 1990 and aimed to collect information on both innovation and production technologies in Portuguese firms. The survey covered firms with 10 or more employees in both mining and manufacturing industries. The Indinova sample was obtained from the database of the Portuguese Ministry of Employment, which covers virtually all the firms in the country and was stratified by size class. Faria, Fenn and Bruce (2001)'s study used an econometric model to estimate firm-level technical efficiency and investigate its determinants. To investigate the effect of flexible production technologies on the technical inefficiency of firms, the researchers used the general translogarithmic functional form for the stochastic frontier production model for the sample of firms involved.

The results supported the hypothesis that technological flexibility, measured through the use of FPTs, was important in explaining differences in efficiency. Furthermore, given the specifications of the stochastic frontier function, the null hypothesis that Portuguese firms are fully technically efficient was precluded. The findings of that research showed that Portuguese firms exhibit various degrees of technical inefficiency. For the sample of firms considered the mean inefficiency level was around 34%. FPTs seem to have a positive impact on the technical efficiency of firms. An interesting finding was the negative impact of Numerically Controlled (NC) machines on technical efficiency. This is a result that had already found support in previous studies, although using different methodologies. The fact that NC machines contribute to increased technical inefficiency was concluded to be the result of two effects. Firstly, it results due to the fact that these machines are described as a more flexible technology within FPTs generally and is thus less productive. Secondly, given that the NC machines may be seen as the first generation of NC machines, the researchers expected that the earlier technology were less efficient than the latter. Finally, the estimates supported the hypothesis that some complementarity effects exist between FPTs and the adoption of other technologies by the firm, which have a positive impact on the technical efficiency of firms.

Amongst studies looking at the determinants of efficiency, Alvarez and Crespi(2003: 233), restricted their analysis to micro, small and medium Chilean manufacturingfirms, found that efficiencyis positively associated with the experience of workers, modernization of physical capital and innovation in products. In contrast, other variables such as outward orientation, owner education and participation in some public programsdo not affect the efficiency of firms. Gumbau-Albert and Maudos (2002: 34), usinga complete panel of 1,149 firms from eighteen manufacturing sectors, claimthat during the period 1991 to 1994 technical efficiency in Spanish manufacturingfirms increased with the size of the firm and with the amount of investmentmade. Also, efficiency tended to be relatively high in those firms, which are thesubject of pronounced competition. At the other extreme, the lowest levels of efficiencyhave been found in firms operating in concentrated markets where thereis presumably less competition and in firms with relatively large public participationin the firms' capital. Torii (1992: 75) claims that efficiency can be related to thescale or size of a firm if it is assumed that it is for maintaining or improving efficiency.

Mohamed and Said (2010: 3178)attempted a very interesting work and assessed the efficiency of the 100 largest listed companies from Malaysia Business magazine in 2009. Six outputs were used: Rate of change of revenue; rate of change of net profit; rate of change of assets; the return on revenue; return on equity; and return on assets. Only one input was used: total operating expenditure (cost). By a constant return to scale (CRS) assumption, 6% of the companies were found to be efficient. However, these 6% companies belonged to the bottom 20 by revenue. Those were also efficient under the variable return to scale (VRS) assumption. Thirteen percent of the companies were found to be efficient under the VRS assumption, in which 99% of the companies have achieved technical efficiency of more than 0.60. However, only one company scored 0.14 and 80% of the companies were scale inefficient. By analyzing return to scale, six companies were scale inefficient and exhibited decreasing return to scale (DRS). Furthermore, by slack analysis, 22.2% in all outputs could be increased. This suggested a peer group analysis for non-performing companies to improve their performance.

Dolage and Sade (2012: 266-274) examined the impact of the adoption of Flexible Manufacturing Technology (FMT) on the technical efficiency of Malaysia's manufacturing industry. According to these researchers, the GDP of the East Asian economies was said to be driven by the perspiration factor of input accumulation rather than the inspiration factor of total productivity growth (TFPG).Owing to the potential multicollinearity, the Principal Component Analysis (PCA) has been adopted to extract the most appropriate underlying dimensions of Flexible Manufacturing Technology (FMT) in an effort to substitute the eight FMT variables. The study has been conducted within FMT intensively adopted by 16 three-digit industries that encompass 50 five-digit industries, covering the years 2000-2005.The basic research hypothesis of the study was: A high degree of Flexible Manufacturing Technology (FMT) adoption enhances the Technical Efficiency (TE) of the manufacturing industry of Malaysia.The Stochastic Frontier Production Function (SFPF)was adopted in this study in order to compute the industry-wide technical efficiency, based on the same adoption by Mahadevan (2002:48-58) in a study on "*A frontier approach to measuring TFPG in Singapore Manufacturing Industry*". The findings of the research showed that the model that included the industry fixed effect dummy variables possesses a greater explanatory power. The two principal components that account for the greater variation in FMT show positive and moderately significant relationships with TE. The study concludes with sufficient evidence that FMT has a direct and moderately significant relationship with TE.The most important finding of the study was that both Process Controltechnologies and Production and Quality Controltechnologies show moderately significant and positive relationships with TE. This indicates that the increasing adoption of process control technologies and production and quality control technologies have direct impact on the TE of the FMT intensively adopted sub-sector of the manufacturing industry. In contrast, General Control shows a very highly significant and negative relationship with TE. Since both Process Control technologies and Production and Quality Control technologies together account for a greater variation (53 percent) and General Control technologies account for a relatively smaller variation (12 percent) amongst the eight FMTs, it can be concluded that a high degree of FMT adoptionenhances the TE of the manufacturing industry of Malaysia.

Görzig and Stephan (2002) found that outsourcing activities have a positive and significant influence on firm performance, measured as a return on sales. Heshmati (2003: 34) provides a comprehensive bibliography on the relationship between outsourcing and efficiency. Yet another important determinant is the ownership structure of the firm (Caves 1992: 11). Using an unbalanced firm-level panel of twelve Italian manufacturing industries over the 1978 to

1993 period, Bottasso and Sembenelli (2004: 75) investigated the effect of ownership structure on a firm's efficiency. They found that the type of ownership matters for large firms. More specifically, subsidiaries of foreign multinationals and state-owned firms are found to be more or less efficient than privately-owned, independent firms. On the contrary, no systematic difference is found between independent firms and subsidiaries of national business groups. Moreover, privatization of a firm leads to an increase of technical efficiency of about 3 to 7 percent. Bitros (2003: 121) conducted a study on Greek manufacturing firms during the 1979 to 1988 period which proved that the cost of inputs per unit of output of state firms was 46.2 percent larger than that of private firms, and that technical and allocative inefficiency accounted for 16.3 and 25.5 percent of this difference respectively. However, ownership turned out to be unimportant for the performance of manufacturing firms in Slovenia between 1994 and 2001 (Orazem and Vodopivec 2003: 232).

Studies by Kraay (1997:111) and Clerides *et al.* (1997: 120) used panel data on a sample of Chinese and Colombian firms; Moroccan and Mexican firmsrespectively to examine the direction of the causality between exports and firm performance. They attempt to explain the correlation between past export and current enterprise performance. At least three alternatives explanation are possible, namely: the effect of learning by exporting; the self-selection of the more efficient firms into the export market; and some unobserved enterprise characteristics (i.e. energetic managers) that affect both performance and exports. Results are contradictory to theory. While Clerides *et al*. (1997: 48) found that a positive correlation between exporting and efficiency is explained by the self-selection of the more efficient firms into the export market, Kraay (1997: 102) found that learning effects are pronounced in established exporters and insignificant or negative for new entrants.

Margaritis and Psillaki (2010: 621) investigated the relationship between capital structure, ownership structure and firm performance using a sample of French manufacturing firms. The study employednon-parametric data envelopment analysis (DEA) methods to empirically construct the industry's best practice frontier and measure firmefficiency as the distance from that frontier. Using these performance measures, the researchers examined if more efficientfirms choose more or less debt in their capital structure. Their study used an estimate of a firm's production efficiency to assess the role of leverage in addressing agency conflicts within a firm. More specifically, the researchers first assessed the direct effect of leverageon firm performance as stipulated by the Jensen and Meckling(1976) Agency Cost model. Secondly, they investigated if firm efficiency has an effect on capital structure and whether this effect was similaror not across different capital structure choices. Throughout these analyses, the studyexplicitly considered the role of equity ownership onboth capital structure and firm performance.

The study estimated the production technology and derived firm efficiency measures using data envelopment analysis (DEA), which is a non-parametric technique that employs linear programming methods to construct a piecewise linear representation of the frontier technology. Thus, DEA is a deterministic enveloping technique and hence is not subject to standard econometric problems. In addition, by modelling technology using a directional distance function, the study allowed firms to optimize in both input and output directions rather than in a single direction, as for example is the case with the more traditional Shephard type distancefunctions. The findings of the research were that average firms in the chemical industry were much larger and more capital intensive than firms in the computer and textile industries. Firms in the computer and Research and Development industries have higher intangibles-to-assets ratios and carry on average more debt in their capital structure. Profitability appears to be much higher on average in the textile industry but its distribution is highly skewed. Firms in the computer industry appear to be closer on average to the technological frontier compared to those in the chemical and textile industries. The researchers do not find any significant differences in efficiency performance over time (from 2002 to 2005). There appears to be a slight improvement in performance for firms in the chemical industry, and a slight decline on average for firms in the textile industry.

3.9.2 African experiences on efficiency in the manufacturing sector

The studies below are extracts from African cases on efficiency. Reviews of African studies mirror efficiency barriers and drivers similar to those of Zimbabwe’s manufacturing sector.

Abokaresh and Kamaruddin (2011: 1) measured the effect on efficiency of 21 Libyan manufacturing firms before and after privatization, from 2000 to 2008. The pre and post-privatized effect suggested no significant difference in technical efficiency. Average technical efficiency of all firms in the years before privatization was 49.5 percent, whereas after privatization it became 62.3 percent. In addition, state-owned firms improved only 9.3 percent after privatization and private firms increased only 15.3 percent after privatization, though in all conditions there was no significant effect.

Aggrey, Eliab and Joseph (2010: 69)investigated the relationship between firm size and technical efficiency in East African manufacturing firms using the DEA approach and the Generalised Least Squares (GLS) technique. Output refered to was all output produced by the firm in a year and inputs were costs of raw material from solid and liquid fuel, electricity and water. They found negative association between firm size and technical efficiency in both Ugandan and Tanzanian manufacturing firms. Din, Ghani and Mahmood (2007: 17) investigated the technical efficiency of the large-scale manufacturing sector in Pakistan using the DEA approach by an output-oriented model under CRS and VRS assumptions. A sample of 101 industries for 2 periods (1995 to 1996 and 2000 to 2001) were considered. Inputs included capital, labor, industrial costs and non-industrial costs. Output was the contribution to GDP. The CCR model indicated that mean efficiency improved from 0.23 in 1995-96 to 0.42 in 2000-01. Furthermore, only two industries could maintain their ranking in both periods. On the other hand, under the Banker, Charnes and Cooper (BCC) model, the average efficiency score has increased from 0.31 in the first period to 0.49 in the second period. Later, Memon and Tahir (2011:98) adopted the approach to investigate the efficiency of top manufacturing companies in Pakistan.

Bigsten, Collier, Dercon, Gunning and Zeufack (2000: 1) made an extensive investigation of exports and firm-level efficiency in the manufacturing sector in four countries, Zimbabwe, Ghana, Cameroon and Kenya was conducted. The study used data on manufacturing firms in these four African countries (Cameroon, Kenya, Ghana and Zimbabwe) obtained during the period 1991 to 1995 as part of the Regional Program on Enterprise Development (RPED) co-ordinated by the World Bank. In each country, over a period of three years, panels of firms in the manufacturing sector were surveyed and information was gathered on a variety of issues, including outputs and resource usage.In obtaining econometric estimates of technical efficiency, the researchers used the balanced panel of firms for which observations exist for all the years because the reliability of the measure of technical efficiency depends crucially upon the length of the time dimension of the panel. The researchers made use ofthe Stochastic Efficiency Frontier Model to estimate production function frontiers and derive technical efficiencies using fixed and random effects models and the time variant productivity approach. The reason for utilizing the Stochastic Efficiency Frontier Model was because the stochastic production frontier is motivated by the idea that deviation from the production frontier might not be entirely under the control of the firm and it also allows some observations to lie above the efficiency frontier, making the estimates less vulnerable to outliers, in contrast to the deterministic models. In documenting the association between exports and firm-level efficiency, panel data models were estimated. Their study presented the results obtained from the estimation of the stochastic frontierproduction model, including parameter estimates, estimated technical efficiencies and parameter estimates ofthe relationship between technical efficiencies and exports.The results of both randomeffects and time-variant productivity models reveal that exporters were more efficient than non-exporters. Furthermore, exporters increased their efficiency during the period more rapidly than non-exporters, and new entrants to exporting had the largest subsequent efficiency gains, controlling for other characteristics. The effect of exporting on efficiency appears to be larger in this African sample than in comparable studies of other regions, which were consistent with the smaller size of domestic markets.

Tingum (2014: 8) studied technical efficiency and manufacturing export performance in Cameroon. The objective of the study was to analyze the efficiency of manufacturing firms in Cameroon and identify the factors that explain increases in the efficiency levels and export performance of firms. The study aimed at addressingthe efficiency of manufacturing firms and determinants of technical efficiency of Cameroonian manufacturing firms. The researcher further investigated the relationship between technical efficiency and export performance while exploring the determinants of the export performance as well. The study employed Stochastic Frontier Analysis (SFA) to study the technical efficiency of the manufacturing firms, and Probit and Tobit models to examine the determinants of export performance of firms. The main finding of the study was that most manufacturing firms in Cameroon were technically inefficient. The most efficient firms were from the food processing sector, followed by wood and furniture. Firms with 5 to 20 years of operational experience in Cameroon were found to be more efficient. With regard to the determinants of manufacturing export performance, the Probit and Tobit models of manufacturing export performance were estimated. The study results indicated that higher levels of efficiency, firm size, foreign ownership, lower tax rates, producing in the industrial zone, and being in the food processing and textile sectors are the major determinants of a propensity to export and decision to export or not. The study also recommended that there is still room for technical efficiency improvements with existing firm technologies.Furthermore, the study concluded that in order to promote efficiency and export performance, policies should be designed for attracting FDIs, more especially in the food processing and textile sectors. Thus, the government should also design strategies to provide incentives, and credit to small and medium sized firms in order to increase output.

Haron and Chellekumar (2012: 234)determined the efficiency of manufacturing businesses in Kenya over the period 2009 to 2011, as well as to suggest appropriate policies to be employed by manufacturing companies in Kenya based on the findings of the study. The study suggested that the manufacturing sector has great potential for promoting economic growth and competiveness in a country like Kenya. It is the third leading sector contributing to GDP in that country. The sector has experienced fluctuations over the years under different financial conditions. Furthermore, the study opined that performance is a quality of any company which is achieved by valuable outcomes such as higher returns. It can also be measured by the levels of efficiency and this can be analyzed by a variety of methods, such as the parametric (stochastic frontier analysis) and non-parametric (data envelopment analysis) techniques. The management of any company would like to identify and eliminate the underlying causes of inefficiencies, thus helping their firms to gain competitive advantage and attain sustainable competitive advantage or, at least withstand challenges from others.

Input-output variables have been selected on the basis of production processes in companies and previous studies. In this study, the researchers used three input variables and two output variables. Input variables were raw materials, staff expenses and plant and machinery, while output variables were net sales and earnings after tax. The analysis contained in this study was based on a sample of manufacturing firms across Kenya. Data for 30 manufacturing companies was gathered from the Kenya Association of Manufacturers' database for the period 2009 to 2011. Companies were grouped by size into three categories: large-sized, medium sized and small-sized company. The firm size was measured by their total assets. Descriptive statistics of the variables were used and Pearson correlation was also used to indicate positive correlations between input and output variables. As a requisite in DEA, the input and outputvariables should be positively correlated (El-Mashaleh 2010: 61). This meansthat the input and output variables used in this study were appropriate as they satisfy the requisites ofDEA.

The research findings indicated that the overall technical efficiency (OTE) for large-sized companies was 61 percent, medium-sized companies 65 percent and small-sized companies 78 percent. In 2010, the OTE for a large-sized company was 67 percent, 71 percent for a medium-sized company and 87 percent for a small-sized company. In 2011, the OTE for a large-sized company was 78 percent, 68 percent for a medium sized company and 84 percent for a small-sized company. The study indicated that small-sized companies are more relatively efficient with 83 percent, as compared to medium and large companies with 68 percent and 69 percent respectively.The average OTE efficiency of a large-sized company was 61%, 67% and 78% in 2009, 2010 and 2011 respectively. The study discoveredthat one company had a maximum efficiency score of 100 percent in 2009, two companies in 2010 and in 2011, there were three companies with maximum efficiency score of 100 percent. The results for the medium-sized companies show that the average OTE was from 65% to 71% and 68% in 2009, 2010 and 2011 respectively. The average OTE scores for small-sized companies were 78%, 87% and 84% in 2009, 2010 and 2011 respectively. The outcomes also divulge clearly that inefficiency observed in manufacturing companies in Kenya are of scale rather than pure technical inefficiencies. Small-sized manufacturing companies were the best performing companies in terms of relative efficiency. These were followed by large-sized manufacturing companies and medium-sized manufacturing companies. The outcomes of the study provided a valuable reference for top manufacturing companies in Kenya in terms of reviewing their efficiency levels, as that would help them to achieve competitiveness and sustainable performance.

Olatunji and Ibidunni (2013: 121) studied the characteristics and efficiency of manufacturing firms in Lagos, Nigeria. The objectives of the study were to ascertain the current characteristics of manufacturing firms in Lagos; estimate the allocative efficiency of the sampled manufacturing firms; as well as to analyse the determinants of allocative efficiency in the sampled firms. The research discusses the determinants of allocative efficiency of a sample of manufacturing firms in Lagos, Nigeria's manufacturing hub. The data collection procedure was done using a survey sample of firms, using a semi-structured questionnaire. Furthermore, the research made use of secondary data which was collected from the National Bureau of Statistics (NBS). Twenty companies were used as a sample in that study. The findings of the research demonstrate that the surveyed firms have invested in technology and skills that may improve technical efficiency, but the allocative efficiency was generally low. The findings of that study also showed that the allocative capabilities of the firms have an average efficiency of only 20 percent of the frontier firm. Such findings, according to the researcher, confirm the existence of a cost efficiency crisis that often indicates Nigeria as a high-cost manufacturing environment. The results of the estimation of the allocative efficiency model indicated that cost efficiency increases with firm size; decreases with local ownership; increases with skill intensity; and increases with investment in technology and hardware.

Danquah and Ouattara (2015: 171) examined whether differences in the transfer and absorption of technology help to explain cross-country differences in national efficiency levels in manufacturing in sub-Saharan Africa over the period 1970–2010. The study opined that over the past four decades, the growth performance of sub-Saharan African (SSA) countries has been poor compared to that of other developing countries. In particular, the average sub-Saharan African per capita real GDP growth has hardly exceeded 2%, whilst East Asia and Pacific countries have been experiencing impressive growth rates in the ranges of 4 to 8%.

The researchers applied stochastic frontier analysis in a macroeconomics context, where countries' manufacturers of output with given inputs empirically examined the determinants of technical efficiency in SSA. The stochastic frontier method constructs an efficient frontier by imposing a common production frontier technology across all countries in the sample.

Deviations from the frontier were decomposed into inefficiency and noise. The introduction of the disturbance termto represent noise captures the effects of exogenous shocks beyond the control of the analysed unit, thereby reducing the volatility in the temporal patterns of efficiency measures.To study the determinants of efficiency, two methodological approaches were adopted in the SFA literature. The first approach, known as the two-stage approach, consists of estimating efficiency scores in the first stage and then in the second stage regress these scores against a set of explanatory variables. The data set used in that study was a panel of 78 countries (including the 18 SSA countries) for the period 1970–2010. The data set was expandedto include other countries in order to enable the researchersto determine the globallyefficient frontier.

The empirical results indicate that trade openness; machinery imports; stock of R&D, landlockedness; and the quality of institutions play a significant and quantitatively important role in explaining differences in efficiency in SSA, thus suggesting that the relatively efficient countries are opened to trade, have democratic regimes, good quality institutions and are located in coastal areas. However, human capital does not appear to be a significant factor in explaining inefficiency in the sampled countries. The findings on human capital provide empirical evidence to support the popular view amongst developmenteconomists that the low levels of education in SSA is a major setback to the technological ‘catch up’ process and achievement of sustainable productivity and economic growth. Also, findings indicate the need for SSA countries to take pragmatic steps to open up their economies to trade in order to boost the stock of Research and Development (R&D) via the increase in access to foreign capital and intermediate capital goods; scale up investments to promote the quality of education; deepen and strengthen the quality of institutions; and finally, pursue vigorous investment in infrastructural development across countries in SSA in order to facilitate trade and improve the transfer of technology and efficiency through the import of better technologies and managerial techniques.

In their analysis of the performance of the Nigerian manufacturing sector, Sodorbom and Teal (2002: 8) indicated that the manufacturing sector is one of the major contributors to the overall GDP, as well as the development of the economy. The study noted that regular aptitude utilisation proportion was about 44 percent. Accumulating above group size, the food sector appears as the segment with the uppermost regular capacity utilisation of about 59 percent. This was greater than in several of the other sub-divisions where modes vary between 40-47 percent. The metal sector appears to be a U-shaped connection amongst firm size and capacity utilisation as the average value for the category of small firms is equal to 38 per cent, which is 5 percentage points lower than for micro firms. At 56 percent, large/macro firms record the highest rate of capacity utilisation of the four size categories considered here. These are clearly very low values by international standards, suggesting ample excess capacity. The following chart shows the capacity utilisation of the Nigerian manufacturing sub-sectors in percentage by size and sector.

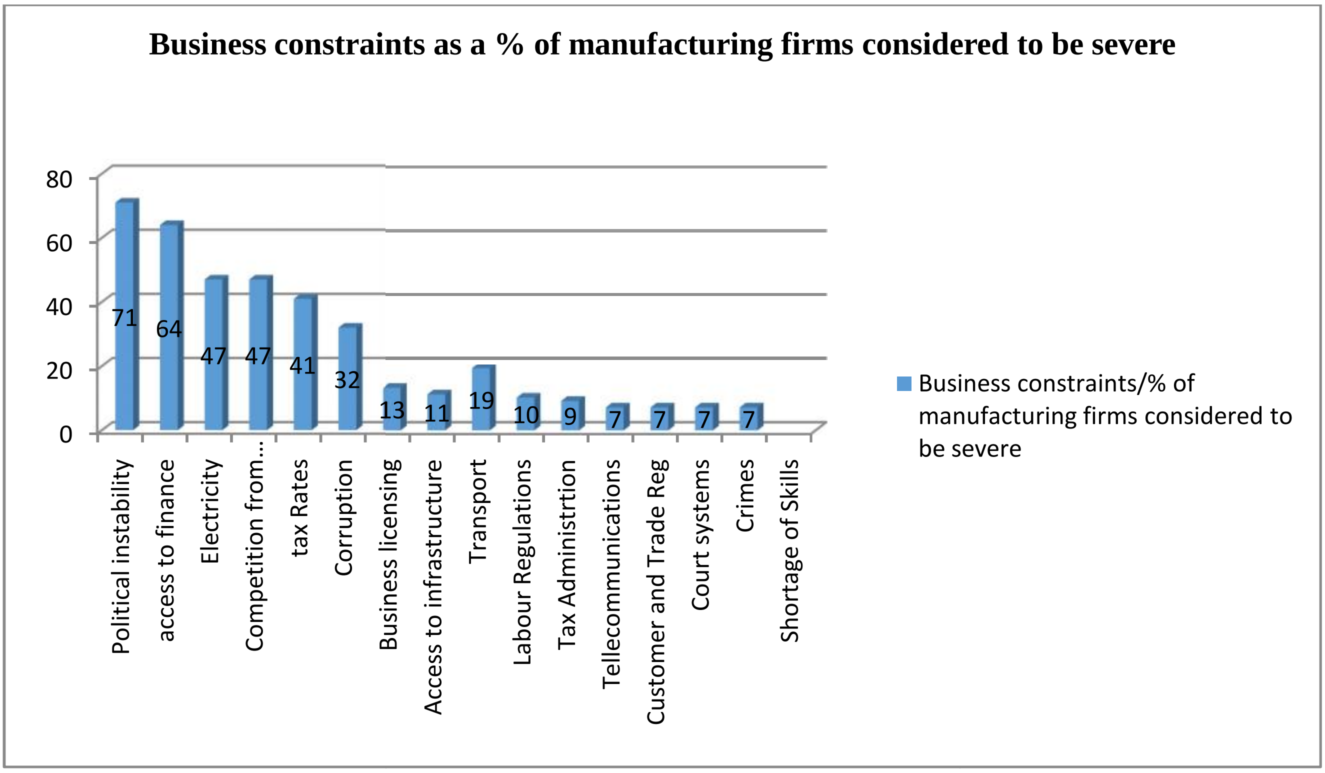
Goriwondo, Mhlanga and Mutsambwa (2013: 38) studied Agility for sustainability in Zimbabwe, using manufacturing Companies in Bulawayo as a case. They opined that agility as a driver of efficiency in manufacturing is critical for competitiveness. Audits were carried out on a spectrum that covers textiles, beverages, pharmaceuticals, foundry and rubber manufacturing, including household and industrial chemicals. Thus, the manufacturing industry in Zimbabwe is stuck on mass production and traditional manufacturing practices. The world has changed and this change needs to be recognized as a vehicle for competitive success. Global competition has moved a step higher, while companies in Zimbabwe have remained stagnant in their practices, technology and agility. Many manufacturing companies elsewhere are employing agile manufacturing principles that drive them towards world-class manufacturing status and sustainability in an ever-changing environment. Thus, the proposal for an agile manufacturing model for Zimbabwe is outlined.The aim of Goriwondo, Mhlanga and Mutsambwa (2013)'s project was to establish the level of agility of companies in Zimbabwe with a focus on manufacturing companies in Bulawayo. The ultimate objective was to develop a conceptual model that could be appliedto manufacturing companies including Small and Medium Enterprises (SMEs).The main challenges that manufacturing companies face in theglobal marketplace played a critical role in the development of the model.The study was conducted using a multiple case study approach. Organizational audits on the systems and operations in place were done on a spectrum of manufacturing companies that covers pharmaceuticals,textiles, beverages, foundry and rubber manufacturing, including household and industrial chemicals.The audits focused on evaluating how companies are performing in order to meet the four underlying principles of agility, which are delivering value to the customer; being ready for change in customer demands and needs; valuing and leveraging human knowledge and skills and strategies; and virtualpartnerships.

The study concluded that the manufacturing industry the world-over is facing challenges due to customer demand dynamics. The first to successfully meet and satisfy these dynamics continually has established a competitive edge overhis/her competitors. If also capable of meeting the dynamics and providing a product of good quality at an acceptable cost with high delivery speed, as well as manufacture the product in the shortest time frame possible, the manufacturer has a competitive advantage over all his/her competitors. It is against this background that the authors endeavor to impart competitive advantage to the SMEs in Zimbabwe to ensure a global-competitive standing through the use of agile manufacturing. This model has been developed to enable SMEs to have small production runs with multiple product variety which matches individual needs. It seeks to promote collaboration in place of specialization such that SMEs will lead to sustainability in manufacturing, effectively competing on the local then the global market.

Davies, Kumar and Shah (2012: 7)studied the manufacturing sector in Zimbabwe, paying particular attention to the constraints and opportunities in a dollarized economy, the findings indicated that the overall capacity utilisation of the manufacturing sector was very low though there exists wide dispersions between various firms in the sector. Thus, the study propounded that industrial policy in Zimbabwe was enclosed in-terms of retrieval, dignified by the intensification in aptitude utilization. The Mid-Term Plan, for instance, sets the strategy objectives for the manufacturing sector to increase capacity utilisation to eighty percent by the year 2015. However, the outcomes of the study posited that average capacity utilization in Zimbabwean manufacturing was indeed low, and much lower than that of comparator countries regionally. Mean capacity equated to 46 percent and was almost identical to the median of 45 percent, but there were big differences in such medians. The collected data from some firms in the sector indicated that those firms' reasons for low capacity utilisation were due to a lack of access to financing, deficiency of raw material inputs and/or poor electricity. Furthermore, demand constraints, like price competition, low local demand and uncertainty were regarded as the major causes of poor capacity utilisation.

The diagram below indicates the various reasons for the failure of most firms in the manufacturing sector.

Figure 2.5: Barriers to efficiency in Zimbabwe's manufacturing sector



Source: Adapted from the World Bank Enterprise Survey (2011)

From this survey analysis, the political environment followed by constraints in accessing finance largely influences the efficiency levels of the Zimbabwean manufacturing sector. Shortage of electricity, competition from external manufacturers, taxes and corruption were the other barrier to efficiency.

3.10 Recommended efficiency models

The following studies offer efficiency models from which Zimbabwe's manufacturing sector can learn from. The recommendations from these studies can be applied together with current results, for instance those which will come from this study.

Chidamoyo and Dombo (2012: 31) used the qualitative research paradigm to investigate competitive strategy and the efficiency drivers of small and medium firms in the Zimbabwean manufacturing sector, specifically in Masvingo. The study posited that competitive considerations by Small and Medium Enterprises have bearing on the performance of Zimbabwe's small manufacturing firms (Chidoko *et al.* 2011: 11). The study probed that fundamental competitive variables and cost discrepancy, as well as modernization of machinery were the basic competitive strategies that can be used by small manufacturing firms in the Masvingo urban area of Zimbabwe. The major theme that was established indicated that small manufacturing firms have to adopt the cost leadership strategies, differentiation and innovation for them to implement enhanced productivity. The researchproposed that those small manufacturing firms in Masvingo urban area lack expanse, capital and know-how of explorations and innovative improvements.

Muranda (2003: 98) studied relationships between firm characteristics and export constraints in SME exporters. This study presented results of an exploratory nationwide survey of 124 manufacturing companies in Zimbabwe involved in exporting all over the world. Calculation of correlation coefficients amongst the 21 export constraints tested indicated no strong correlation amongst individual factors, thus warranting proceeding to the next stage without eliminating factors at this stage. Principal components analysis with varimax rotations was used to investigate the underlying constructs amongst the factors. Analysis led to one extraction of five factors. Varimax rotation uses a conservative method for estimating commonality by means of the square multiple correlations in the diagonal of the correlation matrix. The five extracted factors account for 57.3% of the variance in these factors. Selection of factors was based on an eigenvalue of all factors. Cronbach's alpha was computed as the measure of internal reliability of the constraint variable. All scales had a Cronbach alpha greater than 0.50, which corresponds to Nunally's (1967: 23) threshold level of acceptable reliability for exploratory research. Recovery, growth and competitiveness of Zimbabwe's manufacturing export sector is going to depend on some of the following recommendations:

Firstly is policy implemantation, which recognizes that small-to-medium manufacturing exporters' needs may in essence be the same but different in scale and structure to those of large manufacturing exporters. Policy should also recognize that small to medium exporters lack the capacity to strategically respond and influence external markets. It therefore practically implies that there should be a policy mechanism to monitor and assist small-to-medium exporters to adjust to external market changes. Secondly, there is the need for exporting companies to reform structurally, attitudinally and perceptually towards exporting. Export competitiveness is not only a question of correctly manipulating the marketing mix element, but also a function of commitment of resources and attitudes. It is especially the latter form of commitment which is not being given adequate attention by management. This, therefore implies that until such attitudinal changes take place, efficiency, growth and competitiveness in exports will remain restricted.

Zimbabwe’s manufacturing sector can borrow efficiency recommendations synthesised from Micieta and Binasova (2013: 887), namely

- Machines should communicate their usage profile, which may be used to compare with other companies, and their improvements made.
- Benchmarks for similar equipment should be facilitated.
- Benchmarks should be available, stating where other companies with the same challenges stand, in order to increase efficiency with the same process quality and
- Best practices and the possibility to benchmark efficiency metrics should be given.

3.11 Summary

The study revealed the causes of different types of efficiency that most manufacturing companies face despite being in different market structures of competition. This literature review has guided the researcher on the methodology that is going to be used. The next chapter will focus on the methodology utilised in this study.

CHAPTER FOUR

METHODOLOGY

4.1 Introduction

This chapter provides the methodology employed by this study in the analysis of efficiency levels in the manufacturing sector in Zimbabwe. The methodology applied in the research involves the use of an empirical measure of efficiency of DMU such as manufacturing entities while using non-parametric methods for the estimation of a production frontier referred to as the DEA or balanced benchmarking. This method is based on the theory of production and makes efforts to depict a production frontier, which can be considered to as the best practice-frontier (Cook, Tone and Zhu 2014: 2). Mathematical formulations of the DEA and its orientations, definition of variables and model specification are covered in this chapter, with special recognition to Zimbabwe.

4.2 Research design

Research design emphasizes techniques for organizing a research process to achieve maximum control over factors that may interfere with the validity of the findings (Bechhofer and Paterson 2012: 167). Polit and Beck (2013:7) define a research design as "*the researcher's overall process for answering the research question or testing the research hypothesis*". In brief, research design must at least contain: (a) a clear statement of the research problem; (b) procedures and techniques to be used for gathering information; (c) the population to be studied; and (d) methods to be used in processing and analysing data (Khotari 2011: 32). There are many documented research design categories and none is agreed to be the best (Corbin and Strauss 2014: 8). In order to analyse the efficiency in Zimbabwe's manufacturing sector, this study used the mixed research design.

A mixed methods design is useful to capture the best of both quantitative and qualitative approaches (Creswell 2013: 20). It is suitable for generalizing the findings to a population and developing a detailed view of the meaning of a phenomenon or concept. According to Creswell (2013: 18), a quantitative approach is one in which the researcher primarily uses post-positivist claims for developing knowledge from cause and effect thinking which is reduced to specific variables. Quantitative research design is an excellent way of finalizing results and proving or disproving a hypothesis (Khotari 2011: 32). The questionnaire was used for the quantitative research methodology to approve or disapprove the hypothesised causes of inefficiency in the manufacturing sector in Zimbabwe. It proffered answers to the objective claims in the “what” and “how” research questions in this study. The DEA statistical and computational techniques provided the efficiency ratios. Qualitative research is an exploratory method where the researcher is immersed in the collection and analysis of the data (Corbin and Strauss 2014: 4). The researcher carried out interviews for the qualitative research methodology, where in-depth interpretation on the causes of inefficiencies in the Zimbabwean manufacturing sector was gathered. The interviewees comprised experts in the manufacturing sector in Zimbabwe. This mixed method design, which gives the smallest error is supposed to be the best design in many investigations and analysis. A design which minimises bias and maximises the reliability of the data collected yields maximal information. This provided an opportunity for considering many different aspects of the efficiency problem in Zimbabwe and is therefore considered to be the most appropriate and efficient design. The aspects considered were in line with the research objectives. According to Bechhofer and Paterson (2012: 167), the fundamental principle of mixed research involves combining quantitative and qualitative methods, approaches and concepts that have complementary strengths and non-overlapping weaknesses.

4.3 DEA models

Two main models have been the cornerstone in DEA modelling, that is the CRS Charnes, Cooper and Rhodes (CCR) model and the VRS Banker, Charnes and Cooper Model (BCC) model. These models are applied with a heavy dependency on the conditions at hand. In a more meaningful way, the decision to use an input-oriented model or output-oriented model depends on the fact that whether the DMU in consideration decides to adjust input or output, with an input model used for a firm that adjusts input before output.

4.3.1 The Charnes, Cooper and Rhodes (CCR) Models

The CCR model by Charnes, Cooper and Rhodes (1978) is a model that derives a CRS curve from a DMU which is considered to optimize the ratio of output to input (maximum average productivity). For the model, if data is given for each DMU, efficiency can be measured and evaluated. Productive efficiency is obtained when DMUs are functioning on the frontier of the production technology at a scale of operation characterized by constant returns to scale. Functioning under the IRS denotes lower inefficient output such that the inefficiency associated with non-constant returns to scale is captured by a measure of scale efficiency.

The technical efficiency scores for a DMU with non-optimal operations can be calculated based on the difference between VRS-TE and CRS-TE scores such that two possible decompositions can be given. The first one involves scale inefficiency, while the other is caused by pure technical inefficiency. Determining this involves running both CRS and VRS-DEA upon the same data. Differences between the two TE scores on a DMU reflects it as succumbing to scale inefficiency.

It is important to bear in mind while formulating the CCR-DEA model that it is rather restrictive and unlikely to hold globally in many realistic cases. Given such highlights, if data is given for each DMU that has *n* optimizations one for each DMU_j to be evaluated. For the purpose of the study,DMU_j is a Manufacturing firm who is said to produce output Yr with a given input amount of input Xi. The same DMU assigns U_r *and* V_i as weights, with U being the weight for output r and V the weight for input i. Note that we solve the fractional programming problem to obtain values for input weights $(v_i)(i = 1,\cdots,m)$, while that of output weight is$(u_r)(r = 1,\cdots,s)$.

$\max_{v,u} h = \sum_{r=1}^{s} U_r Y_{rj}$,

$subject\ to\ \sum_{r=1}^{s} U_r Y_{rj} - \sum_{i=1}^{m} V_i X_{ij} \leq$
0…………………………………………….........4.9

$\sum_{i=1}^{m} V_i X_{io} = 1,$

$U_r, V_i \geq 0,$

Equation 4.9 shows how the DMU is to maximize output $u_1 y_o + u_2 y_o + \cdots + u_s y_o$ (which can be summed as above) subject to unit input $v_1 x_{1o} + v_2 x_{2o} + \cdots + v_m x_{mo}$ and should maintain the rule that virtual output cannot exceed virtual input for any DMU. A Pareto optimality condition is fulfilled as increases in the maximal value can be attained only if some of the input values *Xij*are increased or if some of the output values *Yrj*are decreased.

By virtue, the first constraint entails that the manufacting firms have ratios of virtual output vs input not exceeding one, as all firms operate on or below the frontier. The second constraint asserts the objective of obtaining weight Vi and Ur that maximize the ratio of the DMU being assessed. As such, the weights are treated as unknowns obtained in the linear program solution such that the weighted sum of inputs for the given DMU is equal to one. Weights are the variables that help determine which input a particular manufacturing firm is best in using to generate output, resulting in higher rates given to those inputs and output variables which are able to maximize and lower rates to those it utilizes less. If for instance there are a 1000 manufacturing firms in Zimbabwe, such a linear programming model has to be tested a 1000 times once each for every manufacturing firm.

Thus, this model is designed to assess the relative performance of all the DMUs such that if each DMU is asserted to be manufacturing firm_j (DMU_j) and that if it is evaluated on a trail it will be designed as DMUo, where j has a range of 1,2,…,n. A constraint of Yrj, X ij > 0 is provided to represent observed amounts of the r^{th} output and i^{th} input of the j^{th}DMU*j* that has ranges of j = 1,..,n entities who maximize *i* =1..., *m* inputs to produce *r* =1.., *s* outputs. One of the *j* = *i*..., *n*, s is singled out for evaluation, denoted DMUo. The value * 0 *h* obtained from this ratio satisfies 0 ≤ * 0 *h* ≤ 1 and can be interpreted as an efficiency rating in which * 0 *h* = 1 represents full efficiency and * 0 *h* < 1 means inefficiency is present. The asterisk indicates an optimal value obtained from solving the model. The value of * 0 *h* has operational significance in that 1- * 0 *h* provides an estimate of the inefficiency for each DMUo being evaluated.

It is important to note that the co-ordination of DEA is commonly placed to consider efficiency as modified by the above optimization. Thus, any DMU being calculated for maximization will be guided to the subset of j = 1…n DMUs. Dual formulation can now be constructed by minimizing the quantities of the *m* inputs required to meet stated levels of the s outputs, such that branch O is relatively efficient given the efficiency ratio $\theta*$ equals 1. For such a situation to hold, the slack variables should all be zero, meaning that $\theta*$=1 with $S_i^- = S_r^+ = 0$ in all i and r. A DMU will be considered 100% efficient if the above situation holds for each estimated DMU. This can be shown in the equation below:

$minimise: \theta - \varepsilon[\sum_{i=1}^{m} S_i + \sum_{r=1}^{s} S_r],$

$subject\ to: \ \theta X - S_i^- \quad \sum_{j=1}^{n} X_{ij}\sigma_j$ ……………………………………………………..4.10

$$Y_{ro} + S_r^+ = \sum_{j=1}^{n} Y_{rj}\sigma_j$$

$\sigma_j \geq 0, j = 1 \cdots n$ (weights on branches)

$S_i^- \geq 0, i = 1 \cdots m$ (Input slacks)

$S_r^+ \geq 0, r = 1 \cdots s$ (Output slacks)

4.3.2 The Banker, Charnes and Cooper Model (BCC), (1984)

The BCC model approach is one designed to solve a restrictive CCR DEA model, which in many conditions is unlikely to have CRS not holding globally in realistic cases. The model is modified to enable an exhibition of increasing, constant or diminishing returns to scale at different points on the production frontier. To allow for a scenario where the VRS DEA model is applicable, the following (primal) model is run:

$$Maxho = \sum_{r=1}^{s} U_r Y_{rjo} + U_o$$

$St \sum_{r=1}^{s} U_r Y_{rj} - \sum_{i=1}^{m} V_i X_{ij} + U_o \leq 0, j =$
$1 \cdots n$……………………………………………4.11

$$\sum_{i=1}^{m} V_i X_{ijo} = 1$$

$$U_r, X_{ijo} \geq 0$$

$$U_o \gtreqless 0$$

An unconstrained sign of U_o is added to the primal model, with the sign used to determine the returns to scale. As such, Uo< 0 indicates increasing returns to scale, while Uo = shows constant returns to scale, and Uo > 0 is for decreasing returns to scale. An extension from the CCR dual formulation model can then be formulated as:

$$Minimize: \theta - \varepsilon \left[\sum_{i=1}^{m} S_i^- + \sum_{r=1}^{s} S_r^+ \right]$$

$Subject\ to: \ \theta X_{to} - S_t^- =$
$\sum_{j=1}^{n} X_{ij} \sigma_j$……………………………………………………...4.12

$$Y_{ro} + S_r^+ = \sum_{j=1}^{n} Y_{rj} \sigma_j$$

$$1 = \sum \sigma_j$$

The difference between the CCR and BCC models emanates from σ_j, which is restricted to a total of one. This results in the elimination of the constraints which were originally in the CCR model and which stated that DMUs must be efficient. If the model 4.12 is regressed for each DMU, the BCC efficiency scores will be obtained which are purely technically efficient because they are obtained from a model that allows variable returns. This deletes the scale part of efficiency such that the DMU only considers the technically efficient to be important.

The VRS model has technical efficiency scores being greater than or equal to those obtained by CRS, but they cannot be less than the CRS scores.

For example, data input for aDMU that has input (x) and output (y) as shown below:

DMU	DMU1	DMU2	DMU3	DMU4	DMU5
Input	2	4	6	7	5.5
Output	2	6	8	4	6.5

The VRS assumptions will result in a production frontier with a KABC extension. However if CRS assumptions are held, the production frontier is the OR passing through the point B. If both assumptions are considered, A and C are technically efficient under the VRS assumption but not under the CRS. DMU2 will be efficient when CRS is assumed, while DMU4 and DMU5 are inefficient under VRS. Thus, if technology allows variable returns to scale at different points on the frontier of the production possibility set, the technical efficiency (either input or output-oriented) of a firm will differ from its scale efficiency. Technical efficiency is measured by comparing the ray or average productivity of a firm with the corresponding average productivity at its input or output-oriented projection onto the VRS frontier.

4.4 Pre-conditions For The Application of DEA

The Applicability of DEA requires that four Axioms are satisfied in order for there to be effective use, interpretation and acceptability of results. These axioms are Positivity, Isotonicity, Homogeneity of DMUs and the Number of DMUs. The Axioms are explained as follows:

4.4.1 Positivity Axiom

The axiom demands that for all the input and output variable of any DMU should be greater than zero. This axiom bases on common sense that if a DMU is into production of any product, there is bound to be input used in the form of but not limited to land and capital that produces a finished product being the output. These inputs and outputs can be quantifiable such that they have a deterministic value.

Therefore, if the variable is not positive, a positive amount is added to the negative value in order to make sure the input or output in particular is positive. This adjustment should be applied to the same input or output value for all the manufacturing firms in the data set in order to change the efficiency frontier.

4.4.2 Isotonicity Axiom

This axiom draws its basis from a mathematical construct where it is required that an increase in input should mathematically result in an increase in output. For example, a manufacturing firm producing pencils and uses timber as input. It should expect an increase in the pencils it produces should it choose to increase its input "timber." If this axiom is violated in the sense that the DMU does not have output increasing from an increase in input, the Isotonicity requirement can be rectified using reciprocals.

4.4.3 Homogeneity of DMUs Axiom

The DEA demands that there be a relatively homogeneous set of entities. This axioms demands that the inputs and outputs used by the DMUs in the data set should be identical in positive amounts so as to be able to control the case-mix.

4.4.4 Number of DMUs Axiom

The axiom is related to the requirement of degrees of freedom that enables for there to be meaningful results and analysis. Consequently, a large number of DMUs have to be added and have their data collected to increase the degrees of freedom. If a hypothetical situation is considered where for example a small data set is used, there is the risk that analysis will show that more DMUs are efficient as they will receive a rating of one. Such a problems emanates from the fact that the discriminating power of DEA is neutralized when a small sample is used. To help solve this problem, Ganely and Cubbin's (1992:67) rule of thumb is adopted where the research will abide to the fact that the sample size used should be larger than the product of the number of inputs and outputs.

4.5 Mathematical Formulation of the DEA

It has a foregoing value for every entity in an economy to be able to evaluate and compare its performance over a given time period or with other entities. Such comparatives allow them to assess how well they have performed and in the process help create suitable benchmarks which can be adopted as pace setters. In the manufacturing sector, such analysis of efficiency of manufacturing firms has been performed using financial accounting based ratios such as inventory turnover and receivable turnover. However, such ratios have detriments where the inventory turnover only reveals how a given stock is being converted into sales but does not reflect how profitable the turnover process, what the cost and time taken in the production process is and also the input and output relationship that a production process has. The receivables turnover in the same negativity only outlines the cashflows of an organization.

Given such failures in the current financial ratios, in addition to limitations to the one input and output scenario, the DEA has been proposed as a gap filling mechanism which can sum up all methods of comparison in evaluating efficiency with at least two input and two output situations working comprehensively for any manufacturing firm (DMU). In such a method, anDMU's assessment is established from the maximizing of the ratios of weighted output to its inputs, with a constraint set on a rule that the ratio is less than one or equal to one. Such a rule is based on a probability fact that a firm's capacity cannot be above 100% meaning having 100% efficiency, but rather it aims to reach the 100% goal mark and operates between the range of 0 to 100%.

As an application to the manufacturing sector with at least two inputs and two outputs: Economic efficiency calculation where more than one input and output is used and produced respectively, is postulated by Kinda *et al.* (2011:2) as being the summation of weights of output produced during the production process over the weighted sum of inputs used in the production process. This can be mathematically presented as:

$$\text{Efficiency} = \frac{\text{Weighted sum of Output produced during the production process}}{\text{Weighted sum of Input used in the production process}} \quad \ldots\ldots\ldots 4.1$$

It is worth mentioning that weights in the DEA are derived from the data instead of being fixed in advance, with each DMU assigned a best set of weights with the values that may vary from one DMU to another.

4.5.1 The Input-Oriented Constant Returns to Scale Formulation

Charnes, Cooper and Rhodes (CCR) model isthe foundation from which mathematical programming for multiple input and output production scenarios are estimated upon (Springer 2011: 41). The CCR model makes an assumption of constant returns to scale (CRS), with the returns to scale (RTS) considered to be different to the widely classical economic proclamation of a single output situation of increasing if a proportion of all inputs increase, or decreasing returns to scale if more than one output is produced than inputs. As a result, for the DEA if there is data on inputs K and output M for a given number of DMUs N,K,M and N mathematically represent the inputs, outputs and DMUs respectively. Inputs and outputs for the n^{th} firm can be mathematically programmed with the vectors x_n and y_n . More specifically, a non-parametric envelopment curve (NEC) can be obtained from the DMUs data by creating matrices in the form K x N for inputs and M x N for output. The NEC will have all data points from the inputs and outputs of the DMUs such that any point observed is on or below the production curve (Yu *et al*, 2014:212-219).

If weights are to be considered to be single matrix vectors of u = M x1for output, while input weight is v =K x 1, every n[th] DMU will have a ratio outputs over inputs in the form:

$$u'y_n \div v'x_n \quad \ldots\ldots 4.2$$

The principle form of DEA with CRS can thus be derived bearing a notion from Mousa (2015: 78) in the form:

$$\max_{u,v}(u'y_n \div v'x_n,$$

$$st \qquad u'y_j \div v'x_j \leq 1, with\ j = 1,2, \ldots \ldots N,$$

$$u, v \geq 0, \quad \ldots\ldots 4.3$$

Bearing in mind the principle used in constructing equation 4.1 of efficiency not being greater than one but greater than zero, equation 4.3 has maximized weights u and v measuring efficiency for the n^{th} DMU subject to the same constraint. Zhu(1997: 83)condescends equation 4.3 to result in an infinite solution and propose a $v'^{x_n} = 1$ as a problem solving constraint as per the works of Coelli (1996:134), thus rearranging the equation with u and v transforming to μ and γ respectively:

$$\max\ (_{\mu,\gamma}\ \mu' y_n),$$

$$st\ \gamma' x_n = 1,$$

$$\mu' y_j - \gamma' x_j \leq 0, with\ j = 1,2, \cdots N \quad \ldots\ldots 4.4$$

Given the multiplier transformation of the linear programming problem in equation 4.4, its duality results in a piecewise linear approximation for the actual frontier that minimize inputs while maximizing output (Ganley and Cubbin 1992:30).Duality linear programming can be used to formulate a dual equivalent envelopment equation, as shown below where symbols θ and σ represent constants in scalars form of N x 1:

$$\min_{\theta\sigma} \theta,$$

$$st \quad -y_n + Y\sigma \geq 0.$$

$$\theta x_n - X\sigma \geq 0,$$

$$\sigma \geq 0 \text{ ……………………………………………………………………………} 4.5$$

In this regard, equation 4.5 becomes more desirable for calculating efficiency scores as it is limited by only a few constraints, with the value of the θ being used as the efficiency score for the n^{th} DMU that abides with a rule of $\theta \leq 1$. A value score equal to 1 will show efficiency at the point on the efficiency curve that is technically efficient (Mousa 2015:78). As such, linear programming problem is solved N times once for each DMU in the sample and to prove that an assigned value of 1 is really efficient, equation 4.5 can be modified to include a vector OS of output slacks with a M x1 and an input slacks vector IS that is a K x 1. M1 and K1 will represent M x 1 and K x 1 respectively:

$$\min_{\sigma,OS,IS} -M1'OS + K1'IS,$$

$$st -y_n + Y\sigma - OS = 0,$$

$$\theta x_n - X\sigma - IS = 0,$$

$$\sigma \geq 0, OS \geq 0, IS \geq 0 \text{………………………………………………………………} 4.6$$

All the DMUs in the given sample will have the above second stage linear programming applied upon them, and as such the multi-stage DEA which is in partiality to the two-stage DEA is used. The reason for using the multi-stage DEA emanates from its ability to identify efficient points that have input and output mixes which are similar to those of inefficient points (Coelli 1996:134). However, it should be noted that the multi-stage DEA method is not easy to compute.

4.5.2 The Input-Oriented Variable Returns-to-Scale (VRS) Formulation

The most important pillar which DEA builds the efficiency concept on is the CRS which has certain conditions that have to exist for it to hold. These conditions allow for the DEA to be able to identify efficiency for all DMUs. In this regard, the CRS ceteris paribus will hold when DMUs in our case the manufacturing firms, are operating at their maximum such that they are operating at the lowest point of their long-run average cost curve (LRAC). However, the DMUs may fail to operate at this optimal scale owing to market imperfections and financial limitations. To solve this problem, Banker, Charnes and Cooper's (BCC) model proposes an extension of the CRS DEA model to account for the variations in the returns-to-scale. The reason for using a VRS specification emanates from a given fact that VRS will allow the generation of technical efficiency scores that are autonomous from scale efficiencies. If VRS is included in equation 4.5 through the convexity constraint: $N1'\sigma = 1$, the result will be:

$$\min_{\theta\sigma} \theta,$$

$$st \quad -y_n + Y\sigma \geq 0,$$

$$\theta x_n - X\sigma \geq 0,$$

$$N1'\sigma = 1,$$

$$\sigma \geq 0 \qquad (4.7)$$

N1 is an N x 1 vector of DMUs which forms a convex hull that envelopes data supplementary firmer than the CRS hull, making technical efficiency scores of VRS equivalent to those of the CRS model. According to Banker, Charnes and Cooper, a DMU can have technical inefficiency scores which are identified by the differences between CRS and VRS.

4.5.3 Economies of Scales in DEA

The initial DEA model was purposefully modelled to help evaluate the relative efficiency of non-profitmaking entities such as hospitals and schools, but its use grew to be able to explain business firms, financial institutions (Mousa 2015: 78) and also, for the purpose of this research, manufacturing industries. To sum up its abilities, the DEA model also calculates the economies of scale for manufacturing firms to assess their rate of operation and provide supplementary information on whether scale inefficiencies are caused by increasing or decreasing returns-to-scale. To determine economies of scale, a DEA model with non-increasing returns-to-scale are programmed as per the works of Banker, Charnes and Cooper (1984:) through substituting $N1'\sigma = 1$ with $N1'\sigma \leq 1$, resulting in:

$\min_{\theta\sigma} \theta,$

$st - y_n + Y\sigma \geq 0,$

$\theta x_n - X\sigma \geq 0,$

$N1'\sigma \leq 1,$

$\sigma \geq 0$………………………………………………………………………….4.8

As such, given the above equation, determining the cause of scale inefficiencies for given DMUs can be established by equating the NIRS TE score with the VRS TE score. If they are not equal, then they are increasing returns-to-scale in that DMU and if they are equal, then there are decreasing returns-to-scale in the DMU.

4.6 Justification of variables in the estimated empirical model

Given the ideal conditions that DMUs hold regarding what is a firm in economics, it is a firm that basically converts inputs into output with an intention to maximize profit. Taci and Fries (2005: 2) asserts that a DMU is into the production of a variety of products while meeting deadlines. Much thought and decision-making is conducted with regard to cost minimization and how profitability can be increased. Inorder to attain such a goal, organizations engage in budget allocations and other decision-making processes, such that a stream of logical economic decision-making is conducted.

DMUs generally use a variety of inputs to produce a variety of outputs which are demanded by the market. Consequently, the input and output variables used in this study lie in this definition,together with adherence to the assumption of the DEA method and literature.

4.6.1 Input Variables

Similarily, an input is regarded as an ingredient which is used during the production process with its demand not being of its own sake, but derived from the need to make a finished product demanded by the market.

- **Cost of raw material (CM)**

Raw materials are the resources used by a DMU to produce its finished goodsGoncharuk, Goncharuk, Lazareva and Lazareva(2017:24) have used cost of raw material as an input in measuring efficiency in wine manufacturing in Ukraine. Goncharuk, Goncharuk, Lazareva and Lazareva(2017:24-33) viewed the cost of raw material as a huge potential for cost reduction and efficiency growth. Kapelko, Lansink and Stefanou(2017:752) justified the use of raw material cost as an input variable in efficiency measurement. Kapelko, Lansink and Stefanou(2017: 752) posit that raw material cost is a major driver in European Dairy manufacturing firms. Given that this is a major irresistable cost in the manufacturing sector, it will also be used in this study.

- **Energy (E)**

Energy is the the physical, electrical, liquid or mental strength that allows DMUs to transform materials or inputs into finished or semi-finished outputs. Intensive research was conducted by Azadeh, Amalnick, Ghaderi and Asadzadeh (2007: 3792) for the manufacturing firms in OECD countries where energy input was seen as a major barrier to efficiency. The metal manufacturing sector in China concluded that there was need for energy efficiency since Chen and Gong (2017:210) found it to be a major efficiency barrier. Mousavi-Avval, Rafiee and Mohammadi (2011:903) analysed the optimization of energy consumption and input costs for apple production in Iran, using data envelopment analysis. Enegy was observed as a major barrier to efficiency by Mousavi-Avval, Rafiee and Mohammadi (2011:903) in their research on apple production. In Zimbabwe's manufacturing sector, energy-especially electricity-is scarce, expensive and should therefore be used efficiently.

- **Water and sewage (WS)**

Water and sewers are input variables necessary at a manufacturing DMU for the purpose of cooling and cleaning and above all, as an ingredient. Bhaskaran (2012:243) showed that water and sewer constrained efficiency in the Indian transport and transport equipment manufacturing sub-sectors. Bhaskaran (2013:245) indicated that in India, water and sewer services are a major driver of manufacturing efficiency in general and in the textile manufacturing sector to be specific. As a major ingredient in most manufacturing processes, the water and sewage variable is included in this study. de Almeida Guimarães, Junior and de Almada Garcia (2014: 178) carried out a study for the Brazilian manufacturing sector where water and sewers were used as one of the inputs in measuring efficiency using DEA. Their study found that water and sewer reticulation is an important driver of productive efficiency. This major ingredient was also used in this study for Zimbabwe's manufacturing sector.

- **Cost of services (S)**

This is a cost associated with producing a good by a DMU, which, in itself is not involved in the production of the actual product. Merkert and Hensher(2011:686) showed an inefficiency effect of cost of services of the Transport and Transport sector. They were worried as these costs are not related to the physical production in the manufacturing sector. Falsini, Fondi and Schiraldi (2012:4822) have deduced that costs of services are implicit costs hidden in the actual production and only manifest in accounting costs. Falsini, Fondi and Schiraldi (2012:4822) further assert that these costs are embedded in the manufacturing logistics costs, which are a barrier to technical efficiency. This cost is common in all logistical processes in the manufacturing sector and is thus included in this study.

4.6.2 Output Variables

As such, the definition of output will be a finished product which has been synthesized or modified by a DMU with an intention of making profits out of the product.

- **Sales (SLS)**

Sales is the activity or business of selling products or services. The activity features efficiency analysis as it is expected to be efficient in meeting customer needs and its proceeds used for maximising shareholder value.This common variable with available data in Zimbabwe’s manufacturing sector, “sales”, was used with support from existing studies which used it. Banker, Lee, Potter, and Srinivasan(2010:25) used sales as an output variable in measuring managerial and allocative efficiency.Both Cooper, Seiford and Tone (2007:9) and Cook, Tome and Zhu (2014:3) supported the use of sales as an output variable that should be widely used in efficiency studies. Cook, Tome and Zhu (2014:4) further stated that there could be no any other specific justification for using sales as an output variable as long as the DMU is profit-driven. Chen, Delmas and Lieberman (2015: 19-36) narrated the benefits of using sales and value-added variables, or both, in DEA since it can handle multi outputs. In Zimbabwe’s manufacturing sector, this variable can confirm efficiency because despite demand for products, Zimbabwe struggles with a high import bill.

- **Value-added (VA)**

Value-added is the firm or industry's contribution to the gross domestic product (GDP) which is calculated at each stage of production, excluding initial costs. Chiu, Huang and Ma (2011:95) justified the use of value-added as an output variable in assessing China’s transit and economic efficiencies. Value-added data was used as a desirable output in DEA by Chang, Zhang, Danao and Zhang (2013:277) in their Environmental efficiency analysis the of transportation system in China. Cash value-added was surprisingly used by Luo, Bi and Liang(2012:1118-1123) in the efficiency evaluation of Chinese commercial banks. Chen, Delmas and Lieberman (2015: 19) concluded that sales and value-added variables (or both) can be used in DEA since it can handle multi outputs. This output variable is justified as it shows efficiency added at different stages, despite prices changing from inflation pressures.

- **Gross value of production (GVP)**

The gross value of production measures the actual production output of a DMU and excludes all items not involved in production-like transfer gains. Ramalho, Ramalho and Henriques (2010:239) confirm GVP as an output variable that can be used in agricultural DMUs and manufacturing DMUs when analysing efficiency. Volume of output of manufactured goods measured as Gross value of production is the main output variable used as output variable in DEA. The Gross value of production variable is adopted as per the works of Maleku (2013: 12) who proposes this variable to be inclusive of values such as immediate purchases. This volume of output is measured in physical outputs as being the total products that a DMU produces for a given period. It is be important to note that the reason for such a measurement emanates from the advantage with DEA as it is unit invariant and does not require a homogeneous unit of measurement (Coelli 1996: 67)

4.7 Target population

Population in research refers to the totality of units from which cases with research information will legitimately be sampled (Robinson 2014: 25). Manufacturing firms in Zimbabwe is the research population. These are large manufacturing firms which have operated for the past ten years to provide data necessary for efficiency decisions in Zimbabwe's manufacturing sector. The number of large manufacturing firms in Zimbabwe has dropped to around six hundred and fifty firms (CZI 2014: 8). Probability sampling was used to select the 210 firms which constituted the targeted population. Random sampling design was used to randomly select 21 firms in each of the 10 categories. The clusters were the homogenous sub-divisions based on geographic area so that all manufacturing firms in Zimbabwe are represented. Practical considerations of time and cost have underpinned the selection of 210 manufacturing firms, based on random sampling.

4.8 Sample size

Stratified sampling was used to put the firms into different manufacturing categories: foodstuffs (10.7%); beverages and tobacco (21.3%); textiles (3.9%); clothing and footwear (4%); wood and furniture (8%); paper printing and publishing (11.2%); chemicals and petroleum products (3.9%); metals (23.3%); non-metallic minerals (7%); transport and transport equipment (6.7%) (ZIMSTAT 2010: 3-6). The percentage in brackets represents the size of the sub-sectors to the whole manufacturing sector. Probability sampling was utilised as atechnique, were each manufacturing sector category was represented by randomly selected twenty-one firms. The two hundred and ten respondentsto the structured questionnairewere randomly selected. The sample was representative since all manufacturing sector categories were represented.

The validity of the sample size should be statistically supported(Banker and Natarajan 2011: 278); since it is statistically known that large numbers of inputs and outputs compared to the number of DMUs may reduce the discriminatory power of DEA and subsequently the results. Therefore, Cook, Tone and Zhu (2014: 1-4) suggested that by "rule of thumb", the number of DMUs be at least twice the number of inputs and outputs combined (Cook, Tone and Zhu 2014: 1-4). Banker and Natarajan (2011: 273) on the other hand state that the number of DMUs should be at least three times the number of inputs and outputs combined. However, according to Williams (2014: 245), such a rule is neither imperative nor does it have a statistical basis, but rather is often imposed for convenience. In that sense, the size of the sample or the number of DMUs under evaluation may be immaterial (Cook, Tone and Zhu 2014: 3). Based on recommendations by Banker and Natarajan (2011: 273), seven variables made up of two outputs and five inputs will be used, which justifies that each of the ten sectors must have twenty-one firms (7 variables x 3 times= 21 DMUs).

The manufacturing firms and the Apex Boards, namely the Ministry of Industry and Trade, CZI, ZNCC, ZIA and ZIMSTAT,were the targeted population for the interviews. A purposive sampling technique picked the twenty-five Chief Executive Officers (CEO) from the sampled firms and the Apex Boards for the in-depth interviews. The two (one outstanding and one failing) firms from each manufacturing sector category were purposively selected using the extreme or deviant case approach.Siegle (2011: 6) indicates that the extreme or deviant case allows learning from highly unusual manifestations of the phenomenon of interest, such as outstanding firms and notable failing firms.A mixed or purposeful case was utilised to purposively select Chief Executive Officers from the Apex Boards to ensure representation of all manufacturing firms. A combination or mixed purposeful case ensures triangulation, flexibility and which meets multiple interests and needs of the research (Seidman 2013: 3). The research population and sample population for each manufacturing category is presented below:

Table 4.1: Research population and sample

Questionnaire			**Interview**	
Category	**Population**	**Sample**	**Category**	**Sample**
Foodstuffs	70	21	Foodstuffs	2
Beverages and tobacco	138	21	Beverages and tobacco	2
Textiles	25	21	Textiles	2
Clothing and footwear	26	21	Clothing and footwear	2
Wood and furniture	52	21	Wood and furniture	2
Paper printing and publishing	73	21	Paper printing and publishing	2
Chemicals and petroleum products	25	21	Chemicals and petroleum products	2
Metals	151	21	Metals	2
Non- metallic minerals	46	21	Non- metallic minerals	2
Transport and transport	44	21	Transport and transport	2

equipment			equipment	
			Ministry of Industry and Trade	1
			CZI	1
			ZNCC	1
			ZIA	1
			ZIMSTAT	1
Total	**650**	**210**		**25**

Source: Self generated by researcher

As a result of massive closure of manufacturing firms in Zimbabwe in recent times, the targeted population therefore contained firms which have managed to operate for the past decade. This will enable benchmarking efficiency DMUs and analysis on efficiency drivers and barriers. The sample was representative as all sectors were considered and therefore large enough to provide valid results according to how the DEA methodology operates.

Using the rule of thumb, the questionnaire sample was representative as it exceeded 5% of the population. Baker and Edwards (2012: 856) conclude that there is no concrete guidelines on the sample size on interviews. Richards and Morse (2012: 1) and Creswell (2013: 10) suggest that an interview be at least 20-30 interviewees. Purposive sampling is justified for interviewees in this study as Cohen *et al.* (2011: 15) suggested that it accessed 'knowledgeable people' by virtue of their professional roles, work experiences and leadership roles.

4.9 Data Sources

The data used for this research is representative of all manufacturing firms (DMUs) in Zimbabwe. Forthe purpose of this study, a firm is a DMU that is basically into synthesizing of a given input into an output through a determinable production process. Given such a guideline, data was collected for all the DMUs in the various provinces in the country,assisted by ZIMSTAT.

One ought to bear in mind the informalization that has been on the increase in Zimbabwe since 2008 and as such, some DMUs will not have their information available. The main reason for the unavailability of information is due to reluctance by DMUs to have their information published as it attracts the revenue collecting authority- Zimbabwe Revenue Authority(ZIMRA) and firm end up paying more taxes. Furthermore,DMUs do not release information owing to fear that it will expose them to their competitors. Therefore, data from ZIMSTAT was supplemented with data from other organizations that include CZI and the Zimbabwe Stock Exchange (ZSE).The other gap of data is supplemented by the collection of information from different individualDMUs and Apex boards.

Despite the constraint of data, the quality of results and analysis from the research will not be compromised due to the advantage of satisfying the “Number of DMUs” axiom for DEA that is the rule of thumb with the sample size above the one required.

4.10 Data collection tools and procedures

- **Questionnaire**

A pre-validated closed questionnaire from ZIMSTAT was used as a guide. The main body of the questionnaire was divided according to the research objectives. The questionnaire was pre-tested during the draft stage.Cohen *et al.*(2011: 15) suggested that pre-testing was meant to increase the reliability, validity and practicability of the questionnaire. As pointed out by Saunders *et al.* (2009: 67), the purpose of the pre-test is to refine the questionnaire so that respondents will have no difficulty in answering the questions. The results of the pretest study guided the researcher on whether the collected data will meet the study objectives. Two hundred and ten firms comprising twenty- one firms randomly selected from each category filled in the questionnaire. Questionnaires weredelivered directly to the respondents and collected after two months.

❖ **Interviews**

Interviews provide the researcher with an opportunity to probe answers where explanation and further responses are required (Robinson 2014: 25). In-depth interviews with two key informants each from two associations representing each of the ten categories, and one member from each Apex Board was contacted. In-depth interviews also encourage capturing of respondents' perceptions in their own words, a very desirable strategy in qualitative data collection (Robinson 2014: 25). Such a structured interview is where "*the interviewer puts a collection of questions from a previously compiled questionnaire, known as an interview schedule, to a respondent face-to-face and records the latter's responses*" (Corbin and Strauss 2014: 2-11) is advantageous as it can capture the respondents' illustrations. The information received was used to triangulate the data gathered from the questionnaires (Faux 2010: 100) and this was incorporated into the analysis and discussion section of the research.

❖ **Documental review**

Document analysis (Smith and Street 2005: 401) plays an important role in providing a description of the manufacturing sector over time. This segment of the study is designed to focus narrowly on the achievement of pre-determined objectives.

The following documents were accessed in order to triangulate and analyze the efficiency of Zimbabwe's manufacturing sector;

i. Minutes to annual strategic planning meetings;
ii. Policy documents;
iii. Government's reports;
iv. Apex Boards' reports; and
v. Firms' financial statements audited and unaudited.

All the above documents were analyzed in terms of their relevance to efficiency theories and proposed efficiency disclosure and their input to the evaluation of their impact on firm efficiency. Analysis of documents often results in unforeseen or unexpected new insights (Saunders *et al.* 2009: 30) and validates qualitative data. The documental review instrument was useful when comparing financial ratios with the input-output model to identify the kinds of inefficiencies in Zimbabwe's manufacturing sector.

4.11 Data analysis

The quantitative data will be grouped into input and output variables which will be regressed in Stata Version 16, a data enveloping analysis software. This non-parametric methodology has been chosen since it is among other efficiency measures the strongest comparative measure of efficiency suitable for the manufacturing sector situations in Zimbabwe. Besides, it can assess efficiency levels of Decision Making Unit (DMU) with multiple incomparable units and outputs. Furthermore, it can handle both input minimisation and output maximisation which are paramount decisions needed in the Zimbabwe manufacturing sector.

Efficiency scores and benchmarking summariesare presented leading to an understanding of Zimbabwe's manufacturing sector. Narrative and discourse analysis will be used to deduce meaning from the interviews. Content analysis is a way of categorizing various items of the documents analysed into a number of categories. It is employed where large amounts of qualitative data have to be analysed (Olubukunola 2011:5). Manufacturing sector efficiency findings will be compared to financial statements of selected DMUs from cases in similar operations using efficiency scores.

4.12 Delimitation

The study will utilise the manufacturing sector survey data for the period post-dollarization (2009-2014) for the manufacturing sector in Zimbabwe. The data is representative as it is captured from the ten categories of manufacturing. Data for results analysed in this study is for the year-ending 2015, which was complete in 2016 when data was collected. Sectorial efficiency comparisons were therefore feasible. Expert information was obtained from the

Apex Boards made up of the Ministry of Industry and Trade, CZI, ZNCC, ZIA and ZIMSTAT.

4.13 Research limitations

The researcher failed to obtain some of the important information from targeted DMUs under the guise of confidentiality. These DMUs were replaced with those who were willing to avail their information, especially those listed on the ZSE. The researcher was aware of information storage of interviews and therefore kept observation notes and avoided summarizing information where possible. The quantitative research was limited only to manufacturing sector performance for 2015. This was improved by data from financial statements.

4.14 Validity and Reliability

Reliability is the degree to which an assessment tool produces stable and consistent results. This is achieved by pilot testing and the use of different research tools. Validity is how well a test measures what it is purported to measure. Reliability and validity enhances objectivity and credibility of the research (Silverman 2010: 366). The researcher ensured that the evidence provided is corroborated by at least three data sources, namely questionnaires, interviews and documental review, which provided validity to the research in terms of triangulation (Trochim 2013: 3). Tolk (2013: 26) points out that qualitative validity can be judged by the criteria of credibility, transferability, dependability and conformability rather than against some external objective standard. Reproducability in questionnaires is important in order to achieve reliability and validity, which will be attained by administering the same questionnaire to different respondents (Pickard 2012: 3).This reproducability criterion was ensured as the data collected was quantitative in all DMUs in Zimbabwe's manufacturing sector and can be reproduced at anytime. Therefore, there is no need for further statistical validity of the variables used. Conformity will be assessed by noting whether the written records, interviews and questionnaires lead to similar conclusions (triangulation). It is often thought that the inferences and conclusions drawn from a single case study cannot be generalized. The results are for 21 DMUs in Zimbabwe's manufacturing sector, not just one

DMU and can thus be generalized. Silverman (2010: 225) highlights that interviews are validated if interviewees' responses match their experiences. Generalizations from this research should be based on the theoretical framework of efficiency applied. To ensure validity, DEA efficiency ratios are compared to the financial ratios of firms listed on the ZSE.

4.15 Anonymity and confidentiality

Anonymity is defined as the use of an unknown name or unknown authorship. Anonymity refers specifically to removing or obscuring the names of participants or research sites and not including information that might lead participants or research sites to be identified. The main way that researchers seek to protect research participants from the accidental breaking of confidentiality is through the process of anonymisation (Babbie 2015: 60). DMUs which were sampled are only coded in plain numbers which had nothing leading to its name. To achieve anonymity, the respondents use pseudonyms (Stanley and Wise 2010: 12). Corporate names of Apex Boards were used when conducting interviews. Questionnaire respondents will use numerical code names.Confidentiality refers to the management of private information '*that has been communicated in trust of confidence, such that disclosure would or could incur particular prejudice*' (Tilley and Woodthorpe 2011: 200). Data will be responsibly stored for five years before being shredded in order to ensure confidentiality. Clearly, anonymity provided a useful tool to help ensure that confidentiality is maintained for the sampled manufacturing sector firms in Zimbabwe.

4.16 Ethical considerations

The Durban University of Technology's ethical requirements were complied with by adhering to rules regulating higher qualification. In instances where research work of other scholars is used, referencing was done. The Turnitin anti-plagiarism software deters plagiarism. Since the researcher was a part time student, Turnitin software subscribed to by a Zimbabwean university was used. According to Silverman (2013: 173), the consent form signed before the research is done ensures voluntary participation and ethical governance. Undertakings, disclaimers and questionnaire coding will ensure confidentiality of participants. ZIMSTA signed the consent form on behalf of Apex Boards and manufacturing firms in Zimbabwe since they are the custodian of data in Zimbabwe.

4.17Conclusion

The methodological techniques highlighted in this Chapter will be used to obtain efficiency results for firms in the Zimbabwe's manufacturing sector. The DEA regressions will be run and robustness checks will be done. The data presentation procedures are discussed in the next Chapter.

CHAPTER FIVE

DATA PRESENTATION PROCEDURES

5.1 Introduction

In order to analyse efficiency in Zimbabwe's manufacturing sector, a DEA methodology has been applied to the ten sub-sectors in the sector. This chapter will present the results obtained from the DEA methodology in order to meet the following study objectives:

The areas of efficiency will help the study meet the following research objectives:

i. To determine the drivers of efficiency in Zimbabwe's manufacturing sector;

ii. To compare financial ratios with efficiency ratios in the input-output model in order to identify the levels and kinds of inefficiencies in Zimbabwe's manufacturing sector;

iii. To measure efficiency in Zimbabwe's manufacturing sector using production plans of the efficient scores;

iv. To identify the barriers to achieving efficiency levels in Zimbabwe's manufacturing sector; and

v. To develop an efficiency model that will recommend an efficient input-output use in Zimbabwe's manufacturing sector.

DEA results in the different DMUs and manufacturing sub-sectors are based on the following areas relating to efficiency:

i. Orientation;
ii. Returns-to-scale; and
iii. Stages of efficiency.

5.2 Areas of Efficiency

Efficiency analysis is comprensively done in three areas, namely orientation, returns to scale and stages of efficiency. These areas will conceptualise efficiency and ensure that all efficiency dimensions are considered in measuring and fulfilling the objectives of this study.

5.2.1 Orientation

In order to achieve efficiency, DEA can demonstrate either input minimization or output maximization. The two orientations to perform theseare:

i. **Input-Orientation**

An Input-Orientation approach measures input reductions that are necessary for a production unit to become efficient without a reduction in output (Maredza 2009: 28). Input inefficiencies show the degree to which inputs must be reduced for the inefficient manufacturing firm to lie on the best practice frontier. Leontief (1941: 1953) developed a unique case of activity analysis which has come to be known as input-output analysis. His work was directed towards constructing a workable model of general equilibrium, efficiency and productivity analysis; and it is more closely related to the micro-economic production programming models. This analysis is used to measure the efficiency of an industrial firm whose main business is production. The measurement of the inputs used by the manufacturing sector is the amount of capital injected, amount of labour used, as well as physical raw materials.

ii. **Output-Orientation**

Maredza (2009: 42) identified Output-Orientation measures as the expansion of output that is necessary for efficiency improvement, holding inputs constant. Output inefficiencies represent the needed increase in output for the inefficient organisation to become efficient. An expansion of output that is necessary for efficiency improvement that does not affect inputs in manufacturing is done through adding value to by-products. In furniture manufacturing companies, wood pieces can be used to make shoe racks and cooking sticks, hence output is increased.

5.2.2Returns to scale

Returns to scale refers to the variation or change in productivity that is the outputs from a proportionate increase of all the input**.** This is a long-run economic concept of efficiency measurement in DMUs. There are mainly two types of returns to scale, namely:

a) Constant returns to scale (CRS) and
b) Variable returns to scale (VRS), comprising
   i. Increasing returns to scale (IRS)
   ii. Decreasing/ diminishing returns to scale (DRS).

a) Constant returns to scale (CRS)

CRS is when a firm changes their inputs or resources, with the results being exactly the same change in outputs or production. In other words, if a firm increases their inputs or resources, they will see a proportional increase in production or outputs. The same can be true if a firm decreases their inputs, which results in a decrease in outputs. For example, if a company decreases all of their inputs by 15%, their outputs will also decrease by 15%. It is important to clarify what is meant by the term 'resources'. Resources and inputs are often interchangeable and refer to things such as labor, capital and supplies. So, if a firm increases the amount of labor by 20%, a constant returns to scale exists if the firm also experiences a 20% increase in output.

b) Variable Returns to Scale (VRS)

Yari, Bagherpour and Jamali(2017:974) discribed VRS as a production situation where an increase in inputs does not result in a proportional change in outputs. In this situation, returns from the introduced inputs can be more or less proportionate to the output realised, as explained below:

i. I**ncreasing returns to scale** (IRS) occur when the output increases by a larger proportion than the increase in inputs during the production process. For example, if input is increased by 3 times but output increases by 3.75 times, then the firm or economy has experienced an increasing returns to scale.

ii. **Decreasing returns to scale** (DRS) occur when the proportion of output is less than the desired increased input during the production process. For example, if input is increased 3 times, but output is reduced 2 times, the firm or economy has experienced decreasing returns to scale. When increasing returns to scale occur, it results in economies of scale. This is owing to the fact that efficiency increases when organizations progress from small-scale to large-scale production. A loss of efficiency in the production process, even when the production has been expanded, results in decreasing returns to scale. This may occur if the organization becomes too large to be operated as one single entity. In this case, there is no economy of scale.

5.2.3 Data Enveloping Analysis(DEA) Stages

There are two stages involved in computing efficiency using the DEA methodology. They differ in explaining the comprehensiveness or completeness of measuring overall efficiency. These are:

- ✓ Stage 1 and
- ✓ Stage 2.

Stage 1

This is a DEA methodology that facilitates joint estimation of the frontier and the effects of contextual variables. This is the basic necessary condition though not a sufficient condition in efficiency measurement. The analysis will use efficiency scores obtained under Stage 1 only if the efficient DMUs have zero slacks. If the efficiency scores have non-zero slacks, it means they are weakly efficient and therefore the analysis will extend to the Stage 2 DEA analysis.Despotis and Koronakos (2014:299), posit thatStage 1 is assumed to transform external inputs into intermediate efficiency scores as long as the efficient DMUs have slack inefficiencies.

Stage 2

Two-stage data envelopment analysis (2-DEA) is commonly used in productive efficiency analysis to estimate the effects of operational conditions and practices on performance. In this method, the DEA efficiency estimates are regressed on contextual variables representing the operational conditions. The efficient scores obtained in Stage 1 DEA will be regressed against some dummy variables into a linear or non-linear function. A variety of regression techniques have been used, including the classic ordinary least squares (OLS) and the maximum likelihood (ML) based probit, logit, and truncated regression. This Stage 2 is only useful when the Stage1 efficient DMUs have some slacks.Despotis and Koronakos (2014:299)showed Stage 2as a DEA stage where external inputs are transformed to a number of intermediate measures that are then used as inputs to the second stage to produce the final outputs. Kao and Hwang (2008:418) introduced an approach by taking into account a series relationship of the two stages and developed a model to estimate the overall efficiency of the production process as a geometric average of the efficiencies of the two individual stages

5.3 Results presentationprocedures' summary

The results presented under this study are a synthesis of DEA methodology from STATA software. DEA is a mathematical methodology which analyses efficiency by coming up with a composite efficiency score. The efficiency score is determined by the rate at which the existing DMU's technology transforms inputs to outputs. In this study, the input variables are cost of raw materials (CM); energy (E); water and sewage (WS); and cost of services (S) and the output variables are sales (SLS); value-added (VA); and gross value of production (GVP).

Charnes, Cooper and Rhodes'(CCR) (1978) derives a CRS curve from a DMU which is considered to optimize the ratio of output to input (maximum average productivity). Two sets of econometric results for each of the ten sectors will be presented and interpreted in line with the three areas of efficiency: 1) orientation, 2) resturns to scale and 3) stages of efficiency.The separate sets are for CRS and VRS in all the ten sub-sectors under Stage 1. In terms of efficiency orientation, the results are for input minimisation efficiency since the same results apply to the output maximisation from the Duality Theory. The slack analysis was done to show the drivers and barriers to efficiency in each manufacturing sub-sector, as well as the level of improvement necessary for the sector to become efficient.

5.4 Conclusion

The data presentation procedures guides the study on the theoretical assumptions considered when measuring efficiency. These grounded procedures also approves reliability and validity of the results which will be presented. The following Chapter will measure efficiency in Zimbabwe's manufacturing sector using production plans of the efficient scores in all the ten sub-sectors using the efficiency conceptualising procedures.

CHAPTER SIX

MEASURING EFFICIENCY IN ZIMBABWE'S MANUFACTURING SECTOR

6.1 Introduction

The efficiency scores are generated from utilizing DEA methodology via the STATA software. The efficiency scores will be calculated for all the ten manufacturing sub-sectors in Zimbabwe based on the conceptulising areas of efficiency. Results presented addresses the objective: To measure efficiency in Zimbabwe's manufacturing sector using the production plans of the efficiency scores.

6.2 Beverages and Tobacco manufacturing efficiency scores

The efficiency scores are for all the Beverages and Tobacco manufacturing sub-sectors. The scores are calculated based on both the CRS and VRS.

6.2.1CRS Beverages and Tobacco

The following results are based on the assumption that the DMUs exhibit constant returns to scale and attempts to minimise inputs to attain efficiency in Stage 1.

Table 6.1: CRS Beverages and Tobacco Efficiency scores

DMU	Rank	Efficient Score	Decision	Above average
dmu:1	1	1	Efficient	Yes
dmu:2	1	1	Efficient	Yes

dmu:3	12	0.901616	Inefficient	Yes
dmu:4	18	0.668944	Inefficient	No
dmu:5	21	0.559779	Inefficient	No
dmu:6	14	0.860298	Inefficient	No
dmu:7	1	1	Efficient	Yes
dmu:8	1	1	Efficient	Yes
dmu:9	19	0.604745	Inefficient	No
dmu:10	17	0.754275	Inefficient	No
dmu:11	1	1	Efficient	Yes
dmu:12	1	1	Efficient	Yes
dmu:13	16	0.785381	Inefficient	No
dmu:14	11	0.995748	Inefficient	Yes
dmu:15	13	0.868986	Inefficient	No
dmu:16	20	0.563478	Inefficient	No
dmu:17	1	1	Efficient	Yes
dmu:18	15	0.828244	Inefficient	No
dmu:19	1	1	Efficient	Yes
dmu:20	1	1	Efficient	Yes
dmu:21	1	1	Efficient	Yes
Average		**0.875785**		

Source: Adapted from STATA output

The DMUs with an efficiency score of 1 are the efficient firms in the Beverages and Tobacco manufacturing sub-sector. The results above are for a sample of 21 DMUs in the Beverages and Tobacco manufacturing sub-sector. Average efficiency in Beverages and Tobacco is 0.88 = 88%.

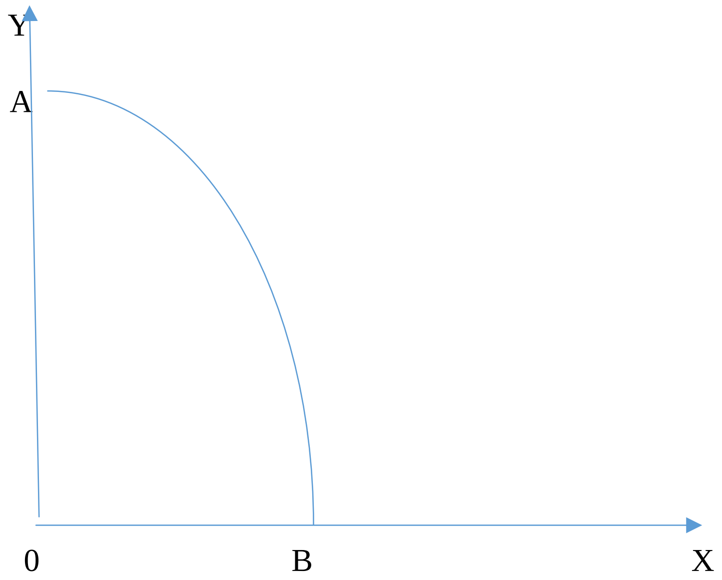
Table 6.2: CRSBeverages and Tobacco Efficiency Score Analysis

	Number	Percentage
Efficient DMUs	10	48
Inefficient DMUs	11	52
Above average efficient DMUs	12	57
Below average efficient DMUs	9	43

Source: Adapted from STATA output

In the Beverages and Tobacco sub-sector of the manufacturing sector, 48% of the DMUs are efficient and 52% are inefficient. At least 57% of the DMUs are operating above the average efficiency of 88%; whereas 43% of the DMUs are struggling below the average efficiency level.

Figure 5.1:CRS Beverages and Tobacco Frontier Analysis



The efficient DMUs (1, 2, 7, 8, 11, 12, 17, 19, 20 and 21) are found on the frontier AB;whilst all the other DMUs (3, 4, 5, 6, 9, 10, 13, 14, 15, 16and 18) operate below frontier AB.

Table 6.3:CRS Beverages and TobaccoBenchmarking Analysis

DMU	Benchmarks
1	1
2	10
3	2 (1.90) 11 (0.87) 17 (0.43)
4	2 (4.08) 11 (0.94) 17 (1.95)
5	2 (2.49) 7 (0.19) 11 (0.22) 17 (1.42)
6	2 (0.71) 7 (0.38) 21 (0.09)
7	8
8	0
9	2 (3.57) 7 (0.47) 17 (1.32) 21 (0.14)
10	2 (1.82) 7 (0.38) 17 (0.88) 21 (0.70)
11	3
12	0
13	2 (1.08) 7 (0.10) 17 (0.06)
14	1 (0.09) 19 (0.09)
15	2 (5.30) 7 (0.51) 17 (0.98) 21 (2.12)
16	2 (1.91) 7 (0.05) 17 (0.17)
17	8
18	2 (6.00) 7 (0.83) 21 (2.97)

19	1
20	0
21	5

Source: Adapted from STATA output

The table above shows the referenced DMUs which the inefficient DMUs can emulate. The extent to which the inefficient firms can reduce their inputs in order to become efficient is also shown in brackets. For example, DMU 3 which is inefficient can emulate DMUs 2, 11 and 17.

3	2 (1.90) 11 (0.87) 17 (0.43)

DMU 3 is expected to reduce its inputs by 190%, 87% and 43%, emulating DMUs 2, 11 and 17 respectively in order to become efficient. This means that DMU 3 could reduce much of its resources if it wants to be efficient, learning from DMU 2 more than when it wants to learn from DMUs 11 and 17.

6.2.2VRS Beverages and Tobacco

The following results are based on the assumption that the DMUs exhibit variable returns to scale and attempt to minimise inputs to attain efficiency in Stage 1.

Table 6.4: VRS Beverages and Tobacco Efficiency scores

DMU	**Rank**	**Efficient Score**	**Decision**	**Above average**
dmu:1	1	1	Efficient	Yes
dmu:2	1	1	Efficient	Yes

dmu:3	1	1	Efficient	Yes
dmu:4	15	0.954644	Inefficient	Yes
dmu:5	21	0.681987	Inefficient	No
dmu:6	16	0.874837	Inefficient	No
dmu:7	1	1	Efficient	Yes
dmu:8	1	1	Efficient	Yes
dmu:9	17	0.869494	Inefficient	No
dmu:10	18	0.83647	Inefficient	No
dmu:11	1	1	Efficient	Yes
dmu:12	1	1	Efficient	Yes
dmu:13	19	0.821863	Inefficient	No
dmu:14	1	1	Efficient	Yes
dmu:15	1	1	Efficient	Yes
dmu:16	20	0.790819	Inefficient	No
dmu:17	1	1	Efficient	Yes
dmu:18	1	1	Efficient	Yes
dmu:19	1	1	Efficient	Yes
dmu:20	1	1	Efficient	Yes
dmu:21	1	1	Efficient	Yes
Average		**0.944291**		

Source: Adapted from STATA output

The DMUs with an efficiency score of 1 are the efficient firms in the Beverages and Tobacco manufacturing sub-sector. The results above are for a sample of 21 DMUs in the Beverages and Tobacco manufacturing sub-sector. Average efficiency in the Beverages and Tobacco manufacturing sub-sector is 0.94 = 94%.

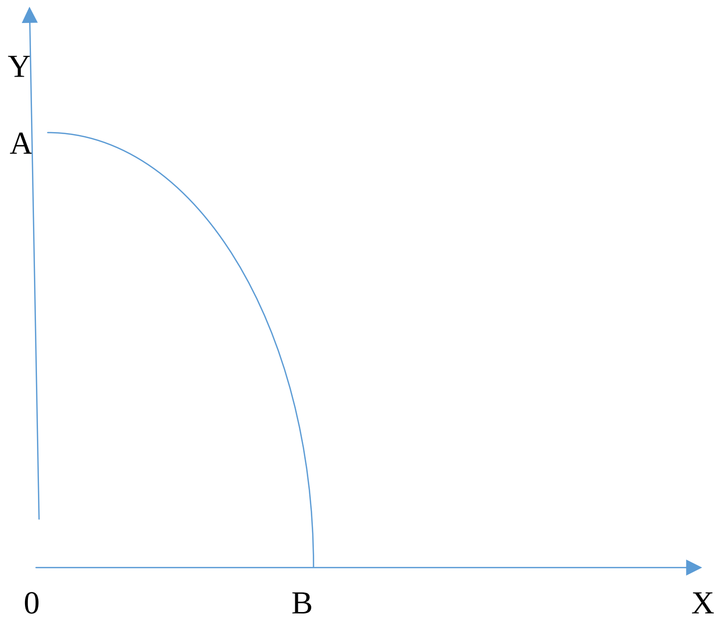
Table 6.5: VRS Beverages and Tobacco Efficiency Score Analysis

	Number	Percentage
Efficient DMUs	14	67
Inefficient DMUs	7	33
Above average efficient DMUs	15	71
Below average efficient DMUs	6	29

Source: Adapted from STATA output

In the Beverages and Tobacco sub-sector of the manufacturing sector, 67% of the DMUs are efficient and 33% are inefficient. At least 71% of the DMUs are operating above the average efficiency of 94%,whereas 29% of the DMUs are struggling below the average efficiency level.

Figure 5.2: VRS Beverages and TobaccoFrontier Analysis



The efficient DMUs (1, 2, 3, 7, 8, 11, 12, 14, 15, 17, 18, 19, 20 and 21) are found on the frontier AB, whereas all the other DMUs (4, 5, 6, 9, 10, 13 and 16) operate below frontier AB.

Table 6.6:VRS Beverages and TobaccoBenchmarking Analysis

DMU	Benchmarks
1	4
2	5
3	0
4	1 (0.09) 8 (0.61) 15 (0.31)
5	1 (0.24) 2 (0.28) 7 (0.14) 8 (0.10) 15 (0.24)
6	2 (0.55) 7 (0.38) 12 (0.06) 18 (0.01)
7	5
8	3
9	1 (0.06) 8 (0.49) 15 (0.45)
10	1 (0.12) 2 (0.15) 7 (0.28) 15 (0.30) 17 (0.15)
11	0
12	3
13	2 (0.73) 7 (0.11) 12 (0.16)
14	0
15	4
16	2 (0.26) 7 (0.14) 12 (0.59)
17	1

18	1
19	0
20	0
21	0

Source: Adapted from STATA output

The table above shows the reference DMUs which the inefficient DMUs can emulate. The extent to which the inefficient firms can reduce their inputs in order to become efficient is also shown in brackets. For example, DMU 4 which is inefficient can emulate DMUs 1, 8 and 15.

4	1 (0.09) 8 (0.61) 15 (0.31)

The DMU4 is expected to reduce its inputs by 9%, 61% and 31%, emulating DMUs 1, 8 and 15 respectively in order to become efficient. This means that DMU 4 can reduce many resources if it wants to be efficient, learning more from DMU 8 than when it wants to learn from DMUs 1 and 15.

6.3 Chemical and Petroleum Products manufacturing efficiency scores

The efficiency scores are for all the Chemical and Petroleum Productsmanufacturing sub-sectors. The scores are calculated based on both the CRS and VRS.

6.3.1 CRS Chemical and Petroleum Products

The following results are based on the assumption that the DMUs exhibit constant returns to scale and attempts to minimise inputs to attain efficiency in Stage 1 level of the variable estimation.

Table 6.7:CRS Chemical and Petroleum Products Efficiency scores

DMU	Rank	Efficient Score	Decision	Above average
dmu:1	1	1	Efficient	Yes
dmu:2	1	1	Efficient	Yes
dmu:3	1	1	Efficient	Yes
dmu:4	19	0.578718	Inefficient	No
dmu:5	13	0.889945	Inefficient	Yes
dmu:6	14	0.76181	Inefficient	No
dmu:7	1	1	Efficient	Yes
dmu:8	12	0.934058	Inefficient	Yes
dmu:9	21	0.210044	Inefficient	No
dmu:10	1	1	Efficient	Yes
dmu:11	15	0.708	Inefficient	No
dmu:12	17	0.613637	Inefficient	No
dmu:13	1	1	Efficient	Yes
dmu:14	1	1	Efficient	Yes
dmu:15	20	0.572491	Inefficient	No
dmu:16	18	0.596783	Inefficient	No
dmu:17	1	1	Efficient	Yes
dmu:18	11	0.959532	Inefficient	Yes
dmu:19	16	0.673165	Inefficient	No
dmu:20	1	1	Efficient	Yes

dmu:21	10	0.970203	Inefficient	Yes
Average		**0.831828**		

Source: Adapted from STATA output

The DMUs with an efficiency score of 1 are the efficient firms in the Chemical and Petroleum Products manufacturing sub-sector. The results above are for a sample of 21 DMUs in the Chemical and Petroleum Products manufacturing sub-sector. Average efficiency in the Chemical and Petroleum Products manufacturing sub-sector is 0.83 = 83%.

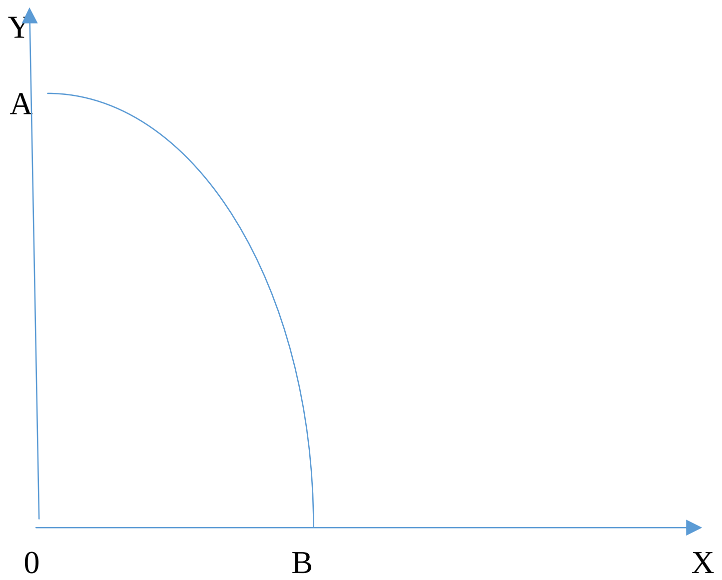
Table 6.8: CRS Chemical and Petroleum Products Efficiency Score Analysis

	Number	**Percentage**
Efficient DMUs	9	43
Inefficient DMUs	12	57
Above average efficient DMUs	13	62
Below average efficient DMUs	8	38

Source: Adapted from STATA output

In the Chemical and Petroleum Products sub-sector of the manufacturing sector, 43% of the DMUs are efficient and 57% are inefficient. At least 62% of the DMUs are operating above the average efficiency of 83%, whereas 38% of the DMUs are struggling below the average efficiency level.

Figure 5.3: CRS Chemical and Petroleum ProductsFrontier Analysis



The efficient DMUs (1, 2, 3, 7, 10, 13, 14, 17 and 20) are found on the frontier AB, whereas all the other DMUs (4, 5, 6, 8, 9, 11, 12, 15, 16, 18, 19 and 21) operate below frontier AB.

Table 6.9: CRS Chemical and Petroleum Products Benchmarking Analysis

DMU	Benchmarks
1	0
2	10 (0.08) 13 (0.62) 17 (5.94)
3	3
4	7 (0.02) 10 (0.00) 13 (0.05)
5	7 (0.09) 10 (0.04)
6	10 (0.01) 13 (0.05) 20 (0.00)
7	2

8	10 (0.66) 17 (17.25) 20 (0.16)
9	10 (0.01) 13 (0.21) 17 (0.11)
10	13
11	3 (0.26) 10 (0.70) 13 (0.52) 20 (0.01)
12	10 (0.20) 13 (0.52) 17 (2.08) 20 (0.11)
13	11
14	0
15	3 (0.03) 10 (0.23) 13 (0.26) 20 (0.00)
16	10 (0.18) 13 (0.40) 17 (1.35) 20 (0.01)
17	6
18	3 (0.06) 10 (0.01) 13 (0.01) 20 (0.03)
19	10 (0.09) 13 (0.44) 17 (2.29) 20 (0.02)
20	8
21	10 (0.44) 13 (1.00)

Source: Adapted from STATA output

The table above shows the reference DMUs which the inefficient DMUs can emulate. The extent to which inefficient firms can reduce their inputs in order to become efficient is also shown in brackets. For example, DMU 2 which is inefficient can emulate DMUs 10, 13 and 17.

2	10 (0.08) 13 (0.62) 17 (5.94)

DMU 2 is expected to reduce its inputs by 10%, 62% and 594%, emulating DMUs 10, 13 and 17 respectively in order to become efficient. This means that DMU 2 can reduce much more of its resources if it wants to be efficient by learning from DMU 17 than when it wants to learn from DMUs 10 and 13.

6.3.2 VRS Chemical and Petroleum Products

The following results are based on the assumption that the DMUs exhibit variable returns to scale and attempt to minimise inputs to attain efficiency in the Stage 1 level of the variable estimation.

Table 6.10: VRS Chemical and Petroleum Products Efficiency scores

DMU	Rank	Efficient Score	Decision	Above average
dmu:1	1	1	Efficient	Yes
dmu:2	15	0.983178	Inefficient	Yes
dmu:3	1	1	Efficient	Yes
dmu:4	1	1	Efficient	Yes
dmu:5	1	1	Efficient	Yes
dmu:6	1	1	Efficient	Yes
dmu:7	1	1	Efficient	Yes
dmu:8	1	1	Efficient	Yes
dmu:9	21	0.416695	Inefficient	No
dmu:10	1	1	Efficient	Yes
dmu:11	16	0.80599	Inefficient	No
dmu:12	18	0.623468	Inefficient	No
dmu:13	1	1	Efficient	Yes
dmu:14	1	1	Efficient	Yes

dmu:15	20	0.587054	Inefficient	No
dmu:16	19	0.604629	Inefficient	No
dmu:17	1	1	Efficient	Yes
dmu:18	1	1	Efficient	Yes
dmu:19	17	0.693897	Inefficient	No
dmu:20	1	1	Efficient	Yes
dmu:21	1	1	Efficient	Yes
Average		**0.891186**		

Source: Adapted from STATA output

The DMUs with an efficiency score of 1 are the efficient firms in the Chemical and Petroleum Products manufacturing sub-sector. The results above are for a sample of 21 DMUs in the Chemical and Petroleum Products manufacturing sub-sector. Average efficiency in the Chemical and Petroleum Products manufacturing sub-sector is 0.89 = 89%.

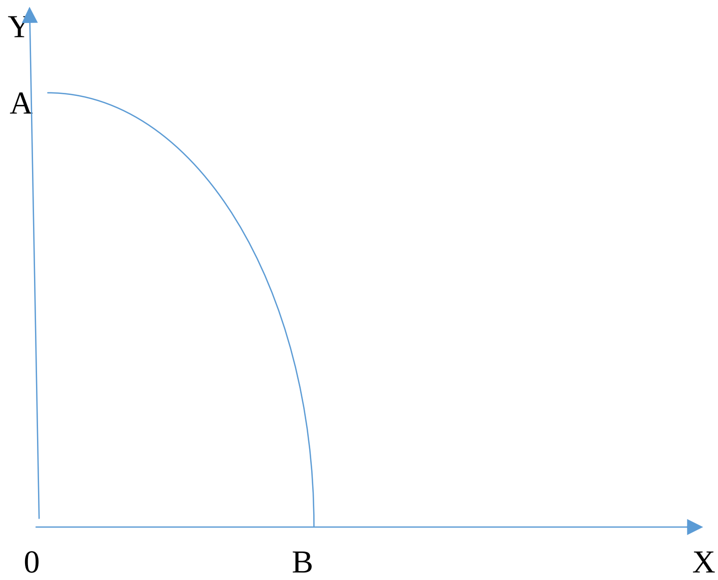
Table 6.11: VRS Chemical and Petroleum Products Efficiency Score Analysis

	Number	**Percentage**
Efficient DMUs	14	67
Inefficient DMUs	7	33
Above average efficient DMUs	15	71
Below average efficient DMUs	6	29

Source: Adapted from STATA output

In the Chemical and Petroleum Products sub-sector of the manufacturing sector, 67% of the DMUs are efficient and 33% are inefficient. At least 71% of the DMUs are operating above the average efficiency of 94%, whereas 29% of the DMUs are struggling below the average efficiency level.

Figure 5.4: VRS Chemical and Petroleum ProductsFrontier Analysis



The efficient DMUs (1, 2, 3, 4, 5, 6, 7, 8, 10, 13, 14, 17, 18, 20 and 21) are found on the frontier AB, whereas all the other DMUs (2, 9, 11, 12, 15, 16 and 19) operate below frontier AB.

Table 6.12: VRS Chemical and Petroleum Products Benchmarking Analysis

DMU	**Benchmarks**
1	0
2	8 (0.19) 10 (0.10) 13 (0.31) 17 (0.40)
3	0
4	1

5		0
6		1
7		1
8		4
9	4 (0.42) 13 (0.15) 17 (0.44)	
10		6
11	7 (0.10) 10 (0.72) 20 (0.18)	
12	8 (0.03) 10 (0.25) 13 (0.63) 20 (0.09)	
13		6
14		0
15	6 (0.19) 10 (0.22) 13 (0.25) 17 (0.09) 18 (0.24)	
16	8 (0.02) 10 (0.21) 13 (0.46) 17 (0.32)	
17		5
18		1
19	8 (0.06) 10 (0.10) 13 (0.52) 17 (0.32)	
20		2
21		0

Source: Adapted from STATA output

The table above shows the reference DMUswhich the inefficient DMUs can emulate. The extent to which the inefficient firms can reduce their inputs in order to become efficient is also shown in brackets. For example, DMU 2 which is inefficient can emulate DMUs 8, 10, 13 and 17.

2	8 (0.19) 10 (0.10) 13 (0.31) 17 (0.40)

DMU 2 is expected to reduce its inputs by 19%, 10%, 31% and 40%, emulating DMUs 8, 10, 13 and 17 respectively in order to become efficient. This means that DMU 2 can reduce many resources if it wants to be efficient by learning more from DMU 17 than when it wants to learn from DMUs 8, 10 and 13.

6.4 Clothing and Footwear manufacturing efficiency scores

The efficiency scores are for all the Clothing and Footwear manufacturing sub-sectors. The scores are calculated based on both the CRS and VRS.

6.4.1 CRS Clothing and Footwear

The following results are based on the assumption that the DMUs exhibit constant returns to scale and attempt to minimise inputs to attain efficiency in Stage 1.

Table 6.13: Clothing and Footwear Efficiency scores of the CRS CCR Input-Oriented Model

DMU	Rank	Efficient Score	Decision	Above average
dmu:1	4	0.253168	Inefficient	Yes
dmu:2	10	0.184046	Inefficient	No
dmu:3	14	0.169383	Inefficient	No
dmu:4	16	0.156989	Inefficient	No
dmu:5	17	0.148711	Inefficient	No
dmu:6	2	0.269685	Inefficient	Yes
dmu:7	15	0.157662	Inefficient	No
dmu:8	7	0.237772	Inefficient	Yes

dmu:9	3	0.253842	Inefficient	Yes
dmu:10	12	0.177401	Inefficient	No
dmu:11	6	0.239095	Inefficient	Yes
dmu:12	20	0.126642	Inefficient	No
dmu:13	8	0.222057	Inefficient	No
dmu:14	21	0.071715	Inefficient	No
dmu:15	9	0.184539	Inefficient	No
dmu:16	11	0.17843	Inefficient	No
dmu:17	1	1	Efficient	Yes
dmu:18	19	0.12939	Inefficient	No
dmu:19	18	0.139585	Inefficient	No
dmu:20	5	0.241372	Inefficient	Yes
dmu:21	13	0.173854	Inefficient	No
Average		**0.22454**		

Source: Adapted from STATA output

The DMUs with an efficiency score of 1 are the efficient firms in the Clothing and Footwear manufacturing sub-sector. The results above are for a sample of 21 DMUs in the Clothing and Footwear manufacturing sub-sector. Average efficiency in Clothing and Footwear manufacturing sub-sector is 0.22 = 22%.

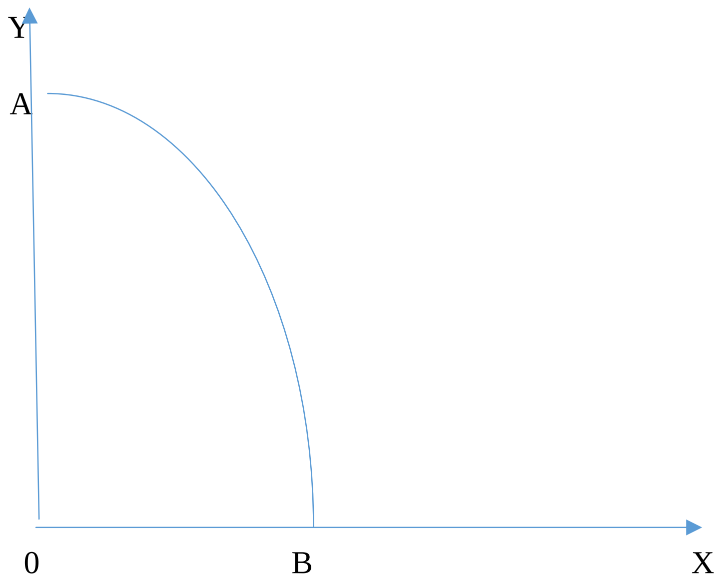
Table 6.14: CRS Clothing and Footwear Efficiency Analysis

	Number	Percentage
Efficient DMUs	1	5
Inefficient DMUs	20	95
Above average efficient DMUs	7	33
Below average efficient DMUs	14	67

Source: Adapted from STATA output

In the Clothing and Footwear sub-sector of the manufacturing sector, 5% of the DMUs are efficient and 95% are inefficient. At least 33% of the DMUs are operating above the average efficiency of 22%, whereas 67% of the DMUs are struggling below the average efficiency level.

Figure 5.5:CRS Clothing and FootwearFrontier Analysis



The efficient DMU 17 is found on the frontier AB, whereas all the other DMUs (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 18, 19, 20 and 21) operate below frontier AB.

Table 6.15: CRS Clothing and Footwear Benchmarking Analysis

DMU	Benchmarks
1	17 (0.13)
2	17 (0.08)
3	17 (3.16)
4	17 (3.10)
5	17 (0.26)
6	17 (0.02)
7	17 (0.02)
8	17 (0.02)
9	17 (0.39)
10	17 (0.24)
11	17 (0.24)
12	17 (0.10)
13	17 (0.22)
14	17 (0.01)
15	17 (0.02)
16	17 (0.19)
17	20
18	17 (0.02)
19	17 (0.46)
20	17 (0.00)
21	17 (0.00)

Source: Adapted from STATA output

The table above shows the reference DMU for which the inefficient DMUs can emulate. The extent to which the inefficient firms can reduce their inputs in order to become efficient is also shown in brackets. For example, DMU 1 which is inefficient can emulate DMU 17.

1	17 (0.13)

It is expected to reduce its inputs by 13% emulating DMU 17 in order to become efficient. This means that DMU 1 can reduce a lot of resources by learning from DMU 17 only.

6.4.2VRS Clothing and Footwear

The following results are based on the assumption that the DMUs exhibit variable returns to scale and attempt to minimise inputs to attain efficiency in Stage 1 level.

Table 6.16: VRS Clothing and Footwear Efficiency Scores

DMU	Rank	Efficient Score	Decision	Above average
dmu:1	14	0.278497	Inefficient	No
dmu:2	16	0.245807	Inefficient	No
dmu:3	1	1	Efficient	Yes
dmu:4	1	1	Efficient	Yes
dmu:5	19	0.151483	Inefficient	No
dmu:6	9	0.473502	Inefficient	No
dmu:7	13	0.315341	Inefficient	No
dmu:8	6	0.619183	Inefficient	Yes
dmu:9	15	0.259638	Inefficient	No
dmu:10	18	0.180972	Inefficient	No
dmu:11	10	0.430722	Inefficient	No
dmu:12	21	0.133758	Inefficient	No
dmu:13	17	0.233759	Inefficient	No
dmu:14	7	0.594728	Inefficient	Yes
dmu:15	12	0.321483	Inefficient	No
dmu:16	11	0.348498	Inefficient	No
dmu:17	1	1	Efficient	Yes

dmu:18	8	0.58114	Inefficient	Yes
dmu:19	20	0.141983	Inefficient	No
dmu:20	5	0.864632	Inefficient	Yes
dmu:21	1	1	Efficient	Yes
Average		**0.48453**		

Source: Adapted from STATA output

The DMUs with an efficiency score of 1 are the efficient firms in the Clothing and Footwear manufacturing sub-sector. The results above are for a sample of 21 DMUs in the Clothing and Footwear manufacturing sub-sector. Average efficiency in Clothing and Footwear manufacturing sub-sector is 0.48 = 48%.

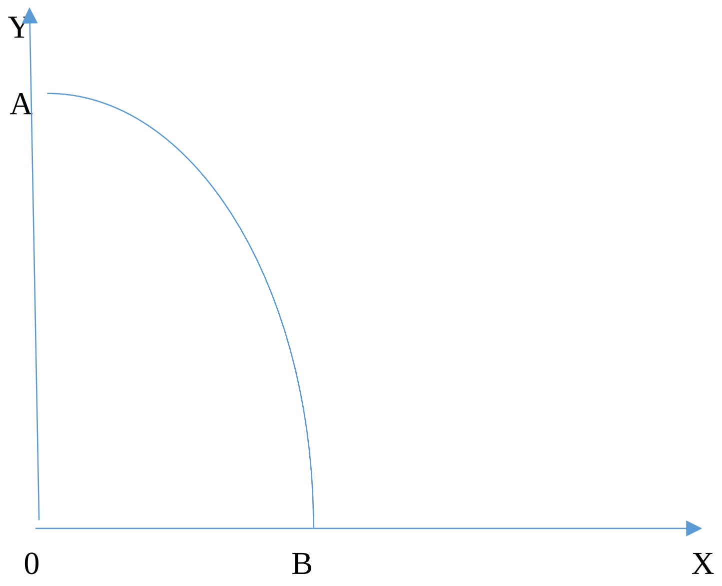
Table 6.17: VRS Clothing and Footwear Efficiency Score Analysis

	Number	**Percentage**
Efficient DMUs	4	19
Inefficient DMUs	17	81
Above average efficient DMUs	8	38
Below average efficient DMUs	13	62

Source: Adapted from STATA output

In the Clothing and Footwear sub-sector of the manufacturing sector, 19% of the DMUs are efficient and 81% are inefficient. At least 38% of the DMUs are operating above the average efficiency of 48%, whereas 62% of the DMUs are struggling below the average efficiency level.

Figure 5.6: VRS Clothing and FootwearFrontier Analysis



The efficient DMUs (3, 4, 17 and 21) are found on the frontier AB, whereas all the other DMUs (1, 2, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 18, 19 and 20) operate below frontier AB.

Table 6.18: Clothing and Footwear Benchmarking Analysis

DMU	**Benchmarks**
1	17 (0.13) 21 (0.87)
2	17 (0.08) 21 (0.92)
3	0
4	0
5	17 (0.26) 21 (0.74)
6	17 (0.02) 21 (0.98)
7	17 (0.01) 21 (0.99)
8	17 (0.05) 21 (0.95)

9	17 (0.39) 21 (0.61)
10	17 (0.24) 21 (0.76)
11	17 (0.43) 21 (0.57)
12	17 (0.10) 21 (0.90)
13	17 (0.22) 21 (0.78)
14	17 (0.08) 21 (0.92)
15	17 (0.02) 21 (0.98)
16	17 (0.19) 21 (0.81)
17	17
18	17 (0.07) 21 (0.93)
19	17 (0.46) 21 (0.54)
20	17 (0.00) 21 (1.00)
21	17

Source: Adapted from STATA output

The table above shows the reference DMUs which the inefficient DMUs can emulate. The extent to which the inefficient firms can reduce their inputs in order to become efficient is also shown in brackets. For example, DMU 1 which is inefficient can emulate DMUs 17 and 21.

1	17 (0.13) 21 (0.87)

DMU 1 is expected to reduce its inputs by 13% and 87% emulating DMUs 17 and 21 respectively in order to become efficient. This means that DMU 1 can reduce more resources if it wants to be efficient by learning from DMU 21, than when it wants to learn from DMU 17.

6.5Foodstuffs manufacturing efficiency scores

The efficiency scores are for all the Foodstuffs manufacturing sub-sectors. The scores are calculated based on both the CRS and VRS.

6.5.1 CRS Foodstuffs

The following results are based on the assumption that the DMUs exhibit constant returns to scale and attempts to minimise inputs to attain efficiency in Stage 1 level of the variable estimation.

Table 6.19: CCR Foodstuffs Efficiency scores

DMU	Rank	Efficient Score	Decision	Above average
dmu:1	12	0.605541	Inefficient	No
dmu:2	7	0.844795	Inefficient	Yes
dmu:3	19	0.445925	Inefficient	No
dmu:4	1	1	Efficient	Yes
dmu:5	18	0.45098	Inefficient	No
dmu:6	6	0.867352	Inefficient	Yes
dmu:7	21	0.291486	Inefficient	No
dmu:8	20	0.425357	Inefficient	No
dmu:9	14	0.543694	Inefficient	No
dmu:10	17	0.4907	Inefficient	No
dmu:11	9	0.798437	Inefficient	Yes

dmu:12	1	1	Efficient	Yes
dmu:13	15	0.532291	Inefficient	No
dmu:14	16	0.517157	Inefficient	No
dmu:15	10	0.665118	Inefficient	No
dmu:16	13	0.558152	Inefficient	No
dmu:17	1	1	Efficient	Yes
dmu:18	11	0.648067	Inefficient	No
dmu:19	8	0.818179	Inefficient	Yes
dmu:20	1	1	Efficient	Yes
dmu:21	1	1	Efficient	Yes
Average		**0.69063**		

Source: Adapted from STATA output

The DMUs with an efficiency score of 1 are the efficient firms in the Foodstuffs manufacturing sub-sector. The results above are for a sample of 21 DMUs in the Foodstuffs manufacturing sub-sector. Average efficiency in the Foodstuffs manufacturing sub-sector is 0.69 = 69%.

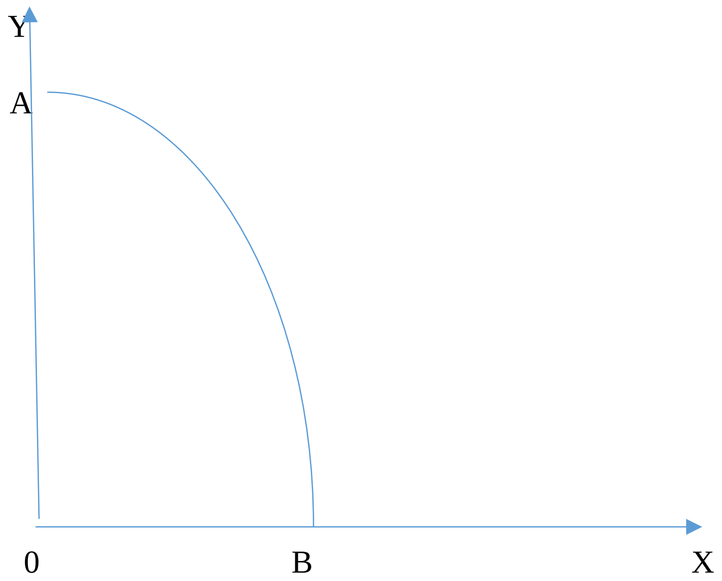
Table 6.20: CRS Foodstuffs Efficiency Analysis

	Number	**Percentage**
Efficient DMUs	5	24
Inefficient DMUs	16	76
Above average efficient DMUs	9	43
Below average efficient DMUs	12	57

Source: Adapted from STATA output

In the Foodstuffs sub-sector of the manufacturing sector, 24% of the DMUs are efficient and 76% are inefficient. At least 43% of the DMUs are operating above the average efficiency of 69%, whereas 57% of the DMUs are struggling below the average efficiency level.

Figure 5.7: CRSFoodstuffsFrontier Analysis



The efficient DMUs (4, 12, 17, 20 and 21) are found on frontier AB, whereas all the other DMUs (1, 2, 3, 5, 6, 7, 8, 9, 10, 11, 13, 14, 15, 16, 18 and 19)operate below frontier AB.

Table 6.21: CRS Foodstuffs Benchmarking Analysis

DMU	Benchmarks
1	4 (0.33) 12 (2.61) 17 (6.18) 21 (71.49)
2	0
3	12 (2.67) 20 (3.91)

4	1
5	12 (0.00) 17 (0.01) 20 (0.00) 21 (0.06)
6	12 (0.31) 20 (0.01) 21 (0.65)
7	12 (0.41) 17 (0.51) 20 (0.72) 21 (4.31)
8	12 (1.93) 20 (4.20)
9	12 (0.76) 17 (0.35) 20 (0.44)
10	12 (1.48) 20 (2.95)
11	1
12	12
13	11 (0.59) 20 (0.01)
14	12 (0.72) 17 (0.26) 20 (1.32)
15	12 (0.52) 20 (0.55)
16	12 (0.01) 20 (0.21) 21 (1.59)
17	5
18	20 (0.26) 21 (2.74)
19	12 (0.62) 20 (0.10) 21 (0.45)
20	13
21	7

Source: Adapted from STATA output

The table aboveshows the reference DMUs which the inefficient DMUs can emulate. The extent to which the inefficient firms can reduce their inputs in order to become efficient is also shown in brackets. For example, DMU 1 which is inefficient can emulate DMUs 4, 12, 17 and 21.

1	4 (0.33) 12 (2.61) 17 (6.18) 21 (71.49)

DMU 1 is expected to reduce its inputs by 190%, 87% and 43%, emulating DMUs 2, 11 and 17 respectively in order to become efficient. This means that DMU 3 can reduce many resources if it wants to be efficient, learning more from DMU 2 than when it wants to learn from DMUs 11 and 17.

6.5.2 VRS Foodstuffs

The following results are based on the assumption that the DMUs exhibit variable returns to scale and attempt to minimise inputs to attain efficiency in Stage 1 level of the variable estimation.

Table 6.22: VRS Foodstuffs Efficiency Scores

DMU	Rank	Efficient Score	Decision	Above average
dmu:1	1	1	Efficient	Yes
dmu:2	1	1	Efficient	Yes
dmu:3	1	1	Efficient	Yes
dmu:4	1	1	Efficient	Yes
dmu:5	1	1	Efficient	Yes
dmu:6	14	0.867781	Inefficient	No
dmu:7	21	0.434068	Inefficient	No
dmu:8	1	1	Efficient	Yes
dmu:9	16	0.806603	Inefficient	No
dmu:10	1	1	Efficient	Yes

dmu:11	1	1	Efficient	Yes
dmu:12	1	1	Efficient	Yes
dmu:13	20	0.532291	Inefficient	No
dmu:14	1	1	Efficient	Yes
dmu:15	17	0.746054	Inefficient	No
dmu:16	19	0.577561	Inefficient	No
dmu:17	1	1	Efficient	Yes
dmu:18	18	0.741052	Inefficient	No
dmu:19	15	0.818179	Inefficient	No
dmu:20	1	1	Efficient	Yes
dmu:21	1	1	Efficient	Yes
Average		**0.882076**		

Source: Adapted from STATA output

The DMUs with an efficiency score of 1 are the efficient firms in the Foodstuffs manufacturing sub-sector. The results above are for a sample of 21 DMUs in the Foodstuffs manufacturing sub-sector. Average efficiency in Foodstuffs manufacturing sub-sector is 0.88 = 88%.

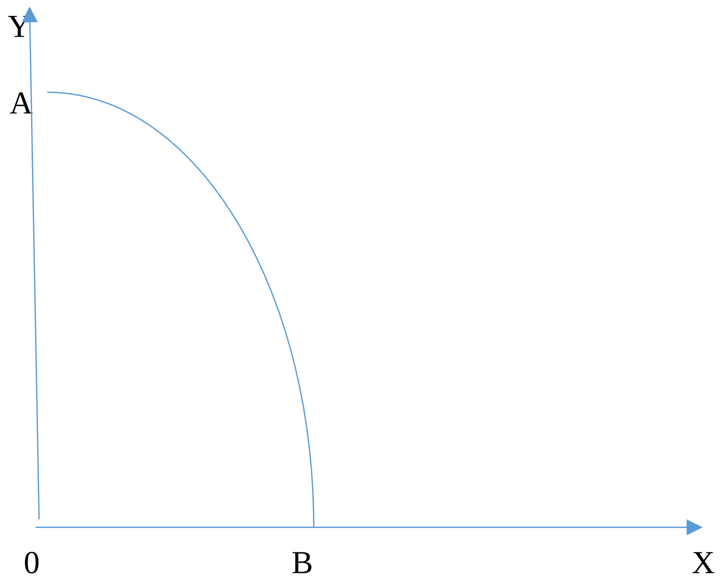
Table 6.23: VRS Foodstuffs Efficiency Score Analysis

	Number	**Percentage**
Efficient DMUs	13	62
Inefficient DMUs	8	38
Above average efficient DMUs	13	62
Below average efficient DMUs	8	38

Source: Adapted from STATA output

In the Foodstuffs sub-sector of the manufacturing sector, 62% of the DMUs are efficient and 38% are inefficient. At least 62% of the DMUs are operating above the average efficiency of 88%, whereas 38% of the DMUs are struggling below the average efficiency level.

Figure 5.8:FoodstuffsFrontier Analysis



The efficient DMUs (1, 2, 3, 4, 5, 8, 10, 11, 12, 14, 17, 20 and 21) are found on frontier AB, whereas all the other DMUs (6, 7, 9, 13, 15, 16, 18 and 19)operate below frontier AB.

Table 6.24: VRS Foodstuffs Benchmarking Analysis

DMU	**Benchmarks**
1	2
2	0
3	0

4	0
5	1
6	5 (0.03) 12 (0.31) 20 (0.01) 21 (0.65)
7	1 (0.04) 8 (0.01) 12 (0.14) 14 (0.15) 20 (0.65)
8	1
9	1 (0.01) 12 (0.68) 14 (0.31)
10	1
11	1
12	7
13	11 (0.36) 20 (0.02) 21 (0.62)
14	3
15	10 (0.00) 12 (0.52) 14 (0.03) 20 (0.45)
16	12 (0.01) 20 (0.22) 21 (0.77)
17	1
18	12 (0.00) 17 (0.03) 20 (0.27) 21 (0.70)
19	12 (0.62) 20 (0.10) 21 (0.28)
20	7
21	5

Source: Adapted from STATA output

The table aboveshows the reference DMUs which the inefficient DMUs can emulate. The extent to which the inefficient firms can reduce their inputs in order to become efficient is also shown in brackets. For example, DMU 6 which is inefficient can emulate DMUs 5, 12, 20 and 21.

6	5 (0.03) 12 (0.31) 20 (0.01) 21 (0.65)

DMU 6 is expected to reduce its inputs by 3%, 31%, 1% and 65%, emulating DMUs 5, 12, 20 and 21 respectively in order to become efficient. This means that DMU 6can reduce many resources if it wants to be efficient by learning more from DMU 21 rather than when it wants to learn from DMUs 5, 12 and 20.

6.6Metals manufacturing efficiency scores

The efficiency scores are for all theMetals manufacturing sub-sectors. The scores are calculated based on both the CRS and VRS.

6.6.1 CRS Metals

The following results are based on the assumption that the DMUs exhibit constant returns to scale and attempt to minimise inputs to attain efficiency in Stage 1.

Table 6.25: CRS Metals Efficiency scores

DMU	Rank	Efficient Score	Decision	Above average
dmu:1	1	1	Efficient	Yes
dmu:2	14	0.495293	Inefficient	No
dmu:3	1	1	Efficient	Yes
dmu:4	1	1	Efficient	Yes
dmu:5	1	1	Efficient	Yes
dmu:6	1	1	Efficient	Yes
dmu:7	16	0.46008	Inefficient	No
dmu:8	18	0.325005	Inefficient	No

dmu:9	19	0.251807	Inefficient	No
dmu:10	15	0.471122	Inefficient	No
dmu:11	13	0.597081	Inefficient	No
dmu:12	12	0.639747	Inefficient	No
dmu:13	11	0.732013	Inefficient	Yes
dmu:14	10	0.776189	Inefficient	Yes
dmu:15	20	0.199249	Inefficient	No
dmu:16	17	0.404965	Inefficient	No
dmu:17	1	1	Efficient	Yes
dmu:18	9	0.951313	Inefficient	Yes
dmu:19	1	1	Efficient	Yes
dmu:20	21	0.03337	Inefficient	No
dmu:21	1	1	Efficient	Yes
Average		**0.682725**		

Source: Adapted from STATA output

The DMUs with an efficiency scores of 1 are the efficient firms in the Metals manufacturing sub-sector. The results above are for a sample of 21 DMUs in the Metals manufacturing sub-sector. Average efficiency in the Metals manufacturing sub-sector is 0.68 = 68%.

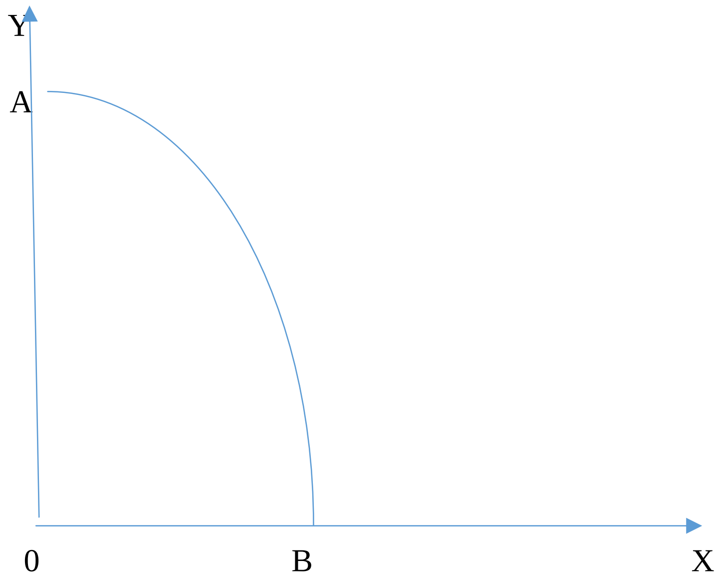
Table 6.26: CRS Metals Efficiency Score Analysis

	Number	**Percentage**
Efficient DMUs	8	38
Inefficient DMUs	13	62
Above average efficient DMUs	11	52
Below average efficient DMUs	10	48

Source: Adapted from STATA output

In the Metals sub-sector of the manufacturing sector, 38% of the DMUs are efficient and 62% are inefficient. At least 52% of the DMUs are operating above the average efficiency of 68% whereas 48%, of the DMUs are struggling below the average efficiency level.

Figure 5.9: CRS MetalsFrontier Analysis



The efficient DMUs (1, 3, 4, 5, 6, 17, 19 and 21) are found on frontier AB, whereas all the other DMUs (2, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 18 and 20) operates below the frontier AB.

Table 6.27: CRS Metals Benchmarking Analysis

DMU	**Benchmarks**
1	0
2	3 (0.46) 19 (1.34)

3	13
4	2
5	1
6	5
7	3 (0.00) 6 (0.00)
8	3 (0.00) 5 (0.00)
9	3 (0.00) 17 (0.00) 19 (0.00)
10	3 (0.00) 4 (0.00) 21 (0.16)
11	3 (0.00) 19 (0.01) 21 (1.31)
12	3 (0.00) 19 (0.01) 21 (0.01)
13	3 (0.02) 6 (0.01)
14	3 (0.00) 17 (0.09) 19 (0.02)
15	3 (0.00) 6 (0.00)
16	3 (0.00) 4 (0.00)
17	3
18	3 (0.00) 6 (0.02) 17 (0.73)
19	5
20	3 (0.00) 6 (0.00)
21	3

Source: Adapted from STATA output

The table aboveshows the reference DMUs which the inefficient DMUs can emulate. The extent to which the inefficient firms can reduce their inputs in order to become efficient is also shown in brackets. For example, DMU 2 which is inefficient can emulate DMUs 3 and 19.

2	3 (0.46) 19 (1.34)

DMU 2 is expected to reduce its inputs by 46% and 134% by emulating DMUs 3 and 19 respectively in order to become efficient. This means that DMU 2can reduce many resources if it wants to be efficient by learning more from DMU 19 rather than when it wants to learn from DMU 3.

5.8.2 VRS Metals

The following results are based on the assumption that the DMUs exhibit variable returns to scale and attempt to minimise inputs to attain efficiency in Stage 1.

Table 6.28: VRS Metals Efficiency scores

DMU	Rank	Efficient Score	Decision	Above average
dmu:1	1	1	Efficient	Yes
dmu:2	21	0.505759	Inefficient	No
dmu:3	1	1	Efficient	Yes
dmu:4	1	1	Efficient	Yes
dmu:5	1	1	Efficient	Yes
dmu:6	1	1	Efficient	Yes
dmu:7	1	1	Efficient	Yes
dmu:8	17	0.621362	Inefficient	No
dmu:9	1	1	Efficient	Yes

dmu:10	20	0.539547	Inefficient	No
dmu:11	18	0.600646	Inefficient	No
dmu:12	1	1	Efficient	Yes
dmu:13	15	0.754574	Inefficient	No
dmu:14	14	0.786542	Inefficient	No
dmu:15	16	0.709416	Inefficient	No
dmu:16	19	0.580793	Inefficient	No
dmu:17	1	1	Efficient	Yes
dmu:18	13	0.954087	Inefficient	Yes
dmu:19	1	1	Efficient	Yes
dmu:20	1	1	Efficient	Yes
dmu:21	1	1	Efficient	Yes
Average		**0.859654**		

Source: Adapted from STATA output

The DMUs with an efficiency score of 1 are the efficient firms in the Metals manufacturing sub-sector. The results above are for a sample of 21 DMUs in the Metals manufacturing sub-sector. Average efficiency in the Metals manufacturing sub-sector is 0.86 = 86%.

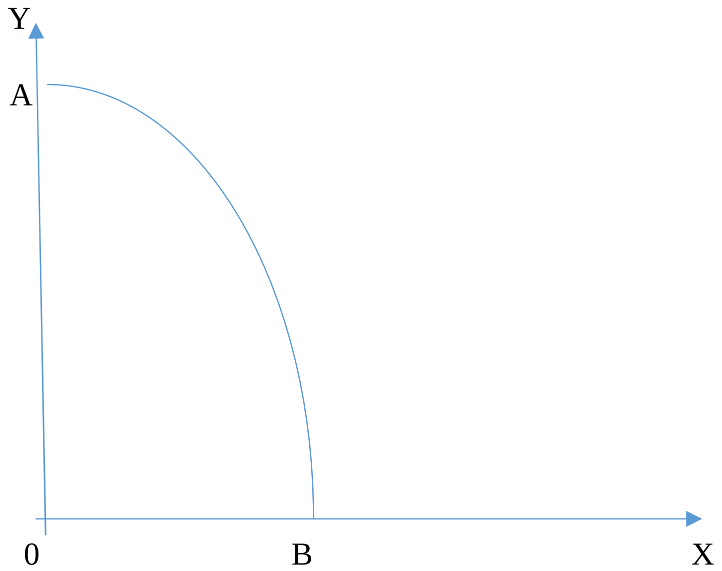
Table 6.29: VRS Metals Efficiency Score Analysis

	Number	**Percentage**
Efficient DMUs	12	57
Inefficient DMUs	9	43
Above average efficient DMUs	13	62
Below average efficient DMUs	8	38

Source: Adapted from STATA output

In the Metals sub-sector of the manufacturing sector, 57% of the DMUs are efficient and 43% are inefficient. At least 62% of the DMUs are operating above the average efficiency of 86%, whereas 38% of the DMUs are struggling below the average efficiency level.

Figure 5.10: VRSMetals Frontier Analysis



The efficient DMUs (1, 3, 4, 5, 6, 7, 9, 12, 17, 19, 20 and 21) are found on frontier AB, whereas all the other DMUs (2, 8, 10, 11, 13, 14, 15, 16 and 18)operate below frontier AB.

Table 6.30: VRS Metals Benchmarking Analysis

DMU	Benchmarks
1	0

2	3 (0.47) 5 (0.02) 19 (0.51)
3	8
4	0
5	1
6	2
7	4
8	3 (0.00) 7 (0.15) 12 (0.79) 21 (0.07)
9	0
10	3 (0.00) 7 (0.44) 12 (0.19) 21 (0.37)
11	3 (0.00) 17 (0.03) 19 (0.00) 21 (0.96)
12	3
13	3 (0.02) 6 (0.01) 7 (0.97)
14	3 (0.00) 17 (0.02) 19 (0.02) 21 (0.95)
15	3 (0.00) 7 (0.15) 12 (0.24) 20 (0.61)
16	0
17	3
18	3 (0.00) 6 (0.02) 17 (0.70) 21 (0.27)
19	3
20	1
21	5

Source: Adapted from STATA output

The tableabove shows the reference DMUs which the inefficient DMUs can emulate. The extent to which the inefficient firms can reduce their inputs in order to become efficient is

also shown in brackets. For example, DMU 2 which is inefficient can emulate DMUs 3, 5 and 19.

2	3 (0.47) 5 (0.02) 19 (0.51)

DMU 2 is expected to reduce its inputs by 47%, 2%, 1% and 51% emulating DMUs 3, 5 and 19 respectively in order to become efficient. This means that DMU 2 can reduce many resources if it wants to be efficient by learning more from DMU 19 rather than when it wants to learn from DMUs 3 and 5.

6.7Non-Metallic Minerals manufacturing efficiency scores

The efficiency scores are for all theNon-Metallic Minerals manufacturing sub-sectors. The scores are calculated based on both the CRS and VRS.

6.7.1 CRS Non-Metallic Minerals

The following results are based on the assumption that the DMUs exhibit constant returns to scale and attempt to minimise inputs to attain efficiency in Stage 1.

Table 6.31: CCR Non-Metallic Minerals Efficiency scores

DMU	Rank	Efficient Score	Decision	Above average
dmu:1	1	1	Efficient	Yes
dmu:2	19	0.40493	Inefficient	No
dmu:3	17	0.512733	Inefficient	No
dmu:4	20	0.379254	Inefficient	No
dmu:5	15	0.54445	Inefficient	No

dmu:6	13	0.654184	Inefficient	No
dmu:7	1	1	Efficient	Yes
dmu:8	14	0.63678	Inefficient	No
dmu:9	1	1	Efficient	Yes
dmu:10	21	0.371057	Inefficient	No
dmu:11	1	1	Efficient	Yes
dmu:12	10	0.795218	Inefficient	Yes
dmu:13	8	1	Efficient	Yes
dmu:14	9	0.840329	Inefficient	Yes
dmu:15	11	0.689677	Inefficient	No
dmu:16	16	0.520837	Inefficient	No
dmu:17	1	1	Efficient	Yes
dmu:18	18	0.452621	Inefficient	No
dmu:19	1	1	Efficient	Yes
dmu:20	12	0.657479	Inefficient	No
dmu:21	1	1	Efficient	Yes
Average		**0.736169**		

Source: Adapted from STATA output

The DMUs with an efficiency score of 1 are the efficient firms in the Non-Metallic Minerals manufacturing sub-sector. The results above are for a sample of 21 DMUs in the Non-Metallic Minerals manufacturing sub-sector. Average efficiency in the Non-Metallic Minerals manufacturing sub-sector is 0.74 = 74%.

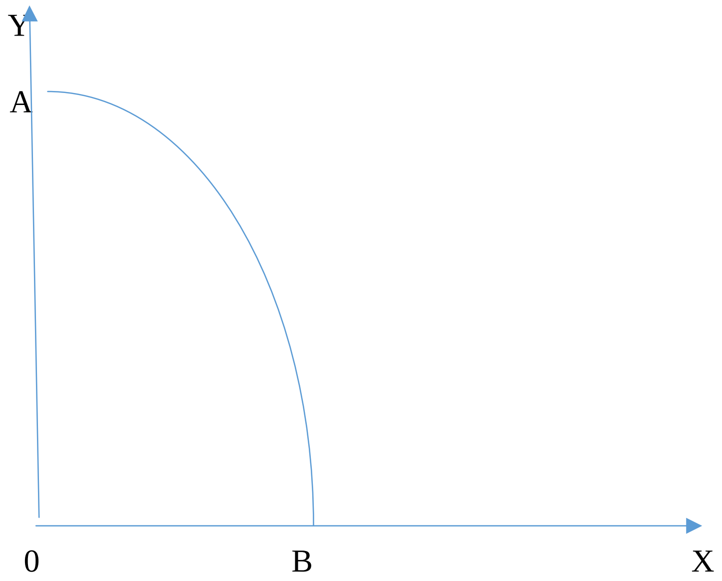
Table 6.32: CRS Non-Metallic Minerals Efficiency score Analysis

	Number	Percentage
Efficient DMUs	7	33
Inefficient DMUs	14	67
Above average efficient DMUs	10	48
Below average efficient DMUs	11	52

Source: Adapted from STATA output

In the Non-Metallic Minerals sub-sector of the manufacturing sector, 33% of the DMUs are efficient and 67% are inefficient. At least 48% of the DMUs are operating above the average efficiency of 74%, whereas 52% of the DMUs are struggling below the average efficiency level.

Figure 5.11: CRSNon-Metallic MineralsFrontier Analysis



The efficient DMUs (1, 7, 9, 11, 17, 19 and 21) are found on frontier AB, whereas all the other DMUs (2, 3, 4, 5, 6, 8, 10, 12, 13, 14, 15, 16, 18 and 20) operate below the frontier AB.

Table 6.33: CRS Non-Metallic Minerals Benchmarking Analysis

DMU	Benchmarks
1	7
2	9 (13.58)
3	9 (0.16) 11 (0.02)
4	7 (4.34) 17 (0.23)
5	1 (0.00) 11 (0.02) 17 (0.03)
6	1 (0.54) 9 (0.86) 11 (0.14)
7	3
8	1 (0.15) 11 (0.77) 17 (1.45)
9	10
10	1 (0.20) 9 (1.24) 17 (0.06)
11	8
12	1 (0.06) 9 (0.11) 11 (0.14) 17 (0.01)
13	1
14	1 (0.04) 7 (0.73) 17 (0.01)
15	9 (42.60) 11 (0.73) 17 (2.09)
16	9 (10.55) 11 (0.53)
17	8
18	1 (0.03) 9 (0.67) 11 (0.04)
19	9 (1.01) 13 (0.27)

20	7 (3.65) 17 (0.00)
21	9 (5.19)

Source: Adapted from STATA output

The tableabove shows the reference DMUs which the inefficient DMUs can emulate. The extent to which the inefficient firms can reduce their inputs in order to become efficient is also shown in brackets. For example, DMU 6 which is inefficient can emulate DMUs 1, 9 and 11.

6	1 (0.54) 9 (0.86) 11 (0.14)

DMU 6 is expected to reduce its inputs by 54%, 86% and 14% by emulating DMUs 1, 9 and 11 respectively in order to become efficient. This means that DMU 6 can reduce many resources if it wants to be efficient by learning more from DMU 9 than when it wants to learn from DMU 1 and 11.

5.9.2 VRSNon-Metallic Minerals

The following results are based on the assumption that the DMUs exhibit variable returns to scale and attempt to minimise inputs to attain efficiency in Stage 1.

Table 6.34: VRS Non-Metallic Minerals Efficiency scores

DMU	Rank	Efficient Score	Decision	Above average
dmu:1	1	1	Efficient	Yes
dmu:2	11	0.984298	Inefficient	Yes
dmu:3	12	0.9375	Inefficient	Yes

dmu:4	19	0.453782	Inefficient	No
dmu:5	1	1	Efficient	Yes
dmu:6	17	0.660043	Inefficient	No
dmu:7	1	1	Efficient	Yes
dmu:8	1	1	Efficient	Yes
dmu:9	1	1	Efficient	Yes
dmu:10	20	0.40863	Inefficient	No
dmu:11	1	1	Efficient	Yes
dmu:12	15	0.815815	Inefficient	No
dmu:13	1	1	Efficient	Yes
dmu:14	14	0.865032	Inefficient	Yes
dmu:15	1	1	Efficient	Yes
dmu:16	13	0.910628	Inefficient	Yes
dmu:17	1	1	Efficient	Yes
dmu:18	18	0.465456	Inefficient	No
dmu:19	21	0.285714	Inefficient	No
dmu:20	16	0.712537	Inefficient	No
dmu:21	1	1	Efficient	Yes
Average		**0.833306**		

Source: Adapted from STATA output

The DMUs with an efficiency score of 1 are the efficient firms in the Non-Metallic Minerals manufacturing sub-sector. The results above are for a sample of 21 DMUs in the Non-Metallic Minerals manufacturing sub-sector. Average efficiency in the Non-Metallic Minerals manufacturing sub-sector is 0.83 = 83%.

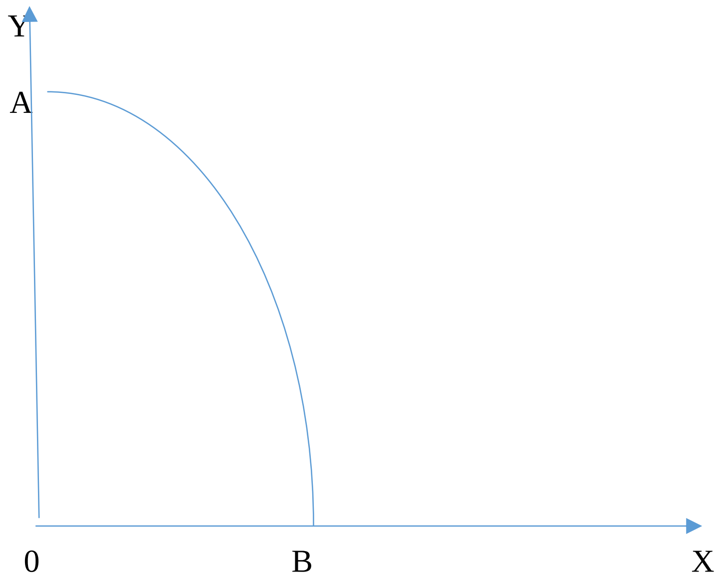
Table 6.35: VRS Non-Metallic Minerals Efficiency Scores Analysis

	Number	Percentage
Efficient DMUs	10	48
Inefficient DMUs	11	52
Above average efficient DMUs	14	67
Below average efficient DMUs	7	33

Source: Adapted from STATA output

In the Non-Metallic Minerals sub-sector of the manufacturing sector, 48% of the DMUs are efficient and 52% are inefficient. At least 67% of the DMUs are operating above the average efficiency of 83%, whereas 33% of the DMUs are struggling below the average efficiency level.

Figure 5.12: VRSNon-Metallic MineralsFrontier Analysis



The efficient DMUs (1, 5, 7, 8, 9, 11, 13, 15, 17 and 21) are found on frontier AB, whereas all the other DMUs (2, 3, 4, 6, 10, 12, 14, 16, 18, 19 and 20)operate below frontier AB.

Table 6.36: VRS Non-Metallic Minerals Benchmarking Analysis

DMU	Benchmarks
1	6
2	1 (0.55) 9 (0.28) 17 (0.17)
3	0
4	7 (0.43) 17 (0.29) 20 (0.28)
5	0
6	1 (0.55) 9 (0.22) 11 (0.14) 21 (0.10)
7	4
8	0
9	7
10	1 (0.22) 9 (0.71) 17 (0.07)
11	4
12	7 (0.24) 9 (0.56) 11 (0.17) 17 (0.02)
13	1
14	1 (0.04) 7 (0.91) 9 (0.05) 17 (0.01)
15	1
16	11 (0.94) 15 (0.06)
17	5
18	1 (0.02) 7 (0.22) 9 (0.72) 11 (0.04)

19	1 (0.00) 9 (0.98) 13 (0.01)
20	1
21	1

Source: Adapted from STATA output

The tableabove shows the reference DMUs which the inefficient DMUs can emulate. The extent to which the inefficient firms can reduce their inputs in order to become efficient is also shown in brackets. For example, DMU 2 which is inefficient can emulate DMUs 1, 9 and 17.

2	1 (0.55) 9 (0.28) 17 (0.17)

DMU 2 is expected to reduce its inputs by 55%, 28% and 17% by emulating DMUs 1, 9 and 17 respectively in order to become efficient. This means that DMU 2 can reduce many resources if it wants to be efficient by learning more from DMU 1 than when it wants to learn from DMU 9 and 17.

6.8Paper Printing and Publishing manufacturing efficiency scores

The efficiency scores are for all thePaper Printing and Publishing manufacturing sub-sectors. The scores are calculated based on both the CRS and VRS.

6.8.1 CRS Paper Printing and Publishing

The following results are based on the assumption that the DMUs exhibit constant returns to scale and attempt to minimise inputs to attain efficiency in Stage 1.

Table 6.37: CRS Paper Printing and Publishing Efficiency scores

DMU	Rank	Efficient Score	Decision	Above average
dmu:1	19	0.433792	Inefficient	No
dmu:2	1	1	Efficient	Yes
dmu:3	18	0.559129	Inefficient	No
dmu:4	20	0.360906	Inefficient	No
dmu:5	1	1	Efficient	Yes
dmu:6	1	1	Efficient	Yes
dmu:7	21	0.037663	Inefficient	No
dmu:8	1	1	Efficient	Yes
dmu:9	1	1	Efficient	Yes
dmu:10	1	1	Efficient	Yes
dmu:11	1	1	Efficient	Yes
dmu:12	1	1	Efficient	Yes
dmu:13	1	1	Efficient	Yes
dmu:14	16	0.701702	Inefficient	No
dmu:15	1	1	Efficient	Yes
dmu:16	15	0.748801	Inefficient	No
dmu:17	17	0.584244	Inefficient	No
dmu:18	1	1	Inefficient	Yes
dmu:19	1	1	Efficient	Yes
dmu:20	14	0.811216	Inefficient	No
dmu:21	13	0.877069	Inefficient	Yes
Average		**0.814977**		

Source: Adapted from STATA output

The DMUs with an efficiency score of 1 are the efficient firms in the Paper Printing and Publishing manufacturing sub-sector. The results above are for a sample of 21 DMUs in the Paper Printing and Publishing manufacturing sub-sector. Average efficiency in the Paper Printing and Publishing manufacturing sub-sector is 0.81 = 81%.

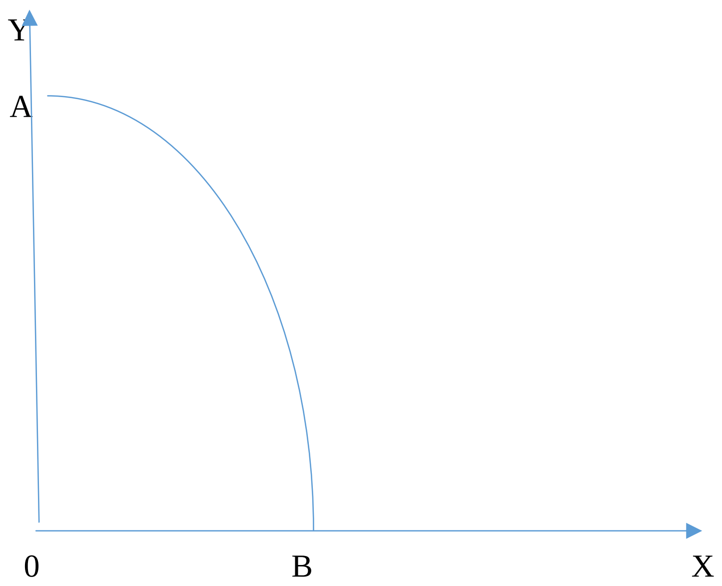
Table 6.38: Paper Printing and Publishing Efficiency Analysis

	Number	**Percentage**
Efficient DMUs	12	57
Inefficient DMUs	9	43
Above average efficient DMUs	13	62
Below average efficient DMUs	8	38

Source: Adapted from STATA output

In the Paper Printing and Publishing sub-sector of the manufacturing sector, 57% of the DMUs are efficient and 43% are inefficient. At least 62% of the DMUs are operating above the average efficiency of 81%, whereas 38% of the DMUs are struggling below the average efficiency level.

Figure 5.13: CRS Paper Printing and PublishingFrontier Analysis



The efficient DMUs (2, 5, 6, 8, 9, 10, 11, 12, 13, 15, 18 and 19) are found on frontier AB, whereas all the other DMUs (1, 3, 4, 7, 14, 16, 17, 20 and 21) operate below frontier AB.

Table 6.39: CRS Paper Printing and Publishing Benchmarking Analysis

DMU	**Benchmarks**
1	6 (0.02) 12 (0.01) 15 (0.02)
2	1
3	6 (0.01) 10 (0.00) 12 (0.09)
4	6 (0.01) 15 (0.73)
5	2
6	7
7	5 (0.00) 10 (0.00)
8	0
9	1
10	6
11	1
12	5
13	0
14	6 (0.12) 10 (0.02) 12 (1.13)
15	2
16	9 (0.01) 11 (0.00) 12 (0.00)
17	2 (0.71) 6 (0.09) 10 (0.02)

18	0
19	0
20	5 (0.04) 6 (0.04) 10 (0.00)
21	6 (0.10) 10 (0.00) 12 (0.76)

Source: Adapted from STATA output

The table above shows the reference DMUs which the inefficient DMUs can emulate. The extent to which the inefficient firms can reduce their inputs in order to become efficient is also shown in brackets. For example, DMU 14 which is inefficient can emulate DMUs 6, 10 and 12.

14	6 (0.12) 10 (0.02) 12 (1.13)

DMU 14 is expected to reduce its inputs by 12%, 2% and 113%, by emulating DMUs 6, 10 and 12 respectively in order to become efficient. This means that DMU 14 can reduce many resources if it wants to be efficient, learning more from DMU 12 than when learns from DMUs 6 and 10.

6.8.2 VRS Paper Printing and Publishing

The following results are based on the assumption that the DMUs exhibit variable returns to scale and attempt to minimise inputs to attain efficiency in Stage 1.

Table 6.40: VRS Paper Printing and Publishing Efficiency scores

DMU	**Rank**	**Efficient Score**	**Decision**	**Above average**

dmu:1	1	1	Efficient	Yes
dmu:2	1	1	Efficient	Yes
dmu:3	19	0.691554	Inefficient	No
dmu:4	21	0.395157	Inefficient	No
dmu:5	1	1	Efficient	Yes
dmu:6	1	1	Efficient	Yes
dmu:7	1	1	Efficient	Yes
dmu:8	1	1	Efficient	Yes
dmu:9	1	1	Efficient	Yes
dmu:10	1	1	Efficient	Yes
dmu:11	1	1	Efficient	Yes
dmu:12	1	1	Efficient	Yes
dmu:13	1	1	Efficient	Yes
dmu:14	18	0.708272	Inefficient	No
dmu:15	1	1	Efficient	Yes
dmu:16	1	1	Efficient	Yes
dmu:17	20	0.591033	Inefficient	No
dmu:18	1	1	Efficient	Yes
dmu:19	1	1	Efficient	Yes
dmu:20	16	0.889615	Inefficient	No
dmu:21	17	0.87875	Inefficient	No
Average		**0.912113**		

Source: Adapted from STATA output

The DMUs with an efficiency score of 1 are the efficient firms in the Paper Printing and Publishing manufacturing sub-sector. The results above are for a sample of 21 DMUs in the Paper Printing and Publishing manufacturing sub-sector. Average efficiency in the Paper Printing and Publishing manufacturing sub-sector is 0.91 = 91%.

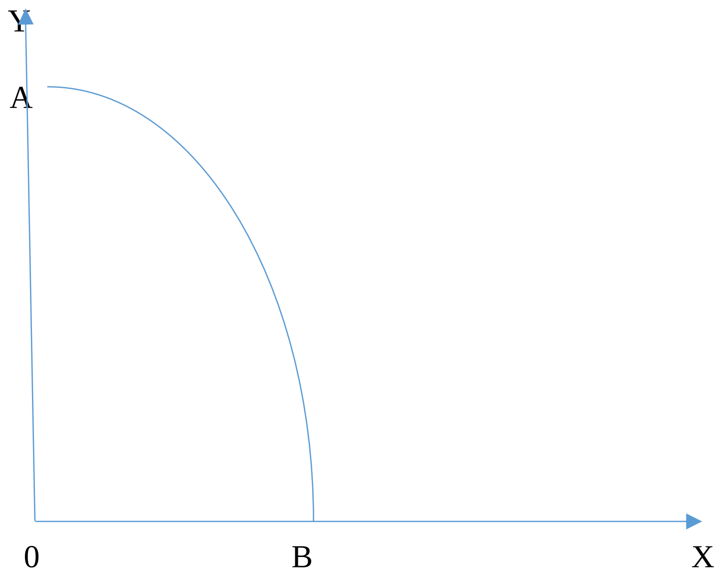
Table 6.41: VRS Paper Printing and Publishing Efficiency

	Number	Percentage
Efficient DMUs	15	71
Inefficient DMUs	6	29
Above average efficient DMUs	16	76
Below average efficient DMUs	5	24

Source: Adapted from STATA output

In the Paper Printing and Publishing sub-sector of the manufacturing sector, 71% of the DMUs are efficient and 29% are inefficient. At least 76% of the DMUs are operating above the average efficiency of 91%, whereas 24% of the DMUs are struggling below the average efficiency level.

Figure 5.14: VRSPaper Printing and PublishingFrontier Analysis



The efficient DMUs (1, 2, 5, 6, 7, 8, 9, 10, 11, 12, 13, 15, 16, 18 and 19) are found on the frontier AB, whereas all the other DMUs (3, 4, 14, 17, 20 and 21) operate below frontier AB.

Table 6.42: VRS Paper Printing and Publishing Benchmarking Analysis

DMU	Benchmarks
1	1
2	1
3	5 (0.02) 6 (0.02) 15 (0.03) 16 (0.68) 18 (0.25)
4	1 (0.10) 15 (0.81) 18 (0.09)
5	2
6	5
7	0
8	0
9	1
10	4
11	0
12	3
13	0
14	6 (0.15) 9 (0.02) 10 (0.01) 12 (0.82)
15	2
16	2
17	2 (0.83) 6 (0.01) 10 (0.02) 12 (0.13)

18	4
19	0
20	5 (0.08) 6 (0.04) 10 (0.00) 16 (0.40) 18 (0.49)
21	6 (0.10) 10 (0.00) 12 (0.77) 18 (0.13)

Source: Adapted from STATA output

The table above shows the reference DMUs which the inefficient DMUs can emulate. The extent to which the inefficient firms can reduce their inputs in order to become efficient is also shown in brackets. For example, DMU 4 which is inefficient can emulate DMUs 1, 15 and 18.

4	1 (0.10) 15 (0.81) 18 (0.09)

DMU 4 is expected to reduce its inputs by 10%, 81% and 9%, emulating DMUs 1, 15 and 18 respectively in order to become efficient. This means that DMU 4 can reduce many resources if it wants to be efficient, learning more from DMU 8 than when it wants to learn from DMUs 1 and 15.

6.9Textiles manufacturing efficiency scores

The efficiency scores are for all theTextiles manufacturing sub-sectors. The scores are calculated based on both the CRS and VRS.

6.9.1 CRS Textiles

The following results are based on the assumption that the DMUs exhibit constant returns to scale and attempt to minimise inputs to attain efficiency in Stage 1.

Table 6.43: CRS Textiles Efficiency scores

DMU	Rank	Efficient Score	Decision	Above average
dmu:1	15	0.165981	Inefficient	No
dmu:2	1	1	Efficient	Yes
dmu:3	14	0.168616	Inefficient	No
dmu:4	3	0.275674	Inefficient	Yes
dmu:5	20	0.120195	Inefficient	No
dmu:6	4	0.266971	Inefficient	Yes
dmu:7	16	0.14452	Inefficient	No
dmu:8	7	0.238277	Inefficient	No
dmu:9	5	0.253747	Inefficient	No
dmu:10	12	0.177501	Inefficient	No
dmu:11	6	0.239199	Inefficient	No
dmu:12	19	0.126264	Inefficient	No
dmu:13	9	0.222107	Inefficient	No
dmu:14	21	0.071227	Inefficient	No
dmu:15	10	0.182491	Inefficient	No
dmu:16	11	0.178377	Inefficient	No
dmu:17	1	1	Efficient	Yes
dmu:18	18	0.128609	Inefficient	No
dmu:19	17	0.13955	Inefficient	No
dmu:20	8	0.222364	Inefficient	No
dmu:21	13	0.170046	Inefficient	No

Average		**0.26151**		

Source: Adapted from STATA output

The DMUs with efficiency scores of one are the efficient firms in the Textiles manufacturing sub-sector. The results above are for a sample of 21 DMUs in the Textiles manufacturing sub-sector. Average efficiency in the Textiles manufacturing sub-sector is 0.26 = 26%.

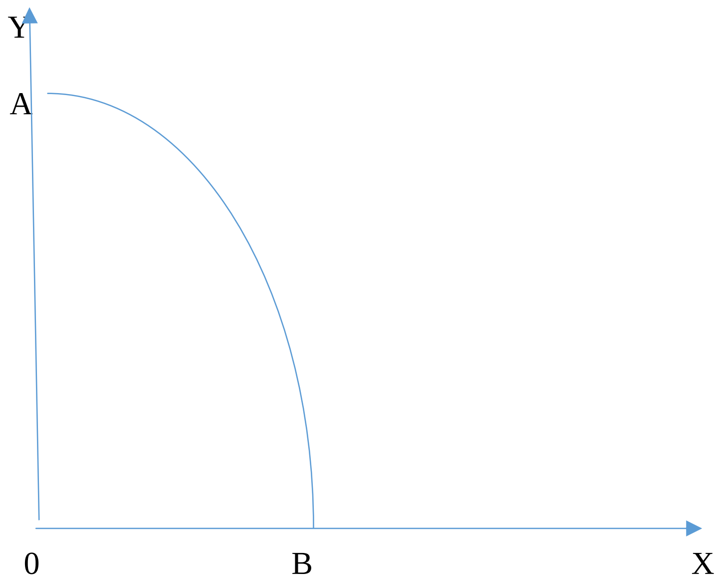
Table 6.44: CRS Textiles Efficiency Analysis

	Number	**Percentage**
Efficient DMUs	2	10
Inefficient DMUs	19	90
Above average efficient DMUs	4	19
Below average efficient DMUs	17	81

Source: Adapted from STATA output

In the Textiles sub-sector of the manufacturing sector, 10% of the DMUs are efficient and 90% are inefficient. At least 19% of the DMUs are operating above the average efficiency of 26%, whereas 81% of the DMUs are struggling below the average efficiency level.

Figure5.15: CRSTextilesFrontier Analysis



The efficient DMUs 2 and 17 are found on the frontier AB, whereas all the other DMUs (1, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 18, 19, 20 and 21) operate below frontier AB.

Table 6.45: CRS Textiles Benchmarking Analysis

DMU	Benchmarks
1	17 (1.04)
2	0
3	17 (2.62)
4	17 (0.86)
5	17 (2.17)
6	17 (0.35)
7	17 (0.24)
8	17 (0.02)

9	17 (0.39)
10	17 (0.24)
11	17 (0.24)
12	17 (0.10)
13	17 (0.22)
14	17 (0.01)
15	17 (0.02)
16	17 (0.19)
17	19
18	17 (0.02)
19	17 (0.46)
20	17 (0.00)
21	17 (0.00)

Source: Adapted from STATA output

The table above shows the reference DMUs which the inefficient DMUs can emulate. The extent to which the inefficient firms can reduce their inputs in order to become efficient is also shown in brackets. For example, DMU 1 which is inefficient can emulate DMU 17.

1	17 (1.04)

DMU 1 is expected to reduce its inputs by 104%, emulating DMU 17 in order to become efficient.

6.9.2 VRS Textiles

The following results are based on the assumption that the DMUs exhibit variable returns to scale and attempt to minimise inputs to attain efficiency in Stage 1.

Table 6.46:VRS Textiles Efficiency scores

DMU	Rank	Efficient Score	Decision	Above average
dmu:1	16	0.234683	Inefficient	No
dmu:2	1	1	Efficient	Yes
dmu:3	1	1	Efficient	Yes
dmu:4	14	0.276343	Inefficient	No
dmu:5	7	0.837173	Inefficient	Yes
dmu:6	1	1	Efficient	Yes
dmu:7	19	0.147556	Inefficient	No
dmu:8	8	0.623442	Inefficient	Yes
dmu:9	15	0.259625	Inefficient	No
dmu:10	18	0.181271	Inefficient	No
dmu:11	11	0.430953	Inefficient	No
dmu:12	21	0.133764	Inefficient	No
dmu:13	17	0.233975	Inefficient	No
dmu:14	10	0.582726	Inefficient	Yes
dmu:15	13	0.323562	Inefficient	No
dmu:16	12	0.349461	Inefficient	No
dmu:17	1	1	Efficient	Yes

dmu:18	9	0.584809	Inefficient	Yes
dmu:19	20	0.141983	Inefficient	No
dmu:20	6	0.888624	Inefficient	Yes
dmu:21	1	1	Efficient	Yes
Average		**0.53476**		

Source: Adapted from STATA output

The DMUs with efficiency scores of 1 are the efficient firms in the Textiles manufacturing sub-sector. The results above are for a sample of 21 DMUs in the Textiles manufacturing sub-sector. Average efficiency inTextiles manufacturing sub-sector is 0.53 = 53%.

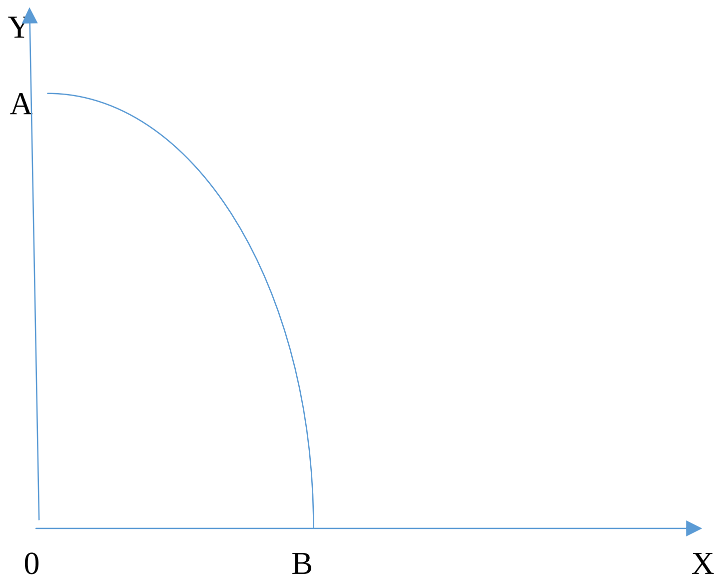
Table 6.47: VRS Textiles Efficiency Analysis

	Number	**Percentage**
Efficient DMUs	5	24
Inefficient DMUs	16	76
Above average efficient DMUs	10	48
Below average efficient DMUs	11	52

Source: Adapted from STATA output

In the Textiles sub-sector of the manufacturing sector, 24% of the DMUs are efficient and 76% are inefficient. At least 48% of the DMUs are operating above the average efficiency of 53%, whereas 52% of the DMUs are struggling below the average efficiency level.

Figure 5.16: VRSTextilesFrontier Analysis



The efficient DMUs (2, 3, 6, 17 and 21) are found on frontier AB, whereas all the other DMUs (1, 4, 5, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 18, 19 and 20) operate below frontier AB.

Table 6.48: VRS Textiles Benchmarking Analysis

DMU	Benchmarks
1	3 (0.03) 17 (0.97)
2	0
3	2
4	17 (0.86) 21 (0.14)
5	3 (0.91) 17 (0.09)
6	17 (0.69) 21 (0.31)
7	17 (0.24) 21 (0.76)
8	17 (0.05) 21 (0.95)

9	17 (0.39) 21 (0.61)
10	17 (0.24) 21 (0.76)
11	17 (0.43) 21 (0.57)
12	17 (0.10) 21 (0.90)
13	17 (0.22) 21 (0.78)
14	17 (0.08) 21 (0.92)
15	17 (0.02) 21 (0.98)
16	17 (0.19) 21 (0.81)
17	17
18	17 (0.07) 21 (0.93)
19	17 (0.46) 21 (0.54)
20	17 (0.00) 21 (1.00)
21	15

Source: Adapted from STATA output

The table above shows the reference DMUs which the inefficient DMUs can emulate. The extent to which the inefficient firms can reduce their inputs in order to become efficient is also shown in brackets. For example, DMU 1 which is inefficient can emulate DMUs 3 and 17.

1	3 (0.03) 17 (0.97)

DMU 1 is expected to reduce its inputs by 3% and 97% from emulating DMUs 3 and 17 respectively in order to become efficient. This means that DMU 1 can reduce a many resources if it wants to be efficient, learning more from DMU 17 than when it wants to learn from DMU 3.

6.10Transport and Transport Equipmentmanufacturing efficiency scores

The efficiency scores are for all theTransport and Transport Equipment manufacturing sub-sectors. The scores are calculated based on both the CRS and VRS.

6.10.1 CRS Transport and Transport Equipment

The following results are based on the assumption that the DMUs exhibit constant returns to scale and attempt to minimise inputs to attain efficiency in Stage 1.

Table 6.49:CRS Transport and Transport Equipment Efficiency scores

DMU	Rank	Efficient Score	Decision	Above average
dmu:1	16	0.543804	Inefficient	No
dmu:2	11	0.910446	Inefficient	Yes
dmu:3	17	0.529878	Inefficient	No
dmu:4	1	1	Efficient	Yes
dmu:5	20	0.421294	Inefficient	No
dmu:6	10	0.922145	Inefficient	Yes
dmu:7	18	0.505795	Inefficient	No
dmu:8	15	0.557026	Inefficient	No
dmu:9	1	1	Efficient	Yes
dmu:10	13	0.665819	Inefficient	No
dmu:11	1	1	Efficient	Yes

dmu:12	1	1	Efficient	Yes
dmu:13	19	0.478052	Inefficient	No
dmu:14	1	1	Efficient	Yes
dmu:15	1	1	Efficient	Yes
dmu:16	1	1	Efficient	Yes
dmu:17	14	0.559483	Inefficient	No
dmu:18	12	0.864874	Inefficient	Yes
dmu:19	21	0.400336	Inefficient	No
dmu:20	1	1	Efficient	Yes
dmu:21	1	1	Efficient	Yes
Average		**0.778998**		

Source: Adapted from STATA output

The DMUs with efficiency scores of 1 are the efficient firms in the Transport and Transport Equipment manufacturing sub-sector. The results above are for a sample of 21 DMUs in the Transport and Transport Equipment manufacturing sub-sector. Average efficiency inTransport and Transport Equipment manufacturing sub-sector is 0.78 = 78%.

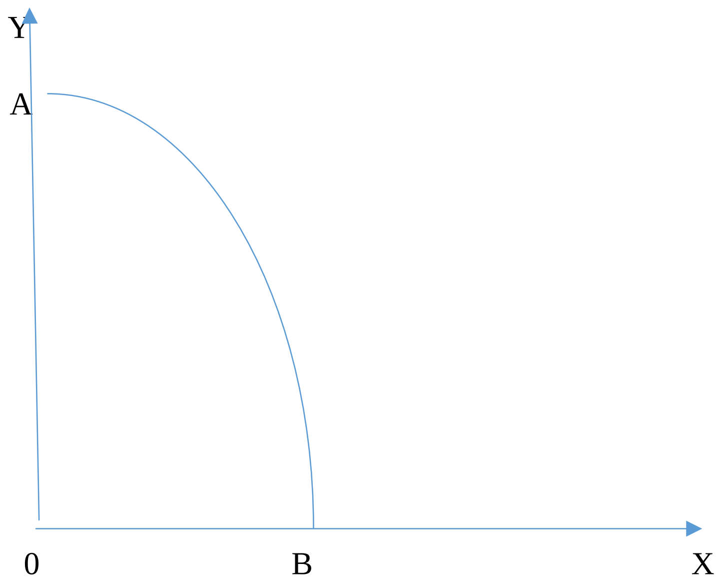
Table 6.50: CRS Transport and Transport Equipment Efficiency Analysis

	Number	**Percentage**
Efficient DMUs	9	43
Inefficient DMUs	12	57
Above average efficient DMUs	12	57
Below average efficient DMUs	9	43

Source: Adapted from STATA output

In the Transport and Transport Equipment sub-sector of the manufacturing sector, 43% of the DMUs are efficient and 57% are inefficient. At least 57% of the DMUs are operating above the average efficiency of 78%, whereas 43% of the DMUs are struggling below the average efficiency level.

Figure 5.17: CRSTransport and Transport EquipmentFrontier Analysis



The efficient DMUs (4, 9, 11, 12, 14, 15, 16, 20 and 21) are found on the frontier AB, whereas all the other DMUs (1, 2, 3, 5, 6, 7, 8, 10, 13, 17, 18 and 19) operate below frontier AB.

Table 6.51: CRS Transport and Transport Equipment Benchmarking Analysis

DMU	Benchmarks
1	12 (10.54) 14 (0.44) 15 (0.27)
2	9 (0.25) 12 (1.03) 14 (0.05)

3	12 (3.33) 21 (1.20)
4	0
5	11 (0.19) 14 (0.11) 15 (0.16)
6	11 (9.37) 15 (0.16)
7	11 (1.25) 14 (0.18) 15 (0.29)
8	12 (3.15) 14 (0.33) 15 (0.40) 21 (1.31)
9	1
10	12 (7.92) 14 (0.29) 21 (0.92)
11	7
12	6
13	11 (0.32) 14 (2.21) 15 (3.71)
14	11
15	10
16	0
17	11 (0.53) 14 (0.32) 15 (0.59)
18	11 (0.78) 14 (0.17) 15 (0.28)
19	12 (0.58) 14 (0.02) 15 (0.00)
20	11 (0.78) 14 (0.04) 15 (0.15)
21	3

Source: Adapted from STATA output

The table above shows the reference DMUs which the inefficient DMUs can emulate. The extent to which the inefficient firms can reduce their inputs in order to become efficient is

also shown in brackets. For example, DMU 1 which is inefficient can emulate DMUs 12, 14 and 15.

1	12 (10.54) 14 (0.44) 15 (0.27)

DMU 1 is expected to reduce its inputs by 1054%, 44% and 27%, from emulating DMUs 12, 14 and 15 respectively in order to become efficient. This means that DMU 1 can reduce many resources if it wants to be efficient in learning from DMU 12 rather than when it wants to learn from DMUs 14 and 15.

6.10.2 VRS Transport and Transport Equipment

The following results are based on the assumption that the DMUs exhibit variable returns to scale and attempt to minimise inputs to attain efficiency in Stage 1.

Table 6.52: VRS Transport and Transport Equipment Efficiency scores

DMU	Rank	Efficient Score	Decision	Above average
dmu:1	14	0.89281	Inefficient	Yes
dmu:2	11	0.943823	Inefficient	Yes
dmu:3	18	0.59029	Inefficient	No
dmu:4	1	1	Efficient	Yes
dmu:5	21	0.432921	Inefficient	No
dmu:6	1	1	Efficient	Yes
dmu:7	20	0.523373	Inefficient	No
dmu:8	17	0.60466	Inefficient	No
dmu:9	1	1	Efficient	Yes

dmu:10	15	0.778942	Inefficient	No
dmu:11	1	1	Efficient	Yes
dmu:12	1	1	Efficient	Yes
dmu:13	1	1	Efficient	Yes
dmu:14	1	1	Efficient	Yes
dmu:15	1	1	Efficient	Yes
dmu:16	1	1	Efficient	Yes
dmu:17	19	0.58122	Inefficient	No
dmu:18	13	0.930849	Inefficient	Yes
dmu:19	16	0.663718	Inefficient	No
dmu:20	12	0.93481	Inefficient	Yes
dmu:21	1	1	Efficient	Yes
Average		**0.851306**		

Source: Adapted from STATA output

The DMUs with an efficiency score of 1 are the efficient firms in the Transport and Transport Equipment manufacturing sub-sector. The results above are for a sample of 21 DMUs in the Transport and Transport Equipment manufacturing sub-sector. Average efficiency in Transport and Transport Equipment manufacturing sub-sector is 0.85 = 85%.

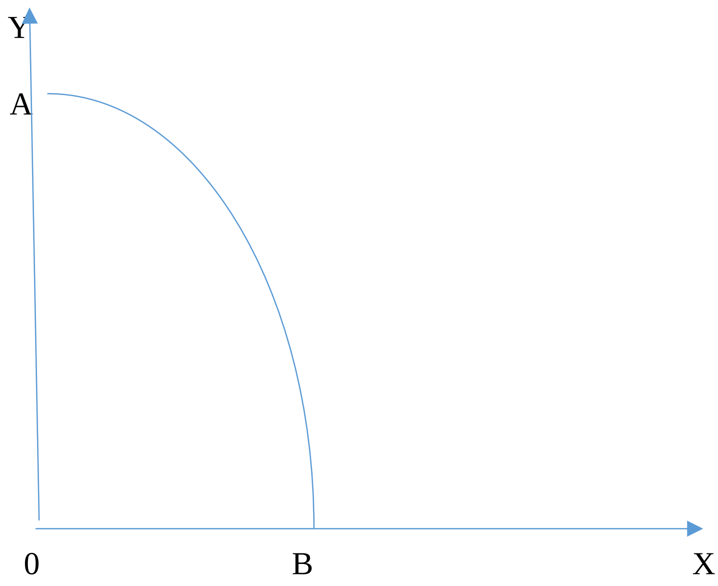
Table 6.53: VRS Transport and Transport Equipment Efficiency Analysis

	Number	**Percentage**
Efficient DMUs	10	48
Inefficient DMUs	11	52
Above average efficient DMUs	14	67
Below average efficient DMUs	7	33

Source: Adapted from STATA output

In the Transport and Transport Equipment sub-sector of the manufacturing sector, 48% of the DMUs are efficient and 52% are inefficient. At least 67% of the DMUs are operating above the average efficiency of 85%, whereas 33% of the DMUs are struggling below the average efficiency level.

Figure 5.18: VRSTransport and Transport Equipment Frontier Analysis



The efficient DMUs (4, 6, 9, 11, 12, 13, 14, 15, 16 and 21) are found on the frontier AB, whereas all the other DMUs (1, 2, 3, 5, 7, 8, 10, 17, 18, 19 and 20) operate below frontier AB.

Table 6.54: VRS Transport and Transport Equipment Benchmarking Analysis

DMU	Benchmarks
1	13 (0.11) 14 (0.30) 15 (0.59)
2	9 (0.30) 12 (0.63) 14 (0.05) 15 (0.02)

3	9 (0.52) 12 (0.12) 15 (0.21) 16 (0.15)
4	0
5	11 (0.22) 12 (0.58) 14 (0.09) 15 (0.11)
6	3
7	6 (0.09) 11 (0.41) 14 (0.23) 15 (0.28)
8	13 (0.00) 14 (0.35) 15 (0.64)
9	3
10	9 (0.06) 14 (0.37) 15 (0.56)
11	5
12	4
13	2
14	10
15	10
16	1
17	6 (0.06) 11 (0.02) 14 (0.35) 15 (0.58)
18	6 (0.02) 11 (0.49) 14 (0.19) 15 (0.29)
19	12 (0.98) 14 (0.02)
20	11 (0.78) 14 (0.07) 15 (0.15)
21	0

Source: Adapted from STATA output

The table above shows the reference DMUs which the inefficient DMUs can emulate. The extent to which the inefficient firms can reduce their inputs in order to become efficient is

also shown in brackets. For example, DMU 1 which is inefficient can emulate DMUs 13, 14 and 15.

1	13 (0.11) 14 (0.30) 15 (0.59)

DMU 1 is expected to reduce its inputs by 11%, 30% and 59% by emulating DMUs 13, 14 and 15 respectively in order to become efficient. This means that DMU 1 can reduce many resources if it wants to be efficient, learning more from DMU 15 than when it wants to learn from DMUs 13 and 14.

6.11Wood and Furniture manufacturing efficiency scores

The efficiency scores are for all theWood and Furniture manufacturing sub-sectors. The scores are calculated based on both the CRS and VRS.

6.11.1 CRS Wood and Furniture

The following results are based on the assumption that the DMUs exhibit constant returns to scale and attempt to minimise inputs to attain efficiency in Stage 1.

Table 6.55: CRS Wood and Furniture Efficiency scores

DMU	Rank	Efficient Score	Decision	Above average
dmu:1	12	0.852447	Inefficient	Yes
dmu:2	18	0.519086	Inefficient	No
dmu:3	1	1	Efficient	Yes
dmu:4	15	0.722556	Inefficient	No
dmu:5	1	1	Efficient	Yes

dmu:6	14	0.768689	Inefficient	No
dmu:7	1	1	Efficient	Yes
dmu:8	1	1	Efficient	Yes
dmu:9	13	0.781638	Inefficient	No
dmu:10	1	1	Efficient	Yes
dmu:11	19	0.504657	Inefficient	No
dmu:12	21	0.502356	Inefficient	No
dmu:13	11	0.959415	Inefficient	Yes
dmu:14	20	0.503083	Inefficient	No
dmu:15	1	1	Efficient	Yes
dmu:16	17	0.526612	Inefficient	No
dmu:17	1	1	Efficient	Yes
dmu:18	1	1	Efficient	Yes
dmu:19	1	1	Efficient	Yes
dmu:20	16	0.531565	Inefficient	No
dmu:21	1	1	Efficient	Yes
Average		**0.817719**		

Source: Adapted from STATA output

The DMUs with an efficiency score of 1 are the efficient firms in the Wood and Furniture manufacturing sub-sector. The results above are for a sample of 21 DMUs in the Wood and Furniture manufacturing sub-sector. Average efficiency in Wood and Furniture manufacturing sub-sector is 0.82 = 82%.

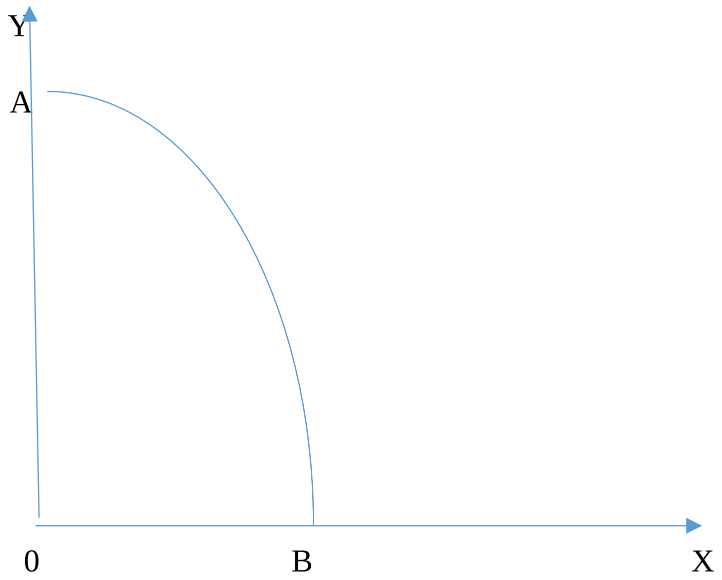
Table 6.56: CRS Wood and Furniture Efficiency Analysis

	Number	**Percentage**
Efficient DMUs	10	48
Inefficient DMUs	11	52
Above average efficient DMUs	12	57
Below average efficient DMUs	9	43

Source: Adapted from STATA output

In the Wood and Furniture sub-sector of the manufacturing sector, 48% of the DMUs are efficient and 52% are inefficient. At least 57% of the DMUs are operating above the average efficiency of 82%, whereas 43% of the DMUs are struggling below the average efficiency level.

Figure 5.19: CRSWood and FurnitureFrontier Analysis



The efficient DMUs (3, 5, 7, 8, 10, 15, 17, 18, 19 and 21) are found on the frontier AB, whereas all the other DMUs (1, 2, 4, 6, 9, 11, 12, 13, 14, 16 and 20) operate below frontier AB.

Table 6.57: CRS Wood and Furniture Benchmarking Analysis

DMU	Benchmarks
1	15 (11.25) 17 (1.57)
2	15 (0.44) 17 (1.41) 18 (0.02) 21 (0.07)
3	0
4	7 (0.00) 18 (0.13) 21 (0.18)
5	0
6	15 (2.84) 17 (1.26) 18 (0.56)
7	2
8	0
9	17 (0.42) 18 (0.01)
10	0
11	7 (0.02) 18 (0.07) 19 (5.55)
12	17 (5.49) 18 (0.27) 19 (3.57) 21 (0.58)
13	15 (4.50) 17 (1.01) 18 (0.08) 19 (0.68) 21 (0.03)
14	17 (0.51) 18 (0.01) 19 (0.22) 21 (0.01)
15	6
16	15 (3.78) 17 (1.34)
17	9

18	8
19	4
20	15 (22.18) 17 (5.60) 21 (0.11)
21	6

Source: Adapted from STATA output

The table above shows the reference DMUs which the inefficient DMUs can emulate. The extent to which the inefficient firms can reduce their inputs in order to become efficient is also shown in brackets. For example, DMU 2 which is inefficient can emulate DMUs 15, 17, 18 and 21.

2	15 (0.44) 17 (1.41) 18 (0.02) 21 (0.07)

DMU 2 is expected to reduce its inputs by 44%, 141%, 2% and 7% from emulating DMUs 15, 17, 18 and 21 respectively in order to become efficient. This means that DMU 2 can reduce many resources if it wants to be efficient, learning more from DMU 17 than when it wants to learn from DMUs 15, 18 and 21.

6.11.2 VRS Wood and Furniture

The following results are based on the assumption that the DMUs exhibit variable returns to scale and attempt to minimise inputs to attain efficiency in Stage 1.

Table 6.58: VRS Wood and Furniture Efficiency scores

DMU	**Rank**	**Efficient Score**	**Decision**	**Above average**
dmu:1	1	1	Efficient	Yes

dmu:2	20	0.580724	Inefficient	No
dmu:3	1	1	Efficient	Yes
dmu:4	16	0.729316	Inefficient	No
dmu:5	1	1	Efficient	Yes
dmu:6	14	0.852687	Inefficient	Yes
dmu:7	1	1	Efficient	Yes
dmu:8	1	1	Efficient	Yes
dmu:9	15	0.785396	Inefficient	No
dmu:10	1	1	Efficient	Yes
dmu:11	18	0.628439	Inefficient	No
dmu:12	1	1	Efficient	Yes
dmu:13	1	1	Efficient	Yes
dmu:14	21	0.543678	Inefficient	No
dmu:15	1	1	Efficient	Yes
dmu:16	19	0.596238	Inefficient	No
dmu:17	1	1	Efficient	Yes
dmu:18	1	1	Efficient	Yes
dmu:19	1	1	Efficient	Yes
dmu:20	17	0.673282	Inefficient	No
dmu:21	1	1	Efficient	Yes
Average		**0.851306**		

Source: Adapted from STATA output

The DMUs with an efficiency score of 1 are the efficient firms in the Wood and Furniture manufacturing sub-sector. The results above are for a sample of 21 DMUs in the Wood and Furniture manufacturing sub-sector. Average efficiency in the Wood and Furniture manufacturing sub-sector is 0.85 = 85%.

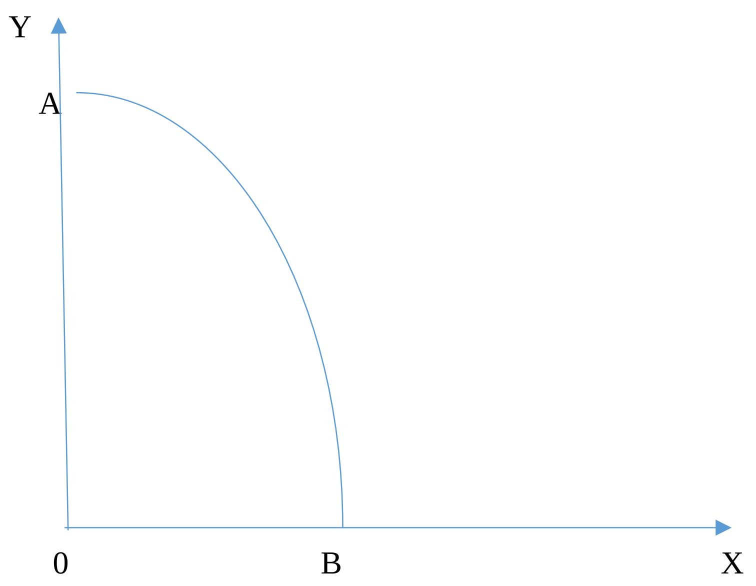
Table 6.59: VRS Wood and Furniture Efficiency Analysis

	Number	Percentage
Efficient DMUs	13	62
Inefficient DMUs	8	38
Above average efficient DMUs	14	67
Below average efficient DMUs	7	33

Source: Adapted from STATA output

In the Wood and Furniture sub-sector of the manufacturing sector, 62% of the DMUs are efficient and 38% are inefficient. At least 67% of the DMUs are operating above the average efficiency of 85%, whereas 33% of the DMUs are struggling below the average efficiency level.

Figure 5.20: VRSWood and FurnitureFrontier Analysis



The efficient DMUs (1, 3, 5, 7, 8, 10, 12, 13, 15, 17, 18, 19 and 21) are found on the frontier AB, whereas all the other DMUs (2, 4, 6, 9, 11, 14, 16 and 20) operate below frontier AB.

Table 6.60: VRS Wood and Furniture Benchmarking Analysis

DMU	Benchmarks
1	2
2	13 (0.02) 17 (0.85) 18 (0.02) 21 (0.11)
3	1
4	18 (0.12) 19 (0.72) 21 (0.16)
5	0
6	13 (0.37) 18 (0.59) 21 (0.03)
7	0
8	2
9	8 (0.60) 17 (0.40) 18 (0.01)
10	0
11	17 (0.73) 18 (0.08) 21 (0.18)
12	0
13	3
14	3 (0.03) 8 (0.01) 17 (0.59) 18 (0.00) 19 (0.37)
15	1
16	1 (0.16) 15 (0.43) 17 (0.33) 21 (0.08)
17	5
18	6

19	2
20	1 (0.13) 13 (0.03) 21 (0.84)
21	6

Source: Adapted from STATA output

The table above shows the reference DMUs which the inefficient DMUs can emulate. The extent to which the inefficient firms can reduce their inputs in order to become efficient is also shown in brackets. For example, DMU 2 which is inefficient can emulate DMUs 13, 17, 18 and 21.

2	13 (0.02) 17 (0.85) 18 (0.02) 21 (0.11)

DMU 2 is expected to reduce its inputs by 2%, 85%, 2% and 11%, by emulating DMUs 13, 17, 18 and 21 respectively in order to become efficient. This means that DMU 2 can reduce many resources if it wants to be efficient, learning more from DMU 17 than when it wants to learn from DMUs 13, 18 and 21.

5.15 Conclusion

The results have been presented based on the three areas of efficiency. The areas of efficiency applied are the two types of returns to scale; both CRS and VRS and Input-Orientation in Stage 1. The data presented managed to measure efficiency in the manufacturing sector in Zimbabwe.

CHAPTER SEVEN

DRIVERS AND BARRIERSOF EFFICIENCY IN ZIMBABWE'S MANUFACTURING SECTOR

7.1 Introduction

The barriers which hinder efficiency in the Zimbabwe's manufacturing sector are going to be presented. The drivers which sustain efficiency in the Zimbabwe's manufacturing sector will be shown. The slacks analysis from the DEA methodology shows the drivers and the barriers of efficiency. There are two types of slacks, namely

i. Input slacks and
ii. Output slacks.

In this study, the analysis of input and output slacks will address the following objectives:

i. To determine the drivers of efficiency in Zimbabwe's manufacturing sector and
ii. Identify the barriers to achieving efficiency levels in Zimbabwe's manufacturing sector.

Slacks analysis is done on all the ten manufacturing sub-sectors in Zimbabwe.

7.2 Slacks analysis in the Beverages and Tobacco

Input slacks show inputs as the source of inefficiency. A zero slack input shows that the particular input use mix is a driver of efficiency in the Beverages and Tobacco manufacturing sub-sector. A non-zero slack input shows that that particular input use mix is a barrier to achieving efficiency in the Beverages and Tobacco manufacturing sub-sector. Minimising these non-zero input slacks towards zero input slacks provides a model that is recommended for efficient input-output use.

Output slacks show outputs as the source of inefficiency. A zero slack output shows that that particular output mix is a driver of efficiency in the Beverages and Tobacco manufacturing sub-sector. A non-zero slack output shows that that particular output mix is a barrier to achieving efficiency in the Beverages and Tobacco sub-sector. Minimising these non-zero output slacks towards zero output slacks provides a model that is recommended for efficient input-output use.

7.2.1 CRS Beverages and Tobacco Slack Analysis

Slacks provide vital information pertaining to the areas which an inefficient DMU needs to improve in its drive towards attaining the status of an efficient one (Yang, Taudes and Dong 2017: 105). Slack analysis provides important information to determine the drivers of efficiency and to identify the barriers to efficiency in the Beverages and Tobacco manufacturing sub-sector in Zimbabwe. In this study, slack analyse are executed under **CRS CCR Input-Orientation in Stage 1** assumptions in order to obtain the long-term improvement directions for the inefficient DMUs.

Tome (2001: 498) explains a slack-based measure as a scalar-based measure of determining the efficiency of a DMU in a non-parametric form by considering both the input and output shortfalls. The smaller the value of the input or output slack, the more the variable drives efficiency in the Beverages and Tobacco manufacturing sub-sector. The greater the value of the input or output slack, the more the variable is a barrier to achieving efficiency in the Beverages and Tobacco manufacturing sub-sector.

Table 7.1: CRS Beverages and Tobacco Slack Analysis

	Inputs				**Outputs**		
DMU	{S} E{I}	{S} CM{I}	{S} WS{I}	{S} S{I}	{S} SLS{O}	{S} GVP{O}	{S} VA{O}
dmu:1							

dmu:2							
dmu:3	0	0	0	13.93	1.73	0	7.45
dmu:4	0	0	0	1.77	9.25	0	33.31
dmu:5	0	0	0	4.71	0	0	5.98
dmu:6	0	0	0	6.27	0	0.64	2.35
dmu:7							
dmu:8							
dmu:9	0	0	0	0	0	1.81	22.35
dmu:10	0	0	0	15.34	0	0	3.95
dmu:11							
dmu:12							
dmu:13	0.87	0	0	0	0	2.49	2.09
dmu:14	11.98	0	6.12	0	0	0.1	1.72
dmu:15	0	0	0	33.78	0	0	8.67
dmu:16	8.97	0	0	0	0	5.66	7.81
dmu:17							
dmu:18	0	0	0	38.31	0	5.98	41.49
dmu:19							
dmu:20							
dmu:21							
Total	**21.82**	**0**	**6.12**	**114.11**	**10.98**	**16.68**	**137.17**

Source: Adapted from STATA output

The efficient DMUs which have zero inputs and zero outputs are the efficient DMUs. The efficient DMUs (1, 2, 7, 8, 11, 12, 17, 19, 20 and 21) have zero slacks on both inputs and outputs and therefore there is no need to carry out a DEA in Stage 2. The inefficient DMUs (3, 4, 5, 6, 9, 10, 13, 14, 15, 16 and 18) have non-zero slacks on both inputs and outputs.

The input variable with the highest contribution to the efficiency mix is **CM,** with a summation of slacks being **0%.** This means that there is a **0%** reduction needed in **CM** in order to keep total output constant and efficient. This explains that **CM** is the major input driver of efficiency in the **Beverages and Tobacco** manufacturing sub-sector. The input variable with the lowest contribution to efficiency mix is **S,** with a summation of slacks being **114.11%**. This means that there is a **114.11%** reduction is needed in **S** in order to keep output constant. This explains that **S** is the major input barrier to efficiency in the **Beverages and Tobacco** manufacturing sub-sector.

The output variable with the highest contribution to the efficiency mix is **SLS** with a summation of slacks being **16.68%.** This means that there is a **16.68%** increase needed in **SLS** in order to keep total output constant and efficient. This explains that **SLS** is the major input driver of efficiency in the **Beverages and Tobacco** manufacturing sub-sector. The output variable with the lowest contribution to the efficiency mix is **VA,** with a summation of slacks being **137.7%**. This means that a 13**7.7%** increase is needed in **VA** in order to keep output constant and efficient. This explains that **VA** is the major output barrier to efficiency in the **Beverages and Tobacco** manufacturing sub-sector.

Overall analysis shows that input CM is the major driver of efficiency in the **Beverages and Tobacco** manufacturing sub-sector. Output variable **VA** is the major barrier to efficiency in the **Beverages and Tobacco** manufacturing sub-sector.

7.2.2 VRS Beverages and Tobacco Slack Analysis

Slacks provide vital information pertaining to the areas which an inefficient DMU needs to improve in its drive towards attaining the status of an efficient one (Yang, Taudes and Dong 2017: 105). Slacks analysis provides important information to determine the drivers of

efficiency and to identify the barriers to efficiency in the Beverages and Tobacco manufacturing sub-sector in Zimbabwe. In this study, slack analyses are executed under **VRS CCR Input-Orientation in Stage 1** assumptions in order to obtain the long-term improvement directions for the inefficient DMUs.

Tome (2001: 498) explains a slack-based measure as a scalar-based measure of determining the efficiency of a DMU in a non-parametric form by considering both the input and output shortfalls. The smaller the value of the input or output slack, the more the variable drives efficiency in the Beverages and Tobacco manufacturing sub-sector. The greater the value of the input or output slack, the more the variable is a barrier to achieving efficiency in the Beverages and Tobacco manufacturing sub-sector.

Table 7.2: VRS Beverages and Tobacco Slack Analysis

	Inputs				**Outputs**		
DMU	{S} E{I}	{S} CM{I}	{S} WS{I}	{S} S{I}	{S} SLS{O}	{S} GVP{O}	{S} VA{O}
dmu:1							
dmu:2							
dmu:3							
dmu:4	28.01	0	19.21	0	8.63	0	45.23
dmu:5	8.19	0	0	0	0	0	12.48
dmu:6	0	0	0	5.8	0	0.38	1.64
dmu:7							
dmu:8							
dmu:9	25.81	0	3.45	0	0	6.14	34.6
dmu:10	0	0	0	5.92	0	0	1.53

dmu:11							
dmu:12							
dmu:13	1.05	0.26	0	0	0	1.77	2.85
dmu:14							
dmu:15							
dmu:16	13.29	5.46	0	0	0	1.92	10.38
dmu:17							
dmu:18							
dmu:19							
dmu:20							
dmu:21							
Total	**76.35**	**5.72**	**22.66**	**11.72**	**8.63**	**10.21**	**108.71**

Source: Adapted from STATA output

The DMUs which have zero inputs and zero outputs slacks are the efficient DMUs. The efficient DMUs (1, 2, 3, 7, 8, 11, 12, 14, 15, 17, 18, 19, 20 and 21) have zero slacks on both inputs and outputs and therefore there is no need to carry out a DEA in Stage 2. The inefficient DMUs (4, 5, 6, 9, 10, 13 and 16) have non-zero slacks on both inputs and outputs.

The input variable with the highest contribution to efficiency mix is **CM** with a summation of slacks being **5.72%.** This means that there is a **5.72%** reduction needed in **CM** in order to keep total output constant and efficient. This explains that **CM** is the major input driver of efficiency in the **Beverages and Tobacco** manufacturing sub-sector. The input variable with the lowest contribution to efficiency mix is **E** with a summation of slacks being **76.35%**. This means that there is a **76.35%** reduction needed in **E** in order to keep output constant. This explains that **E** is the major input barrier to efficiency in the **Beverages and Tobacco** manufacturing sub-sector.

The output variable with the highest contribution to efficiency mix is **SLS** with a summation of slacks being **8.63%.** This means that there is a **8.63%** increase needed in **SLS** in order to keep total output constant and efficient. This explains that **SLS** is the major input driver of efficiency in the **Beverages and Tobacco** manufacturing sub-sector. The output variable with the lowest contribution to efficiency mix is **VA** with a summation of slacks being **108.71%**. This means that a **108.71%** increase is needed in **VA** in order to keep output constant and efficient. This explains that **VA** is the major output barrier to efficiency in the **Beverages and Tobacco** manufacturing sub-sector.

Overall analysis shows that input **CM** is the major driver of efficiency in the **Beverages and Tobacco** manufacturing sub-sector. Output variable **VA** is the major barrier to efficiency in the **Beverages and Tobacco** manufacturing sub-sector.

7.3 Slacks analysis in the Chemicals and Petroleum

Input slacks show inputs as the source of inefficiency. A zero slack input shows that that particular input use mix is a driver of efficiency in the Chemicals and Petroleum Products manufacturing sub-sector. A non-zero slack input shows that that particular input use mix is a barrier to achieving efficiency in the Chemicals and Petroleum Products manufacturing sub-sector. Minimising these non-zero input slacks towards zero input slacks provides a model that is recommended for efficient input-output use.

Output slacks show outputs as the source of inefficiency. A zero slack output shows that that particular output mix is a driver of efficiency in the Chemicals and Petroleum Products manufacturing sub-sector. A non-zero slack output shows that that particular output mix is a barrier to achieving efficiency in the Chemicals and Petroleum Products sub-sector. Minimising these non-zero output slacks towards zero output slacks provides a model that is recommended for efficient input-output use.

7.3.1 CRS Chemicals and Petroleum Products Slack Analysis

Slacks provide vital information pertaining to the areas which an inefficient DMU needs to improve in its drive towards attaining the status of an efficient one (Yang, Taudes and Dong 2017: 105). Slacks analysis provides important information to determine the drivers of efficiency and to identify the barriers to efficiency in the Chemicals and Petroleum Products manufacturing sub-sector in Zimbabwe. In this study, slack analyse are executed under **CRS CCR Input-Orientation in Stage 1** assumptions in order to obtain the long-term improvement directions for inefficient DMUs.

Tome (2001: 498-499) explains a slack-based measure as a scalar-based measure of determining the efficiency of a DMU in a non-parametric form by considering both the input and output shortfalls. The smaller the value of the input or output slack, the more the variable drives efficiency in the Chemicals and Petroleum Products manufacturing sub-sector. The greater the value of the input or output slack, the more the variable is a barrier to achieving efficiency in the Chemicals and Petroleum Products manufacturing sub-sector.

Table 7.3: CRS Chemicals and Petroleum Products Slack Analysis

	Inputs				**Outputs**		
DMU	{S} E{I}	{S} CM{I}	{S} WS{I}	{S} S{I}	{S} SLS{O}	{S} GVP{O}	{S} VA{O}
dmu:1							
dmu:2	0	0	45.26	0	0	2.17	11.7
dmu:3							
dmu:4	1.85	0	0	0	0	0.4	0.61
dmu:5	7.53	0.55	0	0	0	3.6	6.48
dmu:6	4.07	0	0	0	0.24	0	0.42
dmu:7							

dmu:8	0	0	0	20.68	0	40.78	65.91
dmu:9	0	0	11.96	0	0	0.53	3.84
dmu:10							
dmu:11	0	0	0	0	0	41.01	74.49
dmu:12	0	0	0	0	0	12.46	20.61
dmu:13							
dmu:14							
dmu:15	0	0	0	0	0	6.39	16.11
dmu:16	0	0	0	7.61	0	0	2.98
dmu:17							
dmu:18	0	0	0	0	0	2.03	3.88
dmu:19	0	0	0	0	0	4.2	11.01
dmu:20							
dmu:21	0	37.6	46.55	0	0	36.8	55.36
Total	**13.45**	**38.15**	**103.77**	**28.29**	**0.24**	**150.37**	**273.4**

Source: Adapted from STATA output

The efficient DMUs which have zero inputs and zero outputs are the efficient DMUs. The efficient DMUs (1, 2, 3, 7, 10, 13, 14, 17 and 20) have zero slacks on both inputs and outputs and therefore there is no need to carry out a DEA in Stage 2. The inefficient DMUs (4, 5, 6, 8, 9, 11, 12, 15, 16, 18, 19 and 21) have non-zero slacks on both inputs and outputs.

The input variable with the highest contribution to efficiency mix is **E** with a summation of slacks being **13.4%.** This means that there is a **13.4%** reduction needed in **E** in order to keep total output constant and efficient. This explains that **E** is the major input driver of efficiency in the **Chemicals and Petroleum Products** manufacturing sub-sector. The input variable with the lowest contribution to efficiency mix is **WS** with a summation of slacks being **103.77%**. This means that a **103.77%** reduction is needed in **WS** in order to keep output constant and efficient. This explains that W**S** is the major input barrier to efficiency in the **Chemicals and Petroleum Products** manufacturing sub-sector.

The output variable with the highest contribution to efficiency mix is **SLS** with a summation of slacks being **0.24%.** This means that there is a **0.24%** increase needed in **SLS** in order to keep total output constant and efficient. This explains that **SLS** is the major input driver of efficiency in the **Chemicals and Petroleum Products** manufacturing sub-sector. The output variable with the lowest contribution to efficiency mix is **VA** with a summation of slacks being **273.4%**. This means that a **273.4%** increase is needed in **VA** in order to keep output constant and efficient. This explains that **VA** is the major output barrier to efficiency in the **Chemicals and Petroleum Products** manufacturing sub-sector.

Overall analysis shows that **output variable SLS** is the major driver of efficiency in the **Chemicals and Petroleum Products** manufacturing sub-sector. Output variable **VA** is the major barrier to efficiency in the **Chemicals and Petroleum Products** manufacturing sub-sector.

7.3.2 VRS Chemicals and Petroleum Products Slack Analysis

Slacks provide vital information pertaining to the areas which an inefficient DMU needs to improve in its drive towards attaining the status of an efficient one (Yang, Taudes and Dong 2017: 105). Slacks analysis provides important information to determine the drivers of efficiency and to identify the barriers to efficiency in the Chemicals and Petroleum Products manufacturing sub-sector in Zimbabwe. In this study, slack analyses are executed under **VRS CCR Input-Orientation in Stage 1** assumptions in order to obtain the long-term improvement directions for the inefficient DMUs.

Tome (2001: 498) explains that a slack-based measure is a scalar-based measure of determining the efficiency of a DMU in a non-parametric form by considering both the input and output shortfalls. The smaller the value of the input or output slack, the more the variable drives efficiency in the Chemicals and Petroleum Products manufacturing sub-sector. The greater the value of the input or output slack, the more the variable is a barrier to achieving efficiency in the Chemicals and Petroleum Products manufacturing sub-sector.

Table 7.4: VRS Chemicals and Petroleum Products Slack Analysis

	Inputs				**Outputs**		
DMU	{S} E{I}	{S} CM{I}	{S} WS{I}	{S} S{I}	{S} SLS{O}	{S} GVP{O}	{S} VA{O}
dmu:1							
dmu:2	0	0	65.12	0.67	0	0	4.51
dmu:3							
dmu:4							
dmu:5							
dmu:6							
dmu:7							
dmu:8							
dmu:9	0	0.23	27.8	0	0	0.25	2.97
dmu:10							
dmu:11	15.52	0	7.72	0	0	49.57	71.76
dmu:12	0	0	0	4.3	0	12.41	21.98
dmu:13							
dmu:14							

dmu:15	0	0	0	0	0	6.1	14.75
dmu:16	0	0	0	9.99	0	0.08	3.88
dmu:17							
dmu:18							
dmu:19	0	0	0	1.73	0	2.48	9.18
dmu:20							
dmu:21							
Total	**15.52**	**0.23**	**100.64**	**16.69**	**0**	**70.89**	**129.03**

Source: Adapted from STATA output

The DMUs which have zero inputs and zero outputs are the efficient DMUs. The efficient DMUs (1, 2, 3, 4, 5, 6, 7, 8, 10, 13, 14, 17, 18, 20 and 21) have zero slacks on both inputs and outputs and therefore there is no need to carry out a DEA in Stage 2. The inefficient DMUs (2, 9, 11, 12, 15, 16 and 19) have non-zero slacks on both inputs and outputs

The input variable with the highest contribution to efficiency mix is **CM** with a summation of slacks being **0.23%.** This means that there is a **0.23%** reduction needed in **CM** in order to keep total output constant and efficient. This explains that **CM** is the major input driver of efficiency in the **Chemicals and Petroleum Products** manufacturing sub-sector. The input variable with the lowest contribution to efficiency mix is **WS** with the summation of slacks being **103.77%**. This means that a **100.64%** reduction is needed in **WS** in order to keep output constant and efficient. This explains that W**S** is the major input barrier to efficiency in the **Chemicals and Petroleum Products** manufacturing sub-sector.

The output variable with the highest contribution to efficiency mix is **SLS** with a summation of slacks being **0%.** This means that there is a **0%** increase needed in **SLS** in order to keep total output constant and efficient. This explains that **SLS** is the major input driver of efficiency in the **Chemicals and Petroleum Products** manufacturing sub-sector. The output variable with the lowest contribution to efficiency mix is **VA** with a summation of slacks being **129.03%**. This means that **129.03%** increase is needed in **VA** in order to keep output constant and efficient. This explains that **VA** is the major output barrier to efficiency in the **Chemicals and Petroleum Products** manufacturing sub-sector.

Overall analysis shows that **output variable SLS** is the major driver of efficiency in the **Chemicals and Petroleum Products** manufacturing sub-sector. Output variable **VA** is the major barrier to efficiency in the **Chemicals and Petroleum Products** manufacturing sub-sector.

7.4 Slacks analysis in the Clothing and Footwear

Input slacks show inputs as the source of inefficiency. A zero slack input shows that that particular input use mix is a driver of efficiency in the Clothing and Footwear manufacturing sub-sector. A non-zero slack input shows that that particular input use mix is a barrier to achieving efficiency in the Clothing and Footwear manufacturing sub-sector. Minimising these non-zero input slacks towards zero input slacks provides a model that is recommended for efficient input-output use.

Output slacks show outputs as the source of inefficiency. A zero slack output shows that that particular output mix is a driver of efficiency in the Clothing and Footwear manufacturing sub-sector. A non-zero slack output shows that that particular output mix is a barrier to achieving efficiency in the Clothing and Footwear manufacturing sub-sector. Minimising these non-zero output slacks towards zero output slacks provides a model that is recommended for efficient input-output use.

7.4.1 CRS Clothing and Footwear Slack Analysis

Slacks provide vital information pertaining to the areas which an inefficient DMU needs to improve in its drive towards attaining the status of an efficient one (Yang, Taudes and Dong 2017: 105). Slacks analysis provides important information to determine the drivers of

efficiency and to identify the barriers to efficiency in the Clothing and Footwear manufacturing sub-sector in Zimbabwe. In this study, slack analyses are executed under **CRS CCR Input-Orientation in Stage 1** assumptions in order to obtain the long-term improvement directions for the inefficient DMUs.

Tome (2001: 498) explains a slack-based measure as a scalar-based measure of determining the efficiency of a DMU in a non-parametric form by considering both the input and output shortfalls. The smaller the value of the input or output slack, the more the variable drives efficiency in the Clothing and Footwear manufacturing sub-sector. The greater the value of the input or output slack, the more the variable is a barrier to achieving efficiency in the Clothing and Footwear manufacturing sub-sector.

Table 7.5: CRS Clothing and Footwear Slack Analysis

	Inputs				**Outputs**		
DMU	{S} E{I}	{S} CM{I}	{S} WS{I}	{S} S{I}	{S} SLS{O}	{S} GVP{O}	{S} VA{O}
dmu:1	0	1.79	2.03	0.73	0.14	0	1.96
dmu:2	0	3.15	0.47	0.07	0.19	0	3.13
dmu:3	2.42	0	14.4	15.12	3.58	0	56.98
dmu:4	0	2.49	0.72	12.77	4.7	0	56.03
dmu:5	0.69	0	13.25	0.99	0	0.69	6.44
dmu:6	0	0.09	0.48	3.24	0	0.04	0.52
dmu:7	0.1	0	1.38	0.06	0	0.03	0.31
dmu:8	0.03	0	0.12	0.63	0.05	0	0.33
dmu:9	0	1.82	0.26	0.54	0.03	0	7.63
dmu:10	0.15	0	3.02	2.34	0.27	0	5.18

dmu:11	0	1.8	0.11	4.66	0.09	0	5.87
dmu:12	0.29	0	3.26	1.25	0	0	2.6
dmu:13	0	0.54	0.35	2.6	0.03	0	3.6
dmu:14	0.01	0	0.04	0.02	0	0	0.39
dmu:15	0.02	0	0.19	0.08	0	0.07	0.17
dmu:16	0.43	0.1	0.85	0	0.01	0	2.6
dmu:17							
dmu:18	0	0.03	0.07	0.36	0.09	0	0.73
dmu:19	0	2.38	1.39	1.61	0.01	0	17.53
dmu:20	0.02	0	0.2	0.03	0.04	0.04	0
dmu:21	0.01	0	0.06	0.02	0	0	0.04
Total	**4.17**	**14.19**	**42.65**	**47.12**	**9.23**	**0.87**	**172.04**

Source: Adapted from STATA output

The DMUs which have zero inputs and zero outputs are the efficient DMUs. The efficient DMU 17 has zero slacks on both inputs and outputs and therefore there is no need to carry out a DEA in Stage 2. The inefficient DMUs (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 18, 19, 20 and 21) have non-zero slacks on both inputs and outputs.

The input variable with the highest contribution to efficiency mix is **E,** with a summation of slacks being **4.17%.** This means that there is a **4.17%** reduction needed in **E** in order to keep total output constant and efficient. This explains that **E** is the major input driver of efficiency in the **Clothing and Footwear** manufacturing sub-sector. The input variable with the lowest contribution to efficiency mix is **S,** with a summation of slacks being **47.12%**. This means that a **47.12%** reduction is needed in **S** in order to keep output constant and efficient. This explains that W**S** is the major input barrier to efficiency in the **Clothing and Footwear** manufacturing sub-sector.

The output variable with the highest contribution to efficiency mix is **GVP,** with a summation of slacks being **0.87%.** This means that there is a **0.87%** increase needed in **GVP** in order to keep total output constant and efficient. This explains that **GVP** is the major input driver of efficiency in the **Clothing and Footwear** manufacturing sub-sector. The output variable with the lowest contribution to efficiency mix is **VA,** with a summation of slacks being **172.04%**. This means that a **172.04%** increase is needed in **VA** in order to keep output constant and efficient. This explains that **VA** is the major output barrier to efficiency in the **Clothing and Footwear** manufacturing sub-sector.

Overall analysis shows that **output variable GVP** is the major driver of efficiency in the **Clothing and Footwear** manufacturing sub-sector. Output variable **VA** is the major barrier to efficiency in the **Clothing and Footwear** manufacturing sub-sector.

7.4.2 VRS Clothing and Footwear Slack Analysis

Slacks provide vital information pertaining to the areas which an inefficient DMU needs to improve in its drive towards attaining the status of an efficient one (Yang, Taudes and Dong 2017: 105). Slacks analysis provides important information to determine the drivers of efficiency and to identify the barriers to efficiency in the Clothing and Footwear manufacturing sub-sector in Zimbabwe. In this study, slack analyses are executed under **VRS CCR Input-Orientation in Stage 1** assumptions in order to obtain the long-term improvement directions for the inefficient DMUs.

Tome (2001: 498) describes a slack-based measure as a scalar-based measure of determining the efficiency of a DMU in a non-parametric form by considering both the input and output shortfalls. The smaller the value of the input or output slack, the more the variable drives efficiency in the Clothing and Footwear manufacturing sub-sector. The greater the value of the input or output slack, the more the variable is a barrier to achieving efficiency in the Clothing and Footwear manufacturing sub-sector.

Table 7.6: VRS Clothing and Footwear Slack Analysis

	Inputs				Outputs		
DMU	{S} E{I}	{S} CM{I}	{S} WS{I}	{S} S{I}	{S} SLS{O}	{S} GVP{O}	{S} VA{O}
dmu:1	0	2	1.95	0.7	0.14	0	1.93
dmu:2	0.06	4.28	0.32	0	0.19	0	3.1
dmu:3							
dmu:4							
dmu:5	0.68	0	13.26	0.92	0	0.69	6.41
dmu:6	0	0.19	0.52	5.62	0	0.04	0.48
dmu:7	0.21	0.03	2.39	0	0	0.03	0.27
dmu:8	0.06	0	0	1.55	0.9	0.82	1.62
dmu:9	0	1.88	0.06	0.48	0.03	0	7.61
dmu:10	0.12	0	2.83	2.3	0.27	0	5.15
dmu:11	0	3.26	0	8.33	5.83	5.53	14.81
dmu:12	0.27	0	3.15	1.21	0	0	2.57
dmu:13	0	0.59	0.11	2.65	0.03	0	3.57
dmu:14	0.04	0	0	0.08	2.27	2.18	3.89
dmu:15	0	0	0	0.02	0.17	0.24	0.41
dmu:16	1.58	0.87	1.42	0	0.01	0	2.57
dmu:17							
dmu:18	0	0.16	0	1.54	1.79	1.64	3.36

dmu:19	0	2.44	1.23	1.57	0.01	0	17.51
dmu:20	0.07	0.01	0.46	0	0.06	0.06	0
dmu:21							
Total	**3.09**	**15.71**	**27.7**	**26.97**	**11.7**	**11.23**	**75.26**

Source: Adapted from STATA output

The efficient DMUs which have zero inputs and zero outputs slacks are the efficient DMUs. The efficient DMUs 3, 4, 17 and 21 have zero slacks on both inputs and outputs and therefore there is no need to carry out a DEA in Stage 2. The inefficient DMUs (1, 2, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 18, 19 and 20) have non-zero slacks on both inputs and outputs.

The input variable with the highest contribution to efficiency mix is **E** with a summation of slacks being **3.09%.** This means that there is a **3.09%** reduction needed in **E** in order to keep total output constant and efficient. This explains that **E** is the major input driver of efficiency in the **Clothing and Footwear** manufacturing sub-sector. The input variable with the lowest contribution to efficiency mix is **WS** with a summation of slacks being **27.7%**. This means that a **27.7%** reduction is needed in **WS** in order to keep output constant and efficient. This explains that WS is the major input barrier to efficiency in the **Clothing and Footwear** manufacturing sub-sector.

The output variable with the highest contribution to efficiency mix is **GVP** with a summation of slacks being **11.23%.** This means that there is a **11.23%** increase needed in **GVP** in order to keep total output constant and efficient. This explains that **GVP** is the major input driver of efficiency in the **Clothing and Footwear** manufacturing sub-sector. The output variable with the lowest contribution to efficiency mix is **VA** with a summation of slacks being **75.26%**. This means that a **75.26%** increase is needed in **VA** in order to keep output constant and efficient. This explains that **VA** is the major output barrier to efficiency in the **Clothing and Footwear** manufacturing sub-sector.

Overall analysis shows that **input variable E** is the major driver of efficiency in the **Clothing and Footwear** manufacturing sub-sector. Output variable **VA** is the major barrier to efficiency in the **Clothing and Footwear** manufacturing sub-sector.

7.5 Slacks analysis in the Foodstuffs

Input slacks show inputs as the source of inefficiency. A zero slack input shows that that particular input use mix is a driver of efficiency in the Foodstuffs manufacturing sub-sector. A non-zero slack input shows that that particular input use mix is a barrier to achieving efficiency in the Foodstuffs manufacturing sub-sector. Minimising these non-zero input slacks towards zero input slacks provides a model that is recommended for efficient input-output use.

Output slacks show outputs as the source of inefficiency. A zero slack output shows that that particular output mix is a driver of efficiency in the Foodstuffs manufacturing sub-sector. A non-zero slack output shows that that particular output mix is a barrier to achieving efficiency in the Foodstuffs sub-sector. Minimising these non-zero output slacks towards zero output slacks provides a model that is recommended for efficient input-output use.

7.5.1 CRS Foodstuffs Slack Analysis

Slacks provide vital information pertaining to the areas which an inefficient DMU needs to improve in its drive towards attaining the status of an efficient one (Yang, Taudes and Dong 2017: 105). Slacks analysis provides important information to determine the drivers of efficiency and to identify the barriers to efficiency in the Foodstuffs manufacturing sub-sector in Zimbabwe. In this study, slack analyses are executed under **CRS CCR Input-Orientation in Stage 1** assumptions in order to obtain the long-term improvement directions for the inefficient DMUs.

Tome (2001: 498) explains a slack-based measure as a scalar-based measure of determining the efficiency of a DMU in a non-parametric form by considering both the input and output shortfalls. The smaller the value of the input or output slack, the more the variable drives efficiency in the Foodstuffs manufacturing sub-sector. The greater the value of the input or output slack, the more the variable is a barrier to achieving efficiency in the Foodstuffs manufacturing sub-sector.

Table 7.7: CRS Foodstuffs Slack Analysis

	Inputs				**Outputs**		
DMU	{S} E{I}	{S} CM{I}	{S} WS{I}	{S} S{I}	{S} SLS{O}	{S} GVP{O}	{S} VA{O}
dmu:1	0	0	0	0	0	22.23	49.56
dmu:2							
dmu:3	0.37	0	0	19.17	0	14.39	80.36
dmu:4							
dmu:5	0	0	0	0	0	0	0.04
dmu:6	0	1.09	0	2.1	1.33	0	0
dmu:7	0	0	0	0	0	2.06	18.55
dmu:8	0	0	10.15	4.49	0	15.54	56.69
dmu:9	1.96	0	0	0	0	4.02	11.94
dmu:10	0	0	11.65	8.27	0	11.33	37.61
dmu:11							
dmu:12							
dmu:13	0.72	0	1.38	0	0	0	0.34
dmu:14	1.06	0	0	0	0.12	0	15.94

dmu:15	0	0	0.56	2.44	0	0.05	6.4
dmu:16	0	0	0	0.47	0.04	0	0.65
dmu:17							
dmu:18	0.04	0	0.43	0	1.25	0	0.61
dmu:19	0	0	4.06	4.04	0	0	3.45
dmu:20							
dmu:21							
Total	**4.15**	**1.09**	**28.23**	**40.98**	**2.74**	**69.62**	**282.14**

Source: Adapted from STATA output

The DMUs which have zero inputs and zero outputs slacks, are the efficient DMUs. The efficient DMUs (4, 11, 12, 17, 20 and 21) have zero slacks on both inputs and outputs and therefore there is no need to carry out a DEA in Stage 2. The inefficient DMUs (1, 2, 3, 5, 6, 7, 8, 9, 10, 13, 14, 15, 16, 18 and 19) have non-zero slacks on both inputs and outputs.

The input variable with the highest contribution to efficiency mix is **CM** with a summation of slacks being **1.09%.** This means that there is a **1.09%** reduction needed in **CM** in order to keep total output constant and efficient. This explains that **CM** is the major input driver of efficiency in the **Foodstuffs** manufacturing sub-sector. The input variable with the lowest contribution to efficiency mix is **S,** with a summation of slacks being **40.98%**. This means that a **40.98%** reduction is needed in **S** in order to keep output constant and efficient. This explains that **S** is the major input barrier to efficiency in the **Foodstuffs** manufacturing sub-sector.

The output variable with the highest contribution to efficiency mix is **SLS** with a summation of slacks being **2.74%.** This means that there is a **2.74%** increase needed in **SLS** in order to keep total output constant and efficient. This explains that **SLS** is the major input driver of efficiency in the **Foodstuffs** manufacturing sub-sector. The output variable with the lowest contribution to efficiency mix is **VA** with a summation of slacks being **282.14%**. This means that a **282.14%** increase is needed in **VA** in order to keep output constant and efficient. This explains that **VA** is the major output barrier to efficiency in the **Foodstuffs** manufacturing sub-sector.

Overall analysis shows that **input variable CM** is the major driver of efficiency in the **Foodstuffs** manufacturing sub-sector. Output variable **VA** is the major barrier to efficiency in the **Foodstuffs** manufacturing sub-sector.

7.5.2 VRS Foodstuffs Slack Analysis

Slacks provide vital information pertaining to the areas which an inefficient DMU needs to improve in its drive towards attaining the status of an efficient one (Yang, Taudes and Dong 2017: 105). Slacks analysis provides important information to determine the drivers of efficiency and to identify the barriers to efficiency in the Foodstuffs manufacturing sub-sector in Zimbabwe. In this study, slack analyses are executed under **VRS CCR Input-Orientation in Stage 1** assumptions in order to obtain the long-term improvement directions for the inefficient DMUs.

Tome (2001: 498) explains a slack-based measure as a scalar-based measure of determining the efficiency of a DMU in a non-parametric form by considering both the input and output shortfalls. The smaller the value of the input or output slack, the more the variable drives efficiency in the Foodstuffs manufacturing sub-sector. The greater the value of the input or output slack, the more the variable is a barrier to achieving efficiency in the Foodstuffs manufacturing sub-sector.

Table 7.8: VRS Foodstuffs Slack Analysis

	Inputs				**Outputs**		
DMU	{S} E{I}	{S} CM{I}	{S} WS{I}	{S} S{I}	{S} SLS{O}	{S} GVP{O}	{S} VA{O}
dmu:1							
dmu:2							
dmu:3							
dmu:4							
dmu:5							
dmu:6	0	1.11	0	2.12	1.33	0	0
dmu:7	0	0	0	0	0	0.86	13.88
dmu:8							
dmu:9	3.15	0.15	0	0	0	4.07	5.18
dmu:10							
dmu:11							
dmu:12							
dmu:13	0.89	0	1.32	0	0	0.04	0.49
dmu:14							
dmu:15	0	0	0.51	2.74	0	0	5.28
dmu:16	0	0	0.41	0.45	0.08	0	0.6
dmu:17							
dmu:18	0	0	1.52	0	1.35	0	0.46
dmu:19	0	0	4.15	4.04	0.01	0	3.44
dmu:20							

dmu:21							
Total	**4.04**	**1.26**	**7.91**	**9.35**	**2.77**	**4.97**	**29.33**

Source: Adapted from STATA output

The DMUs which have zero inputs and zero outputs slacks, are the efficient DMUs. The efficient DMUs 1, 2, 3, 4, 5, 8, 10, 11, 12, 14, 17, 20 and 21 have zero slacks on both inputs and outputs and therefore there is no need to carry out a DEA in Stage 2. The inefficient DMUs 6, 7, 9, 13, 15, 16, 18 and 19 have non-zero slacks on both inputs and outputs.

The input variable with the highest contribution to the efficiency mix is **CM** with a summation of slacks being **1.26%.** This means that there is a **1.26%** reduction needed in **CM** in order to keep total output constant and efficient. This explains that **CM** is the major input driver of efficiency in the **Foodstuffs** manufacturing sub-sector. The input variable with the lowest contribution to efficiency mix is **S** with a summation of slacks being **9.35%**. This means that a **9.35%** reduction is needed in **S** in order to keep output constant and efficient. This explains that W**S** is the major input barrier to efficiency in the **Foodstuffs** manufacturing sub-sector.

The output variable with the highest contribution to efficiency mix is **SLS** with a summation of slacks being **2.77%.** This means that there is a **2.77%** increase needed in **SLS** in order to keep total output constant and efficient. This explains that **SLS** is the major input driver of efficiency in the **Foodstuffs** manufacturing sub-sector. The output variable with the lowest contribution to efficiency mix is **VA** with a summation of slacks being **29.33%**. This means that a **29.33%** increase is needed in **VA** in order to keep output constant and efficient. This explains that **VA** is the major output barrier to efficiency in the **Foodstuffs** manufacturing sub-sector.

Overall analysis shows that **input variable CM** is the major driver of efficiency in the **Foodstuffs** manufacturing sub-sector. Output variable **VA** is the major barrier to efficiency in the **Foodstuffs** manufacturing sub-sector.

7.6 Slacks analysis in the Metals

Input slacks show inputs as the source of inefficiency. A zero slack input shows that that particular input use mix is a driver of efficiency in the Metals manufacturing sub-sector. A non-zero slack input shows that that particular input use mix is a barrier to achieving efficiency in the Metals manufacturing sub-sector. Minimising these non-zero input slacks towards zero input slacks provides a model that is recommended for efficient input-output use.

Output slacks show outputs as the source of inefficiency. A zero slack output shows that that particular output mix is a driver of efficiency in the Metals manufacturing sub-sector. A non-zero slack output shows that that particular output mix is a barrier to achieving efficiency in the Metals sub-sector. Minimising these non-zero output slacks towards zero output slacks provides a model that is recommended for efficient input-output use.

7.6.1 CRS Metals Slack Analysis

Slacks provide vital information pertaining to the areas which an inefficient DMU needs to improve in its drive towards attaining the status of an efficient one (Yang, Taudes and Dong 2017: 105). Slacks analysis provides important information to determine the drivers of efficiency and to identify the barriers to efficiency in the Metals manufacturing sub-sector in Zimbabwe. In this study, slack analyses are executed under **CRS CCR Input-Orientation in Stage 1** assumptions in order to obtain the long-term improvement directions for the inefficient DMUs.

Tome (2001: 498) explains a slack-based measure as a scalar-based measure of determining the efficiency of a DMU in a non-parametric form by considering both the input and output shortfalls. The smaller the value of the input or output slack, the more the variable drives efficiency in the Metals manufacturing sub-sector. The greater the value of the input or output slack, the more the variable is a barrier to achieving efficiency in the Metals manufacturing sub-sector.

Table 7.9: CRS Metals Slack Analysis

	Inputs				**Outputs**		
DMU	{S} E{I}	{S} CM{I}	{S} WS{I}	{S} S{I}	{S} SLS{O}	{S} GVP{O}	{S} VA{O}
dmu:1							
dmu:2	1.96	0	0	15.67	0	5.23	24.58
dmu:3							
dmu:4							
dmu:5							
dmu:6							
dmu:7	0	0	0.03	0	0	0.01	0.02
dmu:8	0.01	0	0	0.01	0.01	0	0.02
dmu:9	0.02	0	0	0	0	0.01	0.03
dmu:10	0	0	1.16	0	0	0.09	0.15
dmu:11	0	0	0	0.48	0	0.09	0.2
dmu:12	0	0	0	0.02	0	0.01	0.02
dmu:13	3.45	0	0.57	0	0	0.49	0.83
dmu:14	0	0	0	0	0	0.06	0.11
dmu:15	0.03	0	0.01	0	0	0.03	0.05
dmu:16	0	0	0.01	0.01	0	0.05	0.07
dmu:17							

dmu:18	0.83	0	0	0	0	0.16	0.33
dmu:19							
dmu:20	0.01	0	0.03	0	0	0	0.01
dmu:21							
Total	**6.31**	**0**	**1.81**	**16.19**	**0.01**	**6.23**	**26.42**

Source: Adapted from STATA output

The DMUs which have zero inputs and zero outputs slacks, are the efficient DMUs. The efficient DMUs (1, 3, 4, 5, 6, 17, 19 and 21) have zero slacks on both inputs and outputs and therefore there is no need to carry out a DEA in Stage 2. The inefficient DMUs (2, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 18 and 20) have non-zero slacks on both inputs and outputs.

The input variable with the highest contribution to efficiency mix is **CM** with a summation of slacks being **0%.** This means that there is a **0%** reduction needed in **CM** in order to keep total output constant and efficient. This explains that **CM** is the major input driver of efficiency in the **Metals** manufacturing sub-sector. The input variable with the lowest contribution to efficiency mix is **S** with a summation of slacks being **16.19%**. This means that a **16.19%** reduction is needed in **S** in order to keep output constant and efficient. This explains that **S** is the major input barrier to efficiency in the **Metals** manufacturing sub-sector.

The output variable with the highest contribution to efficiency mix is **SLS** with a summation of slacks being **0.01%.** This means that there is a **0.01%** increase needed in **SLS** in order to keep total output constant and efficient. This explains that **SLS** is the major input driver of efficiency in the **Metals** manufacturing sub-sector. The output variable with the lowest contribution to efficiency mix is **VA** with a summation of slacks being **26.42%**. This means that a **26.42%** increase is needed in **VA** in order to keep output constant and efficient. This explains that **VA** is the major output barrier to efficiency in the **Metals** manufacturing sub-sector.

Overall analysis shows that **input variable CM** is the major driver of efficiency in the **Metals** manufacturing sub-sector. Output variable **VA** is the major barrier to efficiency in the **Metals** manufacturing sub-sector.

7.6.2 VRS Metals Slack Analysis

Slacks provide vital information pertaining to the areas which an inefficient DMU needs to improve in its drive towards attaining the status of an efficient one (Yang, Taudes and Dong 2017: 105). Slacks analysis provides important information to determine the drivers of efficiency and to identify the barriers to efficiency in the Metals manufacturing sub-sector in Zimbabwe. In this study, slack analyses are executed under **VRS CCR Input-Orientation in Stage 1** assumptions in order to obtain the long-term improvement directions for the inefficient DMUs.

Tome (2001: 498) explains a slack-based measure as a scalar-based measure of determining the efficiency of a DMU in a non-parametric form by considering both the input and output shortfalls. The smaller the value of the input or output slack, the more the variable drives efficiency in the Metals manufacturing sub-sector. The greater the value of the input or output slack, the more the variable is a barrier to achieving efficiency in the Metals manufacturing sub-sector.

Table 7.10: VRS Metals Slack Analysis

	Inputs				**Outputs**		
DMU	{S} E{I}	{S} CM{I}	{S} WS{I}	{S} S{I}	{S} SLS{O}	{S} GVP{O}	{S} VA{O}
dmu:1							
dmu:2	2.2	0	0	16.27	0	5.63	25.22

dmu:3							
dmu:4							
dmu:5							
dmu:6							
dmu:7							
dmu:8	0.03	0	0	0	0.02	0	0.01
dmu:9							
dmu:10	0	0	1.32	0	0	0.07	0.12
dmu:11	0	0	0	0.49	0	0.09	0.2
dmu:12							
dmu:13	3.56	0	0.53	0	0	0.48	0.81
dmu:14	0.02	0	0	0	0	0.06	0.11
dmu:15	0.07	0	0	0	0	0.02	0.03
dmu:16							
dmu:17							
dmu:18	0.83	0	0	0	0	0.16	0.33
dmu:19							
dmu:20							
dmu:21							
Total	**6.71**	**0**	**1.85**	**16.76**	**0.02**	**6.51**	**26.83**

Source: Adapted from STATA output

The DMUs which have zero inputs and zero outputs slacks, are the efficient DMUs. The efficient DMUs (1, 3, 4, 5, 6, 7, 9, 12, 17, 19, 20 and 21) have zero slacks on both inputs and outputs and therefore there is no need to carry out a DEA in Stage 2. The inefficient DMUs (2, 8, 10, 11, 13, 14, 15, 16 and 18) have non-zero slacks on both inputs and outputs.

The input variable with the highest contribution to efficiency mix is **CM** with a summation of slacks being **0%.** This means that there is a **0%** reduction needed in **CM** in order to keep total output constant and efficient. This explains that **CM** is the major input driver of efficiency in the **Metals** manufacturing sub-sector. The input variable with the lowest contribution to efficiency mix is **S** with a summation of slacks being **16.75%**. This means that a **16.75%** reduction is needed in **S** in order to keep output constant and efficient. This explains that **S** is the major input barrier to efficiency in the **Metals** manufacturing sub-sector.

The output variable with the highest contribution to efficiency mix is **SLS** with a summation of slacks being **0.02%.** This means that there is a **0.01%** increase needed in **SLS** in order to keep total output constant and efficient. This explains that **SLS** is the major input driver of efficiency in the **Metals** manufacturing sub-sector. The output variable with the lowest contribution to efficiency mix is **VA** with a summation of slacks being **26.83%**. This means that a **26.83%** increase is needed in **VA** in order to keep output constant and efficient. This explains that **VA** is the major output barrier to efficiency in the **Metals** manufacturing sub-sector.

Overall analysis shows that **input variable CM** is the major driver of efficiency in the **Metals** manufacturing sub-sector. Output variable **VA** is the major barrier to efficiency in the **Metals** manufacturing sub-sector.

7.7 Slacks analysis in the Non-Metallic Minerals

Input slacks show inputs as the source of inefficiency. A zero slack input shows that that particular input use mix is a driver of efficiency in the Non-Metallic Minerals manufacturing sub-sector. A non-zero slack input shows that that particular input use mix is a barrier to achieving efficiency in the Non-Metallic Minerals manufacturing sub-sector. Minimising these non-zero input slacks towards zero input slacks provides a model that is recommended for efficient input-output use.

Output slacks show outputs as the source of inefficiency. A zero slack output shows that that particular output mix is a driver of efficiency in the Non-Metallic Minerals manufacturing sub-sector. A non-zero slack output shows that that particular output mix is a barrier to achieving efficiency in the Non-Metallic Minerals sub-sector. Minimising these non-zero output slacks towards zero output slacks provides a model that is recommended for efficient input-output use.

7.7.1 CRS Non-Metallic Minerals Slack Analysis

Slacks provide vital information pertaining to the areas which an inefficient DMU needs to improve in its drive towards attaining the status of an efficient one (Yang, Taudes and Dong 2017: 105). Slacks analysis provides important information to determine the drivers of efficiency and to identify the barriers to efficiency in the Non-Metallic Minerals manufacturing sub-sector in Zimbabwe. In this study, slack analyses are executed under **CRS CCR Input-Orientation in Stage 1** assumptions in order to obtain the long-term improvement directions for the inefficient DMUs.

Tome (2001: 498) explains a slack-based measure as a scalar-based measure of determining the efficiency of a DMU in a non-parametric form by considering both the input and output shortfalls. The smaller the value of the input or output slack, the more the variable drives efficiency in the Non-Metallic Minerals manufacturing sub-sector. The greater the value of the input or output slack, the more the variable is a barrier to achieving efficiency in the Non-Metallic Minerals manufacturing sub-sector.

Table 7.11: CRS Non-Metallic Minerals Slack Analysis

	Inputs				**Outputs**		
DMU	{S} E{I}	{S} CM{I}	{S} WS{I}	{S} S{I}	{S} SLS{O}	{S} GVP{O}	{S} VA{O}
dmu:1							
dmu:2	0.64	0	9.46	6.7	0	0.05	8.36
dmu:3	1.84	0	0	1.34	0.01	0.01	0
dmu:4	0.14	0.89	0	0	0.37	0	2.98
dmu:5	0	0	0	0.1	0.04	0	0.3
dmu:6	1.24	0	0	0	0	0.28	3.58
dmu:7							
dmu:8	4.1	0	0	0	2.09	0	7.63
dmu:9							
dmu:10	0	0	3.07	0	0	0.01	2.36
dmu:11							
dmu:12	0	0	0	1.13	0	0	0.82
dmu:13							
dmu:14	0	0	3.78	0	0.08	0.23	0
dmu:15	0	0	0	25.32	0	10.71	22.22
dmu:16	20.81	0	0	1.49	0	1.66	7.26
dmu:17							
dmu:18	1.63	0	0	0	0	0.24	1.19
dmu:19	0.78	0	4.67	0	0	0.14	0.66
dmu:20	2.15	0.18	0	0	0	0.14	0.57

dmu:21	3.99	0	0.6	0.9	0	0.87	0.6
Total	**37.32**	**1.07**	**21.58**	**36.98**	**2.59**	**14.34**	**58.53**

Source: Adapted from STATA output

The DMUs which have zero inputs and zero outputs slacks, are the efficient DMUs. The efficient DMUs (1, 7, 9, 11, 13 and 17) have zero slacks on both inputs and outputs and therefore there is no need to carry out a DEA in Stage 2. The inefficient DMUs (2, 3, 4, 5, 6, 8, 10, 12, 14, 15, 16, 18, 19, 20 and 21) have non-zero slacks on both inputs and outputs

The input variable with the highest contribution to efficiency mix is **CM** with a summation of slacks being **1.07%.** This means that there is a **1.07%** reduction needed in **CM** in order to keep total output constant and efficient. This explains that **CM** is the major input driver of efficiency in the **Non-Metallic Minerals** manufacturing sub-sector. The input variable with the lowest contribution to efficiency mix is **E** with a summation of slacks being **37.32%**. This means that a **37.32%** reduction is needed in **E** in order to keep output constant and efficient. This explains that **S** is the major input barrier to efficiency in the **Non-Metallic Minerals** manufacturing sub-sector.

The output variable with the highest contribution to efficiency mix is **SLS** with a summation of slacks being **2.59%.** This means that there is a **2.59%** increase needed in **SLS** in order to keep total output constant and efficient. This explains that **SLS** is the major input driver of efficiency in the **Non-Metallic Minerals** manufacturing sub-sector. The output variable with the lowest contribution to efficiency mix is **VA** with a summation of slacks being **58.53%**. This means that a **58.53%** increase is needed in **VA** in order to keep output constant and efficient. This explains that **VA** is the major output barrier to efficiency in the **Non-Metallic Minerals** manufacturing sub-sector.

Overall analysis shows that **input variable CM** is the major driver of efficiency in the **Non-Metallic Minerals** manufacturing sub-sector. Output variable **VA** is the major barrier to efficiency in the **Non-Metallic Minerals** manufacturing sub-sector.

7.7.2 VRS Non-Metallic Minerals Slack Analysis

Slacks provide vital information pertaining to the areas which an inefficient DMU needs to improve in its drive towards attaining the status of an efficient one (Yang, Taudes and Dong 2017: 105). Slacks analysis provides important information to determine the drivers of efficiency and to identify the barriers to efficiency in the Non-Metallic Minerals manufacturing sub-sector in Zimbabwe. In this study, slack analyses are executed under **VRS CCR Input-Orientation in Stage 1** assumptions in order to obtain the long-term improvement directions for the inefficient DMUs.

Tome (2001: 498) explains a slack-based measure as a scalar-based measure of determining the efficiency of a DMU in a non-parametric form by considering both the input and output shortfalls. The smaller the value of the input or output slack, the more the variable drives efficiency in the Non-Metallic Minerals manufacturing sub-sector. The greater the value of the input or output slack, the more the variable is a barrier to achieving efficiency in the Non-Metallic Minerals manufacturing sub-sector.

Table 7.12: VRS Non-Metallic Minerals Slack Analysis

	Inputs				**Outputs**		
DMU	{S} E{I}	{S} CM{I}	{S} WS{I}	{S} S{I}	{S} SLS{O}	{S} GVP{O}	{S} VA{O}
dmu:1							
dmu:2	0	0	47.51	24.14	0.03	0	6.98
dmu:3							
dmu:4	0	1.1	0.47	0	0.51	0	3.01
dmu:5							

dmu:6	0.88	0	0	0	0	0.2	3.53
dmu:7							
dmu:8							
dmu:9							
dmu:10	0	0	3.71	0.12	0	0	2.3
dmu:11							
dmu:12	0	0	0	0.74	0.05	0	0.73
dmu:13							
dmu:14	0	0	3.81	0	0.08	0.23	0
dmu:15							
dmu:16	37.11	0	11.03	2.56	0	0.71	2.66
dmu:17							
dmu:18	1.67	0	0	0	0	0.24	1.17
dmu:19	1.05	0	4.86	0	0	0.15	0.68
dmu:20							
dmu:21							
Total	**40.71**	**1.1**	**71.39**	**27.56**	**0.67**	**1.53**	**21.06**

Source: Adapted from STATA output

The DMUs which have zero inputs and zero outputs slacks, are the efficient DMUs. The efficient DMUs (1, 5, 7, 8, 9, 11, 13, 15, 17, 20 and 21) have zero slacks on both inputs and outputs and therefore there is no need to carry out a DEA in Stage 2. The inefficient DMUs (2, 3, 4, 6, 10, 12, 14, 16, 18 and 19) have non-zero slacks on both inputs and outputs.

The input variable with the highest contribution to efficiency mix is **CM** with a summation of slacks being **1.1%.** This means that there is a **1.1%** reduction needed in **CM** in order to keep total output constant and efficient. This explains that **CM** is the major input driver of efficiency in the **Non-Metallic Minerals** manufacturing sub-sector. The input variable with the lowest contribution to efficiency mix is **WS** with a summation of slacks being **71.39%**. This means that a **71.39%** reduction is needed in **E** in order to keep output constant and efficient. This explains that **S** is the major input barrier to efficiency in the **Non-Metallic Minerals** manufacturing sub-sector.

The output variable with the highest contribution to efficiency mix is **SLS** with a summation of slacks being **0.67%.** This means that there is a **0.67%** increase needed in **SLS** in order to keep total output constant and efficient. This explains that **SLS** is the major input driver of efficiency in the **Non-Metallic Minerals** manufacturing sub-sector. The output variable with the lowest contribution to efficiency mix is **VA** with a summation of slacks being **21.06%**. This means that a **21.06%** increase is needed in **VA** in order to keep output constant and efficient. This explains that **VA** is the major output barrier to efficiency in the **Non-Metallic Minerals** manufacturing sub-sector.

Overall analysis shows that **output variable SLS** is the major driver of efficiency in the **Non-Metallic Minerals** manufacturing sub-sector. Input variable **WS** is the major barrier to efficiency in the **Non-Metallic Minerals** manufacturing sub-sector.

7.8 Slacks analysis in the Paper Printing and Publishing

Input slacks show inputs as the source of inefficiency. A zero slack input shows that that particular input use mix is a driver of efficiency in the Paper Printing and Publishing manufacturing sub-sector. A non-zero slack input shows that that particular input use mix is a barrier to achieving efficiency in the Paper Printing and Publishing manufacturing sub-sector. Minimising these non-zero input slacks towards zero input slacks provides a model that is recommended for efficient input-output use.

Output slacks show outputs as the source of inefficiency. A zero slack output shows that that particular output mix is a driver of efficiency in the Paper Printing and Publishing manufacturing sub-sector. A non-zero slack output shows that that particular output mix is a barrier to achieving efficiency in the Paper Printing and Publishing sub-sector. Minimising these non-zero output slacks towards zero output slacks provides a model that is recommended for efficient input-output use.

7.8.1 CRS Paper Printing and Publishing Slack Analysis

Slacks provide vital information pertaining to the areas which an inefficient DMU needs to improve in its drive towards attaining the status of an efficient one (Yang, Taudes and Dong 2017: 105). Slacks analysis provides important information to determine the drivers of efficiency and to identify the barriers to efficiency in the Paper Printing and Publishing manufacturing sub-sector in Zimbabwe. In this study, slack analyses are executed under **CRS CCR Input-Orientation in Stage 1** assumptions in order to obtain the long-term improvement directions for the inefficient DMUs.

Tome (2001: 498) describes a slack-based measure as a scalar-based measure of determining the efficiency of a DMU in a non-parametric form by considering both the input and output shortfalls. The smaller the value of the input or output slack, the more the variable drives efficiency in the Paper Printing and Publishing manufacturing sub-sector. The greater the value of the input or output slack, the more the variable is a barrier to achieving efficiency in the Paper Printing and Publishing manufacturing sub-sector.

Table 7.13: CRS Paper Printing and Publishing Slack Analysis

	Inputs				**Outputs**		
DMU	{S} E{I}	{S} CM{I}	{S} WS{I}	{S} S{I}	{S} SLS{O}	{S} GVP{O}	{S} VA{O}
dmu:1	0	0	0.43	0	0.06	0	0.16

dmu:2							
dmu:3	0	0	0.45	0	0.08	0	0.05
dmu:4	0	0.64	1.2	0	0.16	0.2	0
dmu:5							
dmu:6							
dmu:7	0	0	0.02	0.04	0	0	0
dmu:8							
dmu:9							
dmu:10							
dmu:11							
dmu:12							
dmu:13							
dmu:14	1.39	0	0	0	0.22	0	0.58
dmu:15							
dmu:16	0	0	0.24	0	0	0	0.02
dmu:17	2.61	0	0	0	0.01	0	5.07
dmu:18							
dmu:19							
dmu:20	0	0	0.75	0	0	0.01	0.11
dmu:21	0	0	0.55	0	0	0	0.21
Total	**4**	**0.64**	**3.64**	**0.04**	**0.53**	**0.21**	**6.2**

Source: Adapted from STATA output

The DMUs which have zero inputs and zero outputs slacks are the efficient DMUs. The efficient DMUs (2, 5, 6, 8, 9, 10, 11, 12, 13, 15, 18 and 19) have zero slacks on both inputs and outputs and therefore there is no need to carry out a DEA in Stage 2. The inefficient DMUs (1, 3, 4, 7, 14, 16, 17, 20 and 21) have non-zero slacks on both inputs and outputs.

The input variable with the highest contribution to efficiency mix is **S** with a summation of slacks being **0.04%.** This means that there is a **0.04%** reduction needed in **S** in order to keep total output constant and efficient. This explains that **S** is the major input driver of efficiency in the **Paper Printing and Publishing** manufacturing sub-sector. The input variable with the lowest contribution to efficiency mix is **E** with a summation of slacks being **4%**. This means that a **4%** reduction is needed in **E** in order to keep output constant and efficient. This explains that **E** is the major input barrier to efficiency in the **Paper Printing and Publishing** manufacturing sub-sector.

The output variable with the highest contribution to efficiency mix is **GVP** with a summation of slacks being **0.21%.** This means that there is a **0.21%** increase needed in **GVP** in order to keep total output constant and efficient. This explains that **GVP** is the major input driver of efficiency in the **Paper Printing and Publishing** manufacturing sub-sector. The output variable with the lowest contribution to efficiency mix is **VA** with a summation of slacks being **6.2%**. This means that a **6.2%** increase is needed in **VA** in order to keep output constant and efficient. This explains that **VA** is the major output barrier to efficiency in the **Paper Printing and Publishing** manufacturing sub-sector.

Overall analysis shows that **input variable S** is the major driver of efficiency in the **Paper Printing and Publishing** manufacturing sub-sector. Output variable **VA** is the major barrier to efficiency in the **Paper Printing and Publishing** manufacturing sub-sector.

7.8.2 VRS Paper Printing and Publishing Slack Analysis

Slacks provide vital information pertaining to the areas which an inefficient DMU needs to improve in its drive towards attaining the status of an efficient one (Yang, Taudes and Dong 2017: 105). Slacks analysis provides important information to determine the drivers of

efficiency and to identify the barriers to efficiency in the Paper Printing and Publishing manufacturing sub-sector in Zimbabwe. In this study, slack analyses are executed under **VRS CCR Input-Orientation in Stage 1** assumptions in order to obtain the long-term improvement directions for the inefficient DMUs.

Tome (2001: 498) explains a slack-based measure as a scalar-based measure of determining the efficiency of a DMU in a non-parametric form by considering both the input and output shortfalls. The smaller the value of the input or output slack, the more the variable drives efficiency in the Paper Printing and Publishing manufacturing sub-sector. The greater the value of the input or output slack, the more the variable is a barrier to achieving efficiency in the Paper Printing and Publishing manufacturing sub-sector.

Table 7.14: VRS Paper Printing and Publishing Slack Analysis

	Inputs				**Outputs**		
DMU	{S} E{I}	{S} CM{I}	{S} WS{I}	{S} S{I}	{S} SLS{O}	{S} GVP{O}	{S} VA{O}
dmu:1							
dmu:2							
dmu:3	0	0	0	0	0.08	0	0.02
dmu:4	0	0.72	1.11	0	0.18	0.22	0
dmu:5							
dmu:6							
dmu:7							
dmu:8							
dmu:9							
dmu:10							

dmu:11							
dmu:12							
dmu:13							
dmu:14	1.41	0	0	0	0.22	0	0.61
dmu:15							
dmu:16							
dmu:17	2.27	0	0	0	0.01	0	5.49
dmu:18							
dmu:19							
dmu:20	0	0	0	0	0	0.01	0.07
dmu:21	0	0	0.37	0	0	0	0.21
Total	**3.68**	**0.72**	**1.48**	**0**	**0.49**	**0.23**	**6.4**

Source: Adapted from STATA output

The DMUs which have zero inputs and zero outputs slacks are the efficient DMUs. The efficient DMUs (1, 2, 5, 6, 7, 8, 9, 10, 11, 12, 13, 15, 16, 18 and 19) have zero slacks on both inputs and outputs and therefore there is no need to carry out a DEA in Stage 2. The inefficient DMUs (3, 4, 14, 17, 20 and 21) have non-zero slacks on both inputs and outputs.

The input variable with the highest contribution to efficiency mix is **S** with a summation of slacks being **0%.** This means that there is a **0%** reduction needed in **S** in order to keep total output constant and efficient. This explains that **S** is the major input driver of efficiency in the **Paper Printing and Publishing** manufacturing sub-sector. The input variable with the lowest contribution to efficiency mix is **E** with a summation of slacks being **3.68%**. This means that a **3.68%** reduction is needed in **E** in order to keep output constant and efficient. This explains that **E** is the major input barrier to efficiency in the **Paper Printing and Publishing** manufacturing sub-sector.

The output variable with the highest contribution to efficiency mix is **GVP** with a summation of slacks being **0.23%.** This means that there is a **0.23%** increase needed in **GVP** in order to keep total output constant and efficient. This explains that **GVP** is the major input driver of efficiency in the **Paper Printing and Publishing** manufacturing sub-sector. The output variable with the lowest contribution to efficiency mix is **VA** with a summation of slacks being **6.4%**. This means that a **6.4%** increase is needed in **VA** in order to keep output constant and efficient. This explains that **VA** is the major output barrier to efficiency in the **Paper Printing and Publishing** manufacturing sub-sector.

Overall analysis shows that **input variable S** is the major driver of efficiency in the **Paper Printing and Publishing** manufacturing sub-sector. Output variable **VA** is the major barrier to efficiency in the **Paper Printing and Publishing** manufacturing sub-sector.

7.9 Slacks analysis in the Textiles

Input slacks show inputs as the source of inefficiency. A zero slack input shows that that particular input use mix is a driver of efficiency in the Textiles manufacturing sub-sector. A non-zero slack input shows that that particular input use mix is a barrier to achieving efficiency in the Textiles manufacturing sub-sector. Minimising these non-zero input slacks towards zero input slacks provides a model that is recommended for efficient input-output use.

Output slacks show outputs as the source of inefficiency. A zero slack output shows that that particular output mix is a driver of efficiency in the Textiles manufacturing sub-sector. A non-zero slack output shows that that particular output mix is a barrier to achieving efficiency in the Textiles sub-sector. Minimising these non-zero output slacks towards zero output slacks provides a model that is recommended for efficient input-output use.

7.9.1 CRS Textiles Slack Analysis

Slacks provide vital information pertaining to the areas which an inefficient DMU needs to improve in its drive towards attaining the status of an efficient one (Yang, Taudes and Dong 2017: 105). Slacks analysis provides important information to determine the drivers of efficiency and to identify the barriers to efficiency in the Textiles manufacturing sub-sector in Zimbabwe. In this study, slack analyses are executed under **CRS CCR Input-Orientation in Stage 1** assumptions in order to obtain the long-term improvement directions for the inefficient DMUs.

Tome (2001: 498) describes a slack-based measure as a scalar-based measure of determining the efficiency of a DMU in a non-parametric form by considering both the input and output shortfalls. The smaller the value of the input or output slack, the more the variable drives efficiency in the Textiles manufacturing sub-sector. The greater the value of the input or output slack, the more the variable is a barrier to achieving efficiency in the Textiles manufacturing sub-sector.

Table 7.15: CRS Textiles Slack Analysis

	Inputs				**Outputs**		
DMU	{S} E{I}	{S} CM{I}	{S} WS{I}	{S} S{I}	{S} SLS{O}	{S} GVP{O}	{S} VA{O}
dmu:1	0	0.59	1.88	12.28	13.68	0	18.5
dmu:2							
dmu:3	0	0.63	12.25	0.99	0	9.92	1.84
dmu:4	0	0.3	3.98	2.39	1.5	0	5.07
dmu:5	0.21	0	9.66	8.87	2.68	0	48.22
dmu:6	0	3.19	0.05	1.43	0	0.24	9.17

dmu:7	4.18	0	2.46	0.75	3.2	0	5.51
dmu:8	0.03	0	0.12	0.63	0.05	0	0.33
dmu:9	0	1.82	0.26	0.54	0.03	0	7.63
dmu:10	0.15	0	3.02	2.34	0.27	0	5.18
dmu:11	0	1.8	0.11	4.66	0.09	0	5.87
dmu:12	0.29	0	3.26	1.25	0	0	2.6
dmu:13	0	0.54	0.35	2.6	0.03	0	3.6
dmu:14	0.01	0	0.04	0.02	0	0	0.39
dmu:15	0.02	0	0.19	0.08	0	0.07	0.17
dmu:16	0.43	0.1	0.85	0	0.01	0	2.6
dmu:17							
dmu:18	0	0.03	0.07	0.36	0.09	0	0.73
dmu:19	0	2.38	1.39	1.61	0.01	0	17.53
dmu:20	0.02	0	0.2	0.03	0.04	0.04	0
dmu:21	0.01	0	0.06	0.02	0	0	0.04
Total	**5.35**	**11.38**	**40.2**	**40.85**	**21.68**	**10.27**	**134.98**

Source: Adapted from STATA output

The efficient DMUs which have zero inputs and zero outputs are the efficient DMUs. The efficient DMUs 2 and 17 have zero slacks on both inputs and outputs and therefore there is no need to carry out a DEA in Stage 2. The inefficient DMUs (1, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 18, 19, 20 and 21) have non-zero slacks on both inputs and outputs.

The input variable with the highest contribution to efficiency mix is **E** with a summation of slacks being **5.35%.** This means that there is a **5.35%** reduction needed in **E** in order to keep total output constant and efficient. This explains that **E** is the major input driver of efficiency in the **Textiles** manufacturing sub-sector. The input variable with the lowest contribution to efficiency mix is **S** with a summation of slacks being **40.85%**. This means that a **40.85%** reduction is needed in **S** in order to keep output constant and efficient. This explains that **S** is the major input barrier to efficiency in the **Textiles** manufacturing sub-sector.

The output variable with the highest contribution to efficiency mix is **GVP** with a summation of slacks being **10.27%.** This means that there is a **10.27%** increase needed in **GVP** in order to keep total output constant and efficient. This explains that **GVP** is the major input driver of efficiency in the **Textiles** manufacturing sub-sector. The output variable with the lowest contribution to efficiency mix is **VA** with a summation of slacks being **134.98%**. This means that a **134.98%** increase is needed in **VA** in order to keep output constant and efficient. This explains that **VA** is the major output barrier to efficiency in the **Textiles** manufacturing sub-sector.

Overall analysis shows that **input variable E** is the major driver of efficiency in the **Textiles** manufacturing sub-sector. Output variable **VA** is the major barrier to efficiency in the **Textiles** manufacturing sub-sector.

7.9.2 VRS Textiles Slack Analysis

Slacks provide vital information pertaining to the areas which an inefficient DMU needs to improve in its drive towards attaining the status of an efficient one (Yang, Taudes and Dong 2017: 105). Slacks analysis provides important information to determine the drivers of efficiency and to identify the barriers to efficiency in the Textiles manufacturing sub-sector in Zimbabwe. In this study, slack analyses are executed under **VRS CCR Input-Orientation in Stage 1** assumptions in order to obtain the long-term improvement directions for the inefficient DMUs.

Tome (2001: 498) describes a slack-based measure as a scalar-based measure of determining the efficiency of a DMU in a non-parametric form by considering both the input and output shortfalls. The smaller the value of the input or output slack, the more the variable drives efficiency in the Textiles manufacturing sub-sector. The greater the value of the input or output slack, the more the variable is a barrier to achieving efficiency in the Textiles manufacturing sub-sector.

Table 7.16: VRS Textiles Slack Analysis

	Inputs				**Outputs**		
DMU	{S} E{I}	{S} CM{I}	{S} WS{I}	{S} S{I}	{S} SLS{O}	{S} GVP{O}	{S} VA{O}
dmu:1	0	0.71	0.29	17.17	14.02	0	18.96
dmu:2							
dmu:3							
dmu:4	0	0.3	3.94	2.38	1.5	0	5.06
dmu:5	5.29	0	1.32	56.94	12.07	0	61.19
dmu:6	0	6.46	0	2.87	10.77	10.61	25.96
dmu:7	4.24	0	2.26	0.67	3.2	0	5.48
dmu:8	0.06	0	0	1.55	0.9	0.82	1.62
dmu:9	0	1.88	0.06	0.48	0.03	0	7.61
dmu:10	0.12	0	2.83	2.3	0.27	0	5.15
dmu:11	0	3.26	0	8.33	5.83	5.53	14.81
dmu:12	0.27	0	3.15	1.21	0	0	2.57
dmu:13	0	0.59	0.11	2.65	0.03	0	3.57
dmu:14	0.04	0	0	0.08	2.27	2.18	3.89
dmu:15	0	0	0	0.02	0.17	0.24	0.41
dmu:16	1.58	0.87	1.42	0	0.01	0	2.57
dmu:17							

dmu:18	0	0.16	0	1.54	1.79	1.64	3.36
dmu:19	0	2.44	1.23	1.57	0.01	0	17.51
dmu:20	0.07	0.01	0.46	0	0.06	0.06	0
dmu:21							
Total	**11.67**	**16.68**	**17.07**	**99.76**	**52.93**	**21.08**	**179.72**

Source: Adapted from STATA output

The DMUs which have zero inputs and zero outputs slacks are the efficient DMUs. The efficient DMUs (2, 3, 6, 17 and 21) have zero slacks on both inputs and outputs and therefore there is no need to carry out a DEA in Stage 2. The inefficient DMUs (1, 4, 5, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 18, 19 and 20) have non-zero slacks on both inputs and outputs.

The input variable with the highest contribution to efficiency mix is **E** with a summation of slacks being **11.67%.** This means that there is a **11.67%** reduction needed in **E** in order to keep total output constant and efficient. This explains that **E** is the major input driver of efficiency in the **Textiles** manufacturing sub-sector. The input variable with the lowest contribution to efficiency mix is **S** with a summation of slacks being **99.76%**. This means that a **99.76%** reduction is needed in **S** in order to keep output constant and efficient. This explains that **S** is the major input barrier to efficiency in the **Textiles** manufacturing sub-sector.

The output variable with the highest contribution to efficiency mix is **GVP** with a summation of slacks being **21.08%.** This means that there is a **21.08%** increase needed in **GVP** in order to keep total output constant and efficient. This explains that **GVP** is the major input driver of efficiency in the **Textiles** manufacturing sub-sector. The output variable with the lowest contribution to efficiency mix is **VA** with a summation of slacks being **179.72%**. This means that a **179.72%** increase is needed in **VA** in order to keep output constant and efficient. This explains that **VA** is the major output barrier to efficiency in the **Textiles** manufacturing sub-sector.

Overall analysis shows that **input variable E** is the major driver of efficiency in the **Textiles** manufacturing sub-sector. Output variable **VA** is the major barrier to efficiency in the **Textiles** manufacturing sub-sector.

7.10 Slacks in the Transport and Transport Equipment

Input slacks show inputs as the source of inefficiency. A zero slack input shows that that particular input use mix is a driver of efficiency in the Transport and Transport Equipment manufacturing sub-sector. A non-zero slack input shows that that particular input use mix is a barrier to achieving efficiency in the Transport and Transport Equipment manufacturing sub-sector. Minimising these non-zero input slacks towards zero input slacks provides a model that is recommended for efficient input-output use.

Output slacks show outputs as the source of inefficiency. A zero slack output shows that that particular output mix is a driver of efficiency in the Transport and Transport Equipment manufacturing sub-sector. A non-zero slack output shows that that particular output mix is a barrier to achieving efficiency in the Transport and Transport Equipment manufacturing sub-sector. Minimising these non-zero output slacks towards zero output slacks provides a model that is recommended for efficient input-output use.

7.10.1 CRS Transport and Transport Equipment Slack Analysis

Slacks provide vital information pertaining to the areas which an inefficient DMU needs to improve in its drive towards attaining the status of an efficient one (Yang, Taudes and Dong 2017: 105). Slacks analysis provides important information to determine the drivers of efficiency and to identify the barriers to efficiency in the Transport and Transport Equipment manufacturing sub-sector in Zimbabwe. In this study, slack analyses are executed under **CRS CCR Input-Orientation in Stage 1** assumptions in order to obtain the long-term improvement directions for the inefficient DMUs.

Tome (2001: 498) describes a slack-based measure as a scalar-based measure of determining the efficiency of a DMU in a non-parametric form by considering both the input and output shortfalls. The smaller the value of the input or output slack, the more the variable drives efficiency in the Transport and Transport Equipment manufacturing sub-sector. The greater the value of the input or output slack, the more the variable is a barrier to achieving efficiency in the Transport and Transport Equipment manufacturing sub-sector.

Table 7.17: CRS Transport and Transport Equipment Slack Analysis

	Inputs				**Outputs**		
DMU	{S} E{I}	{S} CM{I}	{S} WS{I}	{S} S{I}	{S} SLS{O}	{S} GVP{O}	{S} VA{O}
dmu:1	2.68	0	0	1.61	0	0	6.99
dmu:2	0	0	12.28	1.45	0	0	1.14
dmu:3	0.13	0	0	0.08	1.42	0	1.56
dmu:4							
dmu:5	0	0	0.54	0.51	0	0	4.89
dmu:6	0	0	3	32.68	9	0	51.87
dmu:7	0	0	9.81	5.59	0	0	20.14
dmu:8	0	0	2.79	0	0	0	3.63
dmu:9							
dmu:10	18.96	0	0	7.29	0	0	6.45
dmu:11							
dmu:12							
dmu:13	0	0	16.86	25.31	0	0	69.39

dmu:14							
dmu:15							
dmu:16							
dmu:17	6.24	0	0	35.7	0	0	21.87
dmu:18	1.04	0	0	0.71	0	0	7.32
dmu:19	0	0	0.79	0.06	0	0	1.02
dmu:20	1.5	0	0	1.77	0	0	4.32
dmu:21							
Total	**30.55**	**0**	**46.07**	**112.76**	**10.42**	**0**	**200.59**

Source: Adapted from STATA output

The efficient DMUs which have zero inputs and zero outputs are the efficient DMUs. The efficient DMUs (4, 9, 11, 12, 14, 15, 16, 20 and 21) have zero slacks on both inputs and outputs and therefore there is no need to carry out a DEA in Stage 2. The inefficient DMUs (1, 2, 3, 5, 6, 7, 8, 10, 13, 17, 18 and 19) have non-zero slacks on both inputs and outputs.

The input variable with the highest contribution to efficiency mix is **CM** with a summation of slacks being **0%.** This means that there is a **0%** reduction needed in **CM** in order to keep total output constant and efficient. This explains that **CM** is the major input driver of efficiency in the **Transport and Transport Equipment** manufacturing sub-sector. The input variable with the lowest contribution to efficiency mix is **S** with a summation of slacks being **113.76%**. This means that a **113.76%** reduction is needed in **S** in order to keep output constant and efficient. This explains that **S** is the major input barrier to efficiency in the **Transport and Transport Equipment** manufacturing sub-sector.

The output variable with the highest contribution to efficiency mix is **GVP** with a summation of slacks being **0%.** This means that there is a **0%** increase needed in **GVP** in order to keep total output constant and efficient. This explains that **GVP** is the major input driver of efficiency in the **Transport and Transport Equipment** manufacturing sub-sector. The output variable with the lowest contribution to efficiency mix is **VA** with a summation of slacks being **200.59%**. This means that a **200.59%** increase is needed in **VA** in order to keep output constant and efficient. This explains that **VA** is the major output barrier to efficiency in the **Transport and Transport Equipment** manufacturing sub-sector.

Overall analysis shows that **input variable CM** and output variable **GVP** are both the major drivers of efficiency in the **Transport and Transport Equipment** manufacturing sub-sector. Output variable **VA** is the major barrier efficiency in the **Transport and Transport Equipment** manufacturing sub-sector.

7.10.2 VRS Transport and Transport Equipment Slack Analysis

Slacks provide vital information pertaining to the areas which an inefficient DMU needs to improve in its drive towards attaining the status of an efficient one (Yang, Taudes and Dong 2017: 105). Slacks analysis provides important information to determine the drivers of efficiency and to identify the barriers to efficiency in the Transport and Transport Equipment manufacturing sub-sector in Zimbabwe. In this study, slack analyses are executed under **VRS CCR Input-Orientation in Stage 1** assumptions in order to obtain the long-term improvement directions for the inefficient DMUs.

Tome (2001: 498) describes a slack-based measure as a scalar-based measure of determining the efficiency of a DMU in a non-parametric form by considering both the input and output shortfalls. The smaller the value of the input or output slack, the more the variable drives efficiency in the Transport and Transport Equipment manufacturing sub-sector. The greater the value of the input or output slack, the more the variable is a barrier to achieving efficiency in the Transport and Transport Equipment manufacturing sub-sector.

Table 7.18 : VRS Transport and Transport Equipment Slack Analysis

	Inputs				**Outputs**		
DMU	{S} E{I}	{S} CM{I}	{S} WS{I}	{S} S{I}	{S} SLS{O}	{S} GVP{O}	{S} VA{O}
dmu:1	7.16	0	11.21	2.28	0	0	2.03
dmu:2	0	0	12.84	1.62	0	0	1.21
dmu:3	0.44	0	0	0	1.04	0	2.07
dmu:4							
dmu:5	0	0	0.21	0.34	0	0	4.81
dmu:6							
dmu:7	0	0	9.86	2.63	0	0	15.56
dmu:8	1.48	0	7.13	1.01	0	0	4.28
dmu:9							
dmu:10	24.17	0	8.34	11.42	0	0	8.3
dmu:11							
dmu:12							
dmu:13							
dmu:14							
dmu:15							
dmu:16							
dmu:17	6.59	0	0	35.06	0	0	18.96
dmu:18	1.3	0.43	0	0	0	0	5.96
dmu:19	0	0	1.3	0.11	0.2	0.39	1.82
dmu:20	1.5	0	0	1.75	0.38	0	4.32

dmu:21							
Total	**42.64**	**0.43**	**50.89**	**56.22**	**1.62**	**0.39**	**69.32**

Source: Adapted from STATA output

The DMUs which have zero inputs and zero outputs slacks are the efficient DMUs. The efficient DMUs (4, 6, 9, 11, 12, 13, 14, 15, 16 and 21) have zero slacks on both inputs and outputs and therefore there is no need to carry out a DEA in Stage 2. The inefficient DMUs (1, 2, 3, 5, 7, 8, 10, 17, 18, 19 and 20) have non-zero slacks on both inputs and outputs.

The input variable with the highest contribution to efficiency mix is **CM** with a summation of slacks being **0.43%.** This means that there is a **0.43%** reduction needed in **CM** in order to keep total output constant and efficient. This explains that **CM** is the major input driver of efficiency in the **Transport and Transport Equipment** manufacturing sub-sector. The input variable with the lowest contribution to efficiency mix is **S** with a summation of slacks being **56.22%**. This means that a **56.22%** reduction is needed in **S** in order to keep output constant and efficient. This explains that **S** is the major input barrier to efficiency in the **Transport and Transport Equipment** manufacturing sub-sector.

The output variable with the highest contribution to efficiency mix is **GVP** with a summation of slacks being **0.39%.** This means that there is a **0.39%** increase needed in **GVP** in order to keep total output constant and efficient. This explains that **GVP** is the major input driver of efficiency in the **Transport and Transport Equipment** manufacturing sub-sector. The output variable with the lowest contribution to efficiency mix is **VA** with a summation of slacks being **69.32%**. This means that a **69.32%** increase is needed in **VA** in order to keep output constant and efficient. This explains that **VA** is the major output barrier to efficiency in the **Transport and Transport Equipment** manufacturing sub-sector.

Overall analysis shows that output variable **GVP** is the major driver of efficiency in the **Transport and Transport Equipment** manufacturing sub-sector. Output variable **VA** is the major barrier to efficiency in the **Transport and Transport Equipment** manufacturing sub-sector.

7.11 Slacks analysis in the Wood and Furniture

Input slacks show inputs as the source of inefficiency. A zero slack input shows that that particular input use mix is a driver of efficiency in the Wood and Furniture manufacturing sub-sector. A non-zero slack input shows that that particular input use mix is a barrier to achieving efficiency in the Wood and Furniture manufacturing sub-sector. Minimising these non-zero input slacks towards zero input slacks provides a model that is recommended for efficient input-output use.

Output slacks show outputs as the source of inefficiency. A zero slack output shows that that particular output mix is a driver of efficiency in the Wood and Furniture manufacturing sub-sector. A non-zero slack output shows that that particular output mix is a barrier to achieving efficiency in the Wood and Furniture manufacturing sub-sector. Minimising these non-zero output slacks towards zero output slacks provides a model that is recommended for efficient input-output use.

7.11.1 CRS Wood and Furniture Slack Analysis

Slacks provide vital information pertaining to the areas which an inefficient DMU needs to improve in its drive towards attaining the status of an efficient one (Yang, Taudes and Dong 2017: 105). Slacks analysis provides important information to determine the drivers of efficiency and to identify the barriers to efficiency in the Wood and Furniture manufacturing sub-sector in Zimbabwe. In this study, slack analyses are executed under **CRS CCR Input-Orientation in Stage 1** assumptions in order to obtain the long-term improvement directions for the inefficient DMUs.

Tome (2001: 498) describes a slack-based measure as a scalar-based measure of determining the efficiency of a DMU in a non-parametric form by considering both the input and output shortfalls. The smaller the value of the input or output slack, the more the variable drives efficiency in the Wood and Furniture manufacturing sub-sector. The greater the value of the input or output slack, the more the variable is a barrier to achieving efficiency in the Wood and Furniture manufacturing sub-sector.

Table 7.19: CRS Wood and Furniture Slack Analysis

	Inputs				**Outputs**		
DMU	{S} E{I}	{S} CM{I}	{S} WS{I}	{S} S{I}	{S} SLS{O}	{S} GVP{O}	{S} VA{O}
dmu:1	13.71	0	28.22	0	0	0.98	1.04
dmu:2	0.05	0	0	0	0	0	0.94
dmu:3							
dmu:4	0	0.46	0	0	0.4	0.5	0
dmu:5							
dmu:6	0	0	0.48	0	0	19.73	33.67
dmu:7							
dmu:8							
dmu:9	1.25	0	2.02	0.32	0	0	0.13
dmu:10							
dmu:11	0	0	0	0.43	0.31	0	4.48
dmu:12	0	0	0	15.23	0	0	8.67
dmu:13	0	0	0	0	0	1.28	0
dmu:14	0	0	0	0.25	0	0	0.06

dmu:15							
dmu:16	5.34	0	2.44	0	0	0.62	1.08
dmu:17							
dmu:18							
dmu:19							
dmu:20	3.25	0	0	0	0	3.79	4.59
dmu:21							
Total	**23.6**	**0.46**	**33.16**	**16.23**	**0.71**	**26.9**	**54.66**

Source: Adapted from STATA output

The efficient DMUs which have zero inputs and zero outputs are the efficient DMUs. The efficient DMUs (3, 5, 7, 8, 10, 15, 17, 18, 19 and 21) have zero slacks on both inputs and outputs and therefore there is no need to carry out a DEA in Stage 2. The inefficient DMUs (1, 2, 4, 6, 9, 11, 12, 13, 14, 16 and 20) have non-zero slacks on both inputs and outputs.

The input variable with the highest contribution to efficiency mix is **CM** with a summation of slacks being **0.46%.** This means that there is a **0.46%** reduction needed in **CM** in order to keep total output constant and efficient. This explains that **CM** is the major input driver of efficiency in the **Wood and Furniture** manufacturing sub-sector. The input variable with the lowest contribution to efficiency mix is **WS** with a summation of slacks being **33.16%**. This means that a **33.16%** reduction is needed in **WS** in order to keep output constant and efficient. This explains that **WS** is the major input barrier to efficiency in the **Wood and Furniture** manufacturing sub-sector.

The output variable with the highest contribution to efficiency mix is **SLS** with a summation of slacks being **0.71%.** This means that there is a **0.71%** increase needed in **SLS** in order to keep total output constant and efficient. This explains that **SLS** is the major input driver of efficiency in the **Wood and Furniture** manufacturing sub-sector. The output variable with the lowest contribution to efficiency mix is **VA** with a summation of slacks being **54.66%**.

This means that a **54.66%** increase is needed in **VA** in order to keep output constant and efficient. This explains that **VA** is the major output barrier to efficiency in the **Wood and Furniture** manufacturing sub-sector.

Overall analysis shows that **input variable CM** is the major driver of efficiency in the **Wood and Furniture** manufacturing sub-sector. Output variable **VA** is the major barrier to efficiency in the **Wood and Furniture** manufacturing sub-sector.

7.11.2 VRS Wood and Furniture Slack Analysis

Slacks provide vital information pertaining to the areas which an inefficient DMU needs to improve in its drive towards attaining the status of an efficient one (Yang, Taudes and Dong 2017: 105). Slacks analysis provides important information to determine the drivers of efficiency and to identify the barriers to efficiency in the Wood and Furniture manufacturing sub-sector in Zimbabwe. In this study, slack analyses are executed under **VRS CCR Input-Orientation in Stage 1** assumptions in order to obtain the long-term improvement directions for the inefficient DMUs.

Tome (2001: 498) describes a slack-based measure as a scalar-based measure of determining the efficiency of a DMU in a non-parametric form by considering both the input and output shortfalls. The smaller the value of the input or output slack, the more the variable drives efficiency in the Wood and Furniture manufacturing sub-sector. The greater the value of the input or output slack, the more the variable is a barrier to achieving efficiency in the Wood and Furniture manufacturing sub-sector.

Table 7.20: VRS Wood and Furniture Slack Analysis

	Inputs				**Outputs**		
DMU	{S} E{I}	{S} CM{I}	{S} WS{I}	{S} S{I}	{S} SLS{O}	{S} GVP{O}	{S} VA{O}
dmu:1							
dmu:2	0	0	0.96	0.14	0	0	1.3
dmu:3							
dmu:4	0.11	0.26	0	0	0.59	0.54	0
dmu:5							
dmu:6	0	0	2.47	0.14	0	21.72	37.9
dmu:7							
dmu:8							
dmu:9	1.18	0	1.5	0.32	0	0	0.15
dmu:10							
dmu:11	0	3.33	0	1.99	0	0.14	4.62
dmu:12							
dmu:13							
dmu:14	0	0	0	0.24	0.13	0	0
dmu:15							
dmu:16	3.14	0	0	0	0	0.21	1.05
dmu:17							
dmu:18							
dmu:19							
dmu:20	0	2.91	24.77	0	0	0.33	3.77

dmu:21							
Total	**4.43**	**6.5**	**29.7**	**2.83**	**0.72**	**22.94**	**48.79**

Source: Adapted from STATA output

The DMUs which have zero inputs and zero outputs slacks are the efficient DMUs. The efficient DMUs (1, 3, 5, 7, 8, 10, 12, 13, 15, 17, 18, 19 and 21)have zero slacks on both inputs and outputs and therefore there is no need to carry out a DEA in Stage 2. The inefficient DMUs (2, 4, 6, 9, 11, 14, 16 and 20) have non-zero slacks on both inputs and outputs.

The input variable with the highest contribution to efficiency mix is **S** with a summation of slacks being **2.83%.** This means that there is a **2.83%** reduction needed in **S** in order to keep total output constant and efficient. This explains that **S** is the major input driver of efficiency in the **Wood and Furniture** manufacturing sub-sector. The input variable with the lowest contribution to efficiency mix is **WS** with a summation of slacks being **29.7%**. This means that a **29.7%** reduction is needed in **WS** in order to keep output constant and efficient. This explains that **WS** is the major input barrier to efficiency in the **Wood and Furniture** manufacturing sub-sector.

The output variable with the highest contribution to efficiency mix is **SLS** with a summation of slacks being **0.72%.** This means that there is a **0.72%** increase needed in **SLS** in order to keep total output constant and efficient. This explains that **SLS** is the major input driver of efficiency in the **Wood and Furniture** manufacturing sub-sector. The output variable with the lowest contribution to efficiency mix is **VA** with a summation of slacks being **48.79%**. This means that a **48.79%** increase is needed in **VA** in order to keep output constant and efficient. This explains that **VA** is the major output barrier to efficiency in the **Wood and Furniture** manufacturing sub-sector.

Overall analysis shows that **output variable SLS** is the major driver of efficiency in the **Wood and Furniture** manufacturing sub-sector. Output variable **VA** is the major barrier to efficiency in the **Wood and Furniture** manufacturing sub-sector.

7.12 Conclusion

The drivers and barriers of efficiency in Zimbabwe's manufacturing sector have been identified. The slacks analysis has managed to assign magnitude of influence of each and every driver and barrier to efficiency. The next Chapter will, therefore, deduce and develop an efficiency model that will recommend efficient input- output use in Zimbabwe's manufacturing sector.

CHAPTER EIGHT

RECOMMENDED EFFICIENCY MODELS IN THE ZIMBABWE'S MANUFACTURING SECTOR

8.1 Introduction

This Chapter attempts to recommend the different dimensions which can improve and restore efficiency in the Zimbabwe's manufacturing sector in Zimbabwe. Three model recommended will be considered based on the conceptualization of efficiency.

8.2 Recommended efficiency model using efficiency scores

An efficiency score is recommended for every manufacturing sub-sector in Zimbabwe. The recommended model of efficiency scores are recommended based on the CRS or VRS assumption. The table below gives a comparative analysis of the efficiency scores.

Table 8.1: Comparative Analysis of Efficiency scores

SECTOR	**Efficiency Score %**		**Efficient DMUs %**		**Efficient Model/scale**	
	CRS	**VRS**	**CRS**	**VRS**	**CRS**	**VRS**
Beverages and Tobacco	88	94	48	67		✓
Chemicals and Petroleum	83	89	43	67		✓
Clothing and Footwear	22	48	5	19		✓
Foodstuffs	69	88	24	62		✓
Metals	68	86	38	57		✓
Non Metallic Minerals	74	83	33	48		✓
Paper Printing and Publishing	81	91	57	71		✓
Textile	26	53	10	24		✓

Transport and Transport Equipment	78	85	43	48		✓
Wood and Furniture	82	85	48	62		✓
Average	**67.1**	**80.2**	**34.9**	**52.5**		

Source: Self-generated by researcher

The average efficiency score for Zimbabwe's manufacturing sector is 67.1% under CRS and 80.2% under VRS. It may be deduced that 34.9% firms in the whole manufacturing sector are efficient under CRS and assuming VRS, 52.5% of the firms are efficient.

8.3 Recommended efficiency model using major efficiency drivers

An efficiency driver is recommended for every manufacturing sub-sector in Zimbabwe. The recommended model of efficiency drivers are based on the CRS or VRS assumption. The model also determines the efficient input and output under CRS and VRS. The table below gives a comparative analysis of the efficiency drivers in each manufacturing sub-sector.

Table 8.2: Comparative Analysis of the Major Efficiency drivers

SECTOR	**Efficient input**		**Efficient output**		**Major driver(s)**	
	CRS	**VRS**	**CRS**	**VRS**	**CRS**	**VRS**
Beverages and Tobacco	CM	CM	SLS	SLS	CM	CM
Chemicals and Petroleum	E	CM	SLS	SLS	SLS	SLS
Clothing and Footwear	E	WS	GVP	GVP	GVP	E
Foodstuffs	CM	CM	SLS	SLS	CM	CM
Metals	CM	CM	SLS	SLS	CM	CM
Non Metallic Minerals	CM	CM	SLS	SLS	CM	SLS

Paper Printing and Publishing	S	S	GVP	GVP	S	S
Textile	E	E	GVP	GVP	E	E
Transport and Transport Equipment	CM	CM	GVP	GVP	CM and GVP	GVP
Wood and Furniture	CM	S	SLS	SLS	CM	SLS

Source: Self-generated by researcher

The input variable which is a major driver of efficiency in the manufacturing sector is CM, both under CRS and VRS. The output variable which is a major driver of efficiency in the manufacturing sector is SLS, both under CRS and VRS.

It can be concluded that under the CRS assumption, 6 out of 10 manufacturing sub-sectors have CM as the major driver of efficiency. Under VRS, variables CM and SLS top as the major drivers of efficiency in the manufacturing sub-sectors.

8.4 Recommended efficiency model using major efficiency drivers

An efficiency barrier model is recommended for every manufacturing sub-sector in Zimbabwe. The model of efficiency barriers are presented based on the CRS or VRS assumption. The model also determines the barrier input and barrier output under CRS and VRS. The table below gives a comparative analysis of the efficiency barriers in each manufacturing sub-sector.

Table 8.3: Comparative Analysis of Major Efficiency barriers

SECTOR	Inefficient input		Inefficient output		Major barrier(s)	
	CRS	**VRS**	**CRS**	**VRS**	**CRS**	**VRS**
Beverages and Tobacco	S	E	VA	VA	VA	VA
Chemicals and Petroleum	WS	WS	VA	VA	VA	VA
Clothing and Footwear	S	WS	VA	VA	VA	VA
Foodstuffs	S	S	VA	VA	VA	VA
Metals	S	S	VA	VA	VA	VA
Non Metallic Minerals	E	E	VA	VA	VA	VA
Paper Printing and Publishing	E	E	VA	VA	VA	VA
Textile	S	S	VA	VA	VA	VA
Transport and Transport Equipment	S	S	VA	VA	VA	VA
Wood and Furniture	WS	WS	VA	VA	VA	VA

Source: Self-generated by the researcher

The input variable which is a major barrier to efficiency in the whole manufacturing sector is S, both under CRS and VRS. The output variable which is a major barrier to efficiency in the whole manufacturing sector is VA, both under CRS and VRS.

It can be concluded that under both CRS and VRS assumptions,output variable VA is the major barrier to efficiency in the manufacturing sector.

8.5 Conclusion

The three models recommended will improve the levels of efficiency in Zimbabwe's manufacturing sector which has been decimating. The recommended model knowledge about efficiency scores, barriers and drivers of efficiency both inputs and outputs have been revealed.

CHAPTER NINE

INTERPRETATION AND DISCUSSION OF RESULTS

9.1 Introduction

This chapter presents the results of the study, which have been interpreted and discussed under key sub-sections in line with the research objectives:

i. To determine the drivers of efficiency in Zimbabwe's manufacturing sector;
ii. To compare financial ratios with efficiency ratios in the input-output model in order to identify the levels and kinds of inefficiencies in Zimbabwe's manufacturing sector;
iii. To measure efficiency in Zimbabwe's manufacturing sector using production plans of the efficient scores;
iv. To identify the barriers to achieving efficiency levels in Zimbabwe's manufacturing sector; and
v. To develop an efficiency model that will recommend an efficient input-output use in Zimbabwe's manufacturing sector.

In addition to the data interpretation and discussion in line with the objectives, it will also follow the major areas of efficiency:

i. Orientation;
ii. Returns to scale; and
iii. Stage.

Lastly, the interpretation and discussion will be done according to the ten manufacturing sub-sectors in Zimbabwe, namely:

i. Beverages and Tobacco

ii. Chemicals and Petroleum
iii. Clothing and Footwear
iv. Foodstuffs
v. Metals
vi. Non-Metallic Minerals
vii. Paper Printing and Publishing
viii. Textile
ix. Transport and Transport Equipment
x. Wood and Furniture

SECTION A: QUANTITATIVE ANALYSIS

The quantitative analysis for each manufacturing sub-sectorin this study was conducted using STATA software to address the research objectives. The results from the STATA output was further triangulated and compared with documental analysis, using a sample of company financial statements collected from the ZSE.

9.2 Beverages and Tobacco Quantitative Analysis

Under the CRS model, average efficiency in Beverages and Tobacco manufacturing sub-sector is 0.88 = 88%. In the Beverages and Tobacco sub-sector of the manufacturing sector, 48% of the DMUs are efficient and 52% are inefficient. At least 57% of the DMUs are operating above the average efficiency of 88%, whereas 43% of the DMUs are struggling below the average efficiency level.

Under the VRS model, average efficiency in Beverages and Tobacco manufacturing sub-sector is 0.94 = 94%. In the Beverages and Tobacco sub-sector of the manufacturing sector, 67% of the DMUs are efficient and 33% are inefficient. At least 71% of the DMUs are operating above the average efficiency of 94%, whereas 29% of the DMUs are struggling below the average efficiency level.

Egilmez, Kucukvar and Tatari (2013: 91) found that US Food Manufacturing had a100% efficiency score, based on DEA results. Although this sector is found to be responsible for high environmental impacts compared to others, it is 100% efficient and did not require any performance improvement. This is basically because of the fact that this manufacturing sub-sector has significantly higher contributions to the U.S. manufacturing sector's total economic output, although they have considerable impacts on the environment.

Under the CRS, the input variable with the highest contribution to efficiency mix is **CM** with a summation of slacks being **0%.** This means that there is a **0%** reduction needed in **CM** in order to keep total output constant and efficient. This explains that **CM** is the major input driver of efficiency in the **Beverages and Tobacco** manufacturing sub-sector. The input variable with the lowest contribution to efficiency mix is **S** with a summation of slacks being **114.11%**. This means that there is a **114.11%** reduction needed in **S** in order to keep output constant. This explains that **S** is the major input barrier to efficiency in the **Beverages and Tobacco** manufacturing sub-sector.

Under VRS, the input variable with the highest contribution to efficiency mix is **CM** with a summation of slacks being **5.72%.** This means that there is a **5.72%** reduction needed in **CM** in order to keep total output constant and efficient. This explains that **CM** is the major input driver of efficiency in the **Beverages and Tobacco** manufacturing sub-sector. The input variable with the lowest contribution to efficiency mix is **E** with a summation of slacks being **76.35%**. This means that there is a**76.35%** reduction needed in **E** in order to keep output constant. This explains that **E** is the major input barrier to efficiency in the **Beverages and Tobacco** manufacturing sub-sector

Hartono, Irawan and Achsani (2011: 77) conducted a study for the Indonesian Beverages and tobacco and found that energy was an important drive in the whole manufacturing sector. It contributed 27% to the efficiency of that sector. These results are in contrast to the results found by **Energy use in Manufacturing Statistics Finland (2015)**found energy input as one of the major drivers of efficiency in the Food industry in Finland. This was as a result of massive investment in energy efficient food processing plants in Helsinki, Finland.

Under the CRS model, the output variable with the highest contribution to efficiency mix is **SLS**with a summation of slacks being **16.68%.** This means that there is a **16.68%** increase needed in **SLS** in order to keep total output constant and efficient. This explains that **SLS** is the major input driver of efficiency in the **Beverages and Tobacco** manufacturing sub-sector. The output variable with the lowest contribution to efficiency mix is **VA** with a summation of slacks being **137.7%**. This means that a 13**7.7%** increase is needed in **VA** in order to keep output constant and efficient. This explains that **VA** is the major output barrier to efficiency in the **Beverages and Tobacco** manufacturing sub-sector.

Under the VRS model, The output variable with the highest contribution to efficiency mix is **SLS**with a summation of slacks being **8.63%.** This means that there is a **8.63%** increase needed in **SLS** in order to keep total output constant and efficient. This explains that **SLS** is the major output driver of efficiency in the **Beverages and Tobacco** manufacturing sub-sector. The output variable with the lowest contribution to efficiency mix is **VA** with a summation of slacks being **108.71%**. This means that a **108.71%** increase is needed in **VA** in order to keep output constant and efficient. This explains that **VA** is the major output barrier to efficiency in the **Beverages and Tobacco** manufacturing sub-sector.

Brandt, Van Biesebroeck and Zhang (2012: 339)identified sales volume as the major driver of efficiency in the Chinese Beverages and Tobacco manufacturing sub-sector. Its not clear though why sales value stimulated efficiency in Zimbabwe given that that of China was as a result of the ever-increasing population. They further noted that efficiency was attributed to value addition (22%), cost of production (5.1%), sales growth (57%) and 4.5% to gross value of production.

9.3 Chemical and Petroleum Products Quantitative Analysis

Under CRS model, average efficiency in the Chemical and Petroleum Productsmanufacturing sub-sector is 0.83 = 83%. In the Chemical and Petroleum Products sub-sector of the manufacturing sector, 43% of the DMUs are efficient and 57% are inefficient. At least 62% of the DMUs are operating above the average efficiency of 83%, whereas 38% of the DMUs are struggling below the average efficiency level.

Under the VRS, average efficiency inChemical and Petroleum Productsmanufacturing sub-sector is 0.89 = 89%. In the Chemical and Petroleum Products sub-sector of the manufacturing sector, 67% of the DMUs are efficient and 33% are inefficient. At least 71% of the DMUs are operating above the average efficiency of 94%, whereas 29% of the DMUs are struggling below the average efficiency level.

The U.S Petroleum manufacturing sub-sector had a 100% efficient score which **Egilmez, Kucukvar, and Tatari (2013: 91)** attributed to its value addition policies.

Under the CRS model, the input variable with the highest contribution to efficiency mix is **E**with a summation of slacks being **13.4%.** This means that there is a **13.4%** reduction needed in **E** in order to keep total output constant and efficient. This explains that **E** is the major input driver of efficiency in the **Chemicals and Petroleum Products** manufacturing sub-sector. The input variable with the lowest contribution to efficiency mix is **WS** with a summation of slacks being **103.77%**. This means that a **103.77%** reduction is needed in **WS** in order to keep output constant and efficient. This explains that W**S** is the major input barrier to efficiency in the **Chemicals and Petroleum Products** manufacturing sub-sector.

Energy intensity in the Indonesian Chemical and Petroleum manufacturing sub-sector had a contribution of 49%, as suggested by **Hartono, Irawan and Achsani (2011: 77)**. This is higher when compared to energy contribution to efficiency in Zimbabwe (13.4%).

Under VRS, the input variable with the highest contribution to efficiency mix is **CM**with a summation of slacks being **0.23%.** This means that there is a **0.23%** reduction needed in **CM** in order to keep total output constant and efficient. This explains that **CM** is the major input driver of efficiency in the **Chemicals and Petroleum Products** manufacturing sub-sector. The input variable with the lowest contribution to efficiency mix is **WS** with a summation of slacks being **103.77%**. This means that a **100.64%** reduction is needed in **WS** in order to keep output constant and efficient. This explains that W**S** is the major input barrier to efficiency in the **Chemicals and Petroleum Products** manufacturing sub-sector.

The results attained by **Bunse, Vodicka, Schönsleben, Brülhart and Ernst (2011: 667)**in the international consortium studyfound that electricity and energy in generalemerged as a barrier to production efficiency. This study forecasted that electricity saving can improve manufacturing efficiency by 20% come 2020. **Bunse, Vodicka, Schönsleben, Brülhart and Ernst (2011: 667-679)**further assert that cost of material is a vital driver of efficiency, especially compounded with an efficient purchasing and logistics model.

Under the CRS model, the output variable with the highest contribution to efficiency mix is **SLS**with a summation of slacks being **0.24%.**This means that there is a**0.24%** increase needed in**SLS** in order to keep total output constant and efficient. This explains that **SLS** is the major input driver of efficiency in the **Chemicals and Petroleum Products** manufacturing sub-sector. The output variable with the lowest contribution to efficiency mix is **VA** with a summation of slacks being **273.4%**. This means that **273.4%** increase is needed in**VA** in order to keep output constant and efficient. This explains that **VA** is the major output barrier to efficiency in the **Chemicals and Petroleum Products** manufacturing sub-sector.

Under the VRS model, the output variable with the highest contribution to efficiency mix is **SLS**with a summation of slacks being **0%.** This means that there is a **0%** increase needed in **SLS** in order to keep total output constant and efficient. This explains that **SLS** is the major input driver of efficiency in the **Chemicals and Petroleum Products** manufacturing sub-sector. The output variable with the lowest contribution to efficiency mix is **VA** with a summation of slacks being **129.03%**. This means that a **129.03%** increase is needed in **VA** in order to keep output constant and efficient. This explains that **VA** is the major output barrier to efficiency in the **Chemicals and Petroleum Products** manufacturing sub-sector.

Value addition as a barrier in Zimbabwe was opposed in findings by **Brandt, Van Biesebroeck and Zhang (2012: 339)**who attributed efficiency in China to be a result of value addition.

9.4 Clothing and Footwear Quantitative Analysis

Under the CRS model, average efficiency in Clothing and Footwear manufacturing sub-sector is 0.22 = 22%. In the Clothing and Footwear sub-sector of the manufacturing sector, 5% of the DMUs are efficient and 95% are inefficient. At least 33% of the DMUs are operating above the average efficiency of 22%, whereas 67% of the DMUs are struggling below the average efficiency level.

Under the VRS model, average efficiency in the Clothing and Footwear manufacturing sub-sector is 0.48 = 48%. In the Clothing and Footwear sub-sector of the manufacturing sector, 19% of the DMUs are efficient and 81% are inefficient. At least 38% of the DMUs are operating above the average efficiency of 48%, whereas 62% of the DMUs are struggling below the average efficiency level.

Under the CRS model, the input variable with the highest contribution to efficiency mix is **E**with a summation of slacks being **4.17%.** This means that there is a **4.17%** reduction needed in **E** in order to keep total output constant and efficient. This explains that **E** is the major input driver of efficiency in the **Clothing and Footwear** manufacturing sub-sector. The input variable with the lowest contribution to efficiency mix is **S** with a summation of slacks being **47.12%**. This means that a**47.12%** reduction is needed in **S** in order to keep output constant and efficient. This explains that W**S** is the major input barrier to efficiency in the **Clothing and Footwear** manufacturing sub-sector.

Under the VRS model, the input variable with the highest contribution to efficiency mix is **E**with a summation of slacks being **3.09%.** This means that there is a**3.09%** reduction needed in **E** in order to keep total output constant and efficient. This explains that **E** is the major input driver of efficiency in the **Clothing and Footwear** manufacturing sub-sector. The input variable with the lowest contribution to efficiency mix is **WS** with a summation of slacks being **27.7%**. This means that a **27.7%** reduction is needed in **WS** in order to keep output constant and efficient. This explains that W**S** is the major input barrier to efficiency in the **Clothing and Footwear** manufacturing sub-sector.

According to Energy Manufacturing, Statistics Finland (2016), in Finland, Clothing and Apparel manufacturingused the least amount of enegy as compared to all the other manufacturing sub-sectors the years 2014 and 2015. This concurred with Zimbabwe's manufacturing sub-sector of Clothing and Footwear, even though the sector was 48% efficient.

Under the CRS model, the output variable with the highest contribution to efficiency mix is **GVP**with a summation of slacks being **0.87%.** This means that there is a **0.87%** increase needed in **GVP** in order to keep total output constant and efficient. This explains that **GVP** is the major input driver of efficiency in the **Clothing and Footwear** manufacturing sub-sector. The output variable with the lowest contribution to efficiency mix is **VA** with a summation of slacks being **172.04%**. This means that a **172.04%** increase is needed in **VA** in order to keep output constant and efficient. This explains that **VA** is the major output barrier to efficiency in the **Clothing and Footwear** manufacturing sub-sector.

Under the VRS model, the output variable with the highest contribution to efficiency mix is **GVP**with a summation of slacks being **11.23%.** This means that there is a **11.23%** increase needed in **GVP** in order to keep total output constant and efficient. This explains that **GVP** is the major input driver of efficiency in the **Clothing and Footwear** manufacturing sub-sector. The output variable with the lowest contribution to efficiency mix is **VA** with a summation of slacks being **75.26%**. This means that a **75.26%** increase is needed in **VA** in order to keep output constant and efficient. This explains that **VA** is the major output barrier to efficiency in the **Clothing and Footwear** manufacturing sub-sector.

9.5 Foodstuffs Quantitative Analysis

Under the CRS model, average efficiency in Foodstuffs manufacturing sub-sector is 0.69 = 69%. In the Foodstuffs sub-sector of the manufacturing sector, 24% of the DMUs are efficient and 76% are inefficient. At least 43% of the DMUs are operating above the average efficiency of 69%, whereas 57% of the DMUs are struggling below the average efficiency level.

Under the VRS model, average efficiency in Foodstuffs manufacturing sub-sector is 0.88 = 88%. In the Foodstuffs sub-sector of the manufacturing sector, 62% of the DMUs are efficient and 38% are inefficient. At least 62% of the DMUs are operating above the average efficiency of 88%, whereas 38% of the DMUs are struggling below the average efficiency level.

Egilmez, Kucukvar, and Tatari (2013: 91) used an input-output frontier approach for the US manufacturing sectors and found that the Food manufacturing sub-sector was 100% efficient as compared to the Zimbabwe's Food manufacturing which had 88% under the VRS model.

Under the CRS model, the input variable with the highest contribution to efficiency mix is **CM**with a summation of slacks being **1.09%.** This means that there is a **1.09%** reduction needed in **CM** in order to keep total output constant and efficient. This explains that **CM** is the major input driver of efficiency in the **Foodstuffs** manufacturing sub-sector. The input variable with the lowest contribution to efficiency mix is **S** with a summation of slacks being **40.98%**. This means that a **40.98%** reduction is needed in **S** in order to keep output constant and efficient. This explains that **S** is the major input barrier to efficiency in the **Foodstuffs** manufacturing sub-sector.

Under the VRS model, the input variable with the highest contribution to efficiency mix is **CM**with a summation of slacks being **1.26%.** This means that there is a **1.26%** reduction needed in **CM** in order to keep total output constant and efficient. This explains that **CM** is the major input driver of efficiency in the **Foodstuffs** manufacturing sub-sector. The input variable with the lowest contribution to efficiency mix is **S** with a summation of slacks being **9.35%**. This means that a **9.35%** reduction is needed in **S** in order to keep output constant and efficient. This explains that **S** is the major input barrier to efficiency in the **Foodstuffs** manufacturing sub-sector.

Under the CRS model, the output variable with the highest contribution to efficiency mix is **SLS**with a summation of slacks being **2.74%.** This means that there is a **2.74%** increase needed in **SLS** in order to keep total output constant and efficient. This explains that **SLS** is the major input driver of efficiency in the **Foodstuffs** manufacturing sub-sector. The output variable with the lowest contribution to efficiency mix is **VA** with a summation of slacks being **282.14%**. This means that a **282.14%** increase is needed in **VA** in order to keep output constant and efficient. This explains that **VA** is the major output barrier to efficiency in the **Foodstuffs** manufacturing sub-sector.

Under the VRS model, the output variable with the highest contribution to efficiency mix is **SLS**with a summation of slacks being **2.77%.** This means that there is a **2.77%** increase needed in **SLS** in order to keep total output constant and efficient. This explains that **SLS** is the major input driver of efficiency in the **Foodstuffs** manufacturing sub-sector. The output variable with the lowest contribution to efficiency mix is **VA** with a summation of slacks being **29.33%**. This means that a **29.33%** increase is needed in **VA** in order to keep output constant and efficient. This explains that **VA** is the major output barrier to efficiency in the **Foodstuffs** manufacturing sub-sector.

Like the Chinese study by **Brandt, Van Biesebroeck and Zhang (2012: 339)**, Zimbabwe's manufacturing efficiency was also driven by sales volume.

9.6 Metals Quantitative Analysis

Under the CRS model, average efficiency in the Metals manufacturing sub-sector is 0.68 = 68%.In the Metals sub-sector of the manufacturing sector, 38% of the DMUs are efficient and 62% are inefficient. At least 52% of the DMUs are operating above the average efficiency of 68%, whereas 48% of the DMUs are struggling below the average efficiency level.

Under the VRS model, average efficiency in Metals is 0.86 = 86%. In the Metals sub-sector of the manufacturing sector, 57% of the DMUs are efficient and 43% are inefficient. At least 62% of the DMUs are operating above the average efficiency of 86%, whereas 38% of the DMUs are struggling below the average efficiency level.

Under the CRS model, the input variable with the highest contribution to efficiency mix is **CM**with a summation of slacks being **0%.** This means that there is a **0%** reduction needed in **CM** in order to keep total output constant and efficient. This explains that **CM** is the major input driver of efficiency in the **Metals** manufacturing sub-sector. The input variable with the lowest contribution to efficiency mix is **S** with a summation of slacks being **16.19%**. This means that a **16.19%** reduction is needed in **S** in order to keep output constant and efficient. This explains that **S** is the major input barrier to efficiency in the **Metals** manufacturing sub-sector.

Under the VRS model, the input variable with the highest contribution to efficiency mix is **CM**with a summation of slacks being **0%.** This means that there is a **0%** reduction needed in **CM** in order to keep total output constant and efficient. This explains that **CM** is the major input driver of efficiency in the **Metals** manufacturing sub-sector. The input variable with the lowest contribution to efficiency mix is **S** with a summation of slacks being **16.75%**. This means that a **16.75%** reduction is needed in **S** in order to keep output constant and efficient. This explains that **S** is the major input barrier to efficiency in the **Metals** manufacturing sub-sector.

In Sweden, **Rohdin, Thollander and Solding (2007: 672)**posit thatenergy is a driver of efficiency in the metal sector. Water is also seen to be a driver in the metal manufacturing sub-sector for cooling, therefore increasing the machine' lifespan.

Under the CRS model, the output variable with the highest contribution to efficiency mix is **SLS**with a summation of slacks being **0.01%.** This means that there is a **0.01%** increase needed in **SLS** in order to keep total output constant and efficient. This explains that **SLS** is the major input driver of efficiency in the **Metals** manufacturing sub-sector. The output variable with the lowest contribution to efficiency mix is **VA** with a summation of slacks being **26.42%**. This means that a **26.42%** increase is needed in **VA** in order to keep output constant and efficient. This explains that **VA** is the major output barrier to efficiency in the **Metals** manufacturing sub-sector.

Under the VRS model, the output variable with the highest contribution to efficiency mix is **SLS**with a summation of slacks being **0.02%.** This means that there is a **0.01%** increase needed in **SLS** in order to keep total output constant and efficient. This explains that **SLS** is the major input driver of efficiency in the **Metals** manufacturing sub-sector. The output variable with the lowest contribution to efficiency mix is **VA** with a summation of slacks being **26.83%**. This means that a **26.83%** increase is needed in **VA** in order to keep output constant and efficient. This explains that **VA** is the major output barrier to efficiency in the **Metals** manufacturing sub-sector.

One of the major barriers to efficiency found by **Terziovski (2010: 892)**in an Australian study to explain efficiency in 600 manufacturing SMEs was technological capabilities. Technological capabilities is a barrier to value addition. The study also explained the need for value addition strategies in the metal sector. This study concurred that Zimbabwe's metal manufacturing sub-sector needs value addition.

9.7 Non-Metallic Minerals Quantitative Analysis

The CRS model showed an average efficiency in the Non-Metallic Minerals is 0.74 = 74%.In the Non-Metallic Minerals sub-sector of the manufacturing sector, 33% of the DMUs are efficient and 67% are inefficient. At least 48% of the DMUs are operating above the average efficiency of 74%, whereas 52% of the DMUs are struggling below the average efficiency level.

Under VRS, average efficiency in the Non-Metallic Minerals is 0.83 = 83%. In the Non-Metallic Minerals sub-sector of the manufacturing sector, 48% of the DMUs are efficient and 52% are inefficient. At least 67% of the DMUs are operating above the average efficiency of 83%, whereas 33% of the DMUs are struggling below the average efficiency level.

Karagiannis and Tzouvelekas (2010: 207) showed that the Non-metallic mineral products sector in Luxemburg had the lowest technical efficiency score of 42.1% in Europe. This is one of the poorest country in Europe in terms of economic performance. Zimbabwe's Non metallic minerals sub-sector perform better than Luxemburg.

The CRS model showed that the input variable with the highest contribution to efficiency mix is **CM**with a summation of slacks being **1.07%.**This means that there is a**1.07%** reduction needed in**CM** in order to keep total output constant and efficient. This explains that **CM** is the major input driver of efficiency in the **Non-Metallic Minerals** manufacturing sub-sector. The input variable with the lowest contribution to efficiency mix is **E** with a summation of slacks being **37.32%**. This means that a**37.32%** reduction is needed in**E** in order to keep output constant and efficient. This explains that **S** is the major input barrier to efficiency in the **Non-Metallic Minerals** manufacturing sub-sector.

Under the VRS model, the input variable with the highest contribution to efficiency mix is **CM**with a summation of slacks being **1.1%.**This means that there is a**1.1%** reduction needed in**CM** in order to keep total output constant and efficient. This explains that **CM** is the major input driver of efficiency in the **Non-Metallic Minerals** manufacturing sub-sector. The input variable with the lowest contribution to efficiency mix is **E** with a summation of slacks being **71.39%**. This means that a**71.39%** reduction is needed in**E** in order to keep output constant and efficient. This explains that **S** is the major input barrier to efficiency in the **Non-Metallic Minerals** manufacturing sub-sector.

Energy intensity contribution, according to **Hartono, Irawan and Achsani (2011: 84)**, was 203% as a major driver to efficiency in Indonesia's Non-Metallic manufacturing sub-sector. In Zimbabwe, energy was a barrier to efficiency.

Bogetić and Olusi (2013:2) studied drivers of firm-level productivity in Russia's manufacturing sector. Using the GMM method, cost of material was found to be a barrier to efficiency, coupled with value addition shocks.

The CRS model showed that the output variable with the highest contribution to efficiency mix is **SLS**with a summation of slacks being **2.59%.**This means that there is a**2.59%** increase needed in**SLS** in order to keep total output constant and efficient. This explains that **SLS** is the major input driver of efficiency in the **Non-Metallic Minerals** manufacturing sub-sector. The output variable with the lowest contribution to efficiency mix is **VA** with a summation of slacks being **58.53%**. This means that a **58.53%** increase is needed in**VA** in order to keep output constant and efficient. This explains that **VA** is the major output barrier to efficiency in the **Non-Metallic Minerals** manufacturing sub-sector.

Under the VRS model, the output variable with the highest contribution to efficiency mix is **SLS**with a summation of slacks being **0.67%.**This means that there is a**0.67%** increase needed in**SLS** in order to keep total output constant and efficient. This explains that **SLS** is the major input driver of efficiency in the **Non-Metallic Minerals** manufacturing sub-sector. The output variable with the lowest contribution to efficiency mix is **VA** with a summation of slacks being **21.06%**. This means that a **21.06%** increase is needed in**VA** in order to keep output constant and efficient. This explains that **VA** is the major output barrier to efficiency in the **Non-Metallic Minerals** manufacturing sub-sector.

Comprehensive results in China by **Brandt, Van Biesebroeck and Zhang (2012: 339)**indicated thatTFP growth coming from improvements in continuing firms (the intensive margin of TFP growth) and through net entry (the extensive margin of TFP growth) was the source of over half of value-added growth in Chinese manufacturing sector over the 1998–2007 period. The high sales appetite by the growing economy of China was a major driver of efficiency in that manufacturing sector. Efficiency was attributed to value addition (22%), cost of production (5.1%), sales growth (57%) and 4.5% to gross value of production.

9.8 Paper Printing and Publishing Quantitative Analysis

Under the CRS model, average efficiency in Paper Printing and Publishing manufacturing sub-sector is 0.81 = 81%.In the Paper Printing and Publishing sub-sector of the manufacturing sector, 57% of the DMUs are efficient and 43% are inefficient. At least 62% of the DMUs are operating above the average efficiency of 81%, whereas 38% of the DMUs are struggling below the average efficiency level.

The VRS model showed that average efficiency in Paper Printing and Publishing manufacturing sub-sector is 0.91 = 91%. In the Paper Printing and Publishing sub-sector of the manufacturing sector, 71% of the DMUs are efficient and 29% are inefficient. At least 76% of the DMUs are operating above the average efficiency of 91%, whereas 24% of the DMUs are struggling below the average efficiency level.

Under the CRS model, the input variable with the highest contribution to efficiency mix is **S**with a summation of slacks being **0.04%.**This means that there is a**0.04%** reduction needed in**S** in order to keep total output constant and efficient. This explains that **S** is the major input driver of efficiency in the **Paper Printing and Publishing** manufacturing sub-sector. The input variable with the lowest contribution to efficiency mix is **E** with a summation of slacks being **4%**. This means that a**4%** reduction is needed in**E** in order to keep output constant and efficient. This explains that **E** is the major input barrier to efficiency in the **Paper Printing and Publishing** manufacturing sub-sector.

Hartono, Irawan and Achsani (2011: 77) found that energy was an efficient driver in the Indonesian Paper Printing and Publishing sector. In Zimbabwe, the research found otherwise- with a 4% improvement needed.

The VRS model showed that the input variable with the highest contribution to efficiency mix is **S**with a summation of slacks being **0%.**This means that there is a**0%** reduction needed in**S** in order to keep total output constant and efficient. This explains that **S** is the major input driver of efficiency in the **Paper Printing and Publishing** manufacturing sub-sector. The input variable with the lowest contribution to efficiency mix is **E** with a summation of slacks being **3.68%**. This means that a **3.68%** reduction is needed in**E** in order to keep output constant and efficient. This explains that **E** is the major input barrier to efficiency in the **Paper Printing and Publishing** manufacturing sub-sector.

Under the CRS model, the output variable with the highest contribution to efficiency mix is **GVP**with a summation of slacks being **0.21%.**This means that there is a**0.21%** increase needed in**GVP** in order to keep total output constant and efficient. This explains that **GVP** is the major input driver of efficiency in the **Paper Printing and Publishing** manufacturing sub-sector. The output variable with the lowest contribution to efficiency mix is **VA** with a summation of slacks being **6.2%**. This means that a **6.2%** increase is needed in**VA** in order to keep output constant and efficient. This explains that **VA** is the major output barrier to efficiency in the **Paper Printing and Publishing** manufacturing sub-sector.

The VRS model showed that the output variable with the highest contribution to efficiency mix is **GVP**with a summation of slacks being **0.23%.**This means that there is a**0.23%** increase needed in**GVP** in order to keep total output constant and efficient. This explains that **GVP** is the major input driver of efficiency in the **Paper Printing and Publishing** manufacturing sub-sector. The output variable with the lowest contribution to efficiency mix is **VA** with a summation of slacks being **6.4%**. This means that a **6.4%** increase is needed in**VA** in order to keep output constant and efficient. This explains that **VA** is the major output barrier to efficiency in the **Paper Printing and Publishing** manufacturing sub-sector.

9.9 Textiles Quantitative Analysis

The CRS model show that average efficiency in Textiles manufacturing sub-sector is 0.26 = 26%.In the Textiles sub-sector of the manufacturing sector, 10% of the DMUs are efficient and 90% are inefficient. At least 19% of the DMUs are operating above the average efficiency of 26%, whereas 81% of the DMUs are struggling below the average efficiency level.

The VRS model show that average efficiency in Textiles manufacturing sub-sector is 0.53 = 53%. In the Textiles sub-sector of the manufacturing sector, 24% of the DMUs are efficient and 76% are inefficient. At least 48% of the DMUs are operating above the average efficiency of 53%, whereas 52% of the DMUs are struggling below the average efficiency level.

Under the CRS model, the input variable with the highest contribution to efficiency mix is **E**with a summation of slacks being **5.35%.**This means that there is a**5.35%** reduction needed in**E** in order to keep total output constant and efficient. This explains that **E** is the major input driver of efficiency in the **Textiles** manufacturing sub-sector. The input variable with the lowest contribution to efficiency mix is **S** with a summation of slacks being **40.85%**. This means that a **40.85%** reduction is needed in**S** in order to keep output constant and efficient. This explains that **S** is the major input barrier to efficiency in the **Textiles** manufacturing sub-sector.

Under the VRS model, the input variable with the highest contribution to efficiency mix is **E**with a summation of slacks being **11.67%.**This means that there is a**11.67%** reduction needed in**E** in order to keep total output constant and efficient. This explains that **E** is the major input driver of efficiency in the **Textiles** manufacturing sub-sector. The input variable with the lowest contribution to efficiency mix is **S** with a summation of slacks being **99.76%**. This means that a **99.76%** reduction is needed in**S** in order to keep output constant and efficient. This explains that **S** is the major input barrier to efficiency in the **Textiles** manufacturing sub-sector.

It was noted by **Hartono, Irawan and Achsani (2011: 77)** that a 92% drive of efficiency in the Textile manufacturing sub-sectorin Indonesia was derived from energy intensity. This also had a bearing on its contribution to national output, which was also supported by research results in Zimbabwe's Textile sector.

Under the the CRS model, the output variable with the highest contribution to efficiency mix is **GVP**with a summation of slacks being **10.27%.**This means that there is a**10.27%** increase needed in**GVP** in order to keep total output constant and efficient. This explains that **GVP** is the major input driver of efficiency in the **Textiles** manufacturing sub-sector. The output variable with the lowest contribution to efficiency mix is **VA** with a summation of slacks being **134.98%**. This means that a **134.98%** increase is needed in**VA** in order to keep output constant and efficient. This explains that **VA** is the major output barrier to efficiency in the **Textiles** manufacturing sub-sector.

Under the VRS model, the output variable with the highest contribution to efficiency mix is **GVP**with a summation of slacks being **21.08%.**This means that there is a**21.08%** increase needed in**GVP** in order to keep total output constant and efficient. This explains that **GVP** is the major input driver of efficiency in the **Textiles** manufacturing sub-sector. The output variable with the lowest contribution to efficiency mix is **VA** with a summation of slacks being **179.72%**. This means that a **179.72%** increase is needed in**VA** in order to keep output constant and efficient. This explains that **VA** is the major output barrier to efficiency in the **Textiles** manufacturing sub-sector.

9.10 Transport and Transport Equipment Quantitative Analysis

Under the CRS model, average efficiency in Transport and Transport Equipment manufacturing sub-sector is 0.78 = 78%.In the Transport and Transport Equipment sub-sector of the manufacturing sector, 43% of the DMUs are efficient and 57% are inefficient. At least 57% of the DMUs are operating above the average efficiency of 78%, whereas 43% of the DMUs are struggling below the average efficiency level.

Under the VRS model, average efficiency in Transport and Transport Equipment manufacturing sub-sector is 0.85 = 85%. In the Transport and Transport Equipment sub-sector of the manufacturing sector, 48% of the DMUs are efficient and 52% are inefficient. At least 67% of the DMUs are operating above the average efficiency of 85%, whereas 33% of the DMUs are struggling below the average efficiency level.

Under the CRS model, the input variable with the highest contribution to efficiency mix is **CM**with a summation of slacks being **0%.**This means that there is a**0%** reduction needed in**CM** in order to keep total output constant and efficient. This explains that **CM** is the major input driver of efficiency in the **Transport and Transport Equipment** manufacturing sub-sector. The input variable with the lowest contribution to efficiency mix is **S** with a summation of slacks being **113.76%**. This means that a **113.76%** reduction is needed in**S** in order to keep output constant and efficient. This explains that **S** is the major input barrier to efficiency in the **Transport and Transport Equipment** manufacturing sub-sector.

Under the VRS model, the input variable with the highest contribution to efficiency mix is **CM**with a summation of slacks being **0.43%.**This means that there is a**0.43%** reduction needed in**CM** in order to keep total output constant and efficient. This explains that **CM** is the major input driver of efficiency in the **Transport and Transport Equipment** manufacturing sub-sector. The input variable with the lowest contribution to efficiency mix is **S** with a summation of slacks being **56.22%**. This means that a **56.22%** reduction is needed in**S** in order to keep output constant and efficient. This explains that **S** is the major input barrier to efficiency in the **Transport and Transport Equipment** manufacturing sub-sector.

Under the CRS model, the output variable with the highest contribution to efficiency mix is **GVP**with a summation of slacks being **0%.**This means that there is a**0%** increase needed in**GVP** in order to keep total output constant and efficient. This explains that **GVP** is the major input driver of efficiency in the **Transport and Transport Equipment** manufacturing sub-sector. The output variable with the lowest contribution to efficiency mix is **VA** with a summation of slacks being **200.59%**. This means that a **200.59%** increase is needed in**VA** in order to keep output constant and efficient. This explains that **VA** is the major output barrier to efficiency in the **Transport and Transport Equipment** manufacturing sub-sector.

Under the VRS model, the output variable with the highest contribution to efficiency mix is **GVP**with a summation of slacks being **0.39%.**This means that there is a**0.39%** increase needed in**GVP** in order to keep total output constant and efficient. This explains that **GVP** is the major input driver of efficiency in the **Transport and Transport Equipment** manufacturing sub-sector. The output variable with the lowest contribution to efficiency mix is **VA** with a summation of slacks being **69.32%**. This means that a **69.32%** increase is needed in**VA** in order to keep output constant and efficient. This explains that **VA** is the major output barrier to efficiency in the **Transport and Transport Equipment** manufacturing sub-sector.

9.11 Wood and Furniture Quantitative Analysis

Under the CRS model, average efficiency in Wood and Furniture manufacturing sub-sector is 0.82 = 82%. In the Wood and Furniture sub-sector of the manufacturing sector, 48% of the DMUs are efficient and 52% are inefficient. At least 57% of the DMUs are operating above the average efficiency of 82%, whereas 43% of the DMUs are struggling below the average efficiency level.

Under the VRS model, average efficiency in the Wood and Furniture manufacturing sub-sector is 0.85 = 85%. In the Wood and Furniture sub-sector of the manufacturing sector, 62% of the DMUs are efficient and 38% are inefficient. At least 67% of the DMUs are operating above the average efficiency of 85%, whereas 33% of the DMUs are struggling below the average efficiency level.

Under the CRS model, the input variable with the highest contribution to efficiency mix is **CM**with a summation of slacks being **0.46%.**This means that there is a**0.46%** reduction needed in**CM** in order to keep total output constant and efficient. This explains that **CM** is the major input driver of efficiency in the **Wood and Furniture** manufacturing sub-sector. The input variable with the lowest contribution to efficiency mix is **WS** with a summation of slacks being **33.16%**. This means that a **33.16%** reduction is needed in**WS** in order to keep output constant and efficient. This explains that **WS** is the major input barrier to efficiency in the **Wood and Furniture** manufacturing sub-sector.

Under the VRS model, the input variable with the highest contribution to efficiency mix is **S**with a summation of slacks being **2.83%.**This means that there is a**2.83%** reduction needed in**S** in order to keep total output constant and efficient. This explains that **S** is the major input driver of efficiency in the **Wood and Furniture** manufacturing sub-sector. The input variable with the lowest contribution to efficiency mix is **WS** with a summation of slacks being **29.7%**. This means that a **29.7%** reduction is needed in**WS** in order to keep output constant and efficient. This explains that **WS** is the major input barrier to efficiency in the **Wood and Furniture** manufacturing sub-sector.

Under the CRS model, the output variable with the highest contribution to efficiency mix is **SLS**with a summation of slacks being **0.71%.**This means that there is a**0.71%** increase needed in**SLS** in order to keep total output constant and efficient. This explains that **SLS** is the major input driver of efficiency in the **Wood and Furniture** manufacturing sub-sector. The output variable with the lowest contribution to efficiency mix is **VA** with a summation of slacks being **54.66%**. This means that a **54.66%** increase is needed in**VA** in order to keep output constant and efficient. This explains that **VA** is the major output barrier to efficiency in the **Wood and Furniture** manufacturing sub-sector.

Under the VRS model, the output variable with the highest contribution to efficiency mix is **SLS**with a summation of slacks being **0.72%.**This means that there is a**0.72%** increase needed in**SLS** in order to keep total output constant and efficient. This explains that **SLS** is the major input driver of efficiency in the **Wood and Furniture** manufacturing sub-sector. The output variable with the lowest contribution to efficiency mix is **VA** with a summation of slacks being **48.79%**. This means that a **48.79%** increase is needed in**VA** in order to keep output constant and efficient. This explains that **VA** is the major output barrier to efficiency in the **Wood and Furniture** manufacturing sub-sector.

9.12 Comparative discussion of the ten manufacturing sub-sectors in Zimbabwe

The objectives will be conclusively met by consolidating the results discussion as follows:

The average efficiency score for Zimbabwe's manufacturing sector is 67.1% under CRS and 80.2% under VRS. It can be deduced that 34.9% of DMU in the whole manufacturing sector are efficient under CRS and assuming VRS, 52.5% are efficient.

Comprehensive research was done in Europe and the weighted efficiency scores were: *Italy (77.9%), Denmark (76.4%), UK (77.0%), Spain (74.8%), Belgium (74.1%), Sweden (73.3%) and Austria (72.3%). Finally, there are four countries with more severe technical inefficiency problems: Portugal (67.0%), Luxemburg (65.9%), Ireland (63.2%) and Finland (63.6%). However, even in Germany, the Netherlands and France, the countries with the highest input technical efficiency scores, there is a significant part of the industrial sector that is faced with notable inefficiency problems* **(Karagiannis and Tzouvelekas 2010: 207)**. These efficiency scores are relatively lower than those for Zimbabwe because they are weighted.

The input variable which is a major driver of efficiency in the manufacturing sector is CM, both under CRS and VRS. The output variable which is a major driver of efficiency in the manufacturing sector is SLS, both under CRS and VRS.It can be concluded that under the CRS assumption, 6 out of 10 manufacturing sub-sectors has CM as the major driver of efficiency. Under VRS, variables CM and SLS top as the major drivers of efficiency in the manufacturing sub-sectors.The input variable which is a major barrier to efficiency in the manufacturing sector is S, both under CRS and VRS. The output variable which is a major barrier to efficiency in the manufacturing sector is VA, both under CRS and VRS.

It can be concluded that under both CRS and VRS assumptions, output variable VA is the major barrier to efficiency in the manufacturing sector.

Table 9.1: Country comparison

SECTOR	Efficiency Score %			
	ZIM CRS	ZIM VRS	US	Thailand
Beverages and Tobacco	88	94	89	58
Chemicals and Petroleum	83	89	94	63
Clothing and Footwear	22	48	91	48
Foodstuffs	69	88	99	54
Metals	68	86	86	45
Non Metallic Minerals	74	83	100	44
Paper Printing and Publishing	81	91	99	51
Textile	26	53	97	48
Transport and Transport Equipment	78	85	93	61
Wood and Furniture	82	85	98	67
Average	**67.1**	**80.2**	**94.6**	**50**

Source: Self-generated by the researcher

Zimbabwe: Generated by the researcher

USA: Adapted from Karagiannis and Tzouvelekas(2010:207-233)

Thailand: Adapted from Charoenrat, Harvie and Amornkitvikai (2013:42-56)

Efficiency is high in America and Europe. The USA has 94.6% efficiency in the manufacturing sector. In Zimbabwe, under CRS, average efficiency is 67.1% and under VRS, average efficiency is 80.2%. Thailand had efficiency level as low as 50% in the manufacturing sector. This means that the USA is a benchmark manufacturing sector for the inefficient countries.

9.13 Documental Analysis

The documental analysis addresses the objective: To compare financial ratios with efficiency ratios in the input-output model in order to identify the levels and kinds of inefficiencies in Zimbabwe's manufacturing sector.

Beverages and Tobacco: African Distillers Limited (AFDIS)

The core business of African Distillers Limited is the manufacture, distribution andmarketing of branded spirits, ciders and wines for the Zimbabwean market and forexport.

Table9.2: AFDIS Financial Performance

Year	**2016**	**2015**	**2014**	**2013**	**2012**
Total Assets	21760275	22238121	19501397	13930330	11648554
Profit	1794594	4026505	2802851	1213127	1665795
Revenue	22040884	25064987	23952028	22091417	19547604
ROA	12.12546	5.522934	6.9577	11.48299	6.99279
ROE	7	21	16	14	23
Attributable earnings per	0.97	2.72	2.01	0.85	1.2

share					

Source: Adapted from the AFDIS Annual Report (2016: 1-48), ZSE

Sales revenue has been the barrier to efficiency at AFDIS. The AFDIS Annual Report (2016: 5-8) posits that the spirits segment of the business registered a decline of 18% in volumes, while ciders, wines and spirit coolers grewby 14%. Consumers in the alcoholic beverage sectorcontinued to migrate to more affordable products. This means that the firm was facing competition from imported wines and drinks, especially from South Africa as attributed by a ZIMSTAT expert. The AFDIS Annual Report (2016: 5-7) noted an improved working capital from an injection of $2.6 million into operations. Despite the sector having credit lines barriers, this injection gave the distilling company a re-tooling drive. Borrowings of $1.9 million have beeneliminated, leaving the company in a positive cash position (AFDIS Annual Report 2016: 5).

To show that the financial ratios do not speak to efficiency scores, most of the ratios on the table were above the efficiency scores for the Beverages and Tobacco manufacturing sub-sector. The Beverages and Tobacco manufacturing sub-sector has 88% under CRS and 94% under VRS.

Transport and Transport Equipment: Chloride and Exide Batteries

AFDIS Annual Report 2016: 5-7) reported that revenue recorded by the division went up by 2% due to increased volumes at the Chloride factory (up 9% on prior year) and improved sales at Battery Express Zimbabwe which were 15% higher than 2015. Operating profit went up 134% to $2.9m due to reduced cost of production at the factory. Capacity utilisation at Chloride improved to 74% and increased factory efficiencies resulted in the cost of production per battery dropping by 4%. Gross margins were therefore firmer at the factory at 29% (2015:26%). The factory also benefitted from Statutory Instrument 20 of 2016 which regulated the import of batteries into the country. Cashflows at the factory were boosted by the export of excess lead from the furnace, though the reduced commodity prices in the international markets adversely affected the margins on lead exports. Battery Express performed better than last year and operating expenses at the retail end were well managed and were 13% below 2015 levels. A total of 4 franchise shops were opened during the year, bringing the total number of franchise shops to 8 and this increased market reach. The Battery Express outlets are being rebranded to Exide Express shops and the exercise should be completed by 2016.

Table 9.3: Battery Manufacturing and Distribution

Year	**2016**	**2015**	**2014**
Total Assets	6018	4778	4928
Profit	2887	873	578
Revenue	19790	19329	18878
ROA	2.084517	5.473081	8.525952
Attributable earnings per share (cents)	41	-13	24
Capacity utilisation	74%	64%	59%

Source: Adapted from the AFDIS Annual Report (2016: 1-48), ZSE

To show that the financial ratios do not speak to efficiency scores, most of the ratios on the above table were above the efficiency scores for the Transport and Transport Equipment manufacturing sub-sector. The Transport and Transport Equipment manufacturing sub-sector has 78% under CRS and 85% under VRS.

Paper Printing and Publishing: ART Paper

The Paper Division, comprising National Waste Collections and Kadoma Paper Mills, recorded a loss of $288,000 compared to a loss of $469,000 in 2015. The weakening of the

South African Rand during the year resulted in reduced selling prices of tissue in the market in order to remain competitive and this contributed to the loss in Kadoma Paper Mills, despite a volume increase of 9%. The Mill has since benefited from SI64 with increased volumes being sold in the second half of the year. Investment in a new Tissue Mill in the medium term will bring the Mill back to sustainable profitability. National Waste Collections recorded a profit before tax of $33.000, from a loss position of $145.000 in the prior year. Operating expenses were 36% down on the previous year as a result of restructuring and streamlining of the business. Collection volumes dropped by 6% compared to the previous year.

Table 9.4: ART Paper

Year	**2016**	**2015**	**2014**
Total Assets	3778	3569	3997
Profit	-288	-469	-1053
Revenue	4565	4573	4230
ROA	133.11	-7.61	-3.8
ROE			
Attributable earnings per share(cents)	41	-13	24
Capacity utilisation	76%	70%	56%

Source: Adapted from the AFDIS Annual Report (2016: 1-48), ZSE

To show that the financial ratios do not speak to efficiency scores, most of the ratios on the above table were above the efficiency scores for the Paper Printing and Publishing manufacturing sub-sector. Some of the ratios were even negative, therefore bringing ambiguity on the relationship between them and efficiency ratio. The Paper Printing and Publishing manufacturing sub-sector has 81% under CRS and 91% under VRS.

Overall Analysisof the manufacturing sector from the RBZ

The manufacturing sector's export performance between 2014 and 2015 indicates that the sector's capacity to export is declining. Estimates from the Reserve Bank of Zimbabwe show that in 2015, manufactured exports were about US$475.2 million, having declined by about 7% compared to 2014. Seven representative manufacturing sub-sectors namely: clothing; furniture; food; beverages; engineering; leather and footwear, as well as agricultural inputs were selected for this analysis. In 2015, these sub-sectors constituted about 10% of total exports, down from 13% in 2014. The leather and footwear sub-sector registered the highest decline of 71% to about US$12 million, followed by horticulture which registered a decline of about 43% to US$25 million. The furniture sub-sector recorded a decline of 42%, engineering 40%, food 27% and agricultural inputs 17%. Processed Foods remained the dominant sub-sector in 2015, constituting approximately32% of manufactured exports, having declined from about 41% in 2014. In 2015, the sub-sector's exports also constituted about 6% of total exports, having declined from about 7% in 2014.

On a positive note, the clothing manufacturing sub-sector registered an increase in exports of about 70% in 2015 compared to 2014. The beverages manufacturing sub-sector also registered an increase of 13% to about US$9 million in 2015. While this is a positive development, it is still far below Zimbabwe's potential. The above performance is a reflection of the difficult environment that Zimbabwean manufacturing companies are operating in. Companies face numerous challenges that negatively impact on production and the conduct of export business. These challenges, which reduce the price competitiveness of Zimbabwean products in export markets, include cost of transportation, strengthening of the US dollar and the erratic supply of macro-economic enablers, amongst others.

SECTION B: Qualitative analysis

Qualitative results for this study were obtained from interviews carried out with the Executive staff of the Apex Boards in the manufacturing sector in Zimbabwe. The information was gathered in such a way in order to address the research objectives of this study as pertaining to the ten manufacturing sub-sectors in Zimbabwe.

The study objectives which were addressed are:

i. To determine the drivers of efficiency in Zimbabwe’s manufacturing sector;
ii. To compare financial ratios with efficiency ratios in the input-output model in order to identify the levels and kinds of inefficiencies in Zimbabwe’s manufacturing sector;
iii. To measure efficiency in Zimbabwe’s manufacturing sector using production plans of the efficient scores;
iv. To identify the barriers to achieving efficiency levels in Zimbabwe’s manufacturing sector; and
v. To develop an efficiency model that will recommend efficient input-output use in Zimbabwe’s manufacturing sector.

9.14 ZIMSTATqualitative analysis

Beverages and Tobacco

Shortages of power, shortage of water and cash flow difficulties were cited as major barriers to efficiency in this sub-sector. Other minor barriers were shortages of raw materials, transport problems and a lack of credit lines which affected efficiency in the Beverages and Tobacco manufacturing sub-sector.

Chemicals and Petroleum

Cash flow difficulties and weak domestic demand were echoed to be the greatest barrier to the efficient manufacturing of chemicals and petroleum in Zimbabwe. Shortage of both local and imported raw materials heavily impacted on the quality of chemical and petroleum being manufactured in Zimbabwe. Shortages of power and frequent power outages constrained chemical and petroleum production, mainly in the light industrial sites where there was no power cut timetable.

Clothing and Footwear and Textile

These combined sub-sectors of Clothing and Footwear and Textile manufacturing sub-sectors are understood to be constrained bycash flow difficulties. The cash flow shortages subsequently impacted the acquisition of imported raw materials. This was further constrained by shortage of local raw materials like cotton and hides.

Foodstuffs

The Foodstuffs manufacturing sub-sector is not spared by the lack of credit access, which further constrained the ability of this sector to re-tool and value add. A lack of value addition opened up fierce competition from imports, especially from South Africa. The few competitive firms had a barrier emanating from the shortages of local raw materials.

Metals

The ubiquitous cash flow difficulties did not spare efficient operations of this manufacturing sub-sector which lacks credit lines and is compounded by low domestic demand. Local raw materials became a barrier because of obsolete machinery despite being locally extractive.

Non-Metallic

Efficiency in this manufacturing sub-sector was affected by difficulties in cash flows and shortage of local raw materials. Its national sales were also affected as high price was not an incentive to cusomers.

Paper Printing and Publishing

Machinery spare parts shortages are a barrier in Paper Printing and Publishing manufacturing sub-sector, compounded by liquidity problems to acquire local raw materials. Transport problems were indicated as a barrier to achieving efficiency as the raw materials are bulk. Imported raw materials were largely delayed at the ports of entry, whilst local raw materials came from Manicaland Province which has bad roads.

Wood and Furniture

Locally available raw materials were constraining the Wood and Furniture manufacturing sub-sector. The local raw materials were being depleted by tobacco farmers who harvest timber for tobacco curing. Obsolete machines are also a barrier to efficiency in this sector, in addition to the low domestic demand and constrained cash flows.

The above interview results were supported by the Business Tendency Survey (BTS) (2015: 10) which was carried out by ZIMSTAT. The BTS (2015: 3-10) concluded that the three major constraints faced bymanufacturing groups were cash flowdifficulties, weak domestic market demand andheavy competition abroad.

9.15 ZNCC qualitative analysis

The Vice President of the Zimbabwe National Chamber of Commerce, said opportunities for investment in Matebeleland (in general) and Bulawayo (in particular) for South African businesspeople were in abundance. These include the manufacturing sector which she said was currently operating at reduced capacity, by investing in distressed existing companies; expansion of the tourism infrastructure through new investments and joint ventures with existing players; mining; agriculture; transport and information and communication technology sectors.The Government estimates US$1 billion is required to revive industry in the country’s second largest city, Bulawayo. This figure tells one that Matabeleland presents several investment opportunities for foreign investors.“We invited South African businesspeople to partner with us in various sectors as we continue on our Economic Growth Path,” said The Vice President of the Zimbabwe National Chamber of Commerce.

9.16 ZIA qualitative analysis

The Chief Executive Officer of the Zimbabwe Investment Authority said: "After about over a decade of economic decline, there has been a serious deterioration in the state of infrastructure in Zimbabwe. Government recognises the need for private sector participation in financing and development of infrastructure. It also acknowledges the important role of the private sector in financing infrastructure development. The private sector is therefore welcome to participate in the development and provision of infrastructure on a public private partnership (PPP) basis."

9.17 CZI/ Buy Zimbabwe/Ministry of Industry and Trade qualitative analysis

The industrial body CZI conducts an annual survey of industrial development and its manufacturing report is the most comprehensive private sector-led survey which assesses industrial performance.

At least 15 economic sub-sectors are surveyed, amongst them clothing and textile, pharmaceuticals, grain and milling and oil, as well as other industrial manufacturing activities.CZI said a combined 65.7% of industrial capacity utilisation was idle in 2015: 2.2 percentage points up from 63,5% in 2014 after more firms failed due to power cuts and difficulties in accessing working capital and expansion from internal and offshore sources.

CZI president, contends that hostile policies such as the indigenisation law have worsened an already bad investment climate and aggravated resentment by business over the status quo. This has the effect of repelling foreign direct investment inflows (FDI) and keeping lenders on the edge.CZI chief economist, said businesses in the country had not been viable, with only about 5% indicating viability. Over 60% were facing stiff competition from both local and international products.

Buy Zimbabwe chief economist, said the decline reflects the messy state of the economy. "*This is just confirming reality, companies are suffering and this is shown by the continued decline in capacity utilisation*." he said. "The decline in capacity utilisation and the rate at which it is declining shows the economy has reached a plateau."

Ministry of Industry and Commerce minister, said the government had put in place several measures to help industries avoid collapse. "*There are things that we have done, but we will not see instant results*," he said.

9.18 Conclusion

The chapter conclusively discussed the research results in addressing the study objectives. The results were linked to existing literature results of other scholars. In instances were results differed much from the expected, the researcher attempted to explain the possible reasons.

CHAPTER TEN

CONCLUSIONS AND RECOMMENDATIONS

10.1Introduction

This chapter provides a brief summary of the study that was conducted and reviews the results in relation to prior studies. This chapter presents the summary, the research conclusions and the recommendations. This final chapter recaps the research problem tackled;the literature that supports efficiency in the manufacturing sector;the research methodology utilised to meet the research objectives and its limitations; major findings of the study; and their implications for practice in salvaging the decimation of Zimbabwe's manufacturing sector.

Wan and Morgan (2017: 2) and Su and Yao(2017: 47) detailed that the manufacturing sector tends to pull along all other sectors, including the extractive and services sectors. Therefore, a decline in the growth rate of the manufacturing sector will negatively affect the growth of all other sectors. This decline can be salvaged by applying efficient production strategies, which have been suggested by this study.However, despite the evidence that the manufacturing sector is a major driver to national and global economic growth, efficiency in the Zimbabwean manufacturing sector has not been adequately analysed. This research has therefore provided some insightful findings, as summarised below:

10.2Summary of the study

The study investigated and analysed how the manufacturing efficiency framework can be used to salvage the declining manufacturing output in Zimbabwe. Besides providing possible options of improving the efficiency of the manufacturing sector, the study also extended the existing knowledge of efficiency models by recommending the use of sectorial efficiency levels generated from Data Enveloping Analysis (DEA) scores. Financial ratios are currently a standard way of measuring corporate efficiency, which uses historical values and not the real input-output relationship (frontier). The use of these accounting-based financial ratios to measure firm performance has been criticized by Cummins and Weiss (2013: 795). For instance, accounting data ignores the current market value of manufacturing firms and does not include economic value-maximizing behaviour (Avkiran 2011: 323). Additionally, these financial ratios do not consider the input - output mix and its value does not compare firms across the sector (Fethi and Pasiouras 2010: 189). However, this study recommends harmonised disclosure of efficiency ratios to augment traditional financial ratios. Therefore, in summary, the aim of the study was to analyse the efficiency levels of the manufacturing sector in Zimbabwe.

The problem statement of this study is that despite the significant contribution that the manufacturing sector can make to the Zimbabwean economy, the efficiency of the firms in the sector has been on the decline, as stated by Bond (1998: 31) and CZI (2013: 10). Manufactured exports declined progressively from US$853.3 million in 2001 to US$210.3 million by 2008 (Kanyenze, Kondo, Chitambara and Martens 2011: 143). Against the backdrop of the overall economic slowdown, the results of the CZI (2013:2) reveal slackening economic activity as overall capacity utilization has continued declining from 44.9% in 2012 to 39.6% in 2013. Large efficiency variations still exist in the sector and performance has not improved significantly (UNDP 2010; Kanyenze *et al.* 2011: 482). Although the economy has stabilized and started to grow in the dollarized era, the efficiency and contribution of the manufacturing sector has not improved. Marongwe (2010: 24-32) attested that capacity utilization of manufacturing firms has remained below 40%, despite the stabilization of the economy after2008. A number of firms remain closed and a number of former workers remain unemployed (CZI 2013: 8). The CZI (2013: 1) indicates that capacity utilisation of the manufacturing sector continues to drop as firms are now operating on average between 10%-48%, which is a decline from 60% in the 1990s. Kanyenze *et al.* (2011: 482) argue that restoration of performance of the manufacturing sector has remained one of the key priorities of the Government of Zimbabwe in the post-dollarized period.

In order to ground the objectives of the study, a detailed literature review that focuses on theoretical literature and the works of other authors on efficiency in general and efficiency in the manufacturing sector, both in Zimbabwe and outside Zimbabwe, has been interrogated. Inefficiency is not a problem to the Zimbabwean manufacturing sector alone, other regional and global countries have faced and or are facing the same.Egilmez, Kucukvar, and Tatari (2013: 91) carried out an input-output frontier approach for the US manufacturing sectorand surprisingly,approximately 90% of these sectors were found to be inefficient using a DEA approach.

This mixed method design, which gives the smallest error, is the best design in many investigations. A design which minimises bias and maximises the reliability of the data collected yields maximal information. This provide an opportunity for considering many different aspects of the efficiency problem in Zimbabwe is therefore considered to be the most appropriate and efficient design. According to Bechhofer and Paterson (2012: 167), the fundamental principle of mixed research involves combining quantitative and qualitative methods, approaches and concepts that have complementary strengths and non-overlapping weaknesses.

10.3 Key findings, conclusions and implications

The important findings, conclusions and implications infered from the study hinges on the main research objectives. Findings on all the ten manufacturing sub-sectors in Zimbabwe has been summarized under the two assumptions of CRS and VRS. The research objectives of the study were:

To determine the drivers of efficiency in Zimbabwe's manufacturing sector;

i. To compare financial ratios with efficiency ratios in the input-output model in order to identify the levels and kinds of inefficiencies in Zimbabwe's manufacturing sector;

ii. To measure efficiency in Zimbabwe's manufacturing sector using production plans of the efficient scores;

iii. To identify the barriers to achieving efficiency levels in Zimbabwe's manufacturing sector; and

iv. To develop an efficiency model that will recommend an efficient input-output usage in Zimbabwe's manufacturing sector.

10.3.1 Beverages and Tobacco manufacturing sub-sector under CRS and VRS

This sector was analysed under the assumptions of CRS and VRS in line with the study objectives. The analysis was narrated to include the literature findings, study findings and the conclusions and implications of the results.

7.3.1.1 Study findings

Under CRS, in the Beverages and Tobacco sub-sector of the manufacturing sector, 48% of the DMUs are efficient and 52% are inefficient. At least 57% of the DMUs are operating above the average efficiency of 88%, whereas 43% of the DMUs are struggling below the average efficiency level. Overall analysis shows that input CM is the major driver of efficiency in the **Beverages and Tobacco** manufacturing sub-sector. Output variable **VA** is the major barrier to efficiency in the **Beverages and Tobacco** manufacturing sub-sector.

Under VRS, in the Beverages and Tobacco sub-sector of the manufacturing sector, 67% of the DMUs are efficient and 33% are inefficient. At least 71% of the DMUs are operating above the average efficiency of 94% whereas 29% of the DMUs are struggling below the average efficiency level. Overall analysis shows that input **CM** is the major driver of efficiency in the **Beverages and Tobacco** manufacturing sub-sector. Output variable **VA** is the major barrier to efficiency in the **Beverages and Tobacco** manufacturing sub-sector.

7.3.1.2Conclusions and implications

Less than half of the DMUs are operating efficiently and this is not a healthy situation for an economy. There is need for recapitalisation of these firms by inviting new investors who can inject fresh capital. This sector is also seasonal, especially the tobacco manufacturing firms and therefore they should build alternative plans for the premises in off-season. Since the efficiency level increases to 94% in the VRS from 88% in CRS, the DMUs should employ VRS production strategies. This will make the firms improve efficiency by 6%. Value addition is the output variable which is a major barrier and there the government can foster value addidtion and beneficiation through its ZIMASSET blueprint. For instance tobacco, has good sales exported abroad. However, the full benefits are not being realised as the product is being exported in raw form or is semi-processed. Recently,Gold Leaf Tobacco Zimbabwe country manager, said the company had managed to gain considerable market share through value addition and beneficiation. He said the company was also considering setting up a plant in Zimbabwe, as well as exploring the entire region and the Common Market for Eastern and Southern (COMESA) trading bloc."*We are already setting out plans to set-up a plant next year. At the moment, we cannot say how much we will invest for competitive strategy but I promise that we will definitely come*". he said.

10.3.2 Chemical and Petroleum Products sub-sector under CRS and VRS

This sector was analysed under the assumptions of CRS and VRS in line with the study objectives. The analysis was narrated to include the literature findings, study findings and the conclusions and implications of the results.

7.3.2.1 Study findings

Under CRS, in the Chemical and Petroleum Products sub-sector of the manufacturing sector, 43% of the DMUs are efficient and 57% are inefficient. At least 62% of the DMUs are operating above the average efficiency of 83%, whereas 38% of the DMUs are struggling below the average efficiency level. Overall analysis shows that **output variable SLS** is the major driver of efficiency in the **Chemicals and Petroleum Products** manufacturing sub-sector. Output variable **VA** is the major barrier to efficiency in the **Chemicals and Petroleum Products** manufacturing sub-sector.

Under the VRS, in the Chemical and Petroleum Products sub-sector of the manufacturing sector, 67% of the DMUs are efficient and 33% are inefficient. At least 71% of the DMUs are operating above the average efficiency of 94%, whereas 29% of the DMUs are struggling below the average efficiency level. Overall analysis shows that **output variable SLS** is the major driver of efficiency in the **Chemicals and Petroleum Products** manufacturing sub-sector. Output variable **VA** is the major barrier to efficiency in the **Chemicals and Petroleum Products** manufacturing sub-sector.

7.3.2.2 Conclusions and implications

Technology has greatly hampered efficiency in the Chemicals and Petroleum Products manufacturing sector in Zimbabwe. This sector is hi-tech and Zimbabwe is left stocked with outdated and obsolete machinery. The high appetite for chemicals and petroleum has managed to improve the performance in the sector. Therefore, it is important to continue promoting sales volume and invest in machinery for value addition.

This implies looking for large markets abroad and also finding new investors for capital in order to replenish capital stock. This implies that ZIA and the Ministry of Industry and Trade should salvage decimation in this sector through finding investor partners and forge bilateral agreements for the chemical and petroleum market. The government should also come in and offer concessionary loans and benefits to this sector as it offers services to the other manufacturing firms, especially energy through fuels.

Sales as a major driver is also supported by The Herald newspaper of 14 March 2016, which reported that Zimbabwe's economy in 2015 imported on average US$100 million of petroleum products a month, making it the most traded commodity. One of the petroleum company, ZUVA boasted of providing the widest range of petroleum products of about 11 brands. They have over 72 retail service stations and in 2015, it was honoured on Overal Highest Compliant in the Excise Duty Category.

10.3.3 Clothing and Footwear sub-sector under CRS and VRS

This sector was analysed under the assumptions of CRS and VRS in line with the study objectives. The analysis was narrated to include the literature findings, study findings and the conclusions and implications of the results.

7.3.3.1 Study findings

Under CRS, in the Clothing and Footwear sub-sector of the manufacturing sector, 5% of the DMUs are efficient and 95% are inefficient. At least 33% of the DMUs are operating above the average efficiency of 22%, whereas 67% of the DMUs are struggling below the average efficiency level. Overall analysis shows that **output variable GVP** is the major driver of efficiency in the **Clothing and Footwear** manufacturing sub-sector. Output variable **VA** is the major barrier to efficiency in the **Clothing and Footwear** manufacturing sub-sector.

Under VRS, in the Clothing and Footwear sub-sector of the manufacturing sector, 19% of the DMUs are efficient and 81% are inefficient. At least 38% of the DMUs are operating above the average efficiency of 48%, whereas 62% of the DMUs are struggling below the average efficiency level. Overall analysis shows that **input variable E** is the major driver of efficiency in the **Clothing and Footwear** manufacturing sub-sector. Output variable **VA** is the major barrier to efficiency in the **Clothing and Footwear** manufacturing sub-sector.

7.3.3.2 Conclusions and implications

The findings imply that cost management is key in the Clothing and Footwear manufacturing sub-sector. Energy is a major driver of efficiency because production will get to a stand still as many machines in this sector are electricity powered. Zimbabwe Clothing Manufacturers

Association chairman, said there was rampant tax evasion by importers, incorrect application of duties by regulatory authorities, as well as a general culture to prefer imports over local products."*Our main threats remain the inability to control the imports of clothing and ensure the correct duties are paid*," Zimbabwe Clothing Manufacturers Association chairman told a parliamentary committee on industry and commerce.He said under-invoicing, abuse of trade agreements, corruption and dumping of second-hand clothing was rampant, which was affecting growth in the sector. This implies that a tight government policy should be enacted to curb this menace. In order to keep pace with value addition, **Clothing and Footwear** manufacturing firms should hold more Clothing Indabas locally and internationally where they can learn and share trending innovations.

10.3.4 Foodstuffs sub-sector under CRS and VRS

This sector was analysed under the assumptions of CRS and VRS in line with the study objectives. The analysis was narrated to include the literature findings, study findings and the conclusions and implications of the results.

7.3.4.1 Study findings

Under CRS, in the Foodstuffs sub-sector of the manufacturing sector, 24% of the DMUs are efficient and 76% are inefficient. At least 43% of the DMUs are operating above the average efficiency of 69%, whereas 57% of the DMUs are struggling below the average efficiency level. Overall analysis shows that **input variable CM** is the major driver of efficiency in the **Foodstuffs** manufacturing sub-sector. Output variable **VA** is the major barrier to efficiency in the **Foodstuffs** manufacturing sub-sector.

Under VRS, in the Foodstuffs sub-sector of the manufacturing sector, 62% of the DMUs are efficient and 38% are inefficient. At least 62% of the DMUs are operating above the average efficiency of 88%, whereas 38% of the DMUs are struggling below the average efficiency level. Overall analysis shows that **input variable CM** is the major driver of efficiency in the

Foodstuffs manufacturing sub-sector. Output variable **VA** is the major barrier to efficiency in the **Foodstuffs** manufacturing sub-sector.

7.3.4.2 Conclusions and implications

The study found that cost of raw material is the major driver of efficiency in the Foodstuffs manufacturing sub-sector, despite the overall efficiencybeing relatively lowly ranked at 69% under CRS and 88% under VRS. The implication is that Zimbabwe's extractive and agricultural sectors are not performing well, despite them being supposed to offer much needed raw materials. Intense value addition is also needed at all levels of the value chain in the Foodstuffs sector as this will offer a trickle down effect to continue sustaining the raw material providing sectors. The government can come in handy by offering managed subsidies mainly to the agricultural sector outputs with large linkages to the Foodstuffs manufacturing sub-sector.

10.3.5 Metals sub-sector under CRS and VRS

This sector was analysed under the assumptions of CRS and VRS in line with the study objectives. The analysis was narrated to include the literature findings, study findings and the conclusions and implications of the results.

7.3.5.1 Study findings

Under CRS, in the Metals sub-sector of the manufacturing sector, 38% of the DMUs are efficient and 62% are inefficient. At least 52% of the DMUs are operating above the average efficiency of 68%, whereas 48% of the DMUs are struggling below the average efficiency level. Overall analysis shows that **input variable CM** is the major driver of efficiency in the **Metals** manufacturing sub-sector. Output variable **VA** is the major barrier to efficiency in the **Metals** manufacturing sub-sector.

Under VRS, in the Metals sub-sector of the manufacturing sector, 57% of the DMUs are efficient and 43% are inefficient. At least 62% of the DMUs are operating above the average efficiency of 86%, whereas 38% of the DMUs are struggling below the average efficiency level. Overall analysis shows that **input variable CM** is the major driver of efficiency in the **Metals** manufacturing sub-sector. Output variable **VA** is the major barrier to efficiency in the **Metals** manufacturing sub-sector.

7.3.5.2 Conclusions and implications

Cost of materials is a major driver in this sector and also a major conclusion is on the need to value add the metal manufacturing sub-sector. The study's literature confirms that small to medium metal manufacturing firms have increased. These are mainly informal and thus pose a threat to government when it comes to instituting efficiency policies. This implies that the government,through the relevant ministries, financial institutions and the private sector, should examine the possibility of accommodating informal metal manufacturing enterprises in the country. In solving the cost of material barriers, they can implement a co-operative buying for all the firms in the sector. This will give the firms much bargaining power and credit facilities and subsequently, much needed efficiency.However,Makate, Siziba, Hanyani-Mlambo, Sadomba and Mango (2016:247)reiterated that such integration should not entail formalising all their activities, as this would deprive them of their current benefits (e.g. low costs) and increase the chances of firm closure. The government also needs to promote competition in the industry by keeping barriers to entry and exit low.

10.3.6 Non-Metallic Mineralssub-sector under CRS and VRS

This sector was analysed under the assumptions of CRS and VRS in line with the study objectives. The analysis was narrated to include the literature findings, study findings and the conclusions and implications of the results.

7.3.6.1 Study findings

Under CRS, in the Non-Metallic Minerals sub-sector of the manufacturing sector, 33% of the DMUs are efficient and 67% are inefficient. At least 48% of the DMUs are operating above the average efficiency of 74%, whereas 52% of the DMUs are struggling below the average efficiency level. Overall analysis shows that **input variable CM** is the major driver of efficiency in the **Non-Metallic Minerals** manufacturing sub-sector. Output variable **VA** is the major barrier to efficiency in the **Non-Metallic Minerals** manufacturing sub-sector.

Under VRS, in the Non-Metallic Minerals sub-sector of the manufacturing sector, 48% of the DMUs are efficient and 52% are inefficient. At least 67% of the DMUs are operating above the average efficiency of 83% whereas 33% of the DMUs are struggling below the average efficiency level. Overall analysis shows that **output variable SLS** is the major driver of efficiency in the **Non-Metallic Minerals** manufacturing sub-sector. Input variable **WS** is the major barrier to efficiency in the **Non-Metallic Minerals** manufacturing sub-sector.

7.3.6.2 Conclusions and implications

This was one of the rare sectors where water and sewerage services are a major barrier in the manufacturing sector. Sales output is the major driver, which is competing with imports from China. This implies that the government can enact a Statutory Instrument to protect this sector from this fierce competition. In today's globally competitive environment, Non metallic firms in Zimbabwe require the best technologies for mineral processing operations and an experienced supplier who can implement them safely and effectively. Chemplex, one of the firms in Zimbabwe has been affected by downtime of machinery, electricity outages and largely by shortage of raw materials constrained by foreign currency problems.

10.3.7 Paper Printing and Publishing sub-sector under CRS and VRS

This sector was analysed under the assumptions of CRS and VRS in line with the study objectives. The analysis was narrated to include the literature findings, study findings and the conclusions and implications of the results.

7.3.7.1 Study findings

Under CRS, in the Paper Printing and Publishing sub-sector of the manufacturing sector, 57% of the DMUs are efficient and 43% are inefficient. At least 62% of the DMUs are operating above the average efficiency of 81%, whereas 38% of the DMUs are struggling below the average efficiency level. Overall analysis shows that **input variable S** is the major driver of efficiency in the **Paper Printing and Publishing** manufacturing sub-sector. Output variable **VA** is the major barrier to efficiency in the **Paper Printing and Publishing** manufacturing sub-sector.

Under VRS, in the Paper Printing and Publishing sub-sector of the manufacturing sector, 71% of the DMUs are efficient and 29% are inefficient. At least 76% of the DMUs are operating above the average efficiency of 91%, whereas 24% of the DMUs are struggling below the average efficiency level. Overall analysis shows that **input variable S** is the major driver of efficiency in the **Paper Printing and Publishing** manufacturing sub-sector. Output variable **VA** is the major barrier to efficiency in the **Paper Printing and Publishing** manufacturing sub-sector.

7.3.7.2 Conclusions and implications

This study concludes that the cost of services are exorbitant in this manufacturing sector. The government should come in and institute control measures that put a cap on the pricing of utilities which are too high for manufacturing companies. These utilities include water, electricity and communication. The research showed the impact of these manufacturing utilities too. Goriwondo, Mhlanga and Mutsambwa (2013: 2-6) has shown that most manufacturing companies in Zimbabwe are being weighed down by high utility bills and in some cases, the bills were arbitrarily charged, making it expensive for organisations to run meaningful businesses.

10.3.8 Textiles sub-sector under CRS and VRS

This sector was analysed under the assumptions of CRS and VRS in line with the study objectives. The analysis was narrated to include the literature findings, study findings and the conclusions and implications of the results.

7.3.8.1 Study findings

Under CRS, in the Textiles sub-sector of the manufacturing sector, 10% of the DMUs are efficient and 90% are inefficient. At least 19% of the DMUs are operating above the average efficiency of 26%, whereas 81% of the DMUs are struggling below the average efficiency level. Overall analysis shows that **input variable E** is the major driver of efficiency in the **Textiles** manufacturing sub-sector. Output variable **VA** is the major barrier to efficiency in the **Textiles** manufacturing sub-sector.

Under VRS, in the Textiles sub-sector of the manufacturing sector, 24% of the DMUs are efficient and 76% are inefficient. At least 48% of the DMUs are operating above the average efficiency of 53%, whereas 52% of the DMUs are struggling below the average efficiency level. Overall analysis shows that **input variable E** is the major driver of efficiency in the **Textiles** manufacturing sub-sector. Output variable **VA** is the major barrier to efficiency in the **Textiles** manufacturing sub-sector.

7.3.8.2 Conclusions and implications

Zimbabwe's textile industry has been under threat from second-hand clothes and Chinese textile. Despite these challenges, the Textile manufacturing sub-sector can get 'infancy' support from the government, which can regulate the influx of second-hand clothes. Whether or not Zimbabwe can survive as an important exporter and raise its market share will depend on ability to use the local raw material base effectively; raise technological levels and skills through the industry; develop better marketing techniques; and move into specialized high-quality marketing niches(ZEPARU 2014: 17). It was also observed that there was the possibility of firms exporting their skills and know-how to less industrialized economies around them. In other words, this would entail partnering with firms in these economies for mutual benefit, including market penetration. ZEPARU (2014: 17) noted that energy, water and transport form significant proportions of their cost drivers when they are available. Service provision of some of these is irregular, unreliable, costly and risky. This made sales variables cause inefficiency as prices become uncompetitive on both domestic and foreign markets. Supported by the research results, the Textile manufacturing sub-sector has obsolete plants, machinery and equipment which is inefficient; constantly breaks down; need for lots of spares and replacing.

10.3.9 Transport and Transport Equipment sub-sector under CRS and VRS

This sector was analysed under the assumptions of CRS and VRS in line with the study objectives. The analysis was narrated to include the literature findings, study findings and the conclusions and implications of the results.

7.3.9.1 Study findings

Under CRS, in the Transport and Transport Equipment sub-sector of the manufacturing sector, 43% of the DMUs are efficient and 57% are inefficient. At least 57% of the DMUs are operating above the average efficiency of 78%, whereas 43% of the DMUs are struggling below the average efficiency level. Overall analysis shows that **input variable CM** and output variable **GVP**are both the major driver of efficiency in the **Transport and Transport Equipment** manufacturing sub-sector. Output variable **VA** is the major barrier to efficiency in the **Transport and Transport Equipment** manufacturing sub-sector.

Under VRS, in the Transport and Transport Equipment sub-sector of the manufacturing sector, 48% of the DMUs are efficient and 52% are inefficient. At least 67% of the DMUs are operating above the average efficiency of 85%, whereas 33% of the DMUs are struggling below the average efficiency level. Overall analysis shows that output variable **GVP**is the major driver of efficiency in the **Transport and Transport Equipment** manufacturing sub-sector. Output variable **VA** is the major barrier to efficiency in the **Transport and Transport Equipment** manufacturing sub-sector.

7.3.9.2 Conclusions and implications

Zimbabwe's Chartered Institute of Logistics and Transport (CILT) agreed that innovative and cost-effective solutions to congestion, safety and travel behaviour change are necessary to improve efficiency in the **Transport and Transport Equipment** manufacturing sub-sector. The actual production less intermediate consumption catalysed efficiency in the **Transport and Transport Equipment** manufacturing sub-sector. This was commendable but surprisingly, value addition was a barrier. This could be that in this sector it is a replacement, as parts and kits are bought for replacement. The current investment laws in Zimbabwe allow for a maximum of 35% foreign ownership in the transport sector and this might hamper investors with funds to build machinery for value addition. Saungweme (2013:11) showed that the **Transport and Transport Equipment** manufacturing sub-sector is heavily regulated, with more than four associations which increases services costs.

10.3.10 Wood and Furniture sub-sector under CRS and VRS

This sector was analysed under the assumptions of CRS and VRS in line with the study objectives. The analysis was narrated to include the literature findings, study findings and the conclusions and implications of the results.

7.3.10.1 Study findings

Under CRS, in the Wood and Furnituresub-sector of the manufacturing sector, 48% of the DMUs are efficient and 52% are inefficient. At least 57% of the DMUs are operating above the average efficiency of 82%, whereas 43% of the DMUs are struggling below the average efficiency level. Overall analysis shows that **input variable CM** is the major driver of efficiency in the **Wood and Furniture** manufacturing sub-sector. Output variable **VA** is the major barrier to efficiency in the **Wood and Furniture** manufacturing sub-sector.

Under VRS, in the Wood and Furniture sub-sector of the manufacturing sector, 62% of the DMUs are efficient and 38% are inefficient. At least 67% of the DMUs are operating above the average efficiency of 85%, whereas 33% of the DMUs are struggling below the average efficiency level. Overall analysis shows that **output variable SLS** is the major driver of efficiency in the **Wood and Furniture** manufacturing sub-sector. Output variable **VA** is the major barrier to efficiency in the **Wood and Furniture** manufacturing sub-sector.

7.3.10.2 Conclusions and implications

Despite the fact that the **Wood and Furniture** manufacturing sub-sector has its sales driving efficiency, it is facing stiff competition from South African and Chinese furniture products. The research found that the cost of raw materials is driving the Wood and Furniture manufacturing sub-sector as timber is abundant in Zimbabwe's Manicaland province which is constrained by bad roads. Innovation for value addition is implied in the global village and Zimbabwe is not an exception. To support the result of value addition as a barrier, Sibanda (2012: 30-56) found that entrepreneurs involved in the manufacture of wood products argued that there was need for them to get access to new technology so that they can manufacture quality and many products. However, it was very encouraging to note that SMEs in Zimbabwe's Mashonaland Central were using some machines in their operations

10.3.11 Overall Manufacturing sector under CRS and VRS

The overall manufacturing sector was analysed under the assumptions of CRS and VRS in line with the study objectives. The analysis was narrated to include the literature findings, study findings and the conclusions and implications of the results.

7.3.11.1 Study findings

Under CRS, the overal average efficiency score for Zimbabwe's manufacturing sector is 67.1% under CRS. It can be deduced that 34.9% in the whole manufacturing sector is efficient under CRS. The input variable that is a major driver of efficiency in the manufacturing sector is CM, under CRS. The output variable which is a major driver of efficiency in the manufacturing sector is SLS, under CRS. It can be concluded that under CRS assumption, 6 out of 10 manufacturing sub-sectors has CM as the major driver of efficiency. The input variable which is a major barrier to efficiency in the manufacturing sector is S, under CRS. The output variable which is a major barrier to efficiency in the manufacturing sector is VA, under VRS. It can be concluded that under a VRS assumption, output variable VA is the major barrier to efficiency in the manufacturing sector.

Under VRS, the overal average efficiency score for the Zimbabwe's manufacturing sector is 80.2% under VRS. It can be deduced that 52.5% of the whole manufacturing sector is efficient, assuming VRS. The input variable which is a major driver of efficiency in the manufacturing sector is CM, under VRS. The output variable which is a major driver of efficiency in the manufacturing sector is SLS, under VRS.Under VRS, variables CM and SLS tops as the major drivers of efficiency in the manufacturing sub-sectors. The input variable which is a major barrier to efficiency in the manufacturing sector is S, under a VRS. The output variable which is a major barrier to efficiency in the manufacturing sector is VA, under VRS. It can be concluded that under VRS assumption, output variable VA is the major barrier to efficiency in the manufacturing sector.

The study did not have any restrictions on the methodology used. The findings are free from limitations and this means that these findings can be generalized to any other sectors in Zimbabwe.

10.4Recommendations of the study

According to the findings of the study and based on the conclusions drawn above, the study came up with several recommendations offered to government and the ten manufacturing sub-sectors. They are described below:

10.4.1 To government and policy makers

The government of Zimbabwe, through its different arms that affect policy in the manufacturing sector can use these findings to influence efficiency in the sector. This can be done at the sub-sectorial level as follows:

- ✓ Government should establish an efficiency framework for the manufacturing sector.
- ✓ An efficiency model to assist struggling manufacturing firms should be established.
- ✓ The Government must advocate for the compulsory publication of financial ratios, together with efficiency ratios.
- ✓ All manufacturing firms should have an Efficiency Officer.

The introduction of efficiency systems and procedures in line with the efficiency results in the manufacturing DMUs would ensure efficiency in production and adherence to efficiency practices.

10.4.2 To the Management of manufacturing firms

This study is a dossier to the management of different firms in different manufacturing sub-sectors. The Management can learn the following efficiency issues:

- ✓ Identify efficiency drivers in their manufacturing sub-sector and the contribution of each input and output variables to efficiency.
- ✓ Identify efficiency barriers in their manufacturing sub-sector and the contribution of each input and output variables to efficiency.
- ✓ Define the source of inefficiency and the the size of improvement needed to become efficient.
- ✓ Rank firm performance against that of their peers in the same sector.

10.5 Areas of further research

While the research has contributed to closing the gap in the literature on the barriers and drivers of efficiency in Zimbabwe's manufacturing sector by offering disclosure as a solution, it also opened avenues for further research on related matters.

The study was restricted to the manufacturing sector so further research can be inferred to other sectors for instance mining or other DMUs. Hence, the research can be used as a knowledge base to investigate the possibility of salvaging the decimation in Zimbabwe's manufacturing sector.

Information from this study can also be valuable in conducting research that assesses the efficiency of manufacturing sectors or any related sector and DMUs in Southern Africa, even using alternative methods. A country sectorial comparison can be done and trade patterns learnt from the analysis.

10.6 Conclusion

There is limited research ondeveloping countries, particularly in Africa, regarding efficiency measurement and improvement using non-parametric approaches. Therefore, this study provides an invaluable contribution on how the efficiency of themanufacturing sector in Zimbabwe can be improved.The non-parametric method used to identify the drivers of efficiency on performance of the manufacturing sector in Zimbabwe will be used to propose guidelines for disclosure of firm efficiency scores together with accounting ratios, as the analysis can assist in salvaging declining manufacturing output in Zimbabwe. If the declining manufacturing output is salvaged, then Zimbabwe will attain a steady economic growth. This study managed to identify the barriers and drivers of efficiency in Zimbabwe’s manufacturing sector.

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APPENDIX A: LETTER OF INFORMATION AND CONSENT FOR RESEARCH INSTRUMENTS AT ZIMSTAT

Bindura University of Science Education

P. Bag 1020

Bindura

c/o Durban University of Technology

9 September 2014

LETTER OF INFORMATION AND CONSENT FOR RESEARCH INSTRUMENTS

RE: Post graduate studies in Doctor of Philosophy: Public Management.

Dear ZIMSTAT

My name is David Damiyano and I am currently a Doctor of Philosophy: Public Management student at the Durban University of Technology- student number 21451838. My research topic is “Analysis of the efficiency levels of the manufacturing sector in Zimbabwe.” My supervisor is Prof Nirmala Dorasamy. The study is meant to investigate theefficiency levels in the Zimbabwe’s manufacturing sector. The aim is to suggest ways to improve efficiency levels and subsequently salvage the declining manufacturing output in the sector. The study will guide the government on the efficiency levels necessary in the manufacturing subsectors.

Participation is voluntary and you are free to withdraw from the study at any time without giving reasons and without prejudice or any adverse consequences. You may also be withdrawn from the study in cases of non- compliance, illness and adverse reactions. Participants will not receive any monetary or other types of remuneration or cover any costs towards the study. The information you will give will be used only for research purposes and will be aggregated with other responses and only the overall information will be used. Your identity and individual answers will be kept totally confidential.

Should you have any queries please feel free to contact the researcher (David Damiyano, davydamex@yahoo.co.uk, cellphone number +263 77 7108 147), my supervisors (Prof Dorasamy, nirmala@dut.ac.za, on cellphone number +27 722678704 and Dr Garbharran, garbharranhl@dut.ac.za on cellphone number +27 82673192) or the Institutional Research Ethics administrator at Durban University of Technology on +27 31 373 2900. Complaints can be reported to the DVC: TIP, Prof F. Otieno on +27 31 373 2382 or dvctip@dut.ac.za.

Your cooperation will be greatly appreciated.

Yours faithfully

David Damiyano

[redacted]

+263 777 108 147

davydamex@yahoo.co.uk

APPENDIX B: LETTER OF PERMISSION GRANTED

Zimbabwe National Statistics Agency

All communications should be addressed to
"THE DIRECTOR- GENERAL"
P.O. Box CY342,
Causeway,
Harare
Zimbabwe
Telephone No. +263 4 706681-8 / +263 4 703971-7
Fax No. . . . +263 4 762494
E-mail: dg@zimstat.co.zw

16 January 2015

Durban University of Technology (DUT)
Faculty of Management Sciences
Department of Public Management and Economics

REF: PERMMISSION TO USE ZIMSTAT STATISTICS

The bearer, Mr David Damiyano, is a PhD student with the Durban University of Technology (DUT) and is carrying out a research project titled 'Analysis of the Efficiency Levels of the Manufacturing Sector in Zimbabwe'.

This letter serves to confirm that I the undersigned Manager for Industry, Mining and Energy Statistics at Zimbabwe National Statistics Agency (ZIMSTAT) have provided published and other statistics to Mr Damiyano, the researcher, relevant to his study.

The researcher can use his own questionnaire to collect other data through interviews and focus group discussions from sources of his own if he wishes to validate the data.

According to the Census and Statistics Act, ZIMSTAT will not provide the researcher with any name(s) of its data sources as this is in violation of the confidentiality provisions of the Act.

Yours faithfully

[redacted]

Godfrey Makware
For: DIRECTOR – GENERAL, ZIMSTAT

ZIMSTAT
REGISTRY
16 JAN 2015
P.O. BOX CY 342, CAUSEWAY
ZIMBABWE TEL: 04-706681-7

APPENDIX C: GATEKEEPERS LETTER

Bindura University of Science Education

P. Bag 1020

Bindura

c/o Durban University of Technology

10 June 2015

GATEKEEPERS LETTER REQUESTING PERMISSION TO CARRY OUT RESEARCH

RE: Post graduate studies in Doctor of Philosophy: Public Management

Dear Participant

My name is David Damiyano and I am currently a Doctor of Philosophy: Public Management student at the Durban University of Technology- student number 21451838. My research topic is “Analysis of the efficiency levels of the manufacturing sector in Zimbabwe.” My supervisor is Prof Nirmala Dorasamy. The study is meant to investigate theefficient levels in Zimbabwe’s manufacturing sector. The aim is to suggest ways to improve efficiency levels and subsequently production in the sector. The study will guide the government on the efficiency levels necessary in any manufacturing subsectors.

I hereby request for permission to carry out this research in your organization. Should you have any queries please feel free to contact the researcher or the Project Supervisor, Prof Nirmala Dorasamy, Telephone number +**27 722678704**.

I will be grateful to your assistance.

Yours faithfully

David Damiyano

[redacted]

+263 77 7108147

davydamex@yahoo.co.uk

Please complete the following as confirmation of your willingness to participate in this research project:

I, ______________________________________, have adequately discussed the study with the researcher, understand that I may withdraw from it at any time without giving reasons, and I voluntarily agree to participate in it.

________________________ ___________ _______

Full Name of Participant **Date** **Signature**

David Damiyano ___________

[redacted]

Full Name of Researcher **Date** **Signature**