TOTAL FACTOR PRODUCTIVITY CHANGE IN THE KENYAN MANUFACTURING SECTOR: A MALMQUIST INDEX ANALYSIS

By

Paul Mwangi Gachanja

BA (Hons), MA (Economics), Kenyatta University

A thesis submitted for the fulfilment of a degree of Doctor of Philosophy in Economics in the School of Humanities and Social Sciences of Kenyatta University

November, 2008

DECLARATION

This thesis is my original work and has not been presented for award of a degree in any other university.

Signature ____________________ Date 26th November, 2008

Paul Mwangi Gachanja

Reg. No. C82/7670/2000

This thesis has been submitted to the School of Humanities and Social Sciences, Kenyatta University, with our approval as supervisors

Signature ____________________ Date 26 - 11 - 2008

Prof. Martin N. Etyang

Department of Economic Theory

Kenyatta University

Nairobi, Kenya

Signature ____________________ Date 26/11/2008

Dr. Nelson H. Were Wawire

Department of Applied Economics

Kenyatta University

Nairobi, Kenya

DEDICATION

I would like to dedicate this research work to my dear wife Keziah and to my two sons David and James.

ACKNOWLEDGMENTS

First and foremost, I would like to thank the Lord God Almighty for by whose grace I was able to come this far. I give all glory and honour to Him. I am so indebted to all those who have been instrumental in different ways including financial, material and more so spiritual support in the course of my study. Since I am not able to reach them all, I mention just a few.

I might never have made it if it were not for the irresistible and persistent support I got from my dear wife Keziah. We spent sleepless nights together as she sat beside me all night through. My dear sons David and James were so patient with me even when I was not available for them. I will never let them down.

I am greatly indebted to my supervisors Prof. Martin N. Etyang and Dr. Nelson H. Were Wawire whose guidance, constructive criticisms, recommendations and suggestions were invaluable in giving shape to this thesis. I am so grateful to them for accepting to commit their time out of their busy schedules and for being so patient with me. I am also very grateful to the Late Dr. Peter M. Makau for the wise guidance he accorded me when he was my supervisor and before the cruel hand of death took his life. May the Lord rest his soul in eternal peace.

I salute all my colleagues in the Department of Economics at Kenyatta University whose comments and criticisms added value to my thesis. I am specifically grateful and I acknowledge the encouragement and support I received from Dr. T. Kimani, Dr. D. Ngui, Mr. A. Obere, Mr. M. Kuuya, Mr. G. Kosimbei, Mrs. J. Njaramba, Mr. J. Kinyanjui, Dr. S. Okeri, Mr. E. Manyasa, Dr. C. Ombuki and Mr. J. Korir.

A note of appreciation goes to Kenyatta University for offering me the opportunity to pursue my studies. Much more appreciation to DAAD for giving me a partial scholarship to do course work in the Centre for Development Research (ZEF), University of Bonn, Germany; and for funding my research towards my PhD. Long live DAAD, Long live Kenyatta University.

Special gratitude goes to Ezekiel Mucheru Mucheru (Ecky) for the efforts he accorded to ensure a success in this work. He was always available for me whenever I needed his special skills. Special appreciation also goes to my begotten sons and daughters Chris, Denis, Cate and Shiru. They were always there for me supporting me spiritually and challenging me never to give up.

Words may fail me to express how grateful I am to my dad the Late David Gachanja and to my mom Mrs. Hannah Njeri Gachanja. I now know the value of having loving and committed parents. Without them, my achievements would only have remained a sweet dream. I am also grateful to my brothers and sisters for the moral support they have accorded me through out.

TABLE OF CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

OPERATIONAL DEFINITION OF TERMS

A Firm: refers to a decision making unit that is engaged in the production of goods and services.

Manufacturing: refers to the transformation of raw materials (inputs) into finished goods for sale.

A Manufacturing firm: refers to a decision making unit engaged in the transformation of raw materials into finished goods for sale.

An Industry: refers to a group of manufacturing firms that produce a homogeneous product.

Productivity: refers to the ratio of output that a firm produces to the inputs that it uses.

Efficiency: refers to the effectiveness with which a given set of inputs are used to produce output, given the technology.

Technology: refers to the plan or process with which inputs are used in production.

Production Frontier: represents the maximum output attainable from each level of input.

Capacity utilization: refers to the ratio of actual output to the capacity available for production.

ACRONYMS AND ABBREVIATIONS

ACP	-	African, Caribbean and Pacific
AGOA	-	African Growth and Opportunities Act
COMESA	-	Common Market for Eastern and Southern Africa
CRS	-	Constant Returns to Scale
DEA	-	Data Envelopment Analysis
DEAP	-	Data Envelopment Analysis Programme
DMU	-	Decision Making Unit
EAC	-	East African Community
EPZ	-	Export Processing Zone
EPZA	-	Export Processing Zones Authority
ERSWEC	-	Economic Recovery Strategy for Wealth and Employment
EU	-	European Union
Forex-Cs	-	Foreign Exchange Certificates
GDP	-	Gross Domestic Product
IMF	-	International Monetary Fund
KAM	-	Kenya Association of Manufacturers
LP	-	Linear Programming
MUB	-	Manufacturing Under Bond
NEMA	-	National Environment Management Authority
OECD	-	Organization for Economic cooperation and Development
PFP	-	Partial Factor Productivity
R&D	-	Research and Development
RPED	-	Regional Programme on Enterprise Development

SAPs	-	Structural Adjustment Programmes
SFA	-	Stochastic Frontier Analysis
SMEs	-	Small and Medium Enterprises
SSA	-	Sub-Saharan Africa
TE	-	Technical Efficiency
TEC	-	Technical Efficiency Change
TFP	-	Total Factor Productivity
TP	-	Technical Progress
VAT	-	Value Added Tax
VRS	-	Variable Returns to Scale
WTO	-	World Trade Organisation

ABSTRACT

Industrialization has been embraced by many developing countries as a means of achieving structural transformation of the economies. In Kenya, the goal to industrialize has long been held as a strategy for economic development. It has received emphasis as the main strategy for addressing the principal challenges of development in Kenya; employment creation and poverty eradication. While Kenya inherited a relatively well established manufacturing sector at independence in 1963, the sector's overall performance has been rather dismal. The share of the manufacturing sector in GDP, which accounts for over 70 percent of the industry, has changed little over the last three decades. At the same time, the sector which was expected to play a leading role in the country's development and growth process has not been dynamic enough to effectively play this role. The study examined Kenya's manufacturing sector to empirically analyze the total factor productivity change. The study used the latest World Bank's Regional Programme on Enterprise Development firm level data for the period 2000-2003 to form a panel over the three year period 2000, 2001 and 2002. The total factor productivity change over the period was measured and decomposed into efficiency change and technical change. The study used data envelopment analysis (DEA) to derive Malmquist productivity indices.

The study revealed an overall decline in Total Factor Productivity (TFP) of about 8.3 percent. The decline resulted mainly from declining efficiency which dropped by about 17.8 percent over the period despite an overall technical progress of about 11.5 percent. In as far as the sub-sectors were concerned, the study revealed that only the chemicals and pharmaceuticals sub-sectors recorded a TFP growth of about 7.9 percent. The textile and wood and furniture sub-sectors recorded an efficiency improvement of about 11.8 and 6 percent, respectively. Efficiency change was revealed to be the major source of TFP changes. The vision 2030 envisages the development of a robust, diversified and competitive manufacturing sector. The overall goal for the sector for the next five years is to increase its contributions to GDP by at least 10 percent per annum and moving Kenya to a middle income country by year 2030. The study concluded that, for the manufacturing sector to play the crucial role in employment creation and poverty eradication, the infrastructural and institutional bottlenecks bedevilling the sector must be addressed. These include; low capacity utilization, poor infrastructure, lack of innovation, licensing and security.

CHAPTER ONE

INTRODUCTION

1.1 The concept of productivity

There is no universal definition of the term productivity. Economists have defined it as the ratio of output to input in a given period of time. In other words, it is the amount of output produced by each unit of input. Business managers, on the other hand, see productivity not only as a measure of efficiency, but also connote effectiveness and performance of individual organizations. For them, productivity would incorporate quality of output, workmanship, adherence to standards, absence of complaints, and customer satisfaction (Udo-Aka, 1983).

Productivity can be computed for a firm, industry group, the entire industry sector or the economy as a whole. It measures the level of efficiency with which scarce resources are being utilized. Higher or increasing productivity will, therefore, mean either getting more output with the same level of inputs or the same level of output with less inputs. Productivity can be divided into two sub-concepts, that is, Partial Factor Productivity (PFP) and Total Factor Productivity (TFP).

PFP estimates the ratio of total output to a single input, usually labour. In most studies, especially in economics, productivity is taken to be synonymous with labour productivity. This is because it is a simpler concept to estimate and it is a rough measure of the effectiveness with which labour is used as the most important factor of production. However, it is worthy to note that productivity is not determined by the efforts of labour alone, but in combination with other factors especially land, capital technology, management and the environment. TFP is the ratio of output to the aggregate measure of the inputs of all the factors of production. Theoretically, this is the true measure of productivity as it incorporates the contribution of all the factor inputs. There are however, some problems associated with measuring total-factor productivity. For example, it is difficult to construct an index number that will serve as the input. This is because this will mean adding hours done by labour to units of investments, the contributions of land, technology, among others to get a single index. Even to quantify them all in monetary terms would be very cumbersome.

In the conventional growth accounting approach to estimate TFP growth, there is an implicit assumption that the economies are producing along the production possibility frontier with full technical efficiency (Solow, 1957). Studies that have adopted the approach estimate TFP growth without distinguishing between its two components: technical progress (TP) and technical efficiency change (TEC); TP is synonymously considered to be the unique source of TFP growth. Defined this way, TFP growth is at best a measure of Hicks-neutral disembodied technological change (Coelli *et al*, 2005). More important, failure to take account of inefficiency and TEC may produce misleading and biased TFP estimates. While high rates of TP could coexist with deteriorating technical efficiency, relatively low rates of TP could also coexist with improving technical efficiency (Nishimizu and Page, 1982). Furthermore, different policy implications result from different sources of variation in TFP.

1.2 The manufacturing sector in Kenya

Kenya has since independence depended heavily upon the agricultural sector as the base for economic growth, employment and foreign exchange generation. An estimated 80 percent of the population live in the rural areas and depend on agriculture for their livelihood. In addition, the sector accounts for two-thirds of the country's exports. Historical experience has however shown that industry has a higher potential for stimulating economic growth. As a supplier of essential inputs to other sectors as well as to itself, and as a user or processor of the output of other sectors, industry represents an effective stimulant to the economic system. In this regard, the growth of the industrial sector raises productivity not only in the sector itself but also in other sectors of economy. Whereas agriculture continues to be the primary foundation of rapid and sustained growth, industry and more particularly the manufacturing sector is more dynamic in accelerating this growth (Republic of Kenya, 1997).

Although under United Nations classifications, the industrial sector includes four sectors namely; mining, manufacturing, building and construction, and public utilities, manufacturing dominates. The sector constitutes about 73 percent of the total industrial output (Wagacha and Ngugi, 1998). The industrial sector has therefore become synonymous with the manufacturing sector. The dynamism in manufacturing sector's growth depends heavily on the success of agriculture, given the strong links between the two sectors in Kenya. Industry induces the development of agriculture by providing markets for its products through the processing of agricultural outputs while at the same time providing required agricultural inputs such as fertilizers, pesticides, farm implements and machinery. In addition, raising agricultural output and incomes create a growing demand for manufactured products and a source of savings needed to finance industry.

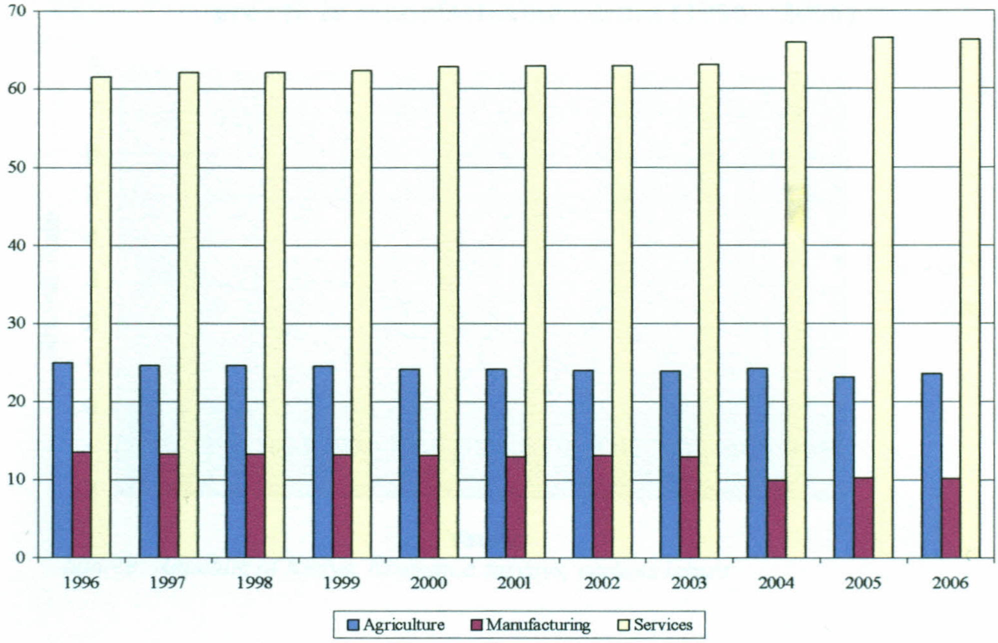
In the light of the foregoing, agriculture and manufacturing are a *twin engine* to rapid economic growth. However, agriculture suffers from vagaries of weather and agricultural commodity exports also suffer from price and revenue instabilities due to inelasticities in their demand and supply. The decision to consider industry as the leading sector in economic recovery is based on the perceived vulnerability of agriculture to many factors outside policy-makers' control, which reduce its reliability as a source of sustained growth. Industry, on the other hand, has shown remarkable resilience and has potential for providing high and dynamic growth. In order to ensure stable and sustainable economic growth therefore, the prospects lie in the development of the manufacturing sector (Republic of Kenya, 1997).

The Kenyan manufacturing sector is classified under three main sub-sectors namely, agro-based, engineering and chemicals and minerals (Republic of Kenya, 1994). The agro-based sector has developed on the basis of domestic resource activities and contributes about 68 percent of manufacturing sector value added (KAM, 2002). This sub-sector consists of fruits and vegetable processing, vegetable oils and fats, cereals and grain melting, bakery, alcoholic beverages, dairy, fish and water resources, tanneries and leather products, cotton, textiles, wood, pulp and miscellaneous food products.

The engineering sub-sector relies heavily on imported raw materials and contributes about 12 percent of manufacturing sector value added (KAM, 2002). The sub-sector consists of fabricated metal products, machinery and equipments, metal furniture and fixtures, structural metal products, electronics, transport machinery and equipment and miscellaneous machinery sector. The chemical and mineral sub-sector is research oriented and contributes about 20 percent of the manufacturing sector value added. The sub-sector includes basic industrial chemicals, fertilizers, salts, pesticides, paints varnishes, pharmaceuticals, soaps, perfumes, cosmetics, rubber and rubber products, plastics and plastic products, cement and lime products, ceramics, glass and glass products. 90 percent of the chemical imports in the chemical and mineral sub-sector are intermediate inputs (KAM, 2002).

The manufacturing sector plays an important role with respect to the country's industrialization strategy. Hence, it is expected to be more dynamic in accelerating economic development through employment creation, linkages between firms and across regions, skill formation and export earnings. The growth of the manufacturing sector has long been considered instrumental for economic development despite the fact that it is usually far from the largest economies in terms of shares of total output and employment (Soderbom, 2001). The sector currently contributes about 10.5 percent of GDP. The agricultural and the services sectors contributing about 24.2 and 65.3 percent respectively (Republic of Kenya, 2006). Figure 1.1 that follows compares the sectoral shares for three sectors, agriculture, manufacturing and services.

Figure 1.1: Sectoral share in the real GDP, 1996 – 2006 (percentages)

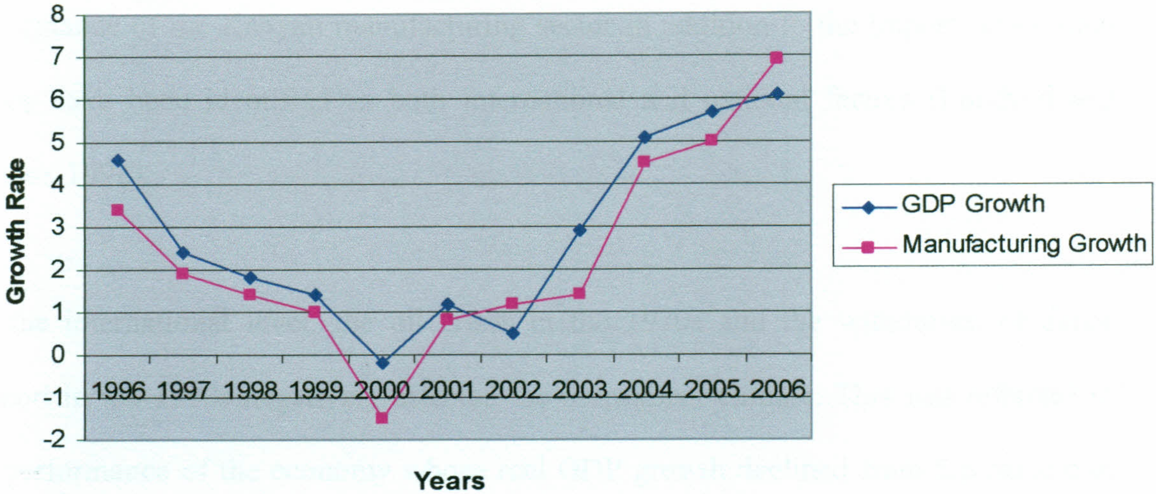


Source: Republic of Kenya, Economic surveys, various issues

From the figure, the contribution of the manufacturing sector has remained almost constant throughout the period at slightly over 10 percent. This was despite the industrialization strategy in Sessional paper No.2 of 1996 that sought to transform Kenya into an industrialized nation by 2020.

Further, the growth in manufacturing output has been a key element in the successful transformation of most economies that have sustained rises in their per capita incomes, the most recent examples being the newly industrialized countries and their successes in exporting manufactured goods (Soderbom, 2001). The effect of the growth in the manufacturing sector on overall economic growth cannot be over-emphasized as depicted in figure 1.2.

Figure 1.2: A comparison of trends in real GDP growth and real growth in manufacturing output (1996 – 2006)



Source: Republic of Kenya, Economic surveys, various issues

Figure 1.2 clearly shows a high level of correlation between the growth of the manufacturing sector and GDP growth in Kenya. Being a component of the GDP, the declining growth in the sector must have contributed significantly to the falling growth in GDP until 2000. After the period of subdued performance, the economy showed strong signs of recovery, registering impressive growth of 4.8 percent in 2004 and to highs of over 6 percent in 2006. The manufacturing sector has been part of the recovery all through after 2000 registering an impressive growth of close to 7 percent in 2006.

This not withstanding, the development in the Kenyan manufacturing sector has been hampered by inefficiency of production, outdated technologies relative to those in use by competitors, limited technological progress, underutilization of installed capacities and sub-optimal plant sizes since the mid 1970s (Lundvall and Battese, 1998; Lundvall *et al* , 2002). This can be partially explained by the unsuccessful import substitution strategy which saw the protection of industries from competition, encouraged capital intensive production technology and limited the potential of the industrial manufacturing sectors to generate employment. Several factors contributing to the unsatisfactory performance of the Kenyan manufacturing sector in addition to the import substitution policy have been identified as both international and national factors (Lundvall and Battese, 1998).

On the international level, the oil crises in the 1970s and the withdrawal of donor support in the 1980s negatively affected the investment climate. This was reflected in the performance of the economy whose real GDP growth declined from 5.6 percent in the period 1974 to 1979 to 4.1 percent, 2.5 percent and 2.0 percent in the periods 1980 to 1989, 1990 to 1995 and 1996 to 2000, respectively. On the national level, the sector has been constrained by a number of factors such as shortage of technically trained personnel, poor state of the country's infrastructure, high electricity tariffs and interest rates, lack of competitiveness, general slowdown of the economy leading to depressed effective demand for manufactured products, credit rationing, insecurity and corruption (Lundvall and Battese, 1998; Republic of Kenya, 2002).

Despite structural reforms undertaken, a close analysis of the manufacturing sector shows that the supply responses to the policies have been lower than expected. The reliance on the import substitution strategy in the early years of independence created a generally inward looking sector, with limited technical progress. Despite a shift from import substitution to export promotion since the mid-1980s, and reforming the policy environment under the structural adjustment programmes (SAPs), the performance of the manufacturing sector in Kenya remained poor most of the 1980s and 1990s as regards to its share in GDP, growth of output and the creation of employment and linkages with other sectors of the economy (Republic of Kenya, 1997).

The average annual growth rate of real GDP for the manufacturing sector declined from 10 percent in the period 1974 – 1979, to 4.8 percent, 3 percent and 1.3 percent in the periods 1980-89, 1990-95 and 1996-2000, respectively. In 2001 however, the sector registered an improved growth rate attributed to the improved power supply, agricultural production, favourable tax reforms and expanded outlets through African Growth and Opportunity Act (AGOA), Common Market for Eastern and Southern Africa (COMESA) and East African Community (EAC). However, the sector's capacity utilization was hampered by low consumer demand, lack of competitiveness and insecurity in the country (Republic of Kenya, 2002). In 2005, the real value added grew by 5 percent from 4.5 percent in 2004, partly attributed to a stable macroeconomic environment that prevailed during that year, improved access to credit and increase in export demand particularly within the EAC and COMESA region (Republic of Kenya, 2006.) However, this was below the target of 8.6 percent per annum for the period 2003-2007. Moreover, the share of the manufacturing sector in GDP was 10.5 percent which was below the projected growth of 15.7 percent in 2007 (Republic of Kenya 2003).

Apart from the low output growth rate per annum, the manufacturing sector faced a problem of inadequate investment partly caused by high cost of domestic funds and reduced foreign direct capital investments. Investment not only adds to the productive capacity but also creates new opportunities for the acquisition of new and more efficient technology (Ronge and Kimuyu, 1997).

According to Bigsten (2002), growth in the size of the manufacturing sector appears to have been driven by increase in factor inputs rather than improvement in efficiency and productivity. Productivity measures the quality of business management at all levels, which is also a reflection of how resources are utilized and what they yield. A study by Gerdin (1997) found that the mean total factor productivity growth from 1964-1994 was -0.12 percent per annum, while a report by International Monetary Fund in 1999 cited in Blattman *et al* (2004), indicated that productivity declined by 0.5 percent per annum between 1991 and 1998 compared to an increase of 2.5 percent per annum between 1981 and 1990. An analysis by Blattman *et al* (2004) suggested that there was no visible improvement of productivity in the average firm between 1999/2000 and 2002/2003. According to the study, the low levels of productivity probably accounted for the poor export performance in the average Kenyan firm. Lundvall *et al* (2002) noted that low productivity translated into high unit costs, which explained the competitive disadvantage in both domestic and foreign markets. According to Lovell (1993:3), "productivity varies due to differences in production technology, differences in the efficiency of the production process and differences in the environment in which the production occurs".

1.3 The statement of the research problem

Kenya has a volatile large manufacturing and industrial service sector whose share of GDP has increased very little over the past three decades (see figure 1.1). The sector has not been dynamic enough to function as an engine of growth for the whole economy and has not contributed significantly to the major challenges of employment creation and poverty eradication. The sector has been facing low capacity utilization, declining productivity and limited technological progress (Republic of Kenya, 2002; KAM, 2006). The government recognizes that employment opportunities can only be created and sustained through encouragement of efficient industries, which are internationally competitive and utilize the latest technologies in their production activities (Republic of Kenya, 2007).

After a period of subdued performance in the late 1990s, the Kenyan economy has in the last few years showed strong signs of recovery, registering an impressive growth of over 6 percent in 2006 from -0.2 percent in 2000. The manufacturing sector has been part and parcel of this recovery, growing from a negative rate of -1.5 percent in 2000 to about 7 percent in 2006. However, a close examination reveals that this growth in the manufacturing sector has been driven more by an increase in inputs and volume of output than by improvements in efficiency and productivity (KAM, 2006; Bigsten, 2002). Yet this growth led by increase in inputs is not sustainable especially due to increasing costs of major inputs to production in the sector, a bulk of which are imported. Efforts must be diverted to productivity growth sourced from efficiency improvement and technical progress. Indeed, the goal of industrialization has been held as a strategy for economic development and it has all along received emphasis as the main strategy for addressing the principal challenges of development in Kenya: employment creation and poverty eradication (Republic of Kenya, 2002).

The overall goal for the manufacturing sector by the year 2012 is to increase its contribution to GDP by at least 10 percent per annum. To achieve this goal, the sector's productivity should be improved to strengthen the local production capacity in order to increase domestically manufactured goods and enhance Kenya's competitiveness globally (Republic of Kenya, 2007).

The sub-sectors in the manufacturing sector in this study are given an individual approach unlike in most of the source-of-productivity studies that focus on the aggregate economy. Studies carried out have either addressed general productivity in the economy with little or no attention given to the productive sectors (Kimuyu, 2007; Onjala, 2002; and Gerdin, 1997). Studies specific to the manufacturing sector have concentrated on efficiency issues without any link of the efficiency or inefficiency changes to productivity (Ngui, 2008; Lundvall, 1999; Lundvall and Battese, 1999). Others focus on other dimensions of manufacturing sector such as input use and substitutability (Onuonga, 2008).

This study addresses itself to the measurement of total factor productivity change in the manufacturing sector and the sources of the productivity change thereby creating a richer policy environment. The study also bridges the knowledge gap that exists in the understanding of productivity in the manufacturing sector in Kenya. Only a few studies exist and hence the study adds on to the available works done on most recently collected panel data. The methodology used is also relatively new and even though it has gained popularity in productivity studies, it has not been applied widely in Kenya. Stochastic frontier analysis is the one that has been widely applied in the past studies. Moreover, this study departs from the commonly used parametric method to a non-parametric method that provides a different approach and enriches the area of study for future research.

1.4 Research questions

The study sought to answer the following questions:

(i) What are the policy episodes in Kenya's industrialization process?

(ii) What is the structure and composition of the Kenyan Manufacturing sector?

(iii) What changes in total factor productivity have occurred in the Kenyan Manufacturing sector?

(iv) What has been the source of such changes?

(v) What are the policy implications of the study findings?

1.5 Objectives of the study

The study aimed at examining the Kenyan Manufacturing sector's environment for changes in total factor productivity. Specifically, the study sought to:

(i) Analyse the policy episodes in Kenya's industrialization process

(ii) Describe the structure and composition of the Kenyan manufacturing sector.

(iii) Measure the Total Factor Productivity changes in the manufacturing sector.

(iv) Establish the sources of changes in Total Factor Productivity.

(v) Propose policy recommendations in the light of the research findings.

1.6 Significance of the study

While Kenya inherited a relatively well established industrial sector, its overall performance has been rather poor for most of the post-independence period, with the exception of the period between 1963 and 1972 when it registered an annual average growth rate of above 10 percent. The share of the manufacturing sector in the GDP has changed little over the past three decades. At the same time, the sector which was expected to play a leading role in the country's growth and development process has not been dynamic enough to effectively play this role. This study comes at a time when the country is on an ambitious vision to transform the economy by the year 2030. Attention is no doubt going to focus on manufacturing as one of the productive sectors in order to achieve this vision. This study will shed light on the productivity environment in the manufacturing sector and therefore provide some basis for policy interventions that would see the sector break from the historical non performance. This study will also be useful to policy makers since it will provide a rich environment for policy decisions that are more focused in order to realize the set targets.

The study also contributes to the existing literature on productivity issues in the manufacturing sector. Most of the studies discuss issues on efficiency without much regard to the other productivity sources.

1.7. The scope and organisation of the study

While majority of the empirical studies carried out in the Kenyan manufacturing sector focused on efficiency issues (Ngui, 2008; Mazumdar and Mazaheri, 2003; Lundvall *et al*, 1999; Lundvall and Battese, 1998; Biggs *et al*, 1995), this study takes a broader look at the sector's Total Factor Productivity. Efficiency change is one of the major sources of growth in productivity. Technical change which forms the other major source of productivity growth has not attracted much attention. From the few studies on the performance of the Kenyan manufacturing sector, growth has not been attributed to Total Factor Productivity growth probably suggesting the reason why no attention has been directed to efficiency and technology issues in policy, hence the un-competitive manufacturing sector. This study therefore only addressed itself to the examination of Total Factor productivity changes and whether such changes resulted from efficiency changes or technical changes. Policy proposals are also made that focused more on the sources of the TFP growth.

One major obstacle in the study has been the availability of very reliable data on the manufacturing enterprises. While the Kenyan manufacturing sector is largely informal, data available is from the formal manufacturing. The study used a panel data of three years 2000, 2001 and 2002. Due to lack of adequate data on majority of the firms, and due to the need to ensure homogeneity in the firms selected, few firms were used in the analysis for some of the sub sectors, therefore posing challenges in the estimation.

The study is organized in five chapters. The foregoing chapter introduced the study by highlighting its principal objectives. Chapter two is devoted to reviewing the relevant literature and ends by presenting the theoretical framework. Chapter three highlights the research design and methodology used in the study. The study findings are presented and discussed in chapter four while chapter five concludes the study.

CHAPTER TWO

LITERATURE REVIEW AND THEORETICAL FRAMEWORK

2.1 Introduction

In this chapter, both the theoretical and empirical works done on productivity and related issues are reviewed. The first section is a review of the methods used in the measurement of productivity and productivity change. The other sections of this chapter review empirical literature carried out elsewhere, and that specific to Kenya. The chapter then presents the theoretical framework for the study.

2.2 Theoretical literature

The material presented in this section was drawn from microeconomics textbooks and well presented in Ceolli *et al* (2005). The section exposes the theoretical foundations that underlie the measurement and decomposition of productivity. The theoretical representations of the production technology and distance functions are briefly described. The concept of a productivity index, with particular attention to the Malmquist productivity index is introduced. The section also briefly describes the methods used to obtain estimates of TFP change, and decompose these measures into the various components, such as technical change (TC) and technical efficiency change (TEC).

2.2.1 The production technology and distance functions

A technology set, S may be defined as:

$$S = \{(\mathbf{x},\mathbf{q}): \mathbf{x} \text{ can produce } \mathbf{q}\}, \quad \ldots\ldots\ldots 2.1$$

Where **x** and **q** denote an N-dimensional input vector of non-negative real numbers and a non-negative M-dimensional output vector, respectively.

This set consists of all input-output vectors (**x**,**q**), such that **x** can produce **q**.

The production technology defined by the set S, may be equivalently defined using the output set, P(**x**), which represents the set of all output vectors, **q** that can be produced using the input vector, **x**. The output vector is defined by:

$$P(\mathbf{x}) = \{\mathbf{q}: \mathbf{x} \text{ can produce } \mathbf{q}\} = \{\mathbf{q}: (\mathbf{x},\mathbf{q}) \in S\}. \quad \ldots 2.2$$

The output sets are referred to as production possibilities sets associated with various input vectors, **x**. The various output combinations that could be produced using a given input level form a production possibility set. The maximum output at various levels of inputs form the production frontier. Closely related to production frontiers is the concept of distance functions that are very useful in describing the technology in a way that makes it possible to measure among other things, productivity.

Distance functions allow one to describe a multi-input, multi-output production technology without the need to specify a behavioural objective such as cost minimization or profit maximization. One may specify both input distance functions and output distance functions.

An input distance function characterizes the production technology by looking at a minimal proportional contraction of the input vector, given the output vector. An output distance function considers a maximal proportional expansion of the output vector, given an input vector.

2.2.2 Output distance functions

The output distance function is defined on the output set, P(**x**), as:

$$d_0(\mathbf{x},\mathbf{q}) = \min\{\delta: (\mathbf{q}/\delta) \in P(\mathbf{x})\} \quad \text{.......} 2.3$$

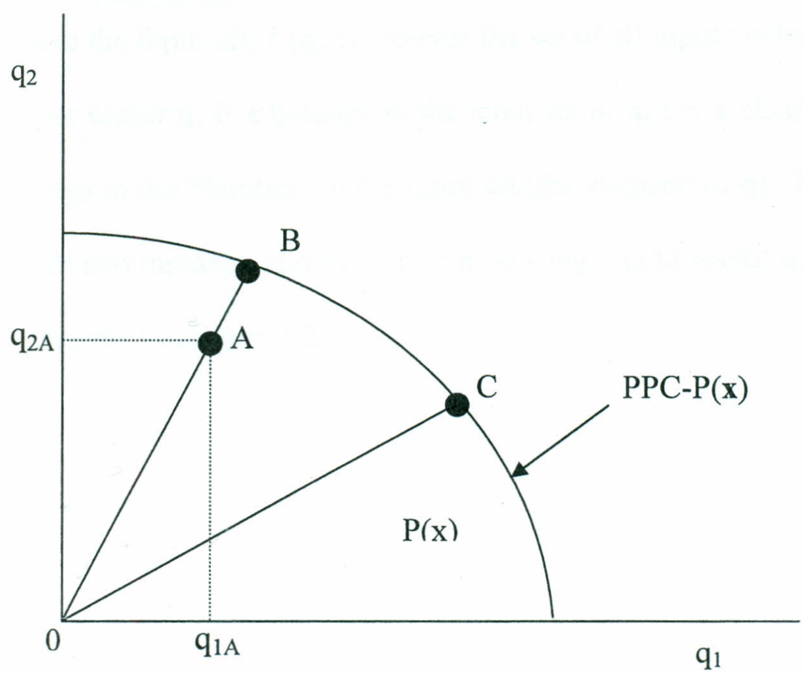
so that if q belongs to the production possibility set of x, i.e. q ϵ P(x), then

$d_0(\mathbf{x},\mathbf{q}) \leq 1$; and

if q belongs to the "frontier" of the production possibility set, then $d_0(\mathbf{x},\mathbf{q}) = 1$.

Suppose q_1 and q_2 are two outputs produced using the input vector, **x**. For a given input vector **x**, the production technology is presented in figure 2.1.

Fig 2.1 Output distance function and production possibility set



Source: Coelli *et al* (2005:48)

The production possibility set, p(**x**) is the area bounded by the production possibility frontier, PPC-P(**x**), and the q_1 and q_2 axis. The value of the distance function for the firm using input level **x** to produce the outputs, defined by the point A is equal to the ratio δ=OA/OB. The distance measure is the reciprocal of the factor by which the production of all output quantities could be increased while still remaining within the feasible production possibility set for the given input level. Points B and C are on the production possibility frontier denoted by PPC-P(**x**), and hence would have distance function values equal to 1.

2.2.3 Input distance functions

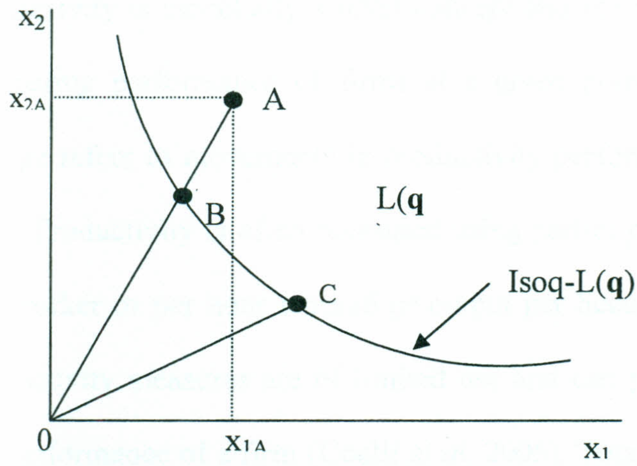
The input distance function, which involves the scaling of the input vector is defined on the input set L(**q**) as:

$d_i(\mathbf{x},\mathbf{q}) = \max\{\rho:(\mathbf{x}/\rho)\epsilon L(\mathbf{q})\}$ ……………………………………………………..2.4

Where the input set, L(**q**) represents the set of all input vectors **x** which can produce the output vector **q**. If **x** belongs to the input set of **q**, i.e. $\mathbf{x}\ \epsilon L(\mathbf{q})$, then $d_i(\mathbf{x},\mathbf{q}) \geq 1$ and if **x** belongs to the "frontier" of the input set (the isoquant of **q**), then $d_i(\mathbf{x},\mathbf{q})=1$.

Given two inputs x_1 and x_2 used in producing output vector **q**, the production technology is presented in figure 2.2.

Fig 2.2 Input distance function and input requirement set



Source: Coelli *et al* (2005:50)

The input set L(**q**) is the area bounded from below by the isoquant, isoq-L(**q**). The value of the distant function from the point A which defines the production point where firm A uses x_{1A} of input 1 and x_{2A} of input 2 to produce the output vector q, is equal to the ratio ρ=OA/OB.

Output and input distant functions are used in defining a variety of index numbers. They also provide the conceptual under pinning for various measures among them, productivity measures. These distance functions can be directly estimated using either econometric methods or mathematical programming methods. In this study, distance functions described in this section are used to define the Malmquist index that measure the total factor productivity changes using Data Envelopment Analysis, a linear programming method as discussed later in section 2.6.

2.2.4 Measuring productivity and productivity change.

Productivity is essentially a level concept and measures of productivity can be used in comparing performance of firms at a given point in time. In contrast, productivity change refers to movements in productivity performance of a firm or an industry over time. Productivity is often measured using partial productivity measures such as output per worker or per hour worked or output per hectare. Though commonly used, partial productivity measures are of limited use and can potentially mislead and misrepresent the performance of a firm (Coelli *et al.* 2005). Total factor productivity (TFP) measures account for the use of a number of factor inputs in production and therefore are more suitable for performance measurement and comparisons across firms and for a given firm over time. In the presence of multiple outputs and inputs, TFP may be defined as a ratio of aggregate output produced relative to aggregate input used. Aggregation of outputs and inputs give rise to index number problems. In this study however, the Malmquist TFP index used is constructed by measuring the radial distance of the observed output and input vectors in different time periods relative to a reference technology.

A simple TFP measure for firms with multiple outputs and multiple inputs is to look at the profitability of a firm, defined as the revenue of the firm divided by its input cost. Suppose there are two firms producing output vector $\mathbf{q}_1$ and $\mathbf{q}_2$ using inputs $\mathbf{x}_1$ and $\mathbf{x}_2$ respectively. Suppose the corresponding output and input price vectors are given by $(\mathbf{p}_1,\mathbf{p}_2)$ and $(\mathbf{w}_1,\mathbf{w}_2)$. Then the profitability ratios of firms 1 and 2 are given by:

$$\pi_1 = \frac{p_1' q_1}{w_1' x_1} = \frac{\sum_{m=1}^{M} p_{m1} q_{m1}}{\sum_{k=1}^{K} w_{k1} x_{k1}} \text{ and } \pi_2 = \frac{p_2' q_2}{w_2' x_2} = \frac{\sum_{m=1}^{M} p_{m2} q_{m2}}{\sum_{k=1}^{K} w_{k2} x_{k2}} \quad \ldots\ldots\ldots\ldots\ldots 2.5$$

A measure of relative performance is given by the ratio, π_2/π_1. Though π_1 and π_2 are scalar measures of total or multifactor productivity, a strict comparison of π_1 and π_2 is difficult since the output and input prices faced by these firms are different. The only option here is to adjust the value aggregates in the equation above for differences in price levels. Such an adjustment requires that the value aggregates in the numerator of equation above are deflated by suitable price deflator or price index numbers. The use of DEA in measuring productivity does not require any price data (Coelli and Rao, 2001). In this study however, accurate data on the quantities of output and inputs was not available and instead values were used that required a deflator for the necessary adjustments. The deflators were constructed from the statistical abstracts over the data period.

2.2.5 Measuring productivity changes and the Total Factor Productivity index

In the case of firms producing multiple outputs using multiple inputs, change in productivity is represented by total factor productivity (TFP) index. There are several simple and intuitive approaches that can be used in deriving meaningful measures of productivity change. Irrespective of which approach is employed in measuring the TFP index, it is important that it satisfies the following property. If a firm produces the same quantities in periods, s, and, t, but the input use is decreased by a certain proportion, the TFP index should increase accordingly. If the inputs are reduced, for example by 25 percent (outputs are produced with only 75 percent of the original inputs) then the TFP index should be equal to 1/0.75. Similarly, if the outputs are increased by a given percentage, keeping the inputs fixed, the TFP index should increase by the same percentage. If all the outputs increase by 30 percent over the period, s, to, t, with input use remaining the same, then the TFP index should be equal to 1.3.

Consider the problem of measuring productivity change for a firm from period, s, to period, t, assuming that the firm makes use of the state of knowledge, as represented by production technologies, S_s, and ,S_t, in period, s, and, t. Suppose the firm produces output $\mathbf{q}_s$ and $\mathbf{q}_t$ using inputs $\mathbf{x}_s$ and $\mathbf{x}_t$ respectively. Where information on output and input prices is available, then the output price vectors and input price vectors are $\mathbf{p}_s$ and $\mathbf{p}_t$, and $\mathbf{w}_s$ and $\mathbf{w}_t$, in periods, s, and t, respectively. Possible approaches used to measure productivity change include:

(a) Hicks-Moorsteen TFP (HM TFP) index

The Hicks-Moorsteen index (Diewert, 1992), represents a fairly simple TFP index that measures the growth in output net of growth in inputs. If output growth and input growth are measured using output and input quantity index numbers, then the HM TFP index is given by:

$$\text{HMTFP Index} = \frac{Growth\,in\,output}{Growth\,in\,input} = \frac{Output\,quantity\,index}{Input\,quantity\,index} \qquad \text{……………………………2.6}$$

The HM index can be made operational once appropriate measures of output and input growth are selected. A range of index numbers formulae are available for this purpose. This index is also closely related to the index that is based on profitability ratios and the

TFP index that is based on the Caves, Christensen and Diewert (CCD) approach, discussed later in this section.

Though this index is easy to measure and interpret, it is quite difficult to identify the main source of productivity growth. The HM index does not have a conceptual framework that underpins a decomposition of TFP growth estimate unless the indexes are defined using a Malmquist quantity index.

(b) TFP index based on the profitability ratio

Let R_s, R_t, C_s and C_t respectively, represent the observed revenue and cost of a given firm in period, s, and, t. The data on input and output quantities and their prices are given by $(\mathbf{x}_s, \mathbf{q}_s, \mathbf{p}_s)$ and $(\mathbf{x}_s, \mathbf{q}_s, \mathbf{w}_s)$ for period s and $(\mathbf{x}_t, \mathbf{q}_t, \mathbf{p}_t)$ and $(\mathbf{x}_t, \mathbf{q}_t, \mathbf{w}_t)$ for period t. The TFP index that is based on the profitability ratio is measured using revenue and cost after adjusting for changes from period t to period s. Let R_s*, R_t*, C_s* and C_t* represent revenues and cost for the firm in period, s, and, t, respectively, after adjusting for price changes from period, s, to period, t. Then the TFP index is defined as:

$$\text{TFP index} = \frac{R_t^* / R_s^*}{c_t^* / c_s^*} = \frac{(R_t / R_s) / \textit{output price index}}{(C_t / C_s) / \textit{input price index}} \quad \text{.................................2.7}$$

Where appropriate index formulae are used in measuring price changes from period, s, to period, t. Since the TFP measure in equation 2.7 above does not contain any price effects, the main sources of TFP change over periods, s, and, t, can be attributed to technical change and efficiency changes over this period (Coelli *et al* (2005).

(c) Malmquist TFP index

The Malmquist TFP index was first introduced by Caves, Chritensen and Diewert (1982a, 1982b). Caves, Chritensen and Diewert defined the TFP index using Malmquist input and output distance functions, and thus the resulting index has come to be known as the Malmquist TFP Index. The method of using the distance functions as described in section 2.2.1 of this study in defining the TFP index is due to the approach proposed by Caves, Chritensen and Diewert.

Malmquist TFP index is constructed by measuring the radial distance of the observed level of output and input vector in periods, s, and, t, relative to a reference technology. As the distance can be either output oriented or input oriented, the Malmquist TFP indices differ according to the orientation used.

The output oriented productivity measures focus on the maximum level of output that could be produced using a given input vector and a given production technology relative to the observed level of outputs. This is achieved using the output distance functions. The period, s, Malmquist productivity index maybe given by the following equation:

$$m_o^s(q_s, q_t, x_s, x_t) = \frac{d_o^s(q_t, x_t)}{d_o^s(q_s, x_s)} \text{..} 2.8$$

Assuming that the firm is technically efficient in both periods, then $d_o^s(q_s x_s) = 1$ and so;

$$m_o^s(q_s, q_t, x_s, x_t) = d_o^s(q_t, x_t) \text{..} 2.9$$

Equation (2.9) shows that $m_o^s(q_s, q_t, x_s, x_t)$ is the minimal output-deflation factor such that the deflated-output vector for the firm in period, t, $q_t / [m_0^s(\cdot)]$ and the input vector, $x_{t,}$ are just on the production surface of the technology in period s. If the firm has a higher level of productivity than is implied by the period s technology, then, $m_o^s(\cdot) > 1$.

An output oriented Malmquist productivity index can be similarly defined based on period, t, technology

$$m_o^t(q_s, q_t, x_s, x_t) = \frac{d_o^t(q_t, x_t)}{d_o^t(q_s, x_s)} \quad \text{..2.10}$$

If the firm is technically efficient in period t, then $d_o^t(q_t x_t) = 1$

Since the Malmquist productivity index can be defined using period, s, technology as well as period, t, technology, the Malmquist TFP index is defined as the geometric average of the two indices based on period-t and period-s technologies. Thus the output oriented Malmquist productivity index is given by:

$$m_o(q_s, q_t, x_s, x_t) = \left[m_o^s(q_s, q_t, x_s, x_t).m_o^t(q_s, q_t, x_s, x_t)\right]^{0.5} \quad \text{.......................2.11}$$

It is noted that the Malmquist TFP index, defined in the equation above requires the computation of four distance functions namely,

$d_o^s(q_s, x_s), d_o^t(q_t, x_t), d_o^s(q_t, x_t)$ and $d_o^t(q_s, x_s)$.

In order to compute these distance functions, the production technologies in periods, s, and, t, should be described. If data is very limited, such as only observed output and input quantities in periods, s, and, t, then the index number approach is used. If data on a cross-section of firms in periods, s, and, t, is accessible, then the data envelopment analysis (DEA) approach or the stochastic frontier analysis (SFA) are used.

The input oriented productivity focuses on the level of inputs necessary to produce observed output vectors $\mathbf{q}_s$ and $\mathbf{q}_t$ under a reference technology. Suppose period, s, technology is used as the reference technology, then the period-s input oriented Malmquist productivity index for period, s, and, t, is defined as:

$$m_i^s(q_s, q_t, x_s, x_t) = \frac{d_i^s(q_t, x_t)}{d_i^s(q_s, x_s)} \quad \text{...2.12}$$

Assuming that the firm is technically efficient, in both periods, then $d_i^s(q_s x_s) = 1$ and also

$$m_i^s(q_s, q_t, x_s, x_t) = d_i^s(q_t, x_t) \quad \text{...2.13}$$

Similarly, the input-oriented Malmquist productivity index, based on period, t, technology is defined as:

$$m_i^t(q_s, q_t, x_s, x_t) = \frac{d_i^t(q_t, x_t)}{d_i^t(q_s, x_s)} \quad \text{...2.14}$$

If the firm is technically efficient in period t, then $d_i^t(q_t, x_t) = 1$

Since the Malmquist input oriented index can be defined using period, s, or period, t, technology as the reference technology, Caves, Chritensen and Diewert defined the input oriented Malmquist TFP index as:

$$m_i(q_s, q_t, x_s, x_t) = \left[m_i^t(q_s, q_t, x_s, x_t).m_i^t(q_s, q_t, x_s, x_t)\right]^{1/2} \quad \text{...2.15}$$

To compute the Malmquist TFP index in the equation 2.15 above, four different distances are computed that are involved in equations 2.12 and 2.14. If the firm is assumed to be technically efficient, then only two distances need to be computed. There are however problems in the calculation of the Malmquist TFP indices. That is, in order to compute these indices, the distances functions as well as the numerical values of the relevant parameters or equivalently, a description of the underlying technology need be known. This requires firm level data on inputs and outputs in periods, s, and, t, as well as frontier methods that do not require the assumption of technical efficiency of the firms observed.

The Malmquist TFP index can give different numerical values depending on the type of orientation used (output or input orientation). However, if the underlying production technology exhibits constant returns to scale (CRS) in both periods, then the input-and output-oriented Malmquist TFP indices coincide.

In choosing the appropriate approach to select, the purpose of measuring productivity levels and change; and the kind of data available are major considerations. If a summary measure of productivity changes is required without any need to identify their sources, then the HM approach is recommended. If however panel data sets are available on a large number of firms over some period of time, then the Malmquist index approach is recommended. In that case, the constant returns to scale assumption is tenable and the Malmquist TFP Index is sufficient because it coincides with the index resulting from the source-based measure of TFP growth.

2.2.6 Calculation and decomposition of productivity change using frontier method

The Malmquist TFP index measures the TFP change between two data points by calculating the ratio of the distances of each data point relative to a common technology. If the period, t, technology is used as the reference technology, the Malmquist (output oriented) TFP change index between period, s, (the base period) and the period, t, can be written as:

$$m_0^t(q_s, x_s, q_t, x_y) = \frac{d_0^t(q_t, x_t)}{d_0^t(q_s, x_s)} \qquad \text{.....2.16}$$

Alternatively, if the period s reference technology is used, it maybe defined as:

$$m_0^s(q_s, x_s, q_t, x_y) = \frac{d_0^s(q_t, x_t)}{d_0^s(q_s, x_s)} \qquad \text{.....2.17}$$

In the above equations, the notation $d_0^s(q_t, x_t)$ represents the distance from the period, t, observation to the period, s, technology, and all other notation is as previously defined. A value of m_0 greater that one indicates positive growth in TFP from period, s, to period, t, while a value less than one indicates a TFP decline.

The TFP index is defined as the geometric mean of the above two indices, according to Fisher (1922) and Caves, Christensen and Diewert (1982b). That is,

$$m_0(q_s, x_s, q_t, x_t) = \left[\frac{d_0^s(q_t, x_t)}{d_o^s(q_s, x_s)} \times \frac{d_0^t(q_t, x_t)}{d_0^t(q_s, x_s)} \right]^{1/2} \qquad \text{.....2.18}$$

The distance functions in this productivity index can be rearranged to show that the index is equivalent to the product of a technical efficiency change index and an index of technical change. This is given in equation 2.19 that follows:

$$m_0(q_s, x_s, q_t, x_t) = \frac{d_0^t(q_t, x_t)}{d_0^s(q_s, x_s)} \left[\frac{d_0^s(q_t, x_t)}{d_o^t(q_t, x_t)} \times \frac{d_0^s(q_s, x_s)}{d_0^t(q_s, x_s)} \right]^{1/2} \qquad \text{.....2.19}$$

The ratio outside the square brackets in the above equation measures the change in the output oriented measure of technical efficiency between period, s, and, t. The remaining part of the index is a measure of technical change. It is the geometric mean of the shift in technology between the two periods, evaluated at x_t and at x_s. The two terms are:

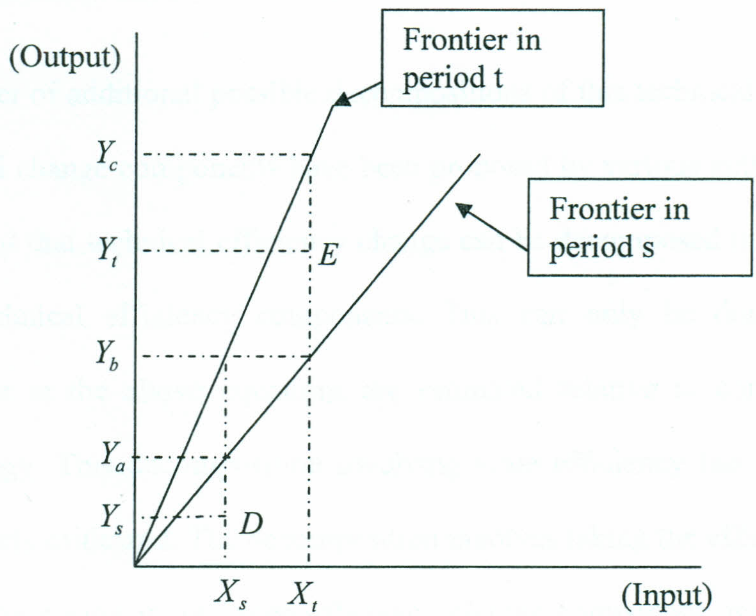
$$\text{Efficiency change} = \frac{d_0^t(q_t, x_t)}{d_0^s(q_s, x_s)} \quad \text{.......} 2.20$$

and

$$\text{Technical Change} = \left[\frac{d_0^s(q_t, x_t)}{d_o^t(q_t, x_t)} \times \frac{d_0^s(q_s, x_s)}{d_0^t(q_s, x_s)}\right]^{1/2} \quad \text{.......} 2.21$$

This decomposition is illustrated in figure 2.3 below.

Fig 2.3: Malmquist productivity indices



Source: Coelli *et al* (2005: 75)

The firm produces at the points D and E in periods, s, and, t, respectively. In each period, the firm is operating below the technology for that period. Hence, there is technical inefficiency in both periods given by the measured distances in output between Y_t and Y_c for period, t, and between Y_s and Y_a for period, s.

Therefore, the efficiency change and the technical change are given by;

$$\text{Efficiency change} = \frac{y_t / y_c}{y_s / y_a}$$

$$\text{Technical change} = \left[\frac{y_t / y_b}{y_t / y_c} \times \frac{y_s / y_a}{y_s / y_b} \right]^{1/2}$$

A number of additional possible decompositions of this technical efficiency change and technical change components have been proposed by various authors. Fare *et al.* (1994) suggested that technical efficiency change can be decomposed into scale efficiency and pure technical efficiency components. This can only be done when the distance functions in the above equations are estimated relative to constant returns to scale technology. This decomposition involving scale efficiency has been widely used and also widely criticized. The decomposition involves taking the efficiency change measure and decomposing it into pure efficiency change component, measured relative to the variable returns to scale (VRS) frontier.

i.e. pure efficiency change $= \dfrac{d_{ov}^{t}(q_t, x_t)}{d_{ov}^{s}(q_s, x_s)}$ 2.22

The scale efficiency change component is in equation 2.23

$$\left[\frac{d_{ov}^{t}(q_{t},x_{t})/d_{oc}^{t}(q_{t},x_{t})}{d_{ov}^{t}(q_{s},x_{s})/d_{oc}^{t}(q_{s},x_{s})}\times\frac{d_{ov}^{s}(q_{t},x_{t})/d_{oc}^{s}(q_{t},x_{t})}{d_{ov}^{s}(q_{s},x_{s})/d_{oc}^{s}(q_{s},x_{s})}\right]^{1/2} \quad \ldots\ldots\ldots 2.23$$

This is actually the geometric mean of two scale efficiency measures. The first is relative to the period, t, technology and the second is relative to the period, s, technology. The extra subscripts, *v* and *c,* relate to the VRS and CRS technologies, respectively. If this extra decomposition is used, the distance functions would all need to be relative to a CRS technology.

The above suggested method of introducing a scale efficiency change component in the Malmquist TFP index decomposition has been the source of considerable debate in recent years (Fare *et al*, 1998; Ray and Desli, 1997). The main point of criticism is essentially that if there is scale efficiency change then, this implies that the true production technology should have VRS. However, the Fare *et al* (1998) decomposition reports a technical change measure that reflects the movement in a CRS frontier and not the VRS frontier. Ray and Desli (1997) point out this inconsistency and suggest an alternative decomposition that has technical change measure relative to VRS frontier and an amended scale change component that is no longer equivalent to the scale efficiency change.

These two alternative decompositions will be approximately equal if the rate of technical change is similar at the observed data point and at the corresponding most productive scale size point but will otherwise differ. The Ray and Desli (1997) decomposition is arguably a more internally consistent decomposition. However, the differences between the two approaches will only be substantive when there are firms within the sample with significantly different scales and there are non-neutral rates of technical change across the different sized firms. Furthermore, the Ray and Desli (1997) method can suffer from computational difficulties when DEA based distance functions are used because of infeasibilities in some VRS calculations.

One important point that is closely related to this issue is that the returns to scale properties of the technology are very important in TFP measurement. According to Grifell-Tatje and Lovell (1995), the Malmquist TFP index may not correctly measure TFP changes when VRS is assumed for the technology. Hence, it is important that CRS be imposed upon the technology that is used to estimate distance functions for the calculation of that Malmquist TFP index, or alternatively, that an appropriate adjustment factor is included to correct for this omission. Orea (2002) suggested the inclusion of an additional scale change component in a Malmquist TFP index derived from a translog technology. Otherwise the resulting measures may not properly reflect the TFP gains or losses resulting from scale effects. This study therefore imposed CRS upon the technology in the estimation of the distance functions to calculate the Malmquist TFP index for the Kenyan manufacturing sector.

There are a number of different methods that could be used to estimate a production technology and hence measure the distance functions that make up the Malmquist TFP index. The most popular methods are; the DEA-like linear programming methods and the Stochastic Frontier methods. The next section briefly introduces the two methods.

2.2.7 Data Envelopment Analysis (DEA)

DEA is a linear programming methodology, which uses data on the input and output quantities of a group of Decision Making Units (DMUs) to construct a piece –wise linear surface over the data point. The frontier surface is constructed by a solution of a sequence of linear programming problems, one of each DMU in the sample. The degree of technical inefficiency of each DMU (the distance between the observed data point and the frontier) is produced as a by product of the frontier construction method.

One of the possible limitations of DEA is that when there are a few observations and many variables, many of the firms will appear on the DEA frontier exaggerating the technical efficiency scores (Coelli *et al* 2005). For example, as the ratio of the number of variables to the sample size increases, the ability of DEA to discriminate among firms is reduced. Hence, many firms are labelled as 100 percent efficient since there are no firms or combination of firms against which they can be compared (Rossi and Ruzzier, 2004).

DEA can be either input-oriented or out-put oriented. In the input-oriented case, the DEA method defines the frontier by seeking the maximum possible proportion reduction in input usage, with output level held constant, for each DMU. While in the output-oriented case, the DEA method seeks the maximum proportional increase in output production, with input level held fixed. The two measures provide the same technical efficiency score when a constant return to scale (CRS) technology applies, but are unequal when variable returns to scale (VRS) is assumed (Coelli *et al*, 2005). The use of

DEA to calculate the required distance functions used to construct the Malmquist TFP index in the current study is presented later in section 2.6.2

2.2.8 The Stochastic Frontier methods

The distance measures required for the Malmquist TFP index calculations can be measured relative to a parametric technology. The methods are based upon the translog distance function methods described by Fuentes, Grifell-Tatje and Perelman (2001) and Orea (2002). Focusing on a production frontier case, which is a single output special case of the more general multi-output distance function, the translog stochastic production frontier is defined in equation 2.24:

$$\ln q_{it} = \beta_0 + \sum_{n=1}^{N} \beta_n \ln x_{nit} + \frac{1}{2}\sum_{n=1}^{N}\sum_{j=1}^{N} \beta_{nj} \ln x_{nit} \ln x_{nit} + \sum_{n=1}^{N} \beta_{tn} t \ln x_{nit} + \beta_t t + \frac{1}{2}\beta_u t^2 + v_{it} - u_{it}$$

$$i = 1,2,\ldots,I,\ t = 1,2,\ldots,T, \quad \ldots\ldots 2.24$$

Where q_{it} is the output of the i[th] firm in the t[th] year;

x_{nit} denotes an n[th] input variable;

t is a time trend representing technical change;

The β_s are unknown parameters to be estimated;

The v_{it} are random errors assumed to be independently identically distributed and have $N(0,\sigma_v^2)$ distribution, independent of the u_{it}; and

The u_{it} are the technical inefficiency effects with appropriately defined structure.

The above model has the time trend, t, interacted with the input variables which allows for non-neutral technical change. The technical efficiencies of each firm in each period can be predicted by obtaining the conditional expectation of $\exp(-u_{it})$, given the value of $e_{it} = v_{it} - u_{it}$. Since u_{it} is a non-negative random variable, this technical efficiency predictions are between zero and one, with a value of one indicating full technical efficiency. In this parametric model, measures of technical efficiency and technical change can be used to calculate the Malmquist TFP index using the equations 2.19 to 2.21. The technical efficiency measure is:

$$TE_{it} = (\exp(-u_{it}) | e_{it}) \quad \text{......} 2.25$$

Where $e_{it} = v_{it} - u_{it}$ can be used to calculate the efficiency change component. i.e by observing that $d_0^t(x_{it}, y_{it}) = TE_{it}$ and $d_o^s(x_{is}, y_{is}) = TE_{is}$ the efficiency change index is calculated as:

$$\text{Efficiency change} = TE_{it} / TE_{is} \quad \text{......} 2.26$$

This measure can be compared directly to equation 2.20. The technical change index between period, s, and, t, for the ith firm can be calculated directly from the estimated parameters. The partial derivative of the production function is first evaluated with respect to time using the data for the ith firm in periods, s, and, t. The technical change index between the adjustment periods, s, and, t, is then calculated as the geometric mean of these two partial derivatives. When a translog function is involved, this is equivalent to the exponential of the arithmetic mean of the log derivatives i.e.

$$\text{Technical change} = \exp\left\{\frac{1}{2}\left[\frac{\partial \ln y_{is}}{\partial s} + \frac{\partial \ln y_{it}}{\partial t}\right]\right\} \quad \text{......} 2.27$$

This measure may be compared directly with equation 2.21. The indices of technical efficiency change and technical change obtained using equations 2.26 and 2.27 can then be multiplied together to obtain a Malmquist TFP index, as defined in equation 2.19.

Some issues are worth noting. First, the above technical change measure involves derivative calculations, which appear to contradict the earlier comments that these indices are derived from distance measures. It can be easily shown (for the translog case in which a time trend is used to represent technical change) that for geometric mean of the distance ratios in equation 2.21 are equivalent to the geometric means of the derivative measures.

One possible criticism of the above method is that, if scale economies are important, then the TFP index may produce biased measures because the productivity changes are not captured. One possible solution to this problem is to impose CRS upon the estimated production technology. Another option is to use the approach proposed by Orea (2002) that uses Diewert's quadratic identity to derive a Malmquist TFP decomposition identical to that proposed above, and then suggested that the scale issues can be addressed in a manner similar to that used by Denny, Fuss and Waverman (1981). This involves the inclusion of a scale change component to the TFP measure,

$$\text{Scale change} = \exp\left\{\frac{1}{2}\sum_{n=1}^{N}\left[\varepsilon_{nis}SF_{is} + \varepsilon_{nit}SF_{it}\right]\ln\left(x_{nit}/x_{nis}\right)\right\}, \qquad \text{2.28}$$

Where $SF_{is} = (\varepsilon_{is} - 1)/\varepsilon_{is}$, $\varepsilon_{is} = \sum_{n=1}^{N}\varepsilon_{nis}$ and $\varepsilon_{nis} = \dfrac{\partial \ln q_{is}}{\partial \ln x_{nis}}$

This scale change index is equal to one if the production technology is CRS. That is, where the scale elasticity (ε_{is}) is equal to 1.

2.3. Overview of the theoretical literature

The reviewed theoretical literature revealed that the approaches widely used in the estimation of productivity changes are broadly classified as traditional Price-based Index Number (PIN) approach and Frontier approaches. The principal weaknesses of the traditional PIN methods are that price and quantity information is required but may be unavailable; and the methods assume that the firms are technically efficient which is likely to be untrue. On the other hand, the methods can not be used to measure technical and efficiency changes.

The Frontier approach includes Stochastic Frontier Analysis which is a parametric approach, and the Data Envelopment Analysis which is non-parametric. The frontier approach is preferred to PIN for four reasons: it does not require price information, does not assume all firms are fully efficient, does not need to assume a behavioural objective such as cost minimization or revenue maximization, and it permits TFP change to be decomposed into components such as technical change (TC), efficiency change (EC) and scale change (SC). The first is a distinct advantage because in general, input price data are seldom available especially in the Kenyan manufacturing sector given its enormous informal nature and more so that the price data available from the formal sector may be distorted due to the government intervention common in developing countries.

Stochastic Frontier Analysis (SFA) imposes a priori functional form to the frontier. When the functional form is specified, the unknown parameters of the function are estimated using econometric techniques. The requirement to first specify a functional form makes the SFA more computationally demanding. However, SFA accounts for noise in the data and can be used to conduct conventional tests of hypotheses. The non-parametric approaches on the other hand are dominated by data envelopment analysis (DEA). The DEA method is computationally simple and has the advantage that it can be implemented without specifying the functional form of the frontier. However, it will not account for noise in the data. Lundvall (1999) applied the DEA method on the same data that was used by Lundvall and Battese (1998) to check the sensitivity of the SFA results obtained by the latter. The results obtained were largely consistent even though the inefficiency scores yielded by DEA were lower than those yielded by SFA.

2.4. General empirical literature

Solow (1957) showed that a composite measure, TFP growth could be isolated from individual inputs by decomposing output growth into that portion attributed to increases in factor input and a residual. This residual or TFP growth is what Abrahamovtz (1956) had earlier aptly labelled as "a measure of our ignorance" and measures the combined effect of pure technical progress and growth in the overall efficiency with which inputs are combined to produce output.

The Solow growth model focused on the four variables: output (Y), capital (K), labour (L) and knowledge (A) or the effectiveness of labour where the production function takes the form:-

$$Y(t) = F(K(t), A(t), L(T)) \qquad 2.29$$

Where t denotes time.

In the model, time did not enter the production function directly but only through Labour, capital and knowledge. That is, output changes over time only if the inputs used in production changed. In particular, the amount of output obtained from given quantities of capital and labour rose over time- there was technical progress - only if the amount of knowledge increased. The model assumed that knowledge entered into the production function through labour implying that technical progress was labour-augmenting or Harrod-neutral.

In the article by Solow (1957) on growth in industrialized countries between 1909 and 1949, knowledge entered the production independently as a residual or a measure of the total factor productivity growth. Such technical progress is said to be Hicks-neutral. Solow found the residue to be quite large and explaining almost 90 percent of US growth per capita while growth in capital per man accounted for some 10 percent. In other industrialized countries, the contribution of the residue was also high. For the UK, West Germany and Japan, TFP growth accounted for 54, 56 and 55 percent respectively.

The Solow model is a conventional growth accounting approach to estimate TFP growth without distinguishing between its two components; technical progress and technical efficiency. Technical progress is synonymously considered to be the unique source of TFP growth. Failure to take account of inefficiency and technical efficiency change may produce misleading and biased TFP estimates. This study therefore estimates the TFP changes and decomposes it into both technical change and technical efficiency change.

Fare *et al* (1994) used Data Envelopment Analysis (DEA) to decompose total output growth into technical change and efficiency change in developed countries. The decomposition involved taking the efficiency change measure in equation 2.20 and decomposing it into a pure efficiency change component in equation 2.22 and a scale efficiency change in equation 2.23. The sample covered 17 OECD countries during the period 1978 to 1988. The study constructed a deterministic frontier from the sample and compared each country's distance from the frontier in the constant returns to scale framework. The authors used distant functions to calculate the Malmquist index as an alternative measure to TFP. The Malmquist index isolated the changes in efficiency interpreted as catching up, from technological change which is measured by shifts in the frontier. The efficiency factor further decomposes into pure technical efficiency change and changes in scale efficiency (Coelli *et al*, 2005).

This study borrows heavily from the methodology used by Fare *et al* (1994) where the total factor productivity change was decomposed into efficiency change (catch- up) and technical change. However, while Fare *at al* (1994) decomposed the efficiency change further into pure efficiency change and scale efficiency change, this study does not. If there is scale efficiency change, then this implies that the true production technology must show VRS. However, the Fare *et al* (1994) reported a technical change measure that reflected the movement in a CRS friontier and not the VRS frontier. For consistency this study assumes CRS for both efficiency and technical changes. According to Grifell-Tetje and Lovell (1995) Malmquist TFP index defined in equation 2.18 may not correctly measure TFP changes where VRS is assumed for the technology and hence the need that CRS be imposed upon the technology that is used to estimate distance functions for the calculation of this Malmquist TFP index. While Fare *et al* (1994) analysed productivity growth at the country level, this study is a firm level analysis in the manufacturing sector.

Mengistae (1996) used an unbalanced panel data of 220 Ethiopian manufacturing firms to investigate age-size effect in productive efficiency. Both fixed effect and random effect models were estimated and the predicted technical efficiency scores regressed on various firm characteristics including firm age and firm size. The study found that the age-size effects detected in the growth of firms in the sample were matched by time-invariant inter-firm differences in technical efficiency. There were also age-size effects in efficiency where bigger firms were more efficient given age and older firms were more efficient given size. Firm age and firm size mainly proxied for owner human capital and location variables in as far as they explained efficiency scores. There was no evidence that efficiency depends on any one of pre-ownership, employment experience, occupational following of parents or prior vocational training. On the other hand, a study by Alvarez and Crespi (2003) found that owner characteristics such as education or job experience were not related to efficiency but input quality variables such as workers experience and capital modernization increased efficiency.

While the study revealed some important determinants of efficiency (catch up) in the manufacturing firms in Ethiopia, no focus was made on the technical progress which is the other major component of productivity. Overall the study concentrated on the efficiency aspect only. This study departed from this partial approach to productivity and sought to consider both sources of productivity change that is efficiency change and technical change. However, Ethiopia being comparable to Kenya in that both are developing countries, the determinants of production efficiency brought out in the Mengistae (1996) study could still explain a Kenyan case. In terms of data, this study has the advantage of using a balanced panel for the period of study.

Chirwa (2000) assessed efficiency of firms during the structural adjustment programme period for four sub-sectors in Malawian manufacturing industry: food processing, clothing and foot ware, pharmaceuticals and soaps. Assuming the inefficiency component to be distributed as both half normal and truncated normal, the study estimated stochastic production frontiers for each sub-sector using Cobb-Douglas and Translog specifications. Firm level inefficiencies were predicted using panel data between 1984 and 1988 and regressed on firm specific and industry characteristics using censored Tobit regression analysis. The study found that technical efficiency significantly declined with firm size, domestic monopoly power and tariff while it was a positive function of factor intensity and skills of workers.

While Chirwa (2000) focused on the manufacturing sector firms as is the case in this study, technical efficiency was the focus with no attention given to technological issues in the Malawian manufacturing sector. It is however worthy noting that while Mangistae (1996) found technical efficiency to increase with firm size in Ethiopia, in Malawi, efficiency declined with firm size.

Battese *et al* (2000) carried out an empirical study of the technical efficiencies of firms in the Indonesian garment industry using panel data from the annual census of manufacturing industries during 1990 to 1995. The study used different stochastic frontier modules in five different regions of Indonesia because of differing technologies involved. However, a stochastic meta-production frontier was applied to obtain alternative estimates for the technical efficiencies of firms in the different regions. A meta-production, which was first introduced by Hayami (1969) can be regarded as the envelope of commonly conceived neo-classical production functions. In this context, it was defined as the envelope of the production points of the most efficient regions. Using a decomposition result obtained by using both the regional and the meta-production frontiers, the mean productivity potential of firms in a given region was estimated. The technical inefficiency effect in the stochastic frontiers was assumed to have the time-varying structure proposed by Battese and Coelli (1992).

The study found that the productivity potential ratio played an important part in explaining the ability of the garment firms in one region to compete with other garment firms from different regions at the national level. This ratio provided an estimate of the technology gap between the region and the country as a whole.

The above study is another case of a partial approach to productivity study. It concentrated on efficiency issues in only one sub-sector of the manufacturing sector. Furthermore, the study used a parametric approach while this study uses a non-parametric approach.

Deraniyagala (2001) examined the effect of technology accumulation on firm level technical efficiency in the Sri Lanka clothing and agricultural machinery industry using cross-sectional survey data. A two-step analysis of efficiency was applied on a Cobb-Douglas stochastic frontier function and estimated using maximum likelihood method. Technical inefficiency was assumed to follow an exponential distribution. The study found that technology accumulation measured by technical change and technical capabilities had a significant and positive effect on firm level technical efficiency. Further, the analysis showed that firms using broadly similar technologies could achieve varying levels of efficiency depending on the extent of incremental, minor technical change undertaken for adaptation and assimilation. This was consistent with Biggs and Raturi (1997) who found that all indicators of learning-related technological capabilities that enhance firms' capacity to build and augment human capital had a positive impact on productivity.

The study introduced a new and interesting dimension in that an attempt was made to relate the two main sources of productivity changes. Efficiency is hypothesized to be dependent on technology accumulation measured by technical change and technical capabilities. This study however takes both efficiency and technical changes to be complementary sources of productivity change.

Chirwa (2001) studied the relationship between privatization and technical efficiency in Malawian manufacturing sector using panel data between 1970 and 1997. Non-parametric production frontier (DEA) was used to derive the technical efficiency scores. The study found that changes in technical efficiency were higher in privatized enterprises compared to the state owned enterprises and private enterprises. Controlling for other sources of technical efficiency, econometric results showed that efficiency scores were 25 percent higher in the period after privatization. Bottasso and Sembenelli (2004) agreed with this study that privatization brings efficiency gains.

However the study again focused on efficiency issues comparing how efficiency differs before and after privatization. While it may add value to a similar study for Kenya, this study uses a broad approach to productivity change sourced from both efficiency changes and technical changes. However, this study similarly uses a non-parametric approach but takes interest in both the efficiency and technical aspect of productivity change.

Coelli and Rao (2003) carried out a study on the TFP growth in agriculture of 93 countries using data of 20 years from 1980 to 2000. In the study, they sought to examine the levels and trends in agricultural output and productivity in the 93 developed and developing countries that accounted for a major portion of the world population and agricultural output. They used data from the food and agriculture organization of United Nations. Due to the non-availability of reliable input price data, the study used Data Envelopment Analysis (DEA) to derive Malmquist productivity indices. The study examined trends in agricultural productivity over the period and issues of catch up and convergence or in some cases possible divergence in productivity in agriculture were examined within a global framework. The study derived the shadow prices and value shares that were implicit in the DEA based Malmquist productivity indices, and examined the plausibility of their levels and trends over the study period.

The results showed an annual growth in TFP of 2.1 percent, with efficiency change (or catch up) contributing 0.9 percent and technical change (or frontier shift) providing the other 1.2 percent. In terms of individual country performance, the most spectacular performance was posted by China with an average annual growth of 6.0 percent on TFP over the study period. Countries with strong performance were, among others, Cambodia, Nigeria and Algeria. The United States had a TFP growth rate of 2.6 percent where as India had posted a TFP growth rate of only 1.4 percent. In terms of regions, Asia was the major performer with annual TFP growth of 2.9 percent. Africa seemed to be the weakest performer with only 0.6 percent growth in TFP. Examining the question of catch up and convergence, there was an encouraging reversal of negative productivity trends and technological regression.

The study clearly measured the TFP changes and decomposed the changes into efficiency changes and the technical change. This study takes a very similar approach to decompose the TFP changes in the Kenyan manufacturing sector. While Coelli and Rao (2003) focused on country level data in the agricultural sector, this study is scaled down to firm level data in the manufacturing sector.

Margono and Sharma (2004) estimated the technical efficiencies and the total factor productivity (TFP) growth in the food, textile, chemical and metal products industries during the period 1993 to 2000 in Indonesia using the stochastic frontier model. The study also analyzed the determinants of inefficiency and the TFP growth was decomposed into technological progress, scale component, and efficiency growth. The results revealed that the food, textile, chemical and metal products sectors were on average 50.79, 47.89, 68.65 and 68.91 per cent technically efficient, respectively. The study also noted that ownership contributed to technical inefficiency in the food sub-sector; location and size contributed to technical inefficiency in the textile sector, whereas size, ownership and age contributed to inefficiencies in the chemical and metal products sector. The estimates of TFP growth indicated that productivity in Indonesian manufacturing industries decreased at the rate of 2.73, 0.26 and 1.65 percent in the food, textile, and metal products respectively, whereas in the chemical sector, it grew at a rate of 0.5 percent during the period of the study. The study revealed that TFP growth was positively driven by technical efficiency changes and not technological progress.

This study is quite similar to Margono and Sharma study in that apart from emphasis placed on technical efficiency, the study estimated the total factor productivity growth, decomposing the growth into technical efficiency and technical progress. However, the study used a stochastic frontier model, a parametric approach which imposes a priori functional form to the frontier and which makes the methodology more computationally demanding (Coelli *et al*, 2005). This study however uses a non-parametric approach (DEA) which is computationally simple and has an advantage in that it can be implemented without specifying the functional form of the frontier.

Limam and Miller (2004) examined cross country patterns of economic growth by estimating a stochastic frontier production function for 80 developed and developing countries and decomposing output change into factor accumulation and production efficiency improvement. The study incorporated the quality of inputs in analyzing the output growth, where productivity of capital depended on its average age while the productivity of labour depended on its average level of education. The growth decomposition involved five geographical regions i.e. Africa, East Asia, Latin America, South Asia and the West. The study found that factor growth especially capital accumulation proved much more important than either improved quality of factors or TFP growth in explaining output growth. The quality of capital positively and significantly affected output growth in all groups. The quality of labour had a positive and significant growth only in Africa, East Asia and the West. Labour quality had a negative and significant effect in Latin America and South Asia.

This study focused on economic growth and identified TFP growth as one determinant of the economic growth at the country level. TFP growth turned not significant in explaining economic growth especially in Africa. The results revealed factor accumulation and labour mobility to explain growth especially in Africa probably explaining why little attention has been given to factor productivity as a means to economic growth. This is despite the fact that competitiveness requires efficiency and technical progress which together lead to TFP growth. This study therefore focuses on TFP growth to give more attention to productivity growth as a means to a competitive manufacturing sector in Kenya.

2.5. Empirical literature specific to Kenya

Biggs *et al* (1995) investigated the technical efficiency level for four manufacturing sub-sectors in three African countries namely; Ghana, Kenya and Zimbabwe. The sub-sectors were: food processing, wood working, metal working and textile and garments. The study used the Cobb-Douglas technology where the dependent variable was defined as value added. The study used firm level data for the period 1992-1994 and found that technological capabilities defined as skills and knowledge needed to set up and efficiently operate a modern industry, was a significant determinant of efficiency at all levels, i.e. the firm, the sector and the country levels.

This study adopts Biggs *et al* (1995) definition of the dependent of variable. The study reviewed defined output as value added and which this study conveniently borrows to reduce the number of independent variables and increase the degrees of freedom in estimation. This study also uses the firm level data of the manufacturing sub-sectors in the above reviewed study. However, Biggs *et al* (1995) focused on technical efficiency only leaving out technical change, which this study gives equal emphasis.

Gerdin (1997) studied productivity and growth in Kenya for the period 1964-1994. In one of the chapters on the Kenyan manufacturing industries, the study used a panel of disaggregated data and specified a translog model proposed by Baltagi and Griffin (1988) to estimate input elasticities, returns to scale, technical change and TFP. The study used nine sub-sectors of the Kenyan manufacturing. From the study, input elasticities suggested that intermediate inputs were the most important while capital was the least important. Intermediate inputs were not only the dominant input but also increased its share of output while the importance of labour and capital decreased. Some input elasticities were negative violating the monotonicity condition but none of the negative elasticities was significant. This indicated that at least in a weak sense, the underlying technology would satisfy the monotonicity condition. There was no particular trend in technical change and the technical change scores ranged between 0.33 percent and -0.82 percent. Technical change was also decomposed to pure and non-neutral technical change and it appeared to be of mainly a pure nature. Both TFP growth and technical change were very low. The mean TFP growth was -0.12 percent, technical change -0.18 percent and scale change 0.06 percent. Even though TFP growth rates were generally negative for most part of the period, there was an increase during the coffee boom period 1976-1978, the dominant factor behind which appeared to be the scale change component. The study revealed that TFP changes followed rather well the shocks and booms that Kenya had experienced.

The study made an attempt to study productivity change and its contribution to growth in Kenya. The results of the study pointed to the dismal performance of the manufacturing sector in Kenya since independence and which this study is concerned about. The timing of this study is appropriate since it uses data collected in the middle of a period when Kenya had started on ambitious industrialization strategy, compared to the reviewed study.

Lundvall and Battese (1998) used an unbalanced panel of 235 Kenyan manufacturing firms in the wood, food, textile and metal sub-sectors to investigate the relationship between age, size and technical efficiency and to test the Jovanovic (1982) theory that efficient firms grow and survive while inefficient firms decline and fail. Lundvall and Battese study used a translog functional form of the Battese and Coelli (1995) model where the natural logarithm of outputs was the dependent variable. The study found a positive relationship between size and efficiency as postulated by the theory, implying that large firms were more efficient than small firms. Specifically, the study found that the mean technical efficiency increased in size in all sectors where size was defined as value of intermediate inputs. When the number of workers was used as a proxy for size, the size effects were significant in the textile sector only, implying that the results were sensitive to the definition of the firm size and to the inclusion of small firms. Nevertheless, the firm age was inconsistent with this theory whose effect on technical efficiency was less systematic than firm size, but insignificant in all sectors except textiles.

The study concluded that one of the main reasons for technical inefficiency in the manufacturing sectors was the large number of small firms and the study recommended support programmes to stimulate growth in size rather than number. The study provided insight into the factors that influence technical efficiency clearly revealing firm size as a major determinant. However, emphasis as again given to only one aspect of productivity (efficiency) leaving out technical progress. Lundvall and Battese and this both place emphasis on the firm level analysis of the manufacturing sector.

Lundvall (1999) applied the DEA method on the same data used by Lundvall and Battese (1998) to check the sensitivity of the stochastic frontier model results. The results obtained were broadly consistent. However, the inefficiency scores yielded by the DEA were lower than those yielded by the stochastic frontier model. Soderbom and Teal (2004) noted that the substantially lower scores yielded by the DEA were consistent with presence of measurement errors in the dependent variable. Lundvall (1999) also investigated the factor intensities and substitution in the Kenyan manufacturing sector using an unbalanced panel of 195 firms and a total of 450 observations. The estimated translog production function suggested that large firms tend to be more capital intensive than small ones in Kenyan manufacturing. This is due to non-homothetic technologies and to different input prices. The study observed that the relative marginal products of capital and labour exhibited tendencies to fall with firm size suggesting a negative relationship between the relative price for capital and firm size. Skilled and unskilled labour exhibited higher substitutability between each other than with capital. Hence capital was more likely to constrain the firm more than skills.

In another study, Lundvall *et al* (1999) studied the performance of four Kenyan manufacturing industries, food, wood, textile and metal. The performance was analyzed in terms of technical efficiency and productivity using fixed-and random-effects Cobb-Douglas production function. The study observed that small and informal firms were comparably inefficient. Food sector followed by metals sector was found to be the most productive sector. The study also found that growing firms are more productive than contracting ones, suggesting that high turnover may increase overall sector productivity, including exporting, skill, access to overdraft facilities and foreign ownership. Textiles appear to have experienced several technological regress after the trade liberalization.

The studies by Lundvall (1999) and Lundvall *et al* (1999) on the Kenyan manufacturing sector shed light on how factors of production are substituted and attempted to analyze productivity on various sub-sectors of the manufacturing sector. However, there was no attempt to explain the productivity in terms of its sources but like most of other studies, emphasis was placed on technical efficiency. The sub-sectors covered in the above studies also form part of the sub-sectors included in this study. Lundvall (1999) and Lundvall *et al* (1999) studies estimated the technical efficiency and productivity using a parametric method while this study applies a non-parametric method. The data used by Lundvall (1999) comprised an unbalanced panel collected in the mid 1990s while this study applied a balanced panel data that was successfully collected from 2000-2002.

Bigsten, *et al* (1999) studied the Kenyan manufacturing sector seeking evidence of any difference between the formal and informal small firms. The unbalanced panel comprised of 276 firms in the food, wood, textile and metals sub-sectors. The study assumed a common Cobb-Douglas technology with capital and labour. The study found that, although informal establishments dominated the small firm-segment in Kenyan manufacturing, there were also formal enterprises with distinct characteristics. Informal firms were younger, less capital-intensive, almost never run by Asians, paid less skilled wages and no taxes, had poor access to credit and had less educated managers. The small firms invested more often and were less efficient than Asian-managed formal firms, but more efficient than those managed by Africans. The study suggested formality status, independent of size, mattered. Important also was how ethnicity affected these differences and the graduation of firms from the informal to the formal sectors.

The study clearly brought out a difference between the formal and the informal manufacturing sector enterprises in terms of performance, features and how the firms were run. The difference in performance was captured using a parametric method, Cobb-Douglas production function. No attempt was however made to address aspects of productivity difference in the divide, which this study addresses in the formal manufacturing sector. Productivity measurement requires particular and detailed data that is not available for the informal sector.

Onjala (2002) carried out a study on TFP in Kenya and the links with trade policy. The study explored productivity sources in the manufacturing and agricultural sectors using aggregated data from 1960 to 1995. The study noted that, while economic growth can be viewed as a process involving the entire economy's output performance, it invariably depends on the productivity of the country in question. The sources of productivity growth over time and of productivity differences among countries and regions have emerged as a central unifying theme of growth and development. The study sought to estimate TFP in the agricultural and manufacturing sectors and linked the productivity to the trade policy episodes.

The study adopted a growth accounting approach based on the procedures by Elias (1992), Shaaeldin (1989), Ritter (1988) and Chen (1977). The model assumed a neo-classical production function where time is an independent variable measuring the TFP. The study specified a translog function in the estimation of the TFP scores, which were then regressed against trade policy variables. The trade policies were the real exchange rate, an import index to measure the productivity effect of domestic pressure brought about by imports, and a measure of productivity effect on export promotion. Import and export penetration ratios were used to capture the effects of foreign competition and greater openness on productivity. The study found out that TFP growth contributed more to output growth in agriculture than in the manufacturing sector in Kenya. However, TFP formed a small portion of growth in all sectors. In the manufacturing sector, output growth was mainly explained by factor inputs. In as far as the trade policies were concerned, fluctuations in TFP growth appeared more strongly correlated with the real exchange rate followed by import penetration and by export penetration.

The results of the above study infer that TFP growth did not explain growth in the manufacturing sector output as it did in the agricultural sector. While this study focuses on the manufacturing sectors' TFP changes and explains the sources of such changes, the above study looked at the aggregate manufacturing sector TFP growth but no attempt was made to decompose such growth into the various sources. Moreover, the study used a growth accounting approach which assumed that all firms in the sector are efficient. This study addresses the various sub-sectors of the manufacturing sector and studies the sub-sectors productivity in details. The methodology used measures the productivity changes and decomposes the changes into efficiency sourced changes and technically sourced changes.

Mazumdar and Mazaheri (2003) investigated technical efficiency of manufacturing firms in Ghana, Kenya, Zimbabwe, Tanzania and Zambia using the Battese and Coelli (1995) model. The study found that correlation between firm size and technical efficiency differed from country to country. Larger firms in both Kenya and Zimbabwe were found to be more efficient, while those in Tanzania suggested an inverse relationship between firm size and technical efficiency. Furthermore, the results only supported a strong relationship between age and technical efficiency in Zimbabwe. As in the Lundvall and Battesse (1998) study, the positive age-efficiency relationship proposed by the Jovanovic (1982) learning model found little support. The study also found that the firms that engaged in trade either as importers or exporters and those with technology transfers or foreign licensing were more efficient irrespective of the country studied. This finding was consistent with Chirwa (2001) and Bottasso and Sembenelli (2004) who found that subsidiaries of multinational firms were more efficient compared to state owned firms indicating that foreign participation had a positive implication on domestic production.

According to the Mazumdar and Mazaheri (2003) study, firms gain experience as they grow and improve work practices, leading to efficiency improvement. Firm size captured qualitative variables such as learning by doing, organizational superiority of larger firms and first mover advantages of larger older firms. Firm size was measured by the total number of employees in the firm in a given period. Moreover, firm size was further divided into three size categories namely small, medium and large in order to investigate whether small firms were more efficient than larger ones (Ngui, 2001; Soderbom, 2004). According to Biggs *et al* (1995), the relative efficiency between firm size classes can help policy makers identify enterprise groups with the highest potential to meeting planned economic targets as well as provide useful inputs into other government policies.

The study was yet another attempt to address only one aspect of productivity namely technical efficiency with the same results reported by other similar studies. The study used the stochastic frontier analysis which required a specification of the functional form of the model. This study as stated earlier, studies TFP changes where technical efficiency is just one of the sources of the changes. The DEA method is used with no need to specify any prior functional form of the model.

Soderbom (2004) studied productivity, exports and firm dynamics in the Kenya manufacturing sector over the period 1999 – 2002, using Regional Program for Enterprise Development (RPED) survey collected in 2003 covering the period 2000 – 2002, in conjunction with data from the year 2000. The study assumed a Cobb-Douglas production function with two inputs, physical capital and labour.

The study found out that significant productivity differences existed across sectors, the most productive sectors being chemical and food, while the least productive ones being leather, wood and textiles. There were however, some signs that the textile sector had recovered somewhat in relation to the food sector over the period considered. There were significant productivity advantages to being located in Nairobi, possibly due to external factors such as relatively good infrastructure.

In line with most other studies, this study found a strong size effect on the decision to export, supporting the notion that firms face significant fixed costs to entering the export market. The study found a positive and significant time trend for international exports, suggesting that firms were responding to policy measures designed to spur exports. A further probing of the data suggested that a large part of the increase was played by more firms in the textiles and garments sector becoming export oriented during the period. On exports, Kimuyu (2007) observed that exporters are forced to remain on the look out for ways of improving product quality, production and delivery schedules because they face stiff competition from foreign firms and have to satisfy exacting demands from foreign customers. Bernard and Jensen (1999) showed that more efficient firms were likely to export but exporting did not lead to change in efficiency. However, Tybout (2000) noted that while most studies found that exporters were more efficient than non-exporters before they started selling abroad, learning-by-exporting hypothesis as evidenced by Bigsten *et al* (2004) could not be ruled out since firms in several industries exhibited several efficiency gains after becoming exporters.

This is one among the few studies that have utilized the most current RPED survey in part of its study. The study used a parametric approach to measure productivity in the Kenyan manufacturing sector among other aspects of the sector. The study shed more light on the link between productivity and export confirming a strong link consistent with other studies. However, there was no attempt to measure productivity changes which this study addresses.

Mulwa *et al* (2005) carried out a study on the productivity growth in small-holder sugarcane farming in Kenya using the Malmquist TFP decomposition. The study noted that the Kenyan agricultural sector had undergone major structural changes since independence in form of institutional arrangements related to the land tenure system and marketing. Considerable changes related to the use of intermediate factors of production such as fertilizers, seeds and machinery were evident. The study also underscored the important role played by small holder firms in Kenya. The study only considered the plant-crops in two cycles, previous and current, for comparison. The main inputs and activities that entered sugarcane production function were seed cane, fertilizer, labour (family and hired), and land preparation.

The study observed that Mumias sugarcane farmers continued to use old technologies causing declining technical change. However, the scheme was efficient to some extent. Chemelil scheme suffered both technical regress and efficiency decline. Similar results were recorded for West Kenya sugarcane farmers. The study suggested that one factor that hindered technical progress and efficiency improvements was the continued land subdivision which brought with it diverse management styles.

This study is quite similar to Mulwa's in terms of the methodology used in measurement and decomposition of TFP changes. However, this study uses a panel of firm level data with a focus on the manufacturing sector. The above study was only a micro-study of sugar cane farming in western Kenya.

Ngui (2008) carried out an empirical study on the efficiency of the Kenyan manufacturing sector. Specifically, the study analyzed efficiency differences, efficiency distribution and efficiency relationship with its determinants for three sub-sectors namely: food, metal, and textile, during the structural reform period. In addition, the study investigated whether the technical efficiency point estimates were estimated with precision and discussed the implications arising from considering the confidence interval estimates. The study used the stochastic frontier analysis to estimate the technical efficiency and confidence intervals were calculated using Horrace and Schmidt (1996) procedure. The Caudill *et al* (1995) specification was applied on an unbalanced panel data for two periods, 1992-1994 and 2000-2002. The study found that the width of confidence intervals varied considerably among the observations for each sub-sector making it hard to separate the firms into distinct groups of high, average and low technical efficiency using the individual efficiency estimates. Furthermore, the confidence interval estimates for most of the observations overlapped making it difficult to identify observations that were significantly less or more efficient than the average.

The study could therefore only roughly differentiate between sets of firms that were efficient and inefficient, a finding consistent with Fraser and Horrace (2003) on Australian wool production and Balcombe *et al* (2006) on Australian dairy farms. On technical efficiency, the study revealed that the technical efficiency distribution for all the sub-sectors significantly changed during the period of analysis. The textile and food sub-sectors showed an improvement while the metals sub-sector declined in efficiency. However, the food sub-sector firms largely remained relatively inefficient. An analysis on the determinants of technical efficiency revealed that the significance and the relationship between technical efficiency and its determinants were not only different across the sub-sectors in each period, but also changed during the period of study.

In respect to the firm size, the study found that there was a negative relationship between firm size and efficiency for the metal and textile sub-sectors between 2000 and 2003. This was attributed partly to the operation of excessively large firms driven by increases in factor inputs rather than improvements in productivity, a finding consistent with Bigsten (2002). The study also found a negative effect of firm age on technical efficiency across both periods. This, according to the study, could be explained by the possibility that relatively young firms utilized more recent technology while the older firms used relatively absolute physical capital. Sunk costs were significant and positively related to technical efficiency for the food and textile sub-sectors in the 2000 – 2003 periods, supporting the argument that capital intensive firms embody the most advanced technology. The analysis further revealed that most of the foreign owned firms were exporting firms probably motivated by the incentives provided in the export promotion policies offered by the Kenya Government during the structural reform period. Apparently, the exporting firms were less efficient in 2000-2003 periods than in the 1992-1995 periods, a finding that could be explained by participation in trade not necessarily being related to higher firm efficiency, but with the export promotion policies adopted during the reform period.

Even though Ngui (2008) is in the category of studies that focused on one aspect of productivity in the manufacturing sector (technical efficiency), it shed light on the determinants of the efficiency changes in three sectors that have been included in this study. Ngui's study used the stochastic frontier analysis, which is quite comparable to this study which uses the data envelopment analysis. The measured technical efficiency changes in the study were quite consistent with the changes reported in this study despite the different methodologies. The two studies are also quite comparable in that the same data set was used. However, this study takes a broad approach to productivity where technical efficiency is one of the sources of TFP changes.

Onuonga (2008) carried out a study on the factors that influenced energy utilization in Kenya manufacturing sector and determined the extent of substitution possibilities between energy input and other non-energy factors of production within the manufacturing sector over the 1970-2005 period. The study noted that the Kenyan manufacturing sector was a major consumer of commercial energy, the second largest user of petroleum products and the largest user of electricity.

According to the study, the analysis of price and non-price variables that affected the use of energy within the sector was necessary for designing policy measures that could lead to the energy conservation. Information on the degree of energy substitution was important in predicting the effects of energy shortage on manufacturing output and industrial employment. The study used the translog model to analyse total factor demands and the inter-fuel substitution.

The study found out that price of energy, cross prices, output, technology, price of capital and unexpected events influenced the sector's use of energy. The results for inter-fuel model indicated that demand for electricity and oil in the Kenyan manufacturing sector were price inelastic and that oil and electricity were substitutes. Limited substitution possibilities between electricity and oil in this sector were found.

The demand for energy and labor were price inelastic while that of capital had a unitary elasticity.

The study concentrated on energy as the major factor of production in the manufacturing sector in Kenya. It indeed portrayed the manufacturing sector as an important sector that is a consumer of energy in its production and hence bringing the sector's overall productivity in focus. While energy may not have been one of the variables in this study, it nevertheless formed a major component in the computation of the value added used as the dependant variable. Furthermore, all the components of energy highlighted in Onuonga's study are used in this study.

2.6 Overview of the empirical literature

In most of the studies carried out and especially in Kenyan manufacturing sector, the focus has been on the issues of efficiency, its measurement and determinants. However, efficiency change is only one of the sources of total factor productivity growth. The studies measure and discuss efficiency without linking its absence or presence to the total factor productivity change. Even where TFP issues were examined, the focus was on the manufacturing sector as a whole among other productive sectors of the economy. This study is a micro level approach to the Kenyan manufacturing sector.

The literature reviewed provides insight into the issues that influence production of manufacturing output. Most of the studies have used variables that are consistent with economic theory and therefore have been useful in deciding the variables used in this study. These variables include capital, labour, raw materials and other indirect inputs which can be measured either in physical or monetary value terms depending on the homogeneity of the variables. For the output variable, both gross output and value added have been used which Soderbom and Teal (2004) found to yield similar results. This study adopts the value added approach more so to avoid the lack of degrees of freedom especially in sub-sectors with relatively few firms. When observations are few but with many inputs and/or outputs, then many firms will appear on the DEA frontier, implying efficiency, which may be misleading (Coelli *et al*, 2005).

The few studies on the Kenyan manufacturing sector revealed that growth in the sector has resulted from growth in input use and not productivity change (Ngui, 2008; Bigsten, 2002; KAM, 2006). This could probably explain why no attention has been given to TFP growth in the sector. Studies done on TFP growth have actually revealed that TFP has been declining (Gerdin, 1997). This study addresses itself to the total factor productivity change with specific attention to the sources of such changes, including technological and efficiency changes.

This study adopts the DEA approach to calculate the Malmquist index scores in the measurement and decomposition of TFP growth in Kenya manufacturing sector. The approach has rarely been used in productivity studies in Kenya. Out of the empirical literature reviewed, only Coelli and Rao (2003), Chirwa (2001), Fare *et al* (1994) and Mulwa *et al* (2005) used the methodology, in which only one, Mulwa *et al* (2005) applies to Kenya but in the agricultural sector. Hence the study will provide a new approach to productivity analysis in Kenya.

Furthermore, the study utilizes the most current firm level data with more sub-sectors to allow more homogeneity among the firms. The study is also quite timely utilizing data that was collected right in the middle of the phase one of an industrialization strategy that could have seen Kenya industrialize by the year 2020. The study is crucial in evaluating the extent to which the strategy met the industrialization goals as specified in the sessional paper No. 2 of 1996, and the lessons that can be learnt to see the manufacturing sector play the critical role in propelling the economy at a 10 percent growth rate, in line with the aspirations of the Kenya vision 2030.

2.7 Theoretical framework

2.7.1 Introduction

Total Factor Productivity (TFP) change was measured using the Malmquist index method described in Fare *et al* (1994) and Coelli, Rao and Battese (1998). This study adopted Data Envelopment Analysis (DEA) method to construct a piece-wise linear production frontier for each year in the sample. The Malmquist TFP index was constructed using the DEA-like linear programs described in section 2.7.2 below.

2.7.2 The Malmquist TFP index

The Malmquist index is defined using distance functions. Distance functions allow one to describe a multi-input, multi-output production technology without the need to specify behavioural objectives such as cost minimization or profit maximization. There are two distance functions namely input distance functions and output distance functions. An input distance function characterizes the production technology by looking at a minimal proportional contraction of the input vector, given an output vector. This study arbitrarily chooses an output oriented case and therefore only considers output distance function in detail. However, input distance function can be defined and used in a similar manner.

Following Fare *et al* (1994), and given that suitable panel data are available, the required distance measures for the Malmquist TFP index can be calculated using DEA linear programmes. For the i[th] DMU, the four distance functions in equation 2.18 to measure the TFP change between two periods, s, and, t, are calculated. This requires the solving of four linear programming (LP) problems. The analysis assumes constant returns to scale (CRS) technology (Fare *et al* (1994). This ensures that the resulting TFP change measures satisfy the fundamental property that if all inputs are multiplied by the positive scalar such as δ, and all outputs are multiplied by the non-negative scalar such as α, then the resulting TFP change index will equal α/δ. Assuming there are data on N inputs and M outputs for each of the I firms. For the i[th] firm, these are represented by the column vectors $\mathbf{x}_i$ and $\mathbf{q}_i$, respectively. The $N\times I$ input matrix, $\mathbf{X}$, and the $M\times I$ output matrix, $\mathbf{Q}$, represent the data for all I firms. The required LPs are:

$$[d_0^t(\mathbf{q}_t,\mathbf{x}_t)]^{-1} = \max_{\varphi,\lambda} \theta \quad \text{.......} 2.30$$

$$\text{s.t} \quad -\theta\mathbf{q}_{it} + \mathbf{Q}_t\boldsymbol{\lambda} \geq 0,$$
$$\mathbf{x}_{it} - \mathbf{X}_t\boldsymbol{\lambda} \geq 0,$$
$$\boldsymbol{\lambda} \geq \mathbf{0},$$

$$[d_0^s(\mathbf{q}_s,\mathbf{x}_s)]^{-1} = \max_{\varphi,\lambda}\theta \quad \text{......} 2.31$$

$$\text{s.t} \quad -\theta\mathbf{q}_{is} + \mathbf{Q}_s\boldsymbol{\lambda} \geq 0,$$
$$\mathbf{x}_{is} - \mathbf{X}_s\boldsymbol{\lambda} \geq 0,$$
$$\boldsymbol{\lambda} \geq \mathbf{0},$$

$$[d_0^t(\mathbf{q}_s,\mathbf{x}_t)]^{-1} = \max_{\varphi,\lambda}\theta \quad \text{......} 2.32$$

$$\text{s.t} \quad -\theta\mathbf{q}_{is} + \mathbf{Q}_t\boldsymbol{\lambda} \geq 0,$$
$$\mathbf{x}_{is} - \mathbf{X}_t\boldsymbol{\lambda} \geq 0,$$
$$\boldsymbol{\lambda} \geq \mathbf{0},$$

and

$$[d_0^s(\mathbf{q}_t,\mathbf{x}_t)]^{-1} = \max_{\varphi,\lambda}\theta \quad \text{......} 2.33$$

$$\text{s.t} \quad -\theta\mathbf{q}_{it} + \mathbf{Q}_s\boldsymbol{\lambda} \geq 0,$$
$$\mathbf{x}_{it} - \mathbf{X}_s\boldsymbol{\lambda} \geq 0,$$
$$\boldsymbol{\lambda} \geq \mathbf{0},$$

Where θ is a scalar and $\boldsymbol{\lambda}$ is a $I \times 1$ vector of constants.

In equations 2.32 and 2.33 where production points are compared with technologies from different time periods, the θ parameter need not be greater than or equal to one, as it should be when calculating output-oriented technical efficiencies. The data point could lie above the feasible production set. This will most likely occur in equation 2.33, where a production point from period, t, is compared with technology in an earlier period, s. If technical progress has occurred, then a value of $\theta < 1$ is possible. It could also possibly occur in equation 2.32 if technical regress has occurred but this is less likely.

The θs and λs are likely to take different values in the four LPs presented in equations 2.30 to 2.33. Furthermore, the above four LPs must be solved for each DMU in the sample. Thus, if there are twenty (20) DMUs and two time periods, 80 LPs must be solved. As extra time periods are added, one must solve an extra three LPs for each firm to construct a chained index. If there are T time periods, then (3T-2) LPs must be solved for each firm in the sample. Hence, if there are I firms, then there are $I \times (3T\text{-}2)$ LPs to be solved. For example, with I = 20 firms and T = 10 time periods, this would involve $20 \times (3 \times 10\text{-}2) = 560$ LPs.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

This chapter describes the research design in the study and presents the empirical model adopted for the study. The variables used in the study are defined. To achieve the objectives of the study, quantitative secondary data were collected and analyzed. The data, the data sources, and the methods used in data analysis are explained.

3.2 Research design

The study sought to empirically analyze the total factor productivity change in the Kenyan manufacturing sector. The study comes at a time when prospects of ensuring stable and sustainable economic growth lie more in the development of industry. Policies that strengthen local production capacity of domestically produced products and enhance Kenya's competitiveness globally should be put in place to realize these goals. This therefore created a need for the study to provide a richer policy environment.

The firm and worker survey formed the core of the study and therefore firm level data were sought. The analysis of the manufacturing sector focused on the analysis of data collected in the 2002/03 survey of 282 formal manufacturing firms. The survey resulted from a partnership between Kenya Institute for Public Policy Research and Analysis (KIPPRA) and the Regional Programme on Enterprise Development (RPED), in the African private sector group of the World Bank.

The sample was drawn from a census conducted by Central Bureau of Statistics (CBS) of nearly 2000 formal manufacturing firms employing more than 250,000 full time employees. In order to ensure representation of all types of firms, the sample was stratified across location, sub-sectors and size in 148 clusters. Four locations were identified namely, Nairobi, Eldoret/Kisumu, Mombasa and Nakuru. Nine manufacturing sub-sectors were Agro-industry, chemicals/paints, construction materials, furniture, metals, paper/printing/publishing, plastics, textiles/leather and wood. Four size classes were used: small (11 - 49 employees), medium (50 - 99 employees), large (100 - 499 employees) and very large (500 and more employees).

Three hundred and sixty eight (368) firms were selected randomly from the clusters representing roughly 20 percent of all formal firms. Due to non-responses, perhaps as a result of survey fatigue, only 282 firms completed the survey. A detailed questionnaire was prepared to capture information from the firms on eight thematic areas namely; entrepreneurship and business history, technology, trade, infrastructure, business environment, sales/ raw materials/ products/ investment, credit and finance, and labour and training. The relevant data for this study was in the thematic area of sales/ raw materials/ products/ investment.

The data were analyzed based on the study objectives and the report prepared consistent with the objectives. The data analysis techniques are briefly explained later in this chapter while the findings are reported in chapter four.

3.3 The empirical model

In this study, total factor productivity (TFP) growth was measured using the Malmquist index method described by Fare *et al* (1994) and Coelli, Rao and Battese (1998). Data Envelopment Analysis (DEA) method was used to construct a piece-wise linear production frontier for each year in the sample.

While DEA can be either input-oriented or output-oriented, in this study, a constant returns to scale (CRS) technology was assumed to estimate the output-oriented DEA, since the two measures provide the same technical efficiency score when a (CRS) technology applies (Coelli *et al*, 2005). Furthermore, Grifell-Tatje and Lovel (1995) used a simple one-input, one-output example to illustrate that a Malmquist TFP index may not correctly measure TFP change when VRS was assumed for the technology. Hence it was important that CRS be imposed upon any technology that was used to estimate distance functions for the calculation of a Malmquist TFP index. Otherwise the resulting measures might not have reflected the TFP gains or losses resulting from scale effect properly.

Given that data were available for I firms in the study time period, the linear programming (LP) problem that was solved for the i^{th} firm in an output oriented DEA model was as follows:

$$
\begin{aligned}
& \max_{\theta,\lambda} \theta \\
\text{s.t} \quad & -\theta \mathbf{q}_{it} + \mathbf{Q}_t\boldsymbol{\lambda} \geq 0, \\
& \mathbf{x}_{it} - \mathbf{X}_t\boldsymbol{\lambda} \geq 0, \\
& \boldsymbol{\lambda} \geq \mathbf{0},
\end{aligned}
$$

Where

$\mathbf{q}_{it}$ is a Mx1 vector of output values for the i-th firm in period t;

$\mathbf{x}_{it}$ is a Nx1 vector of input values for the i-th firm in period t;

$\mathbf{Q}_t$ is a IxM matrix of output values for all I firms in period t;

$\mathbf{X}_t$ is a IxN matrix of input values for all I firms in period t;

λ is a Ix1 vector of weights; and

θ is a scalar.

It was observed that θ will take a value greater than or equal to one and that (θ -1) was the proportional increase in outputs that could be achieved by the i^{th} firm, with input quantities held constant. Note also that 1/θ defined a technical efficiency (TE) score which varies between zero and one.

The above LP was solved I times-once for each firm in the sample. Each LP produced a θ and a λ vector. The θ parameter provided information on the technical efficiency score for the i^{th} firm and the λ vector provided information on the peers of the (inefficient) i^{th} firm. The peers of the i^{th} firm are those efficient firms that defined the facet of the frontier against which the (inefficient) i^{th} firm was projected.

The θ and λ were likely to take different values in the LPs estimated. Furthermore, the LPs were to be solved for each firm in the sample. Thus, if for instance there were I firms and two time periods, $2\times I$ LPs were to be solved. As extra time periods were added, an extra three LPs for each firm were to be solved to construct a chained index. If there were T time periods, then (3T-2) LPs were solved for each firm in the sample. Hence if there were I firms, then there were $I \times (3T\text{-}2)$ LPs to be solved.

In the study, each sub-sector had a different number of firms I and the panel consisted of 3 time periods. For every sub-sector therefore, for T = 3, $(7 \times I)$ different LPs were solved using the appropriate computer programme. There were many pieces of information from the computer output but for the purpose of this particular study, only the Malmquist index summaries of annual means and firm means are reported in chapter four. Where the sub-sectors were compared against the whole manufacturing sector's frontier, the above formulation applied, only that I represented the number of sub-sectors, and not the number of firms as in the sub-sector level.

3.4 Definition and measurement of variables

Output: the dependent variable was measured by value added in Kenyan shillings. It was computed as the difference between the values of each firms output and the value of the intermediate inputs. The value of the firm's output was measured by the total sales figure for the manufactured goods as provided by the firms. The intermediate inputs included energy, raw materials and indirect inputs. Energy comprised of electricity, fuel and other energy related costs as provided by the firms. Raw materials were measured by the direct costs of raw materials as provided by the firms, while indirect inputs were measured by all the aggregate expenses other than capital, labour, energy and raw materials. The expenses included the interest charges and financial fees in the process of production.

Labour was defined as the physical and mental efforts put for wages and salaries. It was measured by the total cost of labour (wage bill) in the period of study. The wage bill component consisted of direct labour cost and indirect labour costs. The direct labour cost component included wages and salaries, allowances, bonuses and other benefits. The indirect labour cost component included the administrative cost. All these costs as provided by the firms were summed up to form a measure of the labour input.

Capital denoted the intermediate goods used in the production of other goods. The major components of capital were machinery and other equipment. It was measured by the replacement value of machinery and other equipment. The value was obtained by subtracting the new purchases in a particular year from the cost of replacing each item at the end of the year, and adding back the sales of the items during the year. The figure was corrected for degree of capital utilization in a given period. For the data set used in this study, it was measured by the declared capacity utilization by the individual firms.

3.5 The data

The empirical analysis was based on micro-data of the Kenyan manufacturing firms collected as part of the World Bank Regional Programme on Enterprise Development (RPED) survey of 2002/2003. The data formed a balanced panel for the period 2000/2001 – 2002/2003 obtained from the firms that gave information for either one or two pervious years using the recall method. This left out all the firms that availed information for only one year in the 2002/2003 data set to ensure completeness and consistency of the data for the estimations.

The data were collected on 282 formal manufacturing firms covering 13 sub-sectors drawn from 5 urban centres in Kenya namely Nairobi, Mombasa, Eldoret, Kisumu and Nakuru. The sub-sectors included agro-industry, bakery, chemicals and paints, construction materials, furniture, metal, machinery, paper printing and publishing, plastic, textile, garment, leather and wood. The original survey touched on eight thematic areas in the manufacturing sector. These were business history, technology, trade, infrastructure, business environment, sales and production, credit and finance and labour and training. For the purposes of this study, the relevant data was under the thematic area of sales and production in which section data on each firm's information on outputs and inputs was contained. Out of the 282 firms included in the survey, the study filtered a total of 119 firms and a total of 357 observations.

The data on the 282 firms contained quite a number of gaps with some vital information on the major variables missing. For these reasons the study made necessary adjustments in the data to ensure substantial degrees of freedom for the estimations as follows: some sub-sectors that had too few firms with complete data were omitted from the study. These were rubber and glass sub-sectors. Some sub-sectors that had a few complete observations but highly similar were merged but ensuring homogeneity as much as possible. The bakery sub-sector was therefore merged with the agro-industry in this study referred to as the food sub-sector; wood sub-sector was merged with furniture sub-sector in the study now referred to as wood and furniture sub-sector; and textile and garment sub-sectors were merged in the study now referred to as textile sub-sector. The value added approach was applied leaving only two inputs that were the independent variables. These were labour and capital.

The study therefore focused on eight sub-sectors namely; food (31), textile (19), wood and furniture (8), metal (22), plastics (11), paper printing and publishing (11), construction materials (7) and chemicals and pharmaceuticals (10).

3.6 Data editing, coding, cleaning and refinement

Every question in the questionnaire had been allocated a code that identified the sub-sector, the firm, the period and the variable of interest. The data collected had been recorded under each of the codes allocated and therefore it was relatively easy to pick the necessary variables that formed the basis of the analysis in the study.

However, not all firms in each sub-sector had complete data sets for all the required variables. In all cases where data on important variables was not provided, the particular firm was dropped culminating into a sample of firms with complete information in each sub-sector. For example, firms with zero output values in particular years were omitted from the analysis while for other variables, they were imputed using the panel dimension of the data sets.

3.7 Validity and reliability of data

While the use of non-parametric methods, such as DEA, may reduce most of the estimation problems associated with parametric analysis, measurement error and other noise may influence the shape and position of the estimated frontier. Noise was expected to signal-ratio for the inputs and outputs due to; the unwillingness of the firms to reveal true values for fear that the information might reach the competitors or the tax authorities, varying degrees of market imperfections which might have caused bias in the value of output, inaccuracy in valuing the capital stock which consisted of a wide range of machinery and equipment acquired over long periods of time, conversion of nominal values to real values in which case the deflators were assumed to be equal across different sub-sectors despite the heterogeneity of the samples and inaccuracy in the values especially in the data set used where recall method was utilized to acquire information on the previous periods (Lundvall *et al.*, 2002). To remove price effects from the variables, different deflators were used for all inputs and outputs with 2000 being the base year.

Outliers might also have affected the results. They may have been caused by data recording or data entry errors, heterogeneous set of one or two types of cases, one of which is much more frequent, and occurrence of extreme observations with greater frequency than expected for a normal distribution (Judd and McClelland, 1989). The outliers present were detected using squared Mahalanobis distance and omitted from the analysis. Squared Mahalanobis distance points out to observations for which the explanatory part lies far from that of the bulk of the data. The values of squared Mahalanobis distance were then compared with 95 percent quartiles of the chi-square distribution with (M-1) degrees of freedom where M represented the number of independent variables (Rousseeuw and Leroy, 1986).

Too few observations and many inputs and/or outputs may provide misleading results where many firms appear on the DEA frontier suggesting all firms are efficient (Coelli, 2005). The sub-sectors with too few firms were therefore omitted while others were merged to improve the results.

3.8 Data analysis

The study sought to address four objectives. The first and second objectives were qualitative and involved a descriptive analysis. The third and fourth objectives were met by empirically analyzing the data collected as described in section 3.3. Data envelopment analysis (DEA) calculations were conducted using Data Envelopment Analysis (computer) programme (DEAP version 2.1). The application calculated indices of total factor productivity changes and decomposed them into technological changes and efficiency changes. These index scores are reported in chapter four of the study. This is followed by conclusions and policy recommendation in the light of the study findings.

CHAPTER FOUR

RESEARCH FINDINGS

4.1. Introduction

This chapter presents the findings of the study. The policy environment that has guided the structure and performance of the manufacturing sector has been traced from independence to the current, followed by the structure and composition of the sector. The empirical results concerning the total factor productivity growth and sources in the sector are also presented and discussed.

4.2 Policy episodes in Kenya's industrialization process

The first objective of the study was to analyse the policy episodes in Kenya's industrialization process, which have been undertaken in phases. To this end, six phases have been identified and analysed as follows.

(a) The import substitution phase

In the period immediately after independence, Kenya pursued an import substitution strategy as a means of promoting industrialization. The strategy was influenced by conventional wisdom prevailing during the period in many developing countries. The objectives of the strategy were rapid growth of industry, easing balance of payment problems, and generation of employment. To achieve the objectives, the government relied on a variety of policy instruments including an overvalued exchange rate, high tariff barriers, import licensing, foreign exchange control and quantitative restrictions to protect local producers against foreign competition (Bienen, 1990; Roemer, 1993; Hill, 1993).

Foreign exchange measures were extensively used during this phase to protect local manufacturers. The foreign exchange allocation committees were established to administer foreign exchange quotas for imports for which a limited quota had been established to protect domestic producers. Foreign exchange controls were used to discriminate against certain imports, promote foreign exchange earning industries and to conserve foreign exchange which was a major constraint in the economy.

Tariffs were also used extensively as an instrument of protection. For most of the time, the Kenya tariff structure reflected the overall import substitution strategy. Tariffs were generally high on imports of final products relative to capital and intermediate goods such as machinery and building materials. Until the collapse of East African Community (EAC) in 1977, Kenya could not unilaterally change external tariffs. However, due to a weak administrative capacity, quantitative restrictions proved to be more effective in controlling imports compared to tariffs. Import license requirement was the main instrument for quantitative regulation, with inputs and certain products receiving preferential or priority treatment in the issuance of import licenses.

The import substitution phase and the policies that sustained it had mixed results. On the positive side, the country enjoyed a considerably high rate of industrial growth during the first decade of independence with the manufacturing sector growing at an average rate of 8 percent compared with the rate of 5 percent in the 1980s and 1990s. Industries that recorded rapid development during this period were processing of plastics, pharmaceuticals, steel rolling and galvanizing electrical cables, pepper, vehicle assembly, industrial gases, rubber, ceramics, and battery manufacture. Some industries expanded from a few establishments into industries with a wide range of products and a large number of employees. They included paper, textiles and garment manufacturing, food processing, leather tanning and footwear (Coughlin, 1988; KAM, 1998).

The impressive performance of the economy in general and industrial sector in particular was due to dynamism and prudent macroeconomic management. Investment was encouraged through high protection, a liberal attitude towards foreign investors, an active role played by the government in promoting industrialization through provision of credit facilities and other incentives and a relative stable political and economic environment that was attractive to both domestic and foreign investors. The high growth rate was also facilitated by the economic dynamism normally associated with the import substitution strategy in the initial stages. The commendable manufacturing sector performance benefited substantially also from the expanding domestic demand partly due to rising agricultural income which was stimulated by modernization and diversification of the agricultural production for both exports and domestic market.

However, towards the end of the 1970s, there was a general deterioration in the country's overall economic performance due to a number of factors. Industrial production for export markets slowed down substantially because the incentive structure favoured production for domestic market creating an inward-looking industrial sector whose potential was severely limited by the size of the domestic market. The situation was aggravated by the collapse of the East African Community (EAC) in 1977. In addition, there was an erosion of fiscal discipline after the coffee boom in the late 1970s, which was worsened by a deterioration in the countries external terms of trade following the second oil shock in 1977 (Foroutan, 1993). The import substitution strategy was also in general strongly biased against exports.

Import substituting industries created too few jobs while many industries used inappropriate capital-intensive technologies that created a manufacturing sector heavily dependent on imported equipment and raw materials. Moreover, the sector failed to develop strong linkages with the rest of the economy partly because of the undue emphasis on production of consumer goods at the expense of capital and intermediate goods. Under the strategy, the indigenous population failed to control a significant portion of the manufacturing sector. Manufactured exports thus formed a small proportion of the country's export while industrial development was concentrated in Nairobi and a few major towns (Ikiara, 1988; Nyongo, 1988; Ogonda, 1990). There was thus growing disenchantment with this strategy by early 1980s due to these and other shortcomings.

It should be pointed out that some of the failures of the import substitution strategy were caused by external factors beyond the control of Kenya's policy makers. First, the 1973 oil crises resulted in an escalation of the cost of production and exerted pressure on the balance of payment with adverse effects on availability of imported raw materials and equipments. Second, the collapse of the regional market in the late 1970s forced manufacturers to depend on a much narrower market, making many of them operate with excess capacity and carrying high overheads which undermined their competitiveness even with various protective measures.

By the end of the 1970s, Kenya had virtually exhausted opportunities for further industrial growth through substitution. Due to the absence of a well articulated industrial policy, few measures were implemented to move the economy to the next stage of the strategy which would have facilitated the production of manufactured exports (Coughlin, 1988).

(b) The export promotion phase (Early 1980s- 1990)

As a result of increasing recognition of the economic realities facing the country, the government made some attempts to change the industrial strategy from import substitution to export-led industrialization. Some of these intentions were evident from development plans and policy documents published during the late 1970s and early 1980s. The fourth development plan (1979-1984), for instance, advocated a more open strategy for the industrial sector (Republic of Kenya, 1979). It outlined policies designed to create an enabling environment for industry through increased reliance on market-based incentives and less regulatory structures. This was to be done through a series of reforms in trade and industrial regimes. First, the quantitative restrictions were to be gradually replaced with equivalent tariffs. Secondly, the tariff rates were to be rationalized and reduced over time. Other recommended measures included more liberal exchange rate policy and strengthening export promotion schemes (Foroutan, 1993).

Despite the expressed need to promote exports, there was lack of commitment in the implementation of the recommended measures. This poor record of implementation of policy measures was partly attributed to policy constraints facing the policy makers (Bienen, 1990). After the initial round of liberalization, the government temporarily reversed the reform process and re-introduced import controls for some items. Tariffs were steeply increased on some items with rates over 100 percent in some cases (Swamy, 1994).

During the period 1985-1990, a number of institutional and market oriented initiatives were taken to re-orient the economy away from their import substitution strategy to export promotion. These included the export compensation scheme, Manufacturing Under Bond (MUB), import duty and VAT remission schemes that were intended to improve exports producers' access to imported inputs at world prices. The export compensation scheme was to compensate exporters for government taxes on inputs, while the manufacturing under bond programme was meant to encourage manufacturing for world market. Under the programme, which was open to local and foreign investors, inputs were imported duty free (Republic of Kenya, 1986).

To attract foreign investors into the export sector, an Export Processing Act was passed in 1996 providing for the development of the Export Processing Zone Authority

(EPZA). This led to the establishment of the export processing zones in Nairobi, Mombasa, Athi- River and Nakuru. Another scheme was initiated in 1991 to promote exports through duty and VAT exemption. The scheme also introduced regulatory changes designed to make investment in bonded factories and export processing zones more attractive.

While traditional commodity products such as food and beverage continued to dominate over the period, accounting for over 50 percent of the total exports, there were signs of increasing diversification. The share of the food and beverage products in total exports had declined from 68 percent in 1986 to 52 percent by 1994 while that of fuels and lubricants had gone down by about two-thirds from 19 percent to 7 percent. Meanwhile the shares of industrial supplies and consumer goods categories had, respectively risen from 15 percent to over 26 percent and 3.8 percent to 13.6 percent between 1984 and 1994 (Republic of Kenya, 1995).

The main export destinations for Kenyan exports continued to be the European Union (EU) and Africa with both accounting for over 70 percent of the total exports between 1985 and 1999. Little or no effort had been made to penetrate and expand new markets such as the Middle East and Eastern Europe which remained unimportant. It is however notable that by 1990s, Africa was emerging as an increasingly important market for Kenya, absorbing 44.6 percent of the country's export in 1994 up from 26.1 percent in 1984 (Republic of Kenya, 1995).

Kenya's industrial sector generally remained inward looking throughout the 1980s and 1990s. A number of factors constrained the country's export growth: Firstly, the government not only was slow in implementing liberalization but also did little to put in place effective export promotion policies. Insufficient exchange rate adjustments in the 1980s frustrated import liberalization while inefficient fiscal adjustment worked against investments. The end result was a persistent bias against exports despite the announced shift away from import substitution to an outward looking export strategy (Wignaraja and Ikiara, 1999). High tariffs rates and burdensome administrative procedures contributed in discouraging Kenyan exporters from vigorously pursing export expansion programmes as manufacturers found it more profitable to produce for the protected domestic market.

Secondly, the government institutional and administrative machinery continued to be biased in favour of import substitution, leading to slow and uneven implementation of export promotion policy reforms. Despite the fact that policy makers clearly identified policy-related constraints to export growth, nothing much was done to change the situation. While many export promotion policies were regularly announced in various government policy documents, development plans and budget speeches, they were either not implemented at all or were implemented in such a bureaucratic manner that their incentives value became eroded or eliminated all together. This was partly due to the fact that some of the policy announcements were largely as a response to donor pressure without genuine domestic ownership of the policies.

Lastly, both the public and private sector exhibited adverse attitudinal stances that worked against a successful push to increase export of manufactured goods. Despite government policy announcements in favour of exports, exporters were often not given adequate support by the government. Exporters frequently experienced difficulties in obtaining foreign exchange to facilitate trade promotion trips and other activities while refunds of their export compensation claims were delayed. The private sector, for its part, was often unwilling to take the steps necessary to raise their competitiveness in international markets (KAM, 1989).

(c) The structural adjustment phase (1991-1996)

The beginning of the 1990s marked the start of sweeping economic and political reforms that included privatization of parastatals, liberalization of the financial and energy sectors, price decontrols, and phasing out of import controls. The main thrust of the adjustment programmes was to effect a shift from a highly protected domestic market to a more competitive environment that would facilitate increased use of local resources through outward oriented production policies that would promote employment creation and export expansion.

However, despite the official adoption of economic reforms in the early 1980s, the government did not implement the reforms. In November 1991, the donors froze their quick disbursement of aid to Kenya as a result of slow pace in economic and political reforms. This worsened the country's economic crisis and balance of payments deficits. This served as a critical catalyst for radical economic and political reforms and by the end of 1991, the government had introduced Foreign Exchange Certificates (Forex-Cs), which became an important source of foreign exchange to the private sector.

The government continued with the reform and in the 1993-94 budget introduced a number of changes relevant to the manufacturing sector, including further reduction of import duties, restructuring of Value Added Tax (VAT), introduction of an Essential Goods Production Support Programme and increased incentives for the Export Processing Zone (EPZ) enterprises. As part of the policy to reduce government participation, there was a need for privatization and restriction of government investment to certain aspects of infrastructure and social services. This period of economic adjustment also witnessed increased pressure for reform in the political system from a single party regime to a more open, accountable and transparent system for efficient management of public affairs.

The introduction of the sweeping economic and political reforms in early 1990s coincided with a particularly difficult period for the country's economy. The period witnessed a sharp decline in major macro economic performance indicators. The GDP growth rate recorded a negative rate of -0.4 percent between 1991 and 1992, the lowest rate in post independent period. The per capita GNP fell from US $ 350 in 1992 to US $ 270 in 1993 while the real annual growth rate of the manufacturing sector fell from 3.8 percent in 1991 to 1.8 percent in 1993. Inflation more than doubled to 46.8 percent from 19.62 percent between 1991 and 1993 (Republic of Kenya, 1995).

In general, the liberalization policies that started in 1980 had a number of weaknesses. First, for a long time the country was unable to attain the necessary speed and the intensity of reform was wanting. The reforms were carried out rather gradually and without full ownership or commitment. The overall protection of the manufacturing sector continued to be high. During the first two phases of liberalization, implementation moved slowly and intermittently, mainly due to little commitment on the part of policy makers and rampant rent seeking which was rapidly becoming one of the serious bottle necks in the country's economic and social political development.

(d) The industrial transformation to the year 2020 (1997-2001)

The industrialization strategy, as outlined in Sessional Paper No. 2 of 1996, had the objective of achieving the transformation of the Kenyan economy to a newly industrialised country by the year 2020. The Eighth National Development Plan was the first five-year planned implementation programme based on the long-term policy framework. It outlined specific programmes and policies to be pursued over the first 5 years (1997 – 2001) of the 25-year industrialization drive. The strategy emphasized selective encouragement of industries to produce for export and in the process increase their employment potential.

Two innovations, however, made the strategy different from past strategies: industry was for the first time taken to be the leading sector in economic development and specific industries were for the first time earmarked for government support. The decision to consider industry as the leading sector in economic recovery was based on the perceived vulnerability of agriculture to many factors outside policy-makers' control, which reduced its reliability as a source of sustained growth. Industry, on the other hand, had shown remarkable resilience and had potential for providing high and dynamic growth. The conclusion that followed from this was that to ensure stable and sustainable economic growth, the prospects lay more with the development of industry and it was therefore necessary to design appropriate measures that would enhance its development (Republic of Kenya, 1996).

The industrialization strategy outlined some of the measures to be implemented, to industrialize over a two-stage period. In the first phase, the government was to selectively encourage labour-intensive, resource-based and light manufacturing industries, where the country enjoys comparative advantage. To be targeted in this phase were primarily small-scale industries that use locally available raw materials and simple labour-intensive technologies that were capable of generating employment. Examples were agro-based industries such as, textiles, horticultural processing, hides and leather, tea, coffee and sugar processing, and building and construction, such as brick manufacturing. The growth rate of industrial production during the first phase was expected to be between 8 to 10 percent per annum and the annual GDP growth rate was expected to reach 6.8 percent by the end of the phase (Republic of Kenya, 1997).

In the second phase, policy was to target intermediate and capital goods industries that were more technology and capital intensive but that had to await the removal of infrastructure, technological, human capital and savings constraints. These industries, which include metallurgical, non-petroleum-based chemical, petro-chemical, pharmaceutical, and machinery and capital goods industries were initially expected to produce for the domestic market with the export market being their eventual goal. The growth rate of industrial production during this phase was expected to accelerate to between 12 to 15 percent per annum and the annual GDP growth rate to 10.6 percent by the end of the phase. If successful, this strategy would have resulted in a diversified and dynamic industrial base by the year 2020 with a GDP per capita that is almost five times its 1996 level (Republic of Kenya, 1996).

In 1999, output in the manufacturing sector in real terms rose by a minimal 1.0 percent, a rate below the 1990 to 1999 average of 2.4 percent, and a growth target of 7.8 percent in the eighth National Development Plan. The slow growth was attributed to a number of factors prime among them being the general slowdown in the economy leading to depressed effective demand for manufactured products, high product prices as a result of high input costs, decline in investment portfolio, power rationing and infrastructure bottlenecks. The quota allocation for Kenya garments to the USA and the fish export ban to the European Union market curtailed growth in the textiles and fish industries respectively. However, the shift by manufacturers from the traditional packaging materials to plastic materials boosted the plastic products industry and the activities at the EPZ improved (Republic of Kenya, 2000).

In 2000, real output growth in the manufacturing sector recorded a decline. The devastating effects of drought compounded the existing structural weaknesses in the sector contributing to the poor performance. Metered power supply to the commercial and industrial sector declined by 5.4 percent, leading to increased use of generators as an alternative source of power. Consequently, there was reduced plant capacity utilization leading to less output, loss of jobs and increase in product prices. Growth in the manufacturing output declined by 1.5 percent in 2000 (Republic of Kenya, 2001).

By midway of the first phase of the industrialization strategy (2001), the performance of the industrial sector was at its worst. The sector faced low capacity utilization, declining productivity and limited technological advancement. The manufacturing sector whose contribution to GDP averaged 13 per cent declined from a growth rate of 3.7 per cent in 1996 to -1.5 per cent in 2000 (Republic of Kenya, 2002).

By 2002, economic growth had not only stagnated but the ground covered had been lost. For the first time, bad governance in government and public sector among others, were cited as being the source of the negative growth in the major sectors of the economy, the manufacturing sector being one of the worst hit. It is against this background of overall economic decline and worsening situations of poverty and employment that a policy framework on recovery needed to be formulated. The government's stated objective was to create employment and eradicate poverty through accelerated economic growth based on a sustained industrialization drive. This necessitated the introduction of the *economic recovery strategy for wealth and employment creation* (ERS) (Republic of Kenya, 2003b).

(e) Economic recovery strategy (2003-2007)

Kenya began to lay a solid foundation upon which to start the journey of building a globally competitive and prosperous economy in 2003. As a response to past economic and social challenges, Kenya implemented bold economic and structural reforms as elaborated in the Economic Recovery Strategy. According to this strategy, interventions in the manufacturing sector were to be built around an industrial master plan which lay the ground work for the first phase of Kenya Industrialization Strategy and restore the sector to a rapid growth path.

The ERS was anchored on three key pillars, namely; restoration of economic growth within the context of a stable macroeconomic environment, enhanced equity and poverty reduction, and improvement of governance to enhance efficiency and effectiveness in the economy. These three pillars were carefully chosen to pull the economy out of a recession and to commence the journey toward a broad-based equitable economic recovery underpinned by improved efficiency in public service delivery (Republic of Kenya, 2003b).

The manufacturing sector had been seen as the major source of economic growth, and was projected to grow during the recovery period at an annual average rate of 8.6 per cent compared to the meagre 1.2 per cent in 2002. Consequently the share of the manufacturing sector in GDP was expected to rise from 13 per cent in 2002 to 15.7 per cent in 2007, driven mainly by higher capacity utilization and reduced costs of production (Republic of Kenya, 2002b).

Indeed, the period after 2002 represented the best phase of sustained economic growth in all sectors of the economy notably manufacturing, agriculture, tourism, trade and telecommunications as well as the social sectors. By 2007, the growth in the manufacturing sector fell short of the targeted growth of 8.6 percent. Its contribution to GDP remained around 10 percent and the 8.6 percent growth was not achieved. However, the recovery strategy saw a remarkable growth in the sector from 1.2 percent in 2002 to close to 7 percent in 2007 (Republic of Kenya, 2007).

The economic recovery strategy came at a time that Kenya experienced a political regime change from a perceived corrupt and insensitive regime to a renewed hope and high expectations in the new regime. Good governance and public sector reforms took a centre stage in the strategies that were supposed to provide an enabling environment for growth in all sectors of the economy. Furthermore, the strategy only covered the five year political term of the new regime. This meant that little attention was given to the individual sectors of the economy but were expected to reap the benefits of the reforms that were undertaken by the new regime. Indeed, the period of the economic recovery strategy saw sustained economic growth in all sectors of the economy notably the manufacturing sector.

However, the growth of the manufacturing sector was still driven largely by increase in inputs and volume of output rather than by improvement in efficiency and productivity (KAM, 2006). If the sector is to play the critical role of propelling the economy's growth, long-term strategies that are specifically directed to the manufacturing sector among other productive sectors are necessary. Besides the quantitative growth in the economy and the productive sector such as manufacturing, improving efficiency and increasing total factor productivity (TFP) are also critical to achieving growth targets set in the vision 2030. The unveiling of *Kenya Vision 2030* marked an important milestone in the country's development coming after the perceived successful implementation of the ERS.

(f) The Vision 2030 (2008 – 2030)

The Vision 2030 envisages a 10 per cent growth in the manufacturing sector that will consequently propel the economy's expected growth rate of above 10 per cent and support the country's social development agenda through the creation of jobs, the generation of foreign exchange and attracting foreign direct investments. To meet these goals, the manufacturing sector has to become more efficient and raise productivity per unit of input (especially of labour and capital) closer to those of Kenya's external competitors (Republic of Kenya, 2008).

Vision 2030 envisages that special economic clusters and small- and medium-enterprise parks will serve as "seed beds" of Kenya's industrial take-off. In the long run, the nation is expected to skip the "smoke stacks" associated with rapid industrialisation and move up the value chain once the more basic industrial infrastructure has been developed. The manufacturing sector will play a vital role in boosting growth in agriculture by stimulating agro-processing activities. The barriers that have hampered the expansion and modernisation of this sector will be addressed to make the manufacturing industry more competitive both at the regional and global levels. These include continued decline in investment and overall lack of competitiveness that have made it difficult for the sector to play a larger role in the economy. As a result, many manufacturing companies in Kenya have struggled to thrive and some key players have moved their operations to other countries. The Vision 2030 identifies four factors that have contributed to the lack of competitiveness in the sector. These are high input costs, low productivity levels, inefficient flows of goods and services, and unfavourable business environment (Republic of Kenya, 2008).

The vision for the manufacturing sector is the development of robust, diversified and competitive manufacturing. The overall goal for the sector over the next five years will be to increase its contribution to GDP by at least 10 per cent per annum. To realise this growth rate, specific goals will be pursued. These are; strengthening local production capacity to increase domestically-manufactured goods by focusing on improving the sector's productivity, raising the share of Kenyan products in the regional market from 7 to 15 percent, and developing niche products through which Kenya can achieve a global competitive advantage (Republic of Kenya, 2008).

Kenya's potential competitive advantage in manufacturing lies in agro-industrial exports. To compete globally in this sector, the country will have to increase the capacity of value addition in agro-based industries. This has to be done by attracting strategic investors to boost agro-based industries and increased exports, especially in new markets. The investors will be offered attractive incentives and will be expected to bring new skills and technologies to the domestic economy. In addition, five cross-cutting strategies will be critical for superior performance of the manufacturing sector as a whole, including strengthening Small and Medium Enterprises (SMEs) to become the key industries of tomorrow by improving their productivity and innovation, boosting science, technology and innovation in the sector by increasing investment in research and development (R&D), improving critical infrastructure, such as ports, energy distribution systems, rail and major highways; improving the business environment in critical areas, such as licensing and security, and implementing efficiency-enhancing institutional reforms in the sector (Republic of Kenya, 2008).

The major challenge of the vision 2030 will be in its implementation. The state of infrastructure in Kenya poses the greatest obstacle to a globally competitive manufacturing sector. Although considerable steps have been made in improving infrastructure since 2003, the importance of rehabilitating, building or expanding infrastructure will still remain a priority. Other priorities include technology and innovation.

Competitiveness in the global market requires dynamism and flexibility in approach. New technologies, products and markets will keep emerging and besides Kenya's traditional market, the vision should take stock of the unprecedented development that is in the competing world. Kenya's economic sectors should strike out in the directions that may not be fully predicted presently, and such is the essence of globally competitive markets. This will call for a pragmatic approach to development, constant monitoring of both internal and external developments and a political will, to make changes rapidly so that the economy does not lose ground.

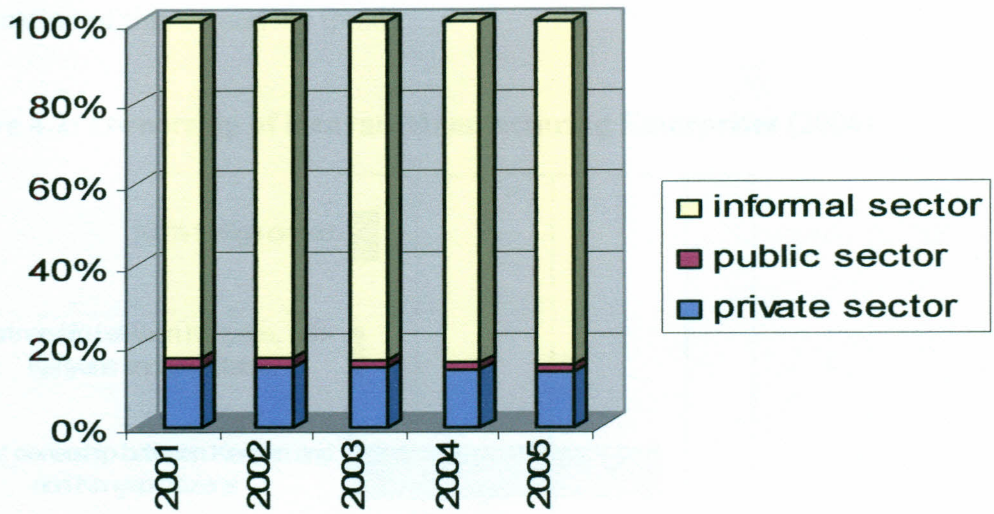
In order to develop a robust, diversified and competitive manufacturing sector, a favourable business environment should be created. Unfavourable business environment arises from heavy regulations, weak trade agreements, lack of rigorous legal enforcement, incidences of insecurity, as well as limited access to capital. In addition, heavy regulations that lead to complex and overlapping business and investment registrations affect both the ease and the cost of doing business in the sector. Weak negotiating capability may impede the country's ability to negotiate for favourable trade agreements and therefore create barriers against Kenyan firms. Weak enforcement of standards and tax laws will lead to importation of sub standard and/or counterfeit goods into the domestic market making it hard for local manufacturers to compete. These and other challenges may stand in the way of successful achievement of the vision 2030. To deliver on the ambitious process of national transformation, it will require a fundamental shift from business as usual to a new management philosophy.

4.3 The structure and composition of the Kenyan manufacturing sector

A distinctive feature of the manufacturing sector in Kenya is the co-existence of the modern sector alongside a rapidly expanding informal sector. While the former comprises mainly of small, medium and large enterprises, the latter consists of numerous open air small and micro scale productive activities in towns and rural trading centres. Traditional artisan production in the informal sector is dominated by small undertakings employing less than 10 workers. These are in most cases unregistered and use production methods which require limited specialization and management capacity. A large proportion of their output is directed towards satisfying basic needs namely, the provision of low income consumer goods and services. While data on this sub-sector are not adequate, there is little doubt that it is one of the fastest growing sectors and a major source of employment in the country (KAM, 2006).

The small and medium scale enterprises, which form part of the formal economy, are characterized by some degree of specialization. These enterprises manufacture a wide range of items including food products, wood and furniture, metal products, glass and pottery, clothing and leather products, among others. These items are generally designed to meet the domestic needs of the low income households although part of these is exported to neighbouring countries, especially Uganda and Rwanda (KAM 2006). This sub-sector employs about 20 percent of the country's labour force. Figure 4.1 shows the employment pattern between the formal private and public manufacturing sector and the informal manufacturing sector

Figure 4.1: Percentages of employees in the manufacturing sector

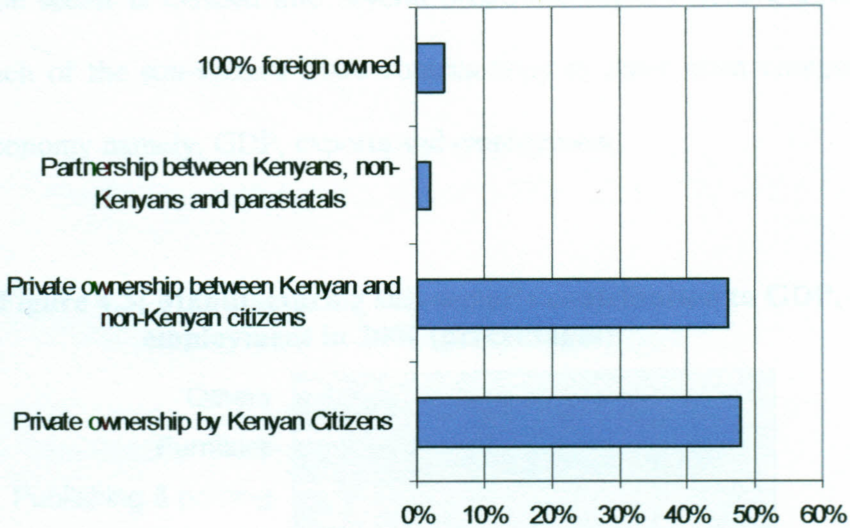


Source of data: Republic of Kenya (2006) Economic survey, Nairobi: Government Printer

From figure 4.1, the role of the informal sector manufacturing cannot be over emphasized. It represents over 80 percent of employment in the manufacturing sector and approximately 20 percent of total employment in all the years (KAM, 2006).

With regard to ownership and management of firms in Kenya's manufacturing industry, there have been some significant changes in the years after independence. Multinationals and parastatals dominate the large industries while Kenya's business people, mainly of Asian origin dominate the small and medium ones. Kenyans of African origin own mainly micro enterprises in the informal sector. Out of over 2300 registered manufacturing units, only close to 2000 are active including branches in the country. About 48 percent of these enterprises are privately owned companies by Kenyan citizens, 46 percent are privately owned partnerships between Kenyans and non-Kenyans, about 2 percent between Kenyans, non-Kenyans, and Government through parastatals, while 4 percent are foreign owned (KAM, 2006). Figure 4.2 shows a classification of this ownership trend.

Figure 4.2: Ownership of Kenyan Manufacturing Enterprises (2006)

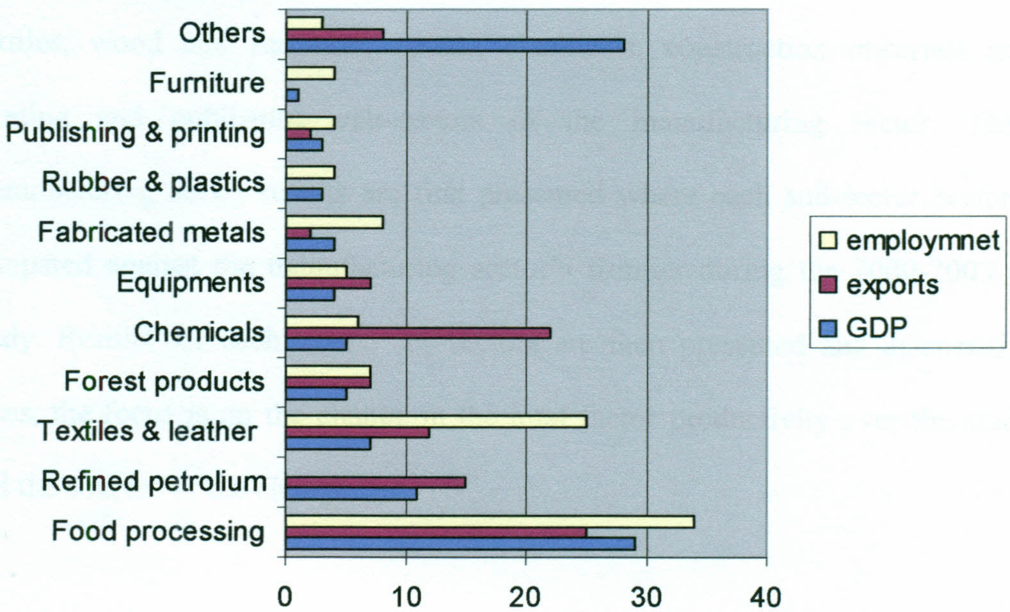


Source: Registrar of Companies, Ministry of Tourism and Industry, Government of Kenya

The structure of Kenya's manufacturing sector has undergone minimal changes despite shifts in policies. Production is largely geared toward consumer goods, the most important sector being food processing. The food processing enterprises form the largest component of manufacturing sector enterprises with the largest turnover, employment contribution and export earnings. Textiles enterprises also form a substantial share in terms of numbers and employment contribution in the manufacturing sector. Metal and allied sub-sector is a significant contributor in manufacturing sector especially in the *Jua kali* enterprises which forms the largest component of the informal manufacturing sector. Details of the sub-sector contributions are presented in table A2 in appendix I.

The manufacturing sector employs 254,000 people, which represents 13 per cent of total employment. An additional 1.4 million people are employed in the informal side of the industry. The sector is highly fragmented with more than 2,000 manufacturing units. The sector is divided into several broad sub-sectors (KAM, 2006). Figure 4.3 shows each of the sub-sectors share contributions to three main components of the Kenyan economy namely, GDP, exports and employment.

Figure 4.3: Manufacturing sub-sector's contribution to GDP, exports and employment in 2006 (percentages)



Source of data: Republic of Kenya (2007) Statistical abstract, Nairobi: Government printer

Figure 4.3 shows that the bottom three manufacturing sub-sectors namely, Food processing, Textiles and Leather, and petroleum products accounted for 50 percent of the manufacturing GDP, 50 percent of manufacturing exports, while food processing and textiles accounted for 60 per cent of formal employment in the manufacturing sector. Nearly 50 per cent of manufacturing firms in Kenya employed 50 workers or less. Most manufacturing firms were family-owned and operated. In addition, the bulk of Kenya's manufactured goods (95 per cent) were basic products such as food, beverages, building materials and basic chemicals. Only 5 per cent of manufactured items, such as pharmaceuticals, were in skill-intensive activities.

4.4 Total Factor Productivity changes in the manufacturing sector

4.4.1 Introduction

This section presents the Malmquist index scores of 119 firms drawn from the food, textiles, wood and furniture, metals, chemicals, construction materials and paper, printing and publishing sub-sectors of the manufacturing sector. The overall manufacturing sector results are first presented where each sub-sector performance is compared against the manufacturing sector's frontier during the 2000-2003 period of study. Results for each of the sub-sectors are then presented and discussed. In both cases, the focus is on the change in the total factor productivity over the study period and the sources of the change.

4.4.2. TFP change, efficiency change and technical change in the manufacturing sector.

The study period coincides with the time when the country was regaining from the effects of liberalization of the trade regime in the early 1990s. Besides, the introduction of power rationing in 2000 due to the droughts caused devastating effects, compounding the existing structural weaknesses in the sector. A combination of these factors saw a decline in the real output in the manufacturing sector by 1.5 percent (Republic of Kenya, 2001). The reduced plant capacity utilization that led to reduced output, loss of jobs and increased product prices was slightly reversed by the favourable weather conditions in 2001. This led to improved supply of raw materials especially to the agro-based industries while the lifting of power rationing ensured a stable supply of power to manufacturers leading to increased plant capacity utilization.

Real output in the sector continued to expand in 2002 by 1.2 percent, attributed to the stable macroeconomic environment, reduction of import duty to zero rate for the majority of industrial intermediate inputs, government intervention in promoting exports opportunities for manufactured goods, among others (Republic of Kenya, 2003). The TFP change, efficiency change and the technical change results presented here, therefore sought to closely examine the manufacturing sector with a view to empirically explain where productivity gains were recorded in the sector and whether any structural change was recorded in terms of technical progress (innovations) and/or improved efficiency (catch-up) during the study period. The study recognized the fact that the sub-sectors were not homogeneous either among themselves or even across the firms in each sub-sector. The productivity scores therefore need to be interpreted with care. From the results, the study makes an attempt to compare the sub-sector's performance with the overall manufacturing sector's best practice.

Table 4.1 presents the summary of the annual means of Efficiency Change, Technical Change and TFP Change over the study period for the 119 firms.

Table 4.1: Malmquist index summary of annual means

Year	Efficiency change	Technical change	TFP change
2	0.679	1.719	1.168
3	0.995	0.724	0.720
Mean	**0.822**	**1.115**	**0.917**

Source: DEAP output, 2008.

The mean TFP change of 0.917 implies that there was a fall in total factor productivity of about 8.3 percent over the period 2000 to 2002. This was despite the fact that technical progress was recorded of about 11.5 percent whose benefits were all eroded by a decline in efficiency by about 17.8 percent over the period. These results seem to concur with the general performance of the manufacturing sector (Republic of Kenya, 2001), during the period when any technical progress would not have yielded the much expected benefits especially due to the drought that hit the country leading to power rationing. Energy is a major input in production in the sector, and lack of it reduced plant capacity utilization leading to decreased output.

The results suggested that the sector's efficiency declined by 32.1 percent between 2000 and 2001 and by 0.5 percent between 2001 and 2002. Technical progress was recorded of about 71.9 percent between 2000 and 2001 which was completely reversed between 2001 and 2002 to technical regress of about 27.6 percent. Between 2000 and 2001, the technical progress offset the effect of decline efficiency to record a TFP growth of about 16.8 percent. These gains were however reversed by a declining efficiency and technical regress between 2001 and 2002 with the sector suffering a fall in TFP of about 28 percent. These results were consistent with the study by Gerdin (1997) that revealed negative TFP growth in Kenya between 1964 and 1994. Even though covering different periods, the current study seems to confirm that the situation did not seem to have changed there after.

A snapshot look at table A5 in the appendix II suggests that majority of the firms under review recorded technical progress but a decline in efficiency. Very few individual firms recorded both technical progress and improved efficiency. Generally, most of the firms that recorded growth in TFP progressed in technology but had a problem with efficiency. The power rationing problem might have had far reaching effects on the manufacturing sector as a whole.

Table 4.2 is a summary of the mean TFP change, efficiency change and technical change per sub-sector in the manufacturing sector. These figures are computed as geometric means from the whole manufacturing sector's DEA results in table A5 in appendix II.

Table 4.2: Summary of malmquist Indices per sub-sector

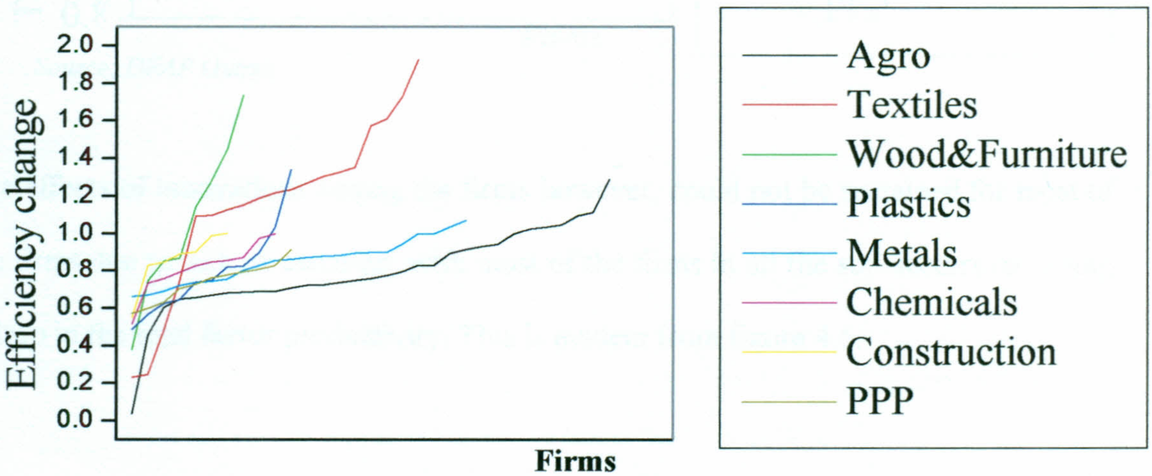
Sub-Sector	Efficiency change	Technical change	TFP Change
Food	0.727	1.153	0.839
Textiles	1.020	0.983	1.002
Wood and Furniture	0.968	1.075	1.040
Plastics	0.764	1.111	0.849
Metals	0.842	1.128	0.950
Chemicals and pharmaceuticals	0.806	1.180	0.951
Construction materials	0.844	1.138	0.961
Paper, printing and publishing	0.731	1.194	0.873
Mean	**0.822**	**1.115**	**0.917**

Note: These are own computations from table A5 in the appendix II.

From these results, all the sub-sectors showed evidence of innovation through recorded technical progress apart from textiles. Improved efficiency was only recorded in the textiles which achieved an efficiency improvement of 15.3 percent but a technical regress of about 1.6 percent leading to a TFP growth of about 12.6 percent in the textiles sub-sector. These results seemed to confirm the study by Ngui (2008), which indicated efficiency improvement in the textiles sub-sector. Soderbom (2004) also showed that despite low levels of productivity in textiles sub-sector, there were signs of recovery in the sub-sector's efficiency. These results were expected since during the period most textile enterprises became export oriented. Wood and furniture sub-sector recorded a modest growth in TFP of about 4 percent resulting from a 7.5 percent technical progress but a slight fall in efficiency of about 3.2 percent.

In the overall, there was no evidence of catch-up in the sector since efficiency was on the decline. Majority of the firms in all the sub-sectors recorded efficiency decline. Only wood and furniture and textiles seemed to have a substantial number of firms that showed signs of catch-up over the period. This is presented in figure 4.4 that follows:

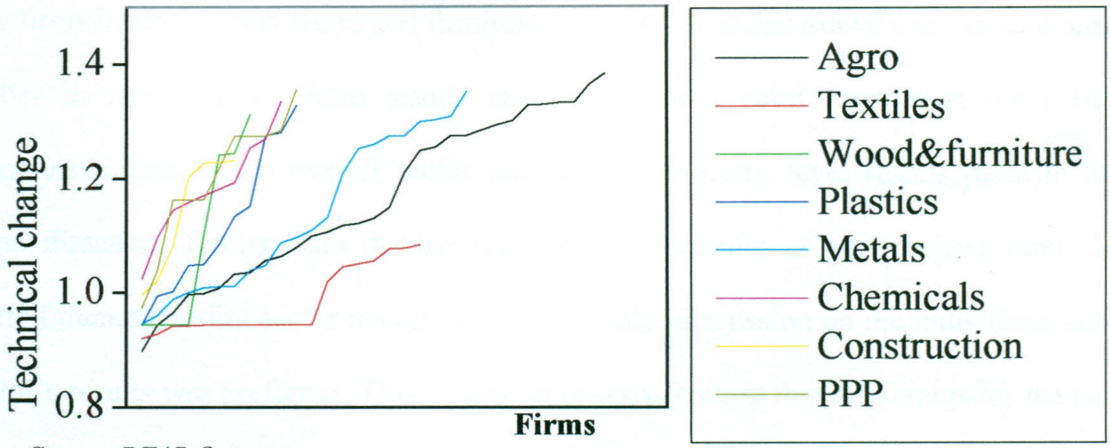
Figure 4.4: Efficiency change scores for manufacturing sub-sectors



Source: DEAP Output

In all sub-sectors, most of the firms showed evidence of innovations with majority recording an index above one, except the textiles that seemed to have had a substantial number of firms that regressed technologically as depicted in figure 4.5 that follows:

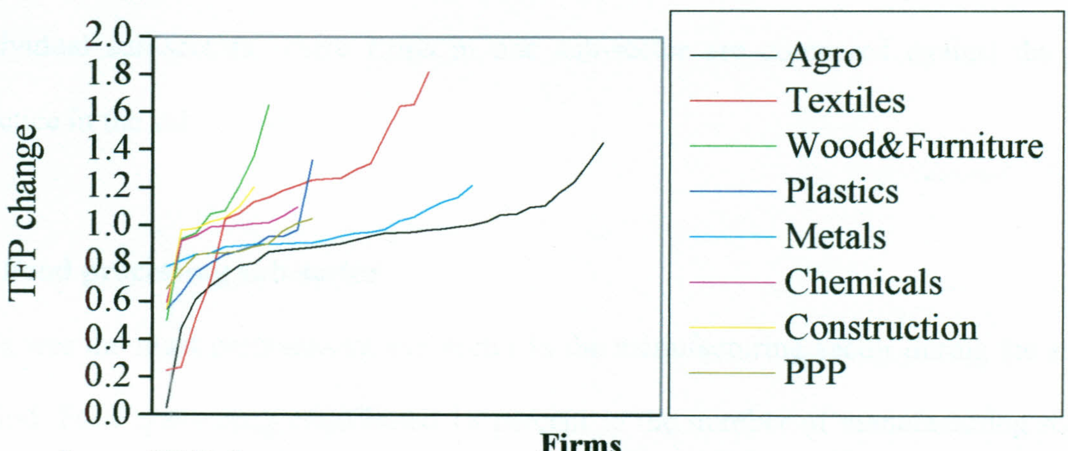
Figure 4.5: Technical change scores for manufacturing sub-sectors



Source: DEAP Output

The effects of innovations among the firms however, could not be sustained for most of the firms due to lack of catch-up, with most of the firms in all the sub-sectors recording a drop in the total factor productivity. This is evident from figure 4.6:

Figure 4.6: TFP change scores for manufacturing sub-sectors



Source: DEAP Output

From figure 4.6, most of the firms in all sub-sectors had an index below one, with only few firms in textiles and wood and furniture recording an index above one. As cautioned earlier in this section, these results may not form a solid foundation for policy recommendation in the overall sector unless the sub-sector level results point to the same direction. Rather than discuss the sub-sector results as summarized from the overall manufacturing sector results in table 4.2 only, discussion on the individuals sub-sector's results was preferred. This is done in the next section that also compares the two sets of results. These individual sub-sector results show a higher degree of homogeneity of individual firms in terms of the products and therefore form a strong basis for policy recommendations.

4.4.3 TFP change, efficiency change and technical change in the individual sub-sectors

After presenting the overall manufacturing sector's results, this section focuses on the individual sub-sectors where firms in one sub-sector are compared against the best practice in the sub-sector.

(a) Food processing sub-sector

This was the most predominant sub-sector in the manufacturing sector during the study period. Food processing contributed 18 percent to the number of manufacturing sector enterprises in Kenya, 70 percent of the manufacturing output and 23 percent of the manufacturing GDP in 2003 (KAM, 2006). The sub-sector also accounted for 26 percent of the total formal employment in the country. The Malmquist scores for 31 firms included in the study from the sub-sector are presented in table 4.3.

Table 4.3: Malmquist index summary of annual means for food sub-sector.

Year	Efficiency change	Technical change	TFP change
2	1.094	1.066	1.167
3	0.754	0.797	0.601
Mean	**0.908**	**0.922**	**0.837**

Source: DEAP output, 2008.

A mean TFP change of 0.837 implies that productivity dropped by 16.3 percent during the period of the study. This drop in productivity was due to both a fall in efficiency and technical regress of about 9.2 and 7.8 percent, respectively. There was however productivity growth recorded between 2000 and 2001 of about 16.7 percent sourced from a 9.4 and 6.6 percent efficiency improvement and technical progress, respectively. The gains were however reversed between 2001 and 2002 when efficiency dropped by 24.6 percent with a technical regress of 20.3 percent, leading to a productivity drop of about 40 percent.

A closer look at the individual firms selected in this sub-sector (see table A6 in the appendix II) suggested that over 50 percent of the firms experienced an efficiency improvement with only 0.3 percent (one firm) experiencing some technical progress of about 6.3 percent even though the same firm experienced a fall in efficiency. The sub-sector was a target of the industrialization strategy pursued in the last decade where Kenya has had comparative advantage. By its nature, the sub-sector's enterprises are labour intensive and would achieve efficiency without overly advanced technology (Republic of Kenya, 1996). The above results are consistent with Ngui (2008), where the food sub-sector remained largely inefficient.

(b) Textiles and garments sub-sector

The textiles sub-sector was the fourth largest sub-sector of manufacturing, contributing 11 percent to the number of manufacturing enterprises. During the study period, the sub-sector employed the second highest number of the labour force after the food sub-sector, i.e 17.5 percent of total formal employment in the manufacturing sector by 2004. This represented about 2.5 percent of the total economy's employment (KAM, 2006). During the same year, the sub-sector contributed about 2.9 percent of government revenue collected from customs duties. In terms of export earnings, the sector contributed about 1.3 percent of the export earnings (KAM, 2006). The Malmquist scores for 19 firms studied are presented in table 4.4.

Table 4.4: Malmquist Index summary of annual means for textiles and garments sub-sector

Year	Efficiency change	Technical change	TFP change
2	1.102	0.954	1.052
3	1.134	0.660	0.748
Mean	**1.118**	**0.794**	**0.887**

Source: DEAP output, 2008.

During the period under review, the sub-sector's TFP on average declined by about 11.3 percent which resulted from technical regress of about 20.6 percent despite the improved efficiency which averaged about 11.8 percent over the period. Between 2000 and 2001, there were signs of catch-up after the TFP grew by 5.2 percent resulting from an efficiency growth of about 10.2 percent even though the sub-sector did not show evidence of innovations. This growth in the TFP could however not be sustained between 2001 and 2002 despite a further improvement in efficiency by about 13.4 percent. A 34 percent regress in technology eroded all the gains from the efficiency improvement. These results seem to confirm the study by Soderbom (2004) who found little productivity in the textiles sub-sector even though there were some signs of recovery.

(c) Wood and furniture sub-sector

The wood products and furniture sub-sector constituted about 7 percent of the manufacturing enterprises in Kenya. The sector registered a product turnover of 1.3 billion in 2004, accounting for 0.4 percent of production turn over in the manufacturing sector. The sub-sector contributed about 3 percent of the manufacturing GDP and 0.3 percent to the economy's GDP. It also contributed 5.7 percent of all jobs in the manufacturing sector while accounting for about 0.8 percent of export earnings from the sector (KAM, 2006). The Malmquist scores in terms of TFP changes and the sources of the changes are presented in table 4.5.

Table 4.5: Malmquist index summary of annual means for wood and furniture sub-sector.

Year	Efficiency change	Technical change	TFP change
2	1.515	1.394	2.112
3	0.741	0.541	0.401
Mean	**1.060**	**0.868**	**0.920**

Source: DEAP output, 2008.

There were 8 firms out of the 119 firms in the study. On average, the sub-sector suffered a decline in TFP of about 8 percent over the study period. This was as a result of technical regress of about 13.2 percent even though the sub-sector recorded improved efficiency of about 6 percent over the period. The exaggerated TFP growth in the year two (2001) under review was largely due to a large efficiency change scores. The number of firms in the sub-sector was quite small and with such few observations, many firms would appear on the DEA frontier (Coelli *et al*, 2005). This is one of the weaknesses associated with DEA estimations and this study takes note and cautions that the large efficiency growth and hence the TFP change could not have been possible. Soderbom (2004) found the sub-sector to be one of the least productive which the current study seems to confirm.

(d) Paper, printing and publishing sub-sector

This sub-sector accounted for about 7 percent of manufacturing contribution to GDP in 2000 but this declined to about 6 percent by 2003 (KAM, 2006). Over the same period, its contribution towards the GDP fell to about 0.7 percent by 2000 and to about 0.6 percent by 2003. The Malmquist index scores for 11 firms in the study are presented in table 4.6.

Table 4.6: Malmquist index summary of annual means for paper, printing and publishing sub-sector.

Year	Efficiency change	Technical change	TFP change
2	0.961	1.143	1.099
3	0.851	0.876	0.745
Mean	**0.904**	**1.001**	**0.905**

Source: DEAP output, 2008.

These results confirm a survey by (KAM 2006) that the sub-sector's contribution to the larger manufacturing and the economy was on the decline. The TFP fell by about 9.5 percent on the average between 2000 and 2002. Declining efficiency was a major undoing for this sub-sector over the entire period under review. On the average, efficiency declined by about 9.6 percent with the sub-sector recording a mere 0.1 percent technical progress.

(e) Plastics sub-sector

The plastics and rubber sub-sector registered a contribution of 5.6 percent to the manufacturing sector in Kenya. The sub-sector's employment accounted for 3.5 percent of all jobs in the manufacturing sector. In 2004, the sub-sector's exports stood at only 1.9 percent of the export earnings from manufacturing. The sub-sector was a net exporter where 89 percent of its raw materials were imported (KAM, 2006). The Malmquist index scores for the sub-sector are presented in table 4.7.

Table 4.7: Malmquist index summary of annual means for plastics sub-sector.

Year	Efficiency change	Technical change	TFP Change
2	1.088	0.907	0.987
3	0.730	0.913	0.666
Mean	**0.891**	**0.910**	**0.811**

Source: DEAP output.

From the results, this was probably one of the sub-sectors that suffered major declines in TFP. The decline was about 18.9 percent. On the average, efficiency in the sub-sector declined by about 10.9 percent while technical regress stood at about 9 percent. Despite some evidence of catch-up between 2000 and 2001 of about 8.8 percent, TFP still declined by about 1.3 percent due to lack of innovations. A technical regress of about 9.3 percent during the period was recorded. The period between 2001 and 2002 was even worse with the sub-sector's TFP declining further by 33.4 percent resulting from efficiency decline and technical regress of about 27 and 8.7 percent, respectively.

The poor performance suggested by these results seemed to contradict figures from government publications that suggested a growth in output in the sub-sector (Republic of Kenya, 2003). However, this study focused on total factor productivity rather than growth in total output which could still happen due to increased use of inputs and not necessarily growth in TFP.

(f) Metals sub-sector

The sub-sector has over the years contributed, on average, 13 percent of the manufacturing sector GDP. In addition, apart from its contribution to total employment within the formal manufacturing which stood at 4.9 percent in 2003, the sub-sector supported a further estimated 128,000 *Jua Kali* artisans with their raw materials requirements. It contributed 5.3 percent of the country's export earnings in 2004 and 5.6 percent to government revenue collected from import duties in 2002 (KAM, 2006). The sub-sector's production turnover declined from a contribution of 3.4 percent of total manufacturing production in 2002 to 3.2 percent in 2004. The Malmquist index scores for 22 firms in the sub-sector are presented in table 4.8.

Table 4.8: Malmquist index summary of annual means for metals sub-sector.

Year	Efficiency change	Technical change	TFP change
2	0.663	1.767	1.172
3	1.070	0.720	0.771
Mean	**0.842**	**1.128**	**0.950**

Source: DEAP output, 2008.

From these results, the sub-sector was perhaps the only sector that recorded a technical progress of about 12.8 percent on the average during the study period. However, the trend in terms of TFP change was not different from all other sub-sectors in the manufacturing sector. The sub-sector suffered a TFP decline of about 5 percent on the average over the study period. This decline resulted from a decline in efficiency of about 15.8 percent. During the period between 2000 and 2001, the sub-sector recorded a positive growth in TFP of about 17.2 percent that could be attributed to a 76.7 percent technical progress. This trend immediately reversed between 2001 and 2002 when the sub-sector suffered technical regress of about 28 percent despite an improvement in efficiency of about 7 percent. TFP therefore declined by about 22.9 percent. These results agree with Ngui (2008), who found the sub-sector to have suffered a drop in efficiency.

(g) Construction materials sub-sector

The sub-sector contributed 11.6 percent of the country's total exports earnings from tangible exports in 2000 and 14.5 percent in 2002, but declined to 4.9 percent in 2003. It contributed 14 percent to manufacturing GDP in 2001 and 12 percent in 2003. This was a minimal 1.0 percent of the economy's GDP during that period (KAM, 2006). The Malmquist index scores for the sub-sector's 7 firms are presented in table 4.9.

Table 4.9: Malmquist index summary of annual means for construction materials sub-sector

Year	Efficiency change	Technical change	TFP change
2	1.433	1.429	2.047
3	0.488	0.875	0.427
Mean	**0.837**	**1.118**	**0.935**

Source: DEAP output, 2008.

From table 4.9, the sector recorded growth in technology that averaged 11.8 percent over the study period. However, on average the firm declined in efficiency by about 16.3 percent and consequently a negative growth in TFP of about 6.5 percent.

(h) Chemicals and pharmaceuticals sub-sector

These were two separate sub-sectors of the manufacturing sector, but the study treated them as highly similar in terms of products and the processes. Furthermore, only a total of 10 firms from both sub-sectors had complete data and hence were included in the study.

While the chemical and allied sub-sector turnover rose from 4.7 percent of manufacturing sector turnover in 2002 to 6 percent in 2004, the pharmaceutical sub-sector's production turnover declined by about 4.4 percent during the same period. The pharmaceuticals contribution to formal manufacturing sector employment was 1.3 percent between 2000 and 2002, and 1.2 percent in 2003. Its overall contribution to total formal employment in the country stood at 0.2 percent. Employment in the chemicals and allied sub-sector stood at 5 percent of all employment in the manufacturing sector (KAM, 2006). The Malmquist index scores for the 10 firms are presented in table 4.10.

Table 4.10: Malmquist index summary of annual means for chemicals and pharmaceuticals sub-sector

Year	Efficiency change	Technical change	TFP change
2	1.582	1.249	1.976
3	0.400	1.472	0.589
Mean	**0.796**	**1.356**	**1.079**

Source: DEAP output, 2008.

The results indicate that on average, the combined sub-sectors recorded a growth in TFP of about 7.9 percent over the study period. This positive growth resulted from technical progress of about 35.6 percent that offset the 20.4 percent decline in efficiency as suggested by the scores.

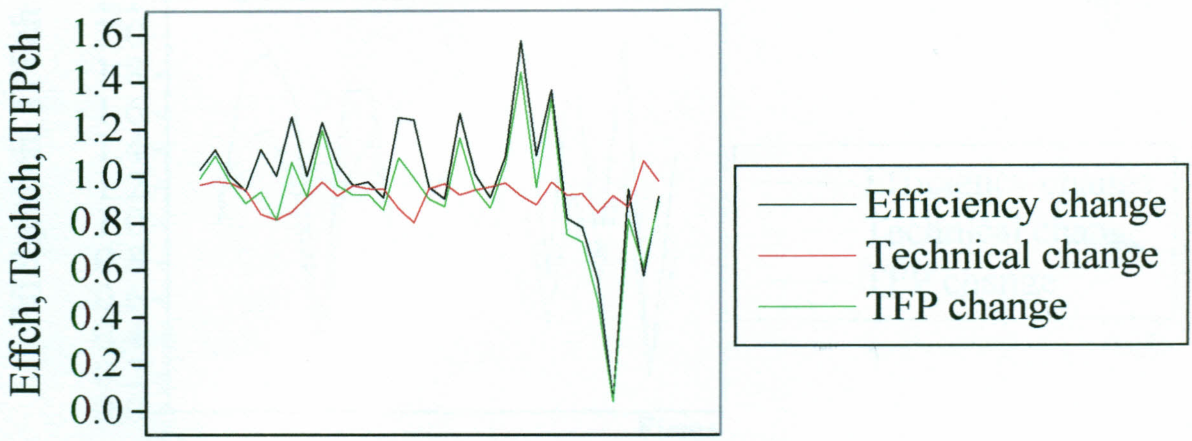
4.5 Sources of Total Factor Productivity changes

The fourth objective of the study was to establish and explain the sources of TFP changes. The total factor productivity changes were to be decomposed into two main sources, technical change and efficiency change. This section examines the trends in the TFP changes and seeks to identify whether the changes were sourced from efficiency changes (catch-up) or technical changes (innovations). The results are presented on sub-sector basis.

(a) Food processing sub-sector

The lack of innovativeness and the evidence of catch-up among the firms in this sub-sector are shown figure 4.7.

Figure 4.7: Efficiency, Technical and TFP change scores for the food sub-sector



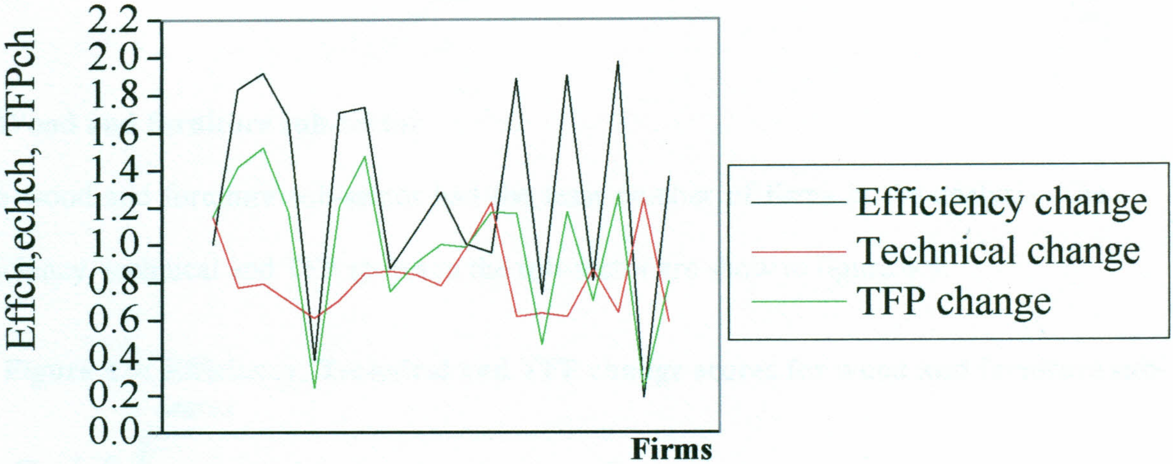
Source: DEAP Output

From the figure above, negative total factor productivity changes were quite evident, where majority of the firms recorded a TFP change index below one. These TFP changes were consistent with efficiency changes. The results suggested that TFP growth in this sector would be sourced from efficiency change. From the pattern, technical change did not seem to contribute to the TFP changes. This observation may probably explain the government reasoning that the food sub-sector if targeted could easily achieve productivity growth from efficiency change without necessarily overly advanced technology (Republic of Kenya, 1996). Ngui (2008) found that the food sub-sector was largely inefficient, suggesting the negative influence this had on TFP changes depicted in figure 4.7.

(b)Textiles and garments sub-sector

Figure 4.8 below shows the pattern of the TFP, Efficiency and Technical changes in the textiles and garments sub-sector.

Figure 4.8: Efficiency, Technical and TFP change scores for textiles sub-sector



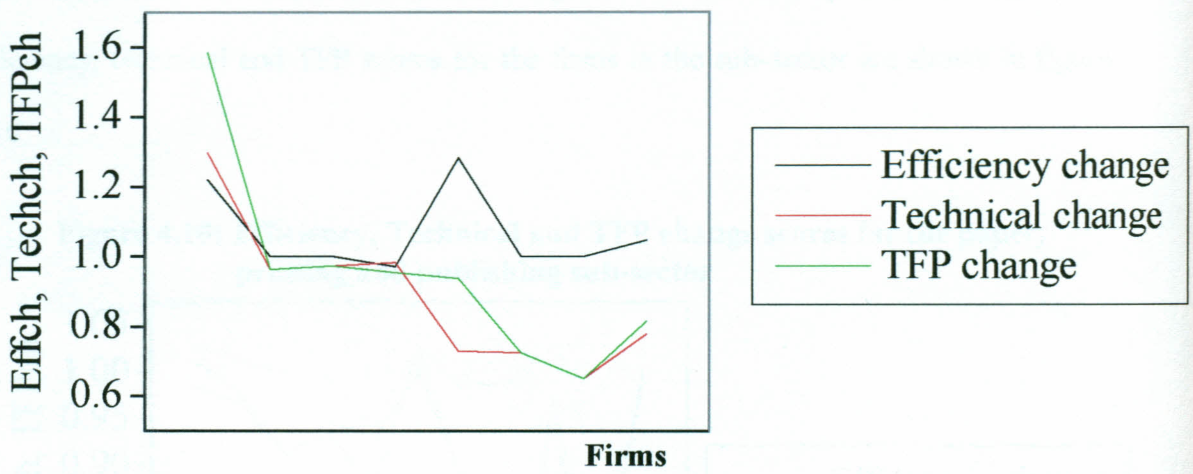
Source: DEAP Output

From the figure, there was evidence of a very strong positive correlation between efficiency changes and the TFP changes suggesting that efficiency was the source of TFP changes in the textiles sub-sector. During the study period, the textiles sub-sector was just recovering from the effect of market liberalization in the early 1990s which was coupled with market restrictions abroad leading to many textile enterprises closing down. The positive efficiency change in the sub-sector was not surprising given that more firms became export oriented compared to other sub-sectors. The export promotion hypothesis postulates that exporting firms are more efficient than non exporting ones (Bigsten *et al*, 2004). Hence, efficient firms self select into exporting and the competitive pressure spur them to raise their performance. From figure 4.8, it is evident that majority of the firms in the sub-sector recorded efficiency growth (catch-up) but largely lacked in innovation leading to negative growth in TFP. It was therefore evident from the pattern that TFP changes in the sub-sector were driven mainly by efficiency changes. Innovations in the sub-sector did not show evidence of contribution to the TFP changes over the study period. These results agree with Ngui (2008) and Soderbom (2004) where both reported efficiency growth in the textiles sub-sector.

(c)Wood and furniture sub-sector

The wood and furniture sub-sector had the least number of firms in the analysis. The efficiency, technical and TFP scores in the sub-sector are show in figure 4.9:

Figure 4.9: Efficiency, Technical and TFP change scores for wood and furniture sub-sector



Source: DEAP Output

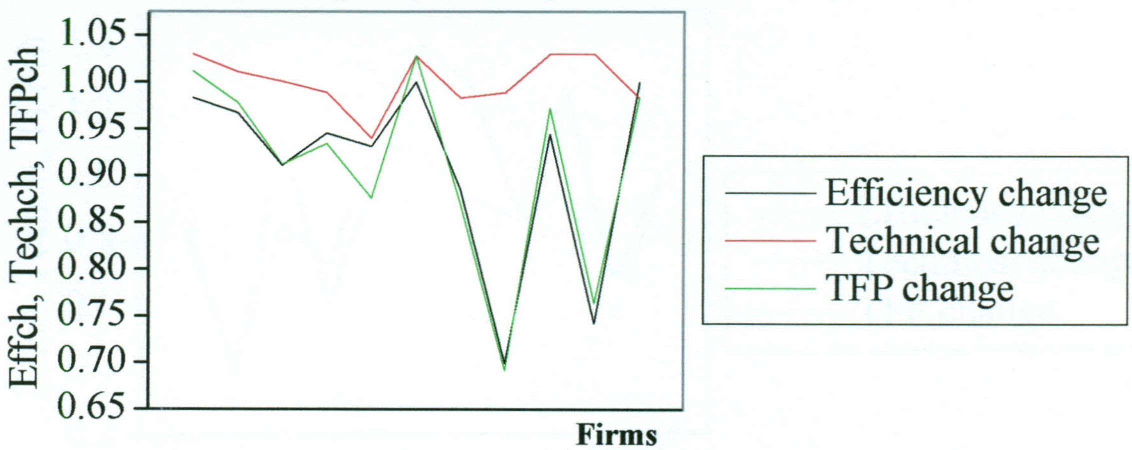
Figure 4.9 shows that most of the firms under study appear to have been efficient, which is most unlikely. The few firms in the sub-sector could have caused all firms to appear on the frontier. That fact not withstanding, the TFP changes in the sub-sector seem quite consistent with both efficiency and technical changes. It is evident that firms that suffered technical regress also declined in TFP. Efficiency changes seem to have had moderate impact on TFP changes but only for some firms.

According to KAM (2006), the sub-sector faced challenges with regard to timber availability since 1999, after the government introduced a ban on logging, unlicensed ferrying and export of timber. The aim was to protect the limited forest resources. The logging ban forced a shift to plantation-grown softwood which is generally of poor quality.

(d) Paper, printing and publishing sub-sector

This is one of the sectors that showed no signs of either catch-up or innovations. The efficiency, technical and TFP scores for the firms in the sub-sector are shown in figure 4.10:

Figure 4.10: Efficiency, Technical and TFP change scores for the paper, printing and publishing sub-sector



Source: DEAP Output

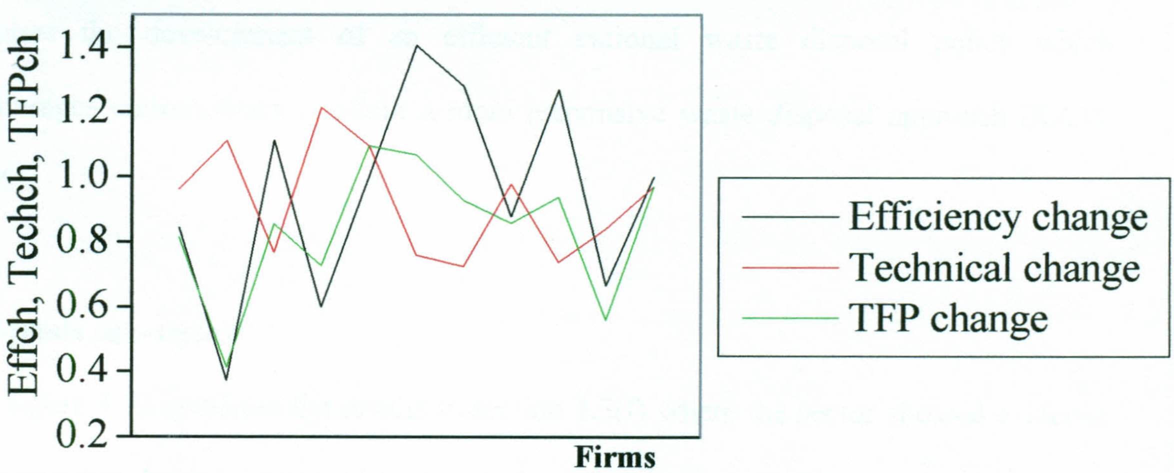
From figure 4.10, it is evident that the technical, efficiency and TFP scores are all below one. Even though a little evidence of innovation is evident, changes in TFP were driven by efficiency changes. There is a clear pattern that the firms that improved on efficiency recorded growth in TFP while those that declined in efficiency also declined in TFP.

According to Republic of Kenya (2002), real output in the sub-sector grew in 2001 due to available local and regional market for paper products even though printing and publishing declined. This is consistent with the index scores in table 4.6, which shows some TFP growth of about 9.9 percent between 2000 and 2001, but mainly driven by technical progress of about 14.3 percent. Efficiency declined by about 3.9 percent during the study.

(e) Plastics sub-sector

Figure 4.11 shows the efficiency, technical and TFP scores for the 11 firms in the plastics sub-sector.

Figure 4.11: Efficiency, Technical and TFP change scores for plastics sub-sector



Source: DEAP Output

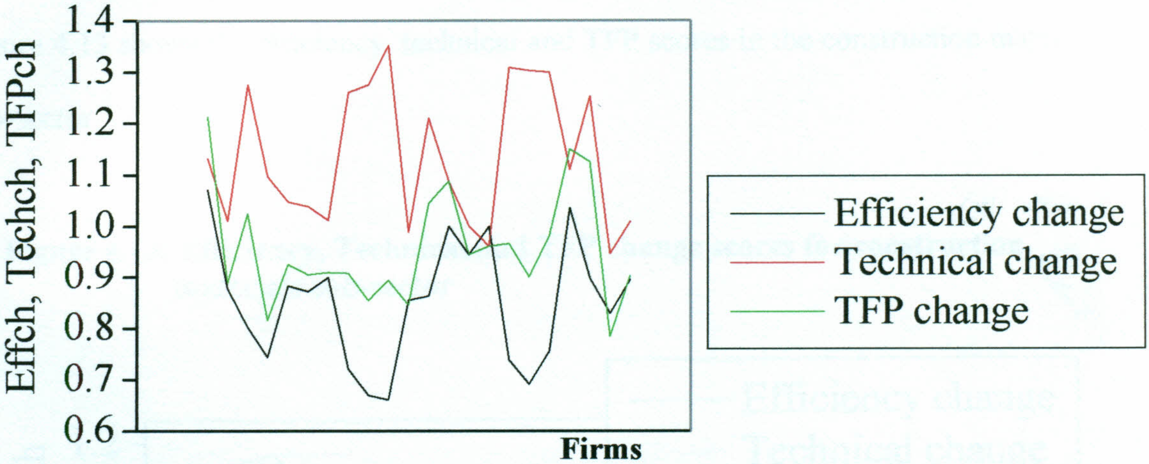
The poor performance in productivity is evident where the efficiency change and technical change scores for most of the firms were below one implying no catch-up and lack of innovations leading to negative TFP growth in the sub-sector. The pattern depicted in figure 4.11 suggests some neutrality in terms of the drivers to the TFP changes. Even though the TFP changes seem more consistent with efficiency changes among the firms, there is some evidence of neutrality where firms which improved in efficiency but regressed technologically did not experience TFP change.

The sub-sector faced a major challenge from environment regulating bodies such as NEMA and the Ministry of Environment which came up with threats to ban the use of plastic packaging in the country, due to problems of disposal and recycling. The increasing trend in the use of plastic packaging has resulted in an increase in waste generation, and since the products are non-bio-degradable, this has presented a challenge regarding their disposal and impact on the environment. This is an area that requires the development of an efficient national waste disposal policy which encourages communities to adopt a more responsive waste disposal approach (KAM, 2006).

(f) Metals sub-sector

The figure 4.12 confirms the results in section 4.3(f) where the sector showed evidence of innovations but no catch-up over the study period.

Figure 4.12: Efficiency, Technical and TFP change scores for Metals sub-sector



Source: DEAP Output

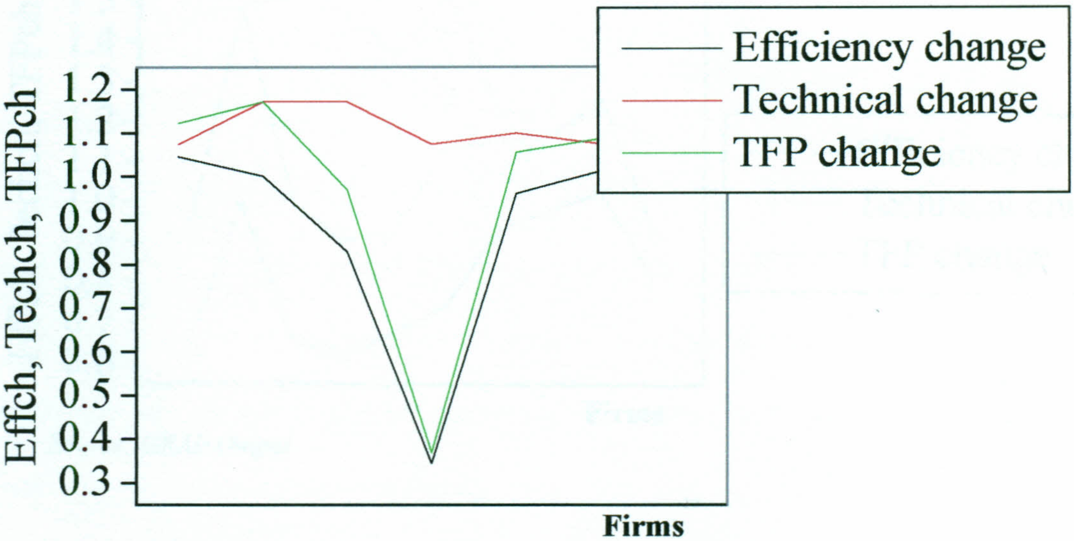
The results show that almost all firms suffered efficiency decline, so much so that the efforts to innovate did not reverse the situation leading to negative TFP growth during the period. The pattern therefore suggests that TFP changes in the sub-sector resulted mainly from efficiency changes. There is evidence from figure 4.12 that even where firms progressed technologically, declining efficiency largely drove the TFP changes to record negative growth.

The above results were expected given the forward linkages the sub-sector has had to the building and construction industry, which had been declining since 1996. This was coupled with a weak demand in the packaging industry. Over the years, the metals sub-sector had the packaging and building and construction sub-sectors as the traditional consumers of its products. On account of manufacturer preference for cheaper plastic packaging materials and the slow down in the building and construction sectors, the metal sub-sector has suffered immensely (Republic of Kenya, 2003).

(g) Construction materials sub-sector

Figure 4.13 shows the efficiency, technical and TFP scores in the construction materials sub-sector.

Figure 4.13: Efficiency, Technical and TFP change scores for construction materials sub-sector



Source: DEAP Output

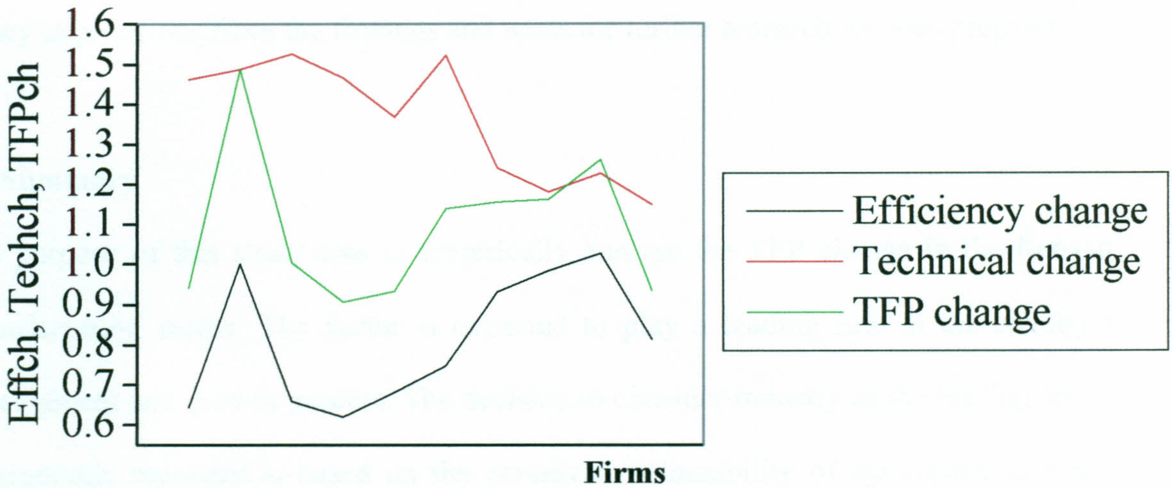
From the figure, there was evidence of innovation but the TFP changes were highly consistent with efficiency changes with perhaps technical progress having little or no effect on TFP.

These results are not surprising and confirm the situation in the metals sub-sector. The declining productivity in construction materials sub-sector led to negative growth in the metals sub-sector which has strong forward linkages to the construction materials sub-sector.

(h) Chemicals and pharmaceuticals sub-sector

The efficiency, technical and TFP change scores for this sub-sector are ploted in figure 4.14:

Figure 4.14: Efficiency, Technical and TFP change scores for chemicals and pharmaceuticals sub-sector



Source: DEAP Output

It is quite evident that the TFP changes are highly consistent with efficiency changes despite the evidence of technical progress. The positive effects of innovations are not ruled out but the sub-sector's changes in TFP seem sourced from catch-up. If the sector improved on its efficiency, total factor productivity growth would be certain given the trend above.

It appears that the growth in productivity came from the chemicals and allied sub-sector rather than the pharmaceuticals, judging from the survey conducted by KAM (2006). However, it might not be wise to make such a conclusion since the turnover contribution was measured in terms of output sold which may not necessarily imply growth in productivity.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND POLICY IMPLICATIONS

5.1 Introduction

This chapter summarises the study findings and makes the necessary conclusions. The policy implications from the findings and areas for further research are also proposed.

5.2 Summary

The purpose of this study was to empirically analyse the TFP change in the Kenyan manufacturing sector. The sector is expected to play a leading role in the country's development and growth process. The decision to consider industry as the leading sector in economic recovery is based on the perceived vulnerability of agriculture to many factors outside policy-makers' control, which reduces its reliability as a source of sustained growth. Manufacturing, on the other hand, has shown remarkable resilience and has potential for providing high and dynamic growth. To ensure stable and sustainable economic growth, the prospects lie more with the development of industry and it is therefore necessary to design appropriate measures that would enhance its development.

The manufacturing sector has not been dynamic enough to function as an engine of growth for the whole economy and has not contributed significantly to the major challenges of employment creation and poverty eradication. A close examination revealed that the sector's growth has not been driven by technical progress and efficiency but by growth in input use, which is not sustainable given the increasing costs of inputs. The study therefore sought to examine the structure and composition of the sector within a changing policy environment. The study further sought to examine the sector for changes in total factor productivity with a view to identifying the sources of such growth.

Specifically, the study measured the total factor productivity changes in various sub-sectors of the manufacturing sector and decomposed the TFP changes into efficiency change (a movement to the frontier) and technical change (a shift of the frontier). Data Envelopment Analysis was employed to calculate the Malmquist indices that were used to measure the TFP changes and decomposed them into the various components.

The results revealed that despite the structural changes that saw policy changes from time to time, there was a decline in total factor productivity during the study period. In the overall, the sector recorded a decline in TFP which was attributed to lack of efficiency even though technical progress was recorded. The results from the individual sub-sector were quite similar. All the sub-sectors apart from chemicals and pharmaceuticals recorded a decline in TFP. Among the eight sub-sectors included in the study, only textiles and wood and furniture recorded some efficiency improvement over the study period. Metals and construction materials sub-sectors recorded some technical progress while food, paper, printing and publishing, and plastics did not record any growth in technology or efficiency. It was quite evident that TFP changes were driven more by efficiency changes rather that technical progress. Seven sub-sectors revealed a consistent and direct relationship between TFP changes and efficiency changes. The metals sub-sector showed some neutrality between the two sources of TFP changes, but with efficiency change showing more consistency.

5.3 Conclusions

The study concludes that manufacturing sector did not experience any growth in total factor productivity. The sector is still inefficient and lacks in innovations. This confirms the results of studies done by KAM (2006) and Bigsten (2002), that over the years, growth in the size of the manufacturing sector has been driven largely by increase in inputs and volume of output, rather than by improvements in efficiency and productivity.

The manufacturing sector is yet to experience the big leap to high sustainable growth in productivity. Although the sector's current performance seems to be on an upward trend, there is no guarantee that there is any productivity growth. Productivity growth would be sourced from enhanced efficiency and innovations.

The poor performance of the manufacturing sector was not unexpected. Kenya enjoys a comparative advantage in the labour-intensive, resource based and light manufacturing industries that include food processing, textiles, wood and furniture, to mention just a few. These are primarily small-scale industries that use locally available raw materials and simple labour-intensive technologies and are therefore capable of generating employment. However, these sectors recorded no growth in productivity and therefore the sector could not have experienced any growth. This confirms the importance of these sub-sectors in any effort to enhance the sector's productivity and strengthen the local production capacity to increase domestically manufactured goods. The vision 2030 aspires to raise the share of Kenyan products in the regional market and to develop niche products through which Kenya can achieve a global competitive advantage. The challenge lies in how efficiently the local resources are mobilized and how innovative the main stakeholders will be to bring the vision to pass. Successful implementation of the vision 2030 will have to be built on a common determination and heritage and the hope for a more prosperous nation offering a high quality of life to all its citizens.

5.4 Policy implications and areas for further research

In the light of the research findings, the Kenyan manufacturing sector suffers from declining productivity due to lack of efficiency and innovations. The implications of the low productivity are high costs of operations leading to lack of competitiveness in the entire sector. To enhance productivity, manufacturing firms must increase efficiency in the use of available resources and make use of modern technologies that other competitors are using.

Kenya's potential competitive advantage in manufacturing lies in the agro-industrial exports. To compete globally in this sector, the country will need to increase capacity of value addition in the agro-based industries. This could be done by attracting strategic investors to boost agro-based industries and increase exports, especially in new markets. The investors should be offered attractive incentives by the government and should be expected to bring new skills and technologies to the domestic market.

In order for the sector to play a leading role in employment creation and poverty eradication, selective encouragement of industries should be embraced by the government. The target should be the labour intensive resource based and light manufacturing industry, where the country enjoys comparative advantage. These include the agro-based and textile sub-sectors which are heavily dependent on locally available resources. To this end, agriculture and manufacturing should develop in tandem as sources of economic growth. Since the largest sub-sector of manufacturing is agro-industry, the government should focus on developing the agricultural sector which is the main source of raw materials.

The Kenyan manufacturing sector is characterized by a large informal manufacturing sector. The formal manufacturing sector's poor performance may not have provided the impetus for the informal sector to become formal and significantly contribute to the country's economic growth. Other bottlenecks such as credit availability could have hampered the growth of the informal sector. In this regard, the government should strengthen the Small and Medium Enterprises (SMEs) to become the key industries of tomorrow by enhancing their productivity and innovation. Such SMEs should be encouraged in all urban centres where the local authorities could play a critical role in developing them. The relevant infrastructure and services that make them attractive should be provided.

Different regions of the country are suitable for different types of industrial and manufacturing activities. In order to harness the resources available and efficiently use the same, in different parts of the country, regional specific industrial and manufacturing clusters should be encouraged by the government. The necessary infrastructure and services should be provided to stimulate the development of such clusters. This will not only address the unemployment problems but will also ensure efficient use of available resources based on the regional resource endowments. It will also bring about regional balancing in the distribution of resources.

As a major stakeholder, the government should boost science, technology and innovation in the sector by increasing investment in research and development. The government needs to utilize the provisions of the World Trade Organization (WTO) to fund research and development activities that benefit producers. Key sectors like the textiles and clothing would greatly benefit from research on seed varieties that produce better quality fibres, instead of relying on imports. The government should also improve the critical infrastructure such as ports, energy distribution systems, rail and major highways. The business environment needs to be improved in critical areas such as licensing and security.

According to KAM (2006), the sector faces many external challenges, which include difficulties in penetrating COMESA and EAC markets, as well as understanding and exploiting the opportunities arising out of the various provisions of WTO, EU-ACP countries' tariff preferences, and AGOA. To this end, institutions such as the Kenya

Investment Authority Promotion Centre and Kenya Association of Manufacturers should play a more active role, not only in creating investment opportunities, but also in promoting the manufactured products both locally and internationally. Manufacturers also need to address their internal weaknesses, for example, the use of old and inefficient technologies. This would imply updating of technologies used and retraining of labour so that the sector can increase its efficiency.

The role of information in shedding light on the existing bottlenecks cannot be underestimated. To ensure that a focused approach is used to address the constraints, a proper understanding of the constraints, challenges, and opportunities is required. Manufacturers have a duty to give correct and timely data which is then used to make policy recommendations. Such information collected and analysed should form a platform for action oriented discussions, whose end result should be to make Kenyan manufacturing a more competitive undertaking compared to competitor countries.

Finally, the study used the latest firm level data set collected in 2002 – 2003. Since then statistics from government publications reveal that the manufacturing sector has grown from a 0.2 percent growth rate in 2002 to close to 7 percent growth in 2007. A new survey would be necessary and a similar analysis carried out to establish whether the growth reported has led to any positive changes in TFP through enhanced efficiency and/ or technical progress. In as far as the methodology is concerned, the study proposes that parametric distance functions using the stochastic frontier analysis (SFA) could be used to study the robustness of the findings to the choice of methodology.

BIBLIOGRAPHY

Abrahamovtz, M. (1956) "Resources and Output Trends in the United States since 1870." *American Economic Review,* **46,** 5 – 23.

Alvarez, R. and Crespi, G. (2003), Determinants of Technical Efficiency in Small Firms, *Small Business Economics,* **20,** 233-244.

Balcombe, K., Fraser, I. and Kim, J. H. (2006), "Estimating Technical Effciciency of Australian Dairy Farms Using Alternative Frontier Methodologies", *Applied Economics*, **38**, 2221-2236.

Baltagi, B.H., J.M. Griffin. (1988) "A general Index of Technical Change" *Journal of Political Economy* **96,** 20 – 41.

Battese, G. E. and Coelli, T. J. (1988), "Prediction of Firm-Level Technical Efficiencies with a Generalized Frontier Production Function and Panel Data", *Journal of Econometrics*, **38**, 387-399.

Battese, G. E. and Coelli, T. J. (1992), "Frontier Prodcution Function, Technical Efficiency and Panel Data: With Application to Paddy Farmers in India", *Journal of Productivity Analysis*, **3**, 153-169.

Battese, G. E. and Coelli, T. J. (1995), "A Model for Technical Inefficiency Effects in a Stochastic Frontier Production Function for Panel Data", *Empirical Economics*, **20**, 325- 332.

Battese, G. E., Heshmati, A. and Hjalmarsson, L. (2000), "Efficiency of Labour Use in the Swedish Banking Industry: A Stochastic Frontier Approach", *Empirical Economics*, **25**, 623-640.

Battese, G. E., Prasada Rao, D. S. and O'Donnel, C. J. (2004), "A Metafrontier Production Function for Estimation of Technical Efficiency and Technology Gaps for Firms Operating under Different Technologies", *Journal of Productivity analysis*, **21**, 91-103.

Bernard, A. B. and Jensen, J. B. (1999), "Exceptional Exporter Performance: Cause, Effect, or Both?" *Journal of International Economics*, **47**, 1-25.

Bienen H. (1990), "The Politics of Trade Liberalisation in Africa," *Economic Development and Cultural Change*, **38 (4),** 713-731.

Biggs, T. and Raturi, M. (1997), Productivity and Competitiveness of African Manufacturing, RPED Paper Number 80, http://www1.worldbank.org/rped/documents/rped080.pdf

Biggs, T., Shah, M and Srivastava, P. (1995), Technological capabilities and Learning in African Enterprises. http://www1.worldbank.org/rped/documents/aft288.pdf,

Bigsten, A. (2002), "History and Policy of Manufacturing in Kenya", in: Bigsten, A. and Kimuyu, P. (eds.), *Structure and Performance of Manufacturing in Kenya*: New York Palgrave Publisher, , 7-30.

Bigsten, A., and Kimuyu, P. (eds.) (2002), *Structure and Performance of Manufacturing in Kenya*, Palgrave Publishers, New York.

Bigsten, A., and Kimuyu, P. and Lundvall, K. (1999), "What to do with the informal Sector?" *Development Policy Review*, **22 (6)**, 701-715.

Bigsten, A., Collier, P., Dercon, S., Fafchamps, M., Gauthier, B., Gunning, J.W., Oduro, A., Oostendrop, R., Pattilo, C., Soderbom, M., Teal, F. and Zeufack, A. (2004), "Do

African Manufacturing Firms Learn From Exporting?", *Journal of Development Studies*, **40 (3)**, 115-141.

Blattman, C., Cotton, L., Elbadawi, I., Marchat, J. M., Ramachandran, V., Shah, M. K., Ajayi, K., Kimuyu, P., Ngugi, R., Bigsten, A. and Soderbom, M. (2004), Enhancing Competitiveness of Kenya's Manufacturing Sector: The Role of Investment Climate, African Region Human Development Working Paper Series Number 60, Africa Private Sector Group.

Bottasso, A. and Sembenelli, A. (2004), "Does Ownership Affect Firms' Efficiency? Panel Data Evidence on Italy", *Empirical Economics*, **29 (4)**, 769-786.

Caudill, S. B., Ford, J. M. and Gropper, D. M. (1995), "Frontier Estimaton and Firm Specific Inefficiency Measures in the Presence of Heteroscedasticity", *Journal of Business and Economic Statistics*, **13 (1)**, 105-111.

Caves, D. W., Christensen, L. R. and Diewert W. E. (1982a), "Multilateral Comparisons of Output, Input and Productivity Using Superlative Index Numbers," *Economic Journal,* **92,** 73-86.

Caves, D. W., Christensen, L. R. and Diewert W. E. (1982b), "The Economic Theory of Index Numbers and the Measurement of Input, Output and Productivity," *Econometrica,* **50,** 1393-1414.

Chen, K. Y. E. (1977). "Factor Inputs, Total Factor Productivity, and Economic Growth: The Asian case." *The Developing Economies,* vol. XV, no. 1 (March): 121–43.

Chirwa E. W. (2001), Privatisation and Technical Efficiency: Evidence from the Manufaturing Sector in Malawi, *African Development Review*, **13 (2)**, 267-307.

Chirwa, E. W. (2000), "Structural Adjustment Programmes and Technical Efficiency in the Malawian Manufacturing Sector", *African Development Review*, **12 (1)**, 89-113.

Coelli, T. J. (1995), "Estimator and Hypothesis Test for a Stochastic Frontier Function: A Monte Carlo Analysis", *Journal of Productivity Analysis*, **6**, 247-268.

Coelli, T .J. and Rao, D. S. (2003). Total Factor Productivity Growth in Agriculture: a Malmquist Index Analysis of 93 Countries, 1980-2000. Center for Effciciency and Productivity Analysis. School of Economics, University of Queensland. Australia.

Coelli, T. J., Perelman, S. and Romano, E. (1999), "Accounting for Enviromental Influence in Stochastic Frontier Models: With Appreciation to International Airlines", *Journal of Productivity Analysis*, **11**, 251-273.

Coelli, T. J., Prasada Rao, D. S. and Battese, G. E. (1998), *An Introduction to Efficiency and Productivity Analysis*, London: Kluwer Academic Publishers.

Coelli, T. J., Prasada Rao, D. S., O'Donnell, C. J. and Battese, G. E. (2005), *An Introduction to Efficiency and Productivity Analysis*, 2nd Edition, New York :Springer.

Coughlin P. (1988), "Towards a New Industrialization Strategy in Kenya," *In* Coughlin P. and G.K. Ikiara (Eds), *Industrialization in Kenya: In Search of Strategy*, Heinemann, Nairobi.

Denny, M., M. Fuss and L. Waverman (1981), "The Measurement and Interpretation of Total Factor Productivity in Regulated Industries with an Application to Canadian Telecommunications." In T. G. Cowing and R. E. Stevenson (eds.), *Productivity Measurement in Regulated Industries,* Academic Press New York, 179- 218.

Deraniyagala, S. (2001), "The Impact of Technology Accumulation on Technical Efficiency: An analysis of the Sri Lankan Clothing and Agricultural Machinery Industries", *Oxford Development Studies*, **29 (1)**, 101-114.

Diewert, W. E. (1992), "Fisher Ideal Output, Input and Productivity Indexes Revisited," *Journal of Productivity Analysis,* **3,** 211-248.

Elias, V. J. (1992). "Sources of Growth in Latin American Countries." *Review of Economics and Statistics,* **60**: 363–70.

Fare, R., Grosskopf S. and Russell R. R. (1998), *Index Numbers: Essays in Honour of Sten Malmquist,* Kluwer Academic Publishers, Boston.

Fare, R., Grosskopf, S., Norris, M. and Zhang, Z. (1994), "Productivity Growth, Technical Progress and Efficiency Changes in Industrialized Countries", *American Economic Review*, **84**, 66-83.

Fisher, I. (1922), *The Making of Index Numbers,* Houghton Mifflin, Boston.

Foroutan F. (1993), "Trade Reforms in Ten Sub-Saharan African Countres: Achievements and Failures," in *World Bank Policy Research Paper* No. 1222.

Fraser, I. M. and Horrace, W. C. (2003), "Technical Efficiency of Austrarian Wool Production: Point and Confidence Interval Estimates", *Journal of Productivity Analysis*, **20**, 169-190.

Fuentes, H .J. Grifell-Tatje, E. and Perelman, S. (2001), "A Parametric Distance Function Approach for Malmquist Productivity Index Estimation," *Journal of Productivity Analysis,* **15,** 79-94.

Gerdin, A. (1997), On Productivity and Growth in Kenya, 1964-94, Ekonomiska Studier 72, Doctoral Thesis, Goteborg University, Sweden.

Grifell-Tajje, E. and. Lovell, C. A. K. (1995), "A Note on the Malmquist Productivity Index", *Economic Letter*, **47**,169-175.

Hayami, Y. (1969), "Sources of Agricultural Productivity Gap among Selected Countries," *American Journal of Agricultural Economics*, **51**, 564-575.

Heshmati, A. (2003), "Productivity Growth Efficiency and outsourcing in Manufacturing and Services Industries", *Journal of Economic Survey*, **17 (1)**, 79-112.

Hicks, J. R. (1961), "Measurement of Capital in Relation to the Measurement of other Economic Aggregate," In F. A. Lutz and D. C. Hague (Eds.), *The Theory of Capital*, Macmillan London.

Hill C. (1993), "Trade Policy and Promotion of Manufactured Exports," *In* Lindauer D. L. and M. Romerer (Eds), *Asia and Africa: Legacies and Opportunities in Development International Center for Economic Growth*, Cambridge.

Horrace, W. C. and Schmidt, P. (1996), "Confidence Statement for Efficiency Estimates from Stochastic Frontier Models", *Journal of Productivity Analysis*, **7**, 257-282.

Ikiara G.K. (1988), "The Role of Government Institutions in Kenyan industrialization," *In* Coughlin and G. K. Ikiara (Eds), *Industrialization in Kenya: in Search of a Strategy*, Heinemann, Nairobi

Jovanovic, B. (1982), "Selection and the Evolution of Industry", *Econometrica*, **50 (3)**, 649-670.

Judd, C. M. and McClelland, G. H. (1989), *Data Analysis: A Model-Comparison Approach,* Harcourt Brace Jovanovich, New York.

KAM (2002), Directory, Kenya Association of Manufacturers. Nairobi.

KAM (2006), Manufacturing in Kenya: A Survey of Kenya's Manufacturing Sector, Nairobi: Kenya Association of Manufacturers

KAM (1989), *Rural Industrialization in Kenya: Opportunities and Constraints in Providing Basic Infrastructures*, KAM, Nairobi.

Kimuyu, P. (2007), "Corruption, Firm Growth and Export Propensity in Kenya", *International Journal of Social Economics*, **34 (3)**, 197-217.

Limam, Y. R. and Miller, S. M. (2004), "Explaining Economic Growth: Factor Accumulation, Total Factor Productivity Growth and Production Efficiency Improvement," *Working paper No. 20,* University of Connecticut.

Lundvall, K. (1999), Essays on Manufacturing Production in a Developing Economy: Kenya 1992-94, Economiska Studier 93, Doctoral Thesis, Goteborg University, Sweden.

Lundvall, K. and Battesse, G. E. (1999), Firm Size, Age and Efficiency: Evidence from Kenyan Manufacturing Firms, Working Paper Number 7/98, Center for Efficiency and Productivity Analysis, University of New England, Armidale.

Lundvall, K., Ochoro, W. and Hjalmarsson, L. (1999), "Productivity and Technical Efficiency", in: Bigsten, A. and Kimuyu, P. (eds.) *Structure and Performance of Manufacturing in Kenya*, New York: Palgrave Publishers, 151-172.

Margono, H. and Sharma S. C. (2004). Efficiency and Productivity Analysis of Indonesia Manufacturing Industries. Department of Economics, Southern Illinois University Carbondale.

Mazumdar, D. and Mazaheri, A. (2003), *The African Manufacturing Firms: An Analysis Based on Firms in Sub-Saharan Africa*, New York: Routledge..

McCormick, D. (1998). "Policies affecting Kenyan Industrialisation: 1964-1994". In Njuguna Ngethe and Wasunna Owino, (eds), *Towards Indigenizing the Policy Debate*. Nairobi: Institute of Policy Analysis and Research. 183-218.

Mengistae, T. (1996), Age Size Effect in Productive Efficiency: A Second Test of the Passive Learning Model, http://csae.ox.ac.uk/workingpaper/pdfs/9602text.pdf,

Moorsteen, R. H. (1961), "On Measuring Productive Potential and Relative Efficiency," *Quarterly Journal of Economics*, **75**, 451-467.

Mulwa, R., Nuppenau E.A. and Emrouznejad, A. (2005). Productivity Growth in Small Holder Sugarcane Farming in Kenya: A Malmquist TFP Decomposition. http://www.tropentag.de/2005/abstracts/full/53.pdf.

Ngui D. M. (2001), Determinants of Performance of Woodwork and Metal Work in Makueni District, Unpublished Master of Art Thesis, Kenyatta University, Nairobi.

Ngui D. M. (2008), On the Efficiency of the Kenyan Manufacturing Sector: An Empirical Analysis, Aachen: Shaker Verlag.

Nishimizu, M., and J. M. Page, Jr. (1982), "Total Factor Productivity Growth, Technological Progress, and Technical Efficiency Change: Dimensions of Productivity Change in Yugoslavia, 1965-1978," *The Economic Journal* , **2**, 920-936.

Nyongo P. A., (1988), "The Possibilities and Historical Limitations of Imports-Substitution Industrialisation in Kenya" In Coughlin P. and G. K. Ikiara (Eds.), Industrialisation in Kenya: In search of a strategy, Heinemann, Nairobi.

Ogonda, R. T. (1990), "Kenya's Industrial Progress in Post Independence Era: An Overview of Kenya's Industrial Performance up to 1980," *In* Ochieng, W.R. and Maxon (Eds.), *An Economic History of Kenya*, EAP, Nairobi.

Onjala, J. O. (2002), "Total Factor Productivity in Kenya: The Links With Trade Policy," *AERC Research Paper 118,* AERC, Nairobi.

Onuonga, S. M. (2008), An Econometric Analysis of Energy Utilisation in the Kenyan Manufacturing Sector, Unpublished Doctoral Thesis, Kenyatta University, Nairobi.

Orea, L. (2002), "Econometric Decomposition of a Generalised Malmquist Productivity Index," *Journal of Productivity Analysis,* **18,** 5-22.

Ray, S.C. and Desli, E. (1997), "Productivity Growth, Technical Progress and Efficiency Changes in Industrialised Countries: Comment," *American Economic Review,* **87,** 1033-1039.

Republic of Kenya (1965) . *African Socialism and its Application to Planning in Kenya.* Sessional Paper No.10. Nairobi: Government Printer.

Republic of Kenya (1979) *National Development Plan.* Nairobi :Government Printer.

Republic of Kenya (1986). *Economic Management for Renewed Growth.* Sessional Paper No.1. Nairobi : Government Printer.

Republic of Kenya (1994) *National Development Plan.* Nairobi: Government Printer

Republic of Kenya (1995) *Economic Survey.* Nairobi: Government Printer

Republic of Kenya (1996) *Industrial Transformation to the Year 2020.* Sessional Paper No. 2. Nairobi: Government Printer.

Republic of Kenya (1997) *National Development Plan.* Nairobi :Government Printer.

Republic of Kenya (2000) *Economic Survey.* Nairobi: Government Printer.

Republic of Kenya (2001) *Economic Survey*. Nairobi: Government Printer.

Republic of Kenya (2002a) *Economic Survey*. Nairobi: Government Printer.

Republic of Kenya (2002b) *National Development Plan*. Nairobi: Government Printer.

Republic of Kenya (2003a) *Economic Survey*. Nairobi: Government Printer.

Republic of Kenya (2003b) *Economic Recovery Strategy for Wealth Creation and Employment*. Nairobi: Government Printer.

Republic of Kenya (2004) *Economic Survey*. Nairobi: Government Printer.

Republic of Kenya (2005) *Economic Survey*. Nairobi: Government Printer.

Republic of Kenya (2006) *Economic Survey*. Nairobi: Government Printer.

Republic of Kenya (2007) *Economic Survey*. Nairobi: Government Printer.

Republic of Kenya (2008) *Kenya Vision 2030*. Nairobi: Government Printer.

Ritter, A. R. M. (1988). "Productivity Change in the Non-agricultural Economy of Kenya, 1966–1987". Mimeo. African Economic Research Consortium (AERC) library.

Roemer M., (1993), "Industrial Strategies: Outward Bound," In Lindauer D. L. and M. Reomer (Eds.), Asia *and Africa: Lagacies and Opportunities in Development*, International Centre for Economic Growth, Cambridge.

Ronge E. E. and Nyangito H. O. (2000). A Review of Kenya's Current Industrialization Policy. *Discussion Paper No. 3,* Kenya Institute of Public Policy Research and Analysis. Nairobi.

Rossi, M.A. and Ruzzier, C.A. (2000), "On the Regulatory Application of Efficiency Measures", *Utility Policy*, **9**, 81-92.

Rousseeuw, P.J. and Leroy, A.M. (1986), *Robust Regression and Outlier Detection,* Wiley, New York.

Shaaeldin, E. (1989). "Sources of industrial growth in Kenya, Tanzania, Zambia and Zimbabwe: Some estimates."*African Development Review,* vol. 1 no. 1: 21–39.

Soderbom, M. (2001), Constraints and Oportunities in Kenyan Manufacturing: Report on the Kenyan Manufacturing Enterprise Survey 2000, http://www.unido.org/userfiles/puffK/kenya2000.pdf.

Soderbom, M. (2004), Productivity, Exports and Firm Dynamics in Kenya 1999-2002, http://www.unido.org/file-storage/download/?file%5fid=38989.

Soderbom, M. and Teal, F. (2004), "Size and Efficiency in Africa Manufacturing Firms: Evidence from Firm-Level Panel Data", *Journal of Development Economics*, **73**, 369 394.

Solow R. M. (1957), "Technical Change and the Aggregate Production Function," *The Review of Economics and Statistics,* **39,** 312-320.

Swamy, G., (1994), "Kenya Patchy, Intermittent Commitment, In Hussein, I. and Faruquee, R. (Eds.), *Adjustment in Africa: Lessons from Case Study Countries*, World Bank, Washington D C: Oxford University Press.

Todaro, M. P. (1985). *Economic Development in the Third World.* London: Longman.

Tybout, J. R. (2000), Manufacturing Firms in Developing Countries: How Well They Do, and Why? Journal of Economic Literature, **38:1,** 11-44.

Udo-Aka, U. (1983), "Measuring productivity: Issues and Problems in Productivity in Nigeria" Proceedings of a national conference.

Wagacha, M., and Ngugi, R. (1999) "Macroeconomic structure and outlook." (Eds), *Kenya's strategic policies for the 21st century*. Nairobi: Institute of Policy Analysis and Research.

Wignaraja, G. and G. K. Ikiara, (1999), "Adjustments, Technological Capabilities and Enterprise Dynamics in Kenya," in Lall (Ed.) *The Technological Response to Import Liberalisation in Subsaharan Africa,* London: Macmillian Press.

APPENDICES

APPENDIX I: MANUFACTURING SECTOR SHARES

Table A1: Total Number of Employees in Manufacturing Sector – 2001 to 2005

Manufacturing Category	2001	2002	2003	2004	2005
Private sector	183,100	196,400	208,300	211,000	217,600
Public sector	33,500	33,400	31,400	31,000	29,600
Informal sector	1,039,400	1,121,000	1,199,300	1,281,000	1,386,000
Total Manufacturing	1,256,000	1,350,000	1,439,000	1,523,000	1,633,500
Total Economy	6,411,200	6,873,500	7,339,400	7,822,800	8,281,700

Source: Republic of Kenya (2006) *Economic Survey*, Nairobi: Government printer

Table A2: Structure, Contributions and Performance of Kenya's Manufacturing Sub-sectors

	Enterprises (2002)		Production Turnover (2004)		Employment (2003)		Exports (2004)	
Sub Sector	**No. of Enterprises**	**%**	**Production turnover**	**%**	**Emp't 2003**	**%**	**Exports (Kshs Mn)**	**%**
Food, beverages and tobacco	422	18	232,535	70	83,098	34	8,903	18
Textiles & Garments	255	11	6,123	2	42,646	17	1,777	4
Metal & Allied	258	11	7,621	2	20,671	8	8,356	17
Leather Products	271	12	8,880	3	18,798	8	3,860	8
Paper & paperboard	144	6	16,692	5	16,299	7	1,026	2
Timber, wood & 5furniture	162	7	1,284	0	14,066	6	399	1
Chemical & Allied	165	7	19,720	6	12,197	5	5,593	12
Building, construction & mining	89	4	9,915	3	12,031	5	6,713	14
Plastic & rubber	173	8	18,785	6	8,636	4	919	2
Pharmaceutical & medical	36	2	4,337	1	3,230	1	2,394	5
Motor vehicle assembly	75	3	1,525	1	3,190	1	286	1
Electric & electronics	49	2	4,624	1	3,073	1	602	1
Others	221	10	2,128	1	7,876	3	7,467	16
Total	**2,320**	**100**	**334,169**	**100**	**245,811**	**100**	**48,295**	**100**

Source: KAM, 2006

Table A3: Sectoral Shares in the Real GDP, 1964-2006 (Percentages)

Year	Agriculture	Manufacturing	Services	Total
1964-73	36.6	10	53.4	100
1974-79	33.2	11.8	55	100
1980-89	29.8	12.8	57.4	100
1990-95	26.2	13.6	60.2	100
1997	24.6	13.3	62.1	100
1998	24.6	13.3	62.1	100
1999	24.5	13.2	62.3	100
2000	24.1	13.1	62.8	100
2001	24.1	13	62.9	100
2002	24	13.1	62.9	100
2003	23.9	13	63.1	100
2004	24.2	9.9	65.9	100
2005	23.2	10.3	66.5	100
2006	23.6	10.2	66.2	100

Source: Republic of Kenya, *Economic surveys*, various issues

Table A4: Percentage Growth in GDP and Percentage Growth in Manufacturing Contribution to GDP

Year	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
GDP growth	4.6	2.4	1.8	1.4	-0.2	1.2	0.5	2.9	5.1	5.7	6.1
Manufacturing growth	3.4	1.9	1.4	1.0	-1.5	0.8	1.2	1.4	4.5	5.0	6.9

Source: Republic of Kenya, *Economic surveys*, various issues

APPENDIX II: MALMQUIST INDICES

Table A5: Malmquist Index Summary of Firm Means

	Firm	Efficiency change	Technical change	TFP change
FOOD SUB-SECTOR	1	0.774	1.294	1.002
	2	0.829	1.333	1.105
	3	0.736	1.328	0.977
	4	0.757	1.149	0.869
	5	0.914	1.033	0.944
	6	0.795	1.008	0.801
	7	1.023	1.035	1.060
	8	1.095	0.898	0.983
	9	0.941	1.249	1.175
	10	0.930	1.099	1.022
	11	0.688	1.301	0.895
	12	0.721	1.332	0.960
	13	0.669	1.383	0.925
	14	1.033	1.063	1.098
	15	0.996	0.997	0.993
	16	0.707	1.364	0.965
	17	0.685	1.255	0.860
	18	1.114	1.106	1.232
	19	0.724	1.211	0.877
	20	0.681	1.329	0.905
	21	0.830	1.275	1.059
	22	1.287	1.118	1.439
	23	0.892	1.079	0.962
	24	1.045	1.275	1.332
	25	0.602	1.130	0.681
	26	0.656	1.121	0.735
	27	0.456	0.999	0.455
	28	0.037	0.965	0.036
	29	0.747	1.056	0.789
	30	0.647	0.944	0.611
	31	0.688	1.285	0.884
TEXTILES SUB-SECTOR	32	1.325	0.944	1.251
	33	1.573	0.944	1.484
	34	1.924	0.943	1.815
	35	1.304	0.929	1.211
	36	0.232	1.084	0.251
	37	1.353	0.921	1.246
	38	1.729	0.944	1.632
	39	1.217	0.943	1.147
	40	1.609	1.020	1.641
	41	1.189	0.944	1.123
	42	1.127	0.944	1.064

	43	1.093	0.944	1.032
	44	1.153	1.077	1.241
	45	0.482	1.056	0.509
	46	1.098	1.078	1.184
	47	1.269	1.046	1.328
	48	0.750	0.944	0.708
	49	1.233	1.051	1.296
	50	0.248	0.944	0.234
PAPER PRINTING AND PUBLISHING SUB-SECTOR	51	0.794	1.275	1.012
	52	0.727	1.163	0.845
	53	0.704	1.218	0.857
	54	0.778	1.164	0.905
	55	0.830	1.040	0.863
	56	0.808	1.284	1.037
	57	0.632	1.355	0.856
	58	0.573	1.163	0.667
	59	0.762	1.275	0.972
	60	0.599	1.275	0.764
	61	0.914	0.974	0.890
METAL SUB-SECTOR	62	1.071	1.132	1.212
	63	0.878	1.011	0.888
	64	0.803	1.275	1.025
	65	0.743	1.097	0.816
	66	0.883	1.048	0.925
	67	0.872	1.039	0.905
	68	0.899	1.012	0.910
	69	0.721	1.260	0.908
	70	0.670	1.275	0.855
	71	0.661	1.352	0.894
	72	0.855	0.989	0.846
	73	0.863	1.210	1.045
	74	1.000	1.088	1.088
	75	0.944	1.001	0.945
	76	1.000	0.961	0.961
	77	0.738	1.309	0.966
	78	0.691	1.303	0.901
	79	0.755	1.300	0.981
	80	1.036	1.110	1.150
	81	0.898	1.253	1.125
	82	0.829	0.946	0.784
	83	0.895	1.009	0.903

PLASTICS SUB-SECTOR	84	0.566	1.328	0.752
	85	0.486	1.152	0.559
	86	0.747	1.134	0.847
	87	0.626	1.281	0.802
	88	1.341	1.003	1.345
	89	0.899	1.048	0.942
	90	0.822	1.085	0.891
	91	0.739	1.276	0.942
	92	0.825	1.050	0.867
	93	0.646	0.995	0.643
	94	1.034	0.944	0.976
WOOD AND FURNITURE SUB-SECTOR	95	0.380	1.313	0.499
	96	0.852	1.245	1.060
	97	0.869	1.103	0.958
	98	0.746	1.242	0.926
	99	1.141	0.944	1.077
	100	1.449	0.944	1.368
	101	1.734	0.944	1.638
	102	1.279	0.944	1.208
CONSTRUCTION MATERIALS SUB-SECTOR	103	0.987	0.997	0.984
	104	1.002	1.202	1.204
	105	0.829	1.229	1.019
	106	0.549	1.022	0.561
	107	0.846	1.228	1.040
	108	0.901	1.082	0.975
	109	0.891	1.233	1.099
CHEMICALS SUB-SECTOR	110	0.847	1.171	0.992
	111	0.515	1.159	0.597
	112	0.857	1.182	1.013
	113	0.873	1.145	1.000
	114	0.974	1.025	0.998
	115	0.733	1.254	0.919
	116	0.757	1.335	1.011
	117	0.827	1.270	1.050
	118	0.792	1.194	0.946
	119	1.000	1.097	1.098
	Mean	**0.822**	**1.115**	**0.917**

[Note that all Malmquist index averages are geometric means.]
Source: DEAP output.

Table A6: Malmquist Index Summary of Firms Means (Food)

Firm	Efficiency change	Technical change	TFP change
1.	1.027	0.963	0.989
2.	1.111	0.978	1.087
3.	1.000	0.972	0.972
4.	0.938	0.942	0.884
5.	1.113	0.838	0.933
6.	1.000	0.815	0.815
7.	1.252	0.847	1.060
8.	1.000	0.911	0.911
9.	1.228	0.974	1.196
10.	1.049	0.916	0.961
11.	0.959	0.960	0.920
12.	0.975	0.946	0.922
13.	0.906	0.944	0.856
14.	1.249	0.863	1.078
15.	1.239	0.801	0.993
16.	0.952	0.947	0.901
17.	0.901	0.966	0.870
18.	1.265	0.919	1.162
19.	1.007	0.939	0.945
20.	0.906	0.953	0.863
21.	1.084	0.969	1.051
22.	1.572	0.915	1.439
23.	1.086	0.876	0.951
24.	1.364	0.973	1.328
25.	0.818	0.918	0.750
26.	0.779	0.923	0.719
27.	0.554	0.843	0.467
28.	0.046	0.915	0.042
29.	0.941	0.866	0.815
30.	0.575	1.063	0.611
31.	0.909	0.977	0.889
Mean	**0.908**	**0.922**	**0.837**

[Note that all Malmquist index averages are geometric means.]
Source: DEAP output.

Table A7: Malmquist Index Summary of Firms Means (Textiles)

Firm	Efficiency change	Technical change	TFP change
1.	1.000	1.150	1.150
2.	1.830	0.774	1.417
3.	1.916	0.795	1.522
4.	1.673	0.702	1.174
5.	0.388	0.613	0.238
6.	1.705	0.708	1.207
7.	1.735	0.849	1.474
8.	0.874	0.859	0.751
9.	1.072	0.841	0.901
10.	1.278	0.783	1.000
11.	1.003	0.983	0.986
12.	0.959	1.223	1.172
13.	1.886	0.618	1.167
14.	0.738	0.637	0.470
15.	1.902	0.618	1.175
16.	0.808	0.870	0.703
17.	1.974	0.640	1.264
18.	0.187	1.243	0.233
19.	1.360	0.590	0.803
Mean	**1.118**	**0.794**	**0.887**

[Note that all Malmquist index averages are geometric means.]
Source: DEAP output.

Table A8: Malmquist Index Summary of Firms Means (Wood and Furniture)

Firm	Efficiency change	Technical change	TFP change
1.	1.220	1.298	1.584
2.	1.000	0.964	0.964
3.	1.000	0.974	0.974
4.	0.971	0.984	0.955
5.	1.283	0.731	0.938
6.	1.000	0.726	0.726
7.	1.000	0.651	0.651
8.	1.047	0.780	0.816
Mean	**1.060**	**0.868**	**0.920**

[Note that all Malmquist index averages are geometric means.]
Source: DEAP output.

Table A9: Malmquist Index Summary of Firms Means (Paper, Printing and Publishing)

Firm	Efficiency change	Technical change	TFP change
1.	0.983	1.030	1.012
2.	0.967	1.011	0.978
3.	0.911	1.001	0.912
4.	0.945	0.989	0.934
5.	0.931	0.940	0.876
6.	1.000	1.028	1.028
7.	0.885	0.983	0.870
8.	0.699	0.989	0.692
9.	0.944	1.030	0.972
10.	0.742	1.030	0.764
11.	1.000	0.983	0.983
Mean	**0.904**	**1.001**	**0.905**

[Note that all Malmquist index averages are geometric means.]
Source: DEAP output.

Table A10: Malmquist Index Summary of Firms Means (Plastics)

Firm	Efficiency change	Technical change	TFP change
1.	0.845	0.963	0.814
2.	0.373	1.111	0.414
3.	1.113	0.769	0.856
4.	0.599	1.214	0.727
5.	1.000	1.096	1.096
6.	1.406	0.760	1.068
7.	1.280	0.725	0.928
8.	0.877	0.978	0.858
9.	1.270	0.738	0.937
10.	0.666	0.841	0.560
11.	1.000	0.970	0.970
Mean	**0.891**	**0.910**	**0.811**

[Note that all Malmquist index averages are geometric means.]
Source: DEAP output.

Table A11: Malmquist Index Summary of Firms Means (Metals)

Firm	Efficiency change	Technical change	TFP change
1.	1.071	1.132	1.212
2.	0.878	1.011	0.888
3.	0.803	1.275	1.025
4.	0.743	1.097	0.816
5.	0.883	1.048	0.925
6.	0.872	1.039	0.905
7.	0.899	1.012	0.910
8.	0.721	1.260	0.908
9.	0.670	1.275	0.855
10.	0.661	1.352	0.894
11.	0.855	0.989	0.846
12.	0.863	1.210	1.045
13.	1.000	1.088	1.088
14.	0.944	1.001	0.945
15.	1.000	0.961	0.961
16.	0.738	1.309	0.966
17.	0.691	1.303	0.901
18.	0.755	1.300	0.981
19.	1.036	1.110	1.150
20.	0.898	1.253	1.125
21.	0.829	0.946	0.784
22.	0.895	1.009	0.903
Mean	**0.842**	**1.128**	**0.950**

[Note that all Malmquist index averages are geometric means.]
Source: DEAP output

Table A12: Malmquist Index Summary of Firms Means (Construction Materials)

Firm	Efficiency change	Technical change	TFP change
1.	1.045	1.074	1.122
2.	1.000	1.171	1.171
3.	0.828	1.171	0.970
4.	0.345	1.074	0.370
5.	0.960	1.099	1.055
6.	1.011	1.074	1.086
7.	0.992	1.171	1.161
Mean	**0.837**	**1.118**	**0.935**

[Note that all Malmquist index averages are geometric means.]
Source: DEAP output

Table A13: Malmquist Index Summary of Firms Means (Chemicals and Pharmaceuticals)

Firm	Efficiency change	Technical change	TFP change
1.	0.643	1.463	0.941
2.	1.000	1.488	1.488
3.	0.658	1.526	1.004
4.	0.619	1.466	0.907
5.	0.681	1.369	0.933
6.	0.748	1.522	1.139
7.	0.931	1.241	1.155
8.	0.984	1.181	1.162
9.	1.027	1.228	1.262
10.	0.813	1.149	0.934
Mean	**0.796**	**1.356**	**1.079**

[Note that all Malmquist index averages are geometric means.]
Source: DEAP output

APPENDIX III: DEFLATORS

Table A14: Output and Input Deflators for each Sub-Sector in the 2000/2001-2001/2002 period

Year

2000=100	2000	2001	2002
Outputs			
Food	1	1.010619	0.992662
Textile	1	1.018793	0.834904
Wood & Furniture	1	0.490628	0.56998
Paper Printing and Publishing	1	1.018569	1.015474
Plastics	1	1.070606	1.175876
Metals	1	1.036492	1.084488
Construction Materials	1	0.883108	0.880926
Chemicals & Pharmaceuticals	1	1.04623	0.969417
Inputs			
Capital	1	1.069491	1.12187
CPI (Labour)	1	1.057565	1.078314

Source: Own calculations from Government of Kenya (Statistical Abstract; 1995, 2003, 2006) http://www.cbs.go.ke/