# Improving manufacturing performance in LDCs : the case of Zambia

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# Preface

Manufacturing represents a potential engine of growth in economies of Less Developed Countries (LDCs). This thesis deals with manufacturing performance and its improvement in firms in LDCs, particularly Zambia. It presents an analysis of the impact of the enterprise's internal control factors and external influences on the firm's performance improvement, and details improvement processes.

The book is the culmination of five years of research on and collaboration with industrial firms in Zambia. It stems from the increasing need to address manufacturing stagnation in African LDCs. It aims to demonstrate the relevance of combining firm-level and sectoral analysis of manufacturing performance for the understanding of the dynamics of industrial developments, and attempts to improve performance.

This book could not have been completed without the support of many people. Prof ir P.W. Sanders, the then chairman of the Manufacturing Technology Group initially was the first supervisor. I would like to thank him for the many engaging discussions I had with him until he retired. Following Prof ir P.W. Sanders' retirement, Prof dr ir A.C. Brombacher took over as first supervisor. It was wonderful working with him. I greatly benefited from his supervision and guidance.

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Francis K. Yamfwa
Eindhoven, The Netherlands
October, 2001

# Summary

This study aims to develop an approach to improve performance in manufacturing firms in Less Developed Countries (LDCs), especially African LDCs. Zambia is used as a case. In this study, manufacturing performance is defined as the relationship between the quality and quantity of physical output in relation to inputs used in the production process and as the efficiency with which inputs are transformed into desired outputs. The research methodology employs a sector comparative study approach and a company case study approach.

The sector study used the country's secondary manufacturing sector data to provide information about the general economic environment within which the firms under study operate. Four company case studies helped provide insight into firm-level mechanisms, which cannot easily be studied at sectoral level. They also provide some insight into the "black box" of the production function. The use of production functions at both sectoral and firm levels is an attempt to bridge the gap between meso- and micro-analysis of productivity performance. The international comparative study, which uses the USA as the "numéraire", helps to quantify the technology and productivity gap with which firms are faced in a wider context.

In order to investigate manufacturing performance in Zambia, we included the characteristics of the external environment. These characteristics include country specific characteristics and characteristics common to LDCs or subgroups of LDCs.

The sectoral study provides an analysis of Zambian manufacturing performance since 1964 and presents new information on labour productivity growth and total factor productivity (TFP) growth. After a period of output growth and labour productivity improvement till 1974, Zambian manufacturing suffered from increasing inefficiencies in an import substituting and state-interventionist environment. Growth of output slowed down, labour productivity and investment declined, though TFP showed some fluctuation. In the period of liberalisation between 1991-95, output shrank dramatically, TFP collapsed and labour productivity continued to decline. After 1995 indicators of performance point to a modest recovery.

Following an industry-of-origin approach to international comparisons, the Zambian productivity estimates are placed in comparative perspective in a binary comparison with the USA. In 1990, labour productivity in Zambia stood at 5.9 percent of the US level, while relative total factor productivity stood at 16.7 percent. Over time comparative labour productivity has been declining, indicating an increasing technology gap relative to the world frontier. By 1998, comparative labour productivity stood at 3.2 percent of the US level and relative total factor productivity at 9.2 percent.

The company case studies employ the concept of the "production function" and use data of four manufacturing companies in Zambia to analyse growth in (physical) qualified gross output per person engaged and the transformation efficiency of the production process as indicators of manufacturing performance. Transformation efficiency is defined as the

product of production time efficiency and production system effectiveness. The production time efficiency is defined as the ratio between the total time intervals during which the system really produces products and the considered production period. The production system effectiveness is defined as the ratio of the average real output flow of qualified products and the average maximum output flow of qualified products per unit of time. Changes in transformation efficiency explain part of the changes in the residual output per unit of input in the production function.

The analysis shows that some changes in performance at the sector level are mirrored at the firm level. Thus, generally in periods of aggregate slowdown, one sees slowdown of firm output growth. Also in the period of recovery from 1995-98, all the case studies had positive growth of transformation efficiency. However, there are also periods in which some firms buck the trend. Thus, during the period of total collapse of manufacturing between 1991-95, two of the four case studies had positive growth in qualified gross output per person engaged (4.0 and 9.3 percent per year), and two firms had positive growth in transformation efficiency (3.3 and 4.2 percent per year).

Some of the interesting substantive findings of the study include the following. Contrary to the development literature that stresses the predominant importance of policies, institutions and the external environment in LDCs, firms in developing countries are able to improve their performance through internal efforts even in a depressed macro-environment. There was a huge disparity in transformation efficiency performance between the four industrial case studies subjected to the same national and sectoral influences. The growth in productivity and transformation efficiency was highest in firms that had a relatively higher proportion of investment in machinery and equipment in addition to implementing programmes to improve efficiency in the production processes. At sectoral level, the most notable results consist of the quantification and analysis of the dramatic collapse of Zambian manufacturing in the early nineties and the quantification of levels and trends in performance over time. The comparative analysis confirms the existence of an enormous technology gap between Zambia and the world productivity leader, the USA. The low level of manufacturing productivity in Zambia is primarily due to the low levels of relative labour productivity within each of the branches of manufacturing, rather than to differences in the structure of production between a developing country such as Zambia and the USA. The sectoral productivity gaps are explained by low capital intensity and a relatively inefficient use of factor inputs. The trend in comparative Zambian labour productivity points to a long-run deterioration of comparative productivity performance and an increase in the technology gap over time.

The efforts at the firm level to improve manufacturing performance are exerted by managers. Efforts to improve external influences relevant to a particular industry (such as improved industrial and financial viability of the sector) stem from government policies and actions or autonomous changes in the environment. The case studies illustrate the importance of the external national and sectoral environment on firm-level performance. The variation in firm performance level, however, indicates that firm-level efforts to improve production performance are also of great importance. Through more efficient and effective use of existing resources and introduction of better management practices firms can improve their production performance, even in a negative environment. The same holds for use of improved technologies. Important factors affecting firm-level performance include acquisition of new technology, orientation to export markets, high levels of investment in machinery and equipment and the deliberate implementation of programmes to improve efficiency and quality.

Firm-level efforts to improve performance need to be complemented by macro-economic and sectoral policies aimed at improving the viability of the sectors. The findings of this research project highlight the usefulness of combining firm-level and sectoral analysis of productive performance and underline the importance of efforts to improve productive performance.

# Samenvatting (Summary in Dutch)

Dit onderzoek is gericht op de ontwikkeling van een benadering om prestaties van productiesystemen in minder ontwikkelde landen (LDCs) te verbeteren. Zambia dient hierbij als voorbeeld. Dit proefschrift richt zich op de productieprestatie. De productieprestatie wordt gedefinieerd als de relatie tussen de kwaliteit en kwantiteit van de geproduceerde producten in relatie tot de inputs die gebruikt worden in het productieproces en tot de efficiëntie waarmee inputs omgezet worden in de gewenste output. Het onderzoek combineert een vergelijkende sectorstudie met casestudies in bedrijven.

De sectorstudie gebruikt secundaire nationale data over de nijverheidssector om informatie te verschaffen over de algemene economische omgeving waarin bedrijven opereren. Casestudies van vier bedrijven dragen bij tot inzichten over mechanismen op bedrijfsniveau, die niet adequaat op sectorniveau bestudeerd kunnen worden. De casestudies geven ook inzicht in de "black box" van de productiefunctie. Het gebruik van productiefuncties op sectoraal zowel als bedrijfsniveau is een poging om de afstand tussen meso- en micro-analyse van productiviteitsprestaties te verkleinen. De internationale vergelijking, waarbij de VS ('s werelds meest technisch geavanceerde industriële economie) gebruikt wordt als referentie, maakt het mogelijk om de technologie- en productiekloof waar bedrijven mee geconfronteerd worden, in bredere context te kwantificeren. Om productieve prestaties in Zambia te kunnen onderzoeken, hebben zijn omgevingskenmerken in het onderzoek betrokken. Hierin vervlochten zijn generieke kenmerken van subgroepen van LDCs.

De sectorstudie geeft een analyse van de prestaties van de Zambiaanse nijverheidssector sinds 1964. Het verschaft nieuwe inzichten met betrekking tot de groei van arbeidsproductiviteit en de groei van de totale factorproductiviteit (TFP). Na een periode van groei in output en arbeidsproductiviteit tot en met 1974, leed de Zambiaanse nijverheidssector daarna onder toenemende inefficiëntie in een externe omgeving gekenmerkt door importsubstitutie en verregaande staatsinterventie. De groei in output nam af, arbeidsproductiviteit en investeringen krompen, terwijl de TFP fluctueerde. In de periode van liberalisering tussen 1991 tot 1995, daalde de output dramatisch, TFP stortte in, en de arbeidsproductiviteit nam verder af. Na 1995 zijn er indicaties van een bescheiden herstel.

Een "industry-of-origin" methode werd gehanteerd voor internationale vergelijkingen, met behulp waarvan de Zambiaanse productiviteit vergeleken kon worden met die van de VS. In 1990 stond de Zambiaanse arbeidsproductiviteit op 5,9 procent van die van de VS, terwijl de relatieve totale factorproductiviteit op 16,7 procent stond. In de loop der jaren is de comparatieve arbeidsproductiviteit afgenomen, hetgeen aangeeft dat er een toenemende technologiekloof bestaat ten opzichte van best practice op mondiaal niveau. In 1998 stond de arbeidsproductiviteit op 3,2 procent van die van de VS en de relatieve factorproductiviteit op 9,2 procent.

De bedrijfscasestudies maken gebruik van de "productiefunctie", waarbij gedetailleerde data van vier Zambiaanse bedrijven worden gebruikt om de groei in (fysieke) gekwalificeerde bruto output per werkend persoon en de transformatie-efficiëntie van het productieproces te analyseren als indicatoren van de productieprestaties. Transformatie-efficiëntie wordt gedefinieerd als het product van de productietijd efficiëntie en de effectiviteit van het productiesysteem. Productietijd efficiëntie wordt gedefinieerd als de verhouding tussen de tijdspanne waarin het productiesysteem feitelijk producten voortbrengt en de totale tijdspanne die voor productie in beschouwing wordt genomen. De effectiviteit van het productiesysteem is de verhouding per tijdseenheid tussen de gemiddelde feitelijke output van gekwalificeerde producten en de gemiddelde maximale output van gekwalificeerde producten. Veranderingen in de transformatie-efficiëntie verklaren een deel van veranderingen in het residu van de output per eenheid input in de productiefunctie.

De analyse van sectorale en bedrijfsgegevens laat zien dat vele veranderingen in prestaties op sectorniveau worden gespiegeld op bedrijfsniveau. Wanneer de groei van de output op sectoraal niveau vertraagt of versnelt, zien wij meestal hetzelfde gebeuren in de afzonderlijke bedrijven. Ook zien wij dat alle vier bedrijven in de periode van herstel na 1995 groei van de transformatie-efficiëntie te zien geven. Toch zijn er ook perioden, waarin de ontwikkelingen in afzonderlijke bedrijven tegen de sectorale trends ingaan. Zo hadden twee van de vier bedrijven in de periode tussen 1991 en 1995 toen de totale productie ineenstortte, niettemin een positieve groei in de gekwalificeerde bruto output per werkende persoon (4,0 en 9,3 procent per jaar). Daarnaast hadden twee bedrijven een positieve groei in de transformatie-efficiëntie (3,3 en 4,2 procent per jaar).

Belangrijke inhoudelijke bevindingen van dit proefschrift omvatten onder meer de volgende punten. In tegenstelling tot de ontwikkelingsliteratuur die de nadruk legt op het overheersend belang van beleid, instituties en externe omstandigheden in ontwikkelingslanden, blijken bedrijven in ontwikkelingslanden wel degelijk in staat om hun prestaties te verbeteren door bedrijfsinterne inspanningen, zelfs in een stagnerende macro-omgeving. Er bleken zeer grote verschillen in de transformatie-efficientie te bestaan tussen de vier casestudie bedrijven, die bloot stonden aan dezelfde negatieve nationale en sectorale invloeden. Verbeteringen in productiviteit en transformatie-efficiëntie waren het grootst in bedrijven waar er relatief meer geïnvesteerd was in machines en apparaten, en waar doelbewuste programma’s werden geïmplementeerd om de efficiëntie van het productieproces te verbeteren. Op sectoraal niveau hebben de meest opzienbarende resultaten van dit onderzoek betrekking op de analyse en kwantificering van de ineenstorting van de industriële productie in de jaren negentig. De comparatieve analyse bevestigt het bestaan van een enorme technologiekloof tussen Zambia en de wereldproductiviteitsleider, de VS. Het lage niveau van comparatieve productiviteit in Zambia heeft vooral te maken met lage productiviteitsniveaus in elk van de nijverheidssectoren en niet met de verschillen in productiestructuur tussen het ontwikkelingsland Zambia en de VS. De sectorale productiviteitskloven worden vooral verklaard door een lage kapitaalintensiteit en een relatief inefficiënt gebruik van factor inputs. De trends in relatieve arbeidsproductiviteit in Zambia wijzen op een lange termijn verslechtering van comparatieve prestaties en op een groei van de technologiekloof over tijd.

Inspanningen tot verbeteringen in de prestaties op bedrijfsniveau komen vanuit het management. Veranderingen in de externe omstandigheden die relevant zijn voor een bepaalde tak van nijverheid (zoals de verbeteringen in de industriële en financiële levensvatbaarheid van een sector) worden beïnvloed door het overheidsbeleid en het overheidshandelen, of door autonome veranderingen in de externe omgeving. De casestudies laten het belang zien van de externe nationale en sectorale omgeving voor prestaties op bedrijfsniveau. De variatie in prestaties op bedrijfsniveau geeft echter aan dat inspanningen om op bedrijfsniveau de productieprestatie te verbeteren uitermate belangrijk kunnen zijn. Door een efficiënter en effectiever gebruik van bestaande hulpmiddelen en de invoering van beter management, kunnen bedrijven hun productieprestaties verbeteren, zelfs in een negatieve omgeving. Hetzelfde geldt voor het gebruik van verbeterde technologieën. Factoren die van belang zijn bij de verbetering van prestaties op een bedrijfsniveau zijn de verwerving van nieuwe technologieën, de oriëntatie op exportmarkten, een hoog niveau van investeringen in machines en apparatuur en de bewuste implementatie van programma's ter verbetering van de efficiëntie en kwaliteit.

Inspanningen op bedrijfsniveau ter verbetering van de bedrijfsprestaties moeten gepaard gaan met beleid op macro-economisch- en sectorniveau, gericht op verbetering van de levensvatbaarheid van sectoren. De bevindingen van dit onderzoek ondersteunen het nut van het combineren van bedrijfs- en sectoranalyses van productieprestaties, alsook van inspanningen om de productieprestaties te verbeteren.

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# 1 Introduction

## 1.1 Introduction

This thesis is based on the results of a study that focuses on improving manufacturing performance in Less Developed Countries (LDCs), with particular reference to firm-level improvement in food, textile, chemical and metal-working manufacturing firms in Zambia. The research methodology used is a sectoral approach and a company case study approach using raw data for 1964-98 and 1986-98, respectively, to provide new information and an analysis of improvement efforts in these firms and how the working setting of firms influences these efforts. These two research approaches are then combined into a performance improvement model for manufacturing firms. An additional dimension of the study is the presentation of an international comparison of real output and productivity levels in manufacturing between Zambia and the United States, the country with the highest known industrial productivity.

The first aim of this chapter is to present a brief discussion of the general characteristics of LDCs that are of relevance for manufacturing performance. These characteristics include common characteristics of LDCs versus developed countries, but also characteristics of specific subgroups of LDCs or specific countries, such as Zambia. Secondly, the concept of firm level manufacturing performance is defined. In sections 3 and 4, the research problem, objectives of the study, and the research methodology are discussed. The chapter ends with a presentation of the structure of the thesis.

Improvement of manufacturing performance is seen as one of the major ways of improving national economies in LDCs. Economic growth generally is interwoven with the development of the manufacturing sector. Manufacturing is the industrial sector that provides the dynamism for increasing productivity and growth (Fransman, 1982; Roy, 1982; Smith *et al.*, 1982; Smith and Hitchens, 1985; Timmer, 2000). Growth of manufacturing performance is closely linked to other indicators of economic performance, such as per capita growth, resource allocation and efficiency. Moreover, manufacturing in LDCs is often viewed as a potential leading sector for modernisation and for the creation of skilled jobs. Manufacturing represents a potential engine of growth.
The economic achievements of Japan since the end of the Second World War and, recently, those of newly industrialising countries (NICs), especially in Asia, confirm the importance of manufacturing. The productivity and quality improvements of firms in Japan and NICs and their competitiveness in terms of price and quality have prompted countries in the less developed world to seriously think about their manufacturing problems.

One of the areas that have been extensively studied is the role of governments in LDCs in promoting manufacturing growth. Typically, government’s role in Africa has traditionally been highly interventionist. Governments, for instance, encourage manufacturing growth by protecting the domestic markets and offering tax concessions and low tariff rates to importers of manufacturing intermediate inputs, machinery and equipment (see Szirmai and

Lapperre, 2001). Evidence from studies in LDCs (Ahluwalia, 1985; Collier and Gunning, 1999a and 1999b; De Valk, 1992) suggests that in the long run protection of manufacturing under import substituting industrial policies leads to increases in price-cost margins of firms instead of boosting growth. Protection of new industries also reduces the efficiency levels at the margin. Furthermore, protected firms are shielded from the international knowledge stock. Learning by doing among local firms does not seem to foster substantial productivity growth, because learning by doing is complementary to access to the international knowledge stock, rather than a substitute for it (Evenson and Westphal, 1995). High rates of protection simply dampen the incentive for firms to make performance improvements, as they cushion firms against the consequences of inferior performance (Fleury, 1995; Weiss, 1988). There have, however, been some challenges to the present preference for free markets and liberalisation. Lall (1996) argues that, in the case of NICs of East Asia, there is evidence that government intervention can lead to successful industrialisation (Also see Amsden, 1989; Wade, 1980). The form of government intervention in the Asian Tigers is different from that practised in Africa and the rest of Asia. Interventions in the NICs of East Asia range from generic policies to selective and targeted interventions to support industry and improvement. Lall concludes that government policies contributed to technological development and industrial depth.

The tragedy of Zambia is that protection of the manufacturing sector did not work (see chapter 4). Subsequent liberalisation did not work as anticipated either. We, therefore, have to find a new mixed industrial policy that creates a viable environment for growth at a firm level. We conclude that the government should take an active enabling role without falling into the extreme interventionist position by focusing on human resource development, infrastructure development, stable incentives, support of learning and technology acquisition. For example, a more outward-oriented and competitive environment stimulates greater and healthier efforts by enterprises to develop their capabilities. On the other hand, restraint on competition, growth or profitability may stifle enterprises’ efforts to develop.

Together with the socio-cultural, political and legal conditions, the economic conditions have long been recognised as important factors in the successful development of industries in LDCs, since these can provide a stimulating environment to local firms (Al-Ghailani, 1995; Eneyo, 1995; East, 1983; Monkiewicz, 1986; Negandhi, 1984; Pack, 1987). Macro-economic conditions are driven by variables such as non-overvalued exchange rates, unrepressed interest rates and moderate government deficits, availability of cheap and abundant labour, bountiful natural resources, and stable, predictable and transparent government policies.

Mersha (1997), Szirmai (1997) and other authors (see Austin, 1990; Caldwell, 1986; Caldwell and Caldwell, 1987; Chirot, 1977; Maddison, 1989; World Bank, 1993) have given qualitative differences, in terms of cultural, economic and political situations, between developing and developed countries. These are summarised in Table 1-1.

**Table 1-1: Differences between developed and developing countries (Mersha, 1997 and Szirmai, 1997)**

| | | *Developing Countries* | *Developed Countries* |
|---|---|---|---|
| *Cultural Indicators* | Social structures | More rigid | Low |
| | Religious influence on behaviour | Stronger | Weaker |
| | Gender roles | Very distinct | Less distinct |
| | Language | High diversity | Low diversity |
| *Economic Indicators* | Availability of skilled labour | Scarce | Abundant |
| | Availability of domestic capital | Low | High |
| | Financial institutions | Weak | Strong |
| | Trade deficits | Medium/high | Low |
| | Export diversification | Low | High |
| | Availability of foreign exchange | Scarce | Available on demand |
| | Physical infrastructure | Undeveloped | Highly developed |
| | Availability of information | Low | High |
| | Technology | Low | High |
| | Share of manufacturing in the economy | Low | High |
| *Political Indicators* | Instability of governments | High | Low |
| | Institutions | Weak | Strong |
| | Role of state in economic development | Greater | Relatively restricted |
| | Predictability of economic processes | Low | High |

Developing countries have varying development indicators as shown in Table 1-1. There are enormous differences among these countries. But nevertheless, developing countries do have important common characteristics, which are important from the perspective of studying manufacturing performance. The most important shared characteristic of LDCs is widespread poverty. They are low-income economies with a relatively low share of industry in the total economic activity (Weiss, 1988; World Bank, 1993).

East (1983) has used the natural resources, income per capita and its distribution, economic growth rate, political structures, and research and development capabilities as criteria to classify developing countries in a three-level subdivision, see Table 1-2.

**Table 1-2: Classification of industrialisation level in developing countries (East, 1983)**

| Subdivision | Examples |
|---|---|
| Pre-industrial level | Most African countries concerned especially with agricultural production and public health |
| Beginning industrialisation level | Nations with demonstrable potentials to improve on the status quo, e.g. Libya, Egypt, Saudi Arabia and Pakistan |
| Relatively advanced industrialisation level | Nations heavily involved with technological adoption and industrial operations, e.g. Brazil, China, Mexico, Argentina, South Korea, Taiwan, India, South Africa and Israel |

In terms of the late start of industrialisation and the small size of the manufacturing sector, Zambia still belongs to the pre-industrial category.

The next section defines the underlying concept of manufacturing performance and performance improvement, as applied to this study. We also highlight elements in the definition of manufacturing performance that have great impact on the development and improvement process of performance in manufacturing firms.

## 1.2 Manufacturing Performance

Performance of a manufacturing firm can be defined in various ways depending on the questions in mind when we inquire about a firm's performance. From a socio-economic perspective, profit is the most common measure of a firm's performance. Other indicators include internal rate of return, productivity, superior quality and reliability, flexibility, efficiency, effectiveness, capacity utilization, growth of output and net present value, and market share (Skinner, 1974; Wheelwright, 1978; Krajewski and Ritzman, 1987; Leong *et al*., 1990; White, 1996; Vokurka *et al.*, 1998; Ward *et al*., 1995 and 1998). Although there seems to be little agreement on precisely which non-financial measures of performance to use, many authors agree on the need to use more non-financial measures of performance that are relevant to the firm's own situation and adequately gauge manufacturing performance relative to a competitive strategy (White, 1996). Non-financial measures of performance give a better description of what goes on in the production of goods than financial measures do.

In this study *manufacturing performance* is defined as the relationship between the quality and quantity of physical output in relation to inputs used in the production process and as the efficiency with which inputs are transformed into desired output. This definition of manufacturing performance reflects the basic rationale for a production system, which is to produce something of value (Buffa, 1984).

At the sectoral level, performance is measured in terms of the standard economic concepts of labour productivity, capital productivity and total factor productivity. At the firm level, this study uses measures of output, of inputs and of time to derive the two measures of manufacturing performance of a firm. These two measures of manufacturing performance of a firm are the qualified gross output per labour engaged and the transformation efficiency of the production system. Physical output with the exclusion of service output is the measure of a company's gross output. Physical outputs are used as measures of company's output for practical statistical reasons and because they easily allow for a comparative investigation. We further define the company's gross output as 'desired' or 'qualified' (De Ron, 1994, p.13). The concept of 'desired or qualified physical outputs' conveys the notion of an output not only meeting technical product specifications and consumer satisfaction, but also a notion of how well the production process transforms inputs. Qualified gross output is defined as the value or quantity of goods meeting quality standards in the first round (without reworking) per time unit. In a production system where there is no reworking or rejection of output, qualified gross output is equal to gross output.

The productivity of a firm is expressed in terms of qualified gross output per unit of labour engaged. Labour engaged, the traditional production function input, is used in the expression because it is the most preferred input in research and policy discussions. Also, it is practical, as data on labour can be easily obtained and interpretation of a measure involving labour can easily be understood. The transformation efficiency of a production system is expressed by the total qualified gross output achieved by the actual production system in relation to the maximum achievable qualified gross output during the considered production period. On the basis of this description, the transformation efficiency depends upon the output-adding production periods and the rate of production of qualified products.

The definition of performance of a manufacturing firm describes a joint impact of several factors. Some of these factors are the efficiency of production, the level of technology in use, and the structure and composition of industry. In the analysis of growth of qualified gross output per labour employed and transformation efficiency in firms, the study looks at the primary and intermediate production function inputs, organisation and control of the production process, and at influences external to the firm. The inclusion of external influences in the analysis of firm performance is meant to extend the analysis to deal with the role of the specific circumstances characterising LDCs.

In the production literature, the term improvement defies a simple definition. Improvement, however, generally means to seek improvement opportunities in daily life (Bakerjian, 1993, p.1-1). Improvement demands repeatedly asking ‘why?’ and a stubborn refusal to give up the search for the best single way (Shingo, 1992, p.29-30).

The abundance of approaches in the literature indicates that no single improvement programme appears to have comprehensively met the requirements of manufacturing performance improvement. In addition, most studies on manufacturing performance improvement reflect the experiences and situations of the developed world, where real social demands and economic and technological constraints are different from those in LDCs. In most LDCs manufacturing firms operate in diverse internal markets where living standards often range from absolute poverty to the most sophisticated lifestyles.

In this study, *improving manufacturing performance* is defined as efforts to improve the transformation efficiency and the quality and quantity of outputs derived from a set of inputs, through more efficient and effective use of existing resources, use of improved technologies and better management practices. The efforts at firm level are exerted by managers. Note that the efforts to improve external influences relevant to a particular industry stem from government policies and actions. Autonomous changes in the environment can of course contribute to improved performance as well.

This definition of manufacturing performance improvement is adopted for four reasons. The first reason is that, from the practical experiences of many manufacturing firms, which took part in our 1996 production research survey, high productivity (sometimes not clearly distinguished from low cost) and consistent high quality were found to be the most critical contributors to the manufacturing business’ success. These contributors, therefore, constituted the main dimensions of competitive advantage (See Yamfwa, 1997. See also Bruun, 1995; Cartaya and Medina, 1989; China Mechanical Engineering Society, 1988; Fleury, 1995; Mefford and Bruun, 1996; Murugesh *et al.*, 1997).

The second reason is that by viewing manufacturing performance improvement as an effort-seeking action, the definition embodies the concept of continuous improvement that is appropriate for LDCs and may offer substantial competitive benefits to implementing firms (Kaplinsky and Posthuma, 1994).

The third reason is that these performance dimensions (i.e. transformation efficiency and productivity expressed as qualified gross output per labour engaged) capture more of what actually goes on inside the firm rather than the aggregate financial measures.

High productivity and consistently high quality, therefore, represent the key performance dimensions of manufacturing firms in LDCs. Improved productivity creates the potential to reduce costs and enhance competitiveness and profitability. Quality, on the other hand, is generally concerned with the improvement of outputs coming out, inputs going into the production process, and of the production process itself. One efficient way to improve product quality is through continuing effort to control and improve the production process, and choosing a better design. Quality improvement is directly linked to productivity improvement in various ways. A decline in the quality of output can increase rework, increase scrap, lower productivity, waste labour-hours, machine time and intermediate inputs, disrupt schedules, delay deliveries, and possibly increase warranty costs. Inspecting work-in-progress, reworking outputs, and the loss of output through scrapping all lower productivity. The absence of consistently high quality can significantly diminish the chance of future sales. Other costs are incurred when there is damage to either the company name or brands, as a result of poor quality that may eventually lead to reduced sales and loss of market share to competitors.

Additionally, as more countries in the less developed world open their markets to imports and foreign direct investment and as protected domestic markets are fast disappearing in these countries, very few manufacturing firms have the luxury of operating plants profitably producing low-quality products at high cost any more. Inefficient firms producing low-quality products can no longer compete in their home markets nor export their products to other countries. This realisation puts great emphasis on consistently high quality and high productivity issues if these firms are to produce products and sell them even in the domestic market. To improve manufacturing performance in LDCs, according to Ebrahimpour and Schonberger (1984, p.426), it ‘is important not so much to compete in the international market as (to survive) in their own local environment’. Fleury and Kaplinsky make a similar point (Fleury, 1995, p.79; Kaplinsky, 1995, p.61).

The last reason for adopting this definition of manufacturing performance improvement is the tendency in African manufacturing to attribute all problems to external influences, and to pay relatively little attention to the internal performance of the firm. Manufacturing performance improvement is one of the significant areas of a company-wide improvement strategy that a firm can pursue to considerably enhance its competitiveness and improve its long-term survival prospects.

## 1.3 Problem Definition and Research Objective

The prime concern of the study is to critically examine the impact of internal factors and external influences on company performance and to examine the possible synergy between sectoral and firm level approaches in the study of manufacturing performance. We use a variant of the Cobb-Douglas production function to analyse manufacturing performance in these firms. The sectoral study and the company case study are then synthesised into a performance improvement model.

Our approach includes a synthesis of manufacturing improvement effort and a development of operational measures of the company’s performance. These measures can be used to produce a profile of the firm-wide performance. They can also be used by decision-makers at various levels in a firm to measure the performance status to direct improvements in the performance areas.

The objective of the development of such an approach is to benefit from available and applicable knowledge in production and developmental literature and the experiences of previous research studies in manufacturing in LDCs to develop a systematic approach for manufacturing performance improvement that reflects the viewpoint of LDCs. In sum, the main objective of this research is to contribute to our understanding of how to improve manufacturing performance in firms in LDCs.

The specific objectives are as follows:
1. To review current performance concepts and develop performance measures relevant to the Zambian manufacturing sector,
2. To present estimates of performance levels and trends in the Zambian manufacturing sector and representative enterprises,
3. To develop a model of firm-level performance and to provide case studies demonstrating the model's applicability and usefulness,
4. To analyse Zambian manufacturing using a sector study approach and to examine the synergy between sectoral and firm-level approaches to the study of manufacturing performance.

The different aspects of the objectives are dealt with in different chapters and sometimes within a chapter. This is to show the interplay between the two chosen research approaches, namely the sectoral and case study approaches. This leads to the discussion from sectoral level to firm level. For example, the examination of the synergy between sectoral and firm-level approaches is dealt with in chapters 3 and 6.

## 1.4 The Research Methodology and Approach

### 1.4.1 Introduction

The approaches chosen for this study are the case study approach, the sector study approach and the international comparative approach. The combination of the case studies and the sector study is justified on the following grounds. The sector study provides information about the general economic environment within which the firms studied operate. The case studies provide insight into firm-level mechanisms, which cannot be studied at a sectoral level. They provide some insight into the "black box" of the production function. The international comparative study helps quantify the sectoral technology and productivity gaps with which firms in the sector are faced.
This research study employs primary data from case firms, and secondary national accounts and census data to investigate issues and problems of performance improvement in manufacturing firms in Zambia.

## 1.4.2 Case Studies

The case studies focus on four manufacturing firms. Research information is gathered through a series of research visits to collaborating companies spaced about twelve months apart over a period of four years. A single researcher tours all the four plants for an extended period of time, collects data, obtains plant-related documents, and conducts both structured and semi-structured interviews with a wide range of company personnel. The research data collected are then used to construct suitable measures of company performance and proxies of factors affecting this performance. These are then analyzed to explain performance growth and provide new insights into the mechanisms of performance improvement processes.

The research study initially started with a survey study of 39 manufacturing firms in Zambia and Zimbabwe to provide a general understanding of issues of performance improvement in manufacturing firms in these two typical LDCs and to help develop the research model. The study sought to determine whether the internal factors and external influences identified in literature (see Yamfwa, 1997) were important variables to explain the differences in performance observed among firms. The survey study was followed by a seminar organized in Zambia. The seminar participants were drawn from the government departments responsible for Commerce, Trade, Industry and Technical Education, academic institutions, the international donor community, the Zambian manufacturing sector and other stakeholders. The seminar provided valuable contributions and further insights into how the manufacturing companies in Zambia viewed improvement of their manufacturing operations as individual organizations and as a sector. For example, issues related to companies' survival were seen as more critical than environmental aspects of production (pollution) that appear to have become prominent in most highly industrialized nations.

Information gathered from the survey study, from site visits, from the working seminar and published material in other regions of the developing world helped in the conceptualization of the research model. The research study hypothesizes that manufacturing performance improvement is an integrated process driven primarily by company internal factors that may be constrained or enhanced by industry relevant external influences.

Four firms made up our case studies, two in agro-processing (foods and textiles), one in fabricated metals and another in chemical production. The four branches were chosen for three reasons. Firstly, these branches are among the largest in the sector in terms of employment, contribution to the GDP and share of industrial value added. In 1998, these branches together accounted for 45.4 percent of employment in manufacturing, 40.7 percent of manufacturing value added (at factor cost), and about 52 percent of manufactured exports. Secondly, these branches have the potential for backward links and income creation, i.e. they may function as growth poles. The third reason is that the production technology in all four branches is largely based on mechanical engineering. The selected branches, therefore, bear similarities to other branches with comparable production systems.

In the case studies the main focus was on the firms' production systems whose performance indicators were qualified gross output per person engaged and transformation efficiency of the production system. Other performance indicators (such as financial indicators), which are equally important in contributing to the competitiveness of an enterprise, were not considered.

In the measurement of variables such as intermediate inputs, we focussed on major types of intermediate inputs that often receive the greatest management attention and subsequently have a relatively more efficient usage. Inclusion of all other intermediate inputs in the analysis would probably result in lower performance indicators, although the main trends will not change.
The number of case studies is small, as is inevitable in a case study approach. This limits their representativeness. In combination with the sector studies, however, the case studies allow for an in-depth study of the mechanism involved in productivity improvement. As such they provide relevant insights which transcend the boundaries of individual firms.

### 1.4.3 Manufacturing Sector Study and International Comparative Study

The manufacturing sector study uses a growth accounting framework to perform a sectoral analysis of manufacturing in Zambia. The sectoral study makes use of Zambia's manufacturing sector data. It aims to unravel more analytical information than hitherto available on sector structures, productive capacities and levels of productivity. It also uncovers the mechanisms through which specific characteristics of Zambian labour and capital are translated into lower productivity.

The international comparative study aims at comparing real output and productivity levels in manufacturing between Zambia and the United States, which is considered to be the world's most technologically advanced industrial economy. The comparative analysis of manufacturing in Zambia with the USA (used as a benchmark) uses the industry-of-origin approach. The industry-of-origin approach broadly matches comparable manufactured products in any two countries, then aggregates them at the sample industry, branch and whole manufacturing sector levels. For similar products in two countries, the estimated unit value ratios (or UVRs) form the basis for real output and productivity comparisons.

## 1.5 The Structure of the Thesis

The thesis consists of seven chapters. Chapter 2 provides an extensive literature review. The aim is to review existing literature to establish what has already been achieved and identify gaps in our production knowledge. The development of a systematic approach to improve manufacturing performance was found to be an important research area.

Chapter 3 is devoted to a detailed description of methodologies used to tackle the problem raised earlier on and analyse performance. An examination of the synergy between these methodologies, specifically the growth accounting framework and the firm-level conceptual model, is also given in this chapter.

Chapter 4 gives a statistical review and an analysis of the development of manufacturing in Zambia to characterise its capabilities and the environment in which it operates. This is followed by a discussion of industrial policies in Zambia and manufacturing experiences for the period under study. The last part of this chapter presents a quantitative analysis of growth trends in Zambian manufacturing. New findings in the analysis of the sources of manufacturing performance growth and stagnation in Zambia are presented and also discussed here. This is done within the framework of a growth accounting approach.

An international perspective to analysing Zambian manufacturing performance is the subject of chapter 5. The binary comparison of Zambian manufacturing performance to that of the USA is based on an industry-of-origin approach. Product matches and unit values from censuses are used to derive conversion factors of real output and productivity comparisons. Chapters 4 and 5 give the necessary sectoral background to the case studies to be discussed in chapter 6.

Chapter 6 combines a simple production function approach with indicators of quality and efficiency to analyse firm-level performance. This approach is applied in the four case studies. Finally, the major findings of this thesis are summarised in chapter 7.

# 2 Improvement of Manufacturing Performance – A Review of Literature

## 2.1 Introduction

The primary aim of this chapter is to present the state of the art of improvement efforts in firms in advanced economies and the actual situation with respect to qualified gross output per labour engaged and transformation efficiency improvement in firms in LDCs. These efforts to improve performance will be classified under two lines of approach, one line of approach for firms in advanced economies and another for firms in LDCs. It will then be shown where the emphasis lies in each of these two groups. Weaknesses in the current line of approach in LDCs will be identified and an approach that uses the available performance literature will be proposed, extended with new aspects. The literature review (details in sections 2.2 and 2.3) on performance is used to give a scientific basis of the study. Furthermore, as these two lines of approach to performance improvement are discussed, empirical evidence will be used to illustrate them.

This chapter begins with a discussion of developments from literature on the improvement process of firm's performance in advanced economies and LDCs, and ends with some conclusions drawn on the basis of the literature review. The review is done from a firm's perspective. This perspective is undertaken because it allows us to make a clear distinction between the experiences of enterprises in advanced economies and those of enterprises in LDCs.

A literature review of manufacturing development in the advanced economies and in the LDCs indicates two discernible approaches to improve performance of manufacturing enterprises in these countries. In advanced economies, the focus is evident on structural factors in order for enterprises there to improve their performance. In enterprises in the LDCs, especially African LDCs, the focus is on the orientation of industrial and trade policies as key elements to achieving manufacturing performance improvement. This difference is partly explained by the fact that manufacturing in many African LDCs is still in the early stages of development and is concentrated in high-volume and standardised production systems where skills and wages are relatively low. In advanced economies, manufacturing competitive advantage is sought in flexible production systems that require higher education and skills to produce customised products.

In the next sections, these two approaches to performance improvement are discussed in detail.

## 2.2 Manufacturing Performance in Advanced Economies

In individual enterprises in advanced economies greater attention is given to issues such as innovation and access to new technology, skills, technological effort and similar issues, in order to increase manufacturing performance. These issues will be referred to as structural factors, because they are the factors that are most important to the development and acquisition of capabilities for an enterprise.

An explanation for the emphasis on “micro” issues (i.e. structural factors) instead of “macro” issues (i.e. issues at industry and national levels) is the realisation in advanced economies that issues concerning enterprises, work groups and individuals are causes of the poor level of performance growth. Enterprises are deeply examining themselves in an attempt to improve efficiency and competitiveness. Technology, human elements, and specific management issues are seen as keys to improving performance, rather than macro-economic issues such as fiscal, monetary and trade policies.
Below are five structural factors derived from the literature (Autio and Laamanen, 1995; Bollinger, 1985; Hitomi, 1993; Kastrinos, 1995; Lutz, 1987; other references are given in subsequent sections) that are the key ways through which firms in advanced economies are currently improving their performance. The related literature will be discussed per topic. The structural factors are:

1. innovation and access to new technology,
2. links with knowledge institutions and best-in-class firms,
3. investment in physical capital,
4. effectiveness of industrial management systems,
5. human resource development.

### *2.2.1 Innovation and Access to New Technology*

Many companies have realised the potential of opportunities that can be exploited through new manufacturing practices and processes, innovation of products and processes (Bollinger, 1985; Hitomi, 1993; Lutz, 1987; Prueitt and Park, 1992). Other opportunities also arise from new materials, design and marketing philosophies, and in new ways of organising manufacturing such as cellular manufacturing (Shaw *et al.*, 1992).

Technological innovations as an approach to performance improvement represent large improvements in an organisation through new and revolutionary ideas. Innovations typically involve the development of new products (to which markets assign a higher value than previously), new processes and new applications, substitution of materials by better ones and efficient use of resources. In its pure form, technological innovation involves major expenditure of funds and specialised staff.

Much innovation, however, does not consist of major breakthroughs, but of a number of incremental steps, though their total effect may be equivalent to that of a breakthrough. Such relatively small steps may consist of adjustments in procedures and materials, slight variations in the manufacturing process, product redesign for easier production, use of fewer components, etc. Although this approach appears to be more appealing in that it is less risky, involves less financial outlays and less need for particular types of specialists, the incremental approach requires a great deal of workers' expertise, particularly at low levels in the organisation. This requirement of incremental innovation and that of breakthrough innovation suggests that the effectiveness of the first structural factor, "innovation and access to new technology", requires that the enterprise should also pay attention to another structural factor, namely "human resource development".

Of particular interest are improvements at the design and mass-production stages. Improvements at the design stage aim at preventing the recurrence of problems experienced in the past, or anticipated in the future. Improvements at the mass-production stage aim at eliminating defective items at each stage of production, stressing the need for quality improvement at each phase of the production process.

In the post Second World War era, production and distribution efficiency of the Japanese manufacturing industry increased considerably. For example, labour productivity (i.e. number of units produced per labour hour worked) in Japanese manufacturing firms increased at an annual average of 9.5 percent, 11 percent and 5.8 percent from 1960 to 1967, 1967 to 1973 and 1973 to 1980 respectively (Shinomiya, 1982) (Also see Pilat, 1994). This increase in productivity is attributed to the effort of individual companies to quickly respond to the diversified consumers' need and the acquisition of automation technology.

In addition to the kind of technological innovations that have been discussed above, a new trend in industrial innovation involves the application of world class manufacturing (WCM) principles (Schonberger, 1986; de Ron, 1997). These principles are sometimes referred to as just-in-time, kanban, group structure and logistics management in modern industry. The application of WCM principles can be seen in the assembly industry where the adaptation of new production requirements transforms a traditional assembly industry to a form of processing industry. Production requirements such as flexibility in batch sizes to enable a rapid adjustment to the market, flexibility in production processes through introduction of product variations as late as possible in the production processes thereby allowing fulfilment of maximum number of customer wishes in the latest stages of assembly, organisation of product development to achieve a minimum number of parts, and production based on market demand instead of supply requirements, have enabled enterprises implementing them to control costs, time and quality.

### *2.2.2 Links with Knowledge Institutions and Best-in-class Firms*

Firms are normally embedded in relationships with customers, suppliers, trade associations, etc. Of these relationships we consider the links with knowledge institutions and best-in-class firms because of the huge potential such relationships hold for participating firms. Firms take advantage of these links to improve performance by obtaining additional knowledge and expertise not generated internally. This stems from the premise that no firm, irrespective of its size or its research and development budget, can possibly be able to have in-house access to all the capabilities it needs either for products, processes or administration. Thus, there will be need for channels for information and knowledge flow into the firm and possibly out of it, depending on its activities.

The importance of these links is often determined by the level of participation and the content of a particular relationship. The more embracing the contact the more potential it holds.

Links with knowledge institutions are particularly important in fostering learning, in securing resources for innovation, and in sharing information (Autio and Laamanen, 1995; Kastrinos, 1995; Pilorget, 1995; Rossum and Cabo, 1995; Shetty and Buehler, 1988; Suri *et al.*, 1995; Withers, 1994). These are sources of new knowledge required to eventually improve manufacturing performance. There are in fact significant potential synergistic benefits in the collaboration with research institutions. While the major advantage for the firm is the technological support from research and tertiary institutions, the joint efforts would also lead to an enhancement of knowledge of academics and researchers.

The knowledge institutions provide advances not only in established fields but also in new fields such as biotechnology, information science and materials. All these areas provide opportunities for knowledge generation. The emphasis on the linkage between a firm and knowledge institutions stems from the apparently inherent weakness of knowledge institutions in executing the difficult transition from R&D prototype to full-scale commercial production which requires the development of manufacturing equipment and processes in order to make this transition, and eventually contributes to the improvement of performance in the firm.

An example of the importance of links is provided by the study by Martin-Vega, Brown, Shaw and Sanders (1995) where they investigate the impact of investments in R&D on reducing the cost and enhancing the effectiveness of manufacturing assembly. This study covered firms in manufacturing of aircraft, microelectronics devices, electronic assemblies, communication devices, missiles, computer systems, mechanical assemblies and welded metal products with annual sales ranging from US$10 million to 2 billion. Firms may employ breakthroughs or incremental innovations in technology originating from R&D that leads to a novel product concept or a new production process and allows for considerable reductions in cost price.

The key finding here is that a research agenda based on an industrial perspective would result in the highest return to investment in R&D. R&D provides the groundwork for the future manufacturing efforts of a technological firm. This structural factor also includes the transfer of technology developed in research laboratories to the manufacturing activity of enterprises.

Links with other firms, on the other hand, allow partners to reach a critical mass of human and other resources (i.e. financial) needed either to undertake large projects or to achieve better performance through the assessment, acquisition and development of capabilities. In the former case, co-operative links allow firms to develop new products and processes more quickly and cheaply. In the latter case, co-operating firms can engage in a benchmarking exercise. We are referring here specifically to the benchmarking aspect of searching for industry best practices that lead to superior performance. Comparison of performance with other firms yields valuable benchmarks and leads to an exchange of best practices.

### 2.2.3 Investment in Physical Capital

The capital investment approach refers to the contribution of investment and accumulation of fixed capital to improve performance. Firms are investing in new machinery, for instance, in order to attain a certain level of automation that will result in the achievement of the highest level of process control and higher energy savings.

Buggie (1995) suggests three approaches to using capital investment to increase performance. These are: (i) replacement of labour in harmful and dangerous situations, and in situations where repetitive and frequent tasks with few variables are sorted out by automatic systems, (ii) aiding labour to do more and at the same time by identifying tasks that could benefit from a facilitating system; and (iii) redesigning tasks by adopting new ways of accomplishing what needs to be done.

High performance in firms in the advanced economies is attained through an aggressive investment in modern manufacturing facilities in view of the long-term growth of the company (Ostwald, 1989). Over a period of time, a study of changes in labour and capital can reveal the extent to which one resource is replaced by another as a source of input factor. As far as the performance goes, it is possible to estimate the manner in which capital is replacing labour. On the basis of relative changes in labour and capital, it would be feasible to show the extent to which factor replacement is taking place, and therefore, to show its impact on performance.

### 2.2.4 Effectiveness of Industrial Management Systems

Improvement in the performance of a firm cannot be achieved through manufacturing efficiency or labour productivity alone. One area with great potential for improvement is the ability to make better decisions in the organisation and operation of manufacturing (Ahmed and Montagno, 1996; Gardiner, 1996; Wilson, 1994). This is particularly true in engineering design. For instance, in commercial aerospace industry where engineering design typically accounts for less than 5 percent of the total product costs, decisions made during design account for about 85 percent of the end product value (Jacobs, 1980). If the bottom line for all improvements in manufacturing is the value of the end product itself, then there is great need to improve decision-making early in the design process.

Firms in advanced economies focus their investments in new engineering technologies so as to improve decision-making effectiveness (that is making better decisions that lead to future improvements in productivity and quality). The use of tools such as computer graphics, computer-aided testing, databases and mathematical simulations have the potential to better decision-making in the early stages in the design process where most of the value of a product is decided. This is a change in focus from improving solely labour productivity in engineering to improving decision making in the design process. Applying aids such as computer-aided engineering for improved design holds promise for improved performance. This is done through information organisation for future design, creation and evaluation of alternative design concepts to predict consequences early in the design process, and through improvement of the flow and communication of information required to make design decision.

An illustration of how better management decision-making contributes to improved performance is Mohanty and Rajput’s (1987) productivity management cycle. It consists of four phases, namely measurement, evaluation, planning and improvement. The conceptual framework describes how improvement strategies can be developed. In Mohanty and Rajput’s conceptual diagram, the company first focuses on one important cause of low performance. An analysis of the factors contributing to low performance, then, gives management some insights and can provide management with guidelines to formulate lower level action plans and programmes. Other descriptive approaches to improve performance along lines of Mohanty and Rajput’s conceptual framework include Edosomwan’s (1988) step-by-step process improvement methodology, Irani and Sharp’s (1997) step-by-step continuous improvement procedure, Oakland and Wynne’s (1991) methodology for improvement and Dale and Boaden’s (in Dale and Prapopoulus, 1995) quality improvement framework. These methods seek to make improvements by detailed analysis of the current practices of the enterprise itself. They are all more or less variants of the Deming wheel. (For a detailed discussion of the Deming wheel see, for example, Huge, 1990).

The objective of the design and industrial management systems is to satisfy customers through the provision of products that meet their needs. This can lead to the generation of revenues for all the stakeholders and enable a firm to remain profitable in the face of the uncertainties and dynamics of (global) competition. Enterprises are implementing integrated and co-operative systems, such as total quality management (TQM), and time-based competition (Buzacott, 1995). These systems are also referred to as incremental industrial innovations because when properly implemented, they lead to incremental improvement.

### *2.2.5 Human Resource Development*

The potential of human resource development (HRD) for the enhancement of a firm’s performance lies in the achievement of a desirable alignment between the individual workers’ goals and those of the firm. The job satisfaction that derives, for instance, from being adequately rewarded or from practising and developing skills on varied and interesting job problems, can be expected to be exhibited in high levels of motivation of workers for their jobs. Enhanced work motivation can contribute to improving workers’ performance in their various tasks. This, in turn, potentially contributes to improving the firm’s performance.

The central idea of HRD in enhancing a firm’s performance is seen in the linkage between the firm’s policies for securing appropriate labour resources and the wider strategic (operational) goals of the company.

Modern HRD techniques include the provision of opportunities for career development and training needs of employees. In operation, HRD includes a mixture of “hard” and “soft” approaches. The composition is determined by the external and internal environment of the firm, its strategy, culture and structure (Armstrong, 2001; Ichniowski and Shaw, 1995; Rieger, 1995; Storey and Sisson, 1993).

The “soft” or qualitative approach is centred on the firm’s interventions designed to elicit commitment and to develop resourceful workers. The “hard” approach, on the other hand, involves the firm’s interventions designed to secure full utilisation of labour resources.

Thus, firms implement appraisal and performance review systems, establish career management and training systems, and establish reward mechanisms (i.e. formal rewards and other motivating factors).
Below, we provide an extended discussion of the development of labour skills because it is the most critical function of HRD.

The quality of the labour force plays an important role in the performance of an enterprise in a fundamental way. This is primarily so because labour force quality affects the company's performance directly and may underlie international differences in company's performance (Lutz, 1987). Another reason for the promotion of workers' education and training is the need to cope with the era of technological innovation and modern management. In a highly automated production environment with a highly diversified product mix, workers are trained beforehand with new technical education (such as the fundamentals of firm's processes, industrial engineering and preventive maintenance) and non-technical skills. In effect, this upgrading of the competence of workers improves the quality of the products, the working ratio of the plant facilities, and the efficiency of the management through small group activities. These all support and improve cost reduction and performance.

A study of the levels of education in firms in the USA and Japan drew attention to the significant differences between these two countries and attributed the higher efficiency of the latter mainly to the higher quality of primary and secondary education there (Silk, 1982). In this respect, the majority of factory workers in Japan are reported to be high school graduates. This factor contributes to the enhancement of the flexibility and the willingness of the labour force to switch to other activities within the firms (Matsumoto, 1982).

Educational curricula and the importance given to mathematics, science, communication, reading and writing skills in these curricula are factors that affect the quality of the labour force in firms in nations that are increasingly built on the application of scientific and technological knowledge. Nations where people are equipped with this kind of knowledge seem to perform better at all levels of the productive process (Lynn, 1982; Szirmai, 1997, p.147-149). Literate employees are capable of reading instructions, keeping records, making calculations and communicating either with peers or superiors.

To have access to adequate and appropriate skills in order to achieve the required high levels of performance is a major concern for firms in advanced economies. More specifically, individual firms place emphasis on educational and training programs for their employees in order to improve their skills and knowledge. The concern for skills not only creates the need for increasing efforts by companies themselves to provide complementary training, but also draws attention to the performance and the relevance of the national educational systems. It is argued that the business competitiveness of a company is influenced by the educational system, in that it is, inter alia, the educational system that forms individuals with the skills necessary to perform the business tasks.

The movement towards automation and the increased application of electronics in plant facilities in manufacturing has been growing tremendously over the years. It is not enough for a worker to simply know his special skill. He must also have knowledge about these facilities. Knowledge about microcomputers becomes necessary and a high level of skills is needed to maintain such facilities. Training workers to have wide and comprehensive skills thus becomes mandatory for firms in industrialised nations rather than an option.

Flexibility of workers also relates to retraining. If workers are flexible enough to undergo retraining and accept new technologies, this improves the capability of firms to easily upgrade their methods of production and product quality. Finally, re-training (or re-schooling) of labour is an important growth strategy of an enterprise because it increases labour mobility by giving actual and potential skills to employees that enable them to move from existing to expanding activities of the firm.

## 2.3 Manufacturing Performance in LDCs

While there is a clear indication in literature that firms in advanced economies focus on structural factors (such as innovation and access to new technology, links with knowledge institutions and best-in-class firms, investment in physical capital, effectiveness of industrial management systems, and human resource development) as the sources of growth, most of the literature on firms in LDCs stresses developmental policies as the major sources of growth. African and other LDC literature on firms shows that many enterprises look at their countries' orientation in industrial and trade policy as a major potential source of their performance growth. These policies include control of foreign investment, import restrictions, protection policies, preferential treatment of local products, incentives for local producers and tax policies (Adjebeng-Asem, 1990; Al-Ghailani and Moor, 1995; O'Donnell, 1997). The most often mentioned industrial and trade policies in the literature are:

1. infant industry protection,
2. export orientation policy.

### *2.3.1 Infant Industry Protection*

Different authors (see Chandra, 1992; Cypher and Dietz, 1997; Harvey, 1996; Lal and Myint, 1996; Thirlwall, 1999) have advanced various arguments in explicit or implicit support of infant industry protection. The cardinal argument for protection lies in the fact that industries in African LDCs are believed to be so weak that they cannot compete either in regional or in international markets. By protecting these "young" enterprises a learning base would be given to them, and these "young" enterprises would also benefit from the lower transaction costs in the domestic markets. In this way industrialisation is encouraged by protecting local firms from import competition.

Although a wave of economic liberalisation has swept across most African LDCs, there is still strong sympathy for infant industry protection. It is argued that both African LDCs and advanced economies use national protective policies to give an impetus to local enterprises to grow. Thus, it becomes more a question of the degree to which trade restrictions are applied and not a case where African LDCs have to be forced to abandon infant industry protection completely. Accompanying these protective policies are the laws that regulate foreign investment. These laws favour co-operation between foreign investors and domestic partners and sometimes prevent foreign investors from engaging in economic activities without the participation of local partners.

The instrument generally used to implement infant industry protection is the import substitution strategy, using tariffs, quota's, subsidies and cheap credit to protect and encourage domestic industrial enterprises. Import substitution strategies constitute one of the foremost mechanisms used in African LDCs to promote growth of local industries. Import substitution offers across-the-board protection to local enterprises. Faced with diminishing resources and the need to conserve foreign exchange, African LDCs are urged to either substitute locally produced inputs for imported ones or to locally manufacture imported goods. During the early decades of independence in the early 1960s, governments in African LDCs instituted the import substituting industrial development programmes in order to facilitate industrial and economic development. However, presently this development strategy is being abandoned in favour of open market trade policies because the anticipated growth did not take place.

### *2.3.2 Export Orientation*

Export orientation is the dominant current perspective on industrial development (Collier and Gunning, 1999a; Garnaut, *et al.*, 1995; Helleiner, 1995; Linnemann, *et al.*, 1987; Lall and Wangwe, 1998; Sangwan, 1993; Thirlwall, 1999; Weiss, 1988). Export orientation is seen as providing the necessary impetus to growth of local enterprises. The comparative advantage of African and other LDCs lies in the cheap labour and raw materials that are available in these countries. By exploiting these cheap resources, enterprises in these countries can maximise comparative advantage on the world market. Enterprises involved in export activity can also benefit from other externalities, such as the interaction with foreign firms leading to the deepening of their technological learning.

The literature on firms in African LDCs is generally silent on the need for improvement efforts at firm level. Even if we admit the importance of external policy influences, firms in African LDCs should be taking steps to improve their own performance. Policies alone can not bring about sustained improvements in their performance.

For example, infant industry protection as a mechanism to foster growth and learning generally overlooks fundamental behavioural characteristics of enterprises. Enterprises are generally very sensitive to competition in making decisions to invest in the development of various capabilities. Under a regime of protection, enterprises have no incentives to develop competitive knowledge and skills and will tend to make insufficient efforts and investments to deepen their capabilities.

The other thing about protection is that it isolates enterprises from potential sources of learning, because enterprises do not generally learn on their own. As a firm develops its capabilities, it draws upon other firms and markets. Offering protection without taking these factors (i.e. the fundamental behaviour of enterprises and the requirements of learning processes) into consideration may simply lead to the creation of "young" enterprises that are perpetually "young" because the development of their capabilities remains both narrow and shallow.

It should be noted that liberalisation has so far also not produced the expected positive impacts on performance of firms in African LDCs (It has, however, had positive influences in South-East Asia, China and India.). Manufacturing enterprises have not performed well, despite the policy reforms that are being undertaken. During the 1990s, most African LDCs experienced substantial liberalisation leading to a decrease in government intervention or even a complete scrapping of controls. During that time, the proportion of enterprises experiencing competition as a major obstacle to their growth rose sharply despite the fact that reduction of controls made importation of inputs and spares easier. In Zimbabwe, for example, by 1995 the percentage of enterprises that regarded competition as a major problem to growth in performance rose from 5 to 37 percent per year (Biggs and Srivastava, 1996; Gunning and Oostendorp, 1996). Similar experiences are observed in Cameroon, Kenya and Zambia (Biggs and Srivastava, 1996; Navaretti *et al.*, 1996; Ministry of Commerce, Trade and Industry, 1998).

This is in sharp contrast with the picture that existed before the adoption of open-market policies. During the period of trade restrictions, firms operating under trade restrictions rated competition from imports and from local competitors as an insignificant problem to their operations. In these situations licensing and foreign exchange controls were seen by firms as major constraints to their growth, instead.

After almost a decade of free market policies, a new perspective on industrial development inspired by the adverse impacts of liberalisation, is emerging. The open-door trade policies adopted by most African LDCs under structural adjustment programmes are increasingly being challenged by local enterprises. Local enterprises have been unable to respond adequately to the exposure to international competition resulting from market liberalisation policies. Local enterprises argue that it is an active open-door trade policy that is likely to lead to an industrial as well as export growth rate instead of a passive open-door trade policy.

Under a structural adjustment programme, a country pursues macroeconomic reforms and adjustment reforms. The macro-economic reforms aim to achieve internal and external balances through adjustment measures such as exchange-rate adjustment, tight control of government expenditure and withdrawal of government from resource allocation. The adjustment reforms aim at improving the allocation of resources by getting the factor price signals right and creating an environment that allows economic activities to respond to such signals in ways that increase the returns to investment. Under a passive open-door trade policy, the domestic market is assumed to be efficient in regulating itself and attaining optimality. The role of government is simply to provide a social infrastructure. But under an active open-door trade policy, enterprises would like to see the government assisting firms to improve their capacities or support human capital development for firms to become efficient.

So far, manufacturing enterprises in African economies that have liberalised their economies show little sign of broad-based responses to the new regime of incentives that include reforms like the removal of quantitative restrictions on imports and the lowering of tariffs, the removal of price controls and subsidies. In the liberalised economies of African LDCs, in the industrial sectors where growth has taken place, the values of output in these sectors remain extremely small with almost no diversification of manufactured products taking place. There is an inability of local enterprises to compete even in their domestic markets.

In view of the above, an alternative approach to performance improvement in firms in these countries is proposed. This approach stresses improvement efforts at firm level, while recognizing the importance of external influences. In this approach we show that the structural factors identified in the advanced country literature on production improvement, when adjusted to the specific conditions facing firms in African LDCs, are relevant to efforts to improve performance in firms in these countries. In addition, some other factors specific to firms in African LDCs are added.

*(1) Adjusted Innovation and Access to New Technology*

Technological process innovations require the support of a well-established infrastructure, both capital and human. They may prove difficult to achieve in African LDCs. As discussed earlier on, in its pure form, technological innovations involve major expenditures of funds and involvement of specialised staff. These requirements may not be met in most African LDCs, given the fact that the economies of these countries are characterised by poor infrastructure and scarce domestic capital.

Since incremental innovation is less risky, has lower financial and personnel requirements, this approach is more suitable for firms in African LDCs. Incremental innovations consist of adjustments in procedures and materials, slight variations in the manufacturing process, product redesign for easier production, and use of fewer components. The major requirement of the incremental approach is for firms in African LDCs to develop a great deal of their workers' expertise, particularly at low levels. Additionally, by exploiting their own assets (i.e. cheap resources in combination with a well-trained labour force), firms in African and other LDCs can effectively compete with firms in advanced economies.

*(2) Adjusted Links with Knowledge Institutions and Best-in-class Firms*

Knowledge institutions in African LDCs are often geared towards general areas of expertise that are generally more relevant to a sector or an industry than to a firm. Strong links between firms and knowledge institutions are, therefore, almost non-existent. Links with knowledge institutions and best-in-class firms at regional and international levels where there is already a wealth of knowledge and experience, offer better potential for obtaining additional knowledge, expertise, and access to valuable benchmarks and to an exchange of best practices that can not be not generated locally.

*(3) Adjusted Investment in Physical Capital*

Since technology is generally developed in advanced economies, firms in African LDCs should invest in a well-designed and proven production processes characterised by simplicity and reliability of the technology of the plant operations. This is to help compensate for the lack of necessary industrial and maintenance experience that is characteristic of the large majority of the work force in firms in African LDCs.

*(4) The Adjusted Effectiveness of Industrial Management Systems*

Firms in African LDCs can benefit greatly by implementing quality control in their production processes, even in simple production operations. Improvement approaches, for example, based on the variants of the Deming wheel and management systems such as JIT and TQM, adjusted to a firm-specific situation, give a firm implementing them possibilities of improving operating performance of their production plants.

*(5) Adjusted Human Resource Development*

An approach to human resource development that seeks to elicit commitment and to develop resourceful workers for firms in African LDCs is favoured. In this context, company management will strive to create an atmosphere of mutual trust, to engender true team working, to develop skills and capabilities, to coach and motivate their employees. Additionally, it will implement a systematic approach to decision making. In disciplinary cases management should base its decisions more on facts than opinions.

The factors above are the structural factors found in the literature on advanced country firms, adapted to the African situation. To these we added some new factors that are specifically relevant to firms in African LDCs. Among these are factors related to management's capacity to influence performance improvement, state of equipment and machinery, levels of skills, worker absenteeism, work attitudes and morale in firms. Management capacity determines 'why' things in a firm are done in certain ways and fosters continuous improvement of performance. We distinguish five driver-elements of management capacity that influence performance improvement. These are:

- (6) inward and outward orientation of management,
- (7) internal communication effort,
- (8) production process improvement effort,
- (9) supply management effort,
- (10) government-industry dialogue effort.

*(6) Inward-outward Orientation of Management*

Competing in the domestic market (to be regarded as an inward orientation of management) provides an opportunity for nurturing improvement efforts. During this period, the firm learns to read and understand well the market segments and specific circumstances to adjust its improvement efforts in order to meet the set achievement goals. An outward orientation of management, on the other hand, is an important condition for a firm to enter into the regional and international export markets. The outward orientation of management helps build alliances with the outside world that are used for supplies sourcing, investment attraction, and obtaining foreign collaborators and technical assistance. The competencies gained during domestic competition are then built upon as the firm ventures either in the regional or international export markets (see Wangwe, 1995).

To maintain their presence in the regional and international markets, these firms will have to start adopting more complex technologies or undertaking more demanding activities such as design and development that will eventually lead to improvement of performance. Such mastery and use of more complex and demanding technologies, and even of relatively less sophisticated equipment, require the firms in question to invest in skills, technical information, organisational methods and external linkages.

*(7) Internal Communication Effort*

This effort aims at breaking down functional isolation within a firm, 'delayering' the organisation structure, reducing overlapping of responsibilities, facilitating information flows, and strengthening vertical and lateral internal lines of communication. All this is aimed at reducing the internal constraints to the adoption of performance improvement techniques. In some cases since investment in language literacy may not be a viable option in an African LDC setting, the use of a local language on the shop floor may provide a medium for effective lateral communication. Provided that the layers of transmission are limited, informal communication for company policy deployment through oral communication may prove to be an effective method as opposed to the normally formalised way of communication through newsletters and memos employed in the more industrialised nations. Improving communication with and involving labour unions in the communication process is a valuable way to industrial harmony.

*(8) Production Process Improvement Effort*

Management effort for process improvement revolves around improving the effectiveness of production scheduling and resource management, the control of quality and maintenance, and introducing new production methods and technologies (with possibilities of using simple and viable labour-intensive methods) into the existing production system. In the introduction of these new production management techniques and new technologies, a distinction is to be drawn between their application as stand alone changes and as part of an integrated production system. It is in the latter that the application of these techniques and technologies creates a new form of competitive behaviour in the firm. In the former case, where application may just be limited to a sub-process, the resulting improvement is not very great.

This effort to improve production processes also involve what may be referred to as ‘technology fitting’ to deal with problems that arise in a plant as a result, on the one hand, of using technologies developed in various parts of the developed world and sourced from different suppliers, and on the other hand of using overstretched/near-obsolete technology in combination with relatively modern technology. It is not uncommon in African LDCs to find near-obsolete operations feeding into modern operations in the same plant or for a firm to be forced to use more labour-intensive technologies, at times, at the risk of compromising quality. The term ‘new’ in the phrase ‘new production management techniques and new technologies’ is used here with respect to a firm’s point of view. This is because what may be considered a new technique in one firm may be considered a common feature in another firm.

*(9) Supply Management Effort*

This refers to the identification of domestic potential suppliers, the development of a supply base (of independent suppliers) weighed against the benefits of vertical integration, and the strengthening of working relationships with overseas suppliers. Given the generally weak supplier infrastructure in African LDCs, a company is required to work closely with local suppliers and get involved in assisting them upgrading their performance, identifying and rectifying problems in their production processes. Reliable and quality deliveries facilitate low holdings of incoming stocks and reduce production disruptions. But, unless other firms in the chain of production are also making the same transition in their production organisation, the lower holding of incoming stocks of one firm may simply mean the transfer of these stocks to the final goods warehouses of its suppliers.

*(10) Government-Industry Dialogue Effort*

In many African LDCs, the national structural conditions are either weak or unfavourable so that improvement in internal operations of the firm may not yield performance outcomes

approaching those of leading edge performers. Management, through national industry and trade associations, needs to identify and develop a clear and effective platform of co-operation with the country's government to gain government's will and eventually lead to an improvement in national technical and economic settings.
A schematic presentation that summarises internal factors and external influences that may act as stimuli to the improvement process of a firm's performance is presented in Figure 2-1.

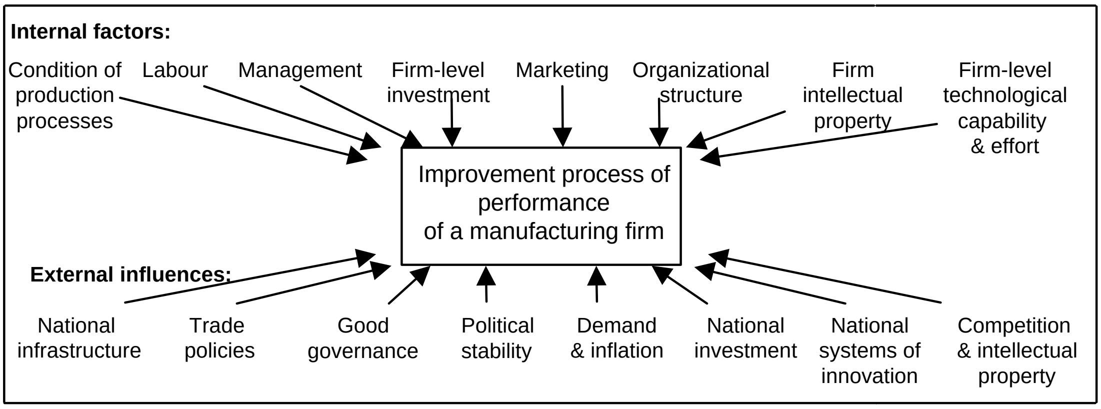


**Figure 2-1: Internal factors and external influences on firm's performance**

The internal factors are elements that are within the control of an enterprise, while external influences are sectoral and national circumstances. It is also assumed that most external influences by their nature will generally evolve over a longer time horizon than internal factors. Some external influences such as the macro-economic environment, trade policies and the supply structure in LDCs can, however, change even at very short notice. Sometimes economic policy reforms are initiated from outside (i.e. the reforms may be IMF and World Bank-inspired). This may result in an abrupt change to the existing economic structure. In other instances, reforms may be a spontaneous government response to popular demand to meet short-term interests of domestic companies. Frequently such reforms do not take the socio-economic realities of the country into account. They may even erode the long-term growth potential of the economy. In both situations, reforms may result in almost overnight changes in the structure of competition.

A synthesis of internal factors and external influences can be represented by a three-tiered pyramid of factors consisting of national, sectoral and firm levels. Thus performance improvements can be studied at three levels. At the national level, the major factors constraining performance are national infrastructure, macro-economic policies, and the role of the state. At the sectoral level, the performance of enterprises is affected by the structure of the industrial sector in the following ways: through the degree of competition, the regional structure of production, the structure of ownership, and the service and intermediate input supply arrangements. In addition, intersectoral relations have a significant influence on enterprise performance. Thus, in Zambia, developments in copper mining have had a great impact on the development of manufacturing as a whole and on the performance of individual firms.

In this study, the focus is on improvements at firm level with a view to relating the improvement process at firm level to the higher levels of influence, the sectoral and national levels. The external influences partly consist of sectoral factors, partly of macro-economic factors which differently impact on firms (including factors such as location, and differences in physical access to markets).

The literature on production frontier analysis (Coelli, *et al.,* 1999; Färe, *et al.*, 1985 and 1994; Farrell, 1957; Lovell, 1993) distinguishes two types of efficiency: technical efficiency and allocative efficiency. Technical efficiency (or X-inefficiency) identifies firm-specific factors, such as firm size, age and education of the manager, etc. A firm operating below the frontier can increase its output to the maximum output attainable with the current state of technology in the industry by becoming technically efficient, and without requiring more input (e.g. labour or capital). Allocative efficiency identifies market characteristics. Allocative efficiency in input selection involves the selection of inputs given their prevailing prices and a behavioural assumption (i.e. cost minimisation or profit maximisation). From a productivity perspective, technical efficiency is the more interesting concept, because it measures the output which can be obtained with a chosen set of factor inputs.

## 2.4 Conclusion

The debate on the impact of structural adjustment and reforms of industrial and trade policies on firm-level performance in African and other LDCs has been going on for about a decade now. A view that is gaining growing acceptance is that structural reforms have a positive and significant effect on growth when they are broadly based instead of being narrowly applied (Ghura and Hadjimichael, 1996). But the question that still remains is how to change the slow response of enterprises to either full or partial reforms in the economies of African LDCs. Across many African LDCs where these reforms have been applied, improvement in the performance of enterprises is still limited.

This can be explained by the fact that for a long time now, much of the industrial sector in African LDCs relied entirely upon the control regimes. State subsidies and protection were important in increasing manufacturing output. At the same time, the control regimes imposed extra costs and burdens on the majority of economic activities while supporting, protecting and subsidising the favoured manufacturing sectors (Bates, 1981).

Evidence in most African LDCs shows that economic liberalization coincides with a sharp decline in manufacturing output (Collier and Gunning, 1999a). In Nigeria and Zambia, manufacturing output declined by almost one third as government protection and subsidies were reduced and removed respectively. This has rendered the current economic liberalizations in many African LDCs less credible (Collier and Gunning, 1999a) and consequently some of the government interventions in labour markets, financial markets or product markets have tended to persist or to be reimposed, usually as a result of government response to requests from its favoured industrial sectors.

The weak or sometimes even non-existent production improvement by enterprises in response to economic liberalization suggests the following. The first thing is that the period of control regimes in African LDCs has left enterprises there with underdeveloped capabilities that have been too weak to take up the opportunities of economic liberalisation. Although these enterprises are likely to gradually improve their performance in the long term, many of them have started from an extremely low capacity base.

Furthermore, in line with the observations made during this research project, in the long run, the increased competition provided by the entry of new enterprises into the domestic market and the entry of local enterprises into regional and international markets can be expected to lower manufacturing costs. In the short run, however, many enterprises are likely to face problems as they adjust to the new economic realities.

The other contributing factor is the weak national and sectoral infrastructure. For example, the current wave of reforms that has swept Africa has essentially been limited to exchange rate and trade policies leaving out infrastructural and institutional reforms that could allow enough reforms to take place at a micro-economic level. This, therefore, suggests that a mixed approach to improve performance in firms in African LDCs is desired, contrary to the literature that emphasises trade and exchange rate policies alone.

It is also worth mentioning the disagreement that exists in the production management and organisation literature (Al-Ghailani and Moor, 1995; Deihl, 1987; Ebrahimpour and Schonberger, 1984; Mersha, 1997) concerning the possibility of applying some of the management techniques that have been developed in advanced economies to manufacturing firms in LDCs. Some contributors indicate that the level of organisational performance and the lack of knowledge about what is going on in the production processes in LDCs make it difficult to assess the benefits of introducing the organisational changes, that are the main components of these management techniques. By contrast, other contributors suggest that the lack of rigidity of organisational structures in LDC firms, might have some advantages. It makes it easier to apply some of the organisational principals that have led to improvements in productivity and quality, in manufacturing firms in the developed world. Each of the above views has some strength, but an application of any of these systems would require an adjustment of the systems to be implemented regarding the firm’s internal environment and external environment.

Dunning (1970) suggests that the missing elements that are important in the development process of LDCs are the acquisition of knowledge, research and development techniques, marketing and managerial skills, and production technology (Denison, 1967; Pack, 1987; Pack and Paxson, 2001). The basic implication that arises from the above is that firms in African and other LDCs should learn the missing elements and, by adaptation, make them function in their own environment of extremely limited resources and relatively knowledge-poor and technically-dependent production structures. As will be shown in chapter 6, it is still possible for a firm in a highly constraining environment to achieve performance improvement.

In sum, given the external circumstances that should be improved through policies, the internal circumstances of a firm are the key factors for the improvement of manufacturing performance. The approach of combining internal and external efforts to improve performance, which is the basis of this study, is discussed in detail in the next chapter where the research model is developed.

# 3 Methodologies for Sectoral and Firm-level Analysis

## 3.1 Introduction

In this chapter, a detailed discussion is presented of the analytical methods used to study the process of performance improvement at firm and sectoral levels. These methods are the growth accounting approach, the industry-of-origin approach to international comparisons, and a conceptual model for performance improvement at firm level. As the conceptual model is the most novel part of this study, it will receive the most emphasis in the discussion.

## 3.2 Growth Accounting Framework for Sector Performance Analysis

The growth accounting approach is specifically used to examine the sector performance and to explain the sources of growth. In this framework, the growth in manufacturing GDP can be viewed as a function of the growth in the volume of factor inputs and of the efficiency with which the factor inputs are used. These are labour and capital. The efficiency with which the factor inputs are used is typically reflected in the changes in total factor productivity (TFP).

The growth accounting framework of the form given below (Solow, 1957; Ghura, 1997; Timmer, 2000) is used to study growth and productivity levels in Zambian manufacturing.

We assume the existence of a differential production function that relates manufacturing gross value added *(Y)* to the primary inputs of labour *(L)* and capital *(K)* and a parameter *(A)* that accounts for all other factors (for example, technological change). It is also assumed that, due to technological change, the shifts in the production function are neutral (Hicks) in the sense that they affect the level of output and not the marginal rates of substitution between inputs.

Given the above assumptions, the production function can be written as, at time t,

$$Y_t = A_t f(K, L)_t \qquad (3.1)$$

The growth in output not accounted for by increases in the factors of production, that is by the total factor productivity (TFP) growth for an homogeneous translog production function is mathematically defined as

$$\ln\frac{A_{t+1}}{A_t} = \ln\frac{Y_{t+1}}{Y_t} - \bar{g}_{t+1}\ln\frac{L_{t+1}}{L_t} - (1-\bar{g}_{t+1})\ln\frac{K_{t+1}}{K_t} \qquad (3.2)$$

where

$$\bar{g}_{t+1} = \frac{g_t + g_{t+1}}{2}$$

and

$\gamma_t$ , $\gamma_{t+1}$ are the shares of total labour cost in output at times t and t+1 , respectively. They capture the partial elasticity of output at a given time with respect to growth in labour and are assumed to approximate the elasticity by labour factor.

Equation (3.2) assumes constant returns to scale, a market situation of perfect competition and profit maximisation. That is where the production factors are paid their marginal product. We have used the Tornqvist index (Diewert, 1976) in equation (3.2) because of its suitability in aggregation of different inputs and due to the fact that it uses changing factor shares instead of constant shares. Changing factor shares is a typical phenomenon in growing developing countries. In order to determine the rates of growth of the TFP (equation 3.2), we require the estimates of capital share [i.e. $(1-g_{t+1})$] and labour share [i.e. $(g_{t+1})$], the rates of growth of manufacturing GDP *(Y)*, capital *(K)* and labour *(L)*.

## 3.3 Industry-of-origin Approach to International Comparisons

### *3.3.1 Introduction*

An analysis of the growth of manufacturing in any country is of greater interest when it can be placed into a comparative perspective. This section aims at presenting a systematic description of the methodology used to explain Zambia's long run comparative productivity performance with the USA. A comparison of changes in Zambian manufacturing performance with those in the US manufacturing is intended to provide such perspective.

It may be asked, however, why it is of interest to compare Zambian manufacturing with the US which is clearly so far away at the frontier of international best practice. The USA was chosen as the denominator because it is the world's most technologically advanced industrial economy and most International Comparisons of Output and Productivity (ICOP) studies have used the USA as benchmark country, thereby, allowing direct comparison of Zambian manufacturing to a large number of developing and more developed manufacturing sectors in different parts of the world, like Chinese, South Korean, Tanzanian, or German manufacturing.

The methodology allows an examination of the relative levels of real output, capital per worker, education per worker, and levels of real productivity. Furthermore, it permits an analysis of the sources of growth over time in each of the two countries, and a corresponding analysis of the sources of difference in their productivity levels.

Benchmark comparisons of productivity levels are based on census data. Census data are most suited for this kind of study because they provide manufacturing output and gross value added data by branch together with their respective labour and capital data. This ensures that consistency is obtained between inputs and outputs. The methodology also highlights the conceptual difficulties that go with this kind of study (i.e. differences in the definition and scope of statistical series), and establishment of a suitable converter that allows the two sectors' outputs to be expressed in a common currency.

There are two major challenges that face international comparisons. Firstly, they require adequate conversion factors to express the value of each country's output (i.e. gross output or value added) in the currency of the other country. Secondly, the use of consistent sources and the application of consistent concepts in obtaining the basic figures for employment and output is an important challenge. Comparisons at the official exchange rate do not necessarily reflect the purchasing power parities of the currencies involved and may considerably underestimate the levels of national income and product of these countries. Exchange rates fluctuate tremendously from year to year. They are highly sensitive to the national policy measures and to the capital flows. In addition to the above, exchange rates, by and large, reflect the purchasing power of currencies in terms of internationally traded goods and services, neglecting non-tradables.

Purchasing power parities (PPPs) are more realistic converters than exchange rates. There are two main approaches to the derivation of purchasing power parities - the expenditure and the industry-of-origin approaches. In the expenditure approach, a common set of international expenditure price weights is used to price a standard set of final goods and services in different countries in the comparison of economic welfare. The expenditure based PPPs are, therefore, useful for the analysis of macro-economic performance and the comparison of standards of living between two or more countries. Expenditure based PPPs are, however, not suitable for sectoral analysis of an economy because they refer only to final goods and services, irrespective of the sectoral content of these final goods and services (Szirmai and Pilat, 1990; Timmer, 1998). For example, branches producing intermediate products like basic metals and textiles will not be covered by these final product PPPs. Expenditure based PPPs also include indirect taxes, transport and trade margins and the prices of imported goods, while excluding the prices of exported goods. Timmer (1998), in his benchmark study of Taiwan manufacturing, observes that there is a huge potential bias of the conversion factor when expenditure PPPs are employed. Alongside this, expenditure PPPs are less suitable to a comparative study involving a developing country because they are principally based on goods produced in advanced economies (Timmer, 1998).

The industry-of-origin approach, on the other hand, uses the output value at producer prices together with output quantities in order to derive unit value ratios (UVRs). Output quantities are then priced at common sets of unit values in order to make real output comparisons between countries (Maddison and van Ark, 1988; Szirmai and Pilat, 1990; van Ark, 1993). The industry-of-origin UVRs are, therefore, preferred to the expenditure based PPPs for the purpose of comparisons by branch of manufacturing sectors of an economy. The industry-of-origin UVRs are closer in definition to producer prices and allow the estimation of productivity ratios in industries producing relatively many semi-finished products and relatively homogeneous goods. This study, therefore, adopts an industry-of-origin approach to estimating relative productivity levels between Zambia and the USA.

The industry-of-origin UVRs calculations do not, in general adjust for differences in the average quality of products in Zambia and the USA. The industry-of-origin UVRs are calculated for fairly detailed product specifications for the USA such as quantity of sausage products but, in general, cannot distinguish both quality variations and sausage types in the Zambian products. A high quality of manufactured products in the USA relative to those in Zambia would impart an upward bias in relative prices and hence imply a higher productivity gap than that obtained in the study.

The next section discusses the International Comparisons of Output and Productivity Project (ICOP) methodology, as applied to the 1990 benchmark comparison between Zambia and the USA.

### *3.3.2 Methodology for the 1990 Level Comparison*

The methodology used in this study has been described in several publications of the ICOP project (see van Ark, 1993; Maddison and van Ark, 1988, 1994; Szirmai and Pilat, 1990; and Timmer, 1996). Here, only a brief outline of methods used is provided.

The primary sources used for this study are the *US 1987 Census of Manufactures*, the *US 1990 Annual Survey of Manufactures*, the *1990 Zambian Census of Industrial Production* and the unpublished data files underlying the *1990 Zambian Quarterly Returns of Industrial Production.* These sources provide information on product quantities and corresponding gross output values, making it possible to derive unit values for products or product groups for sectors of manufacturing for both economies.

The basic approach is to make matches of comparable products or groups of products from the two censuses and to calculate unit value ratios for each of the matches. The matches of broadly defined products are made in sample industries. These sample industries are made out of comparable industries selected from the US census and the Zambian quarterly returns. For Zambia, the information on commodity quantity and output value for the 1990 Zambian Quarterly Returns of Industrial Production is only available in unpublished form. This information was rearranged into one or more ISIC four-digit industries (1968 version, see UN, 1968) and combined with one or more ISIC four-digit industries from the US census (1990 version, see UN, 1990).

The unit values are used to calculate UVRs in a number of steps. The basic assumption is that the UVRs found for the matched sample industries equal UVRs for the entire industry.

(a) The initial unit value ratios for commodity matches combine 1990 Zambian unit values with 1987 US unit values because no census data are available for 1990 for the USA.

(b) In order to put the resulting UVRs on a 1990 basis, the US 1987-1990 price movements for each product group (US Bureau of Labour Statistics, 1998) are used for each product group. The 1990/1990 unit value ratios then obtained are used in subsequent calculations.

(c) The unit value ratios for comparable products in the two countries are aggregated into UVRs at sample industry level using the output quantities of each country as weights.

$$UVR_j^{XU(X)} = \frac{\sum_{i=1}^{s}(Q_{ij}^{X} * P_{ij}^{X})}{\sum_{i=1}^{s}(Q_{ij}^{X} * P_{ij}^{U})} \qquad UVR_j^{XU(U)} = \frac{\sum_{i=1}^{s}(Q_{ij}^{U} * P_{ij}^{X})}{\sum_{i=1}^{s}(Q_{ij}^{U} * P_{ij}^{U})} \qquad (3.3)$$

where

$UVR_j^{XU(X)}$ is the unit value ratios of the Zambian Kwacha against the US dollar in sample industry j, at quantity weights for Zambia;

$UVR_j^{XU(U)}$ is the unit value ratios of the Zambian Kwacha against the US dollar in sample industry j, at quantity weights for the USA;

$P_{ij}$ is the price of item i in sample industry j;

$Q_{ij}$ is the quantity of item i in sample industry j;

*i=1........s* is the sample of matched items.

(d) The sample industry UVRs are aggregated at manufacturing branch level (as in food manufacturing) by taking their weighted average, using the 1990 gross output values as weights.[1]

[1] The reliability of the estimated branch UVRs is affected by the extent of coverage of the products and the degree of variability of unit value ratios within a given sample industry. There are, however, instances of low sample industry coverage and high variance of price relatives that create biases and variance in the estimation of the indices. Should the reliability of the UVR (defined as the ratio of its standard deviation and its mean)

$$UVR_k^{XU(X)} = \frac{\sum_{j=1}^{o} GO_j^{X(X)}}{\sum_{j=1}^{o} [GO_j^{X(X)} / UVR_j^{XU(X)}]} \qquad UVR_k^{XU(U)} = \frac{\sum_{j=1}^{o} [GO_j^{U(U)} * UVR_j^{XU(U)}]}{\sum_{j=1}^{o} GO_j^{U(U)}} \quad (3.4)$$

where

| | |
|---|---|
| $GO_j^{X(X)}$ | is gross output value in Zambian sample industry j in Zambian Kwacha; |
| $GO_j^{U(U)}$ | is gross output value in US sample industry j in dollars; |
| *k* | is a branch of industry; |
| *j=1.....o* | represents the sample industries belonging to branch |

In this study, manufacturing branches consist of one or more ISIC three-digit major sectors. In three instances – i.e. wood products, paper products and non-metallic mineral products – a branch coincides with a two-digit ISIC division.

(e) The UVR for total manufacturing can be calculated as a weighted average of the branch UVRs using branch gross output weights according to equation (3.4).

Throughout all these steps the weighting procedures ensure that unit value ratios in large sample industries and branches receive heavier weights than those in small ones (van Ark, 1993).

(f) At each level of aggregation, say sample industry, branch or total manufacturing, the UVRs derived can be used to transform value added into the currency of the other country in order to calculate the real value added relatives. So far, the real output ratios obtained refer to the gross value of the output. In theory, it would be preferable to calculate UVRs for both inputs and outputs, thus achieving double deflated value added in international comparisons. In practice, detailed information on quantities and values of inputs is seldom available. Therefore, ICOP studies have generally applied output UVRs to value added. This study also follows that procedure.

In binary comparisons, one gets two UVRs at every level of aggregation, one at quantity weights of country A, the other at quantity weights of country B. In the case of the Zambia/USA comparison, it is clear that the two UVRs will differ substantially as the production structures are very different. We use the Fisher geometric average of the two UVRs as a summary measure.

This benchmark analysis is subsequently integrated with the real labour productivity and total factor productivity time series for the manufacturing sectors of both countries to allow interspacial productivity performance comparisons from 1964 to 1998 as well. This is achieved by extrapolating with national accounts time series of gross value added, the number of persons engaged and capital stock.

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for a given sample industry be too low, we use – following Timmer (1996) – the summed gross value of output of the matched items within the sample industry as the sample industry weight in equation (3.4), rather than the sample industry's gross output.

## 3.4 Firm-level Research Model

### 3.4.1 Introduction

This section gives detailed discussion of the concept of production function in order to derive a relationship of the gross output of a firm to the production inputs and the external influences that describe the production environment within which the firm operates. The production inputs considered are the two primary inputs (i.e. labour and capital) and intermediate inputs (for example, raw materials, energy, semi-fabricated parts, etc.). External influences refer to distinct country- and industry-situational characteristics (i.e. national infrastructure, real GDP growth rate, etc.).

Production functions can be used both at sectoral and firm levels. The first variant of the production function uses aggregate data at sectoral level or above to specify the relative contributions of output per unit of input and expansion of factor supplies to economic growth. The second variant uses individual firm data to generate, for instance, cost functions and input demand schedules for a firm (Humphrey, 1997; Oulton, 1997). The important difference between the two variants is in the level of data aggregation.

This study employs both variants and relates them in the analysis of performance improvement in manufacturing firms in LDCs. The theoretical model underlying the firm-level analysis is an extension of the Cobb-Douglas production function (Cobb and Douglas, 1928). In this model the gross output of a firm is produced from skill-adjusted labour, physical capital and intermediate inputs in the presence of particular external influences.

The model is used to identify and analyze say, the contribution of the different elements of the production process (i.e. labour input, skill accumulation and investment efforts, etc.) and elements of the external influences (i.e. specific-country infrastructure, export and import growth rate, industrial competition, etc.) to the growth of the performance in these firms (Yamfwa and de Ron, 1999). We have assumed the existence of a differential production function relating manufacturing output to the inputs of the firm and external influences.

A production process is defined as the way in which resources (inputs) of a firm are transformed into outputs. These outputs will usually be multiple and may also assume a variety of forms. In the case of a manufacturing firm, the output (or qualified production volume) is limited to products and excludes services.

The external influences refer to sectoral and national circumstances that may generally contribute to a stimulating environment.

The above are illustrated in a conceptual model in figure 3-1.

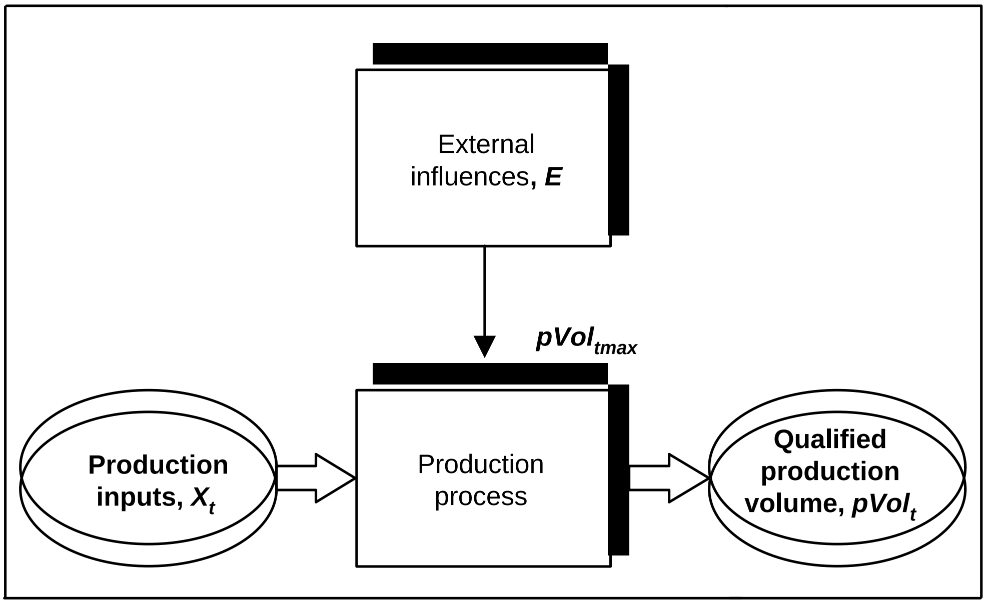


**Figure 3-1: Conceptual model**

Two types of influences can be distinguished in figure 3-1. The external influences on the production process and the influence of production inputs in the production of qualified production volume.

## 3.4.2 External Influences

It is worth mentioning that previous research studies in developing countries have pointed out the need to take account of situational factors when studying performance of manufacturing firms in these countries (Chen and Lu, 1998; Fleury, 1995; Kaplinsky, 1995; Kolay and Sahu, 1995; de Macedo-Soares and Lucas, 1995; Msimangira, 1993; Shaiken, 1991; Sharif, 1997).

Austin (1990) grouped these situational factors into four categories, namely economic, cultural, political and demographic influences. Aswicahyono (1998) divided the situational factors into three sub-groups and classified them as factor endowments (such as the national factor supplies), the initial conditions, and the set of national policies and institutional factors. De Valk (1992) in his study of the performance of textile enterprises in LDCs distinguishes four levels of factors that influence the performance of the textile industry. These are the international, macro, meso and micro levels. Micro-level factors include structural and behavioral characteristics of individual firms, such as management capability, ownership structure, technological capability, demand and location with regard to supply of inputs. At meso level, factors like marketing arrangements, regional structure of production and demand are considered as influencing performance. At the macro and international levels, the study identifies macro-economic policies and constraints, the role of government, development in technology and trade, international institutions and policies of other countries, with the government's role regarded as one of the most important factors (also see Enos and Park, 1988).

Based on the above mentioned literature, we use the following classification of external influences:

(1) public infrastructure;
(2) industry structure and concentration;

(3) foreign trade;
(4) growth of demand;
(5) and sectoral dynamics.

These national-sector variables have been selected on the basis of what the current knowledge suggests as being the most important variables and on the basis of quantifiability. A discussion of these variables is given below.

### Public Infrastructure

In recent years a lot of studies have been directed at investigating the role of public infrastructure in the economy. While some studies found strong productivity impacts (Aschauer, 1988, 1989; Munnell, 1990; Gracia-Milà and McGuire, 1992), others have found either a small or non-existent effect (Hulten and Schwab, 1991; Gracia-Milà *et al.*, 1996; Holtz-Eakin, 1994; Holtz-Eakin and Schwartz, 1995). Still other studies have suggested that the impact of infrastructure depends upon the type of infrastructure and the sector of economy examined (Meade, 1952; Munnell, 1990).

The level of infrastructure services, particularly transport and export-servicing facilities such as ports, airports and communications, has an impact on the manufacturing output, especially in LDCs. Although evidence on the growth effects of underprovision of infrastructure is still somewhat dispersed, there is evidence that public investment in infrastructure, in Africa for example, has a growth-enhancing effect on industrial output (Biggs and Srivastava, 1996; Easterly and Levine, 1997; Ghura and Hadjimichael, 1996; Oshikoya, 1994). In his 1999 study of barriers to innovation for small and medium enterprises in Cyprus, a small less developed country, Hadjimanolis observed that firms in LDCs have to face the limitations of an inadequate infrastructure and problems of inadequate policy infrastructure. Better infrastructure can attract relocation of firms, stimulate existing firms' demand for inputs and influence their efficiency. In this way, better infrastructure can be considered as an input in the production process that increases production output and enhances productivity to the extent that it produces some useful service flow output. As infrastructure is an intermediate input, low cost and high quality of any form of infrastructure service will tend to improve price competitiveness. Equally, by improving communication, say, between importers and exporters and allowing timely and safe delivery of goods, infrastructure can improve non-price competitiveness. An example of improved infrastructure is that improved transportation infrastructure reduces costs for firms, travel time and congestion of inputs (i.e. such as raw materials). A better infrastructure provides faster, safer and more reliable movement of goods in order to make it possible for more trade to take place and specialisation to occur. The services provided by infrastructure are determined by the stock of the public capital and by several other factors, like how efficiently that existing infrastructure is used, and the suitability of the stock design.

Infrastructure is best measured as the dollar value of the infrastructure stock, more specifically as the present value of the stock using a perpetual inventory method based on annual infrastructure expenditures which is compatible with the discounted investment flow (Boarnet, 1997). Alternative measures for highway infrastructure may include total mileage of paved or all-weather roads in the country. This is a departure from earlier studies in LDCs that have used the telephone system (Easterly and Levine, 1997) as a proxy for general infrastructure. This is because the telephone system alone is not a satisfactory characterization of infrastructure in LDCs. Ghura and Hadjimichael (1996) and Oshikoya (1994) have used expenditure of African government on infrastructure as a proxy of infrastructure. Public expenditure on infrastructure is an indicator of public effort to improve infrastructure in a country. This indicator is used in this study.

The assumption is that the changes in public infrastructure stock will be highly related to public investment in infrastructure. For the period under review, public physical capital stock depreciation is assumed to be negligible.

To specify the operational measure of public effort in infrastructure, the approach used by Dalenberg and Partridge (1997) and Munnell (1990) has been adopted: public infrastructure investment is divided into two components. These are investment in public highways, ($Z_1$), and other investment in public infrastructure excluding highways, ($Z_2$ ). The public infrastructure investment excluding highways, ($Z_2$ ), comprises of items like capital expenditures on educational facilities, water facilities, communication facilities and energy facilities (expressed as a percentage of GDP). By separating highway public investment from other forms of public investment it is possible to investigate whether the different types of public effort impact differently on performance in firms.

For time $t$

$$Z_{1t} = \frac{PE_{1t}}{GDP_t} \qquad (3.5)$$

where
$PE_1$ = public expenditure in highways
$Z_1$ = indicator of public effort to improve highways

$$Z_{2t} = \frac{PE_{2t}}{GDP_t} \qquad (3.6)$$

where
$PE_2$ = public expenditure in education facilities, water facilities, energy facilities and communication facilities
$Z_2$ = indicator of public effort to improve infrastructure excluding highways

### Industry Structure and Concentration

Changes in the structure of industry have two distinct effects on production output. The structural changes trigger demand forces for particular outputs that may raise demand for particular goods and lower the share of others. The other effect is the differential pace of technological advance between sectors. As the industry structure moves from low value-adding activities to high value-adding activities, productivity levels can also grow. Moreover, in industrial sectors with stronger competition, firms have comparatively stronger incentives to innovate. In this way an approximate competitive industry makes it possible to have potential innovation related savings.

Two important statistical indicators are often used as measures of industry structural change. These are the share of different industrial sectors in national income and their share in total employment. The sectoral composition of national income is expressed as a percentage of gross domestic product (GDP), while the distribution of the labour force by sector is expressed as sectoral percentage of the total employment.

The measure of industry structure adopted here is the share of non-farm industries in total employment (Dalenberg and Partridge, 1997; and Maddison, 1987). The one-digit industry employment shares capture the share shift and the effects of inter-industry wage differentials, together with the differences in capital intensity.
Industry structure, however, impacts mainly on aggregate productivity. Industry concentration is, on the other hand, a preferred input to the firm-level production function.

According to the industrial organization theory, managers will not always act to maximise the profit of a firm, nor to minimise cost or to locate on their production possibility frontiers (Aswicahyono, 1998). A high level of competition in an industry would drive firms to the search for efficient allocation. Nelson and Winter (1982) have observed that firms facing a complex economic environment will make a set of 'rules of thumb'. These 'rules of thumb' are either closer to an optimal solution or further away from it. Firms with inefficient 'rules of thumb' would be forced to change their 'rules of thumb' because they would experience losses. In the long run, this search process would lead to efficient allocation (Aswicahyono, 1998; Nelson and Winter, 1982). A stimulus for firms in LDCs to change their previous patterns of production organisation is the new competitive environment in many LDCs that has come about as a result of trade policy reforms and a reduction in protection. Producers that have entered the export markets have found that changes are necessary to achieve a higher level of performance. Similarly in the domestic markets, the new conditions are for firms to achieve higher performance in quality and production costs.

Indexes of concentration often measure the extent to which a small number of firms account for a large proportion of an industry's output, employment, assets, or other variables. There are two major drawbacks to these classes of indexes. The concentration ratios ignore the impact of foreign competition. The small number-firm ratio for an industry could be rising, reflecting increased dominance of the domestic market by that small number of firms. At the same time, this small number of firms could, however, be losing its market share to foreign competition. The net result is that the concentration ratios would rise, while the overall market power of the small number of firms has fallen. In such circumstances, concentration ratios would incorrectly measure changes in the market power of the domestic firms. Concentration ratios can also be criticized for the lack of a summary measure utilising all the points on the concentration curve. Concentration ratios depend on only one point on the concentration curve, such that there are many changes in the position of the curve that leave the indexes unchanged.

One summary measure devised to measure industry concentration, *($Z_3$)*, is the Herfindahl index[2] (Henderson *et al.*, 1995; Dalenberg and Partridge, 1997). $Z_3$ is calculated as the sum of squares of employment shares in percentage for all three-digit sector industries. Employment is used to measure concentration in this study since it appears to be a more comprehensive and reliable data. Investigations elsewhere (Rosenbluth, 1955) also indicate that concentration of employment is highly correlated to concentration of output, although employment concentration tends to be lower than concentration of output.

Industry concentration is given by

$$Z_{3it} = \sum_j \left( \frac{L_i^j}{L_i} \right)_t^2 \qquad (3.7)$$

where

$L$ = employment
$i$ = industry at three-digit ISIC classification
$j$ = number of establishments in the industry
$Z_3$ = Herfindahl index

[2] The Herfindahl index is attributed to Orris C. Herfindahl as a result of his investigations in concentration in the steel industry (See Herfindahl, O.C., *Concentration in the U.S. Steel Industry,* PhD thesis, Columbia University, 1950 for details).

### Foreign Trade

The trade regime of a country has an effect on the growth of output (Dollar, 1992; Sachs and Warner, 1995 and 1997). The main manifestation of trade restriction in LDCs is the control of regional and international trade, either directly through export taxes, quotas and tariffs, or indirectly through foreign exchange controls. Favourable foreign trade regimes offer opportunities for output growth. As more countries in the developing world come together through removal of trade restrictions or through trade partnership, such as COMESA (Common Market for East and Southern Africa) in Africa, greater markets offer opportunities for growth for manufacturing.

The foreign trade regime, that is proxied by foreign trade volume, is measured as the average of export and import annual growth (Maddison, 1987). Import and export activity also creates generic external influences. Firms do not exclusively learn on their own. They draw upon other firms and other markets for the development of their capabilities. Export activity in particular encourages learning-by-doing and offers opportunities for technological deepening because enterprises have more possibilities to access improved technology. International competition offers stimulus to cut costs, improve quality and introduce new products. The export activity, besides creating the need to keep up with technical progress, allows a realisation of economies of scale as well.

$$Z_{4t} = \tfrac{1}{2}[\ln(\frac{e_t}{e_{t-1}}) + \ln(\frac{i_t}{i_{t-1}})] \qquad (3.8)$$

where

$Z_{4t}$ = average growth of total Zambian exports and imports at t
$e$ = export volume at t and t-1
$i$ = import volume at t and t-1

There is an additional justification for using changes in export and import volumes as a measure of foreign trade regime. Foreign exchange has long been established in literature as one of the main factors affecting performance of firms in LDCs. Foreign exchange is used to import spare parts, raw materials and other inputs. So until firms in LDCs can use foreign exchange to import the required intermediate inputs, the availability or non-availability of foreign exchange as a major cause of poor performance does not tell the whole story. Growth of exports and imports rather than foreign exchange per se is, therefore, a preferred indicator of external influence on performance.

### Growth of Demand

The constraint on growth from the perspective of markets is now discussed. The level, variability, and growth in demand all have an important impact on performance. A relatively low level of aggregate demand discourages investment and consequently performance growth (Pratten, 1976). A growing national market has impact on manufacturing output, although previous studies have indicated the difficulties in disentangling the effects of the indicative scale of economies from those of technical progress (Ergas, 1984; Maddison, 1987).

It is not the absolute size of the domestic market that matters, but rather its rate of growth (Lall, 1990; Riddell and Coughlin, 1990). A growing domestic market is correlated with a growing demand for manufactured products, thus having an influence on manufacturing expansion. A region, for example, with a large population with a fairly high level of literacy and with a healthy economic growth provides a big market potential for consumer-oriented manufactured goods.

The average real gross domestic product (GDP) growth [i.e. the percentage change in value terms (constant prices) over the years] is used as a proxy for the growth of demand,

i.e.

$$Z_{5t} = \ln(\frac{GDP_t}{GDP_{t-1}}) \qquad (3.9)$$

where

$Z_{5t}$ = average real GDP growth at time t
$GDP$ = real GDP growth at time t and t-1

**Sectoral Dynamics**

Sectoral dynamics relate to the productivity levels within manufacturing industries and the efficiency with which the factor inputs are used in the sector. A dynamic sector gives possibilities and conditions for growth in firms. Growth in the sector, in turn, takes place in a wider context of development phases in the national economy. In the case of Zambia, after Independence, the sector entered the period of post-colonial growth in output and labour productivity. This was followed by a period of a long-term slowdown in growth. The years 1991 and 1995 are the recent structural turning points in the sectoral dynamics of Zambian manufacturing and they will be used in the analysis of firm level performance to underpin the influence of sectoral dynamics on firm performance. 1991 marks the beginning of the period of adjustment followed by the collapse of Zambian manufacturing. 1995 marks the end of the collapse followed by a recovery (See next chapter). Stagnation of the sector clearly has a negative influence on firm performance. An elaborate discussion of sectoral dynamics is covered in chapters 4 and 5.

Given these external influences, we now proceed to present a systematic procedure to develop the research model in the next sections.

In this respect, the actual model has the following areas of interest. Taking the basic production function as a starting point, the model aims at explaining output growth by growth in labour, capital and intermediate inputs and thereafter by some other external influences. Secondly, the transformation efficiency of the production system in the process of performance improvement, which heavily influences the probability for success of the performance improvement process, is used to map out firm-level improvement efforts. The transformation efficiency can be used to benchmark company's improvement efforts or to compare inter-firm improvement efforts in similar or comparable settings. The production system transformation efficiency is a measure that combines time and quality performance aspects in the improvement process.

### *3.4.3 Firm Level: Transformation of Inputs into Qualified Outputs*

We would like to apply the sectoral function to firms. At sectoral level, industrial growth is accounted for by a whole group of factors (Domar, 1961, pp.709). Abstracting from demand and, thus, assuming that in the long-run supply factors are dominant, growth in industrial output can be viewed as a function of the growth in factor inputs and in the efficiency with which these factor inputs are used.
A rise in production output at aggregate level may, therefore, be conceptually decomposed into that due to greater use of inputs and that reflecting the other unaccounted-for-factors (i.e. productivity gains). Productivity gains here capture improvements in industrial

organization, efficiency, (disembodied) technical progress, economies of scale and other external factors.

From the growth accounting theories, the basic production function may be assumed to be of the form:

$$O = AL^{a} K^{b} \qquad (3.10)$$

or

$$O = AL^{a} K^{b} M^{g} \qquad (3.11)$$

where $O$ = real manufacturing value added or gross output
$L$ = aggregate labour input
$K$ = aggregate capital input
$M$ = intermediate inputs
$A$ = parameter that stands for other factors
$a, b, g$ = elasticities of output with respect to labour, capital and intermediate inputs (with $a+b=1$ or $a+b+\gamma=1$)

From equations (3.10) and (3.11), however, only a very partial explanation of production factors is given, namely labour, capital and intermediate inputs.

Parameter $A$ in equation (3.10) has some unexplained factors that account for the change in manufacturing output, besides labour and capital. Nelson (Nelson, 1981, pp.1035) refers to this as some kind of ‘measure of our ignorance about the causes of economic growth’ (See also Abramovitz, 1956). Maddison (Maddison, 1987, pp.651) also points out that this approach ‘does not explain the elements of policy and circumstances, national or international, that underlie them’. In other words, equation (3.10) does not sufficiently ‘discern broad factors or conditions that foster or hinder a generally stimulating environment’ (Nelson, 1981, pp.1035) for growth of production output.

Factor inputs in equation (3.10) have since been adjusted to include factors like the qualitative improvements in the labour input and quality improvement in successive vintages of capital on the basis that physical investment is the prime vehicle by which technical progress is realised.

To be able to apply the sectoral function to firms we use an extended form of equation (3.10) in order to include external influences in the production function. Such a production function would allow us to capture the influences of internal factors and external factors on the changes in the levels of output of a firm. In terms of econometric estimation, this means that additional variables can be found to enter significantly in the production-function-type regressions to directly or indirectly measure the activity that produces the external effect.
In other words, the changes in output (or qualified production volume) of a firm is affected by variations in the firm’s own-inputs-related variations and to some extent in the variations unrelated to its own-inputs.

An empirical analysis such as this has also two challenges that must be met. The first is to define operational measures of external influences on a firm. The second challenge is to define a justifiable manner in which external influences account for productivity differentials that are not caused by a change in the level of firm’s own-inputs.
At sectoral level the residual term, $A$, accounts for the technological change, the sectoral technical efficiency and a statistical error term. For LDCs in particular, the interpretation of the residual term goes beyond the “pure” measure of technical progress. Some authors (Denison, 1967; Maddison, 1987 and 1991) have tried to break the residual down into various components, including market size, structural change, technology diffusion and

foreign trade. Economic historians and development economists (Abramovitz, 1979, 1986 and 1991) have interpreted the residual as being influenced by technical as well as social capabilities to catch up which may also provide a link to a more political-institutional interpretation. Others (Fagerberg, 1988) have used the TFP measures to link to typical technology gap model, which gives a more explicit role to innovation. At firm level, we consider changes in technology to be negligible, and let the technical efficiency to be equal to the transformation efficiency of the production system.

In any case, the technical efficiency can be identified. The remaining is a mixture of external factors and others (such as the possible interaction effects between the various factors). The transformation efficiency is in turn a function of the firm's internal circumstances and external influences. We discuss the specification of the transformation efficiency in the next section.

### 3.4.4 The Transformation Efficiency

We look at the influence of production inputs by introducing a function that describes the efficiency of the production process of a manufacturing firm. The efficiency level provides an indicator of the effectiveness of production improvement efforts.

Consider a manufacturing firm, in which a qualified gross output, $pVol_t$, is produced with a transformation efficiency of $h_t$ over a certain period of time. This production process can be described by the following equation:

$$pVol_t = h_t * pVol_{t\max} \qquad (3.12)$$

where $pVol_{t\max}$ is the maximum qualified gross output that can be obtained in a given time period from an individual manufacturing technology
$0 \le h_t \le 1$.

$h_t$>1 contains qualified gross output that is unattainable in a given time period under the existing technology. The other property of the transformation efficiency is that the poorest production transformation performance will be close to 0, while the best production transformation performance for the available technology set will be close to 1.

Note that it can be shown that the transformation efficiency *($h_t$)* encapsulates the two variables of the transformation factor *($TF_s$)* (see de Ron for details, 1994, p.11-18), namely the effectiveness of the production system ($e_s$) and the production time efficiency *($r_s$)*. In this way, the transformation efficiency, $h_t$, has the same meaning as the transformation factor, $TF_s$. The effectiveness of the production system in (de Ron, 1994), $e_s$, is defined by the ratio of the average output flow of qualified products and the maximum output flow of qualified products; and the production time efficiency, $r_s$, is defined as the ratio between the average effective production period and the available production time in a unit time period of production under consideration. The unit time period of production under consideration is taken to be a year (or a shorter period depending on the available data), because this time period allows comparative analysis between industries. The available production time, *T*, is a year excluding time intervals for which the production transformation is stopped due to legal regulations, local or industrial conventions. The effective production period, $T_e$, is the time for which the production transformation is being operated to produce goods during the available production time.
Mathematically, for a given production period *T*

$$h_t = \frac{\int_0^T pVol\ (t)dt}{\int_0^T pVol_{\max}(t)dt} \qquad (3.13)$$

This relation is based on the law of conservation of matter applied to a production system (de Ron, 1994). If *m(t)* is the mass (kg) which is accumulated in the production system, $pVol_{m,in}(t)$ the material input flow and $pVol_{m,out}(t)$ the product output flow, both expressed in kg/sec, then

$$\frac{dm(t)}{dt} = pVol_{m,in}(t) - pVol_{m,out}(t) \qquad (3.14)$$

We divide the product flow at the output of the system into a flow of qualified products, $pVol_{m,q}(t)$, and a flow of disqualified products, waste and emissions, $pVol_{m,d}(t)$. In the long run (i.e. by considering a period $T$ long enough that the storage term, *m(t)*, can be neglected), a stable production system can not have any inventory accumulation. The material mass entering the production system equals to the leaving product mass. Therefore,

$$\int_0^T pVol_{m,q}(t)dt = \int_0^T pVol_{m,in}(t)dt - \int_0^T pVol_{m,d}(t)dt \qquad (3.15)$$

On the basis that the actual production of qualified output takes place during the accumulated time units, $T_e$, of considered period $T$, and for a production system where the input flow is transformed completely into products, the transformation of the material of the input flow into qualified products can be rewritten as

$$\int_0^T pVol_{m,q}(t)dt = \int_0^{T_e} pVol_{m,in}(t)dt - \int_0^{T_e} pVol_{m,d}(t)dt \qquad (3.16)$$

$T$ tends to ∞ if $T_e$ tends to ∞ as well because $T_e$ is a fraction of the considered production period. Integrating gives:

$$p\hat{V}ol_{m,q} * T = p\hat{V}ol_{m,q\max} * \hat{T}_e - p\hat{V}ol_{m,d} * \hat{T}_e \qquad (3.17)$$

where $p\hat{V}ol_{m,q\max}$ is the average maximun output flow of qualified products

The superscript ∧ indicates average value defined by

$$p\hat{Vol}_{m,q} = \lim_{T\to\infty}[\frac{1}{T}\int_0^T pVol_{m,q}(t)dt] \qquad (3.18)$$

In practice, the considered production period $T$ is chosen such that the error term is extremely small. If we define the effectiveness of the production system, $e_s$ , as the ratio of the average output flow of qualified products and the average maximum output flow of qualified products and dropping the subscripts *m* and *q* we obtain, for a unit of time, *T*

$$e_s = \frac{p\hat{V}ol_{\max} - p\hat{V}ol_d}{p\hat{V}ol_{\max}} = \frac{p\hat{V}ol}{p\hat{V}ol_{\max}} \qquad (3.19)$$

From the definition of the effectiveness of the production system, it follows that the proportion of disqualified products influences the production system effectiveness, such that the effectiveness can be used as a measure of the quality of the production system.

If we call the ratio between the average effective production period and the considered period the production time efficiency of the system, then

$$r_s = \frac{\hat{T}_e}{T} \qquad (3.20)$$

and

$$h_t = \frac{\int_0^T pVol\ (t)dt}{\int_0^T pVol_{\max}(t)dt} = e_s * \frac{\hat{T}_e}{T}$$

then

$$h_t = e_s * r_s \qquad (3.21)$$

where

$p\hat{V}ol =$ average output flow of qualified products
$p\hat{V}ol_d =$ average output flow of disqualified products
$p\hat{V}ol_{\max} =$ average maximum output flow of qualified products
$\hat{T}_e =$ average effective production period
$T =$ considered period of production, less stopping time intervals due to legal regulations, local or industrial conventions
superscript $\wedge$ indicates average value

The transformation efficiency *($h_t$)*, therefore, represents the non-ideal characteristics of the actual production process with regard to its process performance. $h_t$ is directly related to the activities taking place in the firm.

### *3.4.5 Empirical Model*

#### Introduction

In this section, we use the production function framework to build a model to examine the effects of growth in human capital (*H*), in physical capital per worker (*k*) and intermediate inputs per worker (*m*) given the situational circumstances (*E*) on the growth rate of a firm's qualified gross output per person engaged. The resulting model is built to give an indication of the extent of how effectively resources are used to produce a given qualified gross output given the external influences. The estimation of the model attempts to quantify past performance in order to identify and understand the factors that lead to changes in performance. Rather than simply tracking historical performance, the model can, then, be used to plan for future improvement. Obviously, the knowledge of the current level of performance is necessary as a beginning for any planning effort ultimately leading to performance improvement.

The process of model building involves parameterizing a production function with a set of variables, and making inference about the parameters of the assumed function. To make the model applicable to the notion of system perfomance improvement at firm level and to be able later to use manufacturing branch performance insights in the discussion of case studies' performance, some modifications are made to the initial basic production function [i.e. equation (3.11)]. The first modification is the decomposition into two multiplicative terms of the constant of proportionality, *A*. This allows us to introduce a control variable $\eta$. The variable $\eta$ is the system transformation efficiency and allows interaction between system's output and other variables in the production function. The other modification is the alternative specification of firm's output from mere qualified gross output (*Y* or *pVol*) to qualified gross output per unit labour (*pVol/L*). This allows us to relate sector and branch performance (discussed in chapter 4) to case studies' performance (in chapter 6).
In building the model, we have made additional assumptions. We assume that qualified gross output is a function of multiplicative independent factors *X*. The explicit functional form of the production function is assumed to be non-homothetic and non-neutral in the sense that shifts in the production function affect not only the level of output but also the marginal rates of substitution between inputs.

The assumption of constant returns to scale that is usually imposed in the Cobb-Douglas form is maintained, but changing factor shares are used instead of constant shares. In our proposed specification, then, output is allowed to change positively with the system transformation efficiency to approach zero in the limiting case of no production. Entering system transformation efficiency as a multiplicative variable satisfies this factual requirement. We, therefore, expect qualified gross output per worker to be positively affected by the transformation efficiency and input factors.

Due to lack of sufficient production workers' hours, the labour input has not been adjusted for the rate of its utilization. The approach to the use of the model is the analysis of the production system highlighting points where weaknesses are in the production organization and management, and where bottlenecks are in the production processes.

The last sections of the chapter will discuss the measurement issues and estimation of the model.

### Empirical Specification

We employ a variant of the Cobb-Douglas production function at firm level. The Cobb-Douglas functional form has been employed because of its suitability in empirical analysis and also of its potential use in intra-firm comparison. For a typical production process, the gross output production function is

$$Y_t = A_t \prod_{i=1}^{I} X_{it}^{a_i}$$

or

$$Y_t = A_t X_{1t}^{a_1} X_{2t}^{a_2} .....X_{It}^{a_I} \qquad (3.22)$$

where, at time *t*

*Y*= gross output of the production function
*A*= a residual term and greater than 0
$a_i$= elasticities of output with respect to factor inputs ($\Sigma\alpha_i = 1$)
$X_i$= factor inputs
$i \in \{1,......, I\}$
I= number of factor inputs

We also assume a divisibility of the factor-input quantities $X_i$. Growth in output is viewed as a function of the growth in factors and of the residual term. Demand and external factors accounted for in the residual term influence the growth of inputs as well.

So far, our reflections on productive relations of production have assumed a deterministic value of *Y*, i.e. if we use a given factor input quantity efficiently, we will be able to compute a definite output quantity by means of the production function.

Practical examples, however, show that even with unchanged input conditions to the production process, gross output variations can occur. We have attributed such discrepancies to the limitation inherent in the estimated function of the production transformation and to external influences.

The influences of the production environment can be handled by either including the variable, *E*, explicitly into the production function or by experimentally ascertaining the influences with the parameters of the production function being specified as being stochastic.

We choose the former because with the Cobb-Douglas production function, one can incorporate the influence multiplicatively with the deterministic functional relation of the following form. This form is simpler in allowing for changes in external influences and treats the influence variable as an indirect production function variable. Because *E* is assumed to be an external variable, the external influence increases at a natural rate of growth *Z*. Thus:

$$E = e^{\Phi Z + \xi} \qquad (3.23)$$

where *e*= basis of the natural logarithm
Φ= vector of coefficients of the external influence variables
*Z*= vector of external influence variables affecting the production process. We use five variables and these are: public highway and non-highway infrastructure efforts indexes ($Z_1$ and $Z_2$), industrial concentration index ($Z_3$), foreign trade index ($Z_4$) and growth of demand index ($Z_5$).
ξ= error term ($0, \sigma_2^2$)

The term *E* captures the contribution of external environmental change occurring over time to the production output growth.

For a typical firm-level production process, maximum production at time *t* is of the form:

$$pVol_{t\max} = f(L^{*}, K, M, t)$$

or

$$pVol_{tmax}=A'_{t}(H*L)_{t}^{1-\alpha-\beta}(K_{t})^{\alpha}(M_{t})^{\beta} \qquad (3.24)$$

where

$pVol_{max}$ = the maximum weighted gross output obtainable from an individual manufacturing technology
$A'$= partially decomposed residual term and greater than 0 (i.e. $A$ is decomposed into two multiplicative terms, the transformation efficiency $h$ and a smaller residual term $A'$)
$L^{*}$ = skill-adjusted labour input of a representative firm
$L$= labour force of a representative firm
$K$= physical capital input of a representative firm
$H$= human capital available in the labour force
$M$= intermediate inputs of a representative firm (excluding services)
$\alpha$,$\beta$, (1-$\alpha$-$\beta$)= elasticities of output with respect to physical capital, intermediate inputs and labour respectively
Given the assumption that the shifts in the production function affect the level of output but not marginal rates of substitution between inputs, i.e. $0<\alpha+\beta<1$.

We define

$k$= physical capital per effective unit of labour (i.e. $K/L$)
$m$= intermediate inputs per effective unit of labour (i.e. $M/L$)
$q$= level of output per effective unit of labour (i.e. $pVol_{max}/L$)

We divide both sides of equation (3.24) by $L$ and we obtain

$$q_{tmax}=A'_{t}(H_{t})^{1-\alpha-\beta}k_{t}^{\alpha}m_{t}^{\beta} \qquad (3.25)$$

Neglecting changes in technology and equating technical efficiency to transformation efficiency of the production system, the transformation efficiency can be defined by the function g of two multiplicative terms such that:

$$h=g(I,E)$$

where
$E$ = external environment (i.e. if there is no electric power available to the production system, $h$ is affected)
$I$ = also of the form of a natural logarithmic function, captures the contribution of internal circumstances such as firm's organisation structure, control and organisation of the production process, maintenance and state of machinery and equipment.

The gross output production function can, then, be rewritten as:

$$pVol_{t} = f(h, pVol_{t\max})$$

or

$$pVol_{t} = f(h, L^{*}, K, M, t)$$

and substituting the value of $pVol_{tmax}/L_{t}$ (i.e. $q_{tmax}$) into equation (3.12), we obtain

$$\frac{pVol_t}{L_t} = h_t * A'_t H_t^{1-a-b} k_t^a m_t^b \qquad (3.26)$$

Equation (3.26) will then be used to investigate manufacturing performance in the case studies. But external influences will not be estimated statistically.

## 3.4.6 Measurement of Model Variables

This section defines the data sets used to estimate the variables of the empirical model. In analysing gross output growth in manufacturing firms in LDCs, one is often faced with one main drawback. These firms do not often have a sufficiently long time series of data observations. Where it was possible, sources other than companies' were consulted in order to provide a plausible indication of the performance of the companies.

**Gross Output**

The basic gross output measure is the gross physical products because the main interest lies in the determination of changes in output of commodities that undergo no significant changes in characteristics. The gross physical output is expressed in units of physical volume, such as pieces, tons or number of specific products.

These measures are, however, only useful where products are few and with relatively uniform characteristics. Clearly in the case of firms producing a wide range of products, the use of physical units has a very limited value, and adding quantities of products differing widely in utility values gives a meaningless measure. To take into account the non-homogeneity of the output, the different products are weighted at ex-factor cost prices.

Ideally, gross output refers to the number of units produced and not units sold because productivity is concerned with the efficiency of transforming inputs into outputs. The above condition ensures that the gross output is not overstated (for example, some units sold could be from a reduction in finished inventory) nor understated (for example, there may also be other situations where some of the units produced but not sold are not counted when the gross output is defined in terms of units sold). This gross output may be adjusted to take into account work-in-process, in line with the estimation of gross output at industry level.

The non-homogeneous qualified gross output can be stated as follows:

$$pVol_t = \sum_i V_{it} * P_{ib} \quad i=1,2,...,n. \qquad (3.27)$$

*where* $V_{it}$= *qualified volume output of item type i produced in period t*

$P_{ib}$= *producer price per unit output of item type i in base period*

To tackle the problem of quality changes, the quality specification changes of qualified output in the equation are assumed to be negligible. However, in cases where the changes in quality characteristics are significant, one approach to account for these changes is the use of a quality adjustment procedure based on dividing the actual price of the improved product into two components (Clay, 1965). The first price component is what would have been the price of the unimproved product if it had shared the average price adjustment of other product types between the two years being compared. The second price component is the differential change in price assumed to be attributed to the differential change in quality. The actual output quantity of the affected product type during the second year would, then, be multiplied by the ratio of its actual price to what would have been its price. This is to allow for the fact that each unit of the improved product represents more output than the unimproved product of the same type. This adjusted quantity in the second period would be multiplied by the base-year price to obtain the gross output in monetary value.

The other likely pitfall of the method of using equation (3.27) is how to account for the new products where the base-year producer price does not apply. One practice is to extrapolate the initial period producer price of the new product back to the base period by the price movement of a closely related product or group of products. Alternatively, the new products can be included only in the period in which they have actually been produced. Although this may lead to some errors, the errors would often be very small because new products typically account for only a modest proportion of the total gross output initially.

### Labour Input

The basic measure of the quantity labour input is the actual employment for the firm. This includes direct and indirect labour. The alternative measure of labour input is total working hours. Unless complete information on the number of employees and their average working hours is available, calculation of total working hours as a measure for labour input is not possible.

Basic labour input, as total number of employees, can be stated as follows:

$$L_t = (\sum_k D_t) + (\sum_q I_t) \quad k=1,2,....,n. \quad \text{and} \quad q=1,2,......,m \qquad (3.28)$$

*where* *D=* *number of direct employees in category k in period t*
*I=* *number of indirect employees in category q in period t*
*n=* *number of categories of direct employees in period t*
*m=* *number of categories of indirect employees in period t*

### Human Capital

The measure of labour given in equation (3.28) estimates labour input using physical dimensions, in effect treats all workers as if they were identical with no differential marginal productivity influences. Studies (for example Denison, 1967; Jorgenson, 1995; and Young, 1995) have shown that workers' characteristics do influence their marginal productivity. These characteristics of labour force include age, education, work experience, gender and health. Others are the attitudes towards work that reflect differences and changes in cultural and social values.

In highly industrialised countries, however, the effect on labour quality of changes in health and vigour seems to have been small. The problems of inadequate food and parasitic diseases, for instance, so negligible in the richer countries of the world, may not be easily overlooked in LDCs. The focus is, however, on education and training because these aspects of labour quality lend themselves to quantitative measurement and comparison and are unequivocally accepted as factors contributing to the quality of labour. In discussing education and training, it is the average quality levels and the curricula that are of significance for the competence of school leavers in industrial occupations later. Empirical evidence (Fleury, 1995; Kaplinsky, 1995; Kaplinsky and Posthuma, 1994; Salomon, 1990) shows that aiming at a high average level of quality is more important than creating a brilliant elite, because this provides high standards for the whole labour force, that is managers and workers alike.

Education and other efforts to improve the quality of labour constitute an investment in human capital that yields a return, just like an investment in physical capital.
The benefits of human capital (proxied here by the most important characteristic, education) are treated as being embodied in workers and can broadly be defined to include formal education of employees, firm level training, and skills created by experience. Formal education renders itself to be measured easily in a comparable way.

The human capital index is, in principle, derived by developing a distribution of the labour force in each of the time periods to be observed, classified by educational quality characteristics.
From company records, data on the proportions of labour force who have gained the following levels of education can accurately be calculated:

level 1: No schooling
level 2: Attained primary school
level 3: Completed primary school
level 4: Attained secondary school
level 5: Completed secondary school
level 6: Attained higher education
level 7: Completed higher education

With this information and the estimated return to each level of schooling we can calculate the weighted average change in the quality of all employees.

Following Collins and Bosworth (1996) in weighting these seven levels together on the assumption of a 7 percent rate of return to each additional year of schooling, a company human capital index can be generated. In this index, employees with no schooling have the minimum quality weight 1. These weights are based on observed relative earnings of different educational groups and they also reflect the assumption that percentage returns to schooling are constant across levels of schooling and countries. The 7 percent rate of return to schooling (which is a low estimate) is the preferred base because it minimises overestimation of returns to schooling among LDCs. The underlying assumption is that the fraction of income differentials between workers with different levels of education is due to differences in education as distinguished from associated characteristics (Denison, 1967). The justification for the use of income share weights to combine the various indexes derives from the marginal productivity explanation of the income distribution. The main defense of the use of marginal productivity concept of a production function for time series or comparison analysis is that it is a straight forward and common-sense method that gives results, of which simple alternatives are very difficult to find (Denison, 1964).

Company human capital index in period *t* is

$$H_t = \sum_j S_j * P_{jt} \qquad j=level\ 1,2,....,7. \qquad (3.29)$$

*where*
*S= estimated return to level j of schooling*
*P= proportion of company labour force that has attained level j of schooling*

Combining equations (3.28) and (3.29), the skill-adjusted labour input, $L^*$, is the product of actual employment for the firm and the index of labour quality. This is defined as follows:

$$L_t^* = H_t * L_t \qquad (3.30)$$

### Capital Input

Measurement of capital input presents special difficulties (Triplett, 1998). Ideally, if capital input could be separated into a series of number of 'units of capital goods used' that include utilisation and annual quality series, this would to some extent be analogous to the method used to build labour input series where quantitative and qualitative components of labour input can be distinguished.

Two groups of approaches are normally used in analysing the value of capital input. These are the *capital flow-based* approaches and the *capital stock-based* approaches. The capital flow-based approaches include the service value concept of capital and the investor contribution concept of capital, while the capital stock-based approaches comprise of the depreciation (or usage) concept and the stock of capital concept. In total, there are then four approaches to estimate capital input. They are briefly discussed below.

(a) The *service value concept of capital* is a flow concept. This concept fulfills the requirements of productivity measurement and is compatible with output and other input factors that are required for the productivity measurement (Craig and Harris, 1973).

The concept of lease value is a best suited form of the various concepts of service values of capital. This concept can be explained by assuming that the firm has a leasing subsidiary to buy buildings, equipment and other fixed assets. The leasing subsidiary also provides current assets and expects a return from them. The capital input term, usually in the form of annuity, is then the payment made to the leasing subsidiary. The annuity is dependent upon the cost of the asset, its productive life, the desired rate of return to the lessor and the estimated salvage value of the asset. The cost of the asset together with any capitalized costs necessary to prepare the asset for use are adjusted to the base year values using appropriate deflating factors such as the building and equipment indexes. The minimum attractive rate of return is estimated from the cost of capital theory. In the leasing method, the lessors are the firm stockholders and debtors, and a proper rate of return for the lessors is derived from the cost of capital theory. The required rate of return is the cost of capital in the base year, where the cost of capital is calculated by a weighted average method (Lewellen, 1969).
The capital input is, therefore, defined as the sum of the annuity values calculated for each asset on the basis of its base year cost, productive life, salvage value and the firm's cost of capital. This approach to estimating capital input requires complete inventory of all the capital and involves a large amount of data. If no precise data are available, the accuracy of the estimate will be reduced. In this approach, the capital input is stated as:

$$K_t = \sum_{j=1}^{n} C_{jt} \qquad (3.31)$$

*where* $C_{jt}$= *uniform annual (annuity) cost for asset j in period t*

(b) The *investor contribution concept of capital*: Like the service value concept, the investor contribution concept is a flow concept. This concept, too, fulfills the requirements of productivity measurement and is compatible with output and other input factors that are required for the productivity measurement. The investor contribution is defined as real net capital for each year weighted by the rate of return in the base year. The investor contribution is deflated to the base year values.
The capital input using the investor contribution concept can be expressed as:

$$\left.\begin{aligned} K_t &= (C_{ft} + C_{wt}) * i_b * d_t \\ \text{and} \quad i_b &= \frac{P_b}{C_{fb} + C_{wb}} \end{aligned}\right\} \quad (3.32)$$

*where*
- $C_{ft}$= *fixed capital for period t (from balance sheets)*
- $C_{wt}$= *working capital for period t*
- $i_b$ = *investor contribution adjustment*
- $d$= *capital deflating factor (current values are deflated to take account of inflation)*
- $P_b$= *profit before tax in base year*
- $C_{fb}$= *fixed capital in base year*
- $C_{wb}$= *working capital in base year*

The investor contribution is a relatively simple approach to annualizing the capital input, and in cases where full information of older capital assets is not readily available it provides satisfactory means of annualizing the capital input. This approach can be appropriate in many situations in LDCs where comprehensive data on capital may not be obtained.
The concept of investor contribution is justified in the sense that capital input is what investors expect from sacrifice of their capital (Taylor and Davis, 1977).

(c) The *depreciation or usage approach* is used as the approximation of capital consumed in the production process by using estimates of gross capital stock and the average life-time of the capital goods. This approach suffers the deficiency that results from the difficulty of representing the actual consumption of an asset. For example, the expenditure by a firm in connection with a depreciable asset arises out of the purchase decision rather than the depreciation decision. The depreciation approach represents a stock concept and is, therefore, incompatible with the output and other input factors required for productivity measurement. The third controversy that surrounds the depreciation approach is that since factual observation does not determine in any accurate way the annual depreciation charge of an asset, considerable variation in the charge is possible.

(d) The *stock of capital approach* is advocated by the US Labour Bureau of Statistics (Cocks, 1974). According to the Bureau, the approach is supposed to get an estimate of the stock of capital at any point in time so that this stock is representative of the physical amount of capital being used by the firm. It uses investment data and deflating indices to build time series for capital stock. This methodology requires detailed information of investment data to build time series of capital stock and that the investment data should go beyond the average lifetime of the capital stock. In addition to this, detailed information on inflatory developments of specific capital goods is required. Such detailed information is in practice often lacking. Although the methodology is usually used for studies at meso and macro levels to estimate time series for capital stock, it is also applicable at micro level. The Perpetual Inventory Method (PIM) upon which this approach is based is discussed in detail in chapter 4, section 4.5.2.

In summary, given the fact that the Perpetual Inventory Method has been used to estimate capital stock at sectoral level and in order to maintain consistency in the research methodology, we have, in principle, employed the same method at firm level but using a short-cut approximation method (see chapter 6, section 6.2.2) due to the lack of long-enough and consistent annual investment series for the case studies prior to 1980.

**Intermediate Inputs**

In manufacturing sector and branch studies, intermediate inputs from both sides of the production function are excluded to avoid double counting. However, at firm level this exclusion has little credence and for many firms intermediate inputs constitute a large proportion of inputs.

The predominance of intermediate inputs in the cost structure of a lot of manufacturing firms suggests that intermediate inputs should not be ignored in the production function analysis. For example, in 1990 (our benchmark year for the comparative study of Zambia's manufacturing performance), costs of material and business service inputs for the four-digit industries represent about 40 percent to 75 percent of the total costs. Moreover, many modern developments in production techniques and manufacturing productivity enhancement aim at improving the efficiency with which both the primary inputs and intermediate inputs are used. These improvements can only be well understood when the study of production process takes into account all (or most of the) inputs.

The problems encountered in the estimation of intermediate inputs and the methods used to estimate intermediate inputs are very similar to those highlighted in the case of gross output calculations.

Ideally, intermediate inputs are expressed in physical quantities. In order to take into account the non-homogeneity of intermediate inputs, these are also weighted. The actual quantities of intermediate inputs that are consumed in the production of outputs during respective periods are recorded together with their unit costs (i.e. $/ton, $/piece, ..). The physical units of the inputs are tons, pieces, kWh, etc...

Thus:

$$M_t = \sum_j R_{jt} * U_{jb} \qquad (3.33)$$

*where* $R_{jt}$= *volume of intermediate input type j consumed in period t (excluding services)*
$U_{bt}$= *base period cost for material j*

**Shares of Inputs in Gross Output**

Suitable weights are required to combine the indexes of inputs into a combined input measure. For each enterprise, we have used industry (four-digit) average weights that are derived by dividing the estimated cost in current Zambian Kwacha (ZK) for each input by the total cost of all inputs. Because of the possibility of large variations in the cost of inputs that are characteristic of developing economies, we have used the chain-weighted Fisher Ideal indexes. That is for each input at time t, we have used the average value share of that input in the output at time t ant time t-1.

## *3.4.7 Model Estimation and Validation*

This section discusses the estimation procedures of the model, its testing and validation.

Estimation of the model is as follows. Firstly, there is computation and presentation of the transformation efficiency of the production system of the firm in the transformation efficiency diagram based on mathematical relationships developed in section 3.4.4.

Secondly, the theoretical approach of quantifying the effect of internal factors on the one hand and that of external influences on the other hand on the gross qualified output per person engaged through an estimation of a production function by regression analysis requires a large number of monthly or annual observations per firm. Due to data limitation, we have listed the external influences in a table and discussed them, and opted for a growth accounting where external factors turn up in the TFP'.

By performing a firm-level growth accounting and allowing the value shares of inputs to shift every year, we rewrite equation (3.26) as follows:

$$pVol_t = h^* A'_t (H^*L)_t^{\,1-a-b} (K_t)^a (M_t)^b \qquad (3.34)$$

The total factor productivity growth, $\partial TFP$, is decomposed into growth in transformation efficiency, $\partial h$, and growth in a smaller residual, $\partial TFP'$, and is defined from:

$$\partial pVol = \overline{(1 - a - b)}\partial L^* + \overline{a}K + \overline{b}M + \partial h + \partial TFP' \qquad (3.35)$$

where $\partial$ denotes a growth rate (logarithmic derivative with respect to time), and the bar over the partial elasticities indicates that the input shares are averages at times t and t+1. The input shares are assumed to equal the partial elasticities.

Based on equation (3.21), the transformation efficiency diagram in which the production time efficiency is plotted against the production system effectiveness gives a graphical representation of the technical performance spectrum of the production system of the firm over a time period. The production time efficiency is a time-based measure, while the production system effectiveness is a quality-based measure.
We related performance at firm level to performance of the manufacturing branch to which the firm belongs. Branch performance is employed to serve as a benchmark to which firm performance can be compared, and it is an important external influence. As pointed out earlier on, sectoral and branch stagnation will have a negative influence on firm's performance.
To validate the model, we use the empirical evidence given in the company case studies.

## 3.5 Conclusion

The study uses three methods of analysis to investigate the process of performance improvement in LDCs: a growth accounting approach, an industry-of-origin approach to international comparisons, and a conceptual model for performance improvement at the firm level. The analysis of the sector performance has a dual purpose: to present a quantitative analysis of growth trends in Zambian manufacturing and thus providing a background for the study of manufacturing performance in firms. The other purpose is to use it as a benchmark for firm performance. The conceptual model, on the other hand, is used for analysing performance improvement at the firm level by capturing evidence of improvement efforts at a micro-economic level.

The assumption is that much of what happens during the improvement process will be manifested in the relative changes of the performance indicators. These indicators' changes are changes in the qualified gross output per person engaged and transformation efficiency of the production system, which are analysed in the light of changes in input factors and external influences to show their impact on the firm's performance.

# 4 Manufacturing Performance in Zambia, 1964-98

## 4.1 Introduction

This chapter gives a statistical review and analysis of the development of manufacturing in Zambia since Independence, in 1964. National data revised in collaboration with the Zambian Central Statistical Office (CSO) were used to analyse the changes in manufacturing production structure, employment, capital stock, labour productivity and total factor productivity. Published and unpublished primary data on Zambian manufacturing were used in this study. Although the focus here is primarily on manufacturing in Zambia, occasional reference is made to the mining of copper because copper mining has dominated the total economic activity in Zambia. The chapter also provides an overview of the policy environment in different periods.

The early development of Zambian manufacturing took place against a background of high copper export earnings. In 1964, copper mining accounted for about 45 percent of total GDP (at factor cost) and it still provides almost all of Zambia's foreign exchange (CSO National Accounts 1964-65; Ministry of Finance and Economic Development, 1998). In 1964, about 94 percent of foreign exchange earnings stemmed from copper mining (Copper Industries Service Bureau, 1964). In 1997 copper mining contributed over 75 percent of foreign exchange earnings even though the share of copper mining in total GDP (at factor cost) was no more than 10 percent.

As will be shown in this chapter, manufacturing development has been intrinsically related to copper mining especially in the early years of Zambia's independence. Zambia is a landlocked country highly dependent on copper mining. Revenues from copper exports provided the necessary funds to finance a manufacturing take-off in the post-colonial era.

The strong relationship between mining and manufacturing still exists. Mining has had a dual influence on the development of manufacturing in Zambia: provision of foreign exchange and market demand. For instance, in 1990, the manufacturing sector imported 60 percent of its raw materials, while supplying over 90 percent of its output to the domestic market. For the provision of foreign exchange it depended on copper export earnings. Directly or indirectly mining is a major consumer of industrial outputs. This is reflected in the regional distribution of manufacturing activities (See Table 4-1). In 1994, 46 percent of manufacturing establishments and about 50 percent of persons engaged in manufacturing were located in the mining province (also known as Copperbelt province) (Fincham, 1980; Census of Industrial Production, 1964, 1975, 1980 and 1994). These establishments provide intermediate inputs and services to mining. The remaining establishments were spread over the other eight provinces. For many firms the Copperbelt province was the preferred location, because proximity to mining resulted in low transport and distribution costs.

Between 1964 and 1997, the share of mining in GDP declined from about 45 percent of GDP to around 11.4 percent (National Accounts, various issues). The consequence of the double dependence on mining is that declines in copper production and export earnings directly translate into input shortages and low levels of capacity utilisation in manufacturing.

**Table 4-1: Regional distribution of manufacturing establishments and employment**

| Region | 1964 | | 1975 | | 1980 | | 1994 | |
|---|---|---|---|---|---|---|---|---|
| | No. of establish ments | No. of persons engaged | No. of establish ments | No. of persons engaged | No. of establish ments | No. of persons engaged | No. of establish ments | No. of persons engaged |
| Copperbelt | * | * | 396 | 27634 | 295 | 26814 | 270 | 27373 |
| The rest of the other 8 provinces | * | * | 329 | 28136 | 244 | 32095 | 321 | 29727 |
| Total number | 255 | 20940 | 725 | 55770 | 539 | 58909 | 591 | 57100 |

*Note: * Data not available.*
*Sources:*
*Fincham, 1980; Census of Industrial Production, 1964, 1975, 1980 & 1994.*

In the 1970s, following a sharp drop in copper prices in 1975 and an economic deterioration in the terms of trade, a slowdown in manufacturing GDP was recorded together with a decline in the production volume of copper. Post-1975 Zambia experienced a decline in both capital investment and productivity in manufacturing. The average annual growth in total factor productivity (TFP) in manufacturing between 1970 and 1998 is –0.1 percent, while that of gross capital stock during the same period is –1.4 percent (See section 4.5).

A brief discussion of manufacturing in African LDCs is given before embarking on a more detailed analysis of Zambian manufacturing. African LDCs are also called “late starters” because they started their industrialisation from scratch within the last 50 years. Although the initial economic structures, domestic markets and the nature of industrialising agents differed, all countries prioritised industrialisation and encouraged rapid capital formation in manufacturing in the period immediately after independence between the mid 1950s and 1970s.

## 4.2 Manufacturing in African LDCs

Soon after independence most African countries were characterised by very limited levels of industrial and infrastructural development. Agriculture was predominant followed by mineral products. The tiny industrial base that developed in the colonial period consisted of a few agro-processing and consumer goods industries. After attaining independence, industrialisation became the dominant development paradigm. This had to be achieved by establishing a physical and technological infrastructure and accumulating from a primary production to a level where industrial production would become the dominant sector of the whole economy.

African LDCs pursued different industrial development policies. Import substitution, integrated industrial and agricultural development, and export-led industrial development with a high level of government intervention were the main models of industrial development in different periods.

Under import substitution, African LDCs locally manufactured formerly imported goods. This was done by first importing capital equipment and semi-processed materials to be used in the local manufacture of consumer goods. This first step was to be followed by a substitution of locally produced inputs for imported inputs. Finally, this resulted in the domestic manufacture of capital goods. The import substitution model originates from modernisation theory. According to this theory, underdevelopment is largely due to the low levels of capital formation resulting in the presence of a relatively small modern sector enclaved in a large subsistence sector. Consequently, industrial development is perceived as a gradual expansion of the modern sector. This is achieved through capital accumulation in the industrial sector.

The integrated industrial and agricultural development policy, although not totally different from the import substitution, entailed the development of industries that could use locally generated raw materials (the bulk of which was to come from agriculture) and could produce goods for local mass consumption. Other policy goals in this model of development were the establishment of small-scale and labour-intensive industries together with the rational use of existing industrial capacities.

The export-led industrial development policy is based on the rationale of comparative advantage. It is generally believed that the comparative advantage of LDCs lies in the cheap labour and abundant raw materials that are found in these countries. Under export-oriented policies, manufacturing firms that can exploit these resources to maximise comparative advantage on the international market are encouraged to do so by their governments. The export-led industrial development model is also believed to facilitate assimilation of technological change and to break the constraints imposed by the limited size of domestic markets generally found in African LDCs.

In the second half of the 1980s, many African LDCs embraced economic liberalisation, structural adjustment and export-orientation because of the failure of these countries to escape from the bondage of deteriorating industrial performance under the earlier industrial strategies. Ghana, which has the longest history of consistent adjustment in sub-Saharan Africa, started its policy reform with an economic recovery programme in 1983 (Lall, 1996). The underlying assumptions in this new perception of economic development are that government intervention is inefficient and that the market is efficient for both products and production factors. Moreover the institutions required for the functioning of markets were already present or would arise naturally in response to the market signals. The externalities and other distortions that had to be addressed did not exist. It was thought that pursuing such reforms would lead African LDCs to a similar industrial success as that seen in NICs. The removal of market controls was expected to lead to market driven industrial growth and new inflows of foreign direct investment.

However, in the recent past, most enterprises in African LDCs have been disillusioned with the lack of market-driven industrial growth, the collapse of domestic investment and lack of foreign direct investment. The weak response to these changes in the policy environment (as a result of liberalisation) has been particularly significant in the manufacturing industry and manufactured export performance of these countries. Reasons for this include the low levels of firm-level capabilities and human capital, and weak infrastructure and institutions. This contrasts with the NICs' experience. African LDCs need to look at the Asian experience and see what can be learned from different circumstances.

## 4.3 The Development of Manufacturing in Zambia, 1964-98

This section discusses the development of manufacturing in Zambia between 1964 and 1998. The development of manufacturing in pre-independence Zambia (then known as Northern Rhodesia) was greatly affected by the country's relationship with Zimbabwe (Southern Rhodesia) and South Africa, the exploration of copper deposits and the landlocked nature of the economy (Fincham, 1980; Seshamani, 1989; Seshamani and Samanta, 1985; Young, 1973). Compared to both South Africa and Zimbabwe, Zambia had a relatively small population of white settlers and did not have much power to influence the decisions and policies of the colonial government. Instead, Zambia basically provided a market for the manufactured goods produced in the other two countries. The landlockedness of Zambia meant that all raw materials and other inputs that could not be obtained locally, had to be transported over long distances at substantial expense. This provided negative incentives to the development of manufacturing in Zambia. Serious exploration of the copper deposits, around which the early manufacturing base was to be formed, only began in the 1920s.

Manufacturing development in Zambia can be divided into three main periods: a period of expansion, 1964-74, a period of slowdown, 1974-1991 and a period of adjustment, liberalisation and de-industrialisation, 1991-1998.[3] The subdivision reflects external shocks (i.e. oil crises, copper price shocks, and domestic policy changes). The period under review is also subdivided into these three main periods to allow comparability of this study's findings to those in other studies on manufacturing in Zambia, although the other studies only roughly covered the first two decades immediately after independence (See Seshamani and Samanta, 1985; Shaaeldin, 1988; Valentine, 1984; World Bank, 1984; Young, 1972). Soon after independence in 1964, the manufacturing sector in Zambia became one of the country's fast-growing sectors. From 1964 to 1974, it achieved an annual average growth rate of 12.6 percent (see Table 4-2). This, however, was followed by a long period of near stagnation and, thereafter, a dramatic decline, especially between 1991-95. Between 1964 and 1974, the share of manufacturing in total GDP (at factor cost) rose from 6.3 percent in 1964 to 13 percent. After 1974, the share of manufacturing continued to grow, reaching a peak of 26.6 percent in 1991. In the nine years after that, the manufacturing share shrank, reaching 13.6 percent by 1998. The contribution of the manufacturing output growth to growth in the total real GDP and the contribution of manufacturing labour productivity growth to growth in manufacturing GDP provide a good view on the importance of the growth dynamics.

[3] The period 1974-1991 is further subdivided into a period before and after the debt crisis of 1982. The reform period is divided into a period of collapse 1991-95 and a short period with some signs of recovery after 1995.

**Table 4-2: Growth of total GDP, growth of total GDP/capita, growth of manufacturing GDP, growth of manufacturing GDP/worker, contribution of manufacturing sector to growth in total real GDP and its share in total GDP, 1964-98 (in %)**

| | Expansion (1964-74) | | Slowdown (1974-91) | | | | Adjustment (1991-98) | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Post copper price shock (1974-82) | | Debt crisis (1982-91) | | Collapse (1991-95) | | Slight recovery (1995-98) | |
| Growth in total GDP | 3.4 | | -0.5 | | 1.1 | | -1.2 | | 2.1 | |
| Growth GDP/capita | 0.7 | | -3.7 | | -2.0 | | -4.4 | | -1.1 | |
| Growth in manufacturing GDP | 12.6 | | 0.0 | | 2.0 | | -23.6 | | 2.9 | |
| Growth manufacturing GDP/worker | 3.1 | | -0.2 | | -1.5 | | -16.0 | | 11.3 | |
| Contribution of manufacturing growth to growth in total real GDP | 0.8 | | 0.0 | | 0.4 | | -1.5 | | 0.4 | |
| Share of manufacturing in total GDP | 1964 | 1974 | 1975 | 1982 | 1983 | 1991 | 1992 | 1995 | 1996 | 1998 |
| | 6.3 | 13.0 | 17.5 | 20.2 | 19.0 | 26.6 | 18.2 | 11.7 | 13.4 | 13.6 |

*Sources for raw data: GDP, population and manufacturing share from National Accounts, Manufacturing statistics (10+) from the database of the Central Statistical Office (CSO) and Census of Industrial Production, various issues. Manufacturing data have been deflated using Index Numbers of Wholesale Prices 1966=100. See Annex Tables I.1 and I.2.*

*Equality is used to estimate the contribution of the manufacturing sector to the growth of the total economy (Timmer, 2000). The GDP in the total economy (Y) is generated in the manufacturing sector (m), and the non-manufacturing sector (nm). For any given period, the growth per year of the total economy (¶Y) can be decomposed into the growth of the manufacturing sector (¶$Y_m$) and growth of the non-manufacturing sector (¶$Y_{nm}$), each weighted by their share in the total economy GDP ($S_m$ and $S_{nm}$) at the beginning of the period, i.e. ¶Y=$S_m$¶$Y_m$ + $S_{nm}$¶$Y_{nm}$. Also see (Timmer, 2000) for the decomposition of the growth of value added in manufacturing.*

During the periods of positive growth in manufacturing and total economy, 25 percent of the growth of total GDP during the 1964-74 period was accounted for by manufacturing, and 31 percent during the 1982-91 period. The contribution of manufacturing to the total GDP growth was 19 percent during the 1995-98 recovery period, showing an unstable trend. To study the relative importance of manufacturing labour productivity growth and labour force growth in the growth of value added in the manufacturing sector, we decompose the growth of value added into the growth of the labour force, the growth in labour productivity and a remaining (small) interaction effect equal to the product of both (due to the use of discrete data).

The computation of the ratio of the growth in manufacturing labour productivity and the growth of value added in the manufacturing sector shows that the intake of surplus labour is a relatively much more important source of manufacturing output growth than increases in labour productivity (for 1964-98, -25 percent of manufacturing output growth is explained by labour productivity growth). These results for Zambia are different from the experience of the five important Asian countries (i.e. China, India, Indonesia, South Korea and Taiwan), where manufacturing output growth was fuelled by growth in both employment and labour productivity (Timmer, 2000). Indonesia, with the lowest level of labour productivity growth importance in the group, had 39 percent of manufacturing output growth explained by growth of labour productivity between 1960-90. In Zambia, labour productivity growth was an important determinant of output growth in the expansion and recovery periods, while in Asian economies labour productivity growth was important right from the beginning of industrialisation onwards.

Since independence in 1964, industrial policy focused on import substitution and protection (ILO-JASPA, 1981; Ministry of Commerce, Trade and Industry, 1994a; Turok, 1979). In the early, easy, stages of import substitution up to 1974, the manufacturing sector grew rapidly, in tune with high copper export earnings. Between 1964-74, manufacturing output growth was particularly high in textiles, chemical products, rubber and plastic products, electrical machinery and equipment, and leather products and footwear, ranging between 27.1 percent and 32.9 percent per year. These were branches heavily promoted through public investment. After 1974, the highly import-dependent manufacturing sector stagnated in the face of a foreign exchange crisis and input constraints, following the 1973 hike in oil prices, sharp drops in copper prices in 1975 and steadily declining copper output volumes after 1977.[4] High rates of effective protection and the absence of competition, reinforced by decreasing capacity utilisation, resulted in decreasing efficiency and increasing costs.

Following economic reforms in 1968-70, parastatals were assigned an important role, under the principle of state participation in manufacturing. From 1973 onwards, the expansion of the state sector accelerated. By the end of the 1980s the parastatal sector controlled 90 percent of the country’s industrial and commercial activities, accounting for 35 percent of total GDP, 13 percent of the total country’s external debt, 60 percent of total investment, and about 45 percent of total formal sector employment (Ministry of Commerce, Trade and Industry, 1994b). In 1992 the holding company for manufacturing parastatals, INDECO[5], accounted for over 80 percent of non-mining industrial production. Parastatal management was dominated by political appointments. It was weak and had to balance conflicting objectives of profitability on the one hand, and employment creation and low consumer prices on the other.

In 1991, the Zambian government started the implementation of liberalisation policies. Under these policies, there was an initiative to open up the domestic market to allow competitive trade and to encourage active participation of private entrepreneurs in all sectors of the economy (de Bruin and Tambatamba, 1995). Other aspects of the new industrial policy included (a) progressive reduction of all subsidies; (b) de-regulation of foreign exchange, interest rate and price controls; and (c) encouragement of private investment through privatisation of most parastatal firms. On 3rd July 1992, an Act of Parliament was passed providing for the privatisation and commercialisation of state-owned enterprises.

The first five years of this so-called policy of “sustainable industrial growth” witnessed an unprecedented decline of manufacturing GDP and employment due to massive labour retrenchments and establishment closures (see Table 4-2). There still are cries and pleas for maintaining or reinstating limited protection and state subsidies at the moment. Nevertheless, it is envisaged that in time the sector will adjust to the new economic realities and will start growing again. This finds some support in post-1995 data.

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4 By 1998 copper output was only 43 percent of its 1964 level (national accounts, various issues).

5 INDECO stands for the Industrial Development Corporation.

The period of expansion had a high growth rate for both manufacturing GDP and total GDP, the period of slowdown maintained a relatively stable total GDP and a slowing growth in manufacturing performance. The final period is characterised by a greatly uneven trend in total GDP level with manufacturing GDP growth collapsing and marginally picking up in the last part of the reform period. In the next section, we examine the three main periods of the sector development in more detail.

## 4.4 Discussion per Sub-Period

### *4.4.1 Period of Expansion, 1964-74*

At the time of independence, the Zambian production structure can be described as both monolithic and highly dualistic (Seshamani and Samanta, 1985). The monolithic attribute is due to the fact that the Zambian economy was dominated by a single sector: copper mining. The dualism refers to the existence of an export-oriented and capital-intensive mining enclave in a backward and subsistence agricultural-oriented economy.

The small manufacturing base was limited to agro-processing and simple metal fabrication activities to meet some of the needs of the mining industry. With such a small indigenous manufacturing base, many goods were imported using foreign exchange earned from copper exports. The reliance on the export of a single commodity and the dualistic nature of the economy meant that the country was extremely vulnerable. Decreases in international copper prices translated directly into reductions of hard currency which, in turn, meant that fewer products could be imported. Widely fluctuating international metal prices also caused the foreign exchange revenues to fluctuate greatly. The extremely dualistic nature of the economy needed to be changed by diversifying the economy away from copper and away from the urban areas that were concentrated along the main line of the Livingstone-Copperbelt railway. This sectoral and regional diversification, it was thought, would attenuate the influx of the rising number of job seekers from rural to urban areas and would create jobs for them. It is important to note that movements of indigenous Zambians were highly restricted during colonial rule.

In 1965, the Zambian Government announced a policy to promote, accelerate and diversify industrial development in the country through state participation in major industries and control of the same. INDECO, established in 1951, with the sole purpose of providing finance to industries, was expanded and transformed into a unit for state participation in control of major industries.

In January 1966, the Zambian government published a white paper that contained its outline of industrial policy (Seshamani and Samanta, 1985). This policy document was first published in October 1964 and then revised and reissued by the Ministry of Commerce and Industry in January 1966. The government's approach to industrialisation was to support selected industries that could make a net contribution to the development and diversification of the economy, to encourage industries making the country self-supporting in popular consumer goods and to support labour-intensive industries. The emphasis was to reduce imports, save foreign exchange, reduce unemployment and develop skills. Other specific policy objectives were to encourage the setting up of industries outside the main centres along the rail line and to encourage industries that had the potential to lead to the establishment of other related industries.

Sectoral and regional diversification of the economy, thus, became the main objectives of development planning in Zambia. Development of the manufacturing sector was the principal instrument to achieve these objectives. The first role of manufacturing in Zambia was to help in the diversification of the export portfolio. Its second role was to absorb a significant proportion of the labour force released from the contracting mining industry (although mining still remained dominant) and from the subsistence agricultural sector. This was in addition to the theoretical arguments of manufacturing being the provider of dynamism in the economy for increasing productivity and growth, and for imparting the technological dynamism to other sectors of the economy (Fransman, 1982).

The decline in copper production basically was mainly due to ineffective management and policies of the mining companies and technical factors (such as neglect of maintenance) rather than a shortage in foreign exchange.[6]

By 1973, INDECO had a controlling interest in nearly all major industries including commercial and transport enterprises. The total net assets for INDECO rose from a mere ZK 4.9 million in 1965 to ZK 525.6 million in 1983. By 1992 INDECO accounted for over 80 percent of non-mining industrial production. But there was no corresponding improvement in measures of performance, such as profit after tax, reduction in long-term debt and cost performance. While industries that had been established before independence, mainly agro-processing plants, continued to be operated by different parastatal organisations under the control of the Minister of Rural Development, INDECO became the main sponsor of all new important manufacturing projects. This signalled the beginning of the increasing role of the public sector in productive activities. By 1979, INDECO provided jobs for more than 55 percent of all persons employed in manufacturing (Fincham, 1980).

After independence the manufacturing sector grew rapidly. This growth provided the impetus for structural change in the total economy, in terms of GDP and employment. Growth was particularly high in food products, textiles, tobacco and chemicals branches. Employment in manufacturing also increased considerably. The manufacturing sector accounted for 14 percent of the total formal employment in 1974, against 8 percent in 1964. The share of manufacturing in total wage employment was 11 percent. Manufacturing activities consisted of production of beverages, edible oils, cigarettes and sugar. There were also textile and cement factories, chemical and glass plants. Other manufacturing activities included automobile, bicycle and radio assembly, and production of semi-manufactured copper products.

The expansion of the Zambian manufacturing sector, starting from a very small base in the early 1960s, also gained some impetus from the conditions created by the Southern Rhodesia's Unilateral Declaration of Independence in 1965. Southern Rhodesia's declaration of independence resulted in the closure of Zambia's border with Southern

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[6] Mining companies had sufficient influence to be able to place strong demands on the available foreign exchange.

Rhodesia. This deprived Zambia of imports of consumer goods, notwithstanding its uneven distribution of income and high import coefficients. The adoption of the concept of import substitution by the government, therefore, appeared to be the obvious choice (ILO-JASPA, 1981; Turok, 1979). Import substitution was financed from foreign exchange reserves.

Import substitution in Zambia began with the production of consumer and light intermediate goods that had the least linkage effects, and production remained concentrated in these activities. Capital-intensive and import-intensive manufacturing plants were set up to produce these goods. The highest rate of import substitution was achieved during the early years of industrialisation in the post-colonial era. Import substitution accounted for about 55 percent of the overall rise in manufacturing output between 1965 and 1972 (Gulhati and Sekhar, 1982). The ratio of imports in total supply of manufactured goods also fell from 65.8 percent to 47.3 percent during the same period.

By 1973, nearly all manufacturing plants in Zambia produced entirely for the domestic market and enjoyed a great amount of direct and indirect protection. Direct protection was provided by import licences which, for locally produced goods, were issued after consultation with the local producer, in most cases INDECO. Indirect protection was provided by the high transport costs.

In Zambia, as in most African countries and Latin American countries where import substitution was adopted, the initial momentum was not sustained for long. Many manufacturing plants heavily relied on imported raw materials, spare parts, machinery and other inputs. The result was that the growth of manufacturing output arising from import substitution did not contribute to the reduction of the import needs of the country, nor did it reduce the dependence on copper foreign exchange earnings. Instead there was an increasing dependence on manufacturing imports. The dependence of production on imports was reinforced by the fact that there was a low production of local inputs. Also manufacturing was not generating foreign exchange to finance its import requirements, as most of its production was geared towards the domestic market.

The increasing dependence on imported inputs and copper export revenues constrained manufacturing growth. In 1975, when international copper prices fell by 40 percent, the share of mining in total GDP (at factor cost) fell by 46 percent and its production by 9.1 percent. Manufacturing output (in 1990 prices) fell by 7.6 percent in 1975. As early as 1973, a declining trend was noticeable in some industries and erratic trends in the fast-growing industries. The uncertainties and scarcities in the supply of relevant raw materials became a major constraining factor.

Researchers like Pack (1988) suggested that the failure of the import substitution industrialisation model in countries like Zambia is more likely due to the deficient technical ability of management as firms and workers failed to achieve the learning that was anticipated by the early advocates of import substitution industrialisation.

The disregard of all considerations of market forces to give competitive signals caused industries to operate without any considerations for efficiency, optimal scale and specialisation. It was assumed that industries once built would be efficient, which in reality was not the case. Import substitution, though in the short-term apparently successful, turned out to be an inappropriate means for promoting sustainable industrialisation in the country.

### 4.4.2 Period of Slowdown, 1974-91

The beginning of this period coincided with the world oil crisis of 1973 followed by the sharp fall of copper prices in 1974 and 1975. Copper prices started to fall in 1974. In 1975, in real terms, they declined by almost 46 percent. A small improvement occurred in 1979 and 1980, but prices declined even more dramatically thereafter (Meijer and Vingerhoets, 1989).

Following the events of 1973 and 1975, foreign exchange shortages started to develop with the attendant problem of capacity under-utilisation. In 1983, capacity utilisation in the grain milling industry, for example, was 51 percent and in Nitrogen Chemicals of Zambia (the only fertiliser producer in Zambia) was 38 percent (Bank of Zambia Report, 1984). The major thrust of government industrial policy, now, centred on the saving of foreign exchange. Manufacturing firms were induced to actively substitute domestic for imported raw materials and to explore export potentials. With low degrees of success, textile and bicycle manufacturers exported their goods within the Southern African region. The economic policies of the late 1970s focused on the reduction in import expenditure by means of import restrictions, limited devaluations and attempts to reduce the budget deficit.

The Zambian manufacturing sector showed weak growth performance in the period of 1975 to 1991, punctuated by sharp fluctuations in output. Since then the whole economy experienced a shortage of foreign exchange and negative growth per capita due, in part, to the country's rising debt burden. Manufacturing accounted for about 26.5 percent of total GDP (at factor cost) in 1990, mainly due to the decline in copper. The consumer goods industries continued to dominate the sector. There has been relatively little structural change within the manufacturing sector since 1975.

1977 was a year during which manufacturing experienced deep operational difficulties due to the overall economic situation in the country partly caused by its continuing dependence on imports. The adverse effect of the second devaluation of the Kwacha in 1978 increased the purchase costs of raw materials, intermediate goods and spare parts, thereby escalating the production costs of most industries. Other negative influences were the delays due to congestion at the only available port of Dar-es-Salaam and the unsatisfactory performance of the jointly operated Tanzania-Zambia Railways (TAZARA). In 1978, the small private sector responded by laying-off some labour and temporarily closing down factories, while the parastatals tended to keep their workers on payroll even at the expense of lower productivity.

In 1979, the decline in manufacturing output continued side by side with the deterioration of the Zambian economy. The mining industry had a low demand for basic metal products because of immense production difficulties. The parastatal group also had a disastrous performance. The group cited the uneconomic product prices, scarcity of foreign exchange and transport problems as reasons for their disastrous financial year. Thus in 1979, many companies under INDECO started looking for local raw materials and for new products. The other companies faced insufficient domestic demand and started export efforts. For the first time ever, the giant state group, INDECO, was forced to shed labour from 25000 employees in 1978 to 22000 employees in 1979.

Figure 4-1 shows annual variations in the share of manufacturing in total GDP. Each year from 1975 to 1983 is marked by a marginal increase in the contribution of manufacturing to total GDP. The contribution first declined in 1975-76, but rose during the 1976-78 period. A similar pattern was repeated between 1978 and 1983. A decline in manufacturing share was first registered in 1978-79, and gradually rose thereafter. The last period of 1984 to 1991 first saw a rise in manufacturing share up to 1988, then stagnation in 1989, and a substantial rise between 1989 and 1991. By and large, the growth in manufacturing has been rather sporadic. Large variations in growth rates characterised most of the branches of manufacturing. The share of manufacturing sector in total GPD (at factor cost), however, increased from 17.5 percent in 1975 to 26.6 percent in 1991.

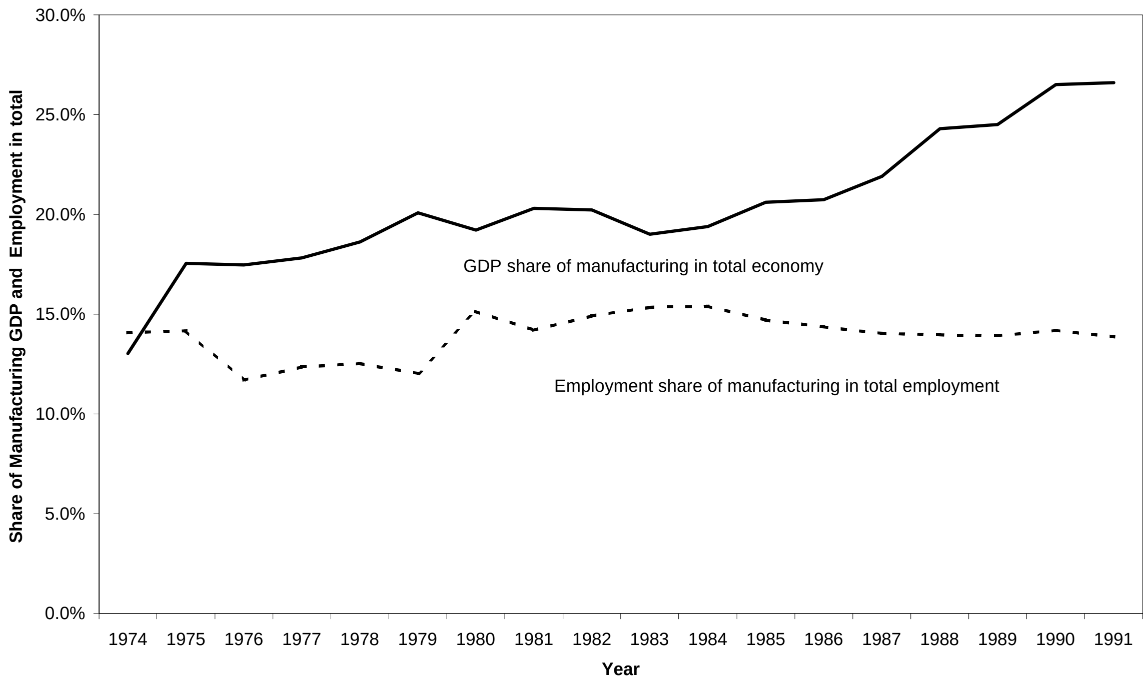


**Figure 4-1: Share of manufacturing GDP and employment in total, 1974–91**

*Sources for raw data: GDP, employment and manufacturing share from National Accounts, Manufacturing statistics (10+) from the database of the Central Statistical Office (CSO) and Census of Industrial Production, various issues.*

## *4.4.3 Period of Adjustment, 1991-98*

The sub-period 1991 to 1995 is characterised by a sharp decline in both the output of manufacturing and the share of manufacturing in total GDP, followed by a modest recovery after 1995. The share of manufacturing in employment fell from 13.9 percent in 1991 to 9.3 percent in 1998. One of the main priorities of government policies during this period was to end manufacturing companies' dependence on government subsidies and other interventions.

1991 saw a change of government, whose economic policy emphasized a shift from the state-run economy to a market economy. Opening of the domestic market, removal of subsidies and encouragement of the private sector participation in the economy were some of the steps undertaken by the new government (Bruin and Tambatamba , 1995) to reverse the gradual decline in manufacturing and other sectors.

It was not until 1992 that a market approach was adopted in earnest in the country. The government's policy was to increase the productive capacity of the country through a liberalised market economy. Unlike the previous periods, where the structure of manufacturing was shaped by policies of import substitution, protection and heavy public sector involvement, the policy focus now was to develop an open, competitive, dynamic and sustainable industrial sector that was to be dominated by the private sector (Ministry of Commerce, Trade and industry, 1994b). The specific objective was to support industries that maximised the use of local raw materials and fostered long-run intersectoral relationship within manufacturing and among other sectors in the economy. In addition to this, branches of industry, such as food products, wood products, textiles, clothing and leather, and other natural resource-based industries that were potentially viable exporters were to be encouraged. This involved a change from the state-led and pervasively regulated import-substituting industrialisation to a private-sector-led and export-oriented industrialisation policy.

In 1995, manufacturing performance declined disastrously as the implementation of the trade liberalisation programme continued and competition in the domestic market increased. As liberalisation spread to most imports without using up the excess capacity, the exposure to regional and world competition led to a steady decline of industrial growth within Zambia. This is primarily so because imported products generally were cheaper and better.

On the other hand, the steep decline in manufacturing output followed by a modest growth in the sector in the sub-period 1995-98 suggests that the sector has almost adjusted to the new economic environment. During this same period (after 1995) the government offered a number of incentives to manufacturers, such as a reduction of customs duty rate for raw materials and productive machinery from 20 to 5 percent, while that on intermediate goods was lowered from 30 to 15 percent.

In 1998, the sector registered a marginal positive growth with its share in total GDP (at factor cost) rising from 13.4 percent in 1997 to 13.6 percent in 1998. Our findings show that the average growth rate of manufacturing, negative in the early 1990s, rose to 2.9 percent per annum over 1995-1998. In the light of this, the sector performance seems to indicate a positive response to the economic environment.

A closer look at the manufacturing sector shows that employment in manufacturing fell from a peak of 77,100 persons engaged in 1991 to 43,320 persons engaged in 1998.

There has been a sharp rise in the number of small enterprises. The majority of these fall under the informal sector with very low-productivity activities aimed at the domestic markets (employment in non-agriculture informal sector, for example, almost doubled between 1986 and 1998). In 1998, total non-agriculture informal sector employment represents 65 percent of total non-agriculture labour force, with the formal non-agriculture sector accounting for only 35 percent. Investment in manufacturing did not respond to liberalisation policies until after 1995. Both foreign and domestic investments did not pick up sufficiently to lead to a surge of manufacturing growth of the kind that was experienced in the post-colonial growth era.

The period of import substitution that characterised the manufacturing sector in Zambia, with the lead assumed by state-owned enterprises, mainly ZIMCO (Zambia Industrial and Mining Company) and INDECO enterprises, left a legacy of inefficiency and technological backwardness. The level of technological capabilities (even when crudely measured in terms of levels of skills and indigenous entrepreneurship) was low too. In 1986[7], 55.3 percent of the employed population in manufacturing only had primary level (grades 1-7) education and 14.6 percent had no education. Only about 11.4 percent of the employed received any formal training (of which 3.2 percent had received some technical and industrial related formal training). These in combination with low investment in the early period of liberalisation could not substantially stimulate the newly privatised enterprises and the unprivatised ones, to quickly move to world manufacturing practices. In fact some of the newly privatised enterprises did not survive beyond a period of two years after privatisation. Other enterprises either closed operations before they were due for privatisation or were immediately liquidated by the state-owned privatisation agency, ZPA (Zambia Privatisation Agency). With the shift in economic policies, Zambia's domestic markets were exposed to the outside and many enterprises lost considerable market shares. In virtually all instances, the major reasons were non-competitive production costs and poor quality products.

The enterprises that have survived and the new ones have basically gone into resource-based activities that provide some comparative advantage. The large enterprises are producing products based on processing of local raw materials or products protected by high transport costs. The small and medium-sized enterprises are involved in the production of either localised goods or low-income goods. These activities are dominated by food processing, wood processing, simple metal products and textiles, with the exception of copper processing and the government-owned petroleum refining. One other feature of privatisation in Zambia is that a relatively small number of some newly privatised enterprises, although registered as manufacturing entities are actually either completely or partially involved in trading activities, trading representing a significant portion of their turnover.

The export of manufactured products remains significantly low and undiversified. Most of the growth in manufacturing comes from already established industries such as food, beverages and tobacco, textiles, leather products, and paper products. Capital-intensive activities such as chemical products, machinery and transport equipment, electrical machinery and equipment experienced a continued decline. Labour-intensive activities such as wood products also failed to take off significantly.

Labour and low skill-intensive industrial activities are clearly leading growth in manufacturing GDP. Their relative increase in manufacturing GDP reflects an expanding consumer market fuelled by a high rate of urbanisation. The decline in basic and fabricated metal products suggests a reduction in the reliance of manufacturing on the market provided by mining operations. Copper production (electrolytic) that was 698,100 metric tons in 1973 was only 291,000 metric tons in 1998 (CSO National Accounts, 1973 and 1998). Most enterprises were set up to supply the mines with construction materials and other fixtures.

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7 This is the year with the latest comprehensive labour force survey data.

## 4.4.4 Conclusion

The development of the manufacturing sector in Zambia is characteristic of that of many other developing countries in Africa (Ahluwalia, 1985; Collier and Gunning, 1999a and 1999b; Hill, 1996a and 1996b; Ndulu and O'Connell, 1999; Szirmai and Lapperre, 2001; Wangwe, 1995). After an initial period of growth soon after independence (in 1964), it stagnated, declined for most of the 1980s and, now, is marginally on the increase. The initial expansion was not sustained, as the sector did not make a significant and necessary transition from import substitution to export expansion. Worse still, the sector made little contribution towards meeting its own import requirements, nor did it contribute significantly to the diversification of the country's export base. Diversification is particularly important in view of the vulnerability of the Zambian economy to the world demand of copper and other mining products, because copper mining is the dominant economic activity. The current trend is that Zambia will continue to be a predominantly resource-based producer.

Structural changes have taken place within the sector, though the sector has not moved away from simple labour-intensive activities to more complex activities like steel products, machinery and transport equipment. Table 4-3 shows that the shares of these complex activities in manufacturing GDP have declined. Food, beverage and tobacco still dominate manufacturing in Zambia, and their importance is on the increase.

**Table 4-3: Structural change in manufacturing (shares in manufacturing GDP, %)**

| | 1964 - 1974 | 1974 - 1991 | 1991 - 1998 |
|---|---|---|---|
| Food, beverages and tobacco | 22.3 | 27.8 | 38.8 |
| Textile mill products | 1.9 | 7.7 | 11.0 |
| Wearing apparel | 3.7 | 2.5 | 1.5 |
| Leather products | 0.2 | 0.3 | 0.6 |
| Wood products | 4.9 | 4.0 | 6.2 |
| Paper, printing and publishing | 8.9 | 6.2 | 4.1 |
| Chemical products | 12.6 | 16.7 | 11.4 |
| Rubber and plastic products | 2.1 | 2.5 | 1.5 |
| Non-metallic mineral products | 13.9 | 6.8 | 1.6 |
| Basic and fabricated metal products | 20.7 | 13.8 | 16.0 |
| Machinery and transport equipment | 5.0 | 5.8 | 2.5 |
| Electrical machinery and equipment | 3.3 | 5.4 | 4.5 |
| Other manufacturing | 0.5 | 0.5 | 0.4 |
| Total | 100.0 | 100.0 | 100.0 |

*Source: Annex Table I.1.*

In the 1964-1974 period, the most important branches of manufacturing were food, beverages, tobacco, basic and fabricated metal products, and non-metallic mineral products. These together account for 56.9 percent of manufacturing GDP share. In the next period, 1974-1991, the leading branches are food, beverages and tobacco, basic and fabricated metal products, and chemical products representing 58.3 percent of manufacturing GDP share. The non-metallic mineral products are no longer an important manufacturing branch with their share in manufacturing GDP sliding from 13.9 percent in 1964-74 to only 1.6 percent in 1991-98. In the reform period, food, beverages and tobacco, textiles, and wood products account for 56 percent of manufacturing GDP share. Zambian manufacturing is dominated by low technology, labour-intensive activities. The capital and skill-intensive branches such as machinery and transport equipment, and electrical machinery and equipment that showed signs of growth in 1974-1991 period have gradually declined to below 1964-1974 levels with the decrease in public investment in these branches.

## 4.5 Productivity

### *4.5.1 Introduction*

In this section, a detailed analysis of real output and productivity levels in manufacturing (10+) in Zambia in national currency is presented.

The development of manufacturing in Zambia has been subjected to two major policy changes. The 1970s and 1980s were characterised by policies of industrialisation through import substitution and a highly state-led economy. This was briefly followed by attempts to restructure the manufacturing sector in the late 1980s. In the 1990s, liberalisation of trade and foreign investment was the main characteristic of the new industrial policies. Although this shift has brought fundamental changes in the economy, Zambia has not reduced its dependence on copper exports and the performance in manufacturing has not improved significantly. In export performance, for example, manufactured exports remain low (less than 15 percent of the total exports, f.o.b., in 1998).

In this section a growth accounting approach is used to examine the sector performance and to explain the sources of growth and stagnation. In this framework, the growth in manufacturing GDP can be viewed as a function of the growth in the volume of factor inputs and of the efficiency with which the factor inputs are used. The factor inputs are labour and capital. The efficiency with which the factor inputs are used is typically reflected in the changes in total factor productivity (TFP).

This analysis is necessary because of the importance of manufacturing productivity to industrial growth and its potential to contribute to an overall increase per capita income. Productivity plays an important role in determining the long-term success of the sector in combination with unit input costs, competitiveness on both domestic and export markets. Since manufacturing is the most dynamic sector of the economy, a deterioration in manufacturing productivity can significantly contribute to relatively low economic growth, high inflation and an unfavourable international balance of payment of the country (Bitran and Chang, 1984; Gullickson and Harper, 1987). A fall in the value of TFP, for example, has an effect similar to an increase in the unit cost of production. In this way, the analysis of the TFP index has a particular relevance to the study of price competitiveness of Zambian manufacturing, where the currency has already tended to be overvalued which, in turn, formed an impediment to the sector's expansion and export diversification.

Conceptually, the sector's productivity is measured in two ways. The manufacturing GDP can be gauged against all the input factors used to produce it or against a single input factor. The resulting measures are TFP and partial factor productivity. An improvement in TFP indicates an improvement in the overall process of efficient use of existing factor inputs either through improved management practice or better technology. TFP, therefore, holds far greater prospects for longer-term growth than partial productivity. The analysis of manufacturing performance is followed by an interpretation of the main results and a discussion of the limitations of the approach used.

## *4.5.2 The Data*

This section discusses issues related to the measurement of variables in the production function (equation 3.1, Section 3.2) and the properties of the underlying data. The censuses of industrial production for 10+ manufacturing are used as the basic sources of data. Given the importance of consistency in the definition of the branches of the sector, several approaches are used to maintain data comparability and consistency. Until 1967 census data in Zambia were published under a system of industrial coding. Then the specification of industrial activity was adopted corresponding to a specific ISIC (International Standard Industrial Classification of all Economic Activities) code, second revised version. Since there were sufficient detailed census data in the former system, it was possible to fully adjust backward all manufacturing data for the change to the ISIC coding. The industrial census publications that contained data on the value added, labour input and investment flows were the primary sources of time series.

### Manufacturing Output

Gross value added at factor cost (national accounts concept) was used as a measure of manufacturing output. The data pertaining to the calculation of manufacturing output were obtained from the censuses of industrial production. The data are on medium and large-scale establishments (i.e. establishments with 10 or more employees) in four-digit industry groups. The advantage of using census data is that census publications have information on labour, capital investments and gross value added data. This ensures that the coverage is the same for all the data sets. The use of the same sources also ensures that the data series are consistent.

The current values of gross value added at factor cost were then converted to values constant at 1990 prices using wholesale price deflators for each branch from the Zambian Central Statistical Office's national accounts. 1990 was chosen as the benchmark year. It was a relatively normal business year in Zambia and was used as a base year in national statistical data. Moreover, after 1990 the response to the census surveys by manufacturing establishments greatly declined as the pace of economic liberalisation accelerated.

There were, unfortunately, some years for which published census data were not available. For 1976-1979, for example, we extrapolated the series using national accounts data and adjusted them with ratios of output and value added in small establishments to output and value added in establishments with 10 or more persons engaged in 1975 and 1980. Proportions of net indirect taxes and subsidies to gross value of output from the input-output tables were applied to the gross value of output in the census. This provided an estimate of net indirect taxes and subsidies in the census that were used to deduct from the extrapolated census gross value added to give census gross value added at factor cost. The complete series are found in Annex Table I.1.

### Labour Input

For most of the series, census data on employment are used. These are persons engaged in the fifteen manufacturing branches. The employment figures are adjusted to include unpaid family workers that were found to be significant in some branches. For the years for which published census data were not available, we were able to make reasonably accurate estimates using the national accounts data, labour force survey data and the data from the yearly reports on employment and earnings. We adjusted these figures to exclude employment in small enterprises (with less than 10 workers), which are normally not covered in the Zambian manufacturing census using employment and value added ratios in the preceding and following census years of the missing periods.

An attempt was made to construct figures on the distribution of employment in terms of hours worked by operatives by branch. Figures are only available for the period from 1970 to 1975 and for the year 1980. We were further informed that the CSO had long discontinued the collection of hours worked by operatives from manufacturing establishments. So, because of insufficient data on hours worked, the number of persons engaged is used in the calculations of labour productivity.

### Capital Input

The measurement of capital input presents special problems in the study of manufacturing productivity. Following Jorgenson *et al.* (1987), the measurement of input of capital to production are the annual capital services, which are derived from the gross capital stock and the average lifetime of the capital goods.

The development of accurate estimates of capital stock is an important step in productivity analysis. Capital stock estimates, 1970-1998 were made according to the Perpetual Inventory Method (Goldsmith, 1955; Ward, 1976). Three types of assets were distinguished: buildings, machinery and equipment, and vehicles and other fixed assets. This distinction is important because each type of capital goods has its own marginal productivity and the changes that arise from the distribution of asset types are reflected in the aggregate capital services. The data requirements of the PIM are historical gross investment series at current prices, price indices to deflate current investments to constant base year values, estimates of asset service lifetimes or rates of depreciation, and a benchmark capital stock.

Data on investment flows for the three types of assets were obtained from the census records as far back as 1941. Real investments were assumed to be discarded according to a rectangular retirement pattern with lifetimes of thirty years for buildings, ten years for machinery and equipment, and five years for vehicles and other fixed assets. A 1970 benchmark stock and vintage, for practical purposes, is found to be suitable for Zambian manufacturing, whose first census of industrial production was only held in 1947. The estimates of lifetimes for the three types of assets used in this study are in line with lifetime estimates of capital goods used in studies in other developing countries (Timmer, 2000; also see Maddison, 1993).

The censuses of industrial production contain data on investment flows only as far back as 1955, measured in current values, although the first census of industrial production in Zambia was held in 1947. Since the aim was to use a fully-fledged perpetual inventory method to estimate gross capital stock, requiring a significantly long capital investment series, the investment flow series were extended backwards to the year 1941 using investment flows from sources other than the censuses of industrial production as follows.

Investment data between 1945-1954 from the National Income and Social Accounts of Northern Rhodesia (now Zambia) were used to derive gross investments in manufacturing. At that time, investment data for the total economy were classified under six nationally defined sectors, namely mining, wholesale and retail trade, local government, central government, railways, European agriculture and other industries.

It has been assumed that “other industries” comprises construction, electricity and water, and part of manufacturing. Then applying average gross investment and value added ratios for 1955 to 1959 to investment data between 1945-1954, the investment component for manufacturing in the total gross investments for “other industries” was obtained. This calculated component together with railways gross investments form manufacturing gross investments between 1945-1954. Again, applying branch average gross investment and value added ratios for 1955 to 1959, gross investments in manufacturing branches were also obtained. Finally, gross investment compositions between 1955 and 1956 were used to calculate investments into buildings, machinery and equipment, and vehicles and other fixed assets for 1945-1954. Investment data for buildings between 1941-44 were obtained by assuming that building investments between 1941-44 grew as fast as the average investment growth in 1945-47. CSO price indices for each type of asset were used to deflate the three asset types for each of the fifteen branches.

Since information on rental prices of the different capital assets (see Jorgenson *et al.,* 1987) was not available, we relied on the stock measures. It was assumed that annual capital services, the input of capital into production, were proportional to the aggregate capital stock.

It is interesting to note that although new equipment embodies technological improvements that improves its ability to generate more revenue, the CSO deflators are not completely adjusted for quality improvement in assets. The growth rates in capital stock obtained in this study are, therefore, lower than those that can be obtained with quality improvements of assets. The growth rates in TFP will, in turn, be higher because they will include the increases in the quality of the capital input.

## *4.5.3 Results*

### Capital and Labour Trends

In this section, an examination of the trends in employment, capital stock and GDP in manufacturing is made. The indices given in Figure 4-2 show considerable fluctuations in manufacturing output as well as in employment. Capital stock, on the other hand, has shown a clear decline after reaching its peak in 1977.

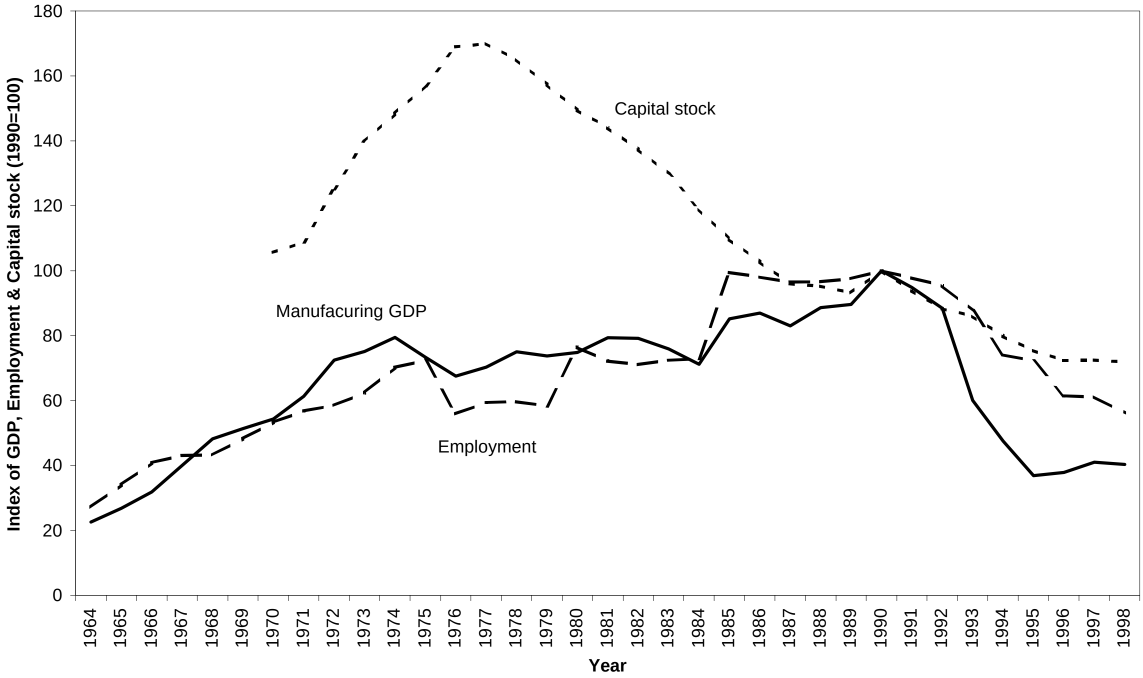


**Figure 4-2: Index of manufacturing GDP, employment and capital stock (1990=100), 1964-98**

*Sources: Annex Tables I.1, I.2 and I.5.*

During the whole period under consideration, manufacturing GDP increased at an average rate of 1.7 percent per annum, employment by 2.1 percent per annum. Capital stock (for the period 1970-98), however, decreased at 1.4 percent per annum. The trend of manufacturing GDP is clearly downward between 1990-95 around which proportionately large fluctuations occur.

Figure 4-3 illustrates the growth of each of the capital stock type in 1970-98. Perhaps the most striking observation from the figure is the steep decline in machinery and equipment capital stock. Since 1977, machinery and equipment capital stock has declined continuously without showing any cyclical patterns. This is because the year-to-year fluctuations in investment in machinery and equipment and scrapping are small in proportion to total machinery and equipment capital stock. Between 1970 and 1998, machinery and equipment capital stock decreased at an average rate of 4.6 percent per annum, but buildings capital stock and vehicles and other assets grew at an average annual rate of 1.0 percent and 0.8 percent respectively.

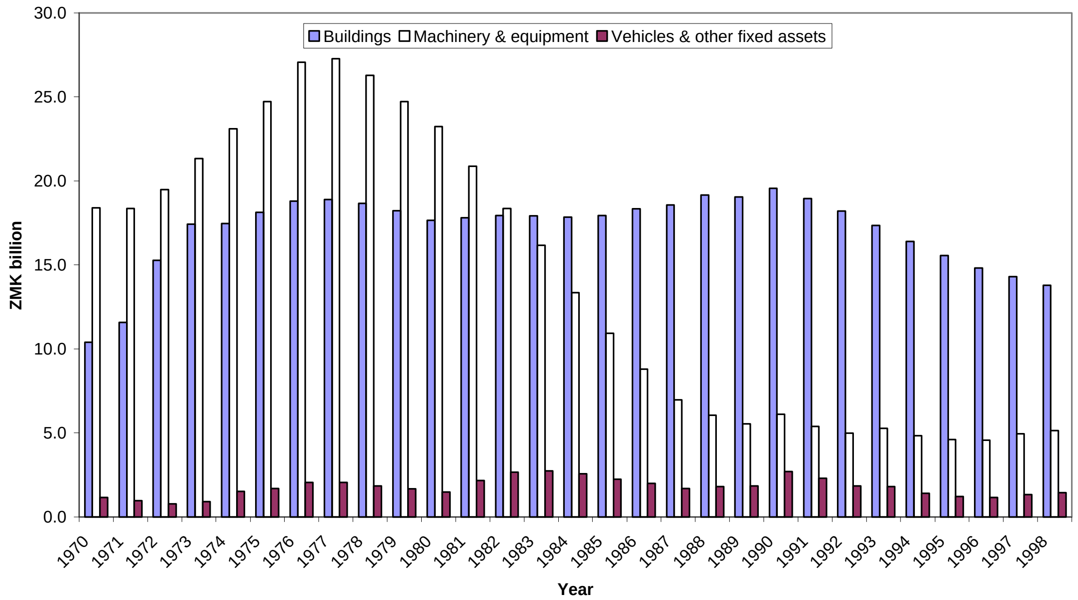


**Figure 4-3: Capital stock in Manufacturing, 1970-98 (1990 ZK billion, manufacturing establishments with 10 or more persons engaged)**

*Source: Annex Table I.5.*

## Capital and Labour Productivity

In Figure 4-4, we see that capital productivity in Zambian manufacturing has increased at a marginal rate (at an average of 0.3 percent per year), while labour productivity decreased at an average annual rate of 1.3 percent. The tracing of the series for labour productivity over the whole period under review (1964-98) shows that the average annual rate of –0.4 percent understates the change that marks this period, though the trend clearly is a downward incline most of the time. In the 1970s, the change in labour productivity index was relatively high and in the late 1980s it was relatively low. The reason for these large fluctuations is that employment grew relatively steadily throughout most of the years so that labour productivity reflects the fluctuations in manufacturing GDP. The two partial productivity indicators were at the lowest level in 1976 for capital and 1995 for labour. After 1995, they rose marginally, with labour productivity rising relatively faster than capital productivity. The sustained increase in labour productivity at an average rate of 11.3 percent per annum in the period 1995-98 at a time of continuous decline in employment (about –8.4 percent per year) and a growth in manufacturing GDP (2.9 percent per year) suggests that significant improvement in manufacturing technology together with a change in the organisation of production have not yet taken place. Most of the growth in labour productivity in this sub-period is due to employment decreasing at a rate higher than the rate of growth of manufacturing GDP. The growth in capital to labour ratio has declined steeply in Zambian manufacturing. This suggests a lack of pronounced capital deepening (average annual rate of –1.6 percent).

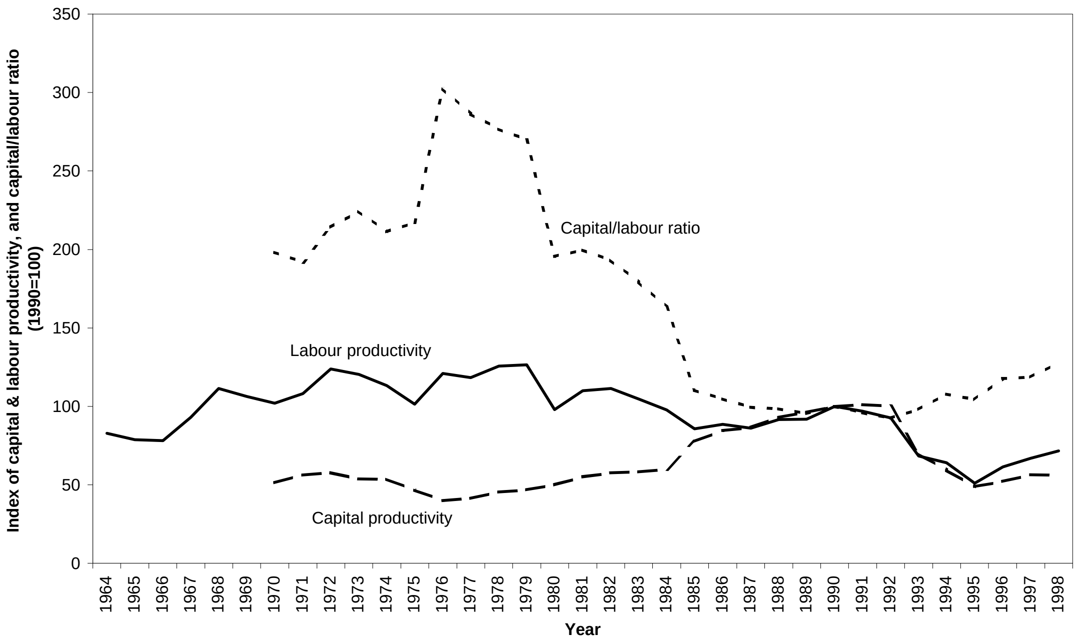


**Figure 4-4: Index of labour productivity, capital productivity and capital/labour ratio (1990=100)**

*Sources: Annex Tables I.1, I.2 and I.5.*

With regard to labour productivity, it was possible to estimate manufacturing performance since independence.

Table 4-4 presents the mixed fortunes of labour productivity growth in Zambian manufacturing. Zambian productivity rose quite significantly soon after independence in 1964. It reached a peak in 1972 and levelled off after this year (except for a deep dip in 1975). From 1979 to 1995 productivity declined very substantially, followed by some recovery after 1995. During the period 1964-74, Zambian productivity growth averaged 3.1 percent per year. This was followed by a real decline in productivity (-0.2 percent per year between 1974 and 1982, -1.5 percent per year between 1982 and 1991). This was followed by a further decline between 1991 and 1995 (-16.0 percent per year). After 1995 the decline eased off and manufacturing productivity increased by an average annual rate of 11.3 percent from 1995 to 1998. However, since this improvement in manufacturing productivity is recent, its effect on growth remains largely prospective.

A breakdown of labour productivity trends by branch is provided in Table 4-4. Productivity growth was highest in textiles and wearing apparel. Other branches with net gains over the whole period were food manufacturing and wood products. All other branches showed absolute declines relative to 1964 levels, most markedly in chemicals, non-metallic minerals and paper products.
Branches with higher initial levels of absolute labour productivity (such as machinery, chemicals and non-metallic minerals) had a clear tendency to stagnate over time. The relationship is especially marked after 1980. Higher levels of productivity in 1980 are negatively correlated with productivity growth, 1980-98. For the whole period the growth rate of the real GDP manufacturing per person engaged in manufacturing is -0.4 percent per

year (1964-98). In 1998, labour productivity stood at 86.5 percent of its 1964 level and 57.9 percent of its 1972 level.

**Table 4-4: Labour productivity levels by manufacturing branch, 1964-98 (1990=100)**

| | 1<br>Food | 2<br>Tex | 3<br>Wear | 4<br>Leat | 5<br>Wood | 6<br>Pap | 7<br>Chem | 8<br>Rub | 9<br>Mine | 10<br>Met | 11<br>Mach | 12<br>Elec | 13<br>Oth | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1964 | 86.9 | 34.4 | 69.7 | 195.5 | 122.9 | 107.8 | 138.0 | 42.0 | 90.0 | 120.4 | 32.6 | 28.1 | 161.5 | 82.9 |
| 1965 | 69.4 | 30.4 | 64.2 | 95.1 | 105.8 | 101.0 | 92.3 | 49.1 | 110.6 | 121.2 | 83.5 | 38.8 | 153.4 | 78.7 |
| 1966 | 73.3 | 24.9 | 59.2 | 157.8 | 144.6 | 105.4 | 80.3 | 30.7 | 88.2 | 128.4 | 64.8 | 45.5 | 113.4 | 78.1 |
| 1967 | 72.9 | 34.6 | 88.4 | 160.0 | 152.4 | 146.3 | 129.1 | 44.4 | 100.4 | 144.6 | 99.0 | 37.9 | 125.8 | 93.0 |
| 1968 | 62.7 | 41.5 | 78.7 | 124.5 | 186.1 | 224.2 | 159.3 | 73.5 | 127.8 | 224.4 | 99.2 | 46.2 | 91.5 | 111.4 |
| 1969 | 67.9 | 55.5 | 111.7 | 77.8 | 157.1 | 109.7 | 149.4 | 137.4 | 131.9 | 197.2 | 137.8 | 94.2 | 144.0 | 106.4 |
| 1970 | 72.8 | 35.0 | 127.1 | 65.1 | 141.8 | 142.5 | 96.6 | 98.4 | 134.5 | 187.3 | 142.5 | 76.0 | 131.4 | 101.9 |
| 1971 | 83.1 | 42.4 | 121.1 | 69.7 | 138.8 | 147.3 | 108.8 | 134.2 | 138.7 | 170.5 | 118.9 | 88.5 | 141.6 | 108.1 |
| 1972 | 87.3 | 49.7 | 143.7 | 120.8 | 127.9 | 195.2 | 174.2 | 123.2 | 175.1 | 155.9 | 147.6 | 113.0 | 124.8 | 123.8 |
| 1973 | 75.9 | 63.6 | 116.8 | 129.4 | 163.1 | 175.8 | 180.3 | 130.5 | 152.9 | 157.0 | 151.9 | 97.2 | 151.2 | 120.5 |
| 1974 | 60.4 | 59.1 | 117.2 | 145.5 | 188.7 | 168.4 | 153.8 | 97.2 | 173.6 | 149.0 | 156.3 | 118.8 | 148.0 | 113.1 |
| 1975 | 50.7 | 52.8 | 93.5 | 122.2 | 151.8 | 130.0 | 168.7 | 91.4 | 162.4 | 112.6 | 194.3 | 72.2 | 138.4 | 101.4 |
| 1976 | 81.9 | 97.4 | 131.6 | 148.8 | 193.4 | 137.0 | 231.6 | 117.3 | 101.1 | 69.0 | 219.4 | 110.3 | 167.2 | 120.9 |
| 1977 | 80.7 | 103.1 | 130.4 | 132.8 | 223.9 | 137.1 | 220.6 | 93.0 | 88.7 | 75.9 | 170.3 | 96.9 | 153.9 | 118.4 |
| 1978 | 81.7 | 104.3 | 133.4 | 155.6 | 214.2 | 158.8 | 219.9 | 89.7 | 116.0 | 89.3 | 157.9 | 96.7 | 148.4 | 125.7 |
| 1979 | 86.4 | 140.9 | 137.1 | 162.8 | 276.9 | 133.7 | 240.7 | 103.0 | 105.3 | 95.3 | 128.1 | 59.4 | 128.0 | 126.4 |
| 1980 | 52.9 | 124.1 | 127.0 | 133.6 | 229.1 | 98.0 | 169.4 | 75.4 | 139.5 | 85.5 | 128.2 | 62.3 | 207.9 | 97.9 |
| 1981 | 103.9 | 126.2 | 69.9 | 139.0 | 179.3 | 76.8 | 128.6 | 63.0 | 152.2 | 125.1 | 136.4 | 67.3 | 206.7 | 110.0 |
| 1982 | 110.8 | 133.2 | 72.1 | 113.8 | 158.7 | 63.1 | 99.3 | 46.6 | 145.5 | 157.0 | 149.3 | 74.7 | 186.3 | 111.4 |
| 1983 | 113.7 | 104.7 | 58.6 | 140.8 | 163.5 | 54.9 | 90.8 | 50.2 | 168.1 | 112.4 | 153.7 | 78.4 | 157.5 | 104.7 |
| 1984 | 118.7 | 96.3 | 56.7 | 80.7 | 149.2 | 51.2 | 38.1 | 37.6 | 75.6 | 177.9 | 125.7 | 83.0 | 262.3 | 97.7 |
| 1985 | 69.4 | 74.7 | 48.4 | 83.7 | 132.7 | 50.2 | 61.2 | 61.1 | 130.8 | 165.9 | 141.4 | 82.3 | 135.5 | 85.7 |
| 1986 | 72.3 | 62.7 | 44.2 | 67.1 | 128.3 | 63.0 | 61.5 | 61.4 | 102.5 | 189.9 | 145.3 | 108.2 | 138.4 | 88.6 |
| 1987 | 77.4 | 65.8 | 50.6 | 68.4 | 112.5 | 96.7 | 59.1 | 59.0 | 19.5 | 143.5 | 196.4 | 134.3 | 137.2 | 86.1 |
| 1988 | 87.6 | 67.1 | 56.3 | 68.4 | 105.0 | 103.3 | 56.9 | 56.9 | 63.4 | 144.4 | 188.7 | 131.2 | 137.5 | 91.7 |
| 1989 | 92.0 | 72.5 | 72.6 | 79.9 | 115.2 | 105.7 | 74.1 | 80.5 | 91.6 | 90.0 | 168.3 | 116.9 | 128.2 | 91.9 |
| 1990 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| 1991 | 115.5 | 61.6 | 63.0 | 124.6 | 115.4 | 92.2 | 86.0 | 50.2 | 44.3 | 128.5 | 94.7 | 99.5 | 111.3 | 97.0 |
| 1992 | 103.0 | 84.3 | 88.4 | 124.9 | 115.7 | 104.0 | 25.3 | 13.9 | 36.3 | 167.5 | 122.5 | 123.2 | 102.4 | 92.6 |
| 1993 | 59.9 | 56.6 | 61.2 | 119.6 | 105.8 | 46.5 | 106.2 | 57.6 | 21.4 | 76.9 | 77.4 | 72.9 | 54.9 | 68.4 |
| 1994 | 50.0 | 47.3 | 53.2 | 109.9 | 113.6 | 23.8 | 80.7 | 44.0 | 15.3 | 136.5 | 72.5 | 63.7 | 74.8 | 64.1 |
| 1995 | 71.1 | 51.7 | 66.9 | 115.0 | 119.0 | 16.0 | 25.8 | 14.2 | 13.9 | 79.5 | 31.0 | 15.9 | 38.1 | 51.1 |
| 1996 | 89.6 | 70.2 | 92.0 | 120.0 | 123.4 | 18.0 | 38.9 | 21.7 | 15.8 | 77.6 | 31.5 | 16.0 | 43.2 | 61.5 |
| 1997 | 95.0 | 89.7 | 95.7 | 124.3 | 130.1 | 24.9 | 36.7 | 20.9 | 11.8 | 98.2 | 30.8 | 15.1 | 40.2 | 67.0 |
| 1998 | 107.1 | 98.0 | 125.7 | 132.9 | 139.4 | 28.4 | 28.7 | 19.6 | 14.7 | 107.3 | 32.5 | 15.3 | 51.2 | 71.7 |

*Note: Food includes beverages and tobacco, pap stands for paper, printing and publishing, rub stands for rubber and plastic products, mine stands for non-metallic mineral products, met stands for basic and fabricated metal products, mach stands for machinery and transport equipment, oth stands for other manufacturing products (& precision).*
*See Annex Table V.1 for full Branch names.*
*Sources: Annex Tables I.1 and I.2.*

**TFP**

A growth accounting framework (Solow, 1957; Ghura, 1997; Timmer, 2000) is used to decompose value added growth into growth of labour input, capital input and total factor productivity. TFP growth is calculated as the difference between value added growth and the weighted growth of factor inputs. Annual sectoral factor shares[8] are used to weight capital and labour growth.

The TFP growth is given by (See Section 3.2)

$$\ln\frac{A_{t+1}}{A_t} = \ln\frac{Y_{t+1}}{Y_t} - \bar{g}_{t+1}\ln\frac{L_{t+1}}{L_t} - (1-\bar{g}_{t+1})\ln\frac{K_{t+1}}{K_t} \qquad (3.2)$$

Table 4-5 gives estimated rates of growth of output, input and TFP for five sub-periods, as well as their contributions to growth in percentage points. The average annual growth rate

[8] For annual contributions we take the average of shares in year t and year t-1. For sub-periods, we take the average of shares in all years of a sub-period.

of TFP from 1970 to 1998 was –0.1 percent. A closer look at the sub-periods reveals striking differences. TFP growth was positive from 1970 till 1991, reaching a respectable 3.5 percent per year from 1982 to 1991. Between 1991 and 1995 TFP collapsed, declining by no less than 17.3 percent per year. This was followed by an equally sudden upturn after 1995. While labour and capital inputs continued to shrink between 1995 and 1998 (at –8.4 percent per year and -1.6 percent per year respectively), TFP improved by 7.4 percent per year.

At branch level (see Annex Table I.7) there is considerable variation in productivity performance. In branches such as food products, textiles, leather products, and other manufacturing, the average annual growth in TFP was positive from 1970-1998, ranging from 3.6 to 9.0 percent. On the other hand, branches like rubber and plastic products, paper products, and non-metallic mineral products had extremely weak productivity performance. In these branches, growth in TFP was between –5.2 and –9.5 percent per year.

Growth in value added was highest in the first sub-period, 1970-74, primarily driven by rapid growth of capital. There was a minor positive contribution of TFP. After 1974, the capital stock started to decline, pointing to a process of net disinvestment in manufacturing that continued all the way up to 1998. Output growth was nil from 1974-82, sluggishly positive between 1982 and 1991, primarily due to improved total factor productivity. Between 1991 and 1995, manufacturing output literally collapsed, shrinking at 23.6 percent per year, with negative contributions of labour, capital, as well as TFP.

**Table 4-5: Growth of Factor Inputs, Value Added and TFP, 1970-98**

| Sub-period | Average growth rates and contributions to growth | | | | | | |
|---|---|---|---|---|---|---|---|
| | Value added | Labour | | Capital | | TFP | |
| | | *growth* | *contrib.* | *growth* | *contrib.* | *growth* | *contrib.* |
| 1970-74 | 9.5 | 6.9 | 2.8 | 8.5 | 5.1 | 1.6 | 1.6 |
| 1974-82 | 0.0 | 0.2 | 0.1 | -1.0 | -0.6 | 0.9 | 0.5 |
| 1982-91 | 2.0 | 3.5 | 1.4 | -4.2 | -2.6 | 3.5 | 3.2 |
| 1991-95 | -23.6 | -7.6 | -3.2 | -5.5 | -3.2 | -17.3 | -17.2 |
| 1995-98 | 2.9 | -8.4 | -3.5 | -1.6 | -0.9 | 7.4 | 7.4 |
| 1970-98 | -1.1 | 0.2 | 0.1 | -1.4 | -0.8 | -0.1 | -0.3 |

*Note: Contribution refers to percentage points of value added growth accounted for by growth of labour, capital or TFP.*

*Sources: Annex Tables I.1, I.2, I.5, I.6 and I.7.*

The very slow growth of TFP between 1970 and 1982 would seem to be related to the rapid accumulation of capital in the post-independence period. The efficiency of new investment was low and the manufacturing sector had considerable difficulties in assimilating new technologies embodied in imported new equipment.[9] Conversely, TFP growth accelerated in 1982-91, when growth of capital was negative, capital intensity declined and existing resources were used more intensively. 1991-95 was a transitional period of great uncertainty, company closures and liquidations and changes in ownership. It was also a

[9] On an annual basis, TFP growth was highly negative in 1973, 74, 75, 76 though this does not show in the period averages in Table 4-5.

period of labour retrenchment. Between 1995 and 1998, most manufacturing units earmarked for privatisation had been privatised. Although the decline in labour and capital input continued, output started growing again. As the surviving enterprises, especially the privatised ones, adopted and implemented programmes directed towards improving the efficiency of labour and capital, TFP also started growing again. Taken over the whole period, output declined by 1.1 percent per year.

### 4.5.4 Discussion and Reliability of the Results

The question of reliability of results often arises because of the large year-to-year variability observed in some of the productivity calculations. The growth rate in the sector total factor productivity varies between a high 12 percent in 1985 and a low -34 percent in 1993. Some of the variations can be accounted for by the trend in productivity. However, some of the seemingly large year-to-year changes observed, the largest being a loss in TFP from –3 percent in 1992 to –34 percent the following year may reflect a change in data coverage essentially due to a deterioration in the response to the industrial survey, as already pointed out. Some variation is due to some marginal errors arising from the estimates by the CSO to account for the non-responding units (usually the small ones). For the non-responding units, estimates were made on the basis of employment data from the Employment Enquiry and other relevant information on production, sales etc. available in the Industrial Statistics Section of the CSO. The relevant figures thus incorporated are likely to be biased upward in some years and downward in others, leading to some fluctuations. Another source of variations consists of improvements to basic industrial data made by CSO from time to time by making use of the data that became available from other sections of the CSO. What is not clear is whether the CSO makes such revisions on a regular basis.

Broadly defined indices at 2 to 3-digit levels were used to deflate current price values although more detailed indices would have been preferred. One could raise the question of the reliability of the deflators. The main thing that was done was to ensure that consistently defined indices were used.

The estimates of TFP are examined for individual years between 1970 and 1998 for each of the fifteen broad industries (see Annex Table I.7). Although the range of TFP estimates is wide in many industries, for example in food this varies between 20.5 (lowest level) in 1975 to 120.6 (highest level) in 1991, there is a high degree of consistency in the direction of the results.

Further examination of the annual changes in the nominal value added suggests that it is variability in output growth in some industries, especially after 1991, that is responsible for the instability in the TFP. Explanations for such variations in industry data arise from the relatively small number of firms in each industry in Zambia such that the extent of the impact arising from a plant opening or closing or from the unusually good or poor performance of individual firms is easily reflected in the industry performance. The results obtained in this study are, however, more reliable because of the extensive cross-checking with other sources and the use of reviewed and more recent data from the CSO.

Table 4-6 compares our findings with those of four other major academic studies of the performance of manufacturing in Zambia. In all cases, the trends in performance are very similar. For example, growth of manufacturing GDP in the period after independence is rapid. The shares of manufacturing in total employment and in total GDP were both on the increase between 1964-1977. All studies have a common finding that the decline in Zambian manufacturing set in in 1973-74.

**Table 4-6: Manufacturing performance (Fincham, 1980; Gulhati, 1981; Seshamani, 1989; Seshamani and Samanta, 1985; This study)**

| Year | Performance | Fincham | Gulhati | Seshamani | Seshamani & Samanta | This study[c] |
|---|---|---|---|---|---|---|
| 1964<br>1972<br>1977 | share of manufacturing GDP in total | 6.1%<br>13.6%<br>15.6%[1] | 6.8%[a]<br>11.5%<br>10.4% | 6.0%<br>14.0%<br>16.0% | *<br>*<br>* | 6.3%<br>13.9%<br>17.8% |
| 1964<br>1972<br>1977 | share of manufacturing employment in total | 7.8%<br>11.7%<br>11.0%[2] | *<br>*<br>* | 9.0%<br>*<br>11.0%[b] | 8.6%<br>11.8%<br>12.4% | 8.4%<br>12.0%<br>12.4% |
| 1965-77 | growth rate in manufacturing GDP | * | 6.7% | * | * | 8.0% |

*Notes:*

*(a) 1965.*

*(b) 1975.*

*(c) Sources for raw data: GDP, population and manufacturing share from National Accounts, Manufacturing statistics (10+) from the database of the Central Statistical Office (CSO) and Census of Industrial Production, various issues. Manufacturing data are deflated using Index Numbers of Wholesale Prices 1966=100.*

*(1) provisional data.*

*(2) preliminary estimates.*

** Data not available.*

## 4.6 Conclusion

The sectoral analysis of performance since 1964 has established that Zambian manufacturing suffered from increasing inefficiencies in an import-substituting and interventionist environment. After a period of output growth and labour productivity improvement till 1974, growth of output slowed down, labour productivity and investment declined, though TFP showed some fluctuation. In the period of liberalisation between 1991-95, output shrank dramatically, TFP collapsed and labour productivity continued to decline. After 1995 indicators of performance point to a modest recovery. We expect poor sector performance to be mirrored across establishments.

The analysis shows that input factors rather than advances in the level of productivity have been the dominant sources of manufacturing growth in Zambia in the sub-period 1970-74. It is only in the last part of the period of adjustment, between 1995 and 1998 that TFP became an important factor of output growth. Labour market distortions coupled with inefficient use of capital were the causes of the negligible growth of TFP in the 1970s and negative growth in the 1980s and early 1990s.

On the whole, these findings have at least two implications. The first is that the supply of labour is an important factor in maintaining and enhancing growth of TFP. The labour force growth in Zambian manufacturing began to decline significantly in 1991. This decline was sustained up to 1998. In 1991, the labour force declined by 2.2 percent, in 1993 by 8.5 percent, in 1994 by 16.4 percent, and 16.1 percent and 8.4 percent in 1996 and 1998 respectively. Over the 1991-1998 period, the decline in labour supply was 7.9 percent per year. At the same time, the average growth in capital factor between 1991 and 1998 was –3.8 percent per year. Against such a background, the growth in manufacturing GDP that is observed in the last part of the period of adjustment can only come about through policies and programmes in enterprises that are directed towards maintaining the efficiency of both the labour and capital markets.

The second implication is that the issue of efficiency of factor markets is linked to the issue of TFP because an improvement in TFP occurs as a result of an improvement in the way factor inputs are used. Since we used unadjusted labour input due to insufficient data on labour quality in the growth accounting exercise, the changes in TFP represent the cumulative effects of education and training of the labour force as well.

Finally, the gradual decline in manufacturing output and employment during the period under review is closely related to the general changes in the Zambian economy. Between 1980 and 1986, the economy was dominated by lower prices of copper, declining copper production output and falling incomes. This situation improved slightly between 1987 and 1989. The price of copper and foreign exchange earnings increased and copper production output remained stable. The extra foreign exchange was used to import additional raw materials and other intermediate inputs, and spares for machines and equipment. In turn real earnings also improved. This general improvement in the economy contributed to the small increase in manufacturing output and employment that was recorded. However, following the liberalisation of the Zambian economy in 1991, there was an unprecedented decline in manufacturing output and employment although the economy as a whole experienced a modest growth. A combination of low capabilities in the sector and low past investments in capital assets are suggested, by this analysis, to be the key factors that contributed to the sharp decline in manufacturing output.

# 5 Zambian Manufacturing Performance in Comparative Perspective

## 5.1 Introduction

Aggregate economic performance in sub-Saharan Africa remains weak in comparison with other developing regions. For example, since the 1980s per capita income in Africa declined by around 1 percent per annum. 32 countries are now poorer than in 1980 (Collier and Gunning, 1999a, b). Growth rates are well below the average for all low-income developing countries (e.g. Ndulu and O'Connell, 1999). Per capita GDP growth in sub-Saharan Africa between 1988 and 98 stood at –0.6 percent per year (for the whole of Africa at –0.2 percent per year)[10]. Slow growth in manufacturing, generally considered to be the most dynamic sector within industry, mirrored aggregate economic performance. The growth rate of manufacturing GDP for sub-Saharan Africa was 1.2 percent per year between 1990 and 1996, down from 2.1 percent per year between 1980-90 (1.5 percent per year, down from 4.2 percent per year for the whole of Africa for the same respective periods)[11]. In the nineties, many countries experienced a process of deindustrialisation in the wake of liberalisation. In 1998 manufacturing's share in GDP stood at 19 percent for the whole of sub-Saharan Africa.[12]

There is a wealth of studies in the development literature on sub-Saharan Africa providing empirical evidence of the unfavourable impact on industrial development of both domestic policies and circumstances, and external factors (Calamitsis *et al.*, 1999; Collier and Gunning, 1999a,b; Hadjimichael *et al*., 1995; Lall, 1990; Meier and Steel, 1989; Riddell and Coughlin, 1990; Wangwe, 1995). The main focus of these studies is on the analysis of trends in growth or stagnation of these sub-continent economies. Studies assessing the absolute size of manufacturing performance gaps of African countries in comparison with others are very scarce. This chapter makes a contribution to the literature by providing a desaggregated comparative quantitative analysis of growth in Zambian manufacturing.

This chapter focuses on one of the sub-Saharan African countries: Zambia. It has the purpose of putting Zambian performance into comparative international perspective by making benchmark comparisons of levels of real productivity (Yamfwa, *et al.*, 2001, in press). It presents a benchmark comparison of levels of real output and productivity in manufacturing for 1990 between Zambia and the USA, the world productivity leader. The benchmark comparisons provide empirical estimates of the size of the productivity and technology gaps between Zambia and the world productivity frontier. Benchmark comparisons and trend analysis are combined to provide estimates of relative productivity performance over time. The analysis of absolute and comparative productivity trends is intended to provide some insight into the mechanics of relative manufacturing stagnation.

[10] Source: World Bank African Development Indicators 2000, table 1-1.
[11] Source: UNIDO International Yearbook of Industrial Statistics 1999, table 1.3.
[12] Source: World Development Report, 1999/2000, table 12.

The main aim of this chapter is to come up with new empirical estimates of comparative productivity performance.

The benchmark study is part of a larger project on international comparisons of output and productivity (ICOP) being carried out at the Universities of Groningen and Eindhoven in the Netherlands and associated research groups elsewhere.[13] Along with Tanzania (Szirmai, Prins and Schulte, 2001) and South Africa (van Dijk and Szirmai, in press), Zambia is among the first countries from sub-Saharan Africa to be included in the comparative study. The study serves not only to put the Zambian manufacturing performance in comparative perspective with the world productivity leader, the USA, but it can also be used to make indirect comparisons of the manufacturing performance of the Zambian economy with other economies in the ICOP project.

The benchmark analysis is integrated with the real labour productivity and total factor productivity time series for the manufacturing sectors of both countries to allow interspacial productivity performance comparisons from 1964 to 1998. This is achieved by extrapolating with national time series of gross value added, the number of persons engaged and capital stock.

The methodology of the level comparison has been discussed in detail in chapter 3 (section 3.3.2). Figure 5-1 presents a simplified representation of the methods and procedures of the industry-of-origin approach, applied in the comparisons of the manufacturing sectors of Zambia and the USA. This representation is intended to guide the reader in subsequent and detailed discussions of the approach. There are several important methodological issues involved in the industry-of-origin approach (Maddison and van Ark, 1988; Timmer, 2000). Some of these are of general nature and others dealing with the specific empirical problems of the ICOP project. These include the representativeness of sample industries, the representativeness of sample of matched products, the differences in economic structure, and the comparability of census sources (i.e. data problems). All these represent potential sources of misinformation in the comparative study. These problems and their remedial actions are discussed in the chapter.

[13] For manufacturing the ICOP project by now covers over thirty-five economies in Eastern and Western Europe, North and South America and Asia.

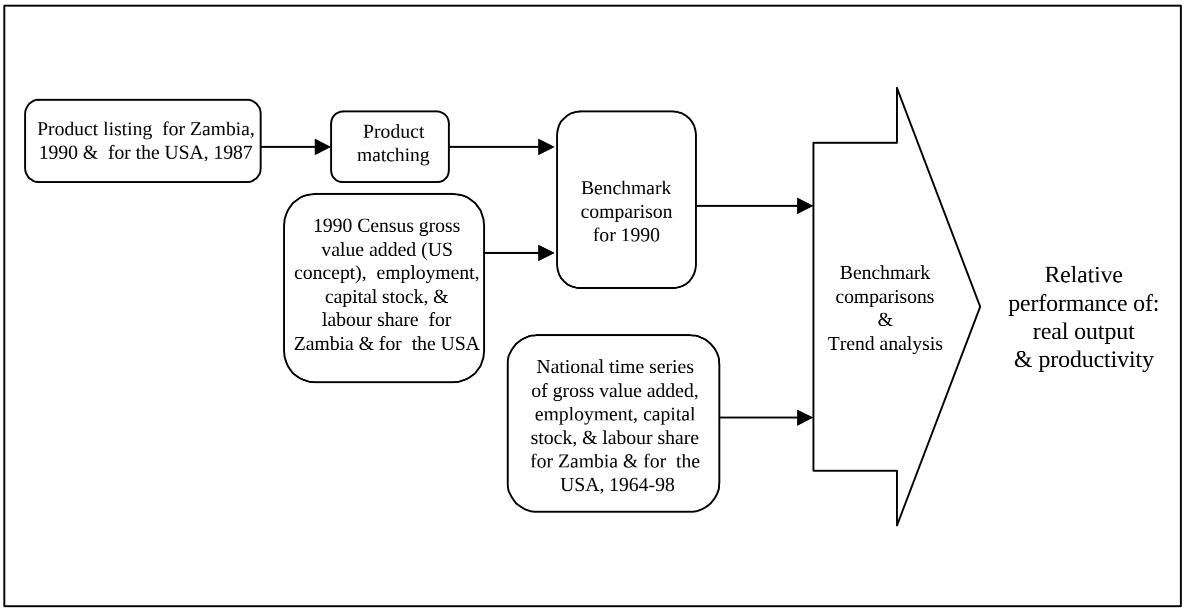


**Figure 5-1: Simplified representation of the industry-of-origin approach to international comparisons**

In the following sections data sources for 1990 are discussed. This is followed by a detailed discussion of the construction of the Zambian product listing from basic data, conceptual and empirical issues that arise from the comparison of the Zambian and US manufacturing. The subsequent sections are devoted to a discussion of the results.

## 5.2 Data Sources

### *5.2.1 Introduction*

The branch UVRs derived from matched samples of products from industrial censuses, can be applied to convert value added figures for branches derived either from industrial censuses or from national accounts. The comparisons in this study are based on census data. The data sources for Zambia and the USA are discussed in this section. Special attention is also paid to the difficulties encountered with some data from Zambia and how some of these data limitations have been overcome. 1990 is the benchmark year.

### *5.2.2 Zambia*

**Introduction**

The principal sources of Zambian data in our study are the *1990 Census of Industrial Production* and unpublished data files underlying the *Quarterly Returns of Industrial Production for 1990.*

The *Zambian Census of Industrial Production* is, in principle, held every year in the second quarter of the year. It covers all manufacturing establishments in the country with 10 or more employees. The census data are collected on a calendar year basis with few exceptions where data supplied is on a financial year basis. The financial year runs from 1st April to 31st March. Employment figures refer to the total number of persons employed on the last pay-day or last working day of the year. The Census classifies industries and branches of industry according to the 1968 United Nations International Standard Industrial Classification (ISIC). Each industry is basically defined in terms of its principal product(s) or service(s). The census report provides information on major characteristics of industries at two, three and four-digit ISIC levels. It does not list products or groups of products per se, and shows fewer details than the US census.

Our second source is the *Zambian Quarterly Returns of Industrial Production.* This is held every quarter of the year and covers a representative sample of 50 plus enterprises. The product class estimates in the *1990 Zambian Quarterly Returns of Industrial Production* are based on reports from a sample of about 290 manufacturing establishments, representing about 79 percent of the total gross value output of 10 plus enterprises.

### Product Listing

In part eight of the census survey questionnaire, establishments are requested to supply information on goods produced. This information includes a description of at most eight principal products, their units of measurement, quantities produced and their values at producer's prices. Product information is normally not published in the census report. Examination of the original census questionnaire forms revealed that most establishments had not provided the required information on their products.

Detailed information on individual products, their quantities and their output values was obtained from the unpublished establishment data files of the *1990 Zambian Quarterly Returns of Industrial Production*. In using unit values derived from the quarterly returns data, we assumed that they were representative for unit values for all establishments included in the census. Where possible, this assumption was checked and was found to be justified. Where unit values could be calculated from the census survey questionnaires, they were generally consistent with unit values calculated from the Quarterly Returns. Therefore, we felt justified in using the Zambia/US UVRs derived from the quarterly surveys on the Zambian side, to convert total value added and output in the benchmark comparisons.

The *1990 Zambian Quarterly Returns of Industrial Production* data files are organised on an establishment basis. They include data on about 290 manufacturing establishments. The results are published in such a way that the actual establishments cannot be identified. The information requested from manufacturing establishments is basically limited to employment, sales and production. The data files provide information on employment and payroll, and on production and sales for the four major products, during the quarter. The information on products includes a rough product description, units of measurement, quantities of output produced, the quantities and values of sales at producers' prices, and maximum quarterly production capacity. To obtain the value of output, production quantities were multiplied by the corresponding unit value derived from the sales data.

The product information was rearranged into one or more ISIC four-digit industries (1968 version, see UN, 1968) and combined with one or more ISIC four-digit industries from the US census (1990 version, see UN, 1990). The 1968 ISIC version was used as our working version in this study. Some products were reclassified to different ISIC categories in our listing because they were being produced as a secondary product by an establishment in another ISIC category.

Prior to using the unpublished quarterly returns product data, they were subjected to an extensive data screening process, involving a careful check of the raw data and of the unit value ranges of all product items. It turned out that the product lists are not always consistent from one year to another. The description of items is often vague and provides insufficient details for the matching with US products. The information on product quantity is often in terms of numbers with no specification of size, weight or quality. In some cases unconventional specifications (such as ‘dozens of glycerine’) are used. Comparison of establishment unit values for the same products revealed that sometimes values and quantities were expressed in the wrong units (Kwacha instead of thousands of Kwacha, in tons instead of kilograms). To improve the data, establishment data from the quarterly returns for 1990 were compared with those from other years, and where possible with census data as well. For some products, visits to local markets or producers were undertaken to improve on product descriptions. Consistency of data items was also checked by checking entered data against quarterly returns questionnaires and against census questionnaires (where such product details were available in the census questionnaires).

There were a few instances of establishments where quantities of output were available, but where unit values could not be calculated, because either the value of sales or the quantity of products sold was missing. In such instances, we used the average unit values of the same products produced by other establishments in the same industry, to compute the product gross value of output. If there was only one establishment in an industry, this establishment was eliminated in case of incomplete information. Other cases where establishments were eliminated from the study were instances of implausible fluctuations in gross output value from one quarter to another, unless it was possible to check these fluctuations back with the establishments concerned. Some entries were simply dropped because they were considered to contain erroneous or imputed data.

Quarterly output quantities of individual products and their output values were summed up to obtain annual output quantities and output values. First, annual product values per establishment were obtained by summing quarterly gross output values at current prices. Next, annual quantities and output values of establishments were summed, to get quantities and values per product.

In cases of establishments reporting production quantities for less than four quarters, further clarifications were also sought from the quarterly survey questionnaire forms and CSO on the production pattern of such establishments. The last part of the quarterly survey questionnaire the CSO specifically requests establishments to provide reasons for major changes in production from one quarter to another. Instances of major machine breakdowns, lack of raw materials, lack of foreign exchange were often attributed to lack of production in a given quarter - reasons that are acceptable to CSO. In such a quarter no sales or production were usually reported. Therefore, establishments that reported sales for less than four quarters and gave reasons for major changes in production from one quarter to another had their annual sales and production computed on the basis of reported quarterly sales and production.

In some cases CSO contacted the original establishments for clarifications with regards to the units and descriptions of products that were used in the survey questionnaires. Where available, additional product information from the census questionnaires was also used to improve product descriptions in the quarterly returns data. This process of checking and cross-checking both with the census data and with information from outside the census resulted in a highly improved and realistic listing of products, their values, quantities and unit values. From the establishment data files a list of 558 products and product groups was constructed using information from all four quarters of the year.

### Employment, Gross Output and Value Added

The data on gross output value, value added, employment and numbers of establishments by industry are derived from the *1990 Census of Industrial Production*. The output data refers to gross value of output at producers' price and includes indirect taxes and subsidies, while the US census data is at factor cost.

For the comparison between the Zambian census and the US census, the gross value of output in the Zambian census was adjusted to factor cost by excluding indirect taxes and subsidies. Since the gross value of output in the Zambian product listings also included indirect taxes and subsidies, the unit value ratios of the sample industries were also adjusted using sample industry proportions to exclude the effects of indirect taxes and subsidies. The Zambia census does not list the indirect taxes and subsidies separately, but it provides at four-digit industry level what is referred to as net indirect taxes. These are indirect taxes less subsidies.

With the help of more detailed information taken from the *1990 Zambian Census of Industrial Production*, it was possible to calculate a "US census concept" of value added (column 4 in Table 5-1). (The US Census value added is defined as the gross value of output at factor cost minus all intermediate inputs, except intermediate service inputs from outside the industrial sector. These service inputs include: bank charges and insurance costs, transport costs, communication services and cost accountancy, management and other professional services.)
The basic data for Zambia on gross output, gross value added and employment are presented in Table 5-1. Employment figures per industry in the Zambian census include all persons who work under the control of the establishment and receive pay (including owners and members of the owners' family if paid a definite wage or salary). They also include salaried managers and directors of incorporated enterprises, except when paid solely for their attendance at board meetings. Employment figures refer to the total number of persons employed on the last pay-day or last working day of the year.

Table 5-1 also gives the level of productivity in national currency. Food, beverages, tobacco and textiles products account for 51 percent of the total manufacturing value added and 47 percent of manufacturing employment. The combined productivity of food, beverages, tobacco and textiles products is above that of total manufacturing (ZK 225,271 per person).

The Zambian manufacturing sector has 434 manufacturing establishments with an average number of 178 employees per establishment.

Insert Table 5-1
Basic Data for Zambia, 1990

### 5.2.3 The USA

In the case of the USA, the *1987 and 1992 Censuses of Manufactures* (US Department of Commerce, 1990 and 1996) together with the *1990 Annual Survey of Manufactures* (US Department of Commerce, 1991) form the primary sources of data. The US Census of Manufactures is carried out on a quinquennial basis and gives detailed and comprehensive tabulation of economic activity in the manufacturing sector. The Annual Survey of Manufactures, on the other hand, is conducted in intervening years using a probability-based sample drawn from the census panel. The 1987 Census of Manufactures categorizes approximately 11,000 products according to the Standard Industrial Classification. For most products, the 1987 US census provides both the quantity and value information.

The matching of products from sample industries are based on the 1987 census. The resulting 1990/1987 UVRs are put on a 1990/1990 basis by dividing them by a 1987/1990 US price ratio for each product category from the Bureau of Labour Statistics (1998). In the subsequent calculations the 1990/1990 UVRs are used.

The *1990 Annual Survey of Manufactures* provides data on gross value of output, gross value added and employment by industry, in 1990. The product class estimates in the *Annual Survey of Manufactures* are based on reports from a representative sample of about 55,000 manufacturing establishments. The total manufacturing establishments with one or more paid employees is about 380,000. Since the Zambian census refers to establishments with 10 or more persons engaged, the US data requires adjustment to 10 plus basis. For this, we used proportions of 10 plus to gross output, gross value added and employment figures from the general summary of the 1992 census to adjust the US data to a 10 plus basis (tables 1-1b and 1-4 of the General Summary of the 1992 Census of Manufactures). Capital stock was not adjusted to a 10+ basis. An adjustment based on a constant capital output ratio would underestimate US capital intensity, as most small firms are far less capital intensive than larger ones. The absence of an adjustment means that US capital intensity is slightly overstated.
In the US census employment figures per industry exclude head office and auxiliary employment. US employment figures at branch level can, however, be readjusted to include head office and auxiliary employment using figures from the General Summary of the 1992 census.

The basic data for the USA are summarised in Table 5-2. In contrast to the Zambian manufacturing sector, the value added share of the ‘traditional industries’ (food, beverage, tobacco and textiles) is only 15 percent with an employment share of 13 percent. In the USA these branches combined have a productivity level 14 percent above that of total manufacturing (in Zambia this relative standing is at 9 percent above total manufacturing).

An average US establishment has only about 90 employees, representing 50.5 percent of the Zambian average employment per establishment.

Insert Table 5-2
Basic Data for the United States, 1990

### 5.2.4 Conceptual and Data Problems

This section summarises the conceptual problems and data adjustments involved in the comparison between the Zambian census and the US census.

*1. Adjustment of Zambian data to US census concept of value added*
The US census concept of gross value added does not deduct the cost of services received from outside the manufacturing sector. The Zambian census value added has been adjusted to include the cost of non-industrial services received. After this adjustment and the adjustment for indirect taxes and subsidies under (3), the two value added concepts are consistent.

*2. Adjustment of 1987/1990 UVRs to a 1990/1990 basis*
The original unit value ratios are calculated using the 1987 US census data and the 1990 Zambian census and survey data. To put them onto a 1990-1990 basis, 1987-1990 US producer price indices are used to adjust each product UVR. Price indices by product category for the USA were obtained from the US Bureau of Labour Statistics (1998).

*3. Adjustment of Zambian data to factor cost*
The gross value of output in the Zambian product listing includes indirect taxes and subsidies, while the US product listing is at factor cost. This means that the unadjusted UVRs are biased upwards. The Zambian census, however, provides information on indirect taxes and subsidies at four-digit industry level. Using the sample industry proportions, sample industry UVRs have been readjusted in order to exclude the effects of indirect taxes and subsidies.

*4. Adjustment of coverage of US data to 10+ establishments*
The Zambian census data used in this study cover all establishments with ten or more persons engaged. The US employment and output data for 1990 have been adjusted to a ten plus basis, using proportions from the 1992 census. US employment figures at branch level have been readjusted to include head office and auxiliary employment using figures from the General Summary of the (1992) census. After these adjustments the employment concepts are consistent. As explained in the previous paragraph, the US capital stock has not been adjusted to a 10+ basis. Therefore, comparative Zambian capital intensity will be slightly understated.

*5. Lack of data on small scale and informal sector*
The Zambian census data do not include the small scale and informal sector. In most developing economies the small scale and informal sector is typically more labour intensive than the formal sector and its inclusion would most likely lower the productivity of the total

Zambian manufacturing. However, given high levels of overmanning in the Zambian formal sector, one cannot be certain whether inclusion of the small-scale informal sector would substantially lower the comparative productivity level of total Zambian manufacturing.

*6. The quality issue*
The quality issue is important in comparing products between a developing and an advanced economy. The quality of both more homogeneous intermediate products (such as basic chemicals) and consumer goods in Zambia is generally lower than that in the USA. Where possible we have tried to account for quality differences by matching the Zambian products with the lower quality segments of the US product listing. However, usually the Zambian product descriptions did not always allow for such adjustments. Often, a few roughly described Zambian products had to be matched with a cluster containing large numbers of specific US products. For example, in the grain milling industry, 26 kinds of US prepared feeds were matched with one type of Zambian stock feed. We may safely assume, therefore, that the UVRs are biased downwards. Conversely, this implies that the productivity comparisons reported in this study are an upper bound.

### 5.2.5 Number of Matches and Coverage

The total number of sample industries within which matches have been made is 23, representing 12 out of 15 major branches of manufacturing. The most important Zambian manufacturing branch, food manufacturing, is represented by 8 sample industries. All the other branches had one sample industry, except for beverages and chemicals. No matches were made in rubber and plastic products, electrical machinery and equipment, and other manufacturing industries. For these branches, we used the calculated UVRs for total manufacturing based on the 12 branches for which there were sample industries.

In total, 91 product matches have been made equalling 15.5 percent of the US gross output value and 42.4 percent of the Zambian gross output value. For Zambia, this coverage is calculated as the ratio of matched gross output value obtained from the quarterly returns to the census gross output value in 1990. The US coverage ratio is comparable with that found in previous ICOP studies (e.g. van Ark, 1990; Kouwenhoven, 1996; Timmer, 1998). The lower coverage on the US side can be attributed to the fact that the comparison is between a very large and highly diversified industrial sector and a small one. Zambian manufacturing also suggests a bias towards traditional manufacturing industries in the sample industries.

Although no matches could be made in some branches (such as rubber and plastic products and other manufacturing), ICOP studies indicate that the results for manufacturing as a whole are rather robust and do not vary substantially with the inclusion of further matches when a large number of matches has already been made (Szirmai, 1994).
Notwithstanding the data limitations discussed above, the study yields useful first estimates of Zambian manufacturing performance in comparison with the USA. It can also be regarded as a further step in what may be considered as an ongoing process in understanding the manufacturing dynamics in sub-Saharan Africa.

## 5.3 Results

### 5.3.1 Unit Value Ratios

The conversion factors used in this study are based on a sample of unit values for value of gross outputs of comparable products and product groups between Zambian and the USA. Table 5-3 presents the resulting unit value ratios. The aggregate Fisher UVR for total manufacturing is ZK 49.15 to the US dollar, somewhat lower than the exchange rate of 50.00[14]. The relative price level is 0.98.

Of greater interest are variations in relative price levels across branches. The aggregate UVR conceals great differences from branch to branch. On average, the UVRs for the branches for which product matchings were achieved differed by about 24 percent from the average UVR for total manufacturing.[15] The highest UVRs are in chemicals, petroleum and coal products (94.42) and in paper, printing and publishing (75.79). Here relative price levels are far above the exchange rate, indicating considerable lack of competitiveness in these sectors. The lowest UVRs are in wearing apparel (21.68) and in beverages (26.40), far below the exchange rate, indicating potential price competitiveness in these sectors.

The UVRs at Zambian quantity weights are lower than the UVRs at US quantity weights. This is an example of the familiar Gerschenkron effect (Gerschenkron, 1962), which operates when comparing a low-income economy to a high-income economy.

The products that are relatively cheap and common in a high-income country such as the USA are likely to be expensive and rare in Zambia. On the other hand, products that are cheap and common in Zambia are likely to be rare in the USA. The net effect of the above is that matches with high unit values will have high quantity weights in the US and low quantity weights in Zambia. Matches with low unit value ratios will, however, receive low weights in the USA and high weights in Zambia. The differences in industrial structure account for the divergence in UVRs.

Insert Table 5-3
UVRs and Price Levels

### 5.3.2 Production Structure

Table 5-4 shows levels of gross value added using the US census definition and UVRs as converters. The gross value added data in national currencies are obtained from Tables 5-1 and 5-2 and converters from Table 5-3. The gross value added level of Zambia

[14] In international publications (such as the world tables published by the World Bank) the Zambian Kwacha is highly valued against the US $ than in national publications.

[15] The average percentage deviation of branch UVRs from the total manufacturing UVR is computed by weighting the percentage difference for each branch by the gross value added in Zambia and by gross value added in the USA when Zambian and US quantity weights were used respectively.

manufacturing sector is as little as 0.029 percent of that of the USA (geometric average). There is, however, a sharp contrast with the relative size of employment. The Zambian manufacturing employment level is 0.49 percent of the US level. The ‘traditional industries’ have a significantly high level of gross value added relative to the USA, whereas the ‘skill and technology-intensive’ industries are almost absent. Beverages and tobacco products, in particular, have a comparatively high level of gross value added relative to the USA (0.195 percent). This branch is followed by textile mill products (0.192 percent) and food manufacturing (0.097 percent). From the above it is possible to observe that the Zambian industrial structure is dominated by industries producing consumer goods with low income elasticities, such as food, beverage, tobacco and textiles.

Insert Table 5-4
Gross Value Added (US Census Concept), by Major Manufacturing Branch, Zambia/USA, 1990

### *5.3.3 Productivity Comparisons*

The converted branch value added from Table 5-4 and employment data in Tables 5-1 and 5-2 have been used to derive labour productivity comparisons in Table 5-5.
Table 5-5, thus, presents the estimates of both comparative and absolute levels of productivity for manufacturing branches. Absolute productivity refers to the average gross value added per person engaged, while the comparative productivity measures the ratio of labour productivity of the economies in the binary study. The first column of Table 5-5 presents Zambian gross value added per person employed in Kwacha for 15 manufacturing branches in 1990. It is converted to US dollars using the UVRs at Zambian quantity weights (column 4). In similar fashion, US gross value added per employee in column 5 is converted to Zambian Kwacha on the basis of UVRs at US quantity weights (column 2). At Zambian prices the gross value added per person engaged is 4.0 percent of that in the USA, and at US prices it is 8.5 percent of the USA. The last column of Table 5-5 shows the geometric average of the productivity ratios at Zambian and US price weights per person engaged. The aggregate productivity in Zambian 10+ manufacturing is 5.9 percent of the US level.

There are striking differences in the levels of comparative labour productivity across branches. The lowest labour productivity is found in Zambian chemicals products (1.8 percent the US level), leather products and footwear (2.1 percent), followed by paper and printing products (4.1 percent), and other manufacturing industries (4.3 percent). In Zambia, the extremely low relative productivity in chemical products, leather products and footwear can be explained by the high level of manning of production processes in combination with low mechanisation. Highest productivity is found in textiles.[16]

16 The relatively high level of productivity in electrical machinery and equipment, and rubber and plastic products needs to be interpreted with caution since the reliability of their unit value ratios is not very robust.

In theory, part of the aggregate productivity gap between Zambia and the USA might be explained by relatively low employment shares of Zambian manufacturing in activities with higher absolute productivity levels, such as electrical machinery and equipment, and rubber and plastic products. Following Timmer and Szirmai's approach (1999), we investigated the structure effects on the relative productivity level by decomposing the difference in labour productivity level at aggregate level for the benchmark year into that due to structural differences between Zambia (ZA) and the US (US) and that due to simply intra-branch productivity differences. The difference in labour productivity levels at the total manufacturing level *($LP^{US}$-$LP^{ZA}$)* was decomposed as follows:

$$LP^{US} - LP^{ZA} = \sum_{i=1}^{n}(LP_i^{US} - LP_i^{ZA})\tfrac{1}{2}(S_i^{ZA} + S_i^{US}) + \sum_{i=1}^{n}(S_i^{US} - S_i^{ZA})\tfrac{1}{2}(LP_i^{ZA} + LP_i^{US}) \quad (5.1)$$

where

*LP* is labour productivity level, $S_i$ the branch share in employment and *i* the number of branches (*n* = 13). The first terms in equation (5.1) represent intra-branch productivity differentials and the second terms differences in the structure of employment.

For 1990, it was found that almost all of the aggregate productivity gap between Zambia and the USA is explained by intra-branch productivity differentials rather than structure effects. The intra-branch productivity differentials explain 100.5 percent of the difference between Zambia and the USA, while the remainder (-0.5 percent) is explained by their employment structure. In sum, the difference in the structure of employment between Zambia and the USA, relative to intra-branch differences, is unimportant in explaining the productivity gap between the countries. This is an interesting finding in the sense that it rejects the commonly held hypothesis that factor inputs in LDCs are usually concentrated in branches of the sector with relatively low levels of labour productivity while labour is concentrated in capital-intensive industries with higher labour productivity levels in DCs, thereby making the structural difference between Zambia and the USA an important factor in explaining the labour productivity gap.

A further investigation into the sources of the productivity gap focuses on differences in capital intensity, using the total factor productivity analysis. We assume a Cobb-Douglas production function. In line with the method used to construct national TFP growth series (Solow, 1957), benchmark estimates of TFP can be constructed to show the impact of the differences in capital intensity on labour productivity difference. For the benchmark year, the relative level of gross value added per person for Zambia (ZA) and the USA (US) for establishments with 10 or more persons engaged is given by the relation (Timmer, 2000)

$$\ln\left(\frac{Y_{ZA}/L_{ZA}}{Y_{US}/L_{US}}\right) = (1-\bar{g}_{ZAUS})\ln\left(\frac{K_{ZA}/L_{ZA}}{K_{US}/L_{US}}\right) + \ln\left(\frac{A_{ZA}}{A_{US}}\right) \quad (5.2)$$

where

*Y* is the gross value added, L is the number of persons engaged, K is the gross fixed capital stock, A is the total factor productivity level and $\bar{\gamma}$ is the unweighted average of the labour share in gross value added in Zambia and the USA. From the above equation it can be seen that the relative TFP level is in fact the difference between the relative labour productivity level and the relative capital intensity level multiplied by the average capital share in value added.

The relative capital intensities in equation (5.2) have been estimated by converting the capital inputs of both countries into international dollars, using purchasing power parities for domestic capital formation from the Penn-World Tables Mark 5.6 (Summers and Heston 1991; Timmer, 2000). The capital inputs for Zambia derive from our capital stock estimates in section 4.5.2, the sources for US capital inputs are stock estimates by Ark and Pilat (1993), Ark (1999), Timmer (2000) and the OECD National Accounts.

In 1990, relative capital intensity in Zambia is 8.0 percent of the US level and relative TFP is 16.7 percent of the US level (Table 5-6). Thus, Zambian relative capital intensity is extremely low. The relative TFP level is one seventh of the US level, which though low is somewhat higher than expected. Given the value of $\bar{\gamma}$ is of 0.58, differences in capital intensity explain 37 percent of the labour productivity gap (Table 5-7). The remainder is due to differences in output per unit of input, indicating among others, differences in efficiency of the use of factor inputs and differences in technological levels. Efficiency of input use is determined by a variety of factors, many of them external to manufacturing, such as availability of infrastructure, intermediate inputs and foreign exchange. These external factors affect TFP primarily via capacity utilisation.

Insert Table 5-5
Gross Value Added (US Census Concept) per Person, Zambia and the USA, 1990

Insert Table 5-6
Comparative Capital Intensity and TFP, Zambia and the USA, 1990

Insert Table 5-7
Percentage Explained of Difference in Labour Productivity, Zambia and the USA, Total Manufacturing, 1990

### 5.3.4 Comparative Productivity Trends

The benchmark estimates of comparative labour productivity and comparative capital intensity are extrapolated with national time series in constant prices of gross value added, capital stocks and the number of persons engaged. In theory, deflating the nominal value added series by an output price index is valid if the price of material inputs relative to the price of output is more or less constant for the period of analysis. For Zambia, the combination of the lack of separate output and material input deflators and the high sensitivity of the double deflation procedure to measurement errors (Hill, 1971; Timmer, 2000) lead to the use of the more reliable single deflation method. Comparative TFP trends are estimated using shifting annual factor shares of the two countries. As in equation (5.2), relative capital intensities have been weighted by the average of US and Zambian capital shares. Here, however, each year's capital intensities are weighted by that year's average capital shares.

The capital intensive nature of the Zambian industrialisation drive of the sixties and seventies is illustrated by the high relative capital intensities found prior to 1977. After that year capital intensity declined dramatically. Figure 5-2 indicates that the Zambian economy is at a very low level in terms of both relative labour productivity and TFP. Relative labour productivity rose to its highest level in 1968 and 1972 and thereafter declined to its lowest level in 1995. The TFP level has remained well below 20 percent of the US level. Between 1982 and 1991 the comparative TFP level first declined then recovered, fluctuating between 14.9 and 18.1 percent. Labour productivity showed a net decline. The movement in TFP is associated with the long-run decline in both absolute and relative capital intensity in Zambia, since 1976/7. Investment in equipment and machinery was particularly low in the 1980s. As a result, there was more intensive use of existing resources during this period, manifesting itself in some improvement in comparative TFP performance in the second half of the eighties. After 1991, the TFP level collapsed. This collapse coincides with the privatisation of manufacturing units in Zambia.

It should be remembered that during the period of expansion (i.e. between 1968 and 1970) the Zambian government implemented industrial policies the essence of which was to encourage industrial development mainly through mining and manufacturing with the parastatals performing a central role under the principle of state participation in these sectors. As a consequence of these policies, by 1992, ZIMCO and INDECO (units for state participation and control in major industries), as holding companies for manufacturing parastatals, accounted for 90 percent of non-mining industrial production. On 3rd July 1992, an Act of Parliament was passed to provide for the privatisation and commercialisation of state-owned enterprises, in order to redress the problem of poor performance of these companies that lived off the huge financial subsidy outlays that went to support them. By that time, the industrial sector itself was characterised by underinvestment in capital assets. Investment in equipment and machinery was particularly low in the 1980s. Improvement of labour productivity and sustained TFP growth, however, requires fresh investment into assets, and improved industrial and financial viability of the sector. So, after 1991, real productivity continued to go down steeply. It should also be noted that in the nineties the productivity performance in the US improved markedly under the impact of new technologies, further increasing the relative productivity gap.

With the relaxation of the regime of trade and payments, the freeing of exchange and interest rates, the reduction in the extent and coverage of commodities covered by price controls, and the increased domestic and foreign private sector competition from 1992 onwards, several inefficient companies closed down. TFP plummeted between 1992 and 1995, both in absolute and relative terms. A slight pick up in both TFP and real productivity is evident between 1995 and 1997 as investment in capital assets also improves and GDP starts growing again.

There are two striking features of Zambia's comparative productivity performance. First, the level of productivity in Zambia is significantly lower than that for the US. Secondly, the productivity differential has increased over more than two decades.

Annex Table III.1 provides sectoral detail on comparative productivity trends. It shows that labour productivity is very low compared to the USA in all Zambian industries. Relatively higher productivity is found in electrical machinery and equipment and textiles. Zambian manufacturing is dominated by traditional industries with low productivity. Food,

beverages, tobacco and textiles products account for 51 percent of the total manufacturing value added. When Zambian industries are matched with the US, factors like comparative levels of capital stock per engaged person, labour and management quality, economies of scale both at firm level and industry level, and ownership types are plausible explanations for the comparative low productivity.
Over the whole period, Zambian manufacturing is marked by a pattern of relative stagnation and declining labour productivity. In this respect it differs markedly from economies in South and East Asia prior to the Asian crisis. These economies either experienced rapid productivity catch up, such as Taiwan and South Korea, or experienced long periods of productivity growth at the same rate as the US, followed by some relative improvement in the nineties, as was the case in India, Indonesia and China (Timmer and Szirmai, 1999).

Finally, it should be emphasized that declining labour productivity is to be expected when labour surplus economies start producing more labour intensively in line with their comparative advantage. From an economic perspective, there is nothing intrinsically wrong with low labour productivity in the short run. In the long run, however, increasing standards of living directly depend on the capacity to improve output per worker.

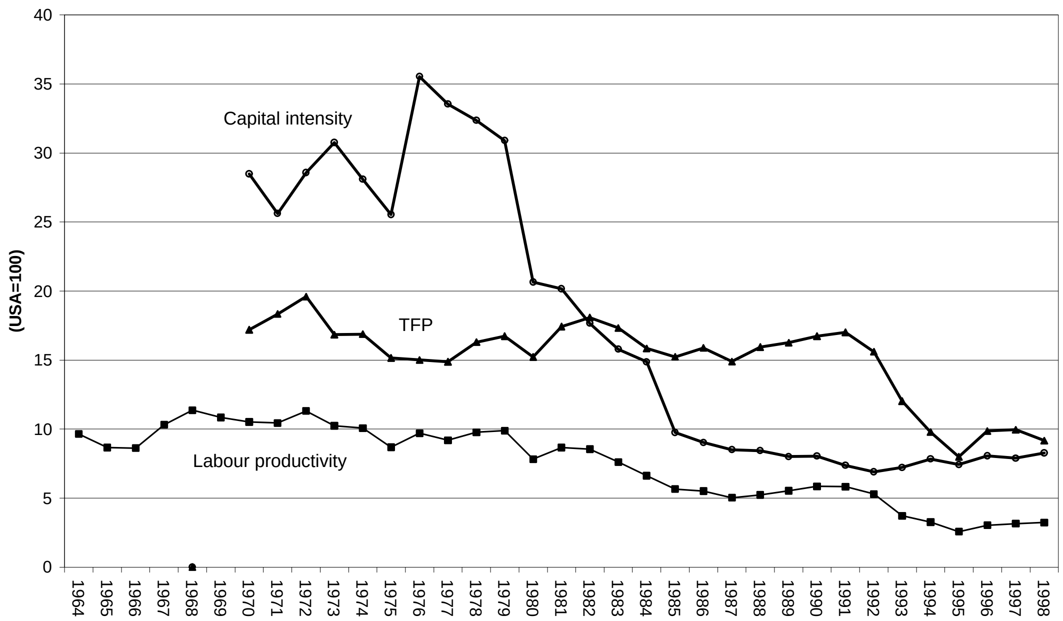


**Figure 5-2: Relative Labour Productivity, TFP and Capital Intensity in Zambian Manufacturing, 1964-98 and 1970-98 (10+ establishments) (USA=100)**

*Source: Annex Tables III.1, III.2 and III.3.*

## 5.4 Conclusion

This chapter set out to determine the economic performance of the Zambian manufacturing sector in comparative perspective. Labour productivity is used as the main performance indicator to assess the performance gap between Zambian manufacturing and that of the USA. The estimates in this study show aggregate real labour productivity in the manufacturing sector in Zambia to be 5.9 percent of that of the USA, in 1990. However, considerable relative productivity variations can be noted between branches. The chemical products branch has 1.8 percent of the US level (the lowest) while electrical machinery and equipment has 11.8 percent, and textiles 12.7 percent.

The results confirm the existence of an enormous technology gap between Zambia and the world productivity leader, the USA. The low level of manufacturing productivity in Zambia is entirely due to the low levels of relative labour productivity within the branches of manufacturing, rather than to differences in the structure of manufacturing between Zambia and the USA. The productivity gaps are explained by low capital intensity and a relatively inefficient use of factor inputs.

The ratio of real output per worker in the Zambian manufacturing sector is significantly lower than that of Asian developing economies such as India, China and Indonesia (Timmer, 2000), though marginally higher than the labour productivity in the Tanzanian manufacturing sector (Szirmai, Prins and Schulte, 2001). Interestingly, (comparing with Timmer, 2000) the results for Zambia's performance were above the results for China, India, and Indonesia before 1973. The trend in comparative Zambian labour productivity points to an increase in the technology gap over time. However, while comparative productivity in Asian economies was stable or improved.

Although considerable efforts were made to improve data quality and coverage, there still are some limitations to this study. The present comparison of the two countries' economic performance is based on a small sample of UVRs, which were used to convert output to common currency. The relative productivity levels obtained in the study are an upper bound. It is likely that adjustments for quality differences and inclusion of the 'unregistered' small-scale manufacturing sector would likely lead to even lower outcomes in terms of relative productivity performance.

**Table 5-1: Basic Data on Output, Employment and Productivity for Zambia, 1990 (Establishments with 10 or more persons engaged)**

| | Number of Establish-ments (1) | Gross Value of Output at factor cost (mill. ZK) (2) | Gross Value Added at factor cost (National Accounts concept) (mill. ZK) (3) | Gross Value Added at factor cost (US Census concept) (a) (mill. ZK) (4) | Gross Value Added in Branch as % of Total (5) | Employment (b) (persons) (6) | Employment Share in Branch as % of Total (7) | Gross value added per person employed (US Census concept) (ZK per person) (8) |
|---|---|---|---|---|---|---|---|---|
| 1 Food Manufacturing (311/12) | 105 | 8,510.8 | 3,397.3 | 3,995.2 | 23.00 | 21,213 | 27.51 | 188,337 |
| 2 Beverages (313) | 15 | 2,031.7 | 162.4 | 1,267.4 | 7.30 | 3,926 | 5.09 | 322,816 |
| 3 Tobacco Products (314) | 3 | 2,072.0 | 1,534.7 | 1,648.2 | 9.49 | 1,282 | 1.66 | 1,285,615 |
| 4 Textile Mill Products (321) | 31 | 3,459.5 | 1,677.5 | 1,867.4 | 10.75 | 9,451 | 12.26 | 197,585 |
| 5 Wearing Apparel (322) | 34 | 817.1 | 265.6 | 275.4 | 1.59 | 4,188 | 5.43 | 65,769 |
| 6 Leather Products and Footwear (323/324) | 4 | 52.2 | 36.6 | 38.2 | 0.22 | 1,260 | 1.63 | 30,278 |
| 7 Wood Products, Furniture & Fixtures (331/2) | 24 | 827.1 | 432.8 | 444.4 | 2.56 | 6,576 | 8.53 | 67,574 |
| 8 Paper Products, Printing & Publishing (341/2) | 35 | 1,948.6 | 1,025.4 | 1,127.0 | 6.49 | 4,700 | 6.10 | 239,778 |
| 9 Chemicals Products (351-53) | 38 | 6,699.2 | 1,883.2 | 2,019.4 | 11.63 | 6,208 | 8.05 | 325,286 |
| 10 Rubber and Plastic Products (355/6) | 17 | 1,197.9 | 475.4 | 643.9 | 3.71 | 2,331 | 3.02 | 276,249 |
| 11 Non-metallic Mineral Products (361-69) | 17 | 2,247.0 | 693.0 | 1,213.0 | 6.98 | 3,584 | 4.65 | 338,448 |
| 12 Basic & Fabricated Metal Products (371-81) | 74 | 2,854.6 | 1,505.1 | 1,601.9 | 9.22 | 8,093 | 10.50 | 197,936 |
| 13 Machinery & Transport Equipment (382/4) | 17 | 804.5 | 442.6 | 462.1 | 2.66 | 2,365 | 3.07 | 195,411 |
| 14 Electrical Machinery & Equipment (383) | 12 | 1,480.8 | 699.2 | 708.8 | 4.08 | 1,540 | 2.00 | 460,244 |
| 15 Other Manufacturing Industries (385-90) | 8 | 106.7 | 54.2 | 56.3 | 0.32 | 383 | 0.50 | 146,930 |
| Total Manufacturing | 434 | 35,109.6 | 14,285.0 | 17,368.4 | 100.00 | 77,100 | 100.00 | 225,271 |

*Source for raw data: The 1990 Zambia Census of Industrial Production, tables 1, 6 and 7.*
*Notes: (a) The gross value added for Zambia in table 5-1 is according to the US Census concept of value added at factor cost. The US Census value added is defined as the Gross value of output at factor cost minus all intermediate inputs, except intermediate service inputs from outside the industrial sector. These include: bank charges and insurance costs, transport costs, communication services and cost accountancy, management and other professional services (codes 408-411 from questionnaire). (b) Total number of employees has been adjusted to include working proprietors and family workers obtained from National Accounts Statistical Bulletin No. 5 and the CSO unpublished report of Labour Trends from 1964 to 1998.*

**Table 5-2: Basic Data on Output, Employment and Productivity for the United States, 1990 (Establishments with 10 or more persons engaged) (a)**

| | Number of Establish-ments | Annual Survey of Manufactures: Gross Value of Output | Gross Value Added | Gross Value Added in Branch as % of Total | Employment | Employment Share in Branch as % of Total | GVA / Person |
|---|---|---|---|---|---|---|---|
| | (a) | (b) (mill. US$) | (b) (mill. US$) | | (c) (persons) | | (US$ per person) |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| 1 Food Manufacturing | 10,917 | 327,050 | 114,400 | 9.26 | 1,298,331 | 8.23 | 88,113.2 |
| 2 Beverages | 1,228 | 51,386 | 24,605 | 1.99 | 143,262 | 0.91 | 171,750.5 |
| 3 Tobacco Products | 83 | 29,904 | 22,556 | 1.83 | 40,792 | 0.26 | 552,952.5 |
| 4 Textile Mill Products | 3,932 | 65,379 | 26,298 | 2.13 | 625,625 | 3.96 | 42,034.9 |
| 5 Wearing Apparel | 11,999 | 51,025 | 26,218 | 2.12 | 781,986 | 4.96 | 33,527.6 |
| 6 Leather Products and Footwear | 1,037 | 9,624 | 4,473 | 0.36 | 113,568 | 0.72 | 39,389.0 |
| 7 Wood Products, Furniture & Fixtures | 17,783 | 106,847 | 46,414 | 3.76 | 1,077,411 | 6.83 | 43,079.2 |
| 8 Paper Products, Printing & Publishing | 26,671 | 277,022 | 155,961 | 12.62 | 2,009,032 | 12.73 | 77,630.0 |
| 9 Chemicals, incl. petrol. refining | 7,947 | 453,492 | 176,982 | 14.32 | 941,947 | 5.97 | 187,889.6 |
| 10 Rubber and Plastic Products | 10,518 | 99,486 | 48,966 | 3.96 | 850,715 | 5.39 | 57,558.9 |
| 11 Non-metallic Mineral Products | 7,882 | 59,692 | 32,322 | 2.62 | 477,498 | 3.03 | 67,690.9 |
| 12 Basic & Fabricated Metal Products | 24,686 | 293,631 | 125,360 | 10.14 | 1,980,307 | 12.55 | 63,303.4 |
| 13 Machinery & Transport Equipment | 29,318 | 614,146 | 273,212 | 22.11 | 3,517,572 | 22.29 | 77,670.6 |
| 14 Electrical Machinery & Equipment | 9,999 | 108,561 | 60,038 | 4.86 | 673,768 | 4.27 | 89,108.0 |
| 15 Other Manufacturing Industries | 11,772 | 153,899 | 97,894 | 7.92 | 1,249,410 | 7.92 | 78,352.2 |
| Total Manufacturing (incl. oil refining) | 175,772.0 | 2,701,143.8 | 1,235,701.1 | 100.00 | 15,781,224 | 100.00 | 78,302.0 |

*Source for raw data: US Department of Commerce, Bureau of the Census, Annual Survey of Manufactures, 1991.*

*Notes: (a) The number of establishments with 10 or more persons engaged is based on the 1992 Census of Manufactures, General Summary, table 1-4 and table 4 from the 1992 Beverages Industry Series. (b) Ratio of 10 plus to total was obtained from 1992 Census of Manufactures, General Summary, table 1-4 and for Beverages Branch from 1992 Beverages Industry Series, table 4. We applied the ratio of 10 plus employment from the 1992 Census of Manufactures (table 1-4 in the General Summary and table 4 in the Beverages Industry Series to 1990 data on gross output, value added and employment). In case of employment, we assume that all Head Office and auxiliary employment can be found in establishments with ten or more persons engaged. (c) including head office and auxiliary employment.*

**Table 5-3: Unit Value Ratios and Price Levels by Major Manufacturing Branch Zambia/USA (ZK to US$), 1990**

| | \|---------- UVR (ZK/US$) -----------\| | | | Relative |
|---|---|---|---|---|
| | at US Quantity Weights | at Zambian Quantity Weights | Geometric Average | Price Level Zambia (USA = 100) |
| 1 Food Manufacturing | 46.25 | 28.29 | 36.17 | 0.72 |
| 2 Beverages | 28.61 | 24.35 | 26.40 | 0.53 |
| 3 Tobacco | 37.05 | 37.89 | 37.47 | 0.75 |
| 4 Textile Mill Products | 51.12 | 26.71 | 36.95 | 0.74 |
| 5 Wearing Apparel | 31.48 | 14.94 | 21.68 | 0.43 |
| 6 Leather Products and Footwear | 37.16 | 37.16 | 37.16 | 0.74 |
| 7 Wood Products, Furnitures and Fixtures | 49.26 | 20.50 | 31.78 | 0.64 |
| 8 Paper, Printing and Publishing | 102.59 | 55.99 | 75.79 | 1.52 |
| 9 Chemicals, Petroleum and Coal Products | 106.91 | 83.39 | 94.42 | 1.89 |
| 10 Non-Metallic Mineral Products | 78.64 | 68.52 | 73.41 | 1.47 |
| 11 Basic & Fabricated Metal Products | 97.48 | 28.52 | 52.73 | 1.05 |
| 12 Machinery & Transport Equipment | 58.00 | 54.15 | 56.04 | 1.12 |
| 13 Rubber and Plastic Products (a) | 56.63 | 33.87 | 43.79 | 0.88 |
| 14 Electrical Machinery & Equipment (a) | 56.63 | 33.87 | 43.79 | 0.88 |
| 15 Other Manufacturing Industries (a) | 56.63 | 33.87 | 43.79 | 0.88 |
| Total Manufacturing, Census Weights (b) | 56.63 | 33.87 | 43.79 | 0.88 |
| Total manufacturing, implicit UVRs (c) | 71.78 | 33.65 | 49.15 | 0.98 |
| Exchange Rate | 50.00 | 50.00 | 50.00 | |

*Sources:*
*Sample industry UVRs from Annex Table IV.2. The UVR for food manufacturing is the weighted average of the UVRs for meat products, dairy products, fats and oils, grainmill products, bakery products, sugar, confectionery and food n.e.c. and preserved vegetables, fruits and fish.*
*Exchange rate: derived from Report on the 1994 Census of Industrial Production, page 8, (Project XA/ZAM/94/631:"National Industrial Statistics Programme (NISP) Plus." prepared in collaboration with UNIDO).*
*Notes:*
*(a) No sample industries for this branch. We used the UVR calculated for the total of branches with sample industries.*
*(b) The UVR for total manufacturing is the gross output weighted average of branch or sample industry UVRs (see Timmer, 1997).*
*(c) Implicit UVRs calculated from the summed branch value added totals. Due to index number problems, the implicit UVRs deviate from the UVRs calculated for total manufacturing. Choosing for the lowest level of aggregation, these implicit UVRs may be preferred to the calculated ones.*

**Table 5-4: Gross Value Added (US Census Concept), by Major Manufacturing Branch, Zambia and the USA, 1990 (Establishments with 10 or more persons engaged)**

| | \|----- at Zambian prices ----\| Zambia | USA | Zambia/ USA | \|--------- at US prices ---------\| Zambia | USA | Zambia/ USA | Geometric Average Zambia/ USA (%) |
|---|---|---|---|---|---|---|---|
| | (in million ZK) | | (%) | (in million US$) | | (%) | |
| 1 Food Manufacturing | 3,995.2 | 5,291,530.1 | 0.076 | 141.2 | 114,400.1 | 0.123 | 0.097 |
| 2 Beverages | 1,267.4 | 703,965.1 | 0.180 | 52.0 | 24,605.3 | 0.212 | 0.195 |
| 3 Tobacco | 1,648.2 | 835,802.1 | 0.197 | 43.5 | 22,556.2 | 0.193 | 0.195 |
| 4 Textile Mill Products | 1,867.4 | 1,344,254.9 | 0.139 | 69.9 | 26,298.1 | 0.266 | 0.192 |
| 5 Wearing Apparel | 275.4 | 825,262.7 | 0.033 | 18.4 | 26,218.1 | 0.070 | 0.048 |
| 6 Leather Products and Footwear | 38.2 | 166,237.4 | 0.023 | 1.0 | 4,473.3 | 0.023 | 0.023 |
| 7 Wood Products, Furnitures and Fixtures | 444.4 | 2,286,483.3 | 0.019 | 21.7 | 46,414.0 | 0.047 | 0.030 |
| 8 Paper, Printing and Publishing | 1,127.0 | 16,000,447.4 | 0.007 | 20.1 | 155,961.2 | 0.013 | 0.010 |
| 9 Chemicals, Petroleum and Coal Products | 2,019.4 | 18,921,646.9 | 0.011 | 24.2 | 176,982.1 | 0.014 | 0.012 |
| 10 Non-Metallic Mineral Products | 1,213.0 | 2,541,875.1 | 0.048 | 17.7 | 32,322.3 | 0.055 | 0.051 |
| 11 Basic & Fabricated Metal Products | 1,601.9 | 12,219,490.8 | 0.013 | 56.2 | 125,360.2 | 0.045 | 0.024 |
| 12 Machinery & Transport Equipment | 462.1 | 15,846,290.4 | 0.003 | 8.5 | 273,211.9 | 0.003 | 0.003 |
| 13 Rubber and Plastic Products | 643.9 | 2,772,746.3 | 0.023 | 19.0 | 48,966.3 | 0.039 | 0.030 |
| 14 Electrical Machinery & Equipment | 708.8 | 3,399,694.9 | 0.021 | 20.9 | 60,038.1 | 0.035 | 0.027 |
| 15 Other Manufacturing Industries | 56.3 | 5,543,311.2 | 0.001 | 1.7 | 97,894.0 | 0.002 | 0.001 |
| Total Manufacturing | 17,368.4 | 88,699,038.6 | 0.020 | 516.2 | 1,235,701.1 | 0.042 | 0.029 |

*Sources: Census value added in national currency from Tables 5-1 and 5-2; converted with UVRs from Table 5-3. Totals are summed branch figures.*

**Table 5-5: Gross Value Added (US Census Concept) per Person, Zambia and the USA, 1990 (Establishments with 10 or more persons engaged)**

| | \|-- at Zambian Prices --\| Zambia | USA | Zambia/ USA | \|--- at US Prices ---\| Zambia | USA | Zambia/ USA | Geometric Average Zambia/ USA (%) |
|---|---|---|---|---|---|---|---|
| | (in ZK) | | (%) | (in US$) | | (%) | |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| 1 Food Manufacturing | 188,337 | 4,075,641 | 4.6 | 6,658 | 88,113 | 7.6 | 5.9 |
| 2 Beverages | 322,816 | 4,913,836 | 6.6 | 13,255 | 171,750 | 7.7 | 7.1 |
| 3 Tobacco | 1,285,615 | 20,489,178 | 6.3 | 33,927 | 552,952 | 6.1 | 6.2 |
| 4 Textile Mill Products | 197,585 | 2,148,659 | 9.2 | 7,397 | 42,035 | 17.6 | 12.7 |
| 5 Wearing Apparel | 65,769 | 1,055,343 | 6.2 | 4,403 | 33,528 | 13.1 | 9.0 |
| 6 Leather Products and Footwear | 30,278 | 1,463,770 | 2.1 | 815 | 39,389 | 2.1 | 2.1 |
| 7 Wood Products, Furnitures and Fixtures | 67,574 | 2,122,201 | 3.2 | 3,296 | 43,079 | 7.7 | 4.9 |
| 8 Paper, Printing and Publishing | 239,778 | 7,964,258 | 3.0 | 4,283 | 77,630 | 5.5 | 4.1 |
| 9 Chemicals, Petroleum and Coal Products | 325,286 | 20,087,804 | 1.6 | 3,901 | 187,890 | 2.1 | 1.8 |
| 10 Non-Metallic Mineral Products | 338,448 | 5,323,316 | 6.4 | 4,939 | 67,691 | 7.3 | 6.8 |
| 11 Basic & Fabricated Metal Products | 197,936 | 6,170,503 | 3.2 | 6,939 | 63,303 | 11.0 | 5.9 |
| 12 Machinery & Transport Equipment | 195,411 | 4,504,894 | 4.3 | 3,609 | 77,671 | 4.6 | 4.5 |
| 13 Rubber and Plastic Products | 276,249 | 3,259,311 | 8.5 | 8,157 | 57,559 | 14.2 | 11.0 |
| 14 Electrical Machinery & Equipment | 460,244 | 5,045,798 | 9.1 | 13,590 | 89,108 | 15.3 | 11.8 |
| 15 Other Manufacturing Industries | 146,930 | 4,436,742 | 3.3 | 4,339 | 78,352 | 5.5 | 4.3 |
| Total Manufacturing | 225,271 | 5,620,542 | 4.0 | 6,695 | 78,302 | 8.5 | 5.9 |

*Sources: Gross value added from Table 5-4, employment from Tables 5-1 and 5-2.*

**Table 5-6: Comparative Capital Intensity and TFP, Zambia and the USA, 1990 (Establishments with 10 or more persons engaged)**

| | 1 Food | 2 Tex | 3 Wear | 4 Leat | 5 Wood | 6 Pap | 7 Chem | 8 Rub | 9 Mine | 10 Met | 11 Mach | 12 Elec | 13 Oth | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Capital per worker as % of USA | 3.8 | 5.6 | 20.1 | 5.1 | 6.9 | 6.9 | 8.4 | 24.0 | 30.5 | 7.1 | 7.1 | 5.3 | 1.4 | 8.0 |
| TFP level as % of USA | 39.9 | 40.1 | 17.8 | 8.3 | 20.3 | 15.3 | 6.4 | 25.3 | 11.8 | 17.2 | 12.3 | 30.1 | 29.8 | 16.7 |

*Sources: Gross value added from Table 5-4, employment from Tables 5-1 and 5-2, labour share and capital in national currency converted into international dollars for 1990 from Annex Tables I.5, I.6, I.10 and I.11. Relative TFP levels have been calculated using a translog production function as given in equation (5.2).*

**Table 5-7 : Percentage Explained of Difference in Labour Productivity, Zambia and the USA, Total Manufacturing, 1990 (Establishments with 10 or more persons engaged)**

| | Percentage explained by gap in | | |
|---|---|---|---|
| | Capital intensity | Total factor productivity | Total |
| Zambia | 37.0 | 63.0 | 100.0 |

*Sources: Tables 5-4 and 5-6.*

# 6 Industrial Case Studies

## 6.1 Introduction

The central theme of this chapter is to present an analysis of the performance improvement process within real-life manufacturing firms. The case study approach is used to investigate this process. The performances of specific branches of manufacturing and firms' statistics are presented as a background to the study of performance improvement in the firms in question.

The analysis indicates that there are areas of improvement in how manufacturing is managed in these firms, and it stresses the importance of firm level efforts to improve performance even in a negative operating environment. In particular, the areas of production planning and control, inventory control, plant maintenance, quality control and continuous quality improvement, and the manufacturing-marketing relationship hold the highest potential. Qualified gross output per person engaged in three of the four cases grew between 1.8 percent per year and 11.0 percent per year on average between 1995-98. The fourth case also experienced a diminishing annual rate of output contraction from 13.5 percent between 1991-95 to 9.7 percent between 1995-98. The transformation efficiency of the production process in the four cases grew at an average annual rate of 0.6 to 2.9 percent between 1995 and 1998. The upturn in performance in the case studies during the modest recovery period (1995-98) of Zambian manufacturing indicates that firms can do better in a dynamic environment.

The research model developed in chapter 3 is used as the basis of analysis of the four case studies. These four case studies are drawn from the food, beverage and tobacco branch, the textile branch, the chemicals branch, and the basic and fabricated metals branch. The reasons for the choice of the four branches were already discussed in chapter 1. From the lessons that were learned from the survey study of manufacturing firms in Zambia and Zimbabwe[17] (Yamfwa, 1997), we selected the case studies on the basis that it would be possible to gain and maintain co-operation of participating companies over a reasonable period of time. Moreover, reasonable time series data could be obtained from them.
The capturing of evidence of improvement efforts at a micro-economic level, however, is beset by two main problems. The first problem is the lack of objective and standard indicators that directly measure improvement efforts. This means that a qualitative analysis is often needed to estimate the impact of various factors that are thought to either promote or give direction to improvement of performance in companies. The other difficulty usually is the sparsity of relevant data of indicators of the improvement process in firms in LDCs. Where classical indicators exist, they are sometimes inadequate for capturing the improvement taking place in these firms due to the informal nature of much of the improvement process that takes place in these firms.

[17] The survey was conducted to help the development of the research model.

In this study, two indicators of the performance dimension are used to capture evidence of improvement efforts. These are the transformation efficiency of the production system and the qualified gross output per worker. The transformation efficiency of the production system, $h_t$, consists of the product of production time efficiency and production system effectiveness. The production time efficiency, $r_s$, is defined as the ratio between the total time intervals during which the system really produces products and the considered production period. The production time efficiency is affected by planned stoppages such as maintenance, set-up, idle time (i.e. due to lack of materials and orders), and waiting time (i.e. times of system's underutilisation due to poor responsiveness to changes). It is also affected by unplanned stoppages in the production process due to operator errors, out-of-range quality, technical interruptions, and unavailability of internal transport and personnel. The production system effectiveness, $e_s$, is defined as the ratio of the average real output flow of qualified products and the average maximum output flow of qualified products per unit of time. The production system effectiveness is affected by a whole range of factors. These include endeavours of quality control and continuous quality improvement, and technical and organisational conditions of the production process. While the production time efficiency and the production system effectiveness combine into one measure, which is the transformation efficiency, the transformation efficiency and the qualified gross output per worker, on the other hand, are related in a production function.

Hence, for a considered production period *T*, (See Section 3.4.4)

$$e_s = \frac{p\hat{V}ol}{p\hat{V}ol_{\max}} \qquad (3.19)$$

$$r_s = \frac{\hat{T}_e}{T} \qquad (3.20)$$

$$\text{and} \qquad h_t = e_s * r_s \qquad (3.21)$$

As already indicated, the assumption is that much of what happens during the improvement process is manifested in the relative changes of the values of these indicators of performance. With sufficient monthly or annual observations per firm, regression analysis could be used to estimate a production function with changes in input factors and external influences as independent variables, to show their relative impacts on qualified gross output per worker (See Section 3.4.7). However, in light of the limited number of observations per firm, we chose to perform a firm-level growth accounting in which the residual term *A* was decomposed into two multiplicative terms, the transformation efficiency *h* and a smaller residual term *A'*, and to present our case studies in a more descriptive fashion, especially with respect to external influences. We used industry changing factor shares at four-digit ISIC classification as weights in the growth accounting exercise.

We used the concept of qualified gross output (see Section 1.2) instead of value added (which is also interesting) because of the predominance of intermediate inputs in the cost structure of most manufacturing firms. For example, for the four-digit industries in which the cases we are studying fall, the costs of material and business service inputs together have increased from a range of 30 percent to 60 percent of all costs in 1990 to that of 40 percent to 75 percent of all costs in 1998 (Census of Industrial Production, 1990, and CSO database). With the tendency of the prices of intermediate inputs to increase faster than those of other inputs, this development is clearly likely to affect production decisions in firms. Furthermore, many modern manufacturing performance improvement techniques are aimed at raising the efficiency with which both the intermediate inputs and primary inputs are used.

To extend the application of the research model in this study to other LDCs, the choice of specific external influences may be varied to take into account the diversity of circumstances in the developing world. The model as described in chapter 3 is used in the investigation of performance improvement in clear beer production, paint production, yarn production, and mining implements production.

## 6.2 Company 1: Clear Beer Production

### 6.2.1 Background

Company 1 was established as a private company in 1963. In 1968, the Zambian Government, through the Industrial Development Company Limited (INDECO), nationalized the company through an initial acquisition of 55 percent of the shares and, in 1988, of a further 20 percent. The company regained its private status in 1994, as part of the Zambian Government's privatization program. Company 1 is a subsidiary of a multi-national company.

Company 1 is situated in Lusaka, the capital city of Zambia. It has a gross sales turnover for the financial year 1997 of Zambian Kwacha 70 billions (1 US$ = Zambian Kwacha 1,315) and a labour force of about 500.

Company 1 produces clear beer for distribution throughout Zambia. The brewery site covers 9.63 hectares. The company locally brews three brands and sells various imported brands.

The company operates a standard clear beer production plant. It has two Zeimann brewhouses with a brewlength of 330 hectoliters each, two SEN candle filters each having a capacity of 300 hectoliters per hour, two SEN packaging lines with a combined capacity of 236 hectoliters per hour and ancillary plants. These include a refrigeration plant, a compressed air plant, a steam generation plant and a water treatment plant. There is no dominant specific period from which the technologies applied in production come. They cover the period from 1960s to the 1990s. The company focuses on the domestic market.
A detailed discussion of the production process of company 1 is presented in Annex VI.1.

## 6.2.2 Results of Performance Improvement Related Activities

The results presented in this case study and others are the outcome of the application of classic methods of efficiency and quality improvement found in literature and non-formalised methods, with the latter having considerable importance in some circumstances.

The raw data sets required for performance analysis were collected during research visits to company 1 totalling 9 weeks. The four research visits were spread over a period of four years. To these data sets, historical data from company's archives were added. This resulted in annual time series covering a period of 13 years between 1986 and 1998, and monthly data sets for the period between 1995 and 1998.

Data to calculate the aggregated physical output were obtained from company packaging production records and books. These data and the rest of the other data were not readily available. There was no electronic access to data. So, to arrive at aggregate figures, daily and weekly production records were consulted. The accounts department provided most of the historical information because the production department did not keep records older than three years. Some data obtained from production and personnel departments were cross-checked with those from the accounts department.

For company 1, with a narrow product range and one single dominant product type, the use of qualified gross output expressed either in monetary value or in quantity did not make much difference in the movement of the time series. One type of beer accounted for 95 percent of the total qualified gross output. The qualified gross output in monetary values was obtained by multiplying the number of units produced of qualified beer (in hectoliters) by their appropriate base period unit prices (1990 was taken as the base year). In the analysis, we used physical quantities. Using physical quantities also allowed us to easily present an international comparative performance of company 1.

A large variety of intermediate inputs are used in the production of clear beer. To determine the most interesting groups of intermediate inputs to focus on, a Pareto analysis was used to identify these inputs on the basis of their relative value and quantity. The intermediate inputs were then reduced to five groups of intermediate inputs. Using the average base prices, the intermediate inputs were calculated. The data required for calculation were obtained from daily and weekly stores issues documents and accounts documents. It was also possible to convert major intermediate inputs to equivalent physical quantities because they had comparable unit values and unit weights.

Information obtained from the planned maintenance records, daily and weekly filler downtime summary records, packaging daily and weekly production reports and record books, full packaged failure rate reports, bottling line reports, and quality control daily and weekly reports was used to compute the production time efficiency, production system effectiveness and transformation efficiency. The considered period was 7,584 hours (1 year). In this case the considered period was equal to 100 percent capacity utilisation. This was available production time, $T$, in a year for a plant running 3 shifts excluding time intervals for which the production transformation was stopped due to legal regulations, local and industrial conventions. The effective time, $T_e$,, is the time for which the bottling line was operated to produce beer during the available production time. The qualified gross output, *pVol*, was the quantity of beer meeting quality standards in the first round per time unit. This excluded the quantity of reworked output that was rejected in the previous time interval. The qualified gross output was, therefore, less than the total gross output in situations with reworked outputs. The disqualified products were calculated as a percentage of the beer "withdraw" (i.e. expected beer yield) per time unit from the knowledge of the qualified products and the beer "withdraw".

Data on raw labour input were obtained from monthly manpower statistics, and employee records provided raw data for the computation of the human capital index.

Most of the raw data for the computation of the capital input were obtained from the company fixed asset register and balance sheets.

The balance sheets, however, presented two difficulties. The balance sheet gives data on company assets on a given date while the company output is measured over a period of time, say one day, one month, or one year. This means that the data in the balance sheet represent a stock concept while data in production documents represent a flow concept. The other problem with the balance sheet is that assets are often represented at purchase prices even though the purchase of the assets was done a long time ago (historical cost prices). This makes it difficult to accurately deflate the cost of assets to a common year.

To estimate the capital input, we decided to use the PIM approach as at sectoral level. Since consistent investment series for the company were available from 1986 onwards, we used the PIM assumption for scrapping only for benchmark estimates. Following Dasgupta *et al.* (1995), Osada (1994) and Timmer (2000), we used the incremental capital-value added ratio (ICVAR) approach instead of the fully-fledged PIM to estimate capital stock. The ICVAR approach assumes that the capital-value added ratio can be approximated by the incremental capital-value added ratio that gives the ratio of investment and value added growth. The impact of the short-run fluctuations in value added was minimised by taking the average of the ICVARs for the years 1987-97, allowing for a one year lag. The average ICVAR for the firm was calculated at 1.67. The estimated average ICVAR was then applied to gross value added in 1986 to derive the benchmark capital stock for 1986. The stock composition in malt and malt liquors branch at the end of 1985 was used to provide a breakdown of this capital stock. The benchmark for 1986 was then combined with annual investment series of the three asset types less annual scrappings at constant prices to generate capital stock estimates forwards to 1998.
The fixed assets were divided into three different categories. These were buildings, machinery and equipment, vehicles and other fixed assets. For simplicity of calculations, it was assumed that the purchase of assets took place at the beginning of each financial year.

In the plant, machinery and equipment is a mixture of old and new pieces of equipment. Most of the core pieces of equipment were acquired between 1968 and 1986, and refurbished after 1994. A large proportion of new investments went into peripheral equipment, utility plants, and into improving process monitoring and control. This dualistic character of the plant machinery contributed to the non-achievement of the large potential offered by improvement in process monitoring and control in raising substantially the line rating performance, for example, due to limited and unstable speeds achievable at the parker and low loadings at the pasteuriser and bottle washer.

The branch performance and the case study results are presented in Tables 6-1 and 6-2, respectively. Branch performance plays a dual role. Firstly, it serves as a benchmark to which firm performance can be compared. Secondly, it is an important external influence. A poor performance of a branch is most likely capable of constraining good firm's performance either on the supply or demand side.

In the case of branch performance, Table 6-1 gives the levels of gross value added, persons engaged in the branch, gross fixed capital stock, labour productivity, capital productivity, and TFP. The case table (Table 6-2) shows levels of qualified gross output per worker, production time efficiency, production system effectiveness, transformation efficiency, human capital index, capital per worker, intermediate inputs per worker, qualified gross output, persons engaged and gross fixed capital stock between 1986 and 1998.

In addition, the indexes of public effort in highway infrastructure and non-highway infrastructure, the Herfindahl index, changes in average growth of exports and imports, average growth of real GDP and average growth of copper production are given in Table 6-4.

At branch level, gross value added per person engaged (column 4 in Table 6-1), gross fixed capital stock per person engaged (column 5) and TFP (column 6) grew at an average annual rate of 3.3 percent, -0.6 percent, and 3.7 percent between 1986 and 1998, respectively. If we divide this period into 3 sub-periods, namely 1986-91 sub-period, 1991-95 sub-period and 1995-98 sub-period, we see that performance in the branch greatly varied. In the first sub-period, labour productivity grew at 9.4 percent per year. It then declined tremendously (-12.1 percent per year), only to pick up in the last sub-period during which it grew at 13.7 percent per year. Capital per worker declined at an average annual rate of 5.4 percent in the first sub-period. Its growth became positive in the second and last sub-periods (0.1 percent per year and 6.4 percent per year, respectively). TFP growth was positive in the first sub-period (13.0 percent per year), steadily declined in the second sub-period (12.3 percent per year), and then grew at an average annual rate of 9.7 percent in the last sub-period.

Performance in company 1 also varied over the period under study. On average, qualified gross output per worker (column 1 in Table 6-2) increased at 9.9 percent per year, above the branch average annual productivity[18]. The transformation efficiency (column 4) improved by an average annual growth rate of 3.0 percent, human capital index (column 5) increased at 1.5 percent per year, capital per worker (column 6) increased at 0.8 percent per year, and intermediate inputs intensity (column 7) increased at an annual rate of 9.6 percent. It is clear that qualified gross output per worker steadily increased over the period under review, punctuated by a slow-down in the second sub-period. The increase in capital investment mainly was significant in the last sub-period. A similar phenomenon is observed at branch level. Improvement in transformation efficiency was due to a significant improvement in production time efficiency (column 3) rather than effectiveness of the production system (column 2). Improvement in production time efficiency picked up in 1994 and relatively stayed high. It accounted for about 77 percent of improvement in the transformation efficiency, with the rest being accounted for by the improvement in production system

[18] It should be noted that at branch level output is defined in terms of value added, while at company level we used qualified gross output. The gap in significance of these two concepts is, however, narrowed by the fact that the qualified physical quantities used showed strong correlation with company' s value added.

effectiveness. The level of transformation efficiency achieved indicates that there is still potential for further improvement.

Table 6-3 shows the results of the decomposition of the total factor productivity growth into a part due to the growth in transformation efficiency and growth in a smaller residual using equation (3.35)[19]. The smaller residual reflects the other unaccounted-for factors that include external influences. It follows that a low growth of the estimated TFP' in relation to the growth of qualified gross output and growth of qualified gross output per worker is observed in Tables 6-2 and 6-3. This leads us to conclude that the external influences are relatively less important compared to internal circumstances in the case of company 1. This result shows that given the external circumstances, sustained internal efforts lead to improvement in performance and, at the same time, questions the exclusive reliance on policies in the literature to improve performance in firms.

The company's production system transformation efficiency can be represented in the transformation efficiency diagram. The transformation efficiency diagram gives a useful visual representation of the path of the transformation efficiency. It can be used to monitor the effect of improvement efforts, and to serve as the basis for decisions for future improvement efforts. In Figure 6-1, the process of transformation efficiency improvement reflects a transformation efficiency spectrum rather than the case of a firm moving along a single curve in time. The observed dispersion reflects that firms, at different times, adopt different improvement techniques that may result in a bias either towards production time efficiency improvement or system effectiveness improvement.

The quadrants in Figure 6-1 indicate the regions of different technical performance. Quadrant 'A' is a region of very high time efficiency and high quality. It is usually for an industry producing one product with high quality performance. Quadrant 'C' is the region for a production system with many interruptions and low quality performance. The ideal situation is for a producer in quadrant 'C' to continuously pay attention to quality control, streamline its product range and reduce set-up times and unplanned stops, thereby moving diagonally into quadrant 'A'. Quadrant 'B' is that of a production system with many production set-up times and unplanned stops. Producers in quadrant 'D' have low quality performance, although their production time efficiency is high. The iso-transformation efficiency lines (i.e. lines t-t and t'-t') are lines of constant transformation efficiency with various proportions of quality performance and time performance.

The size of quadrants can be adjusted according to the type of production circumstances, such as batch or mass production. For example, a batch production that has inherently more production interruptions than mass production would have a relatively smaller low time-low quality performance quadrant than mass production.

Figure 6-1 shows that after the initial efforts to improve quality performance, most of the improvement efforts were directed towards improving the transformation efficiency through reduction of non-value adding periods. This is where there are more opportunities for improvement than in the improvement of the system effectiveness. Figure 6-2 presents, in an enlarged form, the transformation efficiency performance that clearly accelerates after

[19] In an earlier version of the thesis, we did a statistical testing. Due to the small number of cases, this line of analysis was discontinued for this case study and others.

1995. Between 1986-91, the transformation efficiency grew at an average annual rate of 2.7 percent. The growth in time efficiency accounted for 48 percent of the improvement in transformation efficiency while growth in system effectiveness accounted for 52 percent. This situation changed in 1991-95 when improvement in time efficiency accounted for all of the growth in transformation efficiency. Efforts to reduce non-value adding periods intensified in 1995-98 with a moderate improvement in system effectiveness. The net result is a growth of 2.9 percent per year in transformation efficiency, with 70 percent of improvement accounted for by the improvement in time efficiency.

**Table 6-1: Performance in food, beverages and tobacco branch of Zambian manufacturing, 1982-98 (1990=100)**

| | 1<br>GDP | 2<br>Labour Input | 3<br>Capital Input | 4<br>Labour productivity | 5<br>Capital productivity | 6<br>TFP |
|---|---|---|---|---|---|---|
| 1982 | 68.7 | 61.9 | 188.9 | 110.8 | 304.9 | 52.5 |
| 1983 | 70.8 | 62.2 | 172.4 | 113.7 | 277.0 | 57.3 |
| 1984 | 74.3 | 62.6 | 152.9 | 118.7 | 244.3 | 65.0 |
| 1985 | 69.4 | 99.9 | 135.1 | 69.4 | 135.2 | 56.7 |
| 1986 | 71.2 | 98.4 | 120.5 | 72.3 | 122.5 | 63.1 |
| 1987 | 74.9 | 96.7 | 107.0 | 77.4 | 110.6 | 72.4 |
| 1988 | 84.8 | 96.8 | 100.6 | 87.6 | 103.9 | 85.5 |
| 1989 | 89.8 | 97.6 | 94.8 | 92.0 | 97.2 | 93.7 |
| 1990 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| 1991 | 111.1 | 96.2 | 89.8 | 115.5 | 93.3 | 120.6 |
| 1992 | 94.9 | 92.1 | 80.2 | 103.0 | 87.1 | 112.2 |
| 1993 | 49.5 | 82.7 | 76.0 | 59.9 | 92.0 | 63.0 |
| 1994 | 34.0 | 67.9 | 67.0 | 50.0 | 98.6 | 50.3 |
| 1995 | 45.7 | 64.3 | 60.3 | 71.1 | 93.7 | 73.8 |
| 1996 | 47.9 | 53.4 | 55.6 | 89.6 | 104.0 | 87.2 |
| 1997 | 49.0 | 51.6 | 54.1 | 95.0 | 104.9 | 91.9 |
| 1998 | 49.2 | 45.9 | 52.1 | 107.1 | 113.5 | 98.7 |
| | Average annual growth rates (%) | | | | | |
| 1986-91 | 8.9 | -0.5 | -5.9 | 9.4 | -5.4 | 13.0 |
| 1991-95 | -22.2 | -10.1 | -9.9 | -12.1 | 0.1 | -12.3 |
| 1995-98 | 2.4 | -11.3 | -4.9 | 13.7 | 6.4 | 9.7 |
| 1986-98 | -3.1 | -6.4 | -7.0 | 3.3 | -0.6 | 3.7 |

*Sources:*
*Annex Tables I.1, I.2, I.5 and I.7.*

**Table 6-2 : Qualified gross output per worker, effectiveness of production system, production time efficiency, transformation efficiency, human capital index, capital per worker, intermediate inputs per worker, qualified gross output, persons engaged and gross fixed capital stock for company 1, 1986-98 (1990=100)**

| | 1 Qualified gross output per person engaged | 2 Effectiveness of production system | 3 Production time efficiency | 4 Transformation efficiency | 5 Human capital index | 6 Capital per person engaged | 7 Intermediate inputs per person engaged | 8 Qualified gross output | 9 Persons engaged | 10 Gross fixed capital stock |
|---|---|---|---|---|---|---|---|---|---|---|
| 1986 | 63.6 | 94.1 | 93.8 | 88.3 | 91.9 | 138.0 | 55.4 | 57.5 | 90.4 | 124.8 |
| 1987 | 79.5 | 95.4 | 95.5 | 91.1 | 93.2 | 131.3 | 85.5 | 73.0 | 91.8 | 120.5 |
| 1988 | 91.8 | 97.7 | 96.7 | 94.5 | 95.9 | 127.0 | 96.8 | 85.3 | 92.9 | 118.0 |
| 1989 | 95.2 | 98.5 | 98.3 | 96.9 | 97.2 | 103.6 | 92.4 | 99.5 | 104.5 | 108.3 |
| 1990 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| 1991 | 128.1 | 101.0 | 100.1 | 101.1 | 99.6 | 113.9 | 116.6 | 103.4 | 80.7 | 91.9 |
| 1992 | 125.7 | 91.6 | 100.9 | 92.5 | 99.4 | 102.1 | 111.0 | 104.0 | 82.8 | 84.5 |
| 1993 | 101.9 | 91.6 | 101.0 | 92.5 | 99.8 | 94.0 | 114.2 | 82.6 | 81.1 | 76.2 |
| 1994 | 116.4 | 98.0 | 108.4 | 106.2 | 99.7 | 108.2 | 118.5 | 78.2 | 67.2 | 72.7 |
| 1995 | 150.3 | 99.4 | 116.1 | 115.5 | 100.9 | 101.9 | 115.3 | 98.3 | 65.4 | 66.6 |
| 1996 | 156.5 | 100.3 | 121.5 | 121.9 | 103.9 | 121.0 | 120.9 | 92.0 | 58.8 | 68.5 |
| 1997 | 202.3 | 101.8 | 122.5 | 124.7 | 106.4 | 141.8 | 162.7 | 116.7 | 57.7 | 73.3 |
| 1998 | 209.4 | 102.1 | 123.3 | 125.8 | 109.7 | 152.7 | 175.1 | 118.3 | 56.5 | 74.8 |
| | Average annual growth rates ( %) | | | | | | | | | |
| 1986-91 | 14.0 | 1.4 | 1.3 | 2.7 | 1.6 | -3.8 | 14.9 | 11.7 | -2.3 | -6.1 |
| 1991-95 | 4.0 | -0.4 | 3.7 | 3.3 | 0.3 | -2.8 | -0.3 | -1.3 | -5.3 | -8.1 |
| 1995-98 | 11.0 | 0.9 | 2.0 | 2.9 | 2.8 | 13.5 | 13.9 | 6.2 | -4.9 | 3.9 |
| 1986-98 | 9.9 | 0.7 | 2.3 | 3.0 | 1.5 | 0.8 | 9.6 | 6.0 | -3.9 | -4.3 |

*Sources for raw data:*
*Real investment data from company financial reports and statements.*
*Daily and Weekly Production, Maintenance, Quality Control and Stores reports and records, Monthly Personnel reports and records, 1986-98.*
*Qualified gross output, effectiveness of production system, production time efficiency, transformation efficiency and gross fixed capital stock calculated as explained in sections 6.1 and 6.2.2; and human capital calculated with equation 3.29.*
*Sources for deflators: CSO database on Index Numbers of Wholesale Prices 1966=100 (by Industrial Activities); Monthly Digest of Statistics, July-October 1991, tables 48, 49(a) and (b).*

**Table 6-3: Growth of qualified gross output, transformation efficiency, inputs and TFP' for company 1, 1986-98**

| Sub-period | Average growth rates and contributions to growth | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Qualified gross output | Skill-adjusted labour | | Intermediate inputs | | Capital | | Transformation efficiency (a) | | TFP' (a) | |
| | | growth | contrib. | growth | contrib. | growth | contrib. | growth | contrib. | growth | contrib. |
| 1986-91 | 11.7 | -0.7 | -0.1 | 12.6 | 6.4 | -6.1 | -2.2 | 2.7 | 2.7 | 4.9 | 4.9 |
| 1991-95 | -1.3 | -5.0 | -0.8 | -5.6 | -2.7 | -8.1 | -2.9 | 3.3 | 3.3 | 1.8 | 1.8 |
| 1995-98 | 6.2 | -2.1 | -0.3 | 9.1 | 4.6 | 3.9 | 1.3 | 2.9 | 2.9 | -2.2 | -2.2 |
| 1986-98 | 6.0 | -2.4 | -0.4 | 5.7 | 2.9 | -4.3 | -1.5 | 3.0 | 3.0 | 2.1 | 2.1 |

*Sources for raw data:*
*Real investment data from company financial reports and statements.*
*Daily and Weekly Production, Maintenance, Quality Control and Stores reports and records, Monthly Personnel reports and records, 1986-98.*
*Qualified gross output, materials, capital and transformation efficiency calculated as explained in sections 6.1 and 6.2.2; and skill-adjusted labour calculated with equation 3.30.*
*Sources for deflators: CSO database on Index Numbers of Wholesale Prices 1966=100 (by Industrial Activities); Monthly Digest of Statistics, July-October 1991, tables 48, 49(a) and (b).*
*(a) TFP consists of Transformation efficiency and a residual TFP', calculated with equation 3.35.*

**Table 6-4 : Influence variables beyond firm's control (public highways and non-highways effort, Herfindahl index, export and import growth, real GDP growth and copper production growth), 1986-98**

| | 1<br>Public highways effort index | 2<br>The rest of public effort index | 3<br>Herfindahl index | 4<br>Average growth of exports & imports | 5<br>Average Real GDP (total) growth | 6<br>Average growth of copper production | 7<br>Average growth of exports | 8<br>Average growth of imports |
|---|---|---|---|---|---|---|---|---|
| 1986 | 1.956 | 0.740 | 0.064 | -0.309 | 0.009 | -0.042 | -0.223 | -0.395 |
| 1987 | 1.083 | 0.760 | 0.063 | 0.358 | 0.009 | 0.051 | 0.316 | 0.400 |
| 1988 | 0.681 | 0.363 | 0.062 | 0.074 | 0.142 | -0.126 | 0.022 | 0.126 |
| 1989 | 0.841 | 0.289 | 0.061 | 0.119 | 0.013 | 0.068 | 0.311 | -0.072 |
| 1990 | 1.001 | 0.195 | 0.060 | 0.058 | -0.089 | -0.055 | -0.056 | 0.172 |
| 1991 | 1.033 | 0.305 | 0.059 | -0.141 | 0.035 | -0.063 | -0.152 | -0.130 |
| 1992 | 2.000 | 0.179 | 0.058 | 0.193 | -0.055 | 0.106 | 0.036 | 0.350 |
| 1993 | 0.821 | 0.147 | 0.057 | -0.205 | 0.133 | -0.086 | -0.127 | -0.283 |
| 1994 | 0.156 | 0.857 | 0.056 | 0.029 | -0.068 | -0.107 | 0.075 | -0.016 |
| 1995 | 0.117 | 1.285 | 0.055 | 0.092 | -0.060 | -0.146 | 0.106 | 0.078 |
| 1996 | 0.353 | 0.054 | 0.055 | -0.102 | 0.012 | 0.020 | -0.177 | -0.026 |
| 1997 | 1.738 | 0.096 | 0.054 | 0.138 | 0.071 | 0.014 | 0.154 | 0.121 |
| 1998 | 2.317 | 4.092 | 0.054 | -0.218 | -0.021 | -0.086 | -0.283 | -0.153 |

*Sources for raw data: GDP, exports, imports and copper production from National Accounts. Investments from National Accounts and unpublished database of the Central Statistical Office (CSO). Manufacturing branch statistics (10+) from the database of the Central Statistical Office (CSO) and Census of Industrial Production, various issues.*

Table 6-4 shows the variables of influences beyond the company's control. On average, there was a growth rate of 1.4 percent per year in the index of public highway effort. Growth in public non-highways effort index was rapid. This type of public effort grew at 14.2 percent per year. But growth in Herfindahl-Hirschman index (HHI) was negative. Both growth of real GDP and growth of exports and imports were positive, at 1.2 percent per year and 3.3 percent per year, respectively. The HHI gives a declining trend in the level of concentration. As a result of this general trend, the HHI for the food, beverages and tobacco industry declined from the 0.064 level in 1986 to the 0.054 level in 1998. This indicates a moderate movement towards a competitive industry. Copper production, however, declined at an average annual rate of 3.4 percent with the largest decline between 1991 and 1995. The continued decline of copper production eased off between 1995 and 1998, at 1.7 percent per year. The inclusion of copper production is very relevant to an economy that is dominated by mining. Other external influences not included in the table are macro-economic indicators such as inflation, exchange rate fluctuation, access to foreign exchange and the tax policy that influence management decisions in the importation of the needed intermediate inputs and in capital investment.

Annex Tables VI.1 and VI.2 present disaggregated information of Table 6-2 for 1995-98. The wide variations in the levels of performance in Annex Table VI.1 indicate instability in the production system. From Annex Table VI.2, between 1995-98, planned stops accounted for 27.4 percent of the total lost time, bottling line breakdown for 22.5 percent, and other sources (such as waiting and idle time, set-up time and failure of the external utilities) accounted for 50.1 percent of the total lost time. Improvement of production time efficiency offers more scope for the improvement of the transformation efficiency.

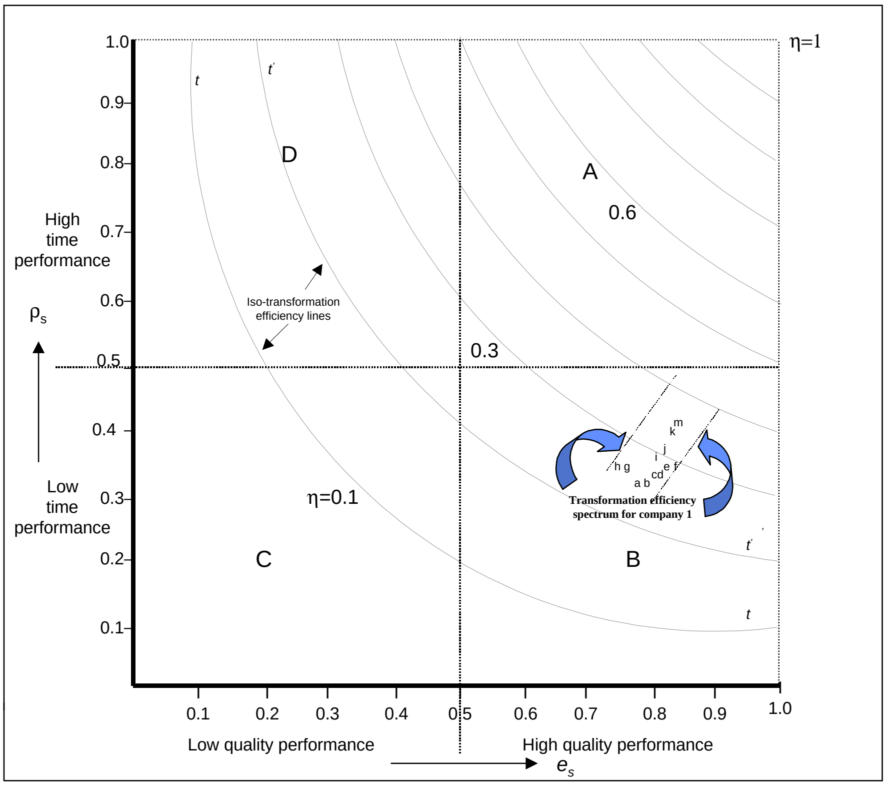


**Figure 6-1 : Transformation efficiency diagram for company 1, 1986-98**

Legend: The letters a, b, .., m are used to denote transformation efficiency performance, $\eta$, in different years, i.e. a= $\eta$ in 1986, b= $\eta$ in 1987, .... , m= $\eta$ in 1998
$\rho_s$ = production time efficiency, $e_s$ = production system effectiveness, t-t=iso-transformation efficiency line
$\eta = \rho_s * e_s$

*Sources for raw data:*
*Daily and Weekly Production, Maintenance, and Quality Control Reports and Records, 1986-98.*

We investigated the sources of key intermediate inputs to give an indication of the development of the domestic supply base. Inputs such as plastic crates, glass bottles and bottle labels are sourced from outside the country. The only domestic supply of glass bottles closed down due to operational difficulties in the period of liberalisation. The bottle labels are sourced from outside the country because the quality of local labels does not meet the company's specifications. Although maize is grown on a large scale in Zambia, the domestic supply of maize grits to the plant is sometimes erratic when the only miller that the company can rely upon for consistent quality maize grits and reliable deliveries experiences internal difficulties.

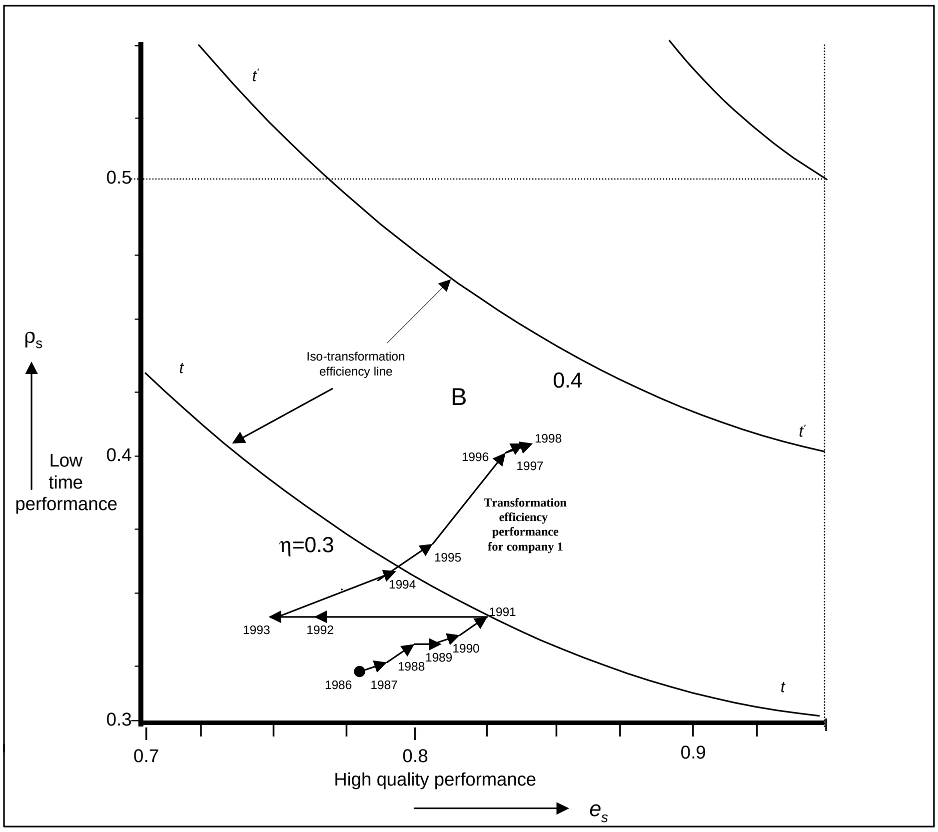


**Figure 6-2: Transformation efficiency performance for company 1 (enlarged diagram), 1986-98**

Legend: $\rho_s$ = production time efficiency, $e_s$ = production system effectiveness, t-t=iso-transformation efficiency line
$\eta = \rho_s * e_s$

*Sources for raw data:*
*Daily and Weekly Production, Maintenance, and Quality Control Reports and Records, 1986-98.*

## 6.2.3 Discussion

Between 1986-93, there was no significant investment in equipment and machinery. This led to a rapid deterioration of plant equipment and machinery characterized by frequent equipment breakdowns. Other production bottlenecks were the lack of spare parts, shortage of skilled technicians, erratic supply of most intermediate inputs, very low pay levels and lack of an aggressive marketing effort. The transformation efficiency in 1993 represents 73.5 percent of the level of the transformation efficiency in 1998. Company 1's approach to improvement of production performance followed the following trajectory.

In the mid-1990s, following the change of the company's status from parastatal to private, the company underwent re-organisation that included changes in top and middle levels of management.

In the same year, there was an initiative to improve quality performance through process improvement effort (Yamfwa, *et al.*, 2000). One aspect of this effort was the implementation of an extensive plant rehabilitation programme. The rehabilitation programme encompassed:
- improvement of quality control by replacement of manually-operated setting control by automated control;
- refurbishment of the plant structural work to improve both hygiene and safety;
- improvement of process reliability by replacement of critical near-obsolete service pieces of equipment by modern ones and introduction of preventive maintenance. On the other hand, in case of a major plant breakdown after normal working hours, there is a prepared 'call out breakdown' procedure that aims at minimising the length of a breakdown by speeding up the decision making process. The procedure stipulates the roles and responsibilities of various levels of company staff who may be called upon in the event of a breakdown, the mode of communication with other higher levels of management and when such communication should be effected. This procedure is necessary as the company is making a transition from breakdown maintenance to preventive maintenance and it is still faced with the problem of technical dualism (i.e. an old piece of equipment feeding into a modern one).

In terms of labour management effort, initial training programmes for employees in supervisory positions were organised within the company and in its sister companies outside Zambia. Recruitment of better-trained staff was also effected. Another aspect of this effort was the improvement of internal communication by reducing the hierarchical levels (i.e. from 13 to 7), the merging of departments/sections, and the creation within the plant of 'green' areas where employees met and exchanged/discussed production performance related problems.

Two years later, the next improvement effort, as part of labour management and internal communication efforts, was a gradual introduction of a learning corporate culture. This effort stemmed from the realisation that there was a general absence of some relevant basic industrial knowledge in the labour force. The following were part of this effort:

- teamwork introduction: as an approach to teaching employees to work as a team and to improving the effectiveness of problem solving and communication, daily MDT (multi-disciplinary team) meetings were introduced. In these meetings, supervisors from different departments discussed issues related to production performance.

- employee's accountability enhancement: to induce a sense of total accountability and responsibility, a labour management instrument was introduced, called the 'OOO' (which stands for One On One agreement meeting). The 'One On One' had 4 levels, i.e.
level 0 - concerns top management and its relationship with the board of directors;
level 1 - concerns heads of departments and sections and their relationship with top management;
level 2 - concerns front-line supervisors and their relationship with heads;
level 3 - concerns shop floor employees and their relationship with front-line supervisors.

The way the instrument works is illustrated as follows:

At level 1, during the OOO meeting**,** the two parties (in this case the head of department/section and one top management representative):
. a) agree on routine goals (basically this is in line with the current job description of the head of department/section);
. b) agree on individual goals (i.e. what the head of a department/section can achieve/contribute outside routine goals and these should also have a major component directed at the professional development of the head himself);
. c) agree on examples of added value (these are specific projects/assignments aimed at value creation in the section and the head is the main initiator of these examples);
. d) discuss follow-up actions (these are unusual occurrences and outstanding issues, which the head brings up in the meeting, and are discussed).

The above goals, then, form the basis for assessment of the head's performance and make the assessment more objective and transparent. This instrument can be greatly appreciated when one considers that a number of companies in Zambia have a background of favouritism and tribal bias in enforcing discipline and effecting job promotions.
The 'OOO' meetings are monthly, on one to one basis as the name indicates and are cascaded downward from senior management to low levels. Currently this instrument is limited to senior and middle management levels.

Top-down communication improvement and trust building are also taking roots. For example, besides the normal communication through the organisational hierarchy, there are regular meetings between the chief executive and all the employees, company performance information (financial and otherwise) is shared with employees in a way it can be understood by all.

One of the more unusual initiatives that the company introduced was the 'happy hour'. Troubled by the high levels of shop floor staff drinking beer on duty that had been allowed to go on for a long time, the company examined ways in which this could be reduced (and eventually be stopped). The novel solution was the introduction of the happy hour. All members of staff after their normal duties were allowed for one hour, at company costs, to drink beer and other beverages in a well-furnished canteen on the company premises. The result has been a tremendous decline in disciplinary cases related to beer drinking on duty, with the resulting savings far outstripping the cost of providing beverages and a drinking place.

Furthermore, as part of the process improvement effort, a waste management practice awareness programme is being implemented to teach concepts of waste recognition and elimination in the plant.

With regard to supply management effort, two instruments are used in the company. For scarce intermediate inputs (often procured from markets outside Zambia) better forecasting of their requirements and getting the intermediate inputs as they are available within the forecasted requirement are being done. For intermediate inputs that may be procured locally, control of input inventories through developing, educating and closely co-operating with local suppliers is being pursued.

Periods of implementation of most of the improvement programmes relate well with growth in production time efficiency and production system effectiveness. Qualified gross output per worker also rose above the branch average. Plant interruptions, resulting from plant failure and lack of intermediate inputs considerably declined. The quality improvement drive gained impetus when, in mid-1996, the company entered the group beer quality benchmarking. It was a test of beer profile taste where the company's beer quality was rated against other breweries in Southern and Eastern Africa and a few breweries outside the African continent. According to that rating, the quality of beer in company 1 improved at an average annual rate of 1.0 percent between 1996 and 1998. From our analysis, the production system effectiveness (which is a quality-based variable) grew at an average annual rate of 0.9 percent over the same period.

Although the company achieved remarkable results in improving system performance, there were still possibilities for further improvement. There were more possibilities of improvement in production time efficiency. If we consider the bottling line only, the labellers, fillers and bottle washer accounted for 33.0 percent, 27.7 percent and 23.6 percent of the line unplanned stops, respectively. The bottle conveyors accounted for 15.8 percent only. Table VI-2 indicates that a more systematic preventive maintenance needs to be implemented. This requires a combination of deeper equipment and process knowledge and use of analytical tools such as the cause and effect fishbone diagram by shop floor personnel. There are huge opportunities in reducing idle and waiting time by improving production planning, and in investing in external utility equipment. Together with planned production stoppages, idle and waiting time accounted for 77.5 percent of the total time lost between 1995-98.

While individual effort was very important, the 'OOO' labour management instrument did not effectively foster teamwork. It, therefore, ran contrary to other improvement programmes such as the daily MDT. This can be reconciled by making the employee' s participation in MDT activities an important issue in the 'OOO' labour management instrument. This is even more important when the 'OOO' labour management instrument is applied at lower levels where the nature of work requires group effort to give motivation for prevention and continuous improvement.

From the transformation efficiency diagram, company performance got closer to the quadrant of high quality and high time efficiency (i.e. quadrant 'A').
The following are situations where the deepening of performance improvement can be pursued. Keeping the momentum in the introduction of structured preventive maintenance and quality-at-source procedures is one area. Moreover, there is need to move investment to core machinery from the peripherals. The current sampling from the line involves time lapse and potential losses before non-quality situations are evaluated and corrected. An on-line monitoring is suggested to give timely and actionable information for decision making to prevent a non-quality situation.
Other areas are to increase the efficiency of the brewery with an eye to ongoing increases in productivity and a strong focus on human resources. Dedicated training programmes should be designed to teach employees equipment and process knowledge and skills in quality control and management planning tools to cover more than just one single skill, the company can also seek to ensure that an optimal spread of responsibility is deployed as low as possible in the organization. This means a higher degree of teamwork and a broader package of tasks.

Finally, a comparison of performance with other breweries will continue to yield valuable benchmarks and lead to an exchange of best practices. For example, the highest level of productivity (measured in qualified hectolitres of beer per person employed per annum) that was achieved at company 1 in 1998 represents only 15.5 percent of the best international level achieved in the same year (Kickuth, 1998).

With a sustained performance improvement in the manufacturing sector and in the country's overall economic environment (i.e. the highest average real growth in GDP among the three sub-periods were recorded in the last sub-period of 1995-98), further performance improvement can be expected to be recorded at company 1. The transformation efficiency diagram gives a simple and clear approach to map and visualize the improvement process in the firm.

## 6.3 Company 2: Paint Production

### 6.3.1 Background

Company 2 was incorporated in the then Northern Rhodesia in 1955. It is located on the Copperbelt on a site area of 1 hectare. The firm is a subsidiary of a large conglomerate, though it has a lot of autonomy.

This company manufactures paint and produces a wide range of surface coatings such as decorative and industrial paint, stoving paint, vehicle refinishing paint, primers and undercoats, and PVA adhesives. It is a medium size batch manufacturing company, with a turnover of Zambian Kwacha 2.83 billion in the financial year 1997/98. The total labour force of the company is 87. The company's installed capacity is 2.5 million litres of paint.
The company makes products to order and for stock, and in several cases prompt delivery is the prime factor affecting the placement of a production order. The company sells all of its products to the domestic market, and 15 percent of its products go directly to the copper mining units.
A description of the paint production process is given in Annex VI.2.

### 6.3.2 Results of Performance Improvement Related Activities

Performance analysis for company 2 is based on data collected during one research visit of 4 weeks. The methods described in the previous case study were applied here to collect the required raw data and compute the qualified gross output, intermediate inputs, capital stock, production time efficiency, effectiveness of production system and transformation efficiency.

Branch performance is shown in Table 6-5. Labour productivity (column 4) in chemical products branch declined at an average annual rate of 6.3 percent and TFP (column 6) at an average annual rate of 6.8 percent. After the disastrous performance of 1991-95 during which both labour productivity and TFP fell by 30.1 percent per year and 30.5 percent per year, respectively, these two indicators of performance improved during 1995-98. Labour productivity picked up at an average growth rate of 3.6 percent per year and TFP at 1.3 percent per year. Branch employment (column 2) declined at 3.0 percent per year, while the branch capital stock (column 3) declined at 2.4 percent per year between 1986-98. The largest decline rate for employment was in 1995-98 (at 5.0 percent per year) and for capital stock was in 1991-95 (at 4.1 percent per year).

Turning to the company's performance, Table 6-6 presents salient features for the performance of company 2 between 1986 and 1998. The company operates a one-shift system for 5 days a week. In this case the considered period was, therefore, equal to just below one-third capacity utilisation. The considered production period that has been estimated on the basis of a one-shift system and the main production lines was 6,765 hours (1 year). Column 1 indicates that the company has experienced a steady decline in qualified gross output per worker at an average annual rate of 9.7 percent. This decline greatly varied over the 1986-98 period. Between 1986 and 1991, gross qualified output per worker fell by about 6.6 percent per year. This situation worsened between 1991 and 1995 with the decline reaching 13.5 percent per year, although a marginal improvement was recorded between 1995 and 1998 during which the decline in qualified gross output per worker stood at 9.7 percent per year (running contrary to the branch performance that recorded a growth of 3.6 percent per year in labour productivity).

While the company experienced a marginal decline in effectiveness of the production system (column 2), there was a significant decrease in the production time efficiency (column 3) with the overall effect being a net decline in the transformation efficiency (column 4) of 5.1 percent per year.

One interesting and somewhat unexpected result is the quality performance. The system effectiveness only declined at an average annual rate of 1.3 percent, while time efficiency declined by 3.8 percent per year between 1986 and 1998. Quality performance improvement has been noticeable during 1995-98 (at 2.9 percent per year). The capital stock (column 10) of company 2 declined by an average annual rate of 5.1 percent, while employment (column 9) also decreased by an average annual rate of 2.9 percent between 1986-98. Except for the 1995-98 remarkable improvement in the system effectiveness, all other performance indicators declined between 1986-98. Tables 6-6 and 6-7 indicate that internal circumstances of the firm and the external influences are both important. The growth of qualified gross output and growth of qualified gross output per person engaged are low in relation to the growth of TFP' in some sub-periods and in others as low as that of the TFP'. With a low level of internal improvement efforts, the company is more vulnerable to external influences.

It is also interesting to note that the chemical products branch experienced a significant increase in the level of competition (See Table 6-8). The Herfindahl index declined from the 0.132 level in 1986 to the 0.120 level in 1998 with the largest rate of decline occurring after 1991.

Annex Table VI.3 shows a large variability in the percentage of disqualified products and in the level of total time lost indicating that the production system is highly unstable. For the 1995-98 period, 75 percent of the time lost was due to organizational problems. These were the supply of the right raw materials and packaging materials, the sequence planning of paint products, the organisation of the different production actions required to minimize the set-up time, and idle time due to lack of customer orders. Because a large proportion of the total time lost was due to organizational problems, the reduction of time lost due to process and maintenance related problems did not have a high priority. Figures 6-3 and 6-4 indicate a large dispersion of the transformation efficiency performance. The instability in the performance of the production system that is evident even over this longer time scale (i.e. 1986-98) points to the presence of deep-rooted performance problems.

**Table 6-5: Performance in chemical products branch of Zambian manufacturing, 1982-98 (1990=100)**

| | 1<br>GDP | 2<br>Labour Input | 3<br>Capital Input | 4<br>Labour productivity | 5<br>Capital productivity | 6<br>TFP |
|---|---|---|---|---|---|---|
| 1982 | 74.2 | 74.8 | 160.2 | 99.3 | 214.3 | 63.2 |
| 1983 | 69.3 | 76.2 | 143.7 | 90.8 | 188.4 | 62.8 |
| 1984 | 29.1 | 76.4 | 125.5 | 38.1 | 164.2 | 28.6 |
| 1985 | 64.0 | 104.6 | 111.5 | 61.2 | 106.5 | 59.0 |
| 1986 | 62.8 | 102.0 | 103.0 | 61.5 | 101.0 | 61.2 |
| 1987 | 58.7 | 99.4 | 96.7 | 59.1 | 97.3 | 60.0 |
| 1988 | 56.1 | 98.5 | 96.3 | 56.9 | 97.8 | 57.7 |
| 1989 | 72.9 | 98.5 | 94.4 | 74.1 | 95.9 | 76.1 |
| 1990 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| 1991 | 86.9 | 101.1 | 96.7 | 86.0 | 95.7 | 88.4 |
| 1992 | 25.9 | 102.3 | 93.1 | 25.3 | 91.0 | 27.0 |
| 1993 | 104.0 | 97.9 | 90.3 | 106.2 | 92.3 | 112.1 |
| 1994 | 69.8 | 86.5 | 85.6 | 80.7 | 98.9 | 81.2 |
| 1995 | 21.4 | 82.9 | 81.9 | 25.8 | 98.8 | 26.0 |
| 1996 | 28.4 | 72.8 | 79.1 | 38.9 | 108.7 | 36.5 |
| 1997 | 27.4 | 74.8 | 78.3 | 36.7 | 104.6 | 35.3 |
| 1998 | 20.5 | 71.3 | 77.3 | 28.7 | 108.4 | 27.1 |
| | Average annual growth rates (%) | | | | | |
| 1986-91 | 6.5 | -0.2 | -1.3 | 6.7 | -1.1 | 7.4 |
| 1991-95 | -35.0 | -4.9 | -4.1 | -30.1 | 0.8 | -30.5 |
| 1995-98 | -1.5 | -5.0 | -2.0 | 3.6 | 3.1 | 1.3 |
| 1986-98 | -9.3 | -3.0 | -2.4 | -6.3 | 0.6 | -6.8 |

*Sources:*
*Annex Tables I.1, I.2, I.5 and I.7.*

**Table 6-6: Qualified gross output per worker, effectiveness of production system, production time efficiency, transformation efficiency, human capital index, capital per worker, intermediate inputs per worker, qualified gross output, persons engaged and gross fixed capital stock for company 2, 1986-98 (1990=100)**

| | 1<br>Qualified gross output per person engaged | 2<br>Effectiveness of production system | 3<br>Production time efficiency | 4<br>Transformation efficiency | 5<br>Human capital index | 6<br>Capital per person engaged | 7<br>Intermediate inputs per person engaged | 8<br>Qualified gross output | 9<br>Persons engaged | 10<br>Gross fixed capital stock |
|---|---|---|---|---|---|---|---|---|---|---|
| 1986 | 116.9 | 108.9 | 108.9 | 118.6 | 80.4 | 103.8 | 101.9 | 110.5 | 94.5 | 98.2 |
| 1987 | 113.9 | 110.8 | 105.4 | 116.8 | 82.9 | 119.3 | 103.5 | 95.2 | 83.6 | 99.7 |
| 1988 | 82.8 | 112.4 | 107.1 | 120.4 | 92.0 | 112.4 | 97.8 | 76.9 | 93.0 | 104.5 |
| 1989 | 94.4 | 82.8 | 107.1 | 88.7 | 96.2 | 105.8 | 104.5 | 93.6 | 99.2 | 105.0 |
| 1990 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| 1991 | 84.2 | 98.5 | 98.2 | 96.7 | 102.3 | 86.8 | 77.2 | 99.3 | 118.0 | 102.4 |
| 1992 | 71.6 | 104.4 | 89.3 | 93.2 | 105.6 | 88.9 | 82.3 | 76.7 | 107.0 | 95.1 |
| 1993 | 69.4 | 97.8 | 82.1 | 80.3 | 107.7 | 88.4 | 53.9 | 71.0 | 102.3 | 90.4 |
| 1994 | 50.5 | 88.2 | 83.9 | 74.1 | 109.1 | 89.6 | 52.4 | 46.1 | 91.4 | 81.9 |
| 1995 | 49.1 | 84.9 | 74.2 | 63.0 | 114.1 | 84.4 | 40.8 | 44.8 | 91.4 | 77.2 |
| 1996 | 55.8 | 85.2 | 80.3 | 68.4 | 117.8 | 77.6 | 58.5 | 48.0 | 85.9 | 66.7 |
| 1997 | 45.4 | 92.3 | 67.2 | 62.0 | 120.0 | 79.1 | 39.7 | 35.8 | 78.9 | 62.4 |
| 1998 | 36.7 | 92.7 | 69.2 | 64.1 | 123.4 | 80.5 | 33.4 | 24.4 | 66.4 | 53.5 |
| | Average annual growth rates ( %) | | | | | | | | | |
| 1986-91 | -6.6 | -2.0 | -2.1 | -4.1 | 4.8 | -3.6 | -5.5 | -2.1 | 4.4 | 0.9 |
| 1991-95 | -13.5 | -3.7 | -7.0 | -10.7 | 2.7 | -0.7 | -16.0 | -19.9 | -6.4 | -7.1 |
| 1995-98 | -9.7 | 2.9 | -2.3 | 0.6 | 2.6 | -1.6 | -6.6 | -20.3 | -10.7 | -12.2 |
| 1986-98 | -9.7 | -1.3 | -3.8 | -5.1 | 3.6 | -2.1 | -9.3 | -12.6 | -2.9 | -5.1 |

*Sources for raw data:*
*Real investment data from company financial reports and statements.*
*Daily and Weekly Production, Maintenance, Quality Control and Stores reports and records, Monthly Personnel reports and records, 1986-98.*
*Qualified gross output, effectiveness of production system, production time efficiency, transformation efficiency and gross fixed capital stock calculated as explained in sections 6.1 and 6.2.2; and human capital calculated with equation 3.29.*

*Sources for deflators: CSO database on Index Numbers of Wholesale Prices 1966=100 (by Industrial Activities); Monthly Digest of Statistics, July-October 1991, tables 48, 49(a) and (b).*

**Table 6-7: Growth of qualified gross output, transformation efficiency, inputs and TFP' for company 2, 1986-98**

| Sub-period | Average growth rates and contributions to growth | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Qualified gross output | Skill-adjusted labour | | Intermediate inputs | | Capital | | Transformation efficiency (a) | | TFP' (a) | |
| | | growth | contrib. | growth | contrib. | growth | contrib. | growth | contrib. | growth | contrib. |
| 1986-91 | -2.1 | 9.3 | 1.0 | -1.1 | -0.3 | 0.9 | 0.3 | -4.1 | -4.1 | 1.0 | 1.0 |
| 1991-95 | -19.9 | -3.6 | -0.4 | -22.3 | -8.3 | -7.1 | -3.7 | -10.7 | -10.7 | 3.2 | 3.2 |
| 1995-98 | -20.3 | -8.0 | -0.9 | -17.3 | -6.8 | -12.2 | -6.1 | 0.6 | 0.6 | -7.1 | -7.1 |
| 1986-98 | -12.6 | 0.6 | 0.0 | -12.2 | -4.6 | -5.1 | -2.6 | -5.1 | -5.1 | -0.3 | -0.3 |

*Sources for raw data:*
*Real investment data from company financial reports and statements.*
*Daily and Weekly Production, Maintenance, Quality Control and Stores reports and records, Monthly Personnel reports and records, 1986-98.*
*Qualified gross output, materials, capital and transformation efficiency calculated as explained in sections 6.1 and 6.2.2; and skill-adjusted labour calculated with equation 3.30.*
*Sources for deflators: CSO database on Index Numbers of Wholesale Prices 1966=100 (by Industrial Activities); Monthly Digest of Statistics, July-October 1991, tables 48, 49(a) and (b).*
*(a) TFP consists of Transformation efficiency and a residual TFP', calculated with equation 3.35.*

**Table 6-8: Influence variables beyond firm's control (public highways and non-highways effort, Herfindahl index, export and import growth, real GDP growth and copper production growth), 1986-98**

| | 1<br>Public highways effort index | 2<br>The rest of public effort index | 3<br>Herfindahl index | 4<br>Average growth of exports & imports | 5<br>Average Real GDP (total) growth | 6<br>Average growth of copper production | 7<br>Average growth of exports | 8<br>Average growth of imports |
|---|---|---|---|---|---|---|---|---|
| 1986 | 1.956 | 0.740 | 0.132 | -0.309 | 0.009 | -0.042 | -0.223 | -0.395 |
| 1987 | 1.083 | 0.760 | 0.133 | 0.358 | 0.009 | 0.051 | 0.316 | 0.400 |
| 1988 | 0.681 | 0.363 | 0.135 | 0.074 | 0.142 | -0.126 | 0.022 | 0.126 |
| 1989 | 0.841 | 0.289 | 0.143 | 0.119 | 0.013 | 0.068 | 0.311 | -0.072 |
| 1990 | 1.001 | 0.195 | 0.139 | 0.058 | -0.089 | -0.055 | -0.056 | 0.172 |
| 1991 | 1.033 | 0.305 | 0.136 | -0.141 | 0.035 | -0.063 | -0.152 | -0.130 |
| 1992 | 2.000 | 0.179 | 0.132 | 0.193 | -0.055 | 0.106 | 0.036 | 0.350 |
| 1993 | 0.821 | 0.147 | 0.129 | -0.205 | 0.133 | -0.086 | -0.127 | -0.283 |
| 1994 | 0.156 | 0.857 | 0.126 | 0.029 | -0.068 | -0.107 | 0.075 | -0.016 |
| 1995 | 0.117 | 1.285 | 0.124 | 0.092 | -0.060 | -0.146 | 0.106 | 0.078 |
| 1996 | 0.353 | 0.054 | 0.123 | -0.102 | 0.012 | 0.020 | -0.177 | -0.026 |
| 1997 | 1.738 | 0.096 | 0.121 | 0.138 | 0.071 | 0.014 | 0.154 | 0.121 |
| 1998 | 2.317 | 4.092 | 0.120 | -0.218 | -0.021 | -0.086 | -0.283 | -0.153 |

*Sources for raw data: GDP, exports, imports and copper production from National Accounts. Investments from National Accounts and unpublished database of the Central Statistical Office (CSO). Manufacturing branch statistics (10+) from the database of the Central Statistical Office (CSO) and Census of Industrial Production, various issues.*

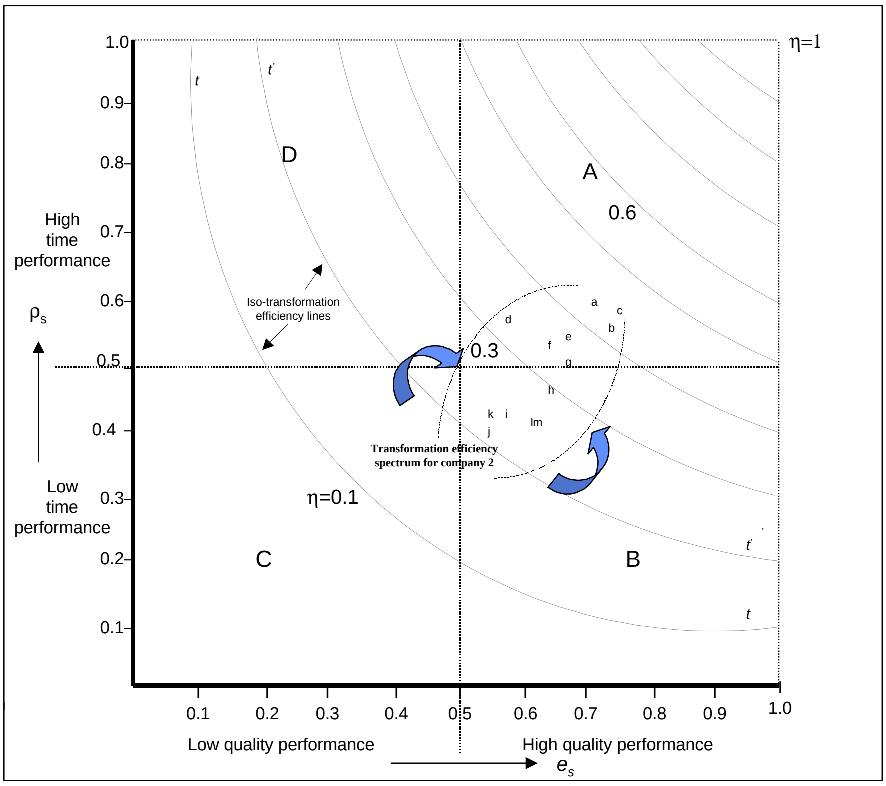


**Figure 6-3: Transformation efficiency diagram for company 2, 1986-98**

Legend: The letters a, b, .., m are used to denote transformation efficiency performance, $\eta$, in different years, i.e. a= $\eta$ in 1986, b= $\eta$ in 1987, .... , m= $\eta$ in 1998

$\rho_s$ = production time efficiency, $e_s$ = production system effectiveness, t-t=iso-transformation efficiency line

*Sources for raw data:*

*Daily and Weekly Production, Maintenance, and Quality Control Reports and Records, 1986-98.*

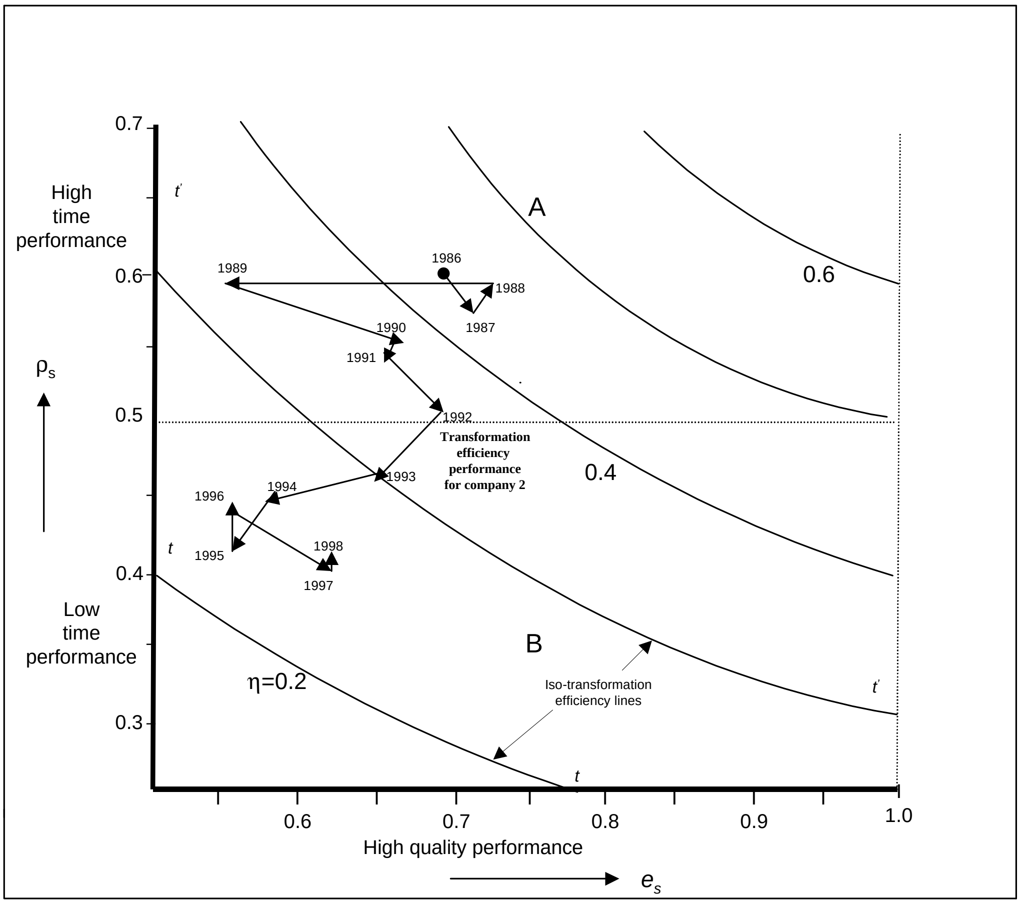


**Figure 6-4: Transformation efficiency performance for company 2 (enlarged diagram), 1986-98**

Legend: $\rho_s$ = production time efficiency, $e_s$ = production system effectiveness, t-t=iso-transformation efficiency line
$\eta = \rho_s * e_s$

*Sources for raw data:*
*Daily and Weekly Production, Maintenance, and Quality Control Reports and Records, 1986-98.*

## 6.3.3 Discussion

The results of company 2 show a strong negative growth in most indicators of performance, despite a remarkable improvement in human capital index (column 5 of Table 6-6). The human capital index rose at an average annual rate of 3.6 percent. We observe a large decline in gross capital stock (column 10 of Table 6-6) in company 2 (at an average annual rate of 5.1 percent during 1986-98). The decline in gross fixed capital stock in company 2 has been even below the branch capital's decline (column 3 of Table 6-5), which stands at

2.4 percent per year. This case gives some credence to Pack and Paxson's position (2001) that higher skills may have very low productivity in the absence of technology inflows. In the case of many firms in LDCs the process of technology inflows is accompanied by an increase in the level of imported capital goods.

The company often encountered problems in obtaining on-time delivery of intermediate inputs from overseas suppliers resulting in shortage of critical inputs. These problems ranged from difficulties in payments reaching suppliers promptly because this was dictated by the availability of foreign exchange, delays in transportation, and delays as a result of the bureaucracy in customs' import procedures. The company tried to reduce the impact of these delays on its operations by producing more to forecast rather than to order, and by holding large just-in-case inventories of intermediate inputs and finished products.

In 1998, for example, a typical quarterly ratio of qualified gross output to sales was 1:1.4 and the ratio of qualified gross output to finished goods in stock was 1:0.4. These results have two explanations. The first explanation is that the stock build-up was due to the high level of reworked outputs. The other explanation is that the company did not always produce the right products in the right quantity for its market in a given period of time, resulting in a build up of wrong products. This way of operations at company 2 made the company's viability vulnerable to changes in the market. It also underlined the need for an information network within the company to provide correct market information on a more timely basis to increase shop floor productivity and to improve inventory management.

The transformation efficiency diagram shows a steeply falling performance. Between 1996 and 97, the company worked towards ISO 9002 certification. Certification was achieved in 1997. From the transformation efficiency diagram, efforts of the ISO 9002 certification resulted in improvement in product quality. After 1997, there was no significant improvement in quality. On average, the observed improvement in transformation efficiency between 1995-98 was accounted for by an improvement in quality. To raise both the quality and time performance would require addressing the production and organizational issues raised above. Company 2 experienced a large dispersion of the transformation efficiency performance. This indicates an excessively large variability in time and quality performance due to high instability of the production system.

Since liberalisation, the number of paint manufacturing companies in Zambia increased from 5 to 10. In addition, there was an increase in importation of paint products and an influx of smuggled cheaper paint products (Times of Zambia, 1999). While measures were taken to put an end to the illegal entry of paint products into the country, the existing paint market was still very competitive. The fact that company 2 accounted for an estimated paint market share of 40 percent, further improvement in efficiency that could result in an increase in transformation efficiency and together with an aggressive marketing programme would lead to a higher demand that could trigger an improvement in productivity. There is need for the company to invest in core technology because the current production system does not offer sufficient possibilities for substantial growth in transformation efficiency.

The company provided some form of training to newly recruited employees and this mainly, consisted of work discipline, house rules of the company and the operation of machines. For instance, machine operation was learnt on the job, and older employees (with experience) were used for the purpose. In light of this, evidence of an in-house systematic training programme for new and old employees was limited.

The application of structured and consistent preventive maintenance and quality-at-source procedures is one area that was sometimes overlooked in preference to the concern about maximising short-run turnover and profits. Another area that has potential for efficiency improvement is the routing of intermediate inputs and their normal flow as products in process. In paint making, a great part of the necessary labour is employed in handling intermediate inputs at the processing stage, the internal transportation and storage stages. Excess handling of intermediate inputs can be reduced and better production control attained if the intermediate inputs in the plant are kept moving in one direction. This entails the re-grouping of the processing machinery and other workstations in such a way that the routing of intermediate inputs and their normal flow as products in process will continue in a forward-like movement along the established channels throughout the various stages of production. This will also release some of the valuable factory floor space.

Many ingenious devices can be developed and attached to the existing standard manufacturing units that are in the plant to raise the level of quality control. In fact, abundant suggestions for such improvements can be tapped among the working crew who have had intimate knowledge of the operating conditions. For example, the current intermittent dipping in the ball mill to estimate the material grind can be enhanced by a counting mechanism for recording the number of revolutions when the mill is operating. It can also be set to shut the mill off after a predetermined number of turns. Such an automatic shut-off is often desirable for some types of paint products. The same goes for the various tests that are done on the products in process in order to maintain the standards of quality. Since the technical control by laboratory personnel is not always feasible and would result in delays on the shop floor, more and more simple testing to maintain quality should be delegated to plant operators.

The final aspect of the improvement effort is the elimination of problems of co-ordination of the activities of the laboratory section, and the production and marketing departments. These are best solved by education, largely effected by the establishment of working procedures that provide quick understanding on the part of all concerned of the problems and limitations of product specifications and production. In the case of unforeseen difficulties, these are quickly dealt with when an attitude of co-operation exists between formulators, operators and those in charge of the marketing function.

## 6.4 Company 3: Yarn Production

### 6.4.1 Background

Company 3 is located in the Copperbelt province and produces products ranging from 100 percent open end yarn, carded and combed spun yarn, polyester blended yarn, two for one twisted yarn, dyed yarn, to cottonwool. It started production in 1969 as a factory making shirts for the domestic market. The company has now grown from a handful of employees and a few tonnes of cotton to more than 1,230 employees and a production of about 1,100 tonnes of cotton yarn products a month in 1998, most of which goes to European markets.

The intermediate inputs that are mostly obtained locally, are processed into final products (i.e. yarn). In 1998, exports of final products accounted for about 95.6 percent of gross output (in quantity), while the remainder 4.4 percent for the domestic market. Between 1986 and 1998, sales (in quantity) on the domestic market declined at an annual average rate of 5.6 percent while export sales grew at 47.1 percent per year.

Products from 1986 are still very similar to today's products. The main product has been cotton yarn, which is made in many counts. Company 3 is a vertically integrated spinning company that grew at a breath taking speed, from one plant in 1984 to 5 plants in 1997. Due to lack of domestic demand for its products and driven by a business strategy to profit from the export market, company 3 started its expansion in 1984 when the first plant was launched. These plants are normally referred to as phases. After the first plant started its operations in 1984, the next two plants started their production in 1993, the fourth plant in 1996 and the fifth plant in 1997. This has resulted in an installed capacity of 49640 ring spindles, 6662 TFO spindles, and 1008 rotors.

Company 3's investment strategy has been to invest in the state-of-the-art equipment, both in core machinery and peripheral equipment. The production process of company 3 is, therefore, not subjected to performance bottlenecks associated with technical dualism. All the equipment was bought new and from one source in Germany. Employees were remunerated well above industry's average. There was an incentive scheme for key personnel. Key personnel were defined as employees in positions with the highest value-adding contribution to the production of high quality cotton yarn in the most cost-effective and safe manner. On top of the list were technical positions. This was a special case in Zambian industry where administrative positions normally were valued above all others. The company had a very low labour turnover at operative and management levels, which had a positive effect on the learning-by-doing in the firm and retention of skills and experiences in the firm. The spectacular growth in employment throughout the period under study with a very low labour turnover indicates an accumulation of capabilities in the firm. The company had a very simple and flexible organization structure with clear communication and reporting mechanisms.
Yarn production details are presented in Annex VI.3.

## 6.4.2 Results of Performance Improvement Related Activities

The raw data for company 3 were collected during four research visits totalling 10 weeks spread over a period of four years. The methods described in the first case study were applied here to collect the required raw data and compute the qualified gross output, intermediate inputs, capital stock, production time efficiency, effectiveness of production system and transformation efficiency.
The first step in the analysis is an exploration of the branch performance to get a general idea of its behaviour (Table 6-9). The overall trend is that of an increase in performance [both in labour productivity (column 4) and TFP (column 6)] over the period under study (1986-98). Labour productivity grew at an average annual rate of 3.7 percent and TFP at an average annual rate of 4.9 percent. During the same period, the branch employment (column 2) declined at an average annual rate of 4.1 percent and the branch capital stock (column 3) at 6.0 percent.

The period between 1995 and 1998, the textile branch experienced an upturn in labour productivity that is almost twice that of the Zambian manufacturing sector (the branch grew at an average annual rate of 21.3 percent while the sector grew at an annual rate of 11.3 percent).

Table 6-10 shows the results of performance computations of company 3. A 3-shift 7 days a week system was used at company 3. We calculated the considered production period on the basis of the total available time to the plants by taking into account the number of production lines in each plant in a year, excluding the time intervals the plants were non-operational due to legal regulations, local or industrial conventions. Because of plant expansion, the considered period was not the same during the period under study. In 1986, the considered period was 320,334 hours and 1998, the considered period was 9,208,404 hours. In both cases, the considered period was equal to 100 percent capacity utilisation. The first column shows a steady growth of qualified gross output per person engaged. Between 1986 and 1991, the growth in qualified gross output per person engaged was 27.1 percent per year, between 1991 and 1995 9.3 percent per year and 4.0 percent per year between 1995-98. Over the whole period (1986-98), the average growth rate was 15.4 percent per year. The transformation efficiency grew at 0.6 percent per year, with most of the growth in transformation efficiency being accounted for by the growth in effectiveness of the production system (68.6 percent). The human capital index grew at an increasing rate. It grew at an average annual rate of 0.4 percent between 1986 and 1991, at 1.1 percent per year between 1991-95 and finally at an average annual rate of 1.8 percent between 1995 and 1998. The remarkable aspect about company 3 is that, on average, all performance indicators showed a positive growth between 1986 and 1998. Growth in qualified gross output per person engaged was accompanied by growth in employment (at a rate of 5.4 percent per year), in capital stock (at a rate of 13.6 percent per year) and in transformation efficiency. During the disastrous period of 1991-95 when the whole manufacturing sector collapsed, only the company’s production system effectiveness performance was affected. It had a growth rate of 0.0 percent per year, but it picked up during 1995-98 period (at an annual rate of 0.9 percent). From Table 6-11, the growth of qualified gross output and growth of qualified gross output per worker are high in relation to the growth of TFP’. This indicates an almost negligible influence of external factors on performance growth of company 3, mainly due to its export orientation. The level of influence of external factors on company 3's performance surprisingly had been consistently low throughout the period under study.

While the branch employment (column 2 of Table 6-9) declined by 4.1 percent per year between 1986 and 1998, at company 3 (column 9 of Table 6-10) this grew at an average annual rate of 5.4 percent. One other remarkable performance feature about company 3 is a very small dispersion of the transformation efficiency performance (Figures 6-5 and 6-6, Table 6-10 and Annex Table VI.4). It reflects consistently high time and quality performance, and indicates a very stable production system.

**Table 6-9: Performance in textile branch of Zambian manufacturing, 1982-98 (1990=100)**

| | 1<br>GDP | 2<br>Labour Input | 3<br>Capital Input | 4<br>Labour productivity | 5<br>Capital productivity | 6<br>TFP |
|---|---|---|---|---|---|---|
| 1982 | 72.0 | 54.1 | 175.7 | 133.2 | 324.9 | 63.8 |
| 1983 | 63.3 | 60.5 | 165.4 | 104.7 | 273.3 | 56.9 |
| 1984 | 62.7 | 65.1 | 148.8 | 96.3 | 228.6 | 59.3 |
| 1985 | 61.3 | 82.0 | 132.8 | 74.7 | 161.9 | 56.6 |
| 1986 | 53.1 | 84.7 | 118.7 | 62.7 | 140.1 | 51.6 |
| 1987 | 57.2 | 86.9 | 105.1 | 65.8 | 120.9 | 59.1 |
| 1988 | 60.7 | 90.4 | 99.0 | 67.1 | 109.6 | 63.8 |
| 1989 | 68.5 | 94.4 | 93.9 | 72.5 | 99.4 | 72.8 |
| 1990 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| 1991 | 59.3 | 96.3 | 89.9 | 61.6 | 93.4 | 64.5 |
| 1992 | 77.8 | 92.3 | 81.2 | 84.3 | 88.0 | 91.9 |
| 1993 | 46.9 | 82.9 | 78.4 | 56.6 | 94.6 | 59.0 |
| 1994 | 32.3 | 68.2 | 69.8 | 47.3 | 102.3 | 47.3 |
| 1995 | 34.9 | 67.4 | 63.5 | 51.7 | 94.3 | 54.2 |
| 1996 | 40.1 | 57.1 | 59.4 | 70.2 | 104.0 | 69.0 |
| 1997 | 50.7 | 56.5 | 58.9 | 89.7 | 104.3 | 88.0 |
| 1998 | 50.7 | 51.7 | 57.9 | 98.0 | 112.0 | 92.8 |
| | Average annual growth rates (%) | | | | | |
| 1986-91 | 2.2 | 2.6 | -5.5 | -0.4 | -8.1 | 4.5 |
| 1991-95 | -13.3 | -8.9 | -8.7 | -4.4 | 0.2 | -4.3 |
| 1995-98 | 12.5 | -8.8 | -3.1 | 21.3 | 5.7 | 17.9 |
| 1986-98 | -0.4 | -4.1 | -6.0 | 3.7 | -1.9 | 4.9 |

*Sources:*
*Annex Tables I.1, I.2, I.5 and I.7.*

**Table 6-10: Qualified gross output per worker, effectiveness of production system, production time efficiency, transformation efficiency, human capital index, capital per worker, intermediate inputs per worker, qualified gross output, persons engaged and gross fixed capital stock for company 3, 1986-98 (1990=100)**

| | 1 Qualified gross output per person engaged | 2 Effectiveness of production system | 3 Production time efficiency | 4 Transformation efficiency | 5 Human capital index | 6 Capital per person engaged | 7 Intermediate inputs per person engaged | 8 Qualified gross output | 9 Persons engaged | 10 Gross fixed capital stock |
|---|---|---|---|---|---|---|---|---|---|---|
| 1986 | 27.7 | 99.8 | 99.4 | 99.2 | 97.5 | 31.4 | 30.0 | 27.6 | 99.7 | 31.3 |
| 1987 | 38.1 | 101.6 | 101.2 | 102.8 | 98.4 | 45.1 | 38.0 | 41.8 | 109.8 | 49.4 |
| 1988 | 46.3 | 95.3 | 99.5 | 94.8 | 98.9 | 89.5 | 44.9 | 47.9 | 103.4 | 92.6 |
| 1989 | 95.5 | 98.8 | 100.6 | 99.4 | 99.0 | 97.1 | 95.6 | 97.8 | 102.5 | 99.5 |
| 1990 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| 1991 | 107.6 | 102.3 | 101.2 | 103.5 | 99.7 | 105.5 | 110.8 | 105.9 | 98.5 | 103.9 |
| 1992 | 104.4 | 102.8 | 101.7 | 104.5 | 100.7 | 100.3 | 102.7 | 110.0 | 105.4 | 105.8 |
| 1993 | 103.2 | 102.6 | 101.5 | 104.1 | 103.1 | 104.3 | 101.6 | 107.7 | 104.3 | 108.8 |
| 1994 | 166.8 | 102.7 | 101.8 | 104.6 | 103.1 | 112.5 | 175.6 | 177.7 | 106.5 | 119.8 |
| 1995 | 156.1 | 102.2 | 101.4 | 103.6 | 104.2 | 111.1 | 164.7 | 180.8 | 115.8 | 128.6 |
| 1996 | 153.4 | 97.1 | 100.2 | 97.3 | 107.7 | 85.6 | 166.1 | 224.6 | 146.4 | 125.3 |
| 1997 | 172.4 | 101.3 | 100.5 | 101.8 | 109.1 | 79.6 | 153.5 | 344.2 | 199.6 | 159.0 |
| 1998 | 175.9 | 105.1 | 101.8 | 107.0 | 110.1 | 83.4 | 191.2 | 337.1 | 191.7 | 159.8 |
| | Average annual growth rates ( %) | | | | | | | | | |
| 1986-91 | 27.1 | 0.5 | 0.4 | 0.8 | 0.4 | 24.3 | 26.1 | 26.9 | -0.3 | 24.0 |
| 1991-95 | 9.3 | 0.0 | 0.1 | 0.0 | 1.1 | 1.3 | 9.9 | 13.4 | 4.1 | 5.4 |
| 1995-98 | 4.0 | 0.9 | 0.1 | 1.1 | 1.8 | -9.6 | 5.0 | 20.8 | 16.8 | 7.2 |
| 1986-98 | 15.4 | 0.4 | 0.2 | 0.6 | 1.0 | 8.1 | 15.4 | 20.9 | 5.4 | 13.6 |

*Sources for raw data:*
*Real investment data from company financial reports and statements.*
*Daily and Weekly Production, Maintenance, Quality Control and Stores reports and records, Monthly Personnel reports and records, 1986-98.*
*Qualified gross output, effectiveness of production system, production time efficiency, transformation efficiency and gross fixed capital stock calculated as explained in sections 6.1 and 6.2.2; and human capital calculated with equation 3.29.*
*Sources for deflators: CSO database on Index Numbers of Wholesale Prices 1966=100 (by Industrial Activities); Monthly Digest of Statistics, July-October 1991, tables 48, 49(a) and (b).*

**Table 6-11: Growth of qualified gross output, transformation efficiency, inputs and TFP' for company 3, 1986-98**

| Sub-period | Average growth rates and contributions to growth | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Qualified gross output | Skill-adjusted labour | | Intermediate inputs | | Capital | | Transformation efficiency (a) | | TFP' (a) | |
| | | growth | contrib. | growth | contrib. | growth | contrib. | growth | contrib. | growth | contrib. |
| 1986-91 | 26.9 | 0.2 | 0.0 | 25.9 | 14.2 | 24.0 | 7.8 | 0.8 | 0.8 | 4.1 | 4.1 |
| 1991-95 | 13.4 | 5.2 | 0.7 | 14.0 | 6.5 | 5.4 | 2.1 | 0.0 | 0.0 | 4.0 | 4.0 |
| 1995-98 | 20.8 | 18.6 | 2.6 | 21.8 | 10.1 | 7.2 | 2.9 | 1.1 | 1.1 | 4.1 | 4.1 |
| 1986-98 | 20.9 | 6.5 | 0.9 | 20.9 | 10.6 | 13.6 | 4.7 | 0.6 | 0.6 | 4.1 | 4.1 |

*Sources for raw data:*
*Real investment data from company financial reports and statements.*
*Daily and Weekly Production, Maintenance, Quality Control and Stores reports and records, Monthly Personnel reports and records, 1986-98.*
*Qualified gross output, materials, capital and transformation efficiency calculated as explained in sections 6.1 and 6.2.2; and skill-adjusted labour calculated with equation 3.30.*
*Sources for deflators: CSO database on Index Numbers of Wholesale Prices 1966=100 (by Industrial Activities); Monthly Digest of Statistics, July-October 1991, tables 48, 49(a) and (b).*
*(a) TFP consists of Transformation efficiency and a residual TFP', calculated with equation 3.35.*

**Table 6-12: Influence variables beyond firm's control (public highways and non-highways effort, Herfindahl index, export and import growth, real GDP growth and copper production growth), 1986-98**

| | 1<br>Public highways effort index | 2<br>The rest of public effort index | 3<br>Herfindahl index | 4<br>Average growth of exports & imports | 5<br>Average Real GDP (total) growth | 6<br>Average growth of copper production | 7<br>Average growth of exports | 8<br>Average growth of imports |
|---|---|---|---|---|---|---|---|---|
| 1986 | 1.956 | 0.740 | 0.162 | -0.309 | 0.009 | -0.042 | -0.223 | -0.395 |
| 1987 | 1.083 | 0.760 | 0.163 | 0.358 | 0.009 | 0.051 | 0.316 | 0.400 |
| 1988 | 0.681 | 0.363 | 0.165 | 0.074 | 0.142 | -0.126 | 0.022 | 0.126 |
| 1989 | 0.841 | 0.289 | 0.164 | 0.119 | 0.013 | 0.068 | 0.311 | -0.072 |
| 1990 | 1.001 | 0.195 | 0.162 | 0.058 | -0.089 | -0.055 | -0.056 | 0.172 |
| 1991 | 1.033 | 0.305 | 0.160 | -0.141 | 0.035 | -0.063 | -0.152 | -0.130 |
| 1992 | 2.000 | 0.179 | 0.157 | 0.193 | -0.055 | 0.106 | 0.036 | 0.350 |
| 1993 | 0.821 | 0.147 | 0.155 | -0.205 | 0.133 | -0.086 | -0.127 | -0.283 |
| 1994 | 0.156 | 0.857 | 0.153 | 0.029 | -0.068 | -0.107 | 0.075 | -0.016 |
| 1995 | 0.117 | 1.285 | 0.151 | 0.092 | -0.060 | -0.146 | 0.106 | 0.078 |
| 1996 | 0.353 | 0.054 | 0.149 | -0.102 | 0.012 | 0.020 | -0.177 | -0.026 |
| 1997 | 1.738 | 0.096 | 0.146 | 0.138 | 0.071 | 0.014 | 0.154 | 0.121 |
| 1998 | 2.317 | 4.092 | 0.144 | -0.218 | -0.021 | -0.086 | -0.283 | -0.153 |

*Sources for raw data: GDP, exports, imports and copper production from National Accounts. Investments from National Accounts and unpublished database of the Central Statistical Office (CSO). Manufacturing branch statistics (10+) from the database of the Central Statistical Office (CSO) and Census of Industrial Production, various issues.*

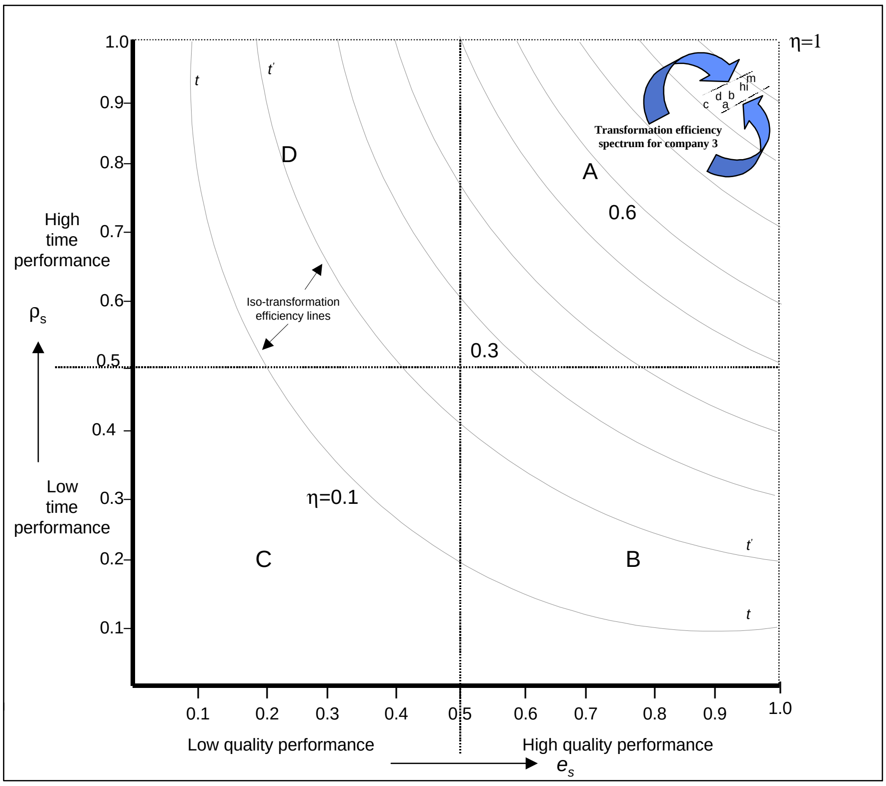


**Figure 6-5: Transformation efficiency diagram for company 3, 1986-98**

Legend: The letters a, b, .., m are used to denote transformation efficiency performance, η, in different years, i.e. a= η in 1986, b= η in 1987, .... , m= η in 1998

$\rho_s$ = production time efficiency, $e_s$ = production system effectiveness, t-t=iso-transformation efficiency line

*Sources for raw data:*

*Daily and Weekly Production, Maintenance, and Quality Control Reports and Records, 1986-98.*

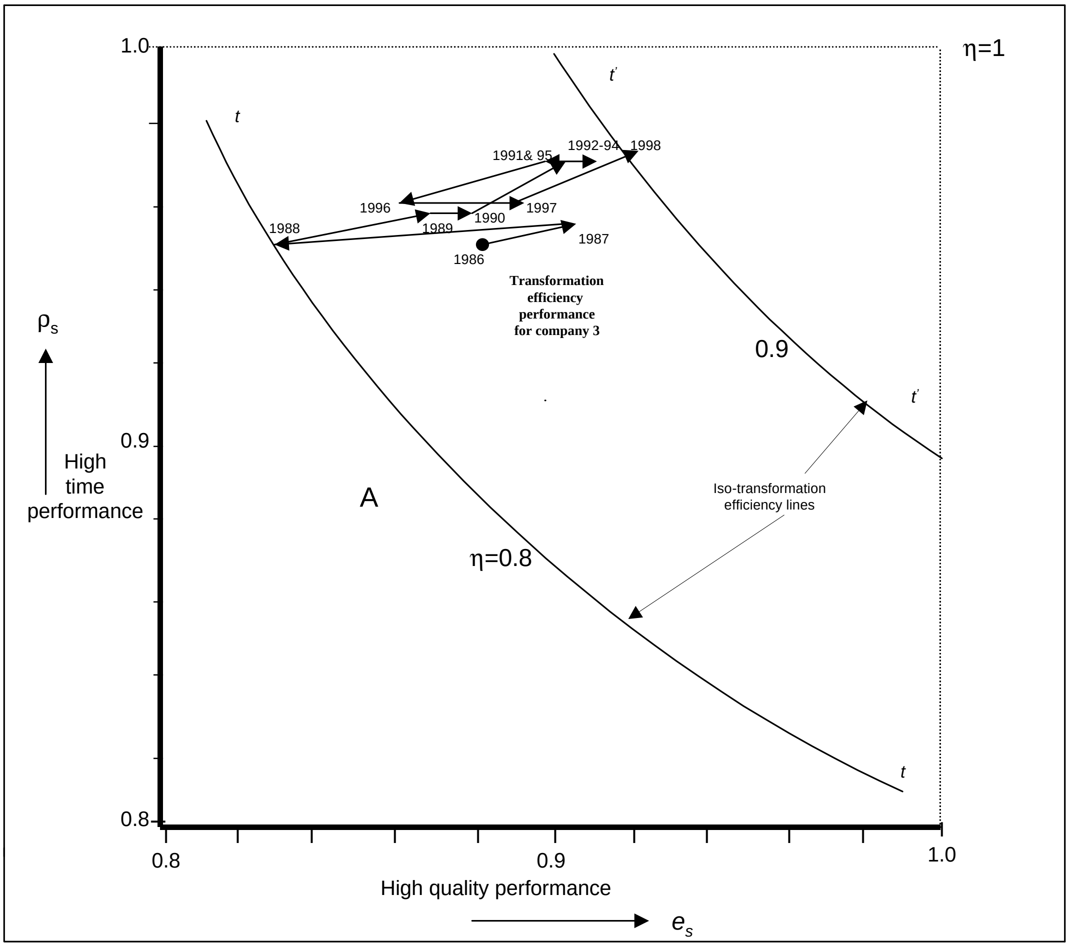


**Figure 6-6: Transformation efficiency performance for company 3 (enlarged diagram), 1986-98**

Legend: $\rho_s$ = production time efficiency, $e_s$ = production system effectiveness, t-t=iso-transformation efficiency line
$\eta = \rho_s * e_s$

*Sources for raw data:*
*Daily and Weekly Production, Maintenance, and Quality Control Reports and Records, 1986-98.*

## 6.4.3 Discussion

Since its inception, company 3 has targeted its plants to achieve world-class quality by aiming at matching best international standards and achieving growing productivity.
Company 3 has been successful in producing and supplying high quality yarn to overseas markets in a timely manner. It has had an advantage compared to the other case studies in adjusting its production organisation to be responsive to the changing overseas market needs. It has also maintained low production costs (for example the average cotton mixing and cone packing costs have remained fairly constant between 1995-98). Its main focus has been achieving high quality consistency through the establishment of standard procedures, process quality control, and performance monitoring systems (by application of physical, chemical and processing tests).

Company 3, from the analysis, is not affected by the fluctuations in the country's economic fortunes.

Over the years, the company has continued to invest in new and the best machinery possible. In 1998, for example, the average age (with respect to the date of machinery's manufacture) of the ring frames, which are the most important pieces of equipment in the spinning cycle both in terms of investment share and factory employment share, was 7.4 years. Investments in other pieces of equipment followed a similar pattern. It has been found that the company's investment in a well designed and proven production process that reflects a widespread emphasis on simplicity and reliability of the technology of the plant operations has helped compensate for the lack of textile industry, maintenance and repair experience on the part of the large majority of the work force. It should be stated that there are no educational institutions in the country which cover the textile industry.

There are other factors that have positively affected the transformation efficiency performance, one of them is the training of shop floor employees. The company runs its own programme in textile technology for newly recruited employees who are mostly secondary school leavers. In the plant, these new employees work under the mentorship of a senior operator and their performance is regularly reviewed at progress panels. A company textile-tailored programme in both the classroom and hands-on training on the shop floor has been the main mode of increasing the stock of skills and knowledge in the labour force. Consultants from within and outside the country are invited to run specialised programmes, such as quality assurance and management systems, internal quality auditing, problem solving, motivation, and project management. Only key personnel are sent to training institutes outside the country for more specialised training. Overseas training is often geared at improving competencies and skills of employees in current positions. Some of these key personnel will in turn act as mentors to new employees. This combination of recruitment of well-educated workers and effective training pre-empts many problems associated with inexperience.

It is important to note that growth in transformation efficiency in company 3 has been very modest in a period of rapid growth of inputs and qualified gross output. We suggest this to be the question of the relationship between technological development and export-oriented growth that is also alluded to in literature (Pack, 1988).

The apparent modest growth in transformation efficiency in company 3 is explained by the fact that company 3 started with a high level of transformation efficiency because of the export-oriented organization of the company's production activities that ensured that productivity was near the best practice levels from the beginning. For example, in 1996, productivity performance at company 3 (measured in terms of kilogrammes of qualified yarn per person engaged) was 76.6 percent of the level of the best spinning mill in Bandung, Indonesia (van der Kamp, 1997). Company 3 has since then surpassed its 1996 performance (i.e. performance level in 1996 is 87.2 percent of its 1998 performance level).

There had, however, been a number of factors that made achieving high performance more difficult or sometimes threatened maintenance of achieved result levels. The supply of consistent and sufficient quality lint cotton was sometimes difficult to secure. This resulted in major fluctuations in the quality of cotton. Production was sometimes affected by deliveries of low quality cotton. One solution was to carefully blend low quality deliveries

with high quality deliveries. This problem was particularly significant during 1991 and 1995. The transformation efficiency also fluctuated from 104.5 index level in 1992 to 104.1 index level in 1993, and then to 104.6 index level the following year. The net effect was 0.0 percent annual growth rate in transformation efficiency between 1991-95.
The lack of highly developed domestic supplier base forced the company to sometimes hold large stocks of incoming inputs, a problem that was common to most Zambian companies. This low level of the domestic supply (quality and quantity) of lint cotton also meant that the company imported from time to time the deficit from neighbouring Zimbabwe. Linking the company to a network of neighbouring country's suppliers would not have been a problem in itself had it not been for the unpredictability of input shipments from regional suppliers due to transportation problems. Bureaucracy in import procedures, for example, which greatly varied in days, also contributed to the high inventory holding.

Notwithstanding the high performance achieved by company 3, additional efforts in human resource management practices are suggested as the company strives to maintain its record of success. In particular, teamwork and information sharing at levels other than senior and middle management are areas that can bring further benefits to the company as this entails a more open door approach to leadership and the shift to a more supportive organizational culture. The rationale of teamwork and information sharing is that employees would be more motivated and, consequently more productive when they obtain an opportunity to co-operate and participate in decision-making at their appropriate levels, and to give their commitment to the shared company goals. With the transformation efficiency so close to 1 ($\eta \cong 1$), significant improvements in the current performance can only result from a technological change and an improvement in input allocation.

Being an export-oriented company, export markets were clearly an important factor in performance improvement efforts. The company operated at international standards. For quality monitoring and control, the Uster statistics and quality requirements from overseas customers were used as reference standards. (The Uster statistics are international quality standards that give cotton yarn specifications, for a given nominal count, with regard to its strength, elongation, thick places, hairiness and neps, for example.) For many quality attributes, the company's final product specifications were above the Uster statistics. In 1996, the company invested to obtain ISO 9002 certification to improve the company's image in quality terms before its overseas customers. In addition, company 3 regularly participated in an inter-mill comparison study administered by SITRA (the South India Textile Research Association of Coimbatore) that focused on key performance indicators such as yarn production costs, operational performance (i.e. productivity particulars, yarn realisation and product diversification), and yarn quality. This benchmark study covered 420 spinning mills spread all over India and seven other nations, namely Ghana, Kenya, Malaysia, Nepal, Sri Lanka, Tanzania, and Zambia. The inter-mill comparison study provided important benchmarks of performance.

Finally, since a large amount of intermediate inputs (i.e. 88.1 percent of total intermediate input requirements in 1998) is sourced locally, export markets become even more important in the sense that this company creates a multiplier effect when it demands from domestic suppliers in rural Zambia quality raw fibres. This is an important indicator of the potential for creating backward industrial linkages for industrial performance improvement.

## 6.5 Company 4: Mining Implements Production

### 6.5.1 Background

Company 4 is based at Ndola in the copper mining province of Zambia, and is a subsidiary of a multi-national company. The company was established in 1963, at the beginning of the so-called “Zambian Golden 60’s”. In other words, the Zambian economy, particularly the mining industry, was surging ahead. Company 4 started by operating as a marketing company. It later started manufacturing diamond crowns and hardmetal mining tools under license, and to carry out contract drilling for the then Northern Rhodesia copper industry [later known as Zambia Consolidated Copper Mines Limited (ZCCM)[20]]. Since the advent of privatization in Zambia in 1993, the mining units (called mining divisions) of ZCCM have been sold either to new private investors or back to the original owners before government-ownership. Privatisation of mining units was, however, consolidated only fairly recently. At the time this research was being conducted, the mining sector was in crisis. This in itself had a special impact on company 4 and its operations.

The company’s turnover for the financial year 1998 was Zambian Kwacha 5.2 billions. It has 115 employees, downsizing from about 280 employees in 1995.

Company 4 is a major supplier of rockdrills and spares to the mining industry in Zambia. The company’s product range initially included carbide tools and diamond products. The company manufactures five main product categories, namely rockdrilling machinery and spares, extension equipment, diamond drilling tools, carbide tipped components, and SECO rockdrill machines and spares. The company makes to order and for stock for the domestic market. Production of mining implements is carried out in four almost adjacent shops, namely the machine shop (which is also the main shop), the heat treatment shop, the button bit shop and the tungsten carbide shop. Another industrial products shop caters basically for non-mining products.
A discussion of the mining implements production process is presented in Annex VI.4.

### 6.5.2 Results of Performance Improvement Related Activities

We used the methods described in section 6.2.2 to analyse company performance. The raw data employed in the analysis were collected during four research visits to the company totalling 13 weeks that were also spread over a period of four years. Since the company had no single dominant product, we used deflated production values of qualified gross output instead of physical quantities of qualified gross output. One-shift 5 days a week system is the normal system of operation at company 4. The considered production period was estimated on the basis of the firm’s major production lines and was 90,000 hours (1 year). This is another case where the considered period was not equal to 100 percent capacity utilisation.

[20] ZCCM was also to become the mining company embracing all mining units national-wide.

The specific branch performance and company performance are reported in Tables 6-13 and 6-14. The results shown in Table 6-13 indicate that while the branch labour productivity (column 4) experienced a total decline between 1986 and 1998 (of 4.8 percent per year), analysis of the sub-period performance shows that branch productivity grew in the last sub-period of 1995-98. The growth was 10 percent per year, and TFP (column 6) grew at an average annual rate of 6.1 percent. The branch capital stock (column 3) that only grew between 1987 and 1990 showed an average decline of 1.2 percent per year between 1986 and 1998. Compared to the total manufacturing performance, the branch recovery was below the sector performance. It must be remembered that the basic and fabricated metal products branch is the branch that is most dependent on mining, and company 4 has an almost 100 percent dependence on Zambian mining. The branch gross value added (column 1) fell by an average annual rate of 9.5 percent between 1986 and 1998, while copper production during the same period fell by an average annual rate of 3.4 percent.

Table 6-14 shows that the company's human capital index (column 5) rose steadily at an average growth rate of 2.5 percent per year. As for other results, the qualified gross output per person engaged (column 1) varied over the whole period. Notice that from 1986 through to 1991, the company experienced a decline in productivity performance. The qualified gross output per person engaged grew at a negative rate of 10.6 percent per year. This negative performance was repeated in the period of 1991 to 1995 (0.2 percent per year). Between 1995 and 1998, a positive growth rate was registered (1.8 percent per year, the branch performance was 10.0 percent per year). The striking difference between the heavy decline in qualified gross output (column 8) at an average annual rate of 25.0 percent and the positive growth in qualified gross output per person engaged (column 1) at an average annual rate of 1.8 percent indicates a successful radical downsizing in the period of 1995 to 1998. The overall decline of qualified gross output per person engaged was at an average annual rate of 4.0 percent between 1986 and 1998.

The growth in company's qualified gross output was at –11.6 percent per year between 1986 and 1998. During this same period copper production declined by 3.4 percent per year (column 6 of Table 6-16). With severely declining mining operations in Zambia and a growing competition in mining products following the privatisation of former ZCCM mining units, the company's long term viability hinges on the maintenance of performance growth achieved in the last sub-period (1995-98) and an aggressive development of regional and international markets. The growth in qualified gross output per worker (1.8 percent per year) and in transformation efficiency (0.8 percent per year) achieved during the 1995-98 sub-period was due to the company's restructuring and downsizing. The branch Herfindahl index that was at 0.051 level in 1986 was at 0.046 level in 1998. This result points to an increase in competition in the branch.

The transformation efficiency (column 4 of Table 6-14) steadily grew at an average annual rate of 3.2 percent. Much of the growth in transformation efficiency was accounted for by an improvement in time efficiency (62.9 percent) and the rest by quality improvement (37.1 percent). Tables 6-14 and 6-15 indicate that external influences were as important as internal circumstances to the growth of performance of company 4. The results in Table 6-15 further show that the impact of external influences on the growth of performance of company 4 grew. Company 4 was a relatively efficient company which was, however, totally locked into a declining domestic sector – Zambian copper mining.

Annex Table VI.5 (column 9) points to a relatively stable production system. This quality of the production system, except for some years, is depicted in Figures 6-7 and 6-8. There are possibilities of improvement in system effectiveness and time efficiency by paying more attention to quality and by reducing non-value-adding periods. The company also needs to orient itself to exports in Africa and elsewhere.

**Table 6-13: Performance in basic and fabricated metal products branch of Zambian manufacturing, 1982-98 (1990=100)**

| | 1<br>GDP | 2<br>Labour Input | 3<br>Capital Input | 4<br>Labour productivity | 5<br>Capital productivity | 6<br>TFP |
|---|---|---|---|---|---|---|
| 1982 | 118.9 | 75.8 | 100.7 | 157.0 | 132.9 | 134.3 |
| 1983 | 85.7 | 76.2 | 98.2 | 112.4 | 128.8 | 98.1 |
| 1984 | 141.0 | 79.3 | 93.9 | 177.9 | 118.5 | 163.2 |
| 1985 | 165.8 | 99.9 | 91.2 | 165.9 | 91.3 | 174.8 |
| 1986 | 186.9 | 98.4 | 90.7 | 189.9 | 92.2 | 199.0 |
| 1987 | 138.9 | 96.8 | 89.8 | 143.5 | 92.8 | 149.8 |
| 1988 | 139.8 | 96.8 | 93.1 | 144.4 | 96.2 | 147.6 |
| 1989 | 87.8 | 97.6 | 93.3 | 90.0 | 95.6 | 92.3 |
| 1990 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| 1991 | 126.0 | 98.0 | 96.4 | 128.5 | 98.3 | 129.8 |
| 1992 | 160.8 | 96.0 | 92.6 | 167.5 | 96.5 | 171.1 |
| 1993 | 68.0 | 88.4 | 90.3 | 76.9 | 102.1 | 76.0 |
| 1994 | 102.4 | 75.0 | 85.6 | 136.5 | 114.2 | 127.3 |
| 1995 | 56.9 | 71.5 | 82.1 | 79.5 | 114.8 | 74.0 |
| 1996 | 47.3 | 61.0 | 79.7 | 77.6 | 130.7 | 66.9 |
| 1997 | 59.7 | 60.7 | 79.7 | 98.2 | 131.2 | 84.6 |
| 1998 | 60.0 | 55.9 | 78.9 | 107.3 | 141.1 | 88.9 |
| | Average annual growth rates (%) | | | | | |
| 1986-91 | -7.9 | -0.1 | 1.2 | -7.8 | 1.3 | -8.6 |
| 1991-95 | -19.9 | -7.9 | -4.0 | -12.0 | 3.9 | -14.0 |
| 1995-98 | 1.8 | -8.2 | -1.3 | 10.0 | 6.9 | 6.1 |
| 1986-98 | -9.5 | -4.7 | -1.2 | -4.8 | 3.5 | -6.7 |

*Sources:*
*Annex Tables I.1, I.2, I.5 and I.7.*

**Table 6-14 : Qualified gross output per worker, effectiveness of production system, production time efficiency, transformation efficiency, human capital index, capital per worker, intermediate inputs per worker, qualified gross output, persons engaged and gross fixed capital stock for company 4, 1986-98 (1990=100)**

| | 1 Qualified gross output per person engaged | 2 Effectiveness of production system | 3 Production time efficiency | 4 Transformation efficiency | 5 Human capital index | 6 Capital per person engaged | 7 Intermediate inputs per person engaged | 8 Qualified gross output | 9 Persons engaged | 10 Gross fixed capital stock |
|---|---|---|---|---|---|---|---|---|---|---|
| 1986 | 219.6 | 86.9 | 106.2 | 92.3 | 86.5 | 87.0 | 149.7 | 212.5 | 96.8 | 84.2 |
| 1987 | 165.1 | 90.8 | 94.4 | 85.7 | 89.0 | 94.8 | 99.9 | 151.2 | 91.6 | 86.8 |
| 1988 | 131.0 | 87.8 | 85.6 | 75.1 | 91.7 | 97.4 | 140.7 | 119.1 | 90.9 | 88.5 |
| 1989 | 108.9 | 98.2 | 100.3 | 98.5 | 97.4 | 103.5 | 126.2 | 102.9 | 94.5 | 97.8 |
| 1990 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| 1991 | 129.0 | 102.7 | 109.2 | 112.1 | 101.7 | 102.4 | 118.8 | 124.4 | 96.4 | 98.8 |
| 1992 | 158.9 | 100.5 | 109.9 | 110.5 | 103.0 | 96.2 | 147.6 | 159.4 | 100.3 | 96.5 |
| 1993 | 168.3 | 100.3 | 118.3 | 118.6 | 103.9 | 84.7 | 113.4 | 186.3 | 110.7 | 93.7 |
| 1994 | 105.6 | 104.4 | 123.8 | 129.3 | 106.3 | 104.0 | 37.9 | 90.3 | 85.4 | 88.8 |
| 1995 | 128.0 | 106.1 | 124.8 | 132.5 | 106.2 | 97.9 | 60.8 | 111.0 | 86.7 | 84.9 |
| 1996 | 188.9 | 102.5 | 128.1 | 131.3 | 112.8 | 131.1 | 69.0 | 114.3 | 60.5 | 79.4 |
| 1997 | 145.2 | 100.9 | 116.4 | 117.5 | 114.7 | 127.0 | 80.0 | 86.0 | 59.2 | 75.2 |
| 1998 | 135.2 | 100.3 | 135.5 | 135.9 | 116.7 | 182.8 | 66.6 | 52.5 | 38.8 | 71.0 |
| | Average annual growth rates ( %) | | | | | | | | | |
| 1986-91 | -10.6 | 3.3 | 0.5 | 3.9 | 3.2 | 3.3 | -4.6 | -10.7 | -0.1 | 3.2 |
| 1991-95 | -0.2 | 0.8 | 3.4 | 4.2 | 1.1 | -1.1 | -16.7 | -2.9 | -2.7 | -3.8 |
| 1995-98 | 1.8 | -1.9 | 2.7 | 0.8 | 3.2 | 20.8 | 3.1 | -25.0 | -26.8 | -6.0 |
| 1986-98 | -4.0 | 1.2 | 2.0 | 3.2 | 2.5 | 6.2 | -6.7 | -11.6 | -7.6 | -1.4 |

*Sources for raw data:*
*Real investment data from company financial reports and statements.*
*Daily and Weekly Production, Maintenance, Quality Control and Stores reports and records, Monthly Personnel reports and records, 1986-98.*
*Qualified gross output, effectiveness of production system, production time efficiency, transformation efficiency and gross fixed capital stock calculated as explained in sections 6.1 and 6.2.2; and human capital calculated with equation 3.29.*
*Sources for deflators: CSO database on Index Numbers of Wholesale Prices 1966=100 (by Industrial Activities); Monthly Digest of Statistics, July-October 1991, tables 48, 49(a) and (b).*

**Table 6-15: Growth of qualified gross output, transformation efficiency, inputs and TFP' for company 4, 1986-98**

| Sub-period | Qualified gross output | Skill-adjusted labour growth | Skill-adjusted labour contrib. | Intermediate inputs growth | Intermediate inputs contrib. | Capital growth | Capital contrib. | Transformation efficiency (a) growth | Transformation efficiency (a) contrib. | TFP' (a) growth | TFP' (a) contrib. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1986-91 | -10.7 | 3.2 | 0.4 | -4.7 | -2.8 | 3.2 | 0.9 | 3.9 | 3.9 | -13.1 | -13.1 |
| 1991-95 | -2.9 | -1.6 | -0.2 | -19.4 | -11.5 | -3.8 | -1.1 | 4.2 | 4.2 | 5.7 | 5.7 |
| 1995-98 | -25.0 | -23.6 | -2.9 | -23.7 | -14.0 | -6.0 | -1.7 | 0.8 | 0.8 | -7.2 | -7.2 |
| 1986-98 | -11.6 | -5.1 | -0.6 | -14.4 | -8.5 | -1.4 | -0.4 | 3.2 | 3.2 | -5.3 | -5.3 |

*Sources for raw data:*
*Real investment data from company financial reports and statements.*
*Daily and Weekly Production, Maintenance, Quality Control and Stores reports and records, Monthly Personnel reports and records, 1986-98.*
*Qualified gross output, materials, capital and transformation efficiency calculated as explained in sections 6.1 and 6.2.2; and skill-adjusted labour calculated with equation 3.30.*
*Sources for deflators: CSO database on Index Numbers of Wholesale Prices 1966=100 (by Industrial Activities); Monthly Digest of Statistics, July-October 1991, tables 48, 49(a) and (b).*
*(a) TFP consists of Transformation efficiency and a residual TFP', calculated with equation 3.35.*

**Table 6-16: Influence variables beyond firm's control (public highways and non-highways effort, Herfindahl index, export and import growth, real GDP growth and copper production growth), 1986-98**

| | 1<br>Public highways effort index | 2<br>The rest of public effort index | 3<br>Herfindahl index | 4<br>Average growth of exports & imports | 5<br>Average Real GDP (total) growth | 6<br>Average growth of copper production | 7<br>Average growth of exports | 8<br>Average growth of imports |
|---|---|---|---|---|---|---|---|---|
| 1986 | 1.956 | 0.740 | 0.051 | -0.309 | 0.009 | -0.042 | -0.223 | -0.395 |
| 1987 | 1.083 | 0.760 | 0.051 | 0.358 | 0.009 | 0.051 | 0.316 | 0.400 |
| 1988 | 0.681 | 0.363 | 0.050 | 0.074 | 0.142 | -0.126 | 0.022 | 0.126 |
| 1989 | 0.841 | 0.289 | 0.050 | 0.119 | 0.013 | 0.068 | 0.311 | -0.072 |
| 1990 | 1.001 | 0.195 | 0.049 | 0.058 | -0.089 | -0.055 | -0.056 | 0.172 |
| 1991 | 1.033 | 0.305 | 0.048 | -0.141 | 0.035 | -0.063 | -0.152 | -0.130 |
| 1992 | 2.000 | 0.179 | 0.048 | 0.193 | -0.055 | 0.106 | 0.036 | 0.350 |
| 1993 | 0.821 | 0.147 | 0.047 | -0.205 | 0.133 | -0.086 | -0.127 | -0.283 |
| 1994 | 0.156 | 0.857 | 0.047 | 0.029 | -0.068 | -0.107 | 0.075 | -0.016 |
| 1995 | 0.117 | 1.285 | 0.046 | 0.092 | -0.060 | -0.146 | 0.106 | 0.078 |
| 1996 | 0.353 | 0.054 | 0.046 | -0.102 | 0.012 | 0.020 | -0.177 | -0.026 |
| 1997 | 1.738 | 0.096 | 0.046 | 0.138 | 0.071 | 0.014 | 0.154 | 0.121 |
| 1998 | 2.317 | 4.092 | 0.046 | -0.218 | -0.021 | -0.086 | -0.283 | -0.153 |

*Sources for raw data: GDP, exports, imports and copper production from National Accounts. Investments from National Accounts and unpublished database of the Central Statistical Office (CSO). Manufacturing branch statistics (10+) from the database of the Central Statistical Office (CSO) and Census of Industrial Production, various issues.*

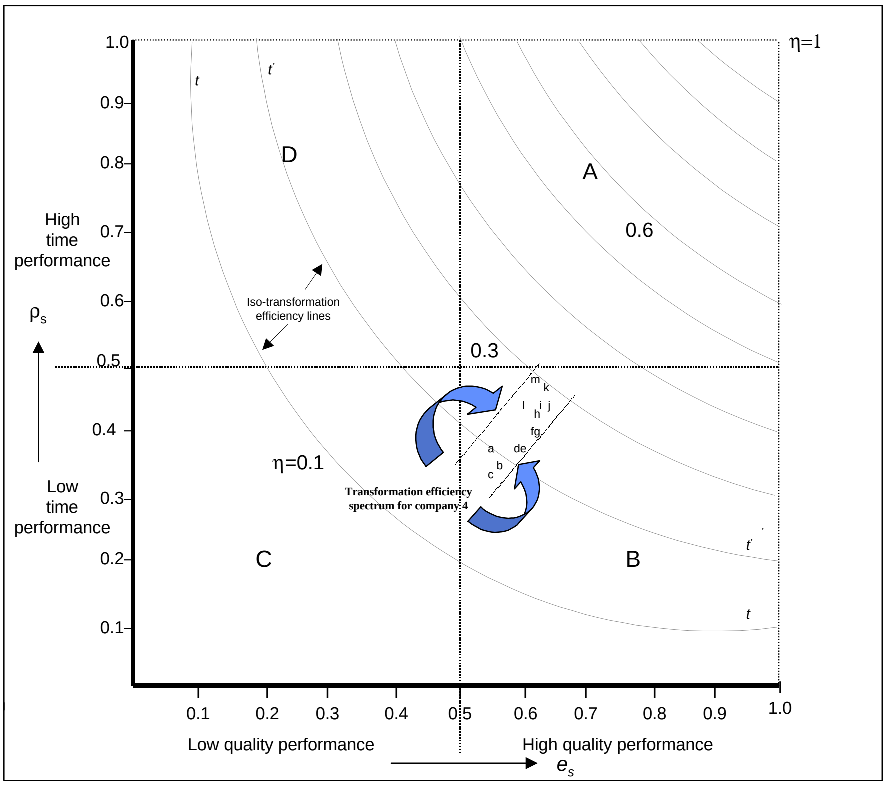


**Figure 6-7: Transformation efficiency diagram for company 4, 1986-98**

Legend: The letters a, b, .., m are used to denote transformation efficiency performance, η, in different years, i.e. a= η in 1986, b= η in 1987, .... , m= η in 1998

$\rho_s$ = production time efficiency, $e_s$ = production system effectiveness, t-t=iso-transformation efficiency line

*Sources for raw data:*

*Daily and Weekly Production, Maintenance, and Quality Control Reports and Records, 1986-98.*

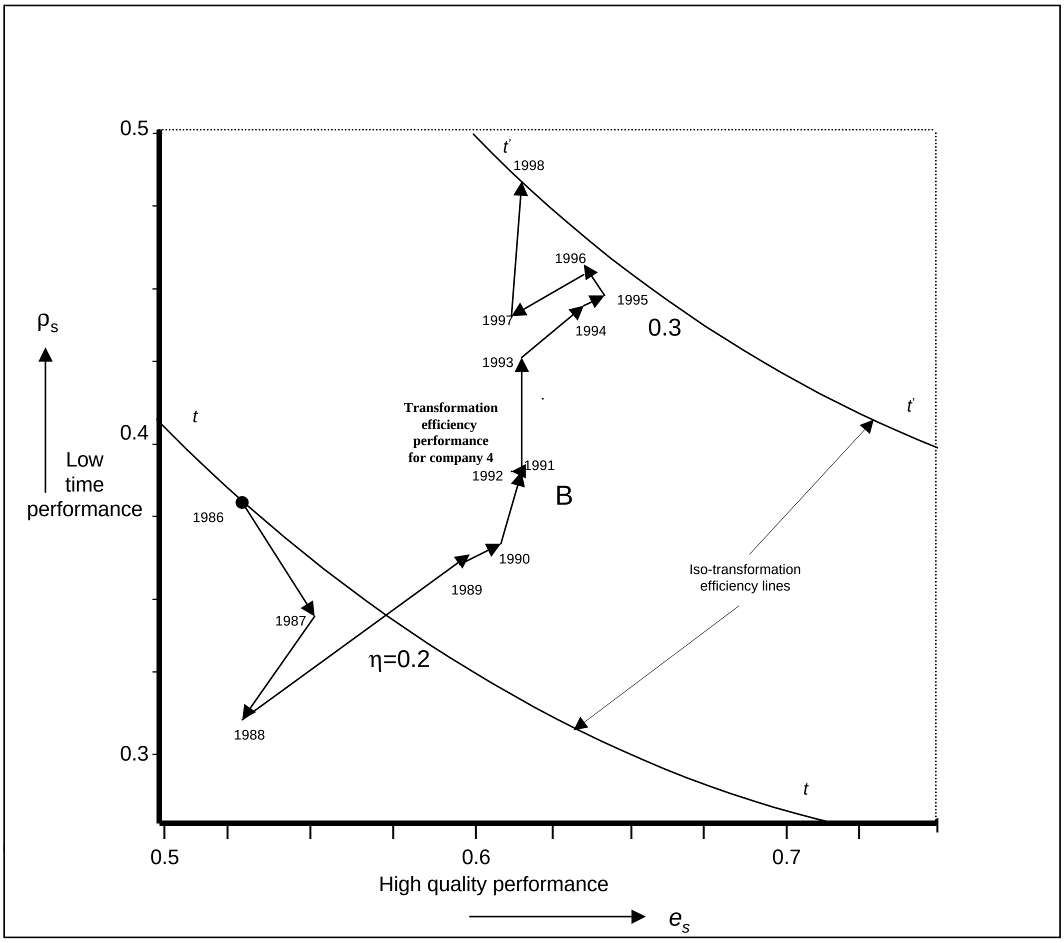


**Figure 6-8: Transformation efficiency performance for company 4 (enlarged diagram), 1986-98**

Legend: $\rho_s$ = production time efficiency, $e_s$ = production system effectiveness, t-t=iso-transformation efficiency line
$\eta = \rho_s * e_s$

*Sources for raw data:*
*Daily and Weekly Production, Maintenance, and Quality Control Reports and Records, 1986-98.*

## 6.5.3 Discussion

To examine the effects of the company's improvement efforts on production performance in more detail, an almost year-by-year analysis is performed.

In the early years of the company's establishment the organisation of production was functional. This meant that in the main production shop there were separate sections dedicated to turning, to boring, to milling, to grinding and so on. The emphasis was on maximising machine utilisation. Large batches of products were manufactured. Production was insensitive to fluctuations in the market. Because of the long lead times, production forecasts were made based on anticipated future orders of mining divisions. This necessitated the holding of high stocks of finished products and intermediate inputs. For example, the ratio of inventory to sales fluctuated between 24 and 46 percent between 1986 and 1989. This declined to between 15 and 21 percent between 1996 and 1998.

The production organisation and control were also more complex and required a large number of specialised supervisors. Work preparation and work-study sections were centralised. The general manager was the overall boss of all sections. In 1986, there were 299 employees, of which about 17 percent were in supervisory positions. Production supervisory positions account for less than 10 percent at present.

From the transformation efficiency diagrams (Figures 6-7 and 6-8), a sustained improvement in transformation efficiency performance is observed from 1990 onwards. In 1989 the company introduced the TE (Towards Excellence) program. The special features of the program were the quality awareness meetings that were cascaded downwards to include operators and the introduction of a system of feedback documentation of product performance for all major products. In the quality awareness meetings emphasis was on communication to the line about poor quality, defects and cost of scrap. Before this program, the reporting system was only limited to returned products by customers and did not include sold products that did not perform satisfactorily in service. Another aspect of the program was encouragement of experimentation on the shop floor. However, since most of the work on the shop floor embraced targets and deadlines, workers did not have much freedom to experiment. The alternative option that was pursued was encouragement of weekend experimentation.

In the production of mining implements, heat treatment of ferrous alloys is the most critical operation both in terms of production lead time and product performance. Mining implements, such as extension equipment and rock drill components, are subjected to intense, complex stresses and wear conditions by the nature of their use. The selected alloy steels to be used in their manufacture are, therefore, heat-treated to achieve the necessary properties that ensure long life and resistance to the above working conditions. From 1991, the company invested a lot of efforts to review all heat treatment cycles and to train operators in matching of gas carbon potential to that of steel surface condition. The review and training lead to the elimination of a multitude of carbon furnaces and a shift to a single carbon dioxide setting for carburising of all products in all furnaces. The introduction of a carburise-diffuse type cycle led to a 50 percent reduction in carburising time. Other changes included the replacement of multiple quenching by single direct quenching for all components to be finish-machined prior to heat treatment. This eliminated the long annealing sequences and improved material flow. Changes in materials on some high volume products were effected to reduce cost and improve product performance. On one product, material substitution resulted in a decline of 6 percent failures in service as a result of product cracking.

Following a directive from the company's corporate headquarters in 1990, TQM (Total Quality Management) as a strategy for productivity improvement was implemented at company 4 in 1993. This was born out of the strong realisation that in order to survive, the company needed to further improve its product quality, and especially in view of the pending liberalisation of the economy in which competition from the region and outside the region was expected to become intense. Much of the TQM approach at company 4 addressed a re-orientation of employees' working practices and attitude into a total quality culture of continuous improvement in order to achieve results in less time (For an expanded discussion of the TQM and its historical development see Heizer and Render, 1996; Lawton, 1989; and US Department of Defence, 1995. Here we only present TQM as implemented and practised at company 4). There was little effort in addressing the core technologies in the production process.

TQM was generally perceived by the company personnel to represent an integrative approach in the pursuit of customer satisfaction.

However, from the company's internal records and author's primary observations made during the periods of research visits, the re-orientation of personnel which was identified to be crucial to the effort in moving towards TQM, practically remained the main approach for an effective organisational change.
A lot of effort was put into influencing employees' attitudes and behaviour. Company 4 emphasised that a quality transformation should begin with individual employees across all the ranks (from top management down to operators on the shop floor). These efforts to change the company into a learning organization were co-ordinated through the human resources department. Training was adjusted to include some of the renowned quality improvement tools, such as: 5s programme that stresses the importance of classifying, arranging efficiently, checking through cleaning, neatness, and discipline (Jones, 1996); statistical quality control (Schippers, 2000) that was introduced to the production line to enhance quality assurance; green areas programme that had the concept of quality control circles (Leboeuf, 1982) but in this case was introduced to generate a spirit of participation in the quality improvement activities and an attitude of pride in the performance of individual employees. These improvement efforts, naturally, proved to be difficult to implement in a period of downsizing.

The green area programme was developed to a level that it became the main instrument of TQM implementation. At company 4, a green area was a small group of employees (6, on average) who met daily at a specific time (usually towards the end of the shift) and place (a reserved central place within the work area) to carry out quality improvement activities within their workshop or section. The purpose of green areas was to provide a forum for communication among members and between members and management, for identification of problems, analysis of causes, generation of new ideas and their implementation.

The change of the roles of members of the company was an additional approach. For example, on the shop floor, workstations were literally known as either internal customer or internal supplier and the relationship was that workstations upstream were to satisfy workstations downstream (internal customers) in quality and delivery performance. Failures to satisfy internal customers attracted high prominence during green area meetings. The premise was that it was virtually impossible to meet external customer satisfaction when internal customer requirements were not met. This idea of internal supplier/customer was also extended to the relationships between sections and departments within the firm.

This human approach to organizational change brought about significant changes. Good housekeeping, for example, became an integral part of the worker's routine activities rather than a separate task, as was the case before. Transformation efficiency performance also surged forward (7.1 percent per year between 1992-93). There was also a positive growth in qualified gross output per worker of 5.8 percent per year.

As mentioned before, the approach was, for practical purposes, geared towards people. Other interrelated approaches for an effective organisational change such as technology and organisational structure approaches did not receive great prominence. With regard to changes in the organisational technology, the efforts towards either altering the equipment or production methods were low. Investments in better production methods were limited. Capital stock has been declining on average at 1.4 percent per year between 1986-98. The decline in capital stock started after 1990. In some instances, the major technological thrust of the company has been to procure second-hand machinery and equipment, and salvage near-obsolete technologies. A case in point, a second-hand Cridan internal threading machine and an early generation CNC (Computer Numerical Control) turning machine that were discarded by its sister companies in the Netherlands and South Africa were rehabilitated and installed at company 4. Although this was evidence of a high level of skills mastered by employees at company 4, it had some serious implications on the maintenance of equipment and machinery and the maintenance of quality and time performance standards due to frequent equipment breakdowns, lack of suitable spares and difficulties in achieving high machining accuracy. The rate of growth of time performance declined. Production time efficiency that grew at 3.4 percent per year between 1991-95, only grew at 2.7 percent per year between 1995-98.

With respect to the structure of the company's managerial hierarchy and lines of communication, some progress was achieved. Functional division and focus on individual function declined. The organizational structure was more responsive to customer demand and co-operation among employees improved drastically. Typically, each section was less concerned with its performance and there was evidence of team-based performance evaluation. The noticeable improvement was in the shorter cycle time, from the time a customer's order was raised to the order delivery time. The composite delivery cycle time index improved from the 0.266 level in 1995 to the 0.259 level in 1998.

In 1996, the company implemented production cells in the main shop (changing from a conventional functional plant layout to cellular layout). Before the introduction of production cells, material flow through the plant was slow, the capability of the centralised planning section to guide work in progress to the right place and at the right time was limited with the net result of long delivery times and a big transportation problem in the shop. One aim of the new organisation of production was to expand the individual responsibilities of shop floor employees and the possibilities for them to influence their work task and its timing.

The production of high volume products was analysed with the view of finding parts that could be done with the family of parts principle. That was identifying common components and operations in the shop's products. The main principle of classification was based on the following components and operations: extension rods, couplings, lug shanks and bits, steel turning, drilling, milling, undercutting and threading. The analysis gave indications that there were really possibilities to make changes in the organisation of production. This was followed by a study of work operations for these parts and production cells were made for part making. In one production cell, for example, it was possible to do turning, milling, NC (Numerical Control)-machining and mounting operations necessary to make a lug shank completely ready. The production program and schedule for cells were under a foreman and a production planner. Special operations such as forging, high accuracy boring, grinding, bar sawing and heat treatment were not divided for every cell. Although production loading and part guiding became relatively easier, co-ordination between production cells and company's general delivery program remained problematic. For example, lug shanks could not be delivered if heat treatment was delayed or jackhammers could not be delivered if pistons were delayed. However, the growth in time efficiency (at 2.6 percent per year between 1995-96) as outputs grew in spite of higher demands of quality was an indication that the change that allowed shop floor personnel to be responsible and to make better decisions for the whole product making process rather than for separate operations was a right one.

As the emphasis in the new production set-up was on rapid response and on making products to orders, a number of changes became necessary. New quality procedures were established. Before there were inspectors and a section dedicated to rehabilitation of rejects. Instead of the end-of-line quality control, machine operators became responsible for their job inspection and for rehabilitating rejects. Members of the cells met daily to discuss production problems. Those problems that required management attention were recorded accordingly in the logbooks.

Individualised tasks were replaced by flexible work teams and this effort was not limited to production sections but was also extended to the other sections of the firm.
Despite these efforts, the company had yet to achieve an effective production system, as the ambitious implementation of such innovative systems company-wide to create the required synergistic spillover that sustained continuous improvement, was at first frustrated by the demand for its mining products.

As the complete privatisation of ZCCM became unclear in the mid-90s, ZCCM's demand for mining implements became erratic and its financial situation got worse. Company 4, in turn started accumulating debts to group companies and experiencing cash flow difficulties as a result of mining units failing to settle their debts in time. This situation was extremely severe in 1995-96. Abstracting the effects of liberalisation policies, consequences of the decline of overall copper production in the country also meant that the company faced a declining market. This exclusive focus on a declining domestic market clearly is in sharp contrast with company 3.

Secondly, as mentioned earlier on, investment in modern machinery and equipment was too low over the years to meet the new quality and performance standards demanded by some new owners of mining units. For instance, a trend in copper production away from pneumatic to hydraulic drilling needed to translate into a change in some of company 4's production methods to meet these new demands. Another case is that, in 1997, one major mining unit changed the acceptance criterion of mining implements. Instead of the old historical bit cost per metre drilled, the new criterion became the penetration rate (i.e. the equivalent linear metres drilled per number of shifts per bit). The rationale was that faster penetration bits were more cost effective than slower penetration bits. Company 4, which had been the preferred supplier of mining implements to mining units based on the old performance criterion, was hence no longer leading on the composite performance criterion of cost per metre drilled, life span and penetration rate of mining implements. As already mentioned, the human approach alone to performance improvement was not sufficient in an environment of shifting quality and performance standards of mining implements. The company's future survival dictates investments to modernise plant and equipment, and to develop export markets.

The domestic demand for mining implements is expected to remain weak in the short run and therefore cannot contribute significantly to a strong growth in performance. A successful privatisation of ZCCM and a return to normal buying patterns of mining implements, however, could give some potential for growth through an increase in capacity utilisation.

Let us recall that the benefits to be obtained either from people or structural approaches to organizational change tends to be severely limited when insufficient efforts are made to upgrade the company's production systems.

An in-depth investigation has also shown that even the TQM enthusiasm quickly waned down the organisational structure, with workers at the shop floor level having the least commitment. The suggestion scheme that was implemented in 1997 had one recorded suggestion per 23 employees and one employee out of 11 employees had participated and submitted a suggestion in the scheme in June 1997. In October 1997, there was only one recorded suggestion per 177 employees and one employee out of 59 employees had participated and submitted a suggestion in the scheme.

A major shake-out in the company occurred in October 1996. To try to redress the diminishing fortunes (i.e. to cut down on costs), the labour force was reduced by 27.1 percent. Consequently the workload for the remaining employees became heavier and work hours stretched as more responsibilities were added with no significant intrinsic or material compensations. It was no wonder that frustrations, though not often visibly expressed, were widespread. The impact of this first-ever massive redundancy of October 1996 is an important logical explanation of the steep fall in transformation efficiency in 1997. Nevertheless, a recovery in transformation efficiency is recorded the following year, as stability in the system was re-established. One interesting aspect is that the time lost through vacations and other holidays, sickness, absenteeism and disciplinary suspension per employee declined from 9.3 days in 1995 to 7.2 days in 1998.

To counteract the fall in copper mining activities that directly translated into the fall of the demand for company 4's products by the mining group, company 4 introduced a number of peripheral activities in the mid 1990s. For example, the company opened additional shops to produce farming implements and spares for motor vehicles. This diversification of effort was not very successful. In one case, when the automobile plant for which company 4 had targeted the production of spare parts closed down, the company suffered losses in unsold inventories of finished and imported intermediate inputs. The products stockpiled have not been reusable due to the changing demand patterns. The company has now closed or opted to hire off non-core activities to third parties in an attempt to cut fixed costs and streamline the organisation. The disastrous failure of the diversification programme can be attributed to lack of a conscious and integrated approach to build a viable business which satisfies a manifested demand or a negotiated opportunity with customers (regional or domestic). Instead, it was more of a case of reacting to the growing plant capacity under-utilization and shrinking demand for its mining products.

In summary, there have been serious efforts to improve performance at company 4 and some excellent results have been achieved. This places the company in a better position to profit from the recent privatisation of mining units. Company 4 has one of the best-trained labour forces, and average growth in human capital index has been at 2.5 percent per year.

Productivity, which has been declining at an average annual rate of 0.2 percent between 1991-95, rose at an average annual rate of 1.8 percent between 1995-98 when the whole manufacturing sector experienced a positive growth. But further substantial improvement in the transformation efficiency is unlikely to be achieved with the current capital stock because of its old age and the change in quality requirements of mining implements. As a strong and quick recovery of Zambian copper production is unlikely and faced with a shift towards higher quality and performance standards of mining implements, company 4 has to continue restructuring and operation-streamlining, to reduce its product range to main and successful products, and re-invest in modern machinery and equipment. The company also needs to reduce dependence on a few customers and to develop export orientation for its mining and non-mining products in Africa and elsewhere.

We summarise the findings in the next chapter. The summary of the research findings is preceded by an analysis of the four case studies by applying a systematic comparison of similarities and differences, and relating the case studies to the sectoral environment.
From the case studies, the different improvement efforts resulted in different levels of performance. Company 3 was the most successful case study. Additionally, the upturn in sectoral performance after 1995 created the necessary dynamism that positively affected performance in all the four case studies.

# 7 Conclusion

## 7.1 Manufacturing Performance Improvement

Chapter 6 analysed the performance of case studies on the basis of qualified gross output per person engaged and transformation efficiency, and related this analysis to specific branch performance. The analysis provides some positive pointers of the changes taking place in some Zambian firms. In their bid to improve performance, firms are developing new (as pointed out earlier on, the term new applies to the implementing firm) productivity and quality improvement approaches, with different degrees of success. The outcome of the interaction between internal company efforts and external influences is captured in the changes in the values of qualified gross output per person engaged and is visualised in the transformation efficiency diagram of the production system.

The four firms studied are private companies now, like all other firms in Zambia, with different histories. Three firms always had been private, while one firm, company 1, is a former parastatal company.

Although the four companies are different, there are no great differences in the human capital indexes. The striking observation is that company 3, which belongs to the textile industry and is consequently considered to be a low-tech industry in literature, had a large proportion of employees with a high level of education compared to the other three companies.

Although the four companies faced the same weak national infrastructure and environment, there are two successful cases and two other cases in trouble. In performance indicators (such as labour productivity, capital intensity and output growths), companies 1 and 3 had growths in these performance indicators even above their specific branch performance growth levels. Company 3 is the most successful case study and had consistently outperformed the textile branch and the sector. It grew even in the face of a declining manufacturing sector.

We attempted to identify some underlying efforts that suggest possible reasons for the case-to-case variation in manufacturing performance. Better performance was found in cases that consistently related their internal production performance indicators to either regional or international standards, were involved in export markets, and that did not necessarily invest in highly advanced technologies but rather in well-designed and proven production processes to suit local manpower capabilities. Such efforts are particularly important in LDCs, where there is scarcity of capital and competent manpower, and a still undeveloped support information infrastructure. Additionally, the case studies underscore the importance of firm-level efforts to improve performance even in a disastrously declining environment. Companies 1 and 3 had their internal production performance indicators aligned to regional and international standards respectively, and they had achieved them. Additionally, company 3 had a strong export orientation and exported its output. Both companies 1 and 3 had better equipment and production layouts (i.e. with regard to high consideration of continuous flow production). Company 1 upgraded and continued to upgrade its production systems, while company 3 had invested in state-of-the-art equipment.

Companies 1 and 3, followed by company 4, were most successful in providing a good working environment creating a sense of belonging in employees, and in which co-operative attitudes were established and promoted. Such efforts engendered the creation of an environment where employees participated in a wider range of the firm's interests and problems thereby creating a real feeling on their part that they were making an important contribution in the enterprise and that economic interests of both employees and employer were clearly seen to be coupled to the success of the company.

Contrary to many studies in literature (references are given in sections 1.1 and 2.4) that had normally emphasised the almost total lack of support information (i.e. technical or managerial) to firms in LDCs, thus constraining performance improvement, this study has found that this situation has greatly improved in Zambia. For example, all the case companies had contacts with suppliers of inputs and capital goods, and customers, who were important sources of information. They had access to a wide range of renowned periodicals and reviews relevant to their industries. The companies also had access to internet. This study observed that rather than information insufficiency, the relatively low level of assimilation and processing capabilities of available information within the firms was an interesting limiting factor to performance improvement for some of the case companies.

One feature that was found in three of the four case companies was a preference for corporate downsizing used to cut costs and trim excesses. If done correctly, companies are able to cut their less productive workers and uncompetitive product lines and retain their more productive workers and profitable products. By trimming the excesses, companies can become leaner and more profitable, and eventually this will lead to increased aggregate qualified gross output per worker. The most successful downsizing happened in company 4. It was unsuccessful in company 2.

The case for a sustained growth in qualified gross output per worker as a result of downsizing alone is not, however, supported by both empirical evidence and theoretical arguments. Empirical evidence shows that a substantial rise in qualified gross output per worker can occur even without widespread downsizing, as was the case in company 3 where no downsizing had taken place. Our in-depth case studies show that often after downsizing, companies experience variations in performance, although profits may increase. This is due to morale problems and reorganizational snags following downsizing. In some cases downsizing has resulted in the loss of more productive workers instead of unproductive workers. Theoretically, several factors can cause a fundamental shift in long-run qualified gross output per worker. For example, a stronger plant and equipment investment can increase qualified gross output per worker by adding to the existing capital stock and increasing the rate of technological progress. With a larger capital stock, workers can increase their qualified gross output per hour of effort. Secondly, it can be argued that innovations in plant and equipment facilitate the use of existing technology and may quicken the arrival of new ideas and future technology. From the case studies, it has been observed that both the supply and demand sides are important in production improvement efforts. This was particularly true in the case of company 4, which was locked into a declining domestic sector and faced performance improvement problems despite being a relatively efficient company.

It was observed that there was a trend towards improving the flow of information in the more successful case companies with an accompanied reduction in management layers. While the advantages of improving the information flow were readily apparent, a reduced system of layers was healthy for the company in the sense that it reduced frictional difficulties in the company control system. The roles of the levels of control were well specified and there was little or no duplication in practice. Above all, a management style that enhanced a free flow of information, either through newsletters, notice boards, or lunch hour contacts at the workers' cafeteria, created in its employees a sense of belonging that was also important for the employees' motivation.

The approaches to improving efficiency also took the form of market repositioning through a process of focusing on specific strengths and rationalisation of products. For example, company 4 shed off activities that did not constitute its core activities. Market repositioning was simultaneously accompanied by introducing new methods of improving the efficiency of productive resources (such as TQM in the case of company 4, and total productivity maintenance in the case of companies 1, 3 and 4). These methods ranged from methods to increase labour productivity (such as continuous training across all levels of the organisation in relevant company operations, related skills and an increase in labour stability), through plant upgrading, to new production methods and classic quality improvement techniques. Company 3 had been particularly successful in implementing these.

Finally, another striking finding is that in three out of four cases (although not totally rejected by the fourth case) a rise in qualified gross output per worker and a rise in transformation efficiency in all the cases occurred during the sector's modest recovery period, giving credence to the importance of external influences. This draws attention to the fact that a dynamic sector has a positive influence on firms, and successful firms will do even better and grow in an environment that is institutionally and economically enabling. The other significant external influence is the growth in copper production. Mining, which has dominated the Zambian economy, has had a dual influence on the development of manufacturing in general and metal products branch in particular. Given the current trend, it will continue to have some influence on the future growth in manufacturing through the provision of foreign exchange and the stimulation of market demand.

But which of the firm-level improvement efforts that were found in the case studies is the most important aspect in performance improvement largely depends on the existing situation in the firm that has decided to improve its performance. The point being stressed here is that, given the external circumstances, firms in Zambia can still do something to improve their performance. Higher benefits, in terms of transformation efficiency improvement and growth in qualified gross output per worker, tend to be reaped when a firm pays attention to all the facets of the improvement efforts. Such an approach holds promise for shifting domestic performance standards to regional and international ones.

## 7.2 Summary of the Findings

In this section comparisons are made between the sectoral study and case studies by examining the major findings and by paying special attention to the synergy between sectoral and firm-level study approaches of manufacturing performance.

This research presented new estimates of labour productivity growth and total factor productivity growth in Zambian manufacturing since 1964. After a period of growth and labour productivity improvement till 1974, Zambian manufacturing suffered from increasing inefficiencies in an import-substituting and interventionist environment. Growth of output slowed down, labour productivity and investment declined; though TFP showed some fluctuation. In the period of liberalisation between 1991-95, output shrank dramatically, TFP collapsed and labour productivity continued to decline. There was, however, a small growth in labour productivity and TFP after 1995.

The firm-level study findings mirror many of the sector findings. Qualified gross output per person engaged generally shrank in the case studies, except for one case that developed a successful export market for its products, consistently re-invested both in employees, machinery and equipment, and from the early stages of its inception adopted international time and quality performance standards. This consistent adherence to high international time and quality performance standards also led to a steady growth in transformation efficiency.

The modest recovery observed in the Zambian manufacturing sector and the case studies after 1995 supports the thesis' argument of an integrative approach to performance improvement in LDCs. Improvement of performance requires effort and fresh investment into firm's assets and capabilities, and improved industrial and financial viability of the sector rather than through policies alone, as emphasised in the literature. The research has further shown that even in a depressed environment, firms can still improve their performances through internal efforts.

Following an industry-of-origin approach to international comparisons, the Zambian estimates are placed in a comparative perspective, using a binary comparison with the USA. In 1990, labour productivity in Zambia stood at 5.9 percent of the US level; relative total factor productivity stood at 16.7 percent. Over time comparative labour productivity has been declining, indicating an increasing technology gap. By 1998, comparative productivity stood at 3.2 percent of the US level. These findings of the international comparative study help to quantify the technology and the productivity gap that firms in Zambia are facing.

## 7.3 Methodological Reflections

As regards the aspects of manufacturing performance investigated, our findings, as with any set of measurements, are vulnerable to the usual pitfalls of analysis based on some weaknesses in the sector's and case companies' data. The quantity and quality of the statistical information available for Zambian manufacturing show some variations, especially in the mid-1980s. However, the key to this study is that the analysis is based on the national primary data available. Every effort was made to locate usable statistical series and where this was not possible to adjust available series based on reference to other related series, unpublished national information, and on advice from the Central Statistical Office to make them usable. This consultation, checking and counter-checking meant that the task of compiling series for the whole of Zambian manufacturing requires considerably more time and effort than would have normally been required.

The major conclusions are, however, not in doubt. Zambia made a promising start in manufacturing development in the early 1960s, although the pace of growth could not be sustained. The modest performance turn-around in the last period of liberalisation is mirrored in the case studies.

Although the limitation of time series at a firm level could not allow for a multivariate regression analysis to further investigate the exact quantification of internal and external influences, there still would not have been a substantial deviation from the conclusions that have been drawn.

## 7.4 Policy Implications

Industrial policy is basically comprised of all actions and measures taken to promote industrial development beyond that permitted by free market forces. It can also create conditions for the more effective operation of market forces (i.e. improving national physical infrastructure, strengthening technology imports or promotion of selected services, and promoting and facilitating investors). At the same time, policy interventions can be distortionary and costly if they do not lead to dynamic competitiveness and do not address market failures.

At a government level, a policy environment that encourages investment in physical capital, the development of human capital, and provides incentives for efficiency and optimality in the use of resources both at sector and firm levels is one approach to redress a situation of declining performance. Policies to attract foreign direct investment need to promote a stable economic environment through the control of government budget deficit and by keeping the inflation rate under control. There ought to be freedom of profit repatriation, a tax break on export investments, a decline in red tape and transparency of rules. Competitive pressures provide the needed incentives for firms to acquire and develop their technological capabilities. Policies also need to promote skill creation and local technological activity by properly supporting technical education and funding higher institutions of learning.

In the case of Zambian manufacturing, the changes from a more interventionist environment to a liberalised one initially brought on a total collapse of the sector. These changes were inevitable given the decline in performance that had taken place in the sector. The pace of liberalisation could not have been slowed either. In line with our findings, a slow pace of liberalisation would only have been appropriate a decade ago. After 1995 indicators of performance (such as labour productivity and TFP) point to a modest turn-around, which is a good foundation for a new beginning for the sector.

The low level of labour productivity found in Zambia is mainly due to low efficiency. It must also be stressed that Zambian manufacturing is a tiny sector. In 1998, its employment share was 9.3 percent of the total formal employment. Policies should, therefore, be aimed at primarily improving the sector efficiency (i.e. in terms of value added improvement) rather than employment creation.

Finally, as already pointed out in the international comparative study, a declining labour productivity is to be expected when a labour surplus economy starts producing more labour intensively in line with its comparative advantage. From an economic perspective, there is nothing intrinsically wrong with low labour productivity in the short run. In the long run, however, increasing standards of living directly depend on the capacity to improve output per worker. In view of the above, if labour intensive production methods are to be encouraged due to the extreme imbalance between the formal and informal sectors (i.e. in 1998, total formal sector employment represented 13.0 percent of total informal sector employment), it must be done without greatly compromising value added improvement.

## 7.5 Recommendations for further Research

It would be presumptuous to indicate that the questions raised by the subject under study have completely been resolved. There is more to know about the mechanisms of performance growth and about the capacity to isolate and measure the external influence impact on this activity.

As far as the understanding of improvement of performance in manufacturing firms in LDC is concerned, there are a number of areas that remain to be explored. Two main areas can be distinguished: recommendations regarding a sector research and an intrafirm research.

In the study of TFP at a sector level, because of data limitation, it was not possible to isolate the growth of manufacturing GDP due to improvement in the quality of the labour force. The quality of capital affects comparative productivity. This effect was not investigated for the same reason as for labour quality. The lower the average age of capital, the more likely that it will incorporate the most up-to-date specifications. A factor relating to the vintage of machinery and equipment is its technical up-to-dateness. The usage of highly automated machines raises labour productivity not only through displacing labour but also by achieving economies in intermediate inputs, floor-space and time in change-over from one product line to another. But even if the capital is technically advanced, there may be other capital-related factors that limit productivity relative to that obtained in a rival country. Economies may differ in the degree to which capital can be kept at relatively full utilisation. In part the rate of capital utilisation depends upon the level of aggregate demand in the economy and in part on factors more directly under the company’s control, such as input feeding and loading systems adopted for machines and the incidences of machinery breakdown.

To be able to take some of these input characteristics into account, measures that can use short rather than the normally long time series need to be explored. The case of Zambia with short time series of some critical indicators is typical of many LDCs. This factor has contributed to the exclusion of many of these economies in orthodox analysis.

In the firm level study, the analysis took into account the changes in the composition of labour, capital, intermediate inputs, and other quality adjustments that were allowed for the labour input index. But there was no consideration of an increase over time in marginal product from advances in technical or organisational knowledge resulting in an increase in input. For example, the problems related to plant capital can not be viewed in isolation from questions on management quality and decision-making qualities of management.

For a more exact estimation of the impact of internal and external factors on performance, systematic collection of firm level data for larger numbers of firms is a desirable option. This is because individual firms in LDCs normally do not have sufficiently long time series suitable for multivariate statistical analysis. The pooling of many case studies to allow sufficient degrees of freedom is an interesting area of further research, which would provide a greater understanding of the mechanism of performance improvement in firms in LDCs.

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# Annex Tables

Annex I: Time Series for Aggregate Manufacturing and by Manufacturing Branch

*Zambia*

**Annex Table I.1: Gross Domestic Product in Zambian Manufacturing (10+) at constant 1990 prices, 1964-98 (ZK million)**

| | 1 Food | 2 Tex | 3 Wear | 4 Leat | 5 Wood | 6 Pap | 7 Chem | 8 Rub | 9 Mine | 10 Met | 11 Mach | 12 Elec | 13 Oth | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1964 | 1,003.5 | 19.6 | 51.0 | 1.8 | 217.2 | 275.7 | 125.6 | 26.0 | 606.3 | 736.0 | 122.3 | 22.8 | 7.5 | 3,215.1 |
| 1965 | 963.6 | 40.5 | 110.0 | 4.0 | 292.3 | 306.1 | 255.8 | 33.8 | 784.1 | 832.2 | 128.8 | 49.0 | 21.9 | 3,822.1 |
| 1966 | 1,083.6 | 53.0 | 160.2 | 9.4 | 339.7 | 361.3 | 405.2 | 29.7 | 749.3 | 1,060.9 | 145.4 | 124.0 | 33.6 | 4,555.2 |
| 1967 | 1,159.6 | 76.4 | 260.5 | 11.9 | 303.9 | 513.1 | 815.8 | 46.5 | 797.9 | 1,176.2 | 345.0 | 154.3 | 55.6 | 5,716.8 |
| 1968 | 1,091.6 | 105.3 | 227.3 | 9.3 | 350.6 | 768.4 | 923.3 | 61.9 | 964.6 | 1,809.2 | 356.8 | 166.5 | 40.3 | 6,875.2 |
| 1969 | 1,606.4 | 155.0 | 318.6 | 8.8 | 298.8 | 642.7 | 1,016.4 | 197.2 | 879.9 | 1,442.0 | 410.8 | 302.1 | 48.3 | 7,327.1 |
| 1970 | 1,749.9 | 175.2 | 369.3 | 9.4 | 314.4 | 745.1 | 921.5 | 225.1 | 948.8 | 1,648.9 | 384.0 | 230.7 | 37.0 | 7,759.5 |
| 1971 | 2,108.9 | 239.9 | 349.2 | 10.2 | 302.0 | 764.1 | 1,052.0 | 316.2 | 997.7 | 1,755.4 | 404.1 | 419.2 | 44.1 | 8,763.0 |
| 1972 | 2,269.4 | 288.5 | 423.4 | 19.4 | 284.2 | 925.4 | 1,694.4 | 334.1 | 1,123.8 | 1,869.7 | 603.8 | 477.1 | 27.4 | 10,340.6 |
| 1973 | 2,306.5 | 324.2 | 360.2 | 25.3 | 314.7 | 938.7 | 2,043.7 | 378.8 | 1,098.6 | 1,799.3 | 633.9 | 458.4 | 44.1 | 10,726.5 |
| 1974 | 1,883.0 | 309.7 | 460.5 | 34.9 | 474.5 | 980.4 | 2,052.4 | 388.5 | 1,413.8 | 1,906.8 | 761.3 | 614.9 | 67.1 | 11,347.8 |
| 1975 | 1,572.3 | 316.5 | 369.5 | 35.0 | 404.2 | 811.9 | 2,424.7 | 303.1 | 1,230.0 | 1,653.9 | 919.4 | 377.4 | 64.5 | 10,482.3 |
| 1976 | 1,939.1 | 486.7 | 388.1 | 32.5 | 384.0 | 677.6 | 2,723.6 | 315.9 | 607.4 | 747.5 | 811.5 | 468.9 | 64.2 | 9,646.9 |
| 1977 | 2,000.4 | 592.9 | 391.9 | 30.4 | 453.2 | 739.8 | 2,931.7 | 281.4 | 582.3 | 826.1 | 678.2 | 462.2 | 66.5 | 10,037.0 |
| 1978 | 2,003.5 | 655.2 | 383.2 | 35.2 | 414.5 | 887.1 | 3,134.9 | 288.9 | 789.3 | 911.6 | 641.3 | 491.9 | 69.3 | 10,705.9 |
| 1979 | 2,214.0 | 775.0 | 415.6 | 34.1 | 411.9 | 697.0 | 3,007.8 | 334.2 | 721.0 | 866.8 | 537.0 | 450.5 | 67.1 | 10,531.8 |
| 1980 | 2,079.6 | 947.1 | 475.9 | 38.1 | 514.2 | 572.8 | 2,728.7 | 307.3 | 954.3 | 994.2 | 540.2 | 486.2 | 46.5 | 10,685.1 |
| 1981 | 3,383.5 | 1,090.0 | 257.0 | 41.2 | 522.8 | 431.1 | 1,845.1 | 228.5 | 978.1 | 1,445.7 | 559.2 | 503.2 | 48.3 | 11,333.8 |
| 1982 | 3,498.2 | 1,208.4 | 244.1 | 32.9 | 459.9 | 388.6 | 1,398.2 | 166.0 | 959.1 | 1,789.8 | 588.7 | 529.7 | 46.7 | 11,310.3 |
| 1983 | 3,606.8 | 1,062.3 | 196.2 | 42.7 | 447.5 | 386.8 | 1,304.2 | 182.2 | 1,138.6 | 1,289.9 | 596.5 | 536.8 | 43.5 | 10,833.7 |
| 1984 | 3,782.9 | 1,051.7 | 184.6 | 25.5 | 425.1 | 349.0 | 548.1 | 138.2 | 472.8 | 2,122.2 | 495.9 | 524.0 | 48.3 | 10,168.3 |
| 1985 | 3,533.6 | 1,028.7 | 174.8 | 30.8 | 491.8 | 455.5 | 1,206.1 | 304.3 | 1,015.8 | 2,496.0 | 689.0 | 687.0 | 58.3 | 12,171.8 |
| 1986 | 3,624.9 | 891.2 | 148.1 | 24.3 | 485.6 | 579.1 | 1,182.1 | 298.3 | 765.3 | 2,813.0 | 683.0 | 857.2 | 62.1 | 12,414.1 |
| 1987 | 3,815.9 | 959.2 | 156.7 | 24.3 | 432.6 | 897.3 | 1,105.6 | 279.0 | 139.6 | 2,089.8 | 889.6 | 1,009.3 | 63.5 | 11,862.6 |
| 1988 | 4,321.9 | 1,017.4 | 164.1 | 24.3 | 416.5 | 981.7 | 1,055.7 | 266.5 | 444.1 | 2,103.5 | 838.7 | 951.5 | 66.8 | 12,652.5 |
| 1989 | 4,575.6 | 1,149.1 | 200.7 | 28.6 | 474.0 | 1,036.6 | 1,373.3 | 377.2 | 633.3 | 1,322.1 | 740.7 | 826.0 | 65.5 | 12,802.6 |
| 1990 | 5,094.4 | 1,677.5 | 265.6 | 36.6 | 432.8 | 1,025.4 | 1,883.2 | 475.4 | 693.0 | 1,505.1 | 442.6 | 699.2 | 54.2 | 14,285.0 |

**Annex Table I.1 (continued)**

| | 1 Food | 2 Tex | 3 Wear | 4 Leat | 5 Wood | 6 Pap | 7 Chem | 8 Rub | 9 Mine | 10 Met | 11 Mach | 12 Elec | 13 Oth | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1991 | 5,658.1 | 995.3 | 157.9 | 47.4 | 501.7 | 927.2 | 1,636.6 | 237.0 | 310.8 | 1,895.7 | 405.5 | 715.8 | 60.5 | 13,549.5 |
| 1992 | 4,833.6 | 1,304.6 | 207.1 | 49.5 | 506.2 | 1,023.7 | 488.2 | 65.2 | 258.7 | 2,420.5 | 505.3 | 914.1 | 56.1 | 12,632.8 |
| 1993 | 2,521.6 | 787.1 | 125.0 | 46.7 | 439.9 | 421.2 | 1,957.8 | 253.0 | 146.0 | 1,023.8 | 288.9 | 528.5 | 28.7 | 8,568.2 |
| 1994 | 1,729.9 | 541.3 | 86.0 | 39.1 | 414.3 | 183.1 | 1,314.7 | 166.9 | 92.7 | 1,540.5 | 226.4 | 416.8 | 34.3 | 6,786.1 |
| 1995 | 2,328.9 | 584.7 | 92.9 | 40.0 | 428.1 | 119.2 | 403.6 | 51.4 | 80.3 | 856.4 | 94.7 | 171.0 | 17.2 | 5,268.3 |
| 1996 | 2,438.1 | 672.9 | 97.2 | 37.5 | 392.9 | 115.6 | 533.9 | 68.0 | 80.1 | 712.0 | 81.9 | 151.1 | 17.4 | 5,398.7 |
| 1997 | 2,498.0 | 850.7 | 87.1 | 41.0 | 428.8 | 160.4 | 516.5 | 65.8 | 61.1 | 897.9 | 79.7 | 146.8 | 16.7 | 5,850.6 |
| 1998 | 2,504.8 | 849.9 | 87.0 | 42.9 | 441.8 | 170.3 | 385.9 | 57.6 | 72.4 | 903.0 | 77.1 | 141.9 | 20.7 | 5,755.4 |

*Note:* *See Annex Table V.1 for full branch names.*

*Sources for current values:*

*Census of Production, 1964, tables 3, 4 and 7; Census of Production, 1965 and 1966, tables III, IV and V; Census of Production, 1967, tables III, IV and V; Census Production, 1968, tables III, IV and V; Census of Industrial Production, 1969, table 7; Census of Industrial Production, 1970, table 7; Census of Industrial Production, 1971, table 7; Census of Industrial Production, 1972, table 4; Census of Industrial Production, 1973, table 4; Census of Industrial Production, 1974, table 4; Census of Industrial Production, 1975, table 4; Census of Industrial Production, 1980, table 4; Census of Industrial Production, 1990, tables 6 and 7; Census of Industrial Production, 1994, tables 3.2, 4.1 and 6.1; Monthly Digest of Statistics vol.XVIII nos.7 to 9, July/September 1982, table 52; Monthly Digest of Statistics vol.XXI nos.2 to 3, February/March 1985, table 50; National Accounts Statistics Bulletin no.2, January 1988, table 2.0; National Accounts Statistics Bulletin no.3, January 1990, table 2.0; National Accounts Statistics Bulletin no.4, June 1992, table 1.0; National Accounts Statistics Bulletin no.5, August 1995, table 1.0; CSO database on GDP and Gross fixed capital formation from 1990 to 1998 in current prices and at 1994 prices; Economic Report 1998, table 2.2.*

*Sources for deflators:*

*CSO database on Index Numbers of Wholesale Prices 1966=100 (by Industrial Activities); Monthly Digest of Statistics, July-October 1991, table 47.*

**Annex Table I.2: Employment in Zambian Manufacturing (10+), 1964-98 (persons)**

| | 1 Food | 2 Tex | 3 Wear | 4 Leat | 5 Wood | 6 Pap | 7 Chem | 8 Rub | 9 Mine | 10 Met | 11 Mach | 12 Elec | 13 Oth | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1964 | 5,991 | 321 | 1,154 | 31 | 2,686 | 1,172 | 300 | 303 | 3,483 | 3,286 | 179 | 2,001 | 33 | 20,940 |
| 1965 | 7,205 | 752 | 2,701 | 145 | 4,198 | 1,389 | 914 | 337 | 3,668 | 3,691 | 278 | 824 | 101 | 26,203 |
| 1966 | 7,668 | 1,202 | 4,269 | 206 | 3,569 | 1,572 | 1,663 | 474 | 4,396 | 4,442 | 601 | 1,198 | 209 | 31,469 |
| 1967 | 8,244 | 1,246 | 4,646 | 255 | 3,030 | 1,608 | 2,083 | 514 | 4,108 | 4,373 | 898 | 1,863 | 312 | 33,180 |
| 1968 | 9,034 | 1,428 | 4,556 | 258 | 2,863 | 1,571 | 1,911 | 413 | 3,904 | 4,335 | 794 | 1,921 | 311 | 33,299 |
| 1969 | 12,277 | 1,574 | 4,498 | 390 | 2,889 | 2,685 | 2,243 | 704 | 3,449 | 3,931 | 706 | 1,593 | 237 | 37,176 |
| 1970 | 12,460 | 2,821 | 4,584 | 498 | 3,369 | 2,397 | 3,144 | 1,122 | 3,648 | 4,733 | 669 | 1,440 | 199 | 41,084 |
| 1971 | 13,163 | 3,189 | 4,547 | 505 | 3,305 | 2,377 | 3,186 | 1,155 | 3,720 | 5,535 | 1,043 | 1,816 | 220 | 43,761 |
| 1972 | 13,486 | 3,268 | 4,646 | 553 | 3,377 | 2,173 | 3,206 | 1,330 | 3,320 | 6,447 | 930 | 2,186 | 155 | 45,077 |
| 1973 | 15,760 | 2,872 | 4,863 | 674 | 2,932 | 2,447 | 3,736 | 1,423 | 3,716 | 6,162 | 1,039 | 2,230 | 206 | 48,060 |
| 1974 | 16,169 | 2,952 | 6,199 | 826 | 3,821 | 2,668 | 4,399 | 1,960 | 4,213 | 6,879 | 1,140 | 2,602 | 320 | 54,148 |
| 1975 | 16,077 | 3,376 | 6,234 | 987 | 4,045 | 2,864 | 4,737 | 1,626 | 3,918 | 7,897 | 1,152 | 2,528 | 329 | 55,770 |
| 1976 | 12,272 | 2,815 | 4,649 | 753 | 3,017 | 2,267 | 3,876 | 1,321 | 3,106 | 5,821 | 936 | 1,976 | 271 | 43,080 |
| 1977 | 12,863 | 3,240 | 4,738 | 789 | 3,075 | 2,474 | 4,380 | 1,483 | 3,395 | 5,849 | 1,051 | 2,128 | 305 | 45,770 |
| 1978 | 12,720 | 3,540 | 4,530 | 780 | 2,940 | 2,560 | 4,700 | 1,580 | 3,520 | 5,490 | 1,120 | 2,170 | 330 | 45,980 |
| 1979 | 13,290 | 3,100 | 4,780 | 720 | 2,260 | 2,390 | 4,120 | 1,590 | 3,540 | 4,890 | 1,670 | 2,240 | 370 | 44,960 |
| 1980 | 20,399 | 4,299 | 5,910 | 983 | 3,410 | 2,680 | 5,311 | 1,999 | 3,539 | 6,250 | 1,719 | 2,252 | 158 | 58,909 |
| 1981 | 16,882 | 4,867 | 5,801 | 1,022 | 4,430 | 2,572 | 4,728 | 1,779 | 3,324 | 6,214 | 1,647 | 2,190 | 165 | 55,621 |
| 1982 | 16,367 | 5,111 | 5,337 | 996 | 4,402 | 2,821 | 4,641 | 1,746 | 3,410 | 6,131 | 1,561 | 2,107 | 177 | 54,807 |
| 1983 | 16,445 | 5,719 | 5,278 | 1,043 | 4,158 | 3,232 | 4,733 | 1,780 | 3,503 | 6,170 | 1,509 | 2,074 | 195 | 55,839 |
| 1984 | 16,534 | 6,150 | 5,133 | 1,088 | 4,329 | 3,122 | 4,746 | 1,803 | 3,235 | 6,414 | 1,390 | 2,107 | 130 | 56,181 |
| 1985 | 26,404 | 7,754 | 5,695 | 1,265 | 5,631 | 4,162 | 6,496 | 2,442 | 4,017 | 8,088 | 1,838 | 2,604 | 304 | 76,700 |
| 1986 | 25,999 | 8,002 | 5,280 | 1,245 | 5,749 | 4,214 | 6,333 | 2,380 | 3,861 | 7,964 | 1,745 | 2,511 | 317 | 75,600 |
| 1987 | 25,562 | 8,210 | 4,886 | 1,222 | 5,842 | 4,252 | 6,168 | 2,318 | 3,708 | 7,830 | 1,655 | 2,420 | 327 | 74,400 |
| 1988 | 25,573 | 8,540 | 4,597 | 1,222 | 6,026 | 4,357 | 6,114 | 2,297 | 3,625 | 7,833 | 1,598 | 2,375 | 343 | 74,500 |
| 1989 | 25,790 | 8,926 | 4,356 | 1,231 | 6,252 | 4,494 | 6,112 | 2,296 | 3,575 | 7,900 | 1,556 | 2,351 | 361 | 75,200 |
| 1990 | 26,421 | 9,451 | 4,188 | 1,260 | 6,576 | 4,700 | 6,208 | 2,331 | 3,584 | 8,093 | 1,540 | 2,365 | 383 | 77,100 |

**Annex Table I.2 (continued)**

| | 1 Food | 2 Tex | 3 Wear | 4 Leat | 5 Wood | 6 Pap | 7 Chem | 8 Rub | 9 Mine | 10 Met | 11 Mach | 12 Elec | 13 Oth | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1991 | 25,415 | 9,099 | 3,952 | 1,309 | 6,607 | 4,608 | 6,274 | 2,315 | 3,631 | 7,934 | 1,585 | 2,287 | 384 | 75,400 |
| 1992 | 24,333 | 8,720 | 3,696 | 1,364 | 6,646 | 4,512 | 6,351 | 2,299 | 3,685 | 7,768 | 1,635 | 2,204 | 387 | 73,600 |
| 1993 | 21,843 | 7,837 | 3,223 | 1,344 | 6,315 | 4,155 | 6,076 | 2,153 | 3,536 | 7,158 | 1,596 | 1,994 | 370 | 67,600 |
| 1994 | 17,942 | 6,447 | 2,550 | 1,226 | 5,542 | 3,522 | 5,372 | 1,860 | 3,136 | 6,068 | 1,442 | 1,669 | 324 | 57,100 |
| 1995 | 16,999 | 6,366 | 2,190 | 1,196 | 5,464 | 3,415 | 5,149 | 1,777 | 2,985 | 5,790 | 2,371 | 1,633 | 319 | 55,654 |
| 1996 | 14,120 | 5,398 | 1,666 | 1,077 | 4,836 | 2,938 | 4,521 | 1,533 | 2,616 | 4,937 | 2,083 | 1,390 | 285 | 47,400 |
| 1997 | 13,640 | 5,341 | 1,435 | 1,136 | 5,009 | 2,952 | 4,645 | 1,546 | 2,681 | 4,915 | 2,143 | 1,381 | 294 | 47,118 |
| 1998 | 12,128 | 4,884 | 1,091 | 1,112 | 4,814 | 2,748 | 4,426 | 1,445 | 2,549 | 4,525 | 2,044 | 1,269 | 285 | 43,320 |

*Note:* *See Annex Table V.1 for full branch names.*
*Employment figures were adjusted using additional sources to include working proprietors and family workers.*

*Sources:*
*Census of Production, 1964, table 2; Census of Production, 1965 and 1966, table II; Census of Production, 1967, table II; Census of Production, 1968, table II; Census of Industrial Production, 1969, table 3.1; Census of Industrial Production, 1970, table 3.1; Census of Industrial Production, 1971, table 3.1; Census of Industrial Production, 1972, table 1.1; Census of Industrial Production, 1973, table 1.1; Census of Industrial Production, 1974, table 1.1; Census of Industrial Production 1975, table 1.1; Census of Industrial Production, 1980, table 1.1; Census of Industrial Production,1990, table 1; Census of Industrial Production, 1994, table 0.1; Monthly Digest of Statistics, July- October 1991, table 17; Report on Employment and Earnings 1978, CSO, January 1981, table 7; Report on Employment and Earnings 1979, CSO, February 1982, tables 1.1, 1.2, 7.0 and 7.1;Employment Trends 1985 to 1993, CSO, 9 September 1994, table 14; Monthly Digest of Statistics Supplement vol.XVIII nos.7 to 9, July/September 1982, table 11; Monthly Digest of Statistics Supplement vol.XXI nos.2 to 3, February/March 1985, table 11; Monthly Digest of Statistics Supplement vol.XXII nos. 1 to 4, January/April 1986, table 11; National Accounts Bulletin No. 5, August 1995, table 7.0; CSO unpublished report of Labour Trends from 1964 to 1998; Economic Report 1998, table 2.4.*

**Annex Table I.3: Investment in Fixed Assets in Zambian Manufacturing (10+), in current prices, 1941-98 (ZK 000)**

| | 1 Food | 2 Tex | 3 Wear | 4 Leat | 5 Wood | 6 Pap | 7 Chem | 8 Rub | 9 Mine | 10 Met | 11 Mach | 12 Elec | 13 Oth | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1941* | 20.0 | 0.1 | 0.3 | 0.0 | 1.4 | 0.6 | 3.0 | 0.0 | 6.7 | 3.0 | 94.3 | 0.0 | 1.0 | 130.5 |
| 1942* | 21.0 | 0.2 | 0.3 | 0.0 | 2.1 | 0.7 | 3.3 | 0.0 | 7.2 | 3.4 | 100.2 | 0.0 | 1.1 | 139.4 |
| 1943* | 24.0 | 0.2 | 0.4 | 0.0 | 1.6 | 1.1 | 3.5 | 0.0 | 9.1 | 3.6 | 120.3 | 0.0 | 1.2 | 164.9 |
| 1944* | 26.5 | 0.2 | 0.4 | 0.0 | 2.5 | 1.4 | 4.1 | 0.1 | 10.2 | 5.0 | 135.3 | 0.0 | 1.2 | 186.9 |
| 1945 | 70.7 | 0.6 | 1.0 | 0.0 | 3.5 | 3.7 | 5.0 | 0.1 | 37.1 | 14.0 | 200.0 | 0.0 | 2.1 | 337.9 |
| 1946 | 109.7 | 1.0 | 1.6 | 0.1 | 5.5 | 5.7 | 7.8 | 0.1 | 57.6 | 21.8 | 412.0 | 0.0 | 3.2 | 626.0 |
| 1947 | 457.8 | 4.0 | 6.5 | 0.3 | 23.0 | 23.6 | 32.5 | 0.5 | 240.5 | 90.8 | 664.0 | 0.0 | 13.4 | 1556.9 |
| 1948 | 224.2 | 2.0 | 3.2 | 0.2 | 11.3 | 11.6 | 15.9 | 0.2 | 117.8 | 44.5 | 706.0 | 0.0 | 6.6 | 1143.4 |
| 1949 | 221.3 | 1.9 | 3.1 | 0.2 | 11.1 | 11.4 | 15.7 | 0.2 | 116.3 | 43.9 | 1172.0 | 0.0 | 6.5 | 1603.6 |
| 1950 | 305.1 | 2.7 | 4.3 | 0.2 | 15.3 | 15.7 | 21.6 | 0.3 | 160.3 | 60.5 | 1344.0 | 0.0 | 9.0 | 1939.0 |
| 1951 | 303.5 | 2.6 | 4.3 | 0.2 | 15.2 | 15.7 | 21.5 | 0.3 | 159.4 | 60.2 | 1354.0 | 0.0 | 8.9 | 1946.0 |
| 1952 | 476.3 | 4.2 | 6.7 | 0.3 | 23.9 | 24.6 | 33.8 | 0.5 | 250.2 | 94.5 | 1794.0 | 0.0 | 14.0 | 2723.0 |
| 1953 | 484.8 | 4.2 | 6.9 | 0.3 | 24.3 | 25.0 | 34.4 | 0.5 | 254.7 | 96.2 | 1900.0 | 0.0 | 14.2 | 2845.7 |
| 1954 | 1266.4 | 11.0 | 17.9 | 0.9 | 63.6 | 65.4 | 89.8 | 1.3 | 665.3 | 251.3 | 290.8 | 0.0 | 37.2 | 2760.8 |
| 1955 | 1146.0 | 31.8 | 51.6 | 2.6 | 228.0 | 60.0 | 82.6 | 1.2 | 428.0 | 328.0 | 282.0 | 0.1 | 34.1 | 2676.0 |
| 1956 | 2558.0 | 5.2 | 8.4 | 0.4 | 40.0 | 192.0 | 54.6 | 0.8 | 1976.0 | 320.0 | 412.0 | 0.1 | 22.5 | 5590.0 |
| 1957 | 1674.0 | 9.6 | 15.6 | 0.8 | 76.0 | 104.0 | 264.6 | 3.8 | 956.0 | 492.0 | 586.0 | 0.0 | 109.6 | 4292.0 |
| 1958 | 934.0 | 12.6 | 20.4 | 1.0 | 42.0 | 30.0 | 170.8 | 2.4 | 428.0 | 230.0 | 442.0 | 0.0 | 70.8 | 2384.0 |
| 1959 | 2094.0 | 14.1 | 22.8 | 1.1 | 36.0 | 48.0 | 23.8 | 0.3 | 628.0 | 298.0 | 208.0 | 0.0 | 9.9 | 3384.0 |
| 1960 | 1728.0 | 27.4 | 44.4 | 2.2 | 130.0 | 102.0 | 64.4 | 32.0 | 266.0 | 332.0 | 622.0 | 12.0 | 27.6 | 3390.0 |
| 1961 | 524.0 | 21.5 | 34.8 | 1.7 | 266.0 | 120.0 | 56.0 | 46.0 | 20.0 | 490.0 | 464.0 | 18.0 | 24.0 | 2086.0 |
| 1962 | 902.0 | 11.1 | 18.0 | 0.9 | 120.0 | 49.0 | 25.2 | 32.0 | 144.0 | 286.0 | 122.0 | 20.0 | 10.8 | 1741.0 |
| 1963 | 1646.0 | 17.0 | 27.6 | 1.4 | 94.0 | 184.0 | 56.0 | 48.0 | 356.0 | 460.0 | 158.0 | 6.0 | 24.0 | 3078.0 |
| 1964 | 2580.0 | 95.5 | 154.8 | 7.7 | 132.0 | 216.0 | 79.8 | 42.0 | 668.0 | 772.0 | 86.0 | 36.0 | 34.2 | 4904.0 |
| 1965 | 2166.0 | 586.0 | 468.0 | 68.0 | 754.0 | 434.0 | 2494.0 | 228.0 | 1082.0 | 1552.0 | 1096.0 | 76.0 | 20.0 | 11024.0 |
| 1966 | 2488.0 | 282.0 | 482.0 | 234.0 | 424.0 | 574.0 | 1418.0 | 138.0 | 842.0 | 1008.0 | 1016.0 | 432.0 | 64.0 | 9402.0 |
| 1967 | 4322.0 | 344.0 | 775.0 | 415.0 | 557.0 | 1075.0 | 1642.0 | 331.0 | 4811.0 | 1554.0 | 1671.0 | 389.0 | 317.0 | 18203.0 |

**Annex Table I.3 (continued)**

| | 1<br>Food | 2<br>Tex | 3<br>Wear | 4<br>Leat | 5<br>Wood | 6<br>Pap | 7<br>Chem | 8<br>Rub | 9<br>Mine | 10<br>Met | 11<br>Mach | 12<br>Elec | 13<br>Oth | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1968 | 6146.0 | 2495.0 | 673.0 | 134.0 | 1078.0 | 1721.0 | 16456.0 | 3291.0 | 7059.0 | 2427.0 | 688.0 | 694.0 | 8.0 | 42870.0 |
| 1969 | 5607.0 | 5852.0 | 509.0 | 75.0 | 922.0 | 1818.0 | 2547.0 | 1061.0 | 1448.0 | 1429.0 | 620.0 | 2570.0 | 114.0 | 24572.0 |
| 1970 | 8061.0 | 3123.0 | 590.0 | 105.0 | 879.0 | 1142.0 | 20395.0 | 642.0 | 689.0 | 1924.0 | 322.0 | 2234.0 | 187.0 | 40293.0 |
| 1971 | 8827.0 | 1016.0 | 581.0 | 70.0 | 726.0 | 938.0 | 1490.0 | 451.0 | 1392.0 | 4759.0 | 2538.0 | 685.0 | 48.0 | 23521.0 |
| 1972 | 12214.0 | 212.0 | 715.0 | 412.0 | 745.0 | 900.0 | 20897.0 | 1141.0 | 7045.0 | 4037.0 | 1824.0 | 459.0 | 8.0 | 50609.0 |
| 1973 | 12203.0 | -732.0 | 544.0 | 223.0 | 1322.0 | 614.0 | 2981.0 | 1045.0 | 27411.0 | 2024.0 | 644.0 | 781.0 | 26.0 | 49086.0 |
| 1974 | 12585.0 | 2345.0 | 2011.0 | 1661.0 | 3771.0 | 1629.0 | 4882.0 | 2265.0 | 8274.0 | 3177.0 | 1004.0 | 666.0 | 218.0 | 44488.0 |
| 1975 | 17455.0 | 5387.0 | 1779.0 | 410.0 | 3113.0 | 1016.0 | 18464.0 | 1672.0 | 3927.0 | 4906.0 | 1673.0 | 897.0 | 172.0 | 60871.0 |
| 1976 | 26180.0 | 7539.0 | 3115.0 | 556.1 | 4112.7 | 2282.4 | 29708.9 | 3371.5 | 4889.8 | 6995.7 | 2666.8 | 1308.4 | 249.3 | 92975.6 |
| 1977 | 23778.9 | 6401.2 | 3198.0 | 456.5 | 3276.2 | 2699.1 | 28647.6 | 3775.1 | 3615.9 | 6054.8 | 2552.3 | 1157.9 | 219.4 | 85833.2 |
| 1978 | 22799.3 | 5746.9 | 3388.9 | 395.2 | 2739.4 | 3135.8 | 28923.1 | 4243.4 | 2744.6 | 5543.5 | 2561.0 | 1083.6 | 204.1 | 83509.0 |
| 1979 | 22180.9 | 5242.9 | 3584.6 | 346.6 | 2306.9 | 3539.1 | 29436.3 | 4684.4 | 2026.3 | 5159.7 | 2593.0 | 1030.4 | 193.0 | 82324.1 |
| 1980 | 21840.0 | 4847.0 | 3790.0 | 307.0 | 1947.0 | 3927.0 | 30159.0 | 5116.0 | 1412.0 | 4869.0 | 2645.0 | 993.0 | 185.0 | 82037.0 |
| 1981 | 24697.9 | 7692.5 | 1866.0 | 49.6 | 5035.4 | 7630.4 | 24904.1 | 6788.9 | 25362.3 | 9277.3 | 2391.3 | 3987.2 | 45.4 | 119728.3 |
| 1982 | 25753.0 | 8220.0 | 1728.0 | 25.0 | 5505.5 | 8243.3 | 25140.1 | 7169.2 | 28583.9 | 10012.9 | 2439.5 | 4415.2 | 32.6 | 127268.2 |
| 1983 | 24523.4 | 7898.2 | 1568.2 | 14.3 | 5333.1 | 7951.6 | 23645.9 | 6858.9 | 27978.2 | 9655.3 | 2303.9 | 4295.9 | 25.8 | 122052.8 |
| 1984 | 25519.5 | 8257.4 | 1589.9 | 9.7 | 5598.9 | 8330.0 | 24446.5 | 7154.9 | 29527.4 | 10112.9 | 2387.1 | 4520.2 | 24.0 | 127478.4 |
| 1985 | 33077.6 | 10733.6 | 2027.2 | 8.5 | 7296.4 | 10841.2 | 31559.6 | 9287.9 | 38601.3 | 13160.3 | 3085.7 | 5898.5 | 28.8 | 165606.7 |
| 1986 | 62588.3 | 20348.9 | 3793.0 | 10.7 | 13856.2 | 20569.9 | 59552.8 | 17592.0 | 73461.1 | 24968.2 | 5828.1 | 11211.7 | 51.6 | 313832.6 |
| 1987 | 91137.8 | 29672.2 | 5478.1 | 10.1 | 20229.4 | 30012.2 | 86546.4 | 25635.3 | 107412.8 | 36427.6 | 8475.4 | 16379.3 | 72.2 | 457488.8 |
| 1988 | 149905.5 | 48856.8 | 8954.5 | 9.7 | 33339.4 | 49438.5 | 142140.4 | 42188.7 | 177225.2 | 60004.3 | 13926.7 | 27007.4 | 114.9 | 753112.0 |
| 1989 | 264770.4 | 86363.9 | 15738.5 | 7.6 | 58976.3 | 87422.8 | 250761.0 | 74547.9 | 313784.1 | 106103.2 | 24578.8 | 47793.3 | 197.7 | 1331045.5 |
| 1990 | 1178239.0 | 384576.0 | 69760.0 | 0.0 | 262771.0 | 389400.0 | 1114844.0 | 331856.0 | 1399071.0 | 472595.0 | 109308.0 | 213010.0 | 861.0 | 5926291.0 |
| 1991 | 739897.4 | 241546.7 | 43757.9 | -6.0 | 165069.6 | 244595.9 | 699900.3 | 208415.6 | 879056.2 | 296851.6 | 68629.8 | 133821.9 | 537.4 | 3722074.3 |
| 1992 | 1615742.3 | 527525.1 | 95500.7 | -20.0 | 360533.4 | 534206.1 | 1528189.4 | 455148.0 | 1920169.8 | 648332.1 | 149855.9 | 292297.2 | 1169.7 | 8128649.8 |
| 1993 | 5141620.3 | 1678820.1 | 303762.7 | -80.8 | 1147454.3 | 1700136.9 | 4862477.2 | 1448431.6 | 6111745.1 | 2063342.6 | 476837.3 | 930314.7 | 3712.8 | 25868574.8 |
| 1994 | 4946169.8 | 1615102.9 | 292105.7 | -91.2 | 1103964.4 | 1635653.8 | 4677219.8 | 1393417.4 | 5880496.5 | 1985079.3 | 458683.9 | 895080.4 | 3564.2 | 24886446.7 |

**Annex Table I.3 (continued)**

| | 1 Food | 2 Tex | 3 Wear | 4 Leat | 5 Wood | 6 Pap | 7 Chem | 8 Rub | 9 Mine | 10 Met | 11 Mach | 12 Elec | 13 Oth | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1995 | 7363277.6 | 2404500.2 | 434716.6 | -152.6 | 1643612.2 | 2435149.0 | 6962378.7 | 2074412.9 | 8755530.9 | 2955365.4 | 682801.0 | 1332651.9 | 5296.7 | 37049540.6 |
| 1996 | 10329856.7 | 3373393.0 | 609697.4 | -233.9 | 2305993.5 | 3416455.0 | 9766826.5 | 2910236.7 | 12284617.9 | 4146299.4 | 957853.6 | 1869752.9 | 7419.8 | 51978168.5 |
| 1997 | 16471453.1 | 5379238.6 | 971971.5 | -400.1 | 3677275.5 | 5447992.2 | 15572836.5 | 4640603.7 | 19590577.9 | 6611817.2 | 1527288.9 | 2981671.8 | 11816.3 | 82884143.1 |
| 1998 | 16293892.4 | 5321423.3 | 961305.0 | -419.0 | 3637855.8 | 5389512.1 | 15404245.1 | 4590656.6 | 19381246.8 | 6540836.5 | 1510778.1 | 2949753.0 | 11676.1 | 81992761.8 |

*Note:* *See Annex Table V.1 for full branch names.*

* *Data in 1941-44 includes only investment in buildings.*

*Assume that building investment between 1941-44 grew as fast as the average investment growth in 1945-47. This assumption is also supported by evidence in growth in value added in both Northern Rhodesia and Southern Rhodesia.*

*Sources:*

*Census of Industrial Production, 1947, table 1; Census of Production, 1962 (with comparisons back to 1955), table 3; Census of Production, 1963 (with comparisons back to 1955), table 3; Census of Production, 1964, table 8; Census of Production, 1965 and 1966, table VIII (A); Census of Production, 1967, table VIII (A); Census of Production, 1968, table VIII (A); Census of Industrial Production, 1969, table 10; Census of Industrial Production, 1970, table 10; Census of Industrial Production, 1971, table 10; Census of Industrial Production, 1972, table 6.1; Census of Industrial Production, 1973, table 6.1; Census of Industrial Production, 1974, table 6.1; Census of Industrial Production, 1975, table 6.1; Census of Industrial Production, 1980, table 6.1; Census of Industrial Production, 1990, tables 8 and 9; Southern Rhodesia Eleventh Report on the Census of Industrial Production 1938-51, The Central African Statistical Office, Salisbury; The National Income and Social Accounts of Northern Rhodesia, 1945-1953, tables III and 21; National Accounts and Input-Output Table 1973 table 5.13; National Accounts and Input-Output Table, 1980, table 1.3; National Accounts Statistics Bulletin no.2, January 1988, table 4.0; National Accounts Statistics Bulletin no.3, January 1990, table 4.0; National Accounts Statistics Bulletin no.4, June 1992, table 4.0; National Accounts Statistics Bulletin no.6, October 1996, table Account:1.0; National Accounts Statistical Bulletin no.7, December 1998, table 10; CSO data base on GDP and Gross fixed capital formation from 1990 to 1998 in current prices and at 1994 prices.*

## Annex Table I.4: Investment in Fixed Assets in Zambian Manufacturing (10+) at constant 1990 prices, 1941-98 (ZK 000)

| | 1 Food | 2 Tex | 3 Wear | 4 Leat | 5 Wood | 6 Pap | 7 Chem | 8 Rub | 9 Mine | 10 Met | 11 Mach | 12 Elec | 13 Oth | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1941* | 4445.6 | 26.7 | 55.6 | 2.7 | 318.1 | 135.1 | 669.1 | 7.6 | 1495.1 | 669.1 | 20970.2 | 0.3 | 222.3 | 29017.3 |
| 1942* | 4576.5 | 34.9 | 54.5 | 3.3 | 457.6 | 228.8 | 719.2 | 9.9 | 1567.6 | 732.7 | 21846.4 | 0.3 | 231.7 | 30463.2 |
| 1943* | 5151.5 | 42.9 | 79.4 | 3.9 | 350.3 | 152.1 | 751.3 | 8.8 | 1946.8 | 764.7 | 25830.7 | 0.3 | 247.5 | 35330.2 |
| 1944* | 5688.1 | 51.5 | 85.9 | 4.3 | 543.5 | 302.5 | 869.3 | 10.8 | 2187.9 | 1072.6 | 29041.1 | 0.3 | 258.3 | 40116.0 |
| 1945 | 19499.9 | 165.2 | 267.9 | 13.4 | 928.2 | 1136.3 | 1243.0 | 17.8 | 11265.1 | 3760.8 | 48550.1 | 0.4 | 514.6 | 87362.5 |
| 1946 | 30253.7 | 256.3 | 415.7 | 20.8 | 1440.1 | 1762.9 | 1928.5 | 27.6 | 17477.6 | 5834.8 | 100013.1 | 0.6 | 798.4 | 160230.0 |
| 1947 | 126246.1 | 1069.6 | 1734.6 | 86.7 | 6009.6 | 7356.5 | 8047.5 | 115.0 | 72932.5 | 24348.1 | 161186.2 | 2.4 | 3331.6 | 412466.4 |
| 1948 | 61836.9 | 523.9 | 849.6 | 42.5 | 2943.6 | 3603.3 | 3941.8 | 56.3 | 35723.2 | 11926.0 | 171381.7 | 1.2 | 1631.9 | 294461.9 |
| 1949 | 61026.4 | 517.1 | 838.5 | 41.9 | 2905.0 | 3556.1 | 3890.1 | 55.6 | 35255.0 | 11769.7 | 284503.4 | 1.2 | 1610.5 | 405970.3 |
| 1950 | 84124.1 | 712.8 | 1155.8 | 57.8 | 4004.5 | 4902.0 | 5362.5 | 76.6 | 48598.5 | 16224.4 | 326256.4 | 1.6 | 2220.0 | 493696.9 |
| 1951 | 83700.5 | 709.2 | 1150.0 | 57.5 | 3984.3 | 4877.3 | 5335.5 | 76.2 | 48353.8 | 16142.7 | 328683.9 | 1.6 | 2208.8 | 495281.4 |
| 1952 | 131349.3 | 1112.9 | 1804.7 | 90.2 | 6252.5 | 7653.8 | 8372.8 | 119.6 | 75880.6 | 25332.4 | 435494.0 | 2.5 | 3466.3 | 696931.5 |
| 1953 | 133704.9 | 1132.8 | 1837.0 | 91.9 | 6364.6 | 7791.1 | 8523.0 | 121.8 | 77241.4 | 25786.7 | 461225.6 | 2.5 | 3528.4 | 727351.8 |
| 1954 | 349227.8 | 2958.9 | 4798.2 | 239.9 | 16624.0 | 20349.8 | 22261.4 | 318.0 | 201749.1 | 67353.0 | 70581.7 | 6.6 | 9216.0 | 765684.3 |
| 1955 | 309193.7 | 8176.5 | 13259.2 | 663.0 | 54580.5 | 19832.2 | 18079.6 | 258.3 | 116562.9 | 88290.5 | 65334.6 | 25.8 | 7464.3 | 701721.0 |
| 1956 | 676610.4 | 1305.6 | 2117.2 | 105.9 | 11165.0 | 53248.2 | 12396.2 | 177.1 | 667060.8 | 85287.6 | 110109.1 | 17.7 | 5117.9 | 1624718.5 |
| 1957 | 443982.9 | 2687.1 | 4357.5 | 217.9 | 20575.7 | 35383.0 | 66186.8 | 945.5 | 277584.0 | 123905.9 | 132607.1 | 0.0 | 27420.3 | 1135853.8 |
| 1958 | 245438.5 | 3345.4 | 5425.0 | 271.2 | 12397.2 | 9759.7 | 42578.3 | 608.3 | 119631.8 | 62546.8 | 106624.0 | 0.0 | 17639.6 | 626265.8 |
| 1959 | 617652.1 | 3983.6 | 6459.9 | 323.0 | 11419.4 | 16281.6 | 6505.6 | 92.9 | 148851.0 | 82586.2 | 46016.6 | 0.0 | 2695.2 | 942867.1 |
| 1960 | 429382.5 | 8509.8 | 13799.6 | 690.0 | 42872.2 | 34355.8 | 17638.2 | 10943.4 | 67919.1 | 97212.2 | 192932.4 | 2656.6 | 7559.2 | 926470.9 |
| 1961 | 157380.1 | 6258.5 | 10149.0 | 507.4 | 82992.4 | 40127.6 | 16547.2 | 13851.5 | -2174.7 | 140422.6 | 135801.6 | 4394.3 | 7091.7 | 613349.2 |
| 1962 | 256819.1 | 3190.4 | 5173.6 | 258.7 | 29005.2 | 15949.4 | 8045.4 | 10122.2 | 39207.5 | 91761.7 | 39746.9 | 5362.0 | 3448.0 | 508090.0 |
| 1963 | 441606.2 | 4563.8 | 7400.8 | 370.0 | 25566.9 | 55740.0 | 18033.5 | 14391.6 | 94142.1 | 135025.5 | 54484.2 | 1566.2 | 7728.6 | 860619.5 |
| 1964 | 710119.1 | 27501.6 | 44597.2 | 2229.9 | 41307.8 | 73178.6 | 20782.3 | 11853.4 | 165239.0 | 206976.7 | 28993.7 | 11205.8 | 8906.7 | 1352892.0 |
| 1965 | 566977.7 | 165322.8 | 126444.8 | 17063.6 | 173630.2 | 112313.2 | 717608.6 | 69805.0 | 285522.7 | 429461.5 | 276468.6 | 24426.4 | 6398.2 | 2971443.1 |
| 1966 | 618066.8 | 75436.1 | 135530.5 | 62682.5 | 108483.7 | 182055.7 | 409240.3 | 39020.9 | 218456.3 | 267138.9 | 267839.2 | 105882.9 | 19445.3 | 2509279.1 |
| 1967 | 1129966.3 | 92884.7 | 199607.0 | 91010.8 | 126756.3 | 258887.4 | 409624.7 | 84680.3 | 1329861.7 | 367746.2 | 398849.6 | 86173.6 | 96383.9 | 4672432.5 |

**Annex Table I.4 (continued)**

| | 1 Food | 2 Tex | 3 Wear | 4 Leat | 5 Wood | 6 Pap | 7 Chem | 8 Rub | 9 Mine | 10 Met | 11 Mach | 12 Elec | 13 Oth | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1968 | 1603972.0 | 547404.3 | 154689.9 | 27288.0 | 314913.7 | 381510.2 | 3512966.9 | 712546.4 | 1891937.5 | 599906.2 | 154281.4 | 164626.2 | 2610.8 | 10068653.6 |
| 1969 | 1390480.8 | 1571763.0 | 124653.4 | 19587.8 | 240767.3 | 492263.2 | 600977.1 | 307770.1 | 347363.8 | 384189.6 | 147198.3 | 666771.5 | 31206.5 | 6324992.3 |
| 1970 | 1799769.8 | 789876.2 | 132764.5 | 22350.2 | 192709.9 | 264875.2 | 5582432.5 | 166778.8 | 157321.4 | 495963.9 | 80466.5 | 565361.6 | 50185.8 | 10300856.4 |
| 1971 | 1868245.1 | 243571.3 | 120613.8 | 13690.7 | 143161.5 | 200959.1 | 300162.6 | 107794.1 | 324260.4 | 934495.9 | 536046.6 | 153114.1 | 11150.3 | 4957265.7 |
| 1972 | 2544679.7 | 43944.6 | 135930.3 | 77021.7 | 84573.1 | 161326.6 | 2975572.4 | 249093.7 | 1568084.6 | 863502.5 | 371272.5 | 79482.7 | 2124.2 | 9156608.7 |
| 1973 | 2131586.0 | -188002.1 | 87921.5 | 50155.6 | 235541.5 | 128461.2 | 486078.4 | 247658.5 | 5351130.7 | 363771.6 | 127437.2 | 142276.9 | 6449.7 | 9170466.7 |
| 1974 | 2177441.5 | 429261.5 | 339040.2 | 280581.1 | 574407.8 | 279553.3 | 965631.0 | 374315.2 | 1858162.0 | 540063.3 | 172814.7 | 121935.7 | 43991.3 | 8157198.5 |
| 1975 | 2442066.5 | 702752.6 | 227340.4 | 55808.3 | 308723.8 | 145803.8 | 3070023.0 | 224568.4 | 573825.1 | 650810.6 | 214483.8 | 126268.6 | 27897.2 | 8770372.0 |
| 1976 | 2819528.1 | 788831.9 | 317139.0 | 58873.7 | 338772.4 | 237570.0 | 3795914.4 | 341006.8 | 664244.4 | 722880.5 | 272209.7 | 141711.9 | 30044.9 | 10528727.7 |
| 1977 | 2034644.4 | 559227.5 | 264579.7 | 38679.2 | 223820.5 | 219668.4 | 2934606.8 | 302931.0 | 468054.6 | 505111.7 | 213316.8 | 100829.1 | 20377.9 | 7885847.7 |
| 1978 | 1557539.1 | 414285.1 | 227411.7 | 27064.1 | 159407.1 | 203142.1 | 2329199.3 | 272746.7 | 332230.4 | 373484.8 | 174487.7 | 75956.7 | 14639.4 | 6161594.1 |
| 1979 | 1294148.4 | 334254.9 | 207456.5 | 20457.2 | 118786.0 | 195463.4 | 2028187.8 | 257481.8 | 261424.3 | 299730.4 | 153217.0 | 62299.3 | 11550.8 | 5244457.8 |
| 1980 | 1135065.9 | 286271.7 | 196789.3 | 16319.5 | 92027.4 | 192551.7 | 1869139.4 | 250023.1 | 224124.2 | 254107.8 | 141111.8 | 54133.1 | 9654.7 | 4721319.8 |
| 1981 | 1159945.1 | 380009.5 | 76203.5 | 2369.3 | 247688.2 | 311795.9 | 1067462.6 | 357789.2 | 1246665.0 | 391331.6 | 103502.2 | 199798.9 | 2149.1 | 5546710.0 |
| 1982 | 1059728.8 | 353545.7 | 60867.8 | 1043.8 | 238230.1 | 297066.0 | 922301.0 | 334097.4 | 1223274.6 | 372793.8 | 91931.4 | 193680.9 | 1358.6 | 5149920.0 |
| 1983 | 908759.9 | 319168.7 | 50392.3 | 542.2 | 221056.5 | 246388.5 | 813599.4 | 328306.1 | 1196163.5 | 339435.1 | 74771.3 | 182262.7 | 1018.0 | 4681864.2 |
| 1984 | 661869.9 | 218066.7 | 41077.7 | 252.7 | 148904.1 | 211544.3 | 638584.5 | 196793.2 | 797049.4 | 264568.0 | 60787.1 | 120813.9 | 632.4 | 3360943.9 |
| 1985 | 621500.5 | 204789.6 | 44957.3 | 158.6 | 140826.4 | 218878.1 | 698818.1 | 183469.7 | 801441.6 | 283607.3 | 60437.3 | 114311.0 | 560.9 | 3373756.4 |
| 1986 | 537426.3 | 170483.6 | 51455.1 | 90.0 | 116677.6 | 232032.7 | 782388.7 | 137754.5 | 732718.9 | 304094.8 | 60372.8 | 93778.7 | 461.4 | 3219735.3 |
| 1987 | 391239.3 | 124380.0 | 44797.7 | 41.9 | 85857.3 | 189825.3 | 681668.5 | 99631.6 | 591389.4 | 259233.4 | 47620.9 | 69105.3 | 329.5 | 2585120.2 |
| 1988 | 640457.7 | 210251.5 | 60583.7 | 40.9 | 145917.8 | 270821.9 | 941927.0 | 182476.9 | 934091.7 | 368598.1 | 70087.0 | 118493.7 | 516.7 | 3944264.6 |
| 1989 | 608815.4 | 204612.6 | 41211.1 | 17.7 | 142043.8 | 208802.9 | 661780.3 | 188534.2 | 810422.2 | 274368.8 | 57359.2 | 116026.6 | 469.4 | 3314464.2 |
| 1990 | 1178239.0 | 384576.0 | 69760.0 | 0.0 | 262771.0 | 389400.0 | 1114844.0 | 331856.0 | 1399071.0 | 472595.0 | 109308.0 | 213010.0 | 861.0 | 5926291.0 |
| 1991 | 382888.7 | 124535.1 | 25470.1 | -3.1 | 85189.5 | 134835.8 | 403699.2 | 106114.0 | 471703.4 | 167282.7 | 37046.7 | 69006.8 | 279.5 | 2008048.6 |
| 1992 | 385697.2 | 130542.4 | 22171.3 | -4.8 | 90636.9 | 121208.5 | 363264.2 | 122321.1 | 493754.4 | 155849.8 | 34200.9 | 74165.7 | 286.0 | 1994093.7 |
| 1993 | 622861.1 | 211410.1 | 24035.2 | -10.0 | 146023.6 | 162719.3 | 411547.3 | 200873.8 | 716035.7 | 193644.8 | 49217.5 | 119526.3 | 452.9 | 2858337.6 |
| 1994 | 337197.6 | 110673.1 | 15851.2 | -6.3 | 75500.2 | 99719.4 | 258964.0 | 97222.6 | 375872.6 | 115585.2 | 29092.5 | 61279.8 | 240.9 | 1577192.9 |

**Annex Table I.4 (continued)**

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Food | Tex | Wear | Leat | Wood | Pap | Chem | Rub | Mine | Met | Mach | Elec | Oth | Total |
| 1995 | 316405.3 | 111341.2 | 18458.3 | -6.7 | 78650.7 | 96073.3 | 309466.0 | 112782.6 | 444140.4 | 133216.8 | 27040.5 | 64960.3 | 239.9 | 1712768.8 |
| 1996 | 402438.8 | 142028.5 | 22746.5 | -9.3 | 100396.4 | 119800.8 | 383419.4 | 144755.1 | 563177.8 | 166214.1 | 33919.2 | 82973.8 | 304.8 | 2162165.8 |
| 1997 | 587137.1 | 207734.9 | 32456.3 | -14.6 | 146945.1 | 172289.3 | 549410.2 | 212818.8 | 820902.1 | 239388.9 | 48983.6 | 121511.9 | 444.3 | 3140007.7 |
| 1998 | 535368.5 | 189828.6 | 29063.9 | -14.1 | 134362.7 | 155257.5 | 493764.0 | 195326.7 | 748246.1 | 216051.5 | 44290.9 | 111160.1 | 404.9 | 2853111.1 |

*Note:* *See Annex Table V.1 for full branch names.*

* *Data in 1941-44 includes only investment in buildings.*

*Assume that building investment between 1941-44 grew as fast as the average investment growth in 1945-47. This assumption is also supported by evidence in growth in value added in both Northern Rhodesia and Southern Rhodesia.*

*Source for investments:*

*Annex Table I.3.*

*Sources for deflators:*

*CSO database on Index Numbers of Wholesale Prices 1966=100 (by Industrial Activities); Monthly Digest of Statistics, July-October 1991, tables 48, 49(a) and (b).*

*We used implicit price indices for GDP in construction, machinery and vehicles.*

**Annex Table I.5: Capital Stock Estimates for Zambian Manufacturing (10+) at constant 1990 prices, 1970-98, midyear (ZK million)**

| | 1 Food | 2 Tex | 3 Wear | 4 Leat | 5 Wood | 6 Pap | 7 Chem | 8 Rub | 9 Mine | 10 Met | 11 Mach | 12 Elec | 13 Oth | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1970 | 6,222.6 | 2,624.0 | 588.8 | 157.7 | 828.9 | 1,313.0 | 9,096.8 | 1,040.1 | 3,111.6 | 2,030.6 | 1,450.7 | 1,318.9 | 165.1 | 29,948.9 |
| 1971 | 7,134.8 | 2,562.7 | 612.9 | 150.8 | 839.2 | 1,339.5 | 8,387.8 | 1,013.0 | 2,975.1 | 2,623.5 | 1,762.4 | 1,321.3 | 148.9 | 30,871.8 |
| 1972 | 8,548.9 | 2,298.6 | 647.2 | 203.6 | 799.2 | 1,321.2 | 10,246.3 | 1,107.7 | 3,972.7 | 3,089.7 | 1,897.6 | 1,247.7 | 125.4 | 35,505.7 |
| 1973 | 9,432.4 | 1,838.0 | 633.0 | 225.8 | 890.5 | 1,266.3 | 9,650.4 | 1,194.8 | 8,348.7 | 3,042.9 | 1,789.0 | 1,229.4 | 106.3 | 39,647.5 |
| 1974 | 10,213.5 | 1,959.2 | 849.0 | 456.7 | 1,266.1 | 1,348.5 | 9,445.7 | 1,375.8 | 9,004.5 | 3,141.1 | 1,713.3 | 1,180.8 | 122.0 | 42,076.4 |
| 1975 | 11,073.9 | 2,312.9 | 942.5 | 458.2 | 1,352.4 | 1,292.4 | 11,110.7 | 1,394.9 | 8,333.4 | 3,324.1 | 1,676.1 | 1,129.0 | 121.2 | 44,521.6 |
| 1976 | 12,074.6 | 2,692.4 | 1,107.6 | 460.8 | 1,446.5 | 1,326.2 | 13,162.0 | 1,503.3 | 7,686.7 | 3,541.5 | 1,692.2 | 1,085.0 | 121.7 | 47,900.6 |
| 1977 | 12,179.8 | 2,799.8 | 1,208.3 | 442.5 | 1,408.7 | 1,335.4 | 14,090.3 | 1,555.7 | 6,880.2 | 3,518.9 | 1,654.2 | 994.4 | 118.7 | 48,186.7 |
| 1978 | 11,793.4 | 2,748.3 | 1,258.9 | 410.2 | 1,328.4 | 1,329.7 | 14,366.3 | 1,588.0 | 6,028.0 | 3,381.1 | 1,572.8 | 880.1 | 108.6 | 46,793.8 |
| 1979 | 11,170.4 | 2,710.0 | 1,280.1 | 370.7 | 1,244.4 | 1,341.7 | 14,179.3 | 1,619.2 | 5,157.5 | 3,181.1 | 1,475.6 | 797.7 | 97.5 | 44,625.1 |
| 1980 | 10,440.5 | 2,653.7 | 1,286.3 | 327.3 | 1,159.0 | 1,351.0 | 14,119.0 | 1,638.1 | 4,241.4 | 2,961.0 | 1,367.3 | 742.4 | 88.1 | 42,375.3 |
| 1981 | 9,770.0 | 2,661.6 | 1,182.8 | 273.1 | 1,232.1 | 1,452.0 | 13,197.8 | 1,741.1 | 4,282.0 | 2,902.3 | 1,251.4 | 819.8 | 72.6 | 40,838.4 |
| 1982 | 9,088.6 | 2,601.1 | 1,075.0 | 223.9 | 1,279.1 | 1,508.9 | 12,091.1 | 1,808.5 | 4,329.3 | 2,866.0 | 1,149.8 | 872.5 | 57.0 | 38,950.9 |
| 1983 | 8,294.7 | 2,448.7 | 963.5 | 180.8 | 1,306.0 | 1,496.6 | 10,842.3 | 1,863.6 | 4,628.5 | 2,795.3 | 1,044.0 | 903.5 | 42.3 | 36,809.8 |
| 1984 | 7,356.0 | 2,202.9 | 868.7 | 158.2 | 1,277.0 | 1,445.5 | 9,472.1 | 1,793.6 | 4,655.6 | 2,672.1 | 933.7 | 870.4 | 31.5 | 33,737.3 |
| 1985 | 6,500.7 | 1,966.2 | 793.9 | 141.0 | 1,232.6 | 1,391.2 | 8,414.7 | 1,710.1 | 4,672.6 | 2,595.8 | 834.4 | 829.9 | 23.5 | 31,106.6 |
| 1986 | 5,798.0 | 1,756.7 | 743.8 | 127.5 | 1,171.0 | 1,377.8 | 7,774.8 | 1,594.9 | 4,649.5 | 2,581.7 | 757.6 | 780.0 | 18.0 | 29,131.3 |
| 1987 | 5,147.0 | 1,555.4 | 702.6 | 116.1 | 1,088.7 | 1,352.9 | 7,298.4 | 1,456.1 | 4,519.4 | 2,555.1 | 690.6 | 716.4 | 14.4 | 27,213.0 |
| 1988 | 4,838.4 | 1,466.2 | 688.9 | 106.1 | 1,064.4 | 1,419.4 | 7,268.1 | 1,401.7 | 4,722.5 | 2,648.5 | 659.1 | 702.1 | 12.2 | 26,997.6 |
| 1989 | 4,563.3 | 1,389.9 | 666.9 | 96.9 | 1,031.8 | 1,432.3 | 7,122.7 | 1,351.8 | 4,790.1 | 2,655.1 | 624.9 | 682.7 | 10.7 | 26,419.1 |
| 1990 | 4,811.6 | 1,480.6 | 681.6 | 88.4 | 1,097.4 | 1,605.6 | 7,547.4 | 1,426.9 | 5,374.7 | 2,845.9 | 642.9 | 743.1 | 10.2 | 28,356.1 |
| 1991 | 4,318.7 | 1,331.7 | 654.1 | 79.9 | 998.3 | 1,531.4 | 7,297.9 | 1,298.2 | 5,094.0 | 2,743.0 | 592.4 | 670.1 | 9.3 | 26,618.9 |
| 1992 | 3,858.1 | 1,201.6 | 624.1 | 71.5 | 913.4 | 1,445.1 | 7,027.2 | 1,203.5 | 4,885.4 | 2,635.5 | 540.3 | 609.9 | 8.4 | 25,024.0 |
| 1993 | 3,658.3 | 1,161.0 | 596.5 | 63.1 | 889.7 | 1,401.8 | 6,815.4 | 1,198.5 | 4,930.2 | 2,570.7 | 504.1 | 600.2 | 7.8 | 24,397.2 |
| 1994 | 3,221.9 | 1,032.9 | 561.5 | 54.8 | 803.8 | 1,304.7 | 6,461.0 | 1,099.4 | 4,663.9 | 2,435.8 | 451.1 | 538.7 | 7.0 | 22,636.7 |
| 1995 | 2,901.0 | 940.7 | 532.0 | 46.5 | 743.5 | 1,241.2 | 6,182.8 | 1,027.4 | 4,501.9 | 2,336.6 | 410.4 | 495.6 | 6.4 | 21,366.0 |
| 1996 | 2,674.3 | 879.5 | 506.8 | 38.8 | 704.9 | 1,201.6 | 5,972.1 | 984.8 | 4,447.9 | 2,269.3 | 378.5 | 471.0 | 5.8 | 20,535.3 |
| 1997 | 2,605.1 | 872.4 | 491.5 | 32.6 | 705.0 | 1,209.6 | 5,907.5 | 997.8 | 4,613.0 | 2,267.6 | 363.3 | 478.9 | 5.5 | 20,549.8 |
| 1998 | 2,507.2 | 856.7 | 473.9 | 26.8 | 693.6 | 1,209.4 | 5,830.3 | 1,000.8 | 4,704.6 | 2,244.9 | 346.3 | 478.3 | 5.1 | 20,377.9 |

*Note:* *See Annex Table V.1 for full branch names.*

*Sources:*

*PIM estimate for 3 asset types on 1970 bench mark with rectangular scrapping after service lives (30 years for buildings, 10 years for machinery and equipment, 5 years for vehicles and others, also see Maddison, 1993, and Timmer, 2000). For method, see main text of chapter 3. Real investment data from Annex Table I.4.*

**Annex Table I.6: Shares of Labour in current manufacturing value added (10+), Zambia, 1970-98**

| | 1 Food | 2 Tex | 3 Wear | 4 Leat | 5 Wood | 6 Pap | 7 Chem | 8 Rub | 9 Mine | 10 Met | 11 Mach | 12 Elec | 13 Oth | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1970 | 0.36 | 0.46 | 0.42 | 0.28 | 0.30 | 0.37 | 0.35 | 0.34 | 0.41 | 0.43 | 0.42 | 0.43 | 0.47 | 0.44 |
| 1971 | 0.34 | 0.46 | 0.47 | 0.31 | 0.22 | 0.37 | 0.36 | 0.31 | 0.42 | 0.45 | 0.44 | 0.43 | 0.44 | 0.42 |
| 1972 | 0.29 | 0.47 | 0.44 | 0.38 | 0.32 | 0.35 | 0.36 | 0.33 | 0.36 | 0.50 | 0.40 | 0.37 | 0.54 | 0.37 |
| 1973 | 0.34 | 0.44 | 0.43 | 0.39 | 0.34 | 0.35 | 0.33 | 0.29 | 0.58 | 0.47 | 0.42 | 0.35 | 0.32 | 0.40 |
| 1974 | 0.35 | 0.44 | 0.41 | 0.40 | 0.40 | 0.34 | 0.33 | 0.32 | 0.43 | 0.45 | 0.36 | 0.33 | 0.40 | 0.39 |
| 1975 | 0.41 | 0.47 | 0.42 | 0.39 | 0.43 | 0.39 | 0.31 | 0.32 | 0.42 | 0.55 | 0.33 | 0.43 | 0.40 | 0.43 |
| 1976 | 0.34 | 0.45 | 0.39 | 0.34 | 0.26 | 0.42 | 0.40 | 0.35 | 0.44 | 0.49 | 0.46 | 0.47 | 0.37 | 0.40 |
| 1977 | 0.33 | 0.32 | 0.30 | 0.37 | 0.38 | 0.38 | 0.33 | 0.43 | 0.42 | 0.39 | 0.41 | 0.43 | 0.37 | 0.37 |
| 1978 | 0.36 | 0.33 | 0.35 | 0.38 | 0.30 | 0.37 | 0.45 | 0.44 | 0.41 | 0.43 | 0.42 | 0.43 | 0.41 | 0.33 |
| 1979 | 0.34 | 0.39 | 0.37 | 0.31 | 0.22 | 0.37 | 0.46 | 0.31 | 0.42 | 0.45 | 0.44 | 0.43 | 0.44 | 0.31 |
| 1980 | 0.30 | 0.26 | 0.41 | 0.26 | 0.30 | 0.41 | 0.34 | 0.34 | 0.43 | 0.40 | 0.43 | 0.42 | 0.41 | 0.35 |
| 1981 | 0.29 | 0.36 | 0.38 | 0.31 | 0.26 | 0.35 | 0.21 | 0.23 | 0.35 | 0.45 | 0.45 | 0.33 | 0.40 | 0.33 |
| 1982 | 0.35 | 0.22 | 0.32 | 0.38 | 0.28 | 0.38 | 0.36 | 0.25 | 0.34 | 0.41 | 0.43 | 0.37 | 0.44 | 0.32 |
| 1983 | 0.36 | 0.31 | 0.33 | 0.39 | 0.35 | 0.37 | 0.36 | 0.37 | 0.38 | 0.35 | 0.38 | 0.35 | 0.36 | 0.33 |
| 1984 | 0.30 | 0.32 | 0.32 | 0.22 | 0.32 | 0.38 | 0.44 | 0.36 | 0.42 | 0.45 | 0.41 | 0.47 | 0.37 | 0.33 |
| 1985 | 0.34 | 0.48 | 0.39 | 0.24 | 0.26 | 0.34 | 0.40 | 0.35 | 0.44 | 0.49 | 0.46 | 0.47 | 0.37 | 0.38 |
| 1986 | 0.34 | 0.39 | 0.37 | 0.31 | 0.22 | 0.31 | 0.46 | 0.31 | 0.42 | 0.45 | 0.44 | 0.43 | 0.34 | 0.37 |
| 1987 | 0.29 | 0.41 | 0.44 | 0.38 | 0.22 | 0.35 | 0.36 | 0.33 | 0.36 | 0.40 | 0.40 | 0.37 | 0.35 | 0.38 |
| 1988 | 0.34 | 0.44 | 0.33 | 0.39 | 0.23 | 0.35 | 0.29 | 0.29 | 0.38 | 0.41 | 0.42 | 0.39 | 0.32 | 0.38 |
| 1989 | 0.39 | 0.44 | 0.31 | 0.40 | 0.24 | 0.34 | 0.29 | 0.32 | 0.43 | 0.45 | 0.36 | 0.37 | 0.40 | 0.43 |
| 1990 | 0.34 | 0.42 | 0.37 | 0.29 | 0.24 | 0.31 | 0.43 | 0.27 | 0.37 | 0.44 | 0.42 | 0.55 | 0.40 | 0.44 |
| 1991 | 0.40 | 0.26 | 0.41 | 0.26 | 0.23 | 0.35 | 0.34 | 0.34 | 0.25 | 0.40 | 0.24 | 0.17 | 0.39 | 0.45 |
| 1992 | 0.39 | 0.36 | 0.38 | 0.31 | 0.25 | 0.41 | 0.21 | 0.35 | 0.35 | 0.45 | 0.45 | 0.33 | 0.41 | 0.46 |
| 1993 | 0.35 | 0.42 | 0.32 | 0.38 | 0.27 | 0.38 | 0.36 | 0.35 | 0.34 | 0.41 | 0.43 | 0.37 | 0.38 | 0.38 |
| 1994 | 0.39 | 0.50 | 0.31 | 0.40 | 0.32 | 0.35 | 0.29 | 0.39 | 0.81 | 0.54 | 0.59 | 0.41 | 0.29 | 0.43 |

**Annex Table I.6 (continued)**

| | 1<br>Food | 2<br>Tex | 3<br>Wear | 4<br>Leat | 5<br>Wood | 6<br>Pap | 7<br>Chem | 8<br>Rub | 9<br>Mine | 10<br>Met | 11<br>Mach | 12<br>Elec | 13<br>Oth | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1995 | 0.39 | 0.36 | 0.38 | 0.31 | 0.33 | 0.35 | 0.21 | 0.35 | 0.35 | 0.45 | 0.45 | 0.33 | 0.47 | 0.44 |
| 1996 | 0.37 | 0.32 | 0.32 | 0.35 | 0.36 | 0.38 | 0.26 | 0.25 | 0.34 | 0.40 | 0.39 | 0.37 | 0.44 | 0.38 |
| 1997 | 0.36 | 0.49 | 0.33 | 0.32 | 0.37 | 0.37 | 0.26 | 0.27 | 0.38 | 0.46 | 0.38 | 0.51 | 0.42 | 0.41 |
| 1998 | 0.38 | 0.52 | 0.42 | 0.22 | 0.36 | 0.38 | 0.44 | 0.26 | 0.42 | 0.49 | 0.42 | 0.47 | 0.47 | 0.46 |

*Note:* *See Annex Table V.1 for full branch names.*

*Sources:*

*Census of Industrial Production, 1970, table 3.2; Census of Industrial Production, 1971, table 3.2; Census of Industrial Production, 1972, table 1.2; Census of Industrial Production, 1973, table 1.2; Census of Industrial Production, 1974, table 1.2; Census of Industrial Production, 1975, table 1.2; Census of Industrial Production, 1980, table 1.2; Census of Industrial Production, 1990, table 2; Census of Industrial Production, 1994, table 0.1; Monthly Digest of Statistics, July-October 1991, table 16; Report on Employment and Earnings 1966-68, CSO, tables 2 and 10.2; Report on Employment and Earnings 1972-74, CSO, tables 2.0, 2.1 and 2.2; Report on Employment and Earnings 1978, CSO, tables 2.0 and 3.2; Report on Employment and Earnings 1979, CSO, tables 2.0 and 3.1; Quarterly Employment and Earnings Statistics, June 1992, tables 1 and 5; CSO database on GDP and Gross fixed capital formation from 1990 to 1998 in current prices and at 1994 prices.*

**Annex Table I.7: Total factor productivity levels by Zambian manufacturing branch (10+), 1970-98 (1990=100)**

| | 1 Food | 2 Tex | 3 Wear | 4 Leat | 5 Wood | 6 Pap | 7 Chem | 8 Rub | 9 Mine | 10 Met | 11 Mach | 12 Elec | 13 Oth | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1970 | 36.4 | 11.1 | 144.1 | 22.3 | 101.4 | 104.7 | 57.2 | 76.4 | 186.0 | 163.1 | 67.3 | 34.4 | 15.2 | 63.3 |
| 1971 | 39.4 | 14.5 | 133.7 | 24.9 | 97.0 | 106.4 | 68.4 | 108.2 | 199.2 | 140.4 | 57.3 | 51.6 | 18.3 | 68.3 |
| 1972 | 37.1 | 18.3 | 155.8 | 37.7 | 94.0 | 134.2 | 96.7 | 102.9 | 196.7 | 127.6 | 75.9 | 63.6 | 14.7 | 73.3 |
| 1973 | 33.6 | 24.7 | 131.6 | 42.8 | 101.4 | 134.3 | 115.1 | 108.4 | 123.1 | 126.6 | 81.8 | 59.3 | 23.1 | 69.3 |
| 1974 | 25.8 | 22.5 | 128.2 | 35.5 | 111.1 | 130.6 | 111.1 | 91.4 | 143.3 | 125.3 | 94.9 | 79.1 | 27.4 | 67.5 |
| 1975 | 20.5 | 19.7 | 96.5 | 33.1 | 88.9 | 108.3 | 114.8 | 75.0 | 134.4 | 98.6 | 117.5 | 49.7 | 26.2 | 59.6 |
| 1976 | 26.5 | 30.4 | 103.6 | 33.8 | 89.3 | 97.8 | 124.3 | 79.8 | 76.8 | 50.7 | 113.5 | 69.4 | 28.0 | 58.4 |
| 1977 | 26.8 | 34.2 | 98.2 | 31.9 | 106.7 | 102.7 | 122.6 | 66.5 | 75.5 | 56.1 | 93.1 | 68.1 | 28.2 | 59.1 |
| 1978 | 27.5 | 37.2 | 94.8 | 38.9 | 103.0 | 121.9 | 126.0 | 65.7 | 108.9 | 65.1 | 89.9 | 75.6 | 30.1 | 64.2 |
| 1979 | 31.0 | 46.6 | 99.8 | 41.3 | 115.0 | 97.7 | 129.3 | 74.9 | 108.6 | 67.3 | 77.0 | 61.7 | 29.6 | 65.7 |
| 1980 | 26.5 | 52.0 | 104.9 | 46.3 | 135.8 | 76.4 | 106.4 | 63.4 | 161.0 | 72.6 | 80.7 | 68.6 | 31.2 | 63.1 |
| 1981 | 47.9 | 57.4 | 60.0 | 56.3 | 122.8 | 55.9 | 78.0 | 46.7 | 168.1 | 107.1 | 88.9 | 67.8 | 35.7 | 69.9 |
| 1982 | 52.5 | 63.8 | 62.5 | 51.7 | 105.3 | 47.5 | 63.2 | 33.1 | 162.2 | 134.3 | 99.8 | 69.9 | 38.6 | 72.4 |
| 1983 | 57.3 | 56.9 | 54.2 | 75.0 | 102.8 | 45.2 | 62.8 | 35.4 | 182.7 | 98.1 | 107.8 | 70.1 | 41.4 | 71.6 |
| 1984 | 65.0 | 59.3 | 55.3 | 48.6 | 97.8 | 42.2 | 28.6 | 27.4 | 78.0 | 163.2 | 95.3 | 72.3 | 64.2 | 71.1 |
| 1985 | 56.7 | 56.6 | 53.5 | 61.9 | 107.7 | 50.9 | 59.0 | 55.8 | 152.5 | 174.8 | 128.7 | 85.2 | 68.1 | 80.4 |
| 1986 | 63.1 | 51.6 | 48.5 | 52.8 | 110.0 | 64.9 | 61.2 | 57.8 | 117.2 | 199.0 | 136.7 | 112.7 | 84.9 | 85.9 |
| 1987 | 72.4 | 59.1 | 54.8 | 56.5 | 103.3 | 101.5 | 60.0 | 58.0 | 22.1 | 149.8 | 190.8 | 142.6 | 99.4 | 86.2 |
| 1988 | 85.5 | 63.8 | 59.5 | 59.8 | 100.5 | 106.7 | 57.7 | 57.0 | 68.9 | 147.6 | 186.3 | 137.9 | 114.7 | 92.4 |
| 1989 | 93.7 | 72.8 | 75.6 | 74.1 | 116.2 | 110.8 | 76.1 | 82.8 | 98.0 | 92.3 | 170.6 | 123.1 | 120.1 | 94.3 |
| 1990 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| 1991 | 120.6 | 64.5 | 62.4 | 137.7 | 124.5 | 93.9 | 88.4 | 53.3 | 46.4 | 129.8 | 97.8 | 108.2 | 118.2 | 99.2 |
| 1992 | 112.2 | 91.9 | 86.4 | 154.0 | 134.2 | 108.4 | 27.0 | 15.5 | 39.5 | 171.1 | 131.1 | 147.2 | 115.7 | 96.7 |
| 1993 | 63.0 | 59.0 | 56.3 | 158.4 | 120.5 | 46.9 | 112.1 | 61.5 | 22.5 | 76.0 | 81.5 | 86.7 | 63.3 | 69.0 |
| 1994 | 50.3 | 47.3 | 43.4 | 150.1 | 126.7 | 22.7 | 81.2 | 45.3 | 15.7 | 127.3 | 73.8 | 76.0 | 84.5 | 61.2 |
| 1995 | 73.8 | 54.2 | 51.2 | 171.9 | 138.6 | 15.4 | 26.0 | 14.8 | 14.2 | 74.0 | 32.7 | 27.4 | 45.4 | 49.6 |
| 1996 | 87.2 | 69.0 | 60.9 | 188.9 | 137.4 | 16.1 | 36.5 | 21.1 | 14.9 | 66.9 | 31.7 | 26.1 | 50.9 | 55.6 |
| 1997 | 91.9 | 88.0 | 58.4 | 227.8 | 148.0 | 22.2 | 35.3 | 20.1 | 11.0 | 84.6 | 31.7 | 24.8 | 49.7 | 60.4 |
| 1998 | 98.7 | 92.8 | 66.2 | 276.9 | 156.3 | 24.3 | 27.1 | 17.9 | 13.2 | 88.9 | 32.6 | 24.6 | 64.5 | 61.9 |

*Note:* *See Annex Table V.1 for full branch names.*

*Sources:*

*Calculated with translog production function with value added, labour and capital input, and labour share in value added from Annex Tables I.1, I.2, I.5 and I.6.*

*USA*

**Annex Table I.8: Gross Domestic Product in US Manufacturing at constant 1982 prices, 1964-98 (million US dollars)**

| | 1 Food | 2 Tex | 3 Wear | 4 Leat | 5 Wood | 6 Pap | 7 Chem | 8 Rub | 9 Mine | 10 Met | 11 Mach | 12 Elec | 13 Oth | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1964 | 45,453 | 9,879 | 13,755 | 4,765 | 19,380 | 42,893 | 40,985 | 9,425 | 17,779 | 84,292 | 107,854 | 23,571 | 17,181 | 437,213 |
| 1965 | 47,010 | 10,833 | 15,099 | 5,046 | 21,711 | 44,476 | 44,117 | 10,230 | 18,425 | 92,077 | 119,624 | 28,073 | 19,052 | 475,772 |
| 1966 | 49,340 | 11,769 | 16,336 | 5,315 | 21,855 | 47,046 | 46,191 | 11,119 | 18,546 | 99,306 | 131,808 | 32,418 | 21,201 | 512,249 |
| 1967 | 48,958 | 11,425 | 15,982 | 4,789 | 21,793 | 46,806 | 47,027 | 11,137 | 18,012 | 97,547 | 131,749 | 33,671 | 21,692 | 510,587 |
| 1968 | 49,937 | 11,992 | 16,767 | 5,003 | 22,902 | 49,575 | 51,604 | 12,630 | 18,700 | 99,639 | 139,691 | 35,226 | 23,470 | 537,135 |
| 1969 | 51,821 | 12,269 | 16,765 | 4,782 | 23,203 | 52,927 | 52,219 | 13,870 | 19,767 | 102,593 | 139,065 | 37,703 | 25,546 | 552,529 |
| 1970 | 52,910 | 12,962 | 15,639 | 4,347 | 22,320 | 49,797 | 55,336 | 12,358 | 18,957 | 93,729 | 124,164 | 34,794 | 23,407 | 520,721 |
| 1971 | 54,747 | 13,430 | 15,829 | 4,349 | 23,148 | 51,015 | 58,616 | 13,365 | 19,274 | 90,550 | 126,564 | 34,856 | 24,136 | 529,879 |
| 1972 | 57,850 | 14,370 | 18,531 | 4,487 | 26,871 | 54,843 | 61,536 | 15,259 | 21,165 | 98,401 | 138,761 | 38,764 | 26,969 | 577,806 |
| 1973 | 62,169 | 14,124 | 19,997 | 4,855 | 28,211 | 60,282 | 67,589 | 17,641 | 23,505 | 113,279 | 155,492 | 44,404 | 28,450 | 639,999 |
| 1974 | 57,133 | 12,650 | 18,874 | 4,672 | 27,156 | 57,800 | 62,561 | 16,359 | 22,073 | 109,561 | 150,371 | 41,372 | 28,465 | 609,046 |
| 1975 | 58,598 | 11,882 | 18,704 | 4,469 | 24,861 | 53,929 | 61,522 | 14,794 | 19,981 | 88,426 | 138,928 | 38,033 | 28,966 | 563,092 |
| 1976 | 61,643 | 14,513 | 20,123 | 4,994 | 27,982 | 58,908 | 69,867 | 15,386 | 22,279 | 95,925 | 154,034 | 41,971 | 31,052 | 618,677 |
| 1977 | 61,240 | 17,632 | 20,834 | 4,754 | 29,489 | 62,686 | 76,413 | 17,884 | 22,650 | 99,353 | 167,642 | 50,111 | 34,102 | 664,790 |
| 1978 | 66,543 | 16,630 | 21,535 | 4,853 | 30,493 | 65,086 | 77,712 | 18,983 | 23,249 | 106,150 | 173,843 | 56,213 | 33,306 | 694,595 |
| 1979 | 69,444 | 17,031 | 21,335 | 4,160 | 32,698 | 65,785 | 81,507 | 19,683 | 23,448 | 108,649 | 173,655 | 60,214 | 34,410 | 712,018 |
| 1980 | 69,444 | 16,430 | 21,135 | 4,259 | 31,795 | 62,783 | 72,816 | 18,584 | 21,253 | 101,852 | 158,682 | 63,314 | 31,613 | 673,959 |
| 1981 | 68,844 | 15,829 | 20,333 | 4,358 | 26,782 | 64,081 | 75,715 | 20,782 | 20,156 | 103,551 | 157,479 | 64,915 | 35,912 | 678,736 |
| 1982 | 70,343 | 14,827 | 18,931 | 4,061 | 25,578 | 65,082 | 79,609 | 19,283 | 18,160 | 81,562 | 141,686 | 61,814 | 33,712 | 634,648 |
| 1983 | 70,742 | 16,230 | 20,133 | 3,764 | 29,289 | 68,582 | 89,395 | 21,581 | 19,657 | 77,664 | 160,178 | 64,615 | 32,615 | 674,444 |
| 1984 | 69,941 | 16,029 | 20,433 | 3,566 | 32,599 | 70,282 | 98,776 | 24,678 | 21,253 | 88,160 | 194,267 | 73,517 | 38,911 | 752,412 |
| 1985 | 71,040 | 15,628 | 20,133 | 3,170 | 31,998 | 72,681 | 98,377 | 26,577 | 22,151 | 88,859 | 216,965 | 74,317 | 37,211 | 779,105 |
| 1986 | 72,641 | 17,031 | 21,034 | 2,674 | 33,401 | 74,681 | 105,569 | 26,676 | 22,850 | 86,960 | 225,877 | 74,117 | 39,711 | 803,224 |
| 1987 | 71,939 | 17,432 | 22,036 | 2,971 | 37,914 | 78,381 | 114,360 | 29,474 | 21,952 | 93,657 | 238,586 | 82,919 | 40,610 | 852,230 |
| 1988 | 77,611 | 17,195 | 23,125 | 3,030 | 37,450 | 81,206 | 117,317 | 31,167 | 22,859 | 99,523 | 268,357 | 93,360 | 47,872 | 920,074 |
| 1989 | 73,384 | 17,432 | 23,460 | 3,088 | 36,309 | 80,456 | 114,343 | 34,254 | 24,180 | 95,865 | 269,738 | 101,959 | 45,692 | 920,159 |
| 1990 | 73,481 | 17,984 | 22,874 | 3,030 | 34,435 | 78,868 | 110,978 | 33,855 | 24,262 | 93,735 | 267,136 | 105,338 | 46,475 | 912,451 |

**Annex Table I.8 (continued)**

| | 1<br>Food | 2<br>Tex | 3<br>Wear | 4<br>Leat | 5<br>Wood | 6<br>Pap | 7<br>Chem | 8<br>Rub | 9<br>Mine | 10<br>Met | 11<br>Mach | 12<br>Elec | 13<br>Oth | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1991 | 74,195 | 17,984 | 22,623 | 3,030 | 31,816 | 77,501 | 105,705 | 34,951 | 22,117 | 88,965 | 246,108 | 111,633 | 44,932 | 881,560 |
| 1992 | 73,563 | 20,192 | 23,209 | 3,030 | 31,922 | 77,927 | 109,295 | 37,739 | 24,427 | 90,768 | 256,664 | 112,555 | 42,733 | 904,024 |
| 1993 | 75,543 | 20,429 | 23,125 | 2,855 | 31,697 | 78,913 | 109,670 | 41,025 | 24,015 | 97,444 | 269,202 | 130,520 | 40,449 | 944,887 |
| 1994 | 75,304 | 21,218 | 23,796 | 2,971 | 32,756 | 80,213 | 118,178 | 44,709 | 26,408 | 107,148 | 290,876 | 158,621 | 39,912 | 1,022,109 |
| 1995 | 89,000 | 20,508 | 23,460 | 3,088 | 34,429 | 72,765 | 126,816 | 46,800 | 27,068 | 109,756 | 324,653 | 197,623 | 39,931 | 1,115,897 |
| 1996 | 79,442 | 19,956 | 22,623 | 2,447 | 33,585 | 74,766 | 134,948 | 49,488 | 27,398 | 112,490 | 342,193 | 235,244 | 40,775 | 1,175,356 |
| 1997 | 76,683 | 19,798 | 21,785 | 2,622 | 34,782 | 75,223 | 131,417 | 53,571 | 30,782 | 117,032 | 391,831 | 280,081 | 40,185 | 1,275,792 |
| 1998 | 75,371 | 19,246 | 20,695 | 2,447 | 36,791 | 73,748 | 123,466 | 53,372 | 32,762 | 121,062 | 461,080 | 341,042 | 40,209 | 1,401,291 |

*Note:* *See Annex Table V.1 for full branch names.*

*Sources:*

*1987-98: BEA, Selected National Income and Product Account Tables, download from the Internet 28 June 2000. (http://www.bea.doc.gov/bea/dn1.htm).*

*Growth rates for 1977-87 from same source are linked in 1987. Breakdown of electrical machinery and precision instruments on basis of series using 1972 SIC.*

*Growth rates for series for 1947-77 from BEA, National Income and Product Accounts of the United States, 1929-82, Washington DC, linked in 1977.*

*DataBase on Producer Price Indexes, from Internet http://146.142.4.24/cgi-bin/srgate version d.d. July 1999.*

**Annex Table I.9: Employment in US Manufacturing, 1964-98 (1000 persons)**

| | 1 Food | 2 Tex | 3 Wear | 4 Leat | 5 Wood | 6 Pap | 7 Chem | 8 Rub | 9 Mine | 10 Met | 11 Mach | 12 Elec | 13 Oth | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1964 | 1,869 | 902 | 1,316 | 350 | 1,142 | 1,629 | 1,040 | 480 | 594 | 2,513 | 3,402 | 1,294 | 1,011 | 17,541 |
| 1965 | 1,875 | 935 | 1,365 | 356 | 1,177 | 1,669 | 1,069 | 516 | 608 | 2,659 | 3,643 | 1,382 | 1,069 | 18,322 |
| 1966 | 1,886 | 973 | 1,415 | 366 | 1,218 | 1,730 | 1,124 | 561 | 623 | 2,820 | 4,022 | 1,590 | 1,161 | 19,490 |
| 1967 | 1,899 | 971 | 1,407 | 356 | 1,196 | 1,775 | 1,159 | 566 | 612 | 2,847 | 4,105 | 1,641 | 1,190 | 19,723 |
| 1968 | 1,898 | 1,005 | 1,422 | 361 | 1,226 | 1,805 | 1,194 | 609 | 617 | 2,898 | 4,162 | 1,656 | 1,218 | 20,071 |
| 1969 | 1,902 | 1,016 | 1,431 | 346 | 1,264 | 1,856 | 1,228 | 650 | 638 | 2,994 | 4,217 | 1,700 | 1,251 | 20,492 |
| 1970 | 1,888 | 989 | 1,382 | 321 | 1,222 | 1,841 | 1,220 | 634 | 622 | 2,842 | 3,872 | 1,603 | 1,206 | 19,642 |
| 1971 | 1,850 | 965 | 1,359 | 302 | 1,237 | 1,776 | 1,178 | 630 | 612 | 2,663 | 3,596 | 1,482 | 1,147 | 18,795 |
| 1972 | 1,824 | 1,004 | 1,389 | 300 | 1,297 | 1,793 | 1,166 | 681 | 632 | 2,718 | 3,738 | 1,527 | 1,200 | 19,266 |
| 1973 | 1,822 | 1,036 | 1,427 | 299 | 1,366 | 1,844 | 1,196 | 737 | 669 | 2,919 | 4,056 | 1,685 | 1,281 | 20,336 |
| 1974 | 1,816 | 990 | 1,369 | 281 | 1,311 | 1,847 | 1,220 | 732 | 664 | 2,935 | 4,136 | 1,701 | 1,328 | 20,329 |
| 1975 | 1,761 | 872 | 1,264 | 250 | 1,129 | 1,772 | 1,216 | 626 | 608 | 2,622 | 3,809 | 1,462 | 1,230 | 18,620 |
| 1976 | 1,787 | 921 | 1,351 | 270 | 1,231 | 1,821 | 1,247 | 677 | 626 | 2,689 | 3,906 | 1,528 | 1,284 | 19,338 |
| 1977 | 1,807 | 915 | 1,345 | 266 | 1,313 | 1,890 | 1,284 | 747 | 647 | 2,785 | 4,106 | 1,612 | 1,363 | 20,081 |
| 1978 | 1,828 | 919 | 1,364 | 270 | 1,374 | 1,953 | 1,309 | 788 | 678 | 2,912 | 4,389 | 1,737 | 1,440 | 20,962 |
| 1979 | 1,833 | 895 | 1,329 | 257 | 1,388 | 2,017 | 1,327 | 822 | 693 | 2,992 | 4,640 | 1,824 | 1,477 | 21,494 |
| 1980 | 1,807 | 858 | 1,296 | 242 | 1,293 | 2,029 | 1,325 | 760 | 649 | 2,787 | 4,450 | 1,811 | 1,466 | 20,774 |
| 1981 | 1,781 | 833 | 1,275 | 250 | 1,258 | 2,048 | 1,332 | 774 | 623 | 2,743 | 4,458 | 1,814 | 1,493 | 20,683 |
| 1982 | 1,741 | 758 | 1,188 | 230 | 1,139 | 2,039 | 1,291 | 722 | 559 | 2,381 | 4,056 | 1,743 | 1,450 | 19,298 |
| 1983 | 1,705 | 754 | 1,189 | 215 | 1,211 | 2,073 | 1,247 | 743 | 560 | 2,224 | 3,831 | 1,743 | 1,423 | 18,917 |
| 1984 | 1,694 | 760 | 1,224 | 198 | 1,298 | 2,157 | 1,239 | 822 | 587 | 2,364 | 4,153 | 1,909 | 1,445 | 19,849 |
| 1985 | 1,687 | 713 | 1,149 | 175 | 1,295 | 2,195 | 1,228 | 822 | 577 | 2,265 | 4,227 | 1,892 | 1,442 | 19,667 |
| 1986 | 1,707 | 715 | 1,133 | 157 | 1,314 | 2,226 | 1,196 | 828 | 572 | 2,206 | 4,130 | 1,827 | 1,425 | 19,436 |
| 1987 | 1,720 | 737 | 1,130 | 152 | 1,367 | 2,269 | 1,195 | 859 | 574 | 2,170 | 4,116 | 1,788 | 1,406 | 19,483 |
| 1988 | 1,718 | 739 | 1,120 | 152 | 1,403 | 2,365 | 1,227 | 873 | 590 | 2,226 | 4,200 | 1,781 | 1,487 | 19,881 |
| 1989 | 1,718 | 730 | 1,118 | 150 | 1,394 | 2,376 | 1,235 | 894 | 586 | 2,240 | 4,236 | 1,760 | 1,493 | 19,930 |
| 1990 | 1,726 | 702 | 1,071 | 140 | 1,359 | 2,393 | 1,254 | 890 | 570 | 2,193 | 4,142 | 1,682 | 1,451 | 19,573 |

**Annex Table I.9 (continued)**

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Food | Tex | Wear | Leat | Wood | Pap | Chem | Rub | Mine | Met | Mach | Elec | Oth | Total |
| 1991 | 1,745 | 680 | 1,047 | 129 | 1,264 | 2,350 | 1,251 | 868 | 539 | 2,102 | 3,965 | 1,604 | 1,410 | 18,954 |
| 1992 | 1,726 | 681 | 1,040 | 124 | 1,278 | 2,307 | 1,245 | 882 | 531 | 2,042 | 3,819 | 1,535 | 1,367 | 18,577 |
| 1993 | 1,748 | 688 | 1,026 | 125 | 1,327 | 2,338 | 1,229 | 918 | 535 | 2,046 | 3,745 | 1,547 | 1,350 | 18,622 |
| 1994 | 1,747 | 687 | 1,020 | 121 | 1,380 | 2,362 | 1,205 | 964 | 551 | 2,113 | 3,793 | 1,591 | 1,326 | 18,860 |
| 1995 | 1,746 | 671 | 977 | 113 | 1,419 | 2,374 | 1,191 | 983 | 560 | 2,175 | 3,899 | 1,634 | 1,297 | 19,039 |
| 1996 | 1,748 | 638 | 909 | 106 | 1,408 | 2,339 | 1,178 | 987 | 578 | 2,185 | 3,933 | 1,669 | 1,316 | 18,994 |
| 1997 | 1,760 | 624 | 857 | 92 | 1,434 | 2,362 | 1,180 | 1,003 | 576 | 2,216 | 4,053 | 1,699 | 1,336 | 19,192 |
| 1998 | 1,755 | 604 | 802 | 88 | 1,482 | 2,373 | 1,186 | 1,020 | 582 | 2,253 | 4,163 | 1,714 | 1,340 | 19,361 |

*Note:* *See Annex Table V.1 for full branch names.*

*Sources: 1987-98: BEA, Selected National Income and Product Account Tables, download from the Internet 28 June 2000. (http://www.bea.doc.gov/bea/dn1.htm).*

*Growth rates for 1977-87 from same source are linked in 1987. Breakdown of electrical machinery and precision instruments on basis of series using 1972 SIC.*

*Growth rates for series for 1947-77 from BEA, National Income and Product Accounts of the United States, 1929-1982, Washington DC, linked in 1977.*

**Annex Table I.10: Gross fixed capital stock in US Manufacturing at constant 1985 prices, 1970-98, midyear (million US dollars)**

| | 1 Food | 2 Tex | 3 Wear | 4 Leat | 5 Wood | 6 Pap | 7 Chem | 8 Rub | 9 Mine | 10 Met | 11 Mach | 12 Elec | 13 Oth | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1970 | 106,813.2 | 39,133.7 | 10,614.0 | 3,632.0 | 36,872.2 | 115,120.0 | 183,043.2 | 28,507.5 | 48,464.6 | 173,745.5 | 172,254.5 | 50,534.9 | 25,990.6 | 994,726.1 |
| 1971 | 108,635.9 | 39,694.4 | 11,223.1 | 3,652.6 | 38,197.1 | 118,727.9 | 190,053.8 | 30,033.5 | 49,507.8 | 178,216.7 | 176,916.5 | 53,335.4 | 27,128.3 | 1,025,322.8 |
| 1972 | 110,603.4 | 40,537.2 | 11,966.1 | 3,645.5 | 39,715.5 | 121,240.6 | 195,924.5 | 31,709.3 | 50,360.9 | 181,694.4 | 180,732.5 | 56,052.0 | 28,215.1 | 1,052,396.9 |
| 1973 | 112,580.8 | 41,591.6 | 12,713.5 | 3,638.8 | 41,433.2 | 123,324.4 | 200,911.5 | 33,940.6 | 51,200.3 | 184,908.8 | 184,858.5 | 59,436.1 | 29,546.4 | 1,080,084.4 |
| 1974 | 114,253.9 | 42,353.8 | 13,287.5 | 3,649.1 | 43,607.4 | 126,265.6 | 207,621.7 | 36,374.3 | 52,012.4 | 188,804.6 | 190,292.9 | 63,585.2 | 31,224.0 | 1,113,332.4 |
| 1975 | 116,659.9 | 43,115.8 | 13,787.7 | 3,645.6 | 45,756.9 | 131,298.0 | 217,027.1 | 38,409.6 | 53,097.2 | 194,787.0 | 196,917.1 | 67,174.7 | 32,764.3 | 1,154,440.9 |
| 1976 | 119,883.1 | 43,980.0 | 14,307.9 | 3,647.4 | 47,337.8 | 137,455.6 | 228,490.8 | 40,090.3 | 54,243.1 | 202,224.8 | 203,619.0 | 70,020.2 | 34,209.0 | 1,199,508.9 |
| 1977 | 123,834.2 | 44,969.8 | 15,002.4 | 3,680.7 | 49,331.7 | 144,008.1 | 240,909.0 | 41,784.1 | 55,341.9 | 209,696.9 | 211,627.7 | 73,124.7 | 35,785.9 | 1,249,097.1 |
| 1978 | 128,298.5 | 46,084.6 | 15,773.7 | 3,751.1 | 51,972.3 | 151,241.1 | 252,204.0 | 43,802.7 | 57,011.0 | 217,669.9 | 222,724.5 | 77,105.6 | 37,402.9 | 1,305,041.8 |
| 1979 | 132,601.8 | 46,987.1 | 16,335.1 | 3,832.3 | 54,685.3 | 159,294.2 | 263,107.7 | 46,139.3 | 59,007.5 | 226,401.6 | 236,490.7 | 82,381.6 | 39,259.5 | 1,366,523.7 |
| 1980 | 136,695.2 | 47,758.4 | 16,600.3 | 3,910.3 | 57,138.1 | 167,825.4 | 274,421.1 | 48,232.3 | 61,167.0 | 234,693.8 | 250,675.7 | 88,932.7 | 41,416.4 | 1,429,466.6 |
| 1981 | 140,605.7 | 48,295.0 | 16,776.1 | 4,004.2 | 58,861.1 | 174,699.5 | 285,519.2 | 49,876.2 | 62,730.8 | 241,773.0 | 264,883.3 | 95,907.0 | 43,524.0 | 1,487,455.0 |
| 1982 | 144,199.3 | 48,190.4 | 16,924.1 | 4,043.3 | 59,507.7 | 179,092.4 | 295,810.5 | 50,869.3 | 62,997.0 | 245,000.7 | 276,139.3 | 102,555.1 | 45,428.8 | 1,530,758.0 |
| 1983 | 147,160.7 | 47,606.2 | 16,982.8 | 4,016.8 | 59,589.3 | 181,911.5 | 303,063.8 | 51,182.1 | 62,420.7 | 243,987.8 | 281,595.7 | 108,623.9 | 47,102.8 | 1,555,244.2 |
| 1984 | 149,859.8 | 47,267.1 | 17,028.1 | 3,985.3 | 60,045.6 | 184,646.1 | 307,740.1 | 51,660.2 | 62,265.1 | 241,882.0 | 286,401.0 | 115,258.7 | 48,716.1 | 1,576,755.3 |
| 1985 | 152,949.2 | 47,209.7 | 17,032.9 | 3,925.1 | 60,788.0 | 189,467.5 | 311,487.3 | 52,841.1 | 62,663.4 | 240,215.5 | 295,063.4 | 123,308.9 | 50,619.3 | 1,607,571.2 |
| 1986 | 155,432.3 | 46,670.0 | 16,920.8 | 3,843.9 | 61,210.3 | 194,474.5 | 313,107.8 | 53,793.7 | 62,478.1 | 237,918.8 | 304,394.1 | 130,495.8 | 52,390.1 | 1,633,130.3 |
| 1987 | 157,762.1 | 46,022.9 | 16,791.6 | 3,790.5 | 61,749.1 | 198,772.3 | 313,563.8 | 54,213.2 | 62,253.4 | 235,705.9 | 312,521.5 | 137,011.9 | 54,017.3 | 1,654,175.5 |
| 1988 | 161,164.4 | 45,713.0 | 16,717.3 | 3,756.7 | 62,560.5 | 205,522.6 | 315,703.4 | 54,774.8 | 62,461.1 | 236,039.7 | 320,838.9 | 145,033.4 | 56,096.8 | 1,686,382.6 |
| 1989 | 165,173.9 | 45,238.4 | 16,498.0 | 3,724.6 | 63,302.4 | 216,821.9 | 320,045.3 | 55,506.6 | 62,714.1 | 238,269.5 | 330,022.8 | 153,799.2 | 58,613.6 | 1,729,730.3 |
| 1990 | 169,578.5 | 44,405.6 | 16,158.2 | 3,688.5 | 64,060.3 | 230,054.8 | 324,290.9 | 55,734.9 | 62,300.4 | 239,841.0 | 338,856.4 | 162,167.0 | 60,953.4 | 1,772,089.8 |
| 1991 | 174,477.1 | 43,314.4 | 15,712.2 | 3,636.8 | 64,010.6 | 239,411.3 | 326,705.1 | 55,367.5 | 60,955.7 | 238,203.7 | 344,623.7 | 169,097.7 | 62,881.8 | 1,798,397.6 |
| 1992 | 179,591.3 | 42,454.2 | 15,276.2 | 3,584.8 | 63,436.1 | 244,898.8 | 327,784.7 | 55,341.6 | 59,669.6 | 234,634.3 | 349,399.8 | 175,227.8 | 64,872.7 | 1,816,171.9 |
| 1993 | 185,245.3 | 42,048.8 | 14,940.3 | 3,542.1 | 64,067.9 | 251,035.7 | 328,990.5 | 55,705.8 | 59,722.7 | 232,186.7 | 358,321.0 | 183,488.0 | 67,058.5 | 1,846,353.4 |
| 1994 | 192,746.0 | 41,686.4 | 14,443.6 | 3,498.0 | 65,481.4 | 260,057.6 | 331,281.3 | 56,544.4 | 60,858.0 | 231,623.8 | 372,736.0 | 193,198.8 | 69,204.1 | 1,893,359.5 |
| 1995 | 202,602.9 | 41,183.0 | 13,859.4 | 3,442.7 | 67,041.3 | 270,777.5 | 335,834.1 | 57,782.5 | 61,997.2 | 232,203.3 | 390,952.3 | 203,573.0 | 71,721.1 | 1,952,970.2 |
| 1996 | 213,821.9 | 40,590.4 | 13,319.1 | 3,388.5 | 69,117.1 | 282,572.4 | 342,613.0 | 59,055.1 | 63,562.0 | 233,026.8 | 412,663.3 | 215,628.1 | 74,767.1 | 2,024,124.8 |
| 1997 | 225,348.4 | 40,048.6 | 12,796.7 | 3,321.9 | 71,618.9 | 294,699.4 | 349,830.5 | 60,750.9 | 66,582.7 | 233,733.5 | 438,337.3 | 229,064.6 | 78,341.0 | 2,104,474.5 |
| 1998 | 225,348.4 | 40,048.6 | 12,796.7 | 3,321.9 | 71,618.9 | 294,699.4 | 349,830.5 | 60,750.9 | 66,582.7 | 233,733.5 | 438,337.3 | 229,064.6 | 78,341.0 | 2,104,474.5 |

*Note:* *See Annex Table V.1 for full branch names.*

*Sources: Timmer, 2000, Annex Table II.21; US Bureau of Labour Statistics, DataBase on Producer Price Indexes, from Internet http://146.142.4.24/cgi-bin/srgate version d.d. July 1999; National Accounts of OECD Countries vol. 2, 1988/1998: Detailed Tables, from http://electrade.gfi.fr/cgi-bin/OECDBookShop.storefront/1969059131/Product/View/302000083E1.*

**Annex Table I.11: Shares of Labour in current manufacturing value added, USA, 1970-98**

| | 1 Food | 2 Tex | 3 Wear | 4 Leat | 5 Wood | 6 Pap | 7 Chem | 8 Rub | 9 Mine | 10 Met | 11 Mach | 12 Elec | 13 Oth | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1970 | 0.58 | 0.81 | 0.81 | 0.81 | 0.77 | 0.77 | 0.66 | 0.66 | 0.77 | 0.82 | 0.78 | 0.78 | 0.77 | 0.78 |
| 1971 | 0.58 | 0.82 | 0.82 | 0.82 | 0.75 | 0.75 | 0.64 | 0.64 | 0.75 | 0.81 | 0.74 | 0.74 | 0.75 | 0.75 |
| 1972 | 0.60 | 0.82 | 0.82 | 0.82 | 0.73 | 0.73 | 0.64 | 0.64 | 0.73 | 0.79 | 0.75 | 0.75 | 0.73 | 0.75 |
| 1973 | 0.62 | 0.83 | 0.83 | 0.83 | 0.73 | 0.73 | 0.62 | 0.62 | 0.73 | 0.79 | 0.78 | 0.78 | 0.73 | 0.76 |
| 1974 | 0.64 | 0.83 | 0.83 | 0.83 | 0.76 | 0.76 | 0.68 | 0.68 | 0.76 | 0.76 | 0.86 | 0.86 | 0.76 | 0.80 |
| 1975 | 0.55 | 0.81 | 0.81 | 0.81 | 0.73 | 0.73 | 0.65 | 0.65 | 0.73 | 0.77 | 0.82 | 0.82 | 0.73 | 0.76 |
| 1976 | 0.60 | 0.81 | 0.81 | 0.81 | 0.72 | 0.72 | 0.63 | 0.63 | 0.72 | 0.78 | 0.79 | 0.79 | 0.72 | 0.76 |
| 1977 | 0.62 | 0.77 | 0.77 | 0.77 | 0.72 | 0.72 | 0.64 | 0.64 | 0.72 | 0.80 | 0.76 | 0.76 | 0.72 | 0.75 |
| 1978 | 0.64 | 0.80 | 0.80 | 0.80 | 0.71 | 0.71 | 0.67 | 0.67 | 0.71 | 0.77 | 0.78 | 0.78 | 0.71 | 0.76 |
| 1979 | 0.65 | 0.82 | 0.82 | 0.82 | 0.72 | 0.72 | 0.69 | 0.69 | 0.72 | 0.77 | 0.82 | 0.82 | 0.72 | 0.79 |
| 1980 | 0.65 | 0.81 | 0.81 | 0.81 | 0.74 | 0.74 | 0.73 | 0.73 | 0.74 | 0.79 | 0.86 | 0.86 | 0.74 | 0.81 |
| 1981 | 0.64 | 0.81 | 0.81 | 0.81 | 0.75 | 0.75 | 0.69 | 0.69 | 0.75 | 0.77 | 0.85 | 0.85 | 0.75 | 0.80 |
| 1982 | 0.63 | 0.80 | 0.80 | 0.80 | 0.76 | 0.76 | 0.68 | 0.68 | 0.76 | 0.86 | 0.86 | 0.86 | 0.76 | 0.81 |
| 1983 | 0.59 | 0.79 | 0.79 | 0.79 | 0.75 | 0.75 | 0.64 | 0.64 | 0.75 | 0.87 | 0.81 | 0.81 | 0.75 | 0.78 |
| 1984 | 0.59 | 0.82 | 0.82 | 0.82 | 0.72 | 0.72 | 0.62 | 0.62 | 0.72 | 0.81 | 0.79 | 0.79 | 0.72 | 0.76 |
| 1985 | 0.60 | 0.81 | 0.81 | 0.81 | 0.72 | 0.72 | 0.63 | 0.63 | 0.72 | 0.81 | 0.83 | 0.83 | 0.72 | 0.77 |
| 1986 | 0.59 | 0.78 | 0.78 | 0.78 | 0.71 | 0.71 | 0.59 | 0.59 | 0.71 | 0.76 | 0.82 | 0.82 | 0.71 | 0.75 |
| 1987 | 0.59 | 0.79 | 0.79 | 0.79 | 0.70 | 0.70 | 0.59 | 0.59 | 0.70 | 0.77 | 0.78 | 0.78 | 0.70 | 0.74 |
| 1988 | 0.59 | 0.80 | 0.80 | 0.80 | 0.70 | 0.70 | 0.52 | 0.52 | 0.70 | 0.75 | 0.79 | 0.79 | 0.70 | 0.72 |
| 1989 | 0.58 | 0.78 | 0.78 | 0.78 | 0.68 | 0.68 | 0.53 | 0.53 | 0.68 | 0.73 | 0.79 | 0.79 | 0.68 | 0.72 |
| 1990 | 0.56 | 0.78 | 0.78 | 0.78 | 0.70 | 0.70 | 0.56 | 0.56 | 0.70 | 0.76 | 0.81 | 0.81 | 0.70 | 0.73 |
| 1991 | 0.56 | 0.78 | 0.78 | 0.78 | 0.70 | 0.70 | 0.56 | 0.56 | 0.70 | 0.76 | 0.81 | 0.81 | 0.70 | 0.73 |
| 1992 | 0.56 | 0.78 | 0.78 | 0.78 | 0.70 | 0.70 | 0.56 | 0.56 | 0.70 | 0.76 | 0.81 | 0.81 | 0.70 | 0.73 |
| 1993 | 0.56 | 0.78 | 0.78 | 0.78 | 0.70 | 0.70 | 0.56 | 0.56 | 0.70 | 0.76 | 0.81 | 0.81 | 0.70 | 0.73 |
| 1994 | 0.57 | 0.79 | 0.76 | 0.77 | 0.68 | 0.70 | 0.53 | 0.55 | 0.65 | 0.72 | 0.78 | 0.73 | 0.74 | 0.71 |
| 1995 | 0.53 | 0.79 | 0.78 | 0.69 | 0.66 | 0.68 | 0.51 | 0.55 | 0.63 | 0.69 | 0.77 | 0.73 | 0.75 | 0.69 |
| 1996 | 0.55 | 0.77 | 0.76 | 0.82 | 0.69 | 0.68 | 0.50 | 0.53 | 0.64 | 0.68 | 0.75 | 0.73 | 0.71 | 0.68 |
| 1997 | 0.57 | 0.78 | 0.79 | 0.75 | 0.69 | 0.71 | 0.51 | 0.53 | 0.58 | 0.68 | 0.75 | 0.72 | 0.72 | 0.69 |
| 1998 | 0.58 | 0.78 | 0.79 | 0.76 | 0.69 | 0.71 | 0.55 | 0.53 | 0.55 | 0.67 | 0.76 | 0.77 | 0.71 | 0.70 |

*Note:* *See Annex Table V.1 for full branch names.*

*Sources:*

*Timmer, 2000, Annex Table II.25. National Accounts of OECD Countries vol. 2, 1988/1998: Detailed Tables, from [http://electrade.gfi.fr/cgi-bin/OECDBookShop.storefront/1969059131/Product/View/302000083E1](http://electrade.gfi.fr/cgi-bin/OECDBookShop.storefront/1969059131/Product/View/302000083E1). US National Accounts database file, 1987-98.*

## Annex II: Benchmark Tables

### Annex Table II.1: Number of UVRs, Coverage Rates and Reliability

| | Number of UVRs | Coverage USA | Coverage Zambia | Reliability UVR at US Quantity Weights | Reliability UVR at Zambian Quantity Weights |
|---|---|---|---|---|---|
| 1 **Food Manufacturing** | **28** | **35** | **61** | **0.12** | **0.07** |
| *Meat Products* | 6 | 49 | 87 | 0.32 | 0.29 |
| *Dairy Products* | 4 | 47 | 20 | 0.16 | 0.03 |
| *Preserved fruits and vegetables and fish* | 5 | 17 | 82 | 0.38 | 0.26 |
| *Fats and Oils* | 3 | 37 | 31 | 0.14 | 0.07 |
| *Grain Mill Products* | 4 | 52 | 71 | 0.12 | 0.08 |
| *Bakery Products* | 3 | 40 | 59 | 0.23 | 0.20 |
| *Sugar* | 1 | 69 | 95 | 0.00 | 0.00 |
| *Confectionary and food n.e.c.* | 2 | 12 | 69 | 0.02 | 0.01 |
| 2 **Beverages (208)** | **2** | **40** | **52** | **0.00** | **0.00** |
| *Malt and Malt beverages* | 1 | 83 | 95 | 0.00 | 0.00 |
| *Soft Drinks* | 1 | 30 | 54 | 0.00 | 0.00 |
| 3 **Tobacco Products** | **2** | **90** | **15** | **0.02** | **0.02** |
| *Tobacco Stemming and redrying* | 2 | 81 | 28 | 0.03 | 0.02 |
| 4 **Textile Mill Products** | **10** | **14** | **41** | **0.09** | **0.22** |
| *Textile Mill Products* | 10 | 27 | 47 | 0.08 | 0.21 |
| 5 **Wearing Apparel** | **7** | **27** | **48** | **0.21** | **0.69** |
| *Wearing Apparel* | 7 | 36 | 56 | 0.20 | 0.63 |
| 6 **Leather Products and Footwear** | **1** | **38** | **46** | **0.00** | **0.00** |
| *Leather footwear* | 1 | 91 | 90 | 0.00 | 0.00 |
| 7 **Wood Products, Furniture & Fixtures** | **5** | **16** | **19** | **0.12** | **0.97** |
| *Wood Products and Furniture* | 5 | 33 | 30 | 0.10 | 0.90 |
| 8 **Paper Products, Printing & Publishing** | **8** | **10** | **22** | **0.17** | **0.56** |
| *Paper, printing and publishing* | 8 | 23 | 23 | 0.16 | 0.56 |
| 9 **Chemicals, incl. petrol. refining** | **11** | **4** | **19** | **1.28** | **0.36** |
| *Industrial inorganic chemicals* | 4 | 4 | 34 | 0.47 | 2.45 |
| *Agricultural Fertilizers* | 2 | 30 | 24 | 0.04 | 0.12 |
| *Paints* | 2 | 67 | 87 | 0.06 | 0.00 |
| *Soaps* | 3 | 25 | 35 | 0.12 | 0.51 |
| 10 **Non-metallic Mineral Products** | **3** | **7** | **40** | **0.11** | **0.01** |
| *Cement and bricks* | 3 | 63 | 80 | 0.07 | 0.01 |
| 11 **Metallic Mineral Products** | **8** | **8** | **19** | **0.33** | **0.99** |
| *Metallic Mineral Products* | 8 | 19 | 31 | 0.31 | 0.91 |
| 12 **Machinery & Transport Equipment** | **6** | **14** | **17** | **0.01** | **0.17** |
| *Motor Vehicles* | 6 | 40 | 75 | 0.01 | 0.09 |
| 13 Rubber and Plastic Products | | | | | |
| 14 Electrical Machinery & Equipment | | | | | |
| 15 Other Manufacturing Industries | | | | | |
| Total manufacturing | 91 | 15.5 | 42.4 | 0.16 | 0.15 |

*Note: Coverage refers to matched output as percentage of total gross value of output. The measure for reliability is calculated as the variation of unit value ratios/divided by the uvr for a sample industry or branch. The 90 percent confidence interval for sample industry or branch uvrs equals the uvr plus or minus a percentage equal to two times the reliability measure.*

**Annex Table III.1: Comparative Labour Productivity by Branch of Manufacturing, Zambia/USA, 1964-98 (%)**
**(Establishments with 10 or more persons engaged)**

| | 1 Food | 2 Tex | 3 Wear | 4 Leat | 5 Wood | 6 Pap | 7 Chem | 8 Rub | 9 Mine | 10 Met | 11 Mach | 12 Elec | 13 Oth | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1964 | 10.3 | 10.2 | 12.9 | 6.4 | 9.1 | 5.5 | 5.7 | 8.9 | 8.7 | 9.1 | 3.0 | 11.4 | 13.0 | 9.6 |
| 1965 | 7.9 | 8.5 | 11.2 | 3.0 | 7.2 | 5.1 | 3.6 | 10.3 | 10.6 | 8.9 | 7.4 | 14.1 | 11.8 | 8.7 |
| 1966 | 9.2 | 6.7 | 9.9 | 4.9 | 10.1 | 5.2 | 3.2 | 6.5 | 8.6 | 9.2 | 5.7 | 16.5 | 8.5 | 8.6 |
| 1967 | 10.0 | 9.6 | 15.0 | 5.3 | 10.5 | 7.5 | 5.2 | 9.4 | 9.9 | 10.7 | 8.9 | 13.6 | 9.5 | 10.3 |
| 1968 | 7.7 | 11.3 | 12.9 | 4.0 | 12.5 | 11.0 | 6.0 | 14.8 | 12.2 | 16.5 | 8.6 | 16.0 | 6.5 | 11.4 |
| 1969 | 7.5 | 15.0 | 18.4 | 2.5 | 10.7 | 5.2 | 5.7 | 26.9 | 12.4 | 14.6 | 12.1 | 31.4 | 9.7 | 10.8 |
| 1970 | 7.9 | 8.7 | 21.7 | 2.2 | 9.7 | 7.1 | 3.5 | 21.0 | 12.8 | 14.4 | 12.9 | 25.9 | 9.3 | 10.5 |
| 1971 | 8.3 | 9.9 | 20.1 | 2.2 | 9.3 | 6.9 | 3.6 | 26.4 | 12.8 | 12.7 | 9.8 | 27.8 | 9.2 | 10.4 |
| 1972 | 8.6 | 11.3 | 20.8 | 3.6 | 7.7 | 8.6 | 5.4 | 22.9 | 15.2 | 10.9 | 11.5 | 32.9 | 7.6 | 11.3 |
| 1973 | 6.4 | 15.2 | 16.1 | 3.6 | 9.9 | 7.2 | 5.2 | 22.7 | 12.6 | 10.3 | 11.5 | 27.2 | 9.3 | 10.2 |
| 1974 | 5.8 | 15.1 | 16.4 | 3.9 | 11.4 | 7.2 | 4.9 | 18.1 | 15.1 | 10.1 | 12.4 | 36.1 | 9.5 | 10.1 |
| 1975 | 4.5 | 12.6 | 12.2 | 3.1 | 8.6 | 5.7 | 5.4 | 16.1 | 14.3 | 8.5 | 15.4 | 20.5 | 8.1 | 8.7 |
| 1976 | 6.7 | 20.1 | 17.1 | 3.6 | 10.6 | 5.7 | 6.7 | 21.5 | 8.2 | 4.9 | 16.1 | 29.7 | 9.5 | 9.7 |
| 1977 | 6.6 | 17.4 | 16.3 | 3.3 | 12.5 | 5.6 | 6.0 | 16.2 | 7.3 | 5.4 | 12.1 | 23.0 | 8.4 | 9.2 |
| 1978 | 6.2 | 18.8 | 16.3 | 3.9 | 12.1 | 6.4 | 6.0 | 15.5 | 9.8 | 6.2 | 11.5 | 22.1 | 8.8 | 9.8 |
| 1979 | 6.3 | 24.1 | 16.5 | 4.5 | 14.7 | 5.5 | 6.4 | 17.9 | 9.0 | 6.7 | 9.9 | 13.3 | 7.5 | 9.9 |
| 1980 | 3.8 | 21.1 | 15.0 | 3.4 | 11.6 | 4.3 | 5.0 | 12.9 | 12.3 | 5.9 | 10.4 | 13.2 | 13.2 | 7.8 |
| 1981 | 6.6 | 21.6 | 8.5 | 3.6 | 10.5 | 3.3 | 3.7 | 9.8 | 13.6 | 8.4 | 11.2 | 13.9 | 11.8 | 8.7 |
| 1982 | 6.7 | 22.2 | 8.7 | 2.9 | 8.8 | 2.7 | 2.6 | 7.3 | 13.0 | 11.6 | 12.4 | 15.6 | 11.0 | 8.5 |
| 1983 | 6.8 | 15.8 | 6.7 | 3.6 | 8.5 | 2.2 | 2.1 | 7.2 | 13.9 | 8.2 | 10.6 | 15.6 | 9.4 | 7.6 |
| 1984 | 7.1 | 14.9 | 6.6 | 2.0 | 7.4 | 2.1 | 0.8 | 5.2 | 6.1 | 12.1 | 7.8 | 15.9 | 13.4 | 6.6 |
| 1985 | 4.3 | 11.1 | 5.3 | 2.1 | 6.7 | 2.0 | 1.2 | 7.9 | 9.9 | 10.7 | 8.0 | 15.5 | 7.2 | 5.7 |
| 1986 | 4.3 | 8.6 | 4.6 | 1.8 | 6.3 | 2.5 | 1.1 | 8.0 | 7.4 | 12.2 | 7.7 | 19.7 | 6.8 | 5.5 |
| 1987 | 4.9 | 9.1 | 5.0 | 1.6 | 5.1 | 3.8 | 1.0 | 7.2 | 1.5 | 8.4 | 9.8 | 21.4 | 6.5 | 5.0 |
| 1988 | 5.3 | 9.4 | 5.3 | 1.5 | 4.9 | 4.0 | 1.0 | 6.6 | 4.7 | 8.2 | 8.5 | 18.5 | 5.9 | 5.2 |
| 1989 | 6.4 | 9.9 | 6.7 | 1.7 | 5.5 | 4.2 | 1.3 | 8.8 | 6.4 | 5.3 | 7.7 | 14.9 | 5.7 | 5.5 |
| 1990 | 6.6 | 12.7 | 9.0 | 2.1 | 4.9 | 4.1 | 1.8 | 11.0 | 6.8 | 5.9 | 4.5 | 11.8 | 4.3 | 5.9 |

**Annex Table III.1 (continued)**

| | 1 Food | 2 Tex | 3 Wear | 4 Leat | 5 Wood | 6 Pap | 7 Chem | 8 Rub | 9 Mine | 10 Met | 11 Mach | 12 Elec | 13 Oth | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1991 | 8.2 | 7.6 | 5.6 | 2.4 | 5.7 | 3.8 | 1.7 | 5.2 | 3.1 | 7.7 | 4.4 | 10.6 | 4.8 | 5.8 |
| 1992 | 7.5 | 9.3 | 7.7 | 2.3 | 5.8 | 4.1 | 0.5 | 1.4 | 2.3 | 9.6 | 5.3 | 12.4 | 4.5 | 5.3 |
| 1993 | 4.3 | 6.2 | 5.2 | 2.3 | 5.5 | 1.8 | 1.9 | 5.4 | 1.4 | 4.1 | 3.1 | 6.4 | 2.5 | 3.7 |
| 1994 | 3.5 | 5.0 | 4.4 | 2.0 | 6.0 | 0.9 | 1.3 | 4.0 | 0.9 | 6.8 | 2.7 | 4.7 | 3.4 | 3.3 |
| 1995 | 4.2 | 5.5 | 5.4 | 1.9 | 6.1 | 0.7 | 0.4 | 1.2 | 0.8 | 4.0 | 1.1 | 1.0 | 1.7 | 2.6 |
| 1996 | 6.0 | 7.3 | 7.1 | 2.3 | 6.5 | 0.8 | 0.6 | 1.8 | 1.0 | 3.8 | 1.0 | 0.8 | 1.9 | 3.0 |
| 1997 | 6.7 | 9.2 | 7.3 | 2.0 | 6.7 | 1.1 | 0.5 | 1.6 | 0.6 | 4.7 | 0.9 | 0.7 | 1.8 | 3.2 |
| 1998 | 7.8 | 10.0 | 9.4 | 2.1 | 7.0 | 1.2 | 0.4 | 1.6 | 0.8 | 5.1 | 0.8 | 0.6 | 2.3 | 3.2 |

*Note:* *See Annex Table V.1 for full branch names.*

*Sources:*

*Extrapolation of 1990 benchmark from Table 5.5 with national time series from Annex Tables I.1, I.2, I.8, and I.9.*

**Annex Table III.2: Comparative Capital Intensity by Branch of Manufacturing, 1970-98 (%) (Establishments with 10 or more persons engaged)**

| | 1 Food | 2 Tex | 3 Wear | 4 Leat | 5 Wood | 6 Pap | 7 Chem | 8 Rub | 9 Mine | 10 Met | 11 Mach | 12 Elec | 13 Oth | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1970 | 18.0 | 53.4 | 31.1 | 53.6 | 15.8 | 17.0 | 34.4 | 50.6 | 24.3 | 15.4 | 48.7 | 66.2 | 83.2 | 28.5 |
| 1971 | 18.8 | 44.4 | 30.4 | 47.3 | 16.0 | 16.4 | 29.1 | 45.1 | 22.0 | 15.6 | 42.4 | 37.3 | 61.8 | 25.6 |
| 1972 | 21.3 | 39.6 | 30.1 | 58.0 | 15.0 | 17.5 | 34.0 | 43.9 | 33.3 | 15.8 | 38.6 | 38.7 | 74.4 | 28.6 |
| 1973 | 19.8 | 36.2 | 27.2 | 52.7 | 19.4 | 15.0 | 27.5 | 44.7 | 65.2 | 17.2 | 37.9 | 35.5 | 48.4 | 30.8 |
| 1974 | 20.5 | 35.3 | 26.3 | 81.6 | 19.3 | 14.4 | 22.5 | 34.7 | 60.6 | 15.6 | 30.8 | 29.3 | 35.0 | 28.1 |
| 1975 | 21.2 | 31.5 | 25.8 | 61.0 | 16.0 | 11.8 | 23.5 | 34.3 | 54.1 | 12.5 | 27.6 | 22.6 | 29.9 | 25.5 |
| 1976 | 29.9 | 45.5 | 41.9 | 86.8 | 24.2 | 15.1 | 33.1 | 47.2 | 63.4 | 17.8 | 35.3 | 26.8 | 36.4 | 35.5 |
| 1977 | 28.2 | 40.0 | 42.5 | 77.7 | 23.7 | 13.8 | 30.6 | 46.0 | 52.6 | 17.6 | 32.4 | 22.1 | 32.0 | 33.5 |
| 1978 | 26.9 | 35.2 | 44.7 | 72.5 | 23.2 | 13.0 | 28.3 | 44.4 | 45.2 | 18.1 | 30.7 | 18.7 | 27.4 | 32.4 |
| 1979 | 23.7 | 37.9 | 40.5 | 66.2 | 27.1 | 13.8 | 31.0 | 44.5 | 38.0 | 18.9 | 27.8 | 11.2 | 21.4 | 30.9 |
| 1980 | 13.8 | 25.2 | 31.6 | 39.5 | 14.9 | 11.8 | 22.9 | 31.7 | 28.2 | 12.4 | 23.2 | 9.3 | 42.6 | 20.7 |
| 1981 | 15.0 | 21.4 | 28.8 | 32.0 | 11.5 | 12.9 | 23.2 | 37.3 | 28.4 | 11.7 | 20.7 | 10.0 | 32.6 | 20.2 |
| 1982 | 13.7 | 18.2 | 26.3 | 24.5 | 10.8 | 11.8 | 20.3 | 36.1 | 25.0 | 10.0 | 17.2 | 10.1 | 22.2 | 17.7 |
| 1983 | 11.9 | 15.4 | 23.8 | 17.7 | 12.4 | 10.3 | 16.8 | 37.3 | 26.3 | 9.1 | 14.7 | 10.2 | 14.2 | 15.8 |
| 1984 | 10.3 | 13.1 | 22.6 | 13.8 | 12.4 | 10.5 | 14.4 | 38.8 | 30.1 | 9.0 | 13.8 | 11.0 | 15.5 | 14.9 |
| 1985 | 5.5 | 8.7 | 17.5 | 9.5 | 9.1 | 7.5 | 9.1 | 26.7 | 23.8 | 6.7 | 9.9 | 7.3 | 4.8 | 9.8 |
| 1986 | 5.0 | 7.6 | 17.6 | 8.0 | 8.5 | 7.3 | 8.4 | 25.3 | 24.5 | 6.6 | 8.8 | 6.6 | 3.3 | 9.0 |
| 1987 | 4.5 | 6.9 | 18.0 | 7.3 | 8.0 | 7.1 | 8.1 | 24.4 | 25.0 | 6.6 | 8.1 | 6.0 | 2.5 | 8.5 |
| 1988 | 4.1 | 6.3 | 18.7 | 6.7 | 7.7 | 7.3 | 8.3 | 23.9 | 27.3 | 7.0 | 7.8 | 5.7 | 2.0 | 8.4 |
| 1989 | 3.8 | 5.7 | 19.3 | 6.1 | 7.1 | 6.8 | 8.0 | 23.3 | 27.8 | 7.0 | 7.3 | 5.3 | 1.6 | 8.0 |
| 1990 | 3.8 | 5.6 | 20.1 | 5.1 | 6.9 | 6.9 | 8.4 | 24.0 | 30.5 | 7.1 | 7.1 | 5.3 | 1.4 | 8.0 |
| 1991 | 3.5 | 5.2 | 20.5 | 4.1 | 5.8 | 6.3 | 8.0 | 21.6 | 27.6 | 6.7 | 6.4 | 4.2 | 1.2 | 7.4 |
| 1992 | 3.1 | 5.0 | 21.4 | 3.5 | 5.4 | 5.9 | 7.5 | 20.5 | 26.2 | 6.5 | 5.8 | 3.5 | 1.0 | 6.9 |
| 1993 | 3.2 | 5.5 | 23.7 | 3.2 | 5.7 | 6.1 | 7.5 | 22.5 | 27.7 | 7.0 | 5.7 | 3.4 | 0.9 | 7.2 |
| 1994 | 3.3 | 6.0 | 28.9 | 3.0 | 5.9 | 6.5 | 7.8 | 24.7 | 29.9 | 8.1 | 5.9 | 3.3 | 0.9 | 7.8 |
| 1995 | 3.0 | 5.5 | 31.9 | 2.4 | 5.6 | 6.2 | 7.6 | 24.1 | 30.3 | 8.3 | 5.4 | 1.8 | 0.8 | 7.4 |
| 1996 | 3.2 | 5.8 | 38.6 | 2.2 | 5.8 | 6.6 | 8.1 | 26.3 | 34.3 | 9.5 | 5.6 | 1.9 | 0.8 | 8.1 |
| 1997 | 3.0 | 5.8 | 42.7 | 1.5 | 5.5 | 6.4 | 7.7 | 26.1 | 33.1 | 9.6 | 5.2 | 1.8 | 0.7 | 7.9 |
| 1998 | 3.1 | 5.7 | 48.4 | 1.3 | 5.5 | 6.7 | 7.8 | 27.1 | 34.0 | 9.9 | 5.5 | 1.8 | 0.6 | 8.3 |

*Note:* *See Annex Table V.1 for full branch names.*
*Sources:*
*Extrapolation of 1990 benchmark from Table 5.6 with national time series from Annex Tables I.2, I.5, I.9, and I.10.*

**Annex Table III.3: Comparative Total Factor Productivity by Branch of Manufacturing, Zambia/USA, 1970-98 (%)**
**(Establishments with 10 or more persons engaged)**

| | 1 Food | 2 Tex | 3 Wear | 4 Leat | 5 Wood | 6 Pap | 7 Chem | 8 Rub | 9 Mine | 10 Met | 11 Mach | 12 Elec | 13 Oth | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1970 | 19.5 | 11.0 | 34.0 | 2.9 | 22.9 | 15.1 | 5.8 | 29.5 | 22.8 | 29.0 | 17.2 | 30.4 | 10.0 | 17.2 |
| 1971 | 20.5 | 13.3 | 30.7 | 3.0 | 23.8 | 15.3 | 6.6 | 40.1 | 23.9 | 25.4 | 13.9 | 41.9 | 11.2 | 18.3 |
| 1972 | 20.4 | 15.7 | 32.4 | 4.5 | 19.0 | 19.2 | 9.2 | 35.1 | 25.0 | 21.0 | 17.2 | 49.8 | 8.5 | 19.6 |
| 1973 | 15.0 | 22.0 | 26.2 | 4.6 | 21.2 | 17.2 | 10.2 | 35.2 | 14.6 | 19.7 | 16.9 | 42.7 | 13.2 | 16.8 |
| 1974 | 12.9 | 22.0 | 27.4 | 4.2 | 22.7 | 17.3 | 10.2 | 30.7 | 18.6 | 21.1 | 19.7 | 59.4 | 14.7 | 16.9 |
| 1975 | 10.2 | 19.2 | 20.6 | 3.7 | 18.7 | 14.7 | 11.5 | 27.9 | 18.6 | 17.1 | 26.7 | 35.7 | 13.7 | 15.2 |
| 1976 | 12.7 | 27.0 | 24.2 | 3.8 | 22.0 | 12.9 | 11.4 | 31.6 | 10.0 | 9.2 | 23.8 | 48.1 | 15.0 | 15.0 |
| 1977 | 12.8 | 26.5 | 24.2 | 3.7 | 23.8 | 13.5 | 11.1 | 23.2 | 9.7 | 10.9 | 19.3 | 42.4 | 14.2 | 14.9 |
| 1978 | 11.9 | 29.6 | 23.0 | 4.4 | 24.9 | 16.3 | 10.4 | 22.3 | 13.9 | 12.3 | 18.6 | 42.8 | 15.6 | 16.3 |
| 1979 | 13.0 | 35.4 | 23.8 | 5.4 | 29.3 | 13.6 | 10.5 | 26.9 | 13.7 | 12.8 | 15.9 | 30.3 | 14.4 | 16.7 |
| 1980 | 10.6 | 40.1 | 23.6 | 5.2 | 29.0 | 10.5 | 10.0 | 21.9 | 20.9 | 13.9 | 17.5 | 31.0 | 19.0 | 15.2 |
| 1981 | 18.3 | 41.1 | 14.0 | 5.9 | 30.7 | 8.3 | 8.2 | 16.6 | 24.0 | 19.4 | 19.4 | 35.6 | 19.0 | 17.4 |
| 1982 | 18.4 | 51.1 | 15.8 | 5.2 | 25.8 | 6.7 | 5.6 | 12.5 | 24.3 | 26.9 | 23.1 | 37.9 | 20.1 | 18.1 |
| 1983 | 20.7 | 36.8 | 12.6 | 7.3 | 21.7 | 6.1 | 5.0 | 11.8 | 24.9 | 20.8 | 23.1 | 40.7 | 22.4 | 17.3 |
| 1984 | 25.2 | 35.8 | 12.5 | 5.2 | 20.4 | 5.8 | 1.9 | 8.4 | 10.2 | 29.5 | 17.1 | 36.2 | 31.2 | 15.8 |
| 1985 | 19.7 | 26.5 | 10.7 | 6.3 | 23.0 | 6.9 | 3.9 | 15.4 | 18.1 | 27.6 | 18.2 | 38.4 | 28.7 | 15.2 |
| 1986 | 21.4 | 25.0 | 9.6 | 5.5 | 23.6 | 9.1 | 3.7 | 17.0 | 13.7 | 35.9 | 18.8 | 54.7 | 34.0 | 15.9 |
| 1987 | 28.2 | 26.4 | 9.7 | 4.7 | 19.9 | 13.3 | 3.8 | 15.4 | 2.8 | 26.0 | 27.4 | 70.4 | 37.5 | 14.9 |
| 1988 | 29.6 | 26.8 | 11.0 | 4.6 | 19.3 | 14.0 | 4.3 | 15.6 | 8.6 | 24.9 | 23.3 | 60.0 | 39.9 | 15.9 |
| 1989 | 34.2 | 30.2 | 14.2 | 5.5 | 23.3 | 15.6 | 5.7 | 20.2 | 11.4 | 15.9 | 23.2 | 51.2 | 38.4 | 16.3 |
| 1990 | 39.9 | 40.1 | 17.8 | 8.3 | 20.3 | 15.3 | 6.4 | 25.3 | 11.8 | 17.2 | 12.3 | 30.1 | 29.8 | 16.7 |
| 1991 | 46.9 | 31.4 | 10.7 | 10.9 | 26.3 | 14.0 | 6.7 | 12.1 | 6.1 | 24.1 | 16.2 | 52.9 | 36.1 | 17.0 |
| 1992 | 46.8 | 33.6 | 14.6 | 10.6 | 27.0 | 14.7 | 2.3 | 3.2 | 4.3 | 28.1 | 15.1 | 52.4 | 35.3 | 15.6 |
| 1993 | 28.4 | 19.8 | 10.1 | 10.0 | 24.4 | 6.7 | 7.9 | 12.1 | 2.6 | 12.3 | 9.3 | 25.9 | 21.5 | 12.0 |
| 1994 | 20.7 | 13.5 | 7.9 | 8.7 | 24.7 | 3.5 | 6.0 | 8.3 | 1.3 | 17.3 | 6.7 | 20.7 | 33.6 | 9.8 |
| 1995 | 28.0 | 19.0 | 8.7 | 12.1 | 26.5 | 2.7 | 2.0 | 2.7 | 1.5 | 11.6 | 3.4 | 6.4 | 11.4 | 8.0 |
| 1996 | 38.6 | 26.6 | 11.1 | 11.5 | 25.1 | 2.7 | 2.6 | 4.1 | 1.7 | 11.3 | 3.6 | 5.1 | 15.1 | 9.9 |
| 1997 | 43.1 | 26.1 | 10.6 | 13.8 | 26.3 | 3.7 | 2.6 | 3.7 | 1.1 | 12.9 | 3.3 | 3.2 | 15.6 | 9.9 |
| 1998 | 47.2 | 27.5 | 12.6 | 19.6 | 27.9 | 4.2 | 1.6 | 3.4 | 1.3 | 13.4 | 2.8 | 2.6 | 19.1 | 9.2 |

*Note:* *See Annex Table V.1 for full branch names.*

*Sources:*

*Extrapolation of 1990 benchmark from Table 5.6 with national time series from Annex Tables III.1 and III.2 and weights from Annex Tables I.6 and I.11.*

# Annex IV: Matching Tables

## Annex Table IV.1: Zambian Product Listings

| Industry ISIC code | Industry name | No. of Establ. | Product | Unit | Product Quantities | Product Values (ZK'000) | Unit Values (Zambian) (Kwacha) |
|---|---|---|---|---|---|---|---|
| 3111 | Slaughtering, preparing & preserving meat | 2 | canned meat | can 250g | 2105535 | 26477 | 12.57 |
| | | | dressed chicken | '000 kg | 634 | 87396 | 137.90 |
| | | | table-eggs | # '000 | 422 | 1196 | 2.83 |
| | | 3 | beef | kilograms | 4003814 | 275,607 | 68.84 |
| | | 3 | pork | kilograms | 891657 | 28,155 | 31.58 |
| | | 2 | sausages | kilograms | 1858461 | 64,024 | 34.45 |
| | | | ribs | kilograms | 6954 | 97 | 13.94 |
| 3112 | Manufacture of dairy products | | biscuits | kilograms | 23377 | 1,517 | 64.89 |
| | | 4 | fresh milk | litres | 5038810 | 89,568 | 17.78 |
| | | | softmix | litres | 7170 | 217 | 30.26 |
| | | 2 | ice cream | litres | 36984 | 2,075 | 56.11 |
| | | 3 | butter | kilograms | 4900.69 | 1,116 | 227.72 |
| | | 2 | r/milk(sour milk) | litres | 691929 | 294 | 0.42 |
| | | | cheese | kilograms | 1299.58 | 331 | 254.70 |
| 3113 | Canning & preserving of fruits & vegetables | | canned pineapple | cases | 4272 | 3,130 | 732.68 |
| | | | pineapple | litres | 3150 | 116 | 36.83 |
| | | | sauce | box/25 | 5,643.2 | 3,071 | 544.19 |
| | | | chutney | box/40 | 1,365.6 | 864 | 632.69 |
| | | | marmalade | box/40 | 2,647.2 | 1,241 | 468.80 |
| | | | jam | kilograms | 27,092.7 | 1,320 | 48.72 |
| | | | juices | litres | 4,353.2 | 239 | 54.90 |
| 3114 | Canning, preserving & processing of fish, crustacean & similar foods | | kapenta | tons | 218.4 | 8,731 | 39977.11 |
| | | 2 | fish | tons | 329.8 | 21,171 | 64200.54 |
| 3115 | Manufacture of vegetable & animal oils & fats | 3 | cooking oils | tons | 15257.667 | 600,121 | 39332.42 |
| | | | soaps | tons | 12823.76 | 364,549 | 28427.62 |
| | | | seedcakes | tons | 7919.888 | 105,743 | 13351.58 |
| | | | fats | tons | 774.39207 | 102,062 | 131795.75 |
| | | | NCDs | tons | 7199.392 | 209,285 | 29069.82 |
| 3116 | Grain mill products | 9 | breakfast meal | tons | 135918.04 | 775264.0 | 5703.91 |
| | | 14 | roller meal | tons | 119812.98 | 508682.0 | 4245.63 |
| | | 3 | maize bran | tons | 32386.483 | 28691.6 | 885.91 |
| | | 7 | stockfeed | tons | 33394.81 | 196522.0 | 5884.81 |
| | | 2 | flour | tons | 4188.76 | 60414.0 | 14422.88 |
| | | | meal samp | tons | 1242.9167 | 4551.0 | 3661.55 |
| | | | maize/M | tons | 1593.55 | 1166.0 | 731.70 |
| | | | rice | kilograms | 75883 | 1530.0 | 20.16 |
| | | | salt | kilograms | 8530 | 2041.4 | 239.32 |
| 3117 | Manufacture of bakery products | 9 | bread | no. of loaves | 2383837 | 160,295 | 67.24 |
| | | 9 | buns | units | 104474326 | 151,537 | 1.45 |
| | | | cake | units | 180.00 | 404 | 2244.44 |
| | | | ring doughnut | units | 12492.00 | 54 | 4.32 |
| | | | cream doughnut | units | 9304 | 86 | 9.24 |
| | | | k/sisters | units | 11286.00 | 52 | 4.61 |
| | | 2 | corn | units | 169861.00 | 3,000 | 17.66 |
| | | 3 | biscuits | cartons | 396332.00 | 103,336 | 260.73 |
| | | | popcorns | cartons | 25716.00 | 1,853 | 72.06 |
| | | | scones | units | 47500.00 | 12 | 0.25 |
| | | 2 | confectionery | units | 349864.00 | 13,572 | 38.79 |
| 3118 | Sugar factories & refineries | 2 | sugar | tons | 80493.024 | 1792795 | 22272.68 |
| 3119 | Manufacture of cocoa, chocolate & sugar confectionery | | hardboiled sweets | kilograms | 19350 | 1,495 | 77.26 |
| | | | fruitdrop | kilograms | 2798.4 | 317 | 113.28 |
| | | | bubble gums | cartons | 6739 | 11,037 | 1637.78 |

**Annex Table IV.1 (continued)**

| Industry ISIC code | Industry name | No. of Establ. | Product | Unit | Product Quantities | Product Values (ZK'000) | Unit Values (Zambian) (Kwacha) |
|---|---|---|---|---|---|---|---|
| 3121 | Manufacture of food products not elsewhere classified | | frozen cans | kilograms | 960774 | 125,209 | 130.32 |
| | | | dry goods | kilograms | 859305 | 171,703 | 199.82 |
| | | | godials | kilograms | 465671 | 23,174 | 49.76 |
| | | | confectionery | cases | 31343 | 38,940 | 1242.38 |
| | | | vinegar | cases | 13277 | 3,605 | 271.52 |
| | | | extrudes | cases | 20202 | 27,037 | 1338.33 |
| | | | peanuts | cases | 5200 | 5,715 | 1099.04 |
| | | | cln/beans | kilograms | 586367 | 45114 | 76.94 |
| | | | b/beans | can 250g | 161330 | 4,125 | 25.57 |
| | | | roast/groundnuts | kilograms | 19826 | 2,657 | 134.02 |
| | | 2 | tea | kilograms | 49943 | 9,639 | 193.00 |
| 3131 | Distilling, rectifying & blending spirits | | spirits | cases | 130391 | 303,015 | 2323.90 |
| 3133 | Malt liqueurs & malt | | beer | hectolitres | 667,016 | 1,143,414 | 1714.22 |
| | | | opaque beer-chibuku | hectolitres | 204,441 | 43,976 | 215.10 |
| 3134 | Soft drinks & carbonated waters industries | | tarino soft drink | dozens | 2799808.8 | 187,761 | 67.06 |
| | | | crushjuice-750mls | dozens | 87404 | 23,668 | 270.79 |
| | | | crush juice-2.5l | dozens | 87776 | 16,143 | 183.91 |
| | | | soft drink | cases | 1334560.8 | 236,989 | 177.58 |
| | | | orange crush | 000litres | 529 | 14,932 | 28226.84 |
| | | | strawberry juice | 000litres | 274 | 7,001 | 25.55 |
| | | | cream soda | 000litres | 65.6 | 2,459 | 37.48 |
| 3140 | Tobacco manufactures | | cigarettes | #'000 | 384118 | 579,186 | 1.51 |
| | | | tobacco | kilograms | 122315 | 11,187 | 91.46 |
| | | | virginia | tons | 5114 | 388 | 75.87 |
| | | | burley | tons | 3812 | 272 | 71.23 |
| 3211 | Spinning, weaving & finishing textiles | | plain dyed cloth | 000metres | 2,890 | 205,676 | 71.16 |
| | | | printed cloth | 000metres | 2,890 | 270,045 | 93.45 |
| | | | loamstate cloth | 000metres | 3,114 | 103,340 | 33.18 |
| | | | lint | tons | 7,416 | 463,572 | 62509.71 |
| | | 2 | knitted fabrics | 000metres | 235 | 22,168 | 94.17 |
| | | | fabrics | 000metres | 1,252 | 80,441 | 64.25 |
| | | | yarn | kilograms | 2,783,157 | 447,257 | 160.70 |
| | | | offcuts | kilograms | 23,374 | 3,909 | 167.24 |
| | | | textile | 000metres | 512 | 86,906 | 169.74 |
| | | | acrylic yarn | kilograms | 151,696 | 65,427 | 431.30 |
| | | | sewing threads | tons | 45 | 20,887 | 466227.68 |
| | | | wastes | tons | 182 | 495 | 2725.77 |
| 3212 | Manufacture of made-up textile goods except wearing apparel | 2 | tarpaulin | numbers | 8291 | 93,174 | 11237.97 |
| | | | vent ducting | numbers | 4255 | 5,317 | 1249.59 |
| | | | travelling bag | numbers | 35228 | 7,590 | 215.45 |
| | | 2 | blankets | each | 877,984 | 303,340 | 345.50 |
| | | | tents | numbers | 65 | 2,391 | 36784.62 |
| | | | poly propylene bags | numbers | 24448940 | 363,806 | 14.88 |
| | | | PE bags | numbers | 1283930 | 8,218 | 6.40 |
| | | | jute/kenaf products | tons | 10 | 603 | 60300.00 |
| 3213 | Knitting mills | 2 | mutton cloth | kilograms | 120100 | 11,363 | 94.61 |
| | | 2 | fabrics | sq.metres | 6,912 | 437 | 63.22 |
| | | 2 | general knitting | numbers | 2275900 | 42,632 | 18.73 |
| | | | poly knitted fabrics | metres | 157,406 | 15,267 | 96.99 |
| | | | polyester | metres | 140179 | 24,230 | 172.85 |
| | | | nylon | metres | 148025 | 4,459 | 30.12 |
| | | | cotton | metres | 166202 | 1,486 | 8.94 |
| | | | clothing | kilograms | 116448 | 3,740 | 32.12 |
| | | | knitting | kilograms | 29940 | 477 | 15.93 |
| | | | material | kilograms | 15092 | 997 | 66.06 |
| 3215 | Cordage, rope & twine industries | | fish nets | kilograms | 28,705 | 2,888.0 | 100.61 |
| | | | twine | kilograms | 53,636 | 9,376.0 | 174.81 |
| | | | ropes | kilograms | 32,005 | 1,232.0 | 38.49 |

**Annex Table IV.1 (continued)**

| Industry ISIC code | Industry name | No. of Establ. | Product | Unit | Product Quantities | Product Values (ZK'000) | Unit Values (Zambian) (Kwacha) |
|---|---|---|---|---|---|---|---|
| 3220 | Manufacture of wearing apparel, | 2 | overalls | numbers | 96,954 | 86,845.0 | 895.73 |
| | except footwear | 2 | dustcoats | numbers | 18,027 | 14,484.0 | 803.46 |
| | | 3 | uniforms | numbers | 60,899 | 43,727.0 | 718.02 |
| | | | lady pants | numbers | 152,608 | 8,005.0 | 52.45 |
| | | 8 | trousers | numbers | 302,753 | 116,177.0 | 383.73 |
| | | | rain wear/coat | numbers | 87,637 | 40,200.0 | 458.71 |
| | | 2 | shirts | numbers | 105,841 | 30,375.0 | 286.99 |
| | | 3 | suits | numbers | 45,476 | 64,881.0 | 1426.71 |
| | | 2 | garments | numbers | 289,528 | 34,062.0 | 117.65 |
| | | | pvc cloths | numbers | 33,448 | 9,602.4 | 287.09 |
| | | 3 | safari suits | numbers | 36,827 | 40,572.0 | 1101.70 |
| | | | jackets | numbers | 3,100 | 4,979.0 | 1606.13 |
| | | 2 | shorts | numbers | 13,220 | 2,304.0 | 174.28 |
| | | | pants | dozens | 10,251 | 7,597.0 | 741.10 |
| | | | T-shirts | numbers | 20,225 | 3,900.0 | 192.83 |
| | | | socks | dozens | 270,995 | 23,793.0 | 87.80 |
| | | 6 | dresses | pieces | 178,482 | 54,735.0 | 306.67 |
| 3240 | Manufacture of footwear, except vulcanized | | foot wear | pairs | 39,206 | 41,420 | 1056.48 |
| | or moulded rubber or plastic footwear | | shoes | pairs | 8,030 | 5,509 | 686.02 |
| | | | wet blue export | #'000 | 143 | 3,978 | 27.82 |
| | | | wet blue galaun | #'000 | 227 | 2,217 | 9.77 |
| 3311 | Sawmills, planing & other wood mills | 5 | sawn timber | cubic metres | 30,205 | 190,795 | 6316.77 |
| | | | poles | cubic metres | 12111 | 16,057 | 1325.82 |
| | | 2 | joinery | #'000 | 20307 | 25,173 | 1.24 |
| | | | baulks | cubic metres | 1074 | 653 | 608.01 |
| | | | parquet tiles | boxes | 9276 | 8,091 | 872.25 |
| | | | doors | pieces | 110 | 524 | 4781.02 |
| | | | black boards | sheet | 21542 | 19,939 | 925.59 |
| | | | plywood | sheet | 5760 | 4,859 | 843.58 |
| | | | pine | cubic metres | 18585 | 99,450 | 5351.09 |
| | | | eucalyptus | cubic metres | 13744 | 35,822 | 2606.37 |
| | | | round poles | pieces | 118152 | 28,210 | 238.76 |
| 3319 | Manufacture of wood & cork product not | | pick handle | numbers | 30000 | 900 | 30.00 |
| | elsewhere classified | | ring hole handle | numbers | 15000 | 450 | 30.00 |
| 3320 | Manufacture of furniture & fixtures, | 3 | lounge suits | sets | 577 | 10,138 | 17570.19 |
| | except primarily of metal | 4 | chairs | numbers | 3,171 | 6,624 | 2088.80 |
| | | 3 | beds | numbers | 1,126 | 6,550 | 5819.12 |
| | | | furnitures | numbers | 55 | 252 | 4581.82 |
| | | | lounge suits | | | 39,196 | |
| | | | polythene | tons | 265 | 76,807 | 289837.74 |
| 3412 | Manufacture of containers & boxes of paper | | lithographic | tons | 658 | 55,977 | 85071.43 |
| | and paperboard | | corrugated cardboard | tons | 213.0 | 21,554.0 | 101192.49 |
| | | | tissue rolls | tons | 213.6 | 20,026.0 | 93754.68 |
| | | | paper boards | tons | 409.6 | 25,468.0 | 62177.73 |
| | | | paper bags/sacks | tons | 301.3 | 19,903.0 | 66050.37 |
| | | 2 | printing | tons | 1,131.0 | 92,395.72 | 81690.94 |
| | | | paper bags | tons | 265 | 45,094 | 170166.04 |
| | | 2 | toilet tissues | tons | 1,111.3 | 33,412 | 30067.04 |
| | | | packaging papers | tons | 1261 | 40,238 | 31909.60 |
| | | | l.g.pty | tons | 304 | 13,278 | 43677.63 |
| 3419 | Manufacture of pulp, paper & paperboard | | paper egg trays | numbers | 84835 | 523 | 6.16 |
| | articles not elsewhere classified | | egg trays | numbers | 69512 | 445 | 6.40 |
| | | | stationery | tons | 1221 | 48,370 | 39615.07 |
| | | | plastics | tons | 734 | 111,587 | 152025.89 |
| | | | paper products | tons | 92 | 24,220 | 263260.87 |
| | | 2 | tissue papers | tons | 238.4 | 36,922 | 154874.16 |
| | | | paper bags | tons | 52.8 | 3,126 | 59204.55 |
| | | | other products | | 38 | 813 | 21400.00 |
| 3420 | Printing, publishing & allied industries | | books | kilograms | 29712 | 17,264 | 581.04 |
| | | | stationary | dozens | 29538 | 27,537 | 932.26 |
| | | | textbooks | numbers | 1171367 | 70,864 | 60.50 |
| | | | exercise books | numbers | 17009242 | 34,872 | 2.05 |

**Annex Table IV.1 (continued)**

| Industry ISIC code | Industry name | No. of Establ. | Product | Unit | Product Quantities | Product Values (ZK'000) | Unit Values (Zambian) (Kwacha) |
|---|---|---|---|---|---|---|---|
| 3511 | Manufacture of basic industrial chemicals, except fertilizers | | aluminium Sulphate | tons | 1563 | 29,240 | 18707.61 |
| | | | zinc oxide | tons | 171.2 | 12,479 | 72891.36 |
| | | 2 | oxygen Gas | 000m-3 | 1447 | 115,342 | 79.71 |
| | | | acetylene Gas | 000m-3 | 290 | 54,700 | 188.62 |
| 3512 | Manufacture of fertilizers & pesticides | | d/dip | litres | 6190 | 4,110 | 663.97 |
| | | | triaxdip | litres | 26370 | 9,866 | 374.14 |
| | | | fly killer | can 150g | 380508 | 17,632 | 46.34 |
| | | | reskott | litres | 20600 | 8,138 | 395.05 |
| | | | fertilizers | tons | 32,995.8 | 366,317 | 11101.91 |
| | | | explosives | tons | 14,193.9 | 245,115 | 17269.01 |
| | | | teepol 26 | tons | 391 | 18,149 | 46416.88 |
| | | | teepol 53 | tons | 26 | 1,570 | 60384.62 |
| | | | liquid thinners | tons | 37 | 3,779 | 102135.14 |
| 3521 | Manufacture of paints, vanishes & lacquers | 3 | paints | litres | 772096 | 154,842 | 200.55 |
| | | | alkyd paints | litres | 25821 | 13,851 | 536.42 |
| | | | adhesive | litres | 908.1 | 424 | 466.91 |
| 3522 | Manufacture of drugs & medicines | | fluids | bag millilitres | 589410 | 22,912 | 38.87 |
| | | | oral rehydration salt | sachet 30g | 1057934 | 1,563 | 1.48 |
| | | 2 | tablets | each | 21875665 | 53,369 | 2.44 |
| | | | liquid/m | litres | 65490 | 9,742 | 148.76 |
| | | 2 | toiletries | litres | 143119 | 28,657 | 200.23 |
| | | 2 | a/cafenol | tab 1*200 | 154735 | 24,942 | 161.19 |
| | | 2 | norolon | tab 1*200 | 11741 | 2,818 | 240.02 |
| | | | panadol | tab 1*200 | 34542 | 2,216 | 64.15 |
| | | | skin conditioner | tube dozens | 46984 | 10,420 | 221.78 |
| 3523 | Manufacture of soap & cleaning preparations, perfumes, cosmetics & other toilet preparations | | pt | dozens | 501764 | 174,144 | 347.06 |
| | | | vicl | dozens | 50728 | 26,032 | 513.17 |
| | | | vht | dozens | 9304 | 3,124 | 335.77 |
| | | | dynamo | tons | 3195 | 133,329 | 41730.52 |
| | | | choice | tons | 1409 | 146,907 | 104300.32 |
| | | | cold power | tons | 1018 | 53,620 | 52677.08 |
| | | | s/pads | dozens | 20898 | 16,836 | 805.63 |
| | | | toiletries | numbers | 46778 | 29,671 | 634.29 |
| | | | hospital | numbers | 67599 | 27,764 | 410.72 |
| | | | glycerine | dozens | 14080 | 3,260 | 231.53 |
| | | | petroleum/jelly | dozens | 4080 | 624 | 152.94 |
| | | | defegen | case/25 | 888 | 472 | 531.53 |
| | | | polishers | kilograms | 651092 | 81,439 | 125.08 |
| | | | aerosols | kilograms | 115886 | 35,820 | 309.10 |
| | | | toiletries | kilograms | 41823 | 11,870 | 283.82 |
| | | | soaps | cases | 405378 | 106,534 | 262.80 |
| | | | vegetable oils | drums | 13716 | 94,404 | 6882.53 |
| 3529 | Manufacture of chemical products not elsewhere classified | | inks | kilograms | 69560 | 36,644 | 526.80 |
| | | | coatings | kilograms | 28623 | 11,714 | 409.25 |
| | | | explosive | tons | 9475 | 501,490 | 52927.70 |
| | | | ANFO | tons | 14670 | 292,927 | 19967.76 |
| | | | fuses led | 000 units | 7350 | 200,897 | 27.33 |
| | | | matches | 000 units | 73 | 94,482 | 1294.27 |
| 3530 | Petroleum refineries | | auto oils | m-3 | 7660 | 500,994 | 65403.92 |
| | | | ind. oils | m-3 | 3986 | 227,603 | 57100.60 |
| | | | grease | tons | 216 | 16,961 | 78523.15 |
| | | | zephyr | kilograms | 15175 | 1,148 | 75.65 |
| | | | 333 | litres | 24757 | 1,665 | 67.25 |
| | | | worrior | litres | 2421 | 191 | 78.89 |
| | | | gasolines | tons | 139991 | 1,707,400 | 12196.50 |
| | | | kerosines | tons | 95039 | 856,146 | 9008.36 |
| | | | gasoils | tons | 270653 | 1,874,466 | 6925.72 |
| | | | blacks | tons | 102115 | 531,134 | 5201.33 |
| 3551 | Tyre & tube industries | 2 | retreads | numbers | 6282 | 838,997 | 133555.71 |
| | | | r/tyres | numbers | 18099 | 71,039 | 3925.02 |
| | | | rubber/l | kilograms | 5436 | 30,055 | 5528.51 |
| | | | batteries | numbers | 2726 | 6,999 | 2567.50 |
| | | | rubber pro | tons | 3652 | 897,057 | 245634.45 |

**Annex Table IV.1 (continued)**

| Industry ISIC code | Industry name | No. of Establ. | Product | Unit | Product Quantities | Product Values (ZK'000) | Unit Values (Zambian) (Kwacha) |
|---|---|---|---|---|---|---|---|
| 3559 | Manufacture of rubber products not elsewhere cl |  | n/ rubber | tons | 279 | 127,388 | 456587.81 |
| 3560 | Manufacture of plastic products not | 2 | plastics | kilograms | 739674 | 72,424 | 97.91 |
|  | elsewhere classified | 2 | plastics | numbers | 1075524 | 28,798 | 26.78 |
|  |  |  | buckets | #'000 | 202 | 1,717 | 8.50 |
|  |  |  | lids | #'000 | 1837 | 4,409 | 2.40 |
|  |  |  | container | #'000 | 1485 | 5,229 | 3.52 |
|  |  |  | pipes | tons | 66 | 5,785 | 87651.52 |
|  |  |  | conduits | tons | 122 | 7,994 | 65524.59 |
|  |  |  | b/castings | tons | 183 | 14,208 | 77744.15 |
|  |  |  | fittings |  | 540 | 441 | 816.67 |
|  |  |  | bags | tons | 397 | 45,530 | 114685.14 |
|  |  |  | polythene | tons | 680 | 61,167 | 89951.47 |
|  |  |  | potato bags | tons | 45 | 7,450 | 165555.56 |
| 3610 | Manufacture of pottery, china & earthware |  | table ware | #'000 | 767 | 35,508 | 46.31 |
|  |  |  | sanitary | pieces | 14458 | 31,220 | 2159.36 |
| 3620 | Manufacture of glass & glass products |  | bottles | tons | 14918 | 314,161 | 21059.19 |
| 3691 | Manufacture of structural clay products |  | bricks | numbers | 763382.4 | 9,535 | 12.49 |
|  |  |  | tiles | pieces | 318132.8 | 8,324 | 26.17 |
| 3692 | Manufacture of cement, lime & plaster |  | cement | tons | 80981.6 | 321,210 | 3966.46 |
|  |  |  | porland cement | tons | 126457.6 | 451,570 | 3570.92 |
|  |  |  | limestone | tons | 78437.6 | 98,935 | 1261.32 |
|  |  |  | q/lime | tons | 32724.8 | 354,354 | 10828.30 |
|  |  |  | h/lime | tons | 9223.2 | 23,835 | 2584.24 |
| 3699 | Manufacture of non-metallic mineral products |  | sleepers | numbers | 59686 | 52,284 | 875.98 |
|  | not elsewhere classified |  | c/blocks | numbers | 214893 | 3,212 | 14.95 |
| 3710 | Iron & steel basic industries |  | mill balls | tons | 10608 | 146,639 | 13823.44 |
|  |  |  | castings | tons | 3022.4 | 212,162 | 70196.53 |
|  |  |  | man-hole covers |  | x | 2,650 |  |
| 3720 | Non-ferrous metal basic industries |  | cast iron | kilograms | 61745.6 | 7,104 | 115.05 |
|  |  |  | bronze | kilograms | 23263.2 | 4,420 | 190.00 |
|  |  | 2 | aluminium | kilograms | 88568.8 | 32,811 | 370.46 |
|  |  |  | castings | tons | 256.8 | 26,366 | 102671.34 |
|  |  |  | white metals | tons | 19 | 8,832 | 464842.11 |
|  |  |  | n.f.seams | tons | 47 | 13,645 | 290319.15 |
| 3811 | Manufacture of cutlery, hand tools & general |  | steel | tons | 374 | 39,700 | 106149.73 |
|  | hardware |  | enamel | dozens | 61970 | 28,263 | 456.08 |
| 3813 | Manufacture structural metal products |  | wheel barrows | numbers | 246 | 912 | 3707.32 |
|  |  |  | dust bins | numbers | 6858 | 5,986 | 872.85 |
|  |  |  | ventpipes | numbers | 86 | 235 | 2732.56 |
|  |  | 7 | steel fabrication | tons | 829.92932 | 22,984 | 27693.92 |
|  |  |  | wire products | tons | 380.8 | 30,412 | 79863.45 |
|  |  |  | steel wire | tons | 28 | 4,343 | 155107.14 |
|  |  |  | l/eng | #'000 |  | 191,280 |  |
|  |  |  | h/eng | #'000 |  | 187,497 |  |
|  |  |  | frames | each | 29763 | 61,728 | 2073.98 |
|  |  |  | geysers | each | 3304 | 42,741 | 12936.14 |
|  |  |  | wire mesh | tons | 617.6 | 41,839 | 67744.49 |
|  |  |  | steel | kilograms | 298616.53 | 12,005 | 40.20 |
| 3819 | Manufacture of fabricated metal products |  |  |  |  |  |  |
|  | except machinery & equipment not |  | water tanks | numbers | 106 | 3,413 | 32198.11 |
|  | elsewhere specified |  | door frames | numbers | 333 | 876 | 2630.63 |
|  |  |  | reconditioning |  |  | 9,398 |  |
|  |  |  | engineering | tons | 82.4 | 10,391 | 126101.63 |
|  |  |  | iron sheet | tons | 1338.4 | 128,210 | 95793.48 |
|  |  |  | locks | numbers | 41426 | 113,851 | 2748.30 |
|  |  |  | blocks | each | 13 | 866 | 66615.38 |
|  |  |  | mixers | each | 31 | 4,493 | 144935.48 |
|  |  |  | mowers | each | 84 | 433 | 5164.34 |
|  |  |  | copper ware | tons | 10 | 537 | 53700.00 |
|  |  | 3 | steel installation | tons | 42401.38 | 63,203 | 1490.59 |
|  |  |  | extension | each | 7155 | 36,063 | 5040.25 |
|  |  |  | integral | each | 10175 | 50,206 | 4934.19 |
|  |  |  | d/mesh | roll | 856 | 2,530 | 2955.61 |

**Annex Table IV.1 (continued)**

| Industry ISIC code | Industry name | No. of Establ. | Product | Unit | Product Quantities | Product Values (ZK'000) | Unit Values (Zambian) (Kwacha) |
|---|---|---|---|---|---|---|---|
| | | | b/bars | roll | 109 | 1,458 | 13376.15 |
| 3822 | Manufacture of agricultural machinery & equipment | | oxdrawn | numbers | 7803 | 15,788 | 2023.32 |
| | | | gratings | numbers | 1180 | 9,163 | 7765.25 |
| | | | wheel barrows | numbers | 2802 | 6,060 | 2162.74 |
| | | | wheel barrows | numbers | 971 | 2,950 | 3038.11 |
| 3824 | Manufacture of special industrial machinery & equipment except metal & wood working machinery | | d/drilling | each | 4560 | 25,080 | 5500.00 |
| | | | c/drilling | each | 31700 | 46,474 | 1466.06 |
| | | | steel | kilograms | 467888 | 18,149 | 38.79 |
| 3831 | Manufacture of electrical industrial machinery & apparatus | | boards | numbers | 11 | 2,608 | 237090.91 |
| | | | b/gulley | numbers | 98 | 3,476 | 35469.39 |
| | | | starters | numbers | 225 | 7,544 | 33528.89 |
| 3832 | Manufacture of radio, television & communication equipment & apparatus | | 1 LPs | each | 103580 | 2,244 | 21.66 |
| | | | 12 SP | each | 12183 | 188 | 15.43 |
| | | | cassettes | each | 32558 | 600 | 18.43 |
| 3839 | Manufacture of electrical apparatus & supplies not elsewhere classified | | batteries | numbers | 39540 | 94,976 | 2402.02 |
| | | | mpbatteries | numbers | 3092 | 14,828 | 4795.60 |
| | | | r20 hd | #'000 | 10873 | 121,143 | 11.14 |
| | | | metals | tons | 830 | 21,269 | 25625.30 |
| | | | rewind | jobs | 274 | 12,107 | 44186.13 |
| | | | coils | jobs | 93 | 1,004 | 10795.70 |
| | | | armoured | tons | 782 | 112,509 | 143873.40 |
| | | | bare/stnd | tons | 7566 | 203,705 | 26923.74 |
| | | | bldg wire | tons | 2958 | 112,714 | 38101.59 |
| 3842 | Manufacture of railroad equipment | | turnout | each | 624 | 12,825 | 20552.88 |
| | | | c/screw | kilograms | 16923 | 3,303 | 195.18 |
| | | | r/fitting | kilograms | 48778 | 14,359 | 294.37 |
| 3843 | Manufacture of motor vehicles | | trailers | numbers | 12 | 12,973.0 | 1118362.07 |
| | | | bus bodies | numbers | 15 | 13,976.0 | 944324.32 |
| | | | bus vehicles | units | 20 | 31,366.0 | 1568300.00 |
| | | | fiat cars | numbers | 18 | 9,042.0 | 502333.33 |
| | | | peugeot | numbers | 9 | 9,031.3 | 1050151.16 |
| | | | benz truck | numbers | 14 | 12,433.5 | 888107.14 |
| | | | mazda 323 | numbers | 6 | 4,220.0 | 703333.33 |
| | | | land rover assembly | each | 18 | 8,532.0 | 463695.65 |
| | | | l/rover recond | each | 40 | 19,430.0 | 490656.57 |
| | | | toyota | each | 15 | 19,989.0 | 1350608.11 |
| | | | brake shoes | each | 3,854 | 3,375 | 875.80 |
| | | | clutch bond | each | 335 | 408 | 1217.18 |
| | | | disc pads | numbers | 355 | 74 | 208.33 |
| 3844 | Manufacture of motorcycles & bicycles | | bicycles | numbers | 33611 | 104,291 | 3102.88 |
| | | | mopeds | numbers | 75 | 3,436 | 45813.33 |

*Source:*
*Zambia Central Statistical Office DataBase for 1990 Quarterly Returns of Industrial Production (unpublished); Returns for 1990 Census of Industrial Production.*

## Annex Table IV.2: Unit Values for Matched Products, by Sample Industry, Zambia/USA, 1990

| SIC Code | USA Product Item | Unit | USA Quantity (sales) | USA Dollar Value (mill. $) | USA Dollar Unit Value | USA Quantity valued at Zambian Unit Values ( mill. ZK.) | PPP ZK./$ USA Quantity Weights | ISIC Code | Zambian Product Item | Unit | Zambian Quantity | Zambian Kwacha Value (000' ZK.) | Zambian Kwacha Unit Value | Zambian Quantity valued at USA. unit Values (1000 $) | PPP ZK./$ Zambian Quantity Weights |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | FOOD PRODUCTS | | | | | | | | | | | | | | |
| | *Sample Industry Meat Products* | | | | | | | | | | | | | | |
| 20117/37 | Sausage and similar products (not canned), | 000 kg. | 729,387.3 | 2,476.9 | 3.40 | 25,126.4 | 10 | 3111 | Sausages | 000 kg. | 1,859 | 64,024 | 34.45 | 6,311.3 | 10 |
| 20114 | Pork, not canned or made into sausage | 000 kg. | 4,356,130.0 | 8,038.9 | 1.85 | 137,549.3 | 17 | 3111 | Pork | 000 kg. | 892 | 28,155 | 31.58 | 1,645.5 | 17 |
| 20118/38 | Canned meats (except dog & cat food and baby) | 000 kg. | 508,888.6 | 1,312.1 | 2.58 | 25,597.0 | 20 | 3111 | Canned meat | 000 kg. | 526 | 26,477 | 50.30 | 1,357.2 | 20 |
| 20111 | Beef, not canned or made into sausage | 000 kg. | 7,112,999.6 | 18,441.9 | 2.59 | 489,631.3 | 27 | 3111 | Beef | 000 kg. | 4,004 | 275,607 | 68.84 | 10,380.7 | 27 |
| 20151/2 | Total chickens | 000 kg. | 6,315,639.4 | 7,155.3 | 1.13 | 870,931.6 | 122 | 3111 | Dressed chicken | 000 kg. | 634 | 87,396 | 137.90 | 718.0 | 122 |
| 20159 | Liquid, dried and frozen eggs | 000 kg. | 245,931.8 | 338.7 | 1.38 | 11,616.7 | 34 | 3111 | Table eggs | 000 kg.<br>000 kg. | 25 | 1,196 | 47.24 | 34.9 | 34 |
| | *Sample Industry Dairy Products* | | | | | | | | | | | | | | |
| 20210 | Creamery butter | mill.tons | 490.6 | 1,544.3 | 3.15 | 111,719.2 | 72.3 | 3112 | Butter | ton | 5 | 1,116 | 227.72 | 15.4 | 72 |
| 20240 | Ice cream | mill.lts | 3,892.9 | 3,269.5 | 0.84 | 218,410.9 | 66.8 | 3112 | Ice cream | ltrs | 37 | 2,075 | 56.11 | 31.1 | 67 |
| 20262 | Milk | mill.tons | 24,205.8 | 10,349.3 | 0.43 | 430,273.9 | 42 | 3112 | Milk | ton | 5,039 | 89,568 | 17.78 | 2,154.4 | 42 |
| 20223 00 | Natural cheese | mill.tons | 2,179.9 | 6,414.5 | 2.94 | 555,222.6 | 87 | 3112 | Cheese | ton | 1 | 331 | 254.70 | 3.8 | 87 |
| | *Preserved fruits and vegetables* | | | | | | | | | | | | | | |
| 2033614 | Catsup and other tomato sauce, paste | mill. kg. | 260.7 | 215.1 | 0.83 | 14,186.2 | 66 | 3113 | Sauce | 000 kg. | 56 | 3,071 | 54.42 | 46.6 | 66 |
| 20336 65 | Tomato paste | mill. kg. | 575.9 | 411.8 | 0.72 | 20,242.5 | 49 | 3113 | Tomato paste | 000 kg. | 25 | 864 | 35.15 | 17.6 | 49 |
| 20338 11 | Jams jellies and preserves | mill.kg. | 1,174.0 | 327.4 | 0.28 | 37,564.0 | 115 | 3113 | Jams | 000 kg. | 80 | 2,561 | 32.00 | 22.3 | 115 |
| 2033A25 | Fruit Juices | mill. lts | 4,331.2 | 3,277.0 | 0.76 | 237,792.0 | 73 | 3117 | Juice | 000 ltrs | 4 | 239 | 54.90 | 3.3 | 73 |
| 20922-6 | Canned fish | mill. kg. | 797.3 | 3,815.8 | 4.79 | 43,493.1 | 11 | 3114 | Fish | 000 kg. | 548 | 29,902 | 54.55 | 2,623.4 | 11 |
| | *Sample Industry Fats and Oils* | | | | | | | | | | | | | | |
| 20741/51/62 | Edible oils | mill. kg. | 7,390.4 | 3,077.8 | 0.42 | 290,683.9 | 94 | 3115 | Cooking oil | 000 kg. | 15,258 | 600,121 | 39.33 | 6,354.2 | 94 |
| 20744 14 | Cottonseed cake and meal | mill. kg. | 1,262.4 | 178.8 | 0.14 | 16,854.5 | 94 | 3115 | Cotton Seed Cake | 000 kg. | 7,920 | 105,743 | 13.35 | 1,121.8 | 94 |
| 20791 | Baking or frying fats | mill. kg. | 3,975.5 | 3,053.5 | 0.77 | 523,947.6 | 172 | 3115 | Fats | 000 kg. | 774 | 102,062 | 131.80 | 594.8 | 172 |
| | *Sample Industry Grain Mill Products* | | | | | | | | | | | | | | |
| 20411 11 | Flour | ton | 14,893,861.2 | 3,085.9 | 207.19 | 214,812.4 | 70 | 3116 | Wheat flour | ton | 4,189 | 60,414 | 14.42 | 867.9 | 70 |
| 20413 15 | Degermed cornmeal | ton | 1,482,460.1 | 335.9 | 226.58 | 7,443.0 | 22 | 3116 | Maize Flour | ton | 255,731 | 1,283,946 | 5.02 | 57,944.3 | 22 |
| 20440 11 | Rice milling | mill. kg. | 4,284.3 | 1,070.1 | 249.77 | 86,382.5 | 81 | 3116 | Rice | 000 kg. | 76 | 1,530 | 20.16 | 19.0 | 81 |
| 2048--- | Prepared feed | mill. tons | 53.2 | 7,898.6 | 148.41 | 313,188.9 | 40 | 3116 | Stock feeds | ton | 33,395 | 196,522 | 5.88 | 4,956.3 | 40 |

**Annex Table IV.2 (continued)**

| SIC Code | USA Product Item | Unit | USA Quantity (sales) | USA Dollar Value (mill. $) | USA Dollar Unit Value | USA Quantity valued at Zambian Unit Values ( mill. ZK.) | PPP ZK./$ USA Quantity Weights | ISIC Code | Zambian Product Item | Unit | Zambian Quantity | Zambian Kwacha Value (000' ZK.) | Zambian Kwacha Unit Value | Zambian Quantity valued at USA. unit Values (1000 $) | PPP ZK./$ Zambian Quantity Weights |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Sample Industry Bakery Products* | | | | | | | | | | | | | | |
| 20511-- | Bread | 000 tons | 5,279.7 | 5,695.8 | 1.08 | 230,881.4 | 41 | 3117 | Bread | ton | 7,131 | 311,832 | 43.73 | 7,692.8 | 41 |
| 20517-- | Doughnuts (cake type) | 000 tons | 163.1 | 399.7 | 2.45 | 18,847.4 | 47 | 3117 | Cream doughnut | ton | 1 | 86 | 115.54 | 1.8 | 47 |
| 20521-- | Crackers, pretzels, biscuits, and related products | 000 tons | 1,036.5 | 2,383.4 | 2.30 | 245,686.1 | 103 | 3117 | Biscuits | ton | 436 | 103,336 | 237.03 | 1,002.5 | 103 |
| | *Sample Industry Sugar* | | | | | | | | | | | | | | |
| 20620 -- | Cane sugar refining | 000 tons | 4,552.3 | 2425.9 | 532.89 | 101,392.4 | 42 | 3118 | Sugar | ton | 80,493 | 1,792,795 | 22,272.68 | 42,894.1 | 42 |
| | *Sample Industry Confectionery and food n.e.c.* | | | | | | | | | | | | | | |
| 20649 -- | Other confectionery-type products | mill. kg | 35.0 | 104.6 | 2.98 | 3,970.3 | 38 | 3119 | fruitdrop | 000 kg. | 3 | 317 | 113.28 | 8.4 | 38 |
| 20680 13 | Peanuts, shipped separately | mill. kg. | 457.1 | 1,526.5 | 3.34 | 44,658.3 | 29 | 3119 | peanuts | 000 kg. | 59 | 5,715 | 97.69 | 195.3 | 29 |
| | BEVERAGES | | | | | | | | | | | | | | |
| | *Malt and Malt beverages* | | | | | | | | | | | | | | |
| 2082 | Malt beverages | mill. lts | 20,653.1 | 13,008.8 | 0.63 | 281,405.3 | 22 | 3133 | Beer | hlts | 871,456 | 1,187,390 | 13.63 | 54,890.6 | 22 |
| | *Soft drinks* | | | | | | | | | | | | | | |
| 20863/4 | Bottled & canned carbonated soft drinks | mill. lts | 15,531.1 | 6,608.9 | 0.43 | 305,443.6 | 46 | 3134 | Soft drinks | 000 ltrs | 21,723 | 427,209 | 19.67 | 9,243.5 | 46 |
| | TOBACCO | | | | | | | | | | | | | | |
| | *Tobacco Stemming and Redrying* | | | | | | | | | | | | | | |
| 21110 | Filter & non-filter tips | millions | 636,352.0 | 16,746.2 | 26.32 | 959,512.9 | 57 | 3140 | Cigarettes | thousand | 384,118 | 579,186 | 1,507.83 | 10,108.4 | 57 |
| 2141- -- | Tobacco Stemming and redrying | ton | 429,257.0 | 1,992.3 | 4,641.28 | 39,260.1 | 20 | 3140 | Tobacco | ton | 122 | 11,187 | 91,460.57 | 567.7 | 20 |
| | TEXTILE MILL PRODUCTS | | | | | | | | | | | | | | |
| | *Textile Mill Products* | | | | | | | | | | | | | | |
| 22811 -- | Cotton Yarn | ton | 915,264.0 | 3,144.2 | 3,435.29 | 147,084.1 | 47 | 3211 | yarn | ton | 2,783 | 447,257 | 160,701.33 | 9,561.0 | 47 |
| 22823 -- | Thrown filament yarns, except textured | ton | 18,523.2 | 90.6 | 4,891.16 | 398.0 | 4 | 3211 | offcuts | ton | 205 | 4,404 | 21,485.69 | 1,002.6 | 4 |
| 22690 | Finished yarn, etc. (a) | ton | 14,800.4 | 104.3 | 7,047.11 | 6,383.5 | 61 | 3211 | acrylic yarn | ton | 152 | 65,427 | 431,303.40 | 1,069.0 | 61 |
| 22840 | Cotton thread | ton | 78,178.8 | 581.2 | 7,434.24 | 36,449.1 | 63 | 3211 | sewing threads | ton | 45 | 20,887 | 466,227.68 | 333.1 | 63 |
| 2211F -- | Finished cotton broadwoven fabrics | m2 | 449,253.0 | 809.9 | 1,802.77 | 31,806.8 | 39 | 3211 | plain dyed cloth | 000 m2. | 9,406 | 665,967 | 70,799.35 | 16,957.6 | 39 |
| 2211B -- | Plain weave fabrics, except pile (grey goods) | 000 m2 | 2,990,622.8 | 3,283.3 | 1,097.86 | 214,220.2 | 65 | 3211 | knitted fabrics | 000 m2. | 1,652 | 118,313 | 71,630.63 | 1,813.4 | 65 |
| 2211H 65 | Blanket sheet type | mill. | 0.7 | 20.8 | 29.71 | 241.8 | 12 | 3212 | blankets | each | 877,984 | 303,340 | 345.50 | 26,088.7 | 12 |

## Annex Table IV.2 (continued)

| SIC Code | USA Product Item | Unit | USA Quantity (sales) | USA Dollar Value (mill. $) | USA Dollar Unit Value | USA Quantity valued at Zambian Unit Values ( mill. ZK.) | PPP ZK./$ USA Quantity Weights | ISIC Code | Zambian Product Item | Unit | Zambian Quantity | Zambian Kwacha Value (000' ZK.) | Zambian Kwacha Unit Value | Zambian Quantity valued at USA. unit Values (1000 $) | PPP ZK./$ Zambian Quantity Weights |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2298 -- | Cordage and Twine | ton | 35,866.0 | 147.9 | 4,123.68 | 1,380.6 | 9 | 3215 | ropes | ton | 32 | 1,232 | 38,494.23 | 132.0 | 9 |
| 22982 28 | Soft fiber cordage and twine, except cotton | ton | 73,911.2 | 118.1 | 1,597.86 | 12,920.3 | 109 | 3215 | twine | ton | 54 | 9,376 | 174,807.96 | 85.7 | 109 |
| 22982 03 | Fish net and fish netting, commercial | ton | 3,087.2 | 28.2 | 9,134.49 | 310.6 | 11 | 3215 | fish nets | ton | 29 | 2,888 | 100,610.35 | 262.2 | 11 |
| | WEARING APPAREL | | | | | | | | | | | | | | |
| | *Wearing Apparel* | | | | | | | | | | | | | | |
| 23111 00 | Men's tailored suits, incl. uniform | thousand | 10,474.0 | 1,219.0 | 116.38 | 10,911.3 | 9 | 3220 | Suits/Uniforms | thousand | 143 | 149,180 | 1,041.75 | 16,666.3 | 9 |
| 23252 10 | Trousers | thousand | 295,921.0 | 3,682.0 | 12.44 | 113,555.2 | 31 | 3220 | Trouser | thousand | 303 | 116,177 | 383.73 | 3,767.0 | 31 |
| 23216 10 | Total Men's woven dress and shirts | thousand | 317,796.0 | 2,328.8 | 7.33 | 91,203.3 | 39 | 3220 | Shirt | thousand | 106 | 30,375 | 286.99 | 775.6 | 39 |
| 23213 20 | T-shirts | thousand | 477,180.0 | 1,004.7 | 2.11 | 92,014.9 | 92 | 3220 | T-shirt | thousand | 20 | 3,900 | 192.83 | 42.6 | 92 |
| 23112 00 | Men's overcoats, topcoats, and tailored | thousand | 23,038.0 | 348.7 | 15.14 | 37,002.0 | 106 | 3220 | Overcoat | thousand | 3 | 4,979 | 1,606.13 | 46.9 | 106 |
| 23353 00 | Dresses (original) | thousand | 135,271.0 | 3,320.7 | 24.55 | 41,483.5 | 12 | 3220 | Ladies Dresses | thousand | 178 | 54,735 | 306.67 | 4,381.5 | 12 |
| 23262 10 | Workpants, overalls | thousand | 57,252.0 | 599.1 | 10.46 | 50,454.3 | 84 | 3220 | Industrial garments, dust coats | thousand | 115 | 101,329 | 881.27 | 1,203.2 | 84 |
| | LEATHER PRODUCTS AND FOOTWEAR | | | | | | | | | | | | | | |
| | *Leather footwear* | | | | | | | | | | | | | | |
| 3143/44 | Footwear (Men's and Women's) | mill. pair | 138.3 | 3,101.1 | 22.42 | 137,401.1 | 44 | 3240 | Shoes, footwear | 000 pairs | 47 | 46,929 | 993.50 | 1,059.2 | 44 |
| | WOOD PRODUCTS FURNITURE AND FIXTURES | | | | | | | | | | | | | | |
| | *Wood Products and Furniture* | | | | | | | | | | | | | | |
| 24212 35 | Total Lumber | 000 m3 | 101,351.0 | 12,330.8 | 121.66 | 640,210.5 | 52 | 3311 | Sawn timber | 000 m3 | 30 | 190,795 | 6,316.77 | 3,674.8 | 52 |
| 24314 33 | Wood doors, interior and exterior | 000 pcs | 33,321.5 | 1,402.2 | 42.08 | 159,310.8 | 114 | 3311 | Doors | pcs | 110 | 524 | 4,781.02 | 4.6 | 114 |
| 2491214 | Wood poles, piles, and posts | pcs | 4,590,200.0 | 152.3 | 33.18 | 1,096.0 | 7 | 3311 | Poles | pcs | 185,404 | 44,267 | 238.76 | 6,151.6 | 7 |
| 25115 11 | Beds | 000 pcs | 1,023.9 | 214.8 | 209.79 | 5,958.2 | 28 | 3320 | Beds | pcs | 1,126 | 6,550 | 5,819.12 | 236.1 | 28 |
| 25120 35 | Chairs | 000 pcs | 8,665.1 | 1,576.0 | 181.88 | 18,099.7 | 11 | 3320 | Chairs | pcs | 3,171 | 6,624 | 2,088.80 | 576.8 | 11 |
| | PAPER PRINTING AND PUBLISHING | | | | | | | | | | | | | | |
| | *Paper, Printing and publishing* | | | | | | | | | | | | | | |
| 2621A 60 | Tissue paper products | 000 tons | 4,387.3 | 4,534.9 | 1,033.63 | 679,485.7 | 150 | 3419 | Tissue paper | ton | 238 | 36,922 | 154.87 | 246.4 | 150 |
| 26764 45 | Toilet tissue | 000 tons | 2,350.4 | 3,895.9 | 1,657.55 | 94,803.7 | 24 | 3412 | Toilet Paper | ton | 1,325 | 53,438 | 40.34 | 2,196.0 | 24 |
| 26217 -- | Unbleached kraft packaging | 000 tons | 2,822.2 | 1,473.1 | 521.96 | 112,569.9 | 76 | 3412 | Packaging papers | ton | 1,009 | 40,238 | 39.89 | 526.6 | 76 |
| 26741 -- | Grocer's bags & sacks & variety & shopping bags, | 000 tons | 1,416.6 | 1,083.9 | 765.17 | 241,231.2 | 223 | 3412 | Millinery Paper Bags | ton | 265 | 45,094 | 170.29 | 202.6 | 223 |
| 26742 12 | Multiwall (three plies or more) | 000 tons | 714.3 | 792.9 | 1,110.10 | 47,177.3 | 59 | 3412 | Multiwall Sacks | ton | 301 | 19,903 | 66.05 | 334.5 | 59 |

**Annex Table IV.2 (continued)**

| SIC Code | USA Product Item | Unit | USA Quantity (sales) | USA Dollar Value (mill. $) | USA Dollar Unit Value | USA Quantity valued at Zambian Unit Values ( mill. ZK.) | PPP ZK./$ USA Quantity Weights | ISIC Code | Zambian Product Item | Unit | Zambian Quantity | Zambian Kwacha Value (000' ZK.) | Zambian Kwacha Unit Value | Zambian Quantity valued at USA. unit Values (1000 $) | PPP ZK./$ Zambian Quantity Weights |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2631- -- | Paperboard | 000 tons | 20,732.2 | 8,890.0 | 428.80 | 1,289,081.6 | 145 | 3412 | Pulp paperboard | ton | 410 | 25,468 | 62.18 | 175.6 | 145 |
| 26211 00 | Newsprint | 000 tons | 5,289.1 | 2,736.5 | 517.39 | 438,645.9 | 160 | 3411 | News Print | ton | 1,789 | 148,373 | 82.93 | 925.6 | 160 |
| 2731A 00 | Mass market paperbound books, rack size | mill.nos. | 411.9 | 836.6 | 2.03 | 31,148.3 | 37 | 3420 | Printed Books | numbers | 937,094 | 70,864 | 75.62 | 1,903.3 | 37 |
| | CHEMICALS, PETROLEUM AND COAL PRODUCTS | | | | | | | | | | | | | | |
| | *Industrial inorganic chemicals* | | | | | | | | | | | | | | |
| 28136 11 | Oxygen gas | 000 m3 | 8,320,200.0 | 405.6 | 48.75 | 663,212.5 | 1,635 | 3511 | Oxygen Gas | 000 m3 | 1,447 | 115,342 | 79,711.13 | 70.5 | 1,635 |
| 28196 51 | Aluminium Sulphate | ton | 1,209,847.3 | 143.7 | 118.78 | 22,632.8 | 158 | 3511 | Aluminium Sulphate | ton | 1,563 | 29,240 | 18,707.13 | 185.7 | 158 |
| 28199 86 | Zinc Compounds | ton | 78,546.2 | 68.8 | 875.92 | 5,725.3 | 83 | 3511 | Zinc Oxide | ton | 171 | 12,479 | 72,891.36 | 150.0 | 83 |
| 28132 | Acetylene | 000 m3 | 87,730.0 | 121.4 | 1,383.79 | 16,547.7 | 136 | 3511 | Acetylene Gas | 000 m3 | 290 | 54,700 | 188,620.69 | 401.3 | 136 |
| | *Agricultural Fertilizers* | | | | | | | | | | | | | | |
| 28731 30 | Total Fertilizers | 000 tons | 16,179.2 | 1,999.3 | 123.57 | 179,619.6 | 90 | 3512 | Fertilizers | ton | 32,996 | 366,317 | 11,101.91 | 4,077.4 | 90 |
| 28731 53 | Explosive and other uses | 000 tons | 1,275.4 | 145.2 | 113.84 | 22,025.3 | 152 | 3512 | Explosives | ton | 14,194 | 245,115 | 17,269.01 | 1,615.9 | 152 |
| | *Paints* | | | | | | | | | | | | | | |
| 28511 -- | Coatings and paints | mill. lts | 3,656.7 | 7,552.9 | 2.07 | 773,085.1 | 102 | 3521 | paints | 000 lts | 798 | 168,693 | 211.42 | 1,648.1 | 102 |
| 28515 98 | Other miscellaneous allied paint products | mill. lts | 194.9 | 280.5 | 1.44 | 91,013.4 | 324 | 3521 | adhesive | 000 lts | 1 | 424 | 466.91 | 1.3 | 324 |
| | *Soaps* | | | | | | | | | | | | | | |
| 28412 07 | Aerosol and spray type household detergents | mill. kg | 60.6 | 67.3 | 1.11 | 18,718.9 | 278 | 3523 | aerosols | 000 kg | 116 | 35,820 | 309.10 | 128.8 | 278 |
| 28413 11 | Toilet Soap: Bars | 000 tons | 427.2 | 1,193.5 | 2.79 | 44,553.8 | 37 | 3523 | Toilet soap | ton | 1,409 | 146,907 | 104,300.32 | 3,935.3 | 37 |
| 28412 24 | Toilet soaps | 000 tons | 1,828.6 | 2,241.5 | 1.23 | 81,145.7 | 36 | 3523 | Laundry soap | ton | 4,213 | 186,949 | 44,375.37 | 5,164.1 | 36 |
| | NON-METALLIC MINERAL PRODUCTS | | | | | | | | | | | | | | |
| | *Cement and bricks* | | | | | | | | | | | | | | |
| 32410 | Portland cement | mill.tons | 47.3 | 2,491.9 | 52.63 | 176,377.4 | 71 | 3692 | Portland Cement | ton | 207,439 | 772,780 | 3.73 | 10,918.0 | 71 |
| 32740 -- | Lime | 1000 tons | 11,714.2 | 664.3 | 56.71 | 46,426.8 | 70 | 3692 | Lime | ton | 120,386 | 477,124 | 3.96 | 6,827.0 | 70 |
| 32510 -- | Brick and structural clay tile: | mill. of brick eq. | 7,302 | 1,078 | 0.15 | 120,580.8 | 112 | 3691 | Bricks | brick eq. | 1,081,515 | 17,859 | 16.51 | 159.6 | 112 |

## Annex Table IV.2 (continued)

| SIC Code | USA Product Item | Unit | USA Quantity (sales) | USA Dollar Value (mill. $) | USA Dollar Unit Value | USA Quantity valued at Zambian Unit Values ( mill. ZK.) | PPP ZK./$ USA Quantity Weights | ISIC Code | Zambian Product Item | Unit | Zambian Quantity | Zambian Kwacha Value (000' ZK.) | Zambian Kwacha Unit Value | Zambian Quantity valued at USA. unit Values (1000 $) | PPP ZK./$ Zambian Quantity Weights |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | METALLIC MINERAL PRODUCTS | | | | | | | | | | | | | | |
| | *Metallic Mineral Products* | | | | | | | | | | | | | | |
| 33122 13 | Blooms, billets, slabs, sheet | 000 tons | 4,367.6 | 1,577.5 | 361.19 | 122,824.4 | 78 | 3710 | castings | ton | 13,949 | 392,271 | 28,121.91 | 5,038.1 | 78 |
| 33348/418/541 | Primary, secondary and extruded aluminium | 000 tons | 2,081.1 | 4,463.2 | 2,144.62 | 770,963.9 | 173 | 3720 | aluminium products | ton | 89 | 32,811 | 370,457.77 | 189.9 | 173 |
| 33511/3 | Copper & copper-base alloy wire, bare & tinned | 000 tons | 485.3 | 939.4 | 1,935.57 | 92,213.6 | 98 | 3720 | bronze products | ton | 23 | 4,420 | 189,999.66 | 45.0 | 98 |
| 33124 16 | Structural shapes (heavy) | 000 tons | 15,906.8 | 6,120.6 | 384.78 | 39,603.5 | 6 | 3819 | steel fabrication | ton | 43,612 | 108,583 | 2,489.73 | 16,781.1 | 6 |
| 33123 | Carbon steel sheets and strips | 000 tons | 8,827.3 | 5,466.6 | 619.28 | 845,596.6 | 155 | 3819 | iron sheet | ton | 1,338 | 128,210 | 95,793.48 | 828.9 | 155 |
| 33155 | Carbon steel wire | 000 tons | 1,483.8 | 904.1 | 609.33 | 230,142.0 | 255 | 3813 | steel wire | ton | 28 | 4,343 | 155,107.14 | 17.1 | 255 |
| 33151/2/9 | Carbon steel wire strand and wire products | 000 tons | 1,127.2 | 1,102.1 | 977.72 | 90,023.6 | 82 | 3813 | wire products | ton | 381 | 30,412 | 79,863.45 | 372.3 | 82 |
| 33157 71 | Woven wire netting | 000 tons | 59.1 | 61.9 | 1,046.73 | 4,006.2 | 65 | 3813 | wire mesh | ton | 618 | 41,839 | 67,744.49 | 646.5 | 65 |
| | MOTOR VEHICLES | | | | | | | | | | | | | | |
| | *Motor Vehicles* | | | | | | | | | | | | | | |
| 37111 -- | Passenger Cars and Car Chassis | 000 units | 7258.3 | 79835.3 | 10,999.17 | 4,963,541.7 | 62 | 3843 | Passenger cars | unit | 33 | 22,293 | 683,843.56 | 358.6 | 62 |
| 37131 01 | Bus bodies | 000 units | 29 | 316.6 | 10,917.24 | 27,385.4 | 86 | 3843 | Bus bodies | unit | 15 | 13,976 | 944,324.32 | 161.6 | 86 |
| 37132 | Vans with unit body-cab: | 000 units | 2.3 | 20.6 | 8,956.52 | 1,600.1 | 78 | 3843 | Truck | unit | 87 | 60,385 | 695,673.96 | 777.4 | 78 |
| 37152 -- | Truck trailers and chassis, axle ratings | 000 units | 14.5 | 126.7 | 8,737.93 | 16,216.3 | 128 | 3843 | Trailers | unit | 12 | 12,973 | 1,118,362.07 | 101.4 | 128 |
| 37148 15 | Brake shoes (with or without lining), | 000 units | 24.5 | 151.8 | 6.20 | 20,077.1 | 132 | 3843 | Brake shoes and disc pads | unit | 4,209 | 3,449 | 819.47 | 26.1 | 132 |
| 37113 | Buses, including military: | 000 units | 21.8 | 1066.4 | 48,917.43 | 34,188.9 | 32 | 3843 | Bus vehicles | unit | 20 | 31,366 | 1,568,300.00 | 978.3 | 32 |

*Sources:*

*See Statistical references.*

## Annex V: Reference Table

**Annex Table V.1: ICOP branch classification and corresponding International Standard Industrial Classification (ISIC), revision 2**

| | ICOP branch abbreviation | ICOP branch long description | ISIC, revision 2 code |
|---|---|---|---|
| 1 | Food | Food, beverages and tobacco | 31 |
| 2 | Tex | Textile mill products | 321 |
| 3 | Wear | Wearing apparel | 322 |
| 4 | Leat | Leather products | 323 and 324 |
| 5 | Wood | Wood products | 33 |
| 6 | Pap | Paper, printing and publishing | 34 |
| 7 | Chem | Chemicals products | 351, 352, 353 and 354 |
| 8 | Rub | Rubber and plactic products | 355 and 356 |
| 9 | Mine | Non-metallic mineral products | 36 |
| 10 | Met | Basic and fabricated metal products | 37 and 381 |
| 11 | Mach | Machinery and transport equipment | 382 and 384 |
| 12 | Elec | Electrical machinery and equipment | 384 |
| 13 | Oth | Other manufacturing | 385 and 39 |

*Source:*
*Szirmai and Pilat, 1990, Appendix I.*

# Company Annex

## Annex VI: Company Production Processes

### Annex VI.1: Clear Beer Production Process

The production process of clear beer consists of two main sub-processes: the brewing and bottling sub-processes. The illustration below (Figure VI-1) shows the outline of the beer production process. The brewing sub-process can, however, be divided into six further sub-processes. These are the malt processing, the mash processing, the wort processing, the fermentation, the conditioning and the filtration.

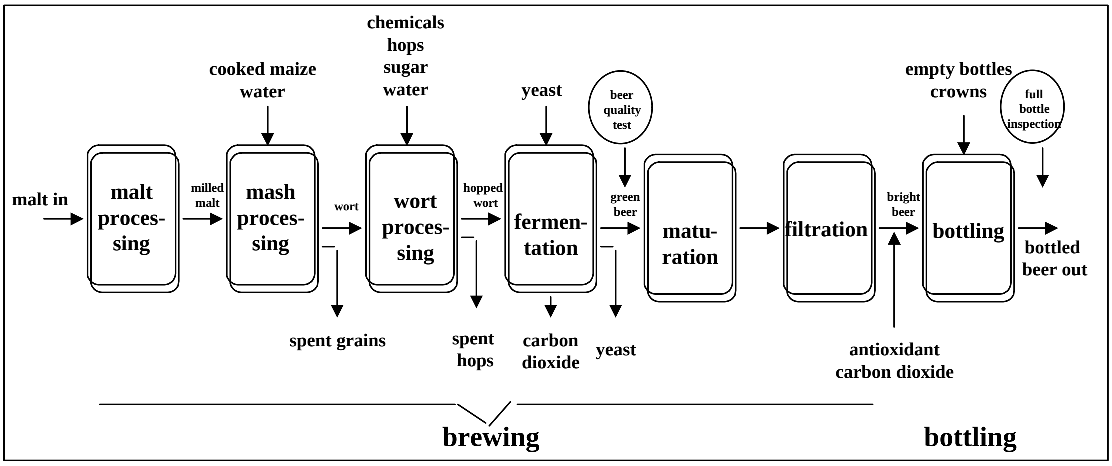


**Figure VI-1: Beer production process**

The following is a brief description of these sub-processes (Figure VI-2):

a) Malt processing
During this processing, barley from storage silos is screened, weighed, soaked in water and allowed to germinate. This initiates the enzyme reactions necessary to convert starch to fermentable sugars. The reaction is then halted by kilning, yielding the colour and flavour compounds which characterise beer. The prepared barley is now known as malted barley or just malt. This malt is then milled and batched.

b) Mash processing
The milled malt is mixed with water and taken through various temperature stands, which allow the natural enzymes to convert all the starch to fermentable sugars. At a temperature of 50ºC enzyme reactions convert insoluble proteins to soluble proteins. After a given period of time the temperature is further raised to about 68ºC to allow other enzymes convert starch into malt sugars. Similarly, after a certain period of time the temperature is further raised to 78ºC where all active enzymes are destroyed. Then, the mash enters the lauter tun filter, where spent grains are separated from the mixture. Additional water at 78ºC, referred to as sparge water, is flushed through the spent grains in order to flush out all

sugars and aroma from the remaining mixture. The spent grains are drained and are ideal for stock feed and compost. The extract is referred to as sweet wort.

c) Wort processing
The wort flows either into the wort kettle or into the wort receiver. In the wort kettle the wort is heated to 100ºC and then boiled to aid flavour formation and sterility. Depending upon the gravity of the initial wort, this may take one to three hours. At this stage hops, extra sugar and some flavour extracts are added. The boiled hopped wort is then pumped to a whirlpool where hops are strained off. From the whirlpool the wort is pumped to a heat exchanger wort cooler, where it is cooled down to about 10ºC and transferred to the fermentation vessels.

d) Fermentation
A selected yeast culture is added to the cooled wort and initiates fermentation. This is a biochemical reaction in which wort is converted into alcohol and carbon dioxide. Part of the carbon dioxide is collected and stored in liquid state for later injection during maturation and after beer filtration. During the reaction, heat is released and the temperature is controlled by use of refrigerant circulation through vessel jackets to produce the required brand characteristics. Fermentation takes about ten days, and yeast is separated from the mixture. The separated mixture is called green beer.

e) Maturation
Once fermentation is complete, the beer goes through a cold maturation process. During this process the beer ripens and gets full taste. This may take about two weeks. The beer is kept cool in vessels that are installed in air-cooled rooms.

f) Filtration
The beer, which has gained some heat during maturation, is cooled down again to about 1ºC. Carbon dioxide is, then, injected into the beer. Thereafter, the beer is filtered to remove remaining yeast and other insoluble matters. The filtered beer is bright and stored in bright beer tanks before packaging.

g) Bottling
Finally, the bright beer is pumped to the filler where it is filled into washed empty bottles. The filled bottles are then pasteurised to eliminate the activities of microbes and those of possible remaining yeast. After this the filled bottles undergo inspection. After bottle labelling, the filled bottles are packed into clean crates at the packer ready for distribution either to company distribution depots located in various parts of the country or to customers. Figure 7-3 gives further details of the layout of a bottle line in the beer-bottling hall. The line is made up of a number of machines that are connected by a system of conveyors.

The layout of one bottle line is presented in Figure VI-3.

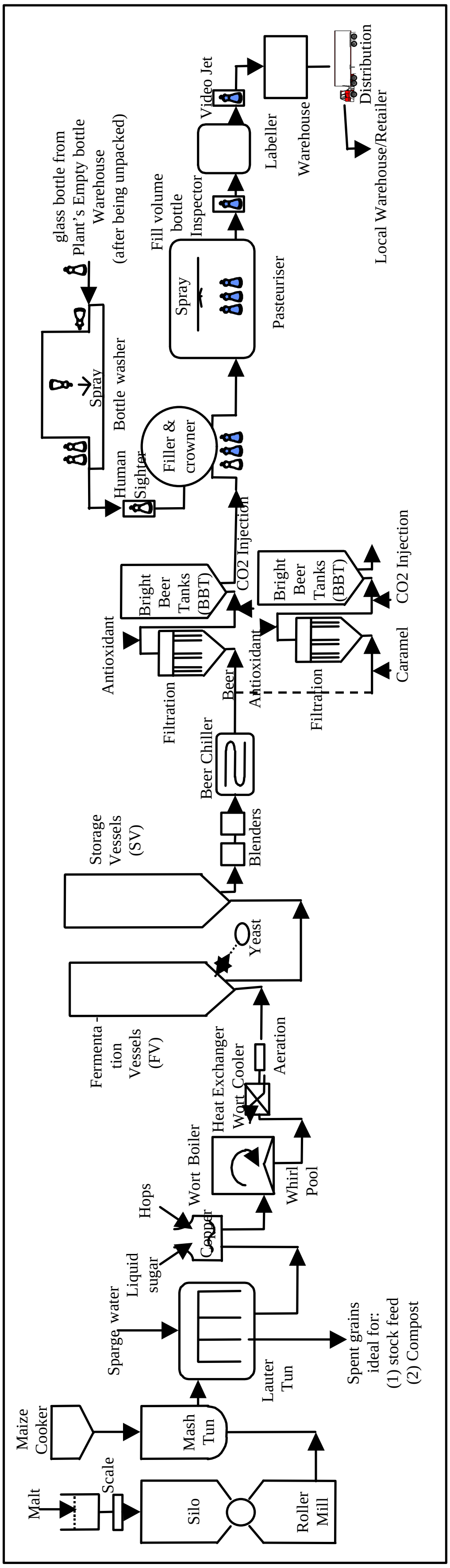


**Figure VI-2: Beer production flow chart**

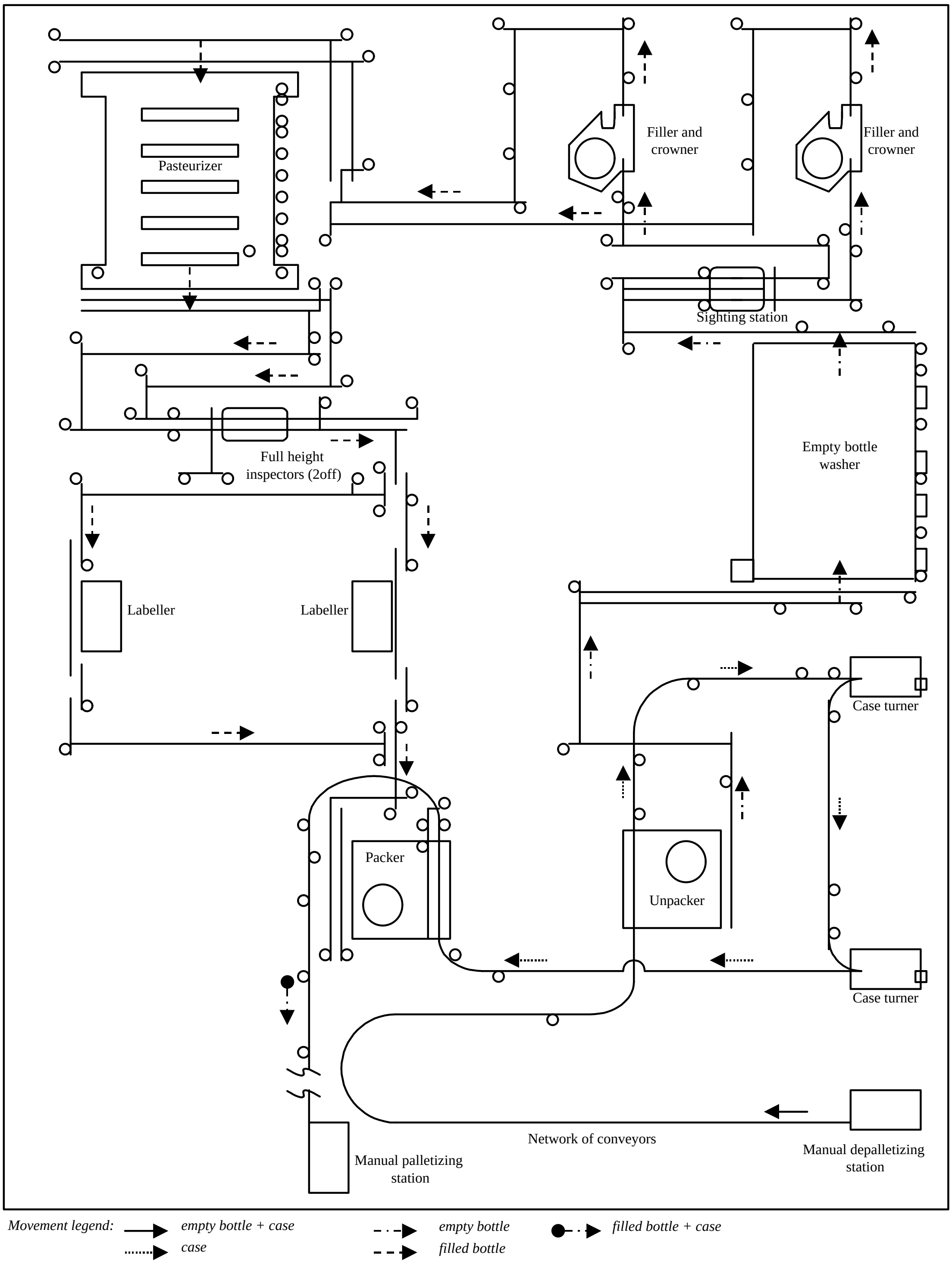


**Figure VI-3: Layout of a bottle line**

**Table VI.1: Monthly output, labour, qualified gross output per worker and transformation efficiency for company 1, January 1995-December 1998**

| | 1<br>Qualified gross output<br>(hectolitres) | 2<br>Employment<br>(persons) | 3<br>Disqualified products ( as a % of beer ' withdraw ')<br>(%) | 4<br>Disqualified products<br>(hectolitres) | 5<br>Qualified gross output per person engaged<br>(hl/worker) | 6<br>Production system transformation efficiency<br>(a) |
|---|---|---|---|---|---|---|
| Jan-95 | 35,185.0 | 623 | 18.7 | 8,073.2 | 56.5 | 0.283 |
| Feb-95 | 28,923.0 | 623 | 21.1 | 7,737.4 | 46.4 | 0.292 |
| Mar-95 | 44,367.0 | 616 | 13.6 | 6,992.7 | 72.0 | 0.387 |
| Apr-95 | 46,719.0 | 605 | 15.9 | 8,822.9 | 77.2 | 0.417 |
| May-95 | 48,702.0 | 601 | 12.8 | 7,146.5 | 81.0 | 0.431 |
| Jun-95 | 39,450.0 | 597 | 13.4 | 6,102.6 | 66.1 | 0.358 |
| Jul-95 | 36,491.0 | 591 | 14.5 | 6,169.5 | 61.7 | 0.312 |
| Aug-95 | 47,526.0 | 612 | 19.2 | 11,302.9 | 77.7 | 0.342 |
| Sep-95 | 32,874.0 | 610 | 27.6 | 12,556.7 | 53.9 | 0.238 |
| Oct-95 | 35,765.0 | 610 | 27.7 | 13,717.8 | 58.6 | 0.219 |
| Nov-95 | 34,444.0 | 608 | 20.6 | 8,933.3 | 56.7 | 0.278 |
| Dec-95 | 37,169.0 | 591 | 13.4 | 5,726.6 | 62.9 | 0.294 |
| Jan-96 | 31,860.0 | 583 | 12.0 | 4,328.3 | 54.6 | 0.374 |
| Feb-96 | 27,504.0 | 565 | 20.5 | 7,112.6 | 48.7 | 0.300 |
| Mar-96 | 30,196.0 | 557 | 10.8 | 3,657.4 | 54.2 | 0.461 |
| Apr-96 | 24,990.0 | 547 | 11.3 | 3,183.6 | 45.7 | 0.470 |
| May-96 | 28,569.0 | 529 | 34.7 | 15,214.0 | 54.0 | 0.252 |
| Jun-96 | 36,566.0 | 507 | 26.6 | 13,222.4 | 72.1 | 0.317 |
| Jul-96 | 33,715.0 | 509 | 25.0 | 11,241.0 | 66.2 | 0.292 |
| Aug-96 | 40,933.0 | 507 | 21.5 | 11,190.9 | 80.7 | 0.293 |
| Sep-96 | 46,173.0 | 506 | 20.5 | 11,879.7 | 91.3 | 0.283 |
| Oct-96 | 44,716.0 | 504 | 4.8 | 2,270.6 | 88.7 | 0.294 |
| Nov-96 | 43,898.0 | 500 | 2.9 | 1,316.5 | 87.8 | 0.422 |
| Dec-96 | 48,814.0 | 499 | 12.9 | 7,198.7 | 97.8 | 0.324 |
| Jan-97 | 33,289.0 | 487 | 4.5 | 1,576.8 | 68.4 | 0.447 |
| Feb-97 | 34,374.0 | 481 | 5.6 | 2,026.1 | 71.5 | 0.438 |
| Mar-97 | 39,758.0 | 477 | 11.6 | 5,206.0 | 83.4 | 0.388 |
| Apr-97 | 40,933.0 | 480 | 13.4 | 6,343.1 | 85.3 | 0.333 |
| May-97 | 47,559.0 | 476 | 14.1 | 7,826.3 | 99.9 | 0.307 |
| Jun-97 | 46,659.0 | 485 | 9.5 | 4,919.3 | 96.2 | 0.339 |
| Jul-97 | 49,739.0 | 488 | 4.1 | 2,116.0 | 101.9 | 0.388 |
| Aug-97 | 47,182.0 | 484 | 22.4 | 13,647.4 | 97.5 | 0.287 |
| Sep-97 | 52,800.0 | 476 | 13.9 | 8,541.9 | 110.9 | 0.338 |
| Oct-97 | 60,669.0 | 476 | 15.0 | 10,701.8 | 127.5 | 0.353 |
| Nov-97 | 47,704.0 | 474 | 40.1 | 31,900.0 | 100.6 | 0.267 |
| Dec-97 | 54,819.0 | 475 | 18.3 | 12,265.7 | 115.4 | 0.353 |
| Jan-98 | 43,025.0 | 472 | 6.9 | 3,166.1 | 91.2 | 0.352 |
| Feb-98 | 47,391.0 | 461 | 9.9 | 5,196.3 | 102.8 | 0.313 |
| Mar-98 | 44,449.0 | 460 | 15.8 | 8,330.5 | 96.6 | 0.341 |
| Apr-98 | 43,002.0 | 460 | 21.1 | 11,489.9 | 93.5 | 0.300 |
| May-98 | 51,097.0 | 464 | 20.4 | 13,117.7 | 110.1 | 0.373 |
| Jun-98 | 37,775.0 | 461 | 9.5 | 3,946.2 | 81.9 | 0.335 |
| Jul-98 | 46,685.0 | 481 | 9.5 | 4,881.3 | 97.1 | 0.366 |
| Aug-98 | 59,947.0 | 484 | 22.9 | 17,821.4 | 123.9 | 0.355 |
| Sep-98 | 45,051.0 | 468 | 24.8 | 14,831.7 | 96.3 | 0.285 |
| Oct-98 | 46,194.0 | 459 | 15.6 | 8,515.5 | 100.6 | 0.386 |
| Nov 98 | 47,449.0 | 459 | 10.6 | 5,643.4 | 103.4 | 0.398 |
| Dec 98 | 50,992.0 | 455 | 15.9 | 9,671.9 | 112.1 | 0.394 |

*Sources for raw data:*

*Daily and Weekly Production and Quality Reports and Record Books; Monthly Personnel Reports and Records, 1995-98, and Table 6-6*

*(a)* *Calculated with equation (3.21)*

**Table VI.2 Basic monthly time data for company 1, January 1995-December 1998**

| | 1<br>Considered period<br>(hours) | 2<br>Planned plant shut down<br>(hours) | 3<br>Recorded line down time (as a results of breakdowns 4, 5, 6, 7)<br>(hours) | 4<br>Filler breakdown time<br>(hours) | 5<br>Labeller breakdown time<br>(hours) | 6<br>Bottle conveyor breakdown time<br>(hours) | 7<br>Bottle washer breakdown time<br>(hours) | 8<br>Other time losses (i.e. idle time, waiting time, set-up time, external utility failure, etc.)<br>(hours) | 9<br>Total lost time (2+3+8)<br>(hours) |
|---|---|---|---|---|---|---|---|---|---|
| Jan-95 | 648.0 | 58.5 | 90.0 | 60.0 | 12.5 | 8.0 | 41.4 | 273.9 | 422.4 |
| Feb-95 | 576.0 | 87.8 | 80.0 | 40.0 | 15.0 | 11.7 | 26.7 | 195.1 | 362.9 |
| Mar-95 | 648.0 | 58.5 | 65.2 | 30.3 | 25.0 | 9.1 | 29.0 | 234.2 | 357.9 |
| Apr-95 | 624.0 | 58.5 | 73.0 | 72.0 | 30.9 | 10.2 | 13.1 | 183.2 | 314.8 |
| May-95 | 648.0 | 58.5 | 61.2 | 60.2 | 16.8 | 14.4 | 47.4 | 207.7 | 327.4 |
| Jun-95 | 624.0 | 58.5 | 61.3 | 61.3 | 14.5 | 425.0 | 49.0 | 246.0 | 365.9 |
| Jul-95 | 648.0 | 87.8 | 284.3 | 43.8 | 19.0 | 0.7 | 34.0 | 39.7 | 411.8 |
| Aug-95 | 648.0 | 73.2 | 88.8 | 23.2 | 12.3 | 30.2 | 9.2 | 211.4 | 373.3 |
| Sep-95 | 624.0 | 146.3 | 94.1 | 19.8 | 17.0 | 16.2 | 50.2 | 178.5 | 418.9 |
| Oct-95 | 648.0 | 117.1 | 112.1 | 15.0 | 3.2 | 10.1 | 1.8 | 222.7 | 451.8 |
| Nov-95 | 624.0 | 161.0 | 65.0 | 40.0 | 20.0 | 30.5 | 2.6 | 179.3 | 405.3 |
| Dec-95 | 624.0 | 117.1 | 50.0 | 35.0 | 7.3 | 14.7 | 1.5 | 245.0 | 412.1 |
| Jan-96 | 648.0 | 156.2 | 42.8 | 74.2 | 5.9 | 4.2 | 4.3 | 174.0 | 373.0 |
| Feb-96 | 576.0 | 213.0 | 41.7 | 41.7 | 0.0 | 0.1 | 16.8 | 104.0 | 358.7 |
| Mar-96 | 648.0 | 227.2 | 26.6 | 26.6 | 15.8 | 9.4 | 0.8 | 59.7 | 313.4 |
| Apr-96 | 624.0 | 284.0 | 7.8 | 17.7 | 4.1 | 0.0 | 1.8 | 1.5 | 293.3 |
| May-96 | 648.0 | 213.0 | 95.0 | 16.0 | 1.4 | 7.2 | 3.2 | 89.8 | 397.8 |
| Jun-96 | 624.0 | 170.4 | 84.2 | 12.0 | 8.3 | 10.1 | 3.5 | 99.7 | 354.3 |
| Jul-96 | 648.0 | 198.8 | 73.5 | 31.0 | 28.2 | 21.3 | 0.7 | 123.3 | 395.6 |
| Aug-96 | 648.0 | 85.2 | 101.7 | 59.2 | 70.3 | 5.8 | 19.9 | 219.4 | 406.3 |
| Sep-96 | 624.0 | 71.0 | 96.8 | 93.3 | 122.8 | 45.7 | 22.0 | 234.5 | 402.3 |
| Oct-96 | 648.0 | 71.0 | 23.7 | 47.3 | 39.0 | 45.8 | 37.0 | 353.4 | 448.0 |
| Nov-96 | 624.0 | 127.8 | 11.1 | 59.7 | 44.8 | 64.5 | 49.2 | 213.6 | 352.5 |
| Dec-96 | 624.0 | 85.2 | 57.6 | 51.7 | 60.2 | 66.7 | 5.2 | 249.2 | 391.9 |
| Jan-97 | 648.0 | 211.8 | 12.3 | 24.5 | 42.7 | 7.5 | 32.2 | 120.8 | 344.8 |
| Feb-97 | 576.0 | 183.5 | 13.8 | 13.8 | 26.3 | 14.1 | 10.8 | 111.7 | 309.1 |
| Mar-97 | 648.0 | 127.1 | 47.3 | 94.5 | 152.8 | 61.6 | 54.3 | 189.6 | 363.9 |
| Apr-97 | 624.0 | 56.5 | 67.0 | 134.0 | 161.1 | 0.0 | 448.4 | 260.9 | 384.3 |
| May-97 | 648.0 | 28.2 | 80.2 | 120.4 | 255.2 | 28.0 | 45.0 | 308.0 | 416.4 |
| Jun-97 | 624.0 | 28.2 | 51.8 | 103.7 | 193.1 | 40.0 | 27.7 | 310.4 | 390.5 |
| Jul-97 | 648.0 | 42.4 | 22.1 | 44.2 | 159.3 | 32.0 | 114.2 | 321.6 | 386.0 |
| Aug-97 | 648.0 | 70.6 | 112.7 | 40.3 | 180.1 | 80.5 | 121.3 | 224.8 | 408.0 |
| Sep-97 | 624.0 | 42.4 | 72.7 | 105.4 | 102.5 | 19.0 | 92.2 | 264.1 | 379.2 |
| Oct-97 | 648.0 | 10.6 | 89.4 | 178.9 | 150.2 | 63.1 | 171.2 | 278.6 | 378.6 |
| Nov-97 | 624.0 | 81.2 | 187.3 | 27.6 | 152.8 | 80.8 | 71.3 | 77.0 | 345.5 |
| Dec-97 | 624.0 | 61.8 | 90.0 | 100.0 | 134.4 | 33.2 | 75.2 | 202.9 | 354.6 |
| Jan-98 | 648.0 | 56.2 | 74.9 | 94.8 | 132.5 | 43.3 | 41.1 | 271.9 | 403.0 |
| Feb-98 | 576.0 | 42.2 | 95.5 | 51.0 | 174.6 | 49.5 | 61.1 | 238.2 | 375.9 |
| Mar-98 | 648.0 | 98.4 | 137.1 | 21.1 | 82.4 | 27.2 | 133.7 | 149.9 | 385.4 |
| Apr-98 | 624.0 | 91.4 | 150.3 | 23.6 | 58.7 | 46.8 | 116.8 | 145.0 | 386.6 |
| May-98 | 648.0 | 66.8 | 188.9 | 37.9 | 173.4 | 15.6 | 44.9 | 88.3 | 344.0 |
| Jun-98 | 624.0 | 91.4 | 85.3 | 70.5 | 99.0 | 14.7 | 96.9 | 216.8 | 393.4 |
| Jul-98 | 648.0 | 116.0 | 82.1 | 64.1 | 69.5 | 20.9 | 70.3 | 187.8 | 385.8 |
| Aug-98 | 648.0 | 105.4 | 164.1 | 128.3 | 94.9 | 30.2 | 17.5 | 80.3 | 349.8 |
| Sep-98 | 624.0 | 84.3 | 198.0 | 196.5 | 70.8 | 0.0 | 47.5 | 105.7 | 388.0 |
| Oct-98 | 648.0 | 94.9 | 80.0 | 70.2 | 90.0 | 1.5 | 5.7 | 177.2 | 352.1 |
| Nov 98 | 624.0 | 91.4 | 70.9 | 50.6 | 59.5 | 25.4 | 44.9 | 183.9 | 346.2 |
| Dec 98 | 624.0 | 70.3 | 90.5 | 56.0 | 20.9 | 45.8 | 38.5 | 171.0 | 331.8 |

*Souces for raw data: Daily and Weekly Production, and Maintenance Reports and Record Books, 1995-98.*

## Annex VI.2: Paint Production Process

Paint is a mixture of pigment with some suitable liquid, such as a water dispersion of glue or protein. When spread in thin films (generally 0.8 to 1.5 mils), these mixtures form a solid, adherent coating for decorative and protective purposes.

Paint production at company 2 is done in batches. The basic production process in paint manufacture is the dispersion of pigments in a paint medium. The pigment solid particles are wetted by the liquid in order to produce a stable dispersion.

Figure VI-4 gives a flow chart of paint production. The main intermediate inputs consist of resins, solvents and pigments, whose nature and relative quantities determine the properties of the paint.

After the intermediate inputs have been tested and approved as conforming to the standard specifications, they are ready for the various stages of production. A system of sampling is used to check incoming intermediate inputs to ensure conformation to specification standards.

The intermediate inputs are weighed according to the batch tickets as designated by the formula for each production item. The dispersion of pigments is accomplished in various types of mixing and grinding equipment.

Pre-mixing produces a coarse dispersion of aggregates from dry pigment and liquid medium, before the aggregates are dispersed by further treatment.

The weighed intermediate inputs that have been pre-mixed to a semi-paste consistency, are transported either to the ball milling stage for the production of red oxide paint or to further dispersion in mixing tanks for the production of white paint. Depending on the quantity required, the mixing is carried out in portable mixing tanks for smaller quantities, or in the varishears for larger quantities.
The breakdown of pigment aggregates and subsequent dispersion of the particles in the liquid medium is brought about by the use of high rates of shear and low consistencies. During dispersion, both shear and attrition are involved in varying amounts in the ball mill and high-speed impellers.

The slurry from the mixing stage is then tinted to give the required paint colours. After this phase of operations, paints are checked and tested against established specifications. The specifications relate to colour and other performance requirements (such as paint drying times, toughness and resistances of various sorts). When the paints have been approved by the control laboratory, they are ready to be packaged into various sizes of containers. The final surface coatings are usually filled in containers of 1, 2.5 and 5 litre capacities. Manual labelling of containers follows immediately after the filling operation.

After dispersion, either in the ball mill or varishear, a dispersion test is carried out to determine whether the acceptable degree of dispersion required for the batch has been obtained.

The factory layout is shown in Figure VI-5. The mixers consist basically of a steel cylinder mounted vertically and carrying stirrers. The stirrers are made up of shafts with arms that are made to rotate mechanically. The ball mills are steel lined cylinders and contain steel balls. They are mounted horizontally and are capable of being rotated about their axes. Dispersion in the ball mills takes place, mainly by shear resulting from the relative movement of the balls, and to a lesser extent by impact. The Torrance mill is a dual-purpose single-roll mill that is supplied with two bars for dispersing pigments and refining paint. The paint or pre-mixed slurry is placed in a hopper over a chilled iron roller, which is hollow for water cooling. Pressure can be applied to the bar fitted at the outlet of the hopper to give the desired degree of refinement or dispersion.

The handling of intermediate inputs and pre-mixed slurry in the factory from one workstation to another is done by means of a fork truck and hand trucks. In the case of intermediate inputs, these are in pallet loads or in drums. The material in process is usually filled in a portable tank after having been drained from one machine and then transported to the next workstation.

Since the eighties the company has not been doing well. The production process degraded more and more, mainly because of old equipment and insufficient maintenance. There were many breakdowns on the ball mills and the varishear high-speed dispensers. The mixing tanks had a serious scale build up as no appropriate method for descaling the tanks was in place. This often led to paint contamination.

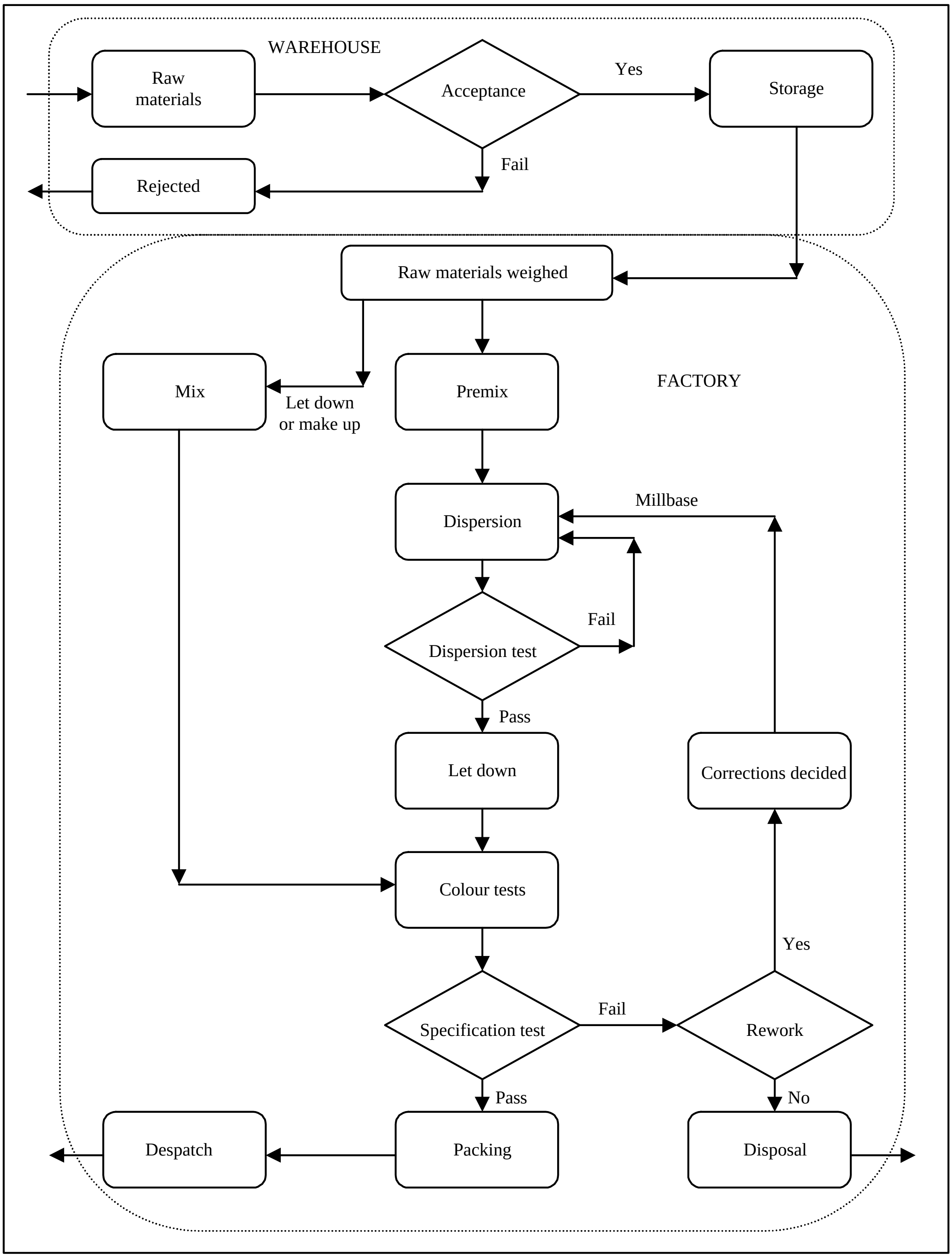


**Figure VI-4: Paint process flow chart**

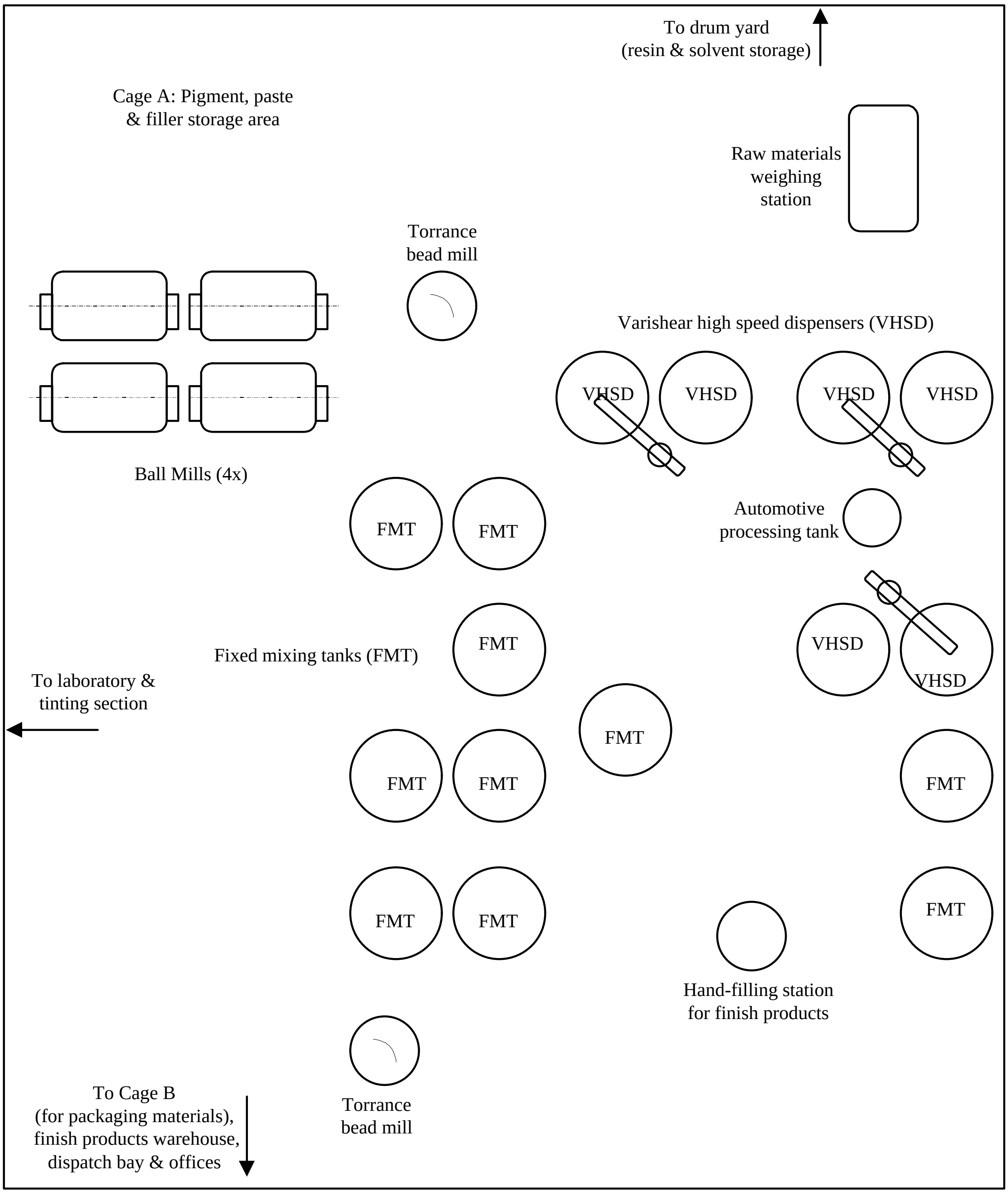


**Figure VI-5: Factory layout**

**Table VI.3: Monthly output, labour, qualified gross output per worker and transformation efficiency for company 2, January 1995-December 1998**

| | 1<br>Qualified gross output<br>(litres) | 2<br>Employment<br>(persons) | 3<br>Percentage of disqualified products<br>(%) | 4<br>Disqualified products<br>(litres) | 5<br>Considered period<br>(hours) | 6<br>Total effective time<br>(hours) | 7<br>Total lost time<br>(hours) | 8<br>Qualified gross output per person engaged<br>(l/worker) | 9<br>Production system transformation efficiency<br>(a) |
|---|---|---|---|---|---|---|---|---|---|
| Jan-95 | 93,635.0 | 125 | 41.0 | 65,103.7 | 583.0 | 306.2 | 276.8 | 749.1 | 0.310 |
| Feb-95 | 56,228.0 | 123 | 42.4 | 41,419.5 | 517.0 | 172.6 | 344.4 | 457.1 | 0.192 |
| Mar-95 | 60,864.0 | 119 | 41.0 | 42,237.3 | 583.0 | 147.5 | 435.5 | 511.5 | 0.149 |
| Apr-95 | 65,158.0 | 119 | 35.1 | 35,268.7 | 561.0 | 171.6 | 389.4 | 547.5 | 0.198 |
| May-95 | 59,966.0 | 119 | 45.1 | 49,351.6 | 583.0 | 243.1 | 339.9 | 503.9 | 0.229 |
| Jun-95 | 82,731.0 | 119 | 29.6 | 34,731.0 | 561.0 | 249.7 | 311.3 | 695.2 | 0.314 |
| Jul-95 | 66,543.0 | 119 | 52.8 | 74,548.3 | 583.0 | 278.0 | 305.0 | 559.2 | 0.225 |
| Aug-95 | 91,543.0 | 119 | 36.1 | 51,793.9 | 583.0 | 117.6 | 465.4 | 769.3 | 0.129 |
| Sep-95 | 90,312.0 | 118 | 48.5 | 85,124.4 | 561.0 | 389.3 | 171.7 | 765.4 | 0.357 |
| Oct-95 | 63,537.0 | 117 | 53.1 | 72,038.7 | 583.0 | 238.0 | 345.0 | 543.1 | 0.191 |
| Nov-95 | 71,669.0 | 117 | 48.7 | 68,061.5 | 561.0 | 280.0 | 281.0 | 612.6 | 0.256 |
| Dec-95 | 62,530.0 | 117 | 45.8 | 52,880.7 | 517.0 | 222.0 | 295.0 | 534.4 | 0.233 |
| Jan-96 | 66,386.0 | 117 | 53.9 | 77,687.5 | 561.0 | 287.6 | 273.4 | 567.4 | 0.236 |
| Feb-96 | 84,166.0 | 85 | 34.2 | 43,790.9 | 539.0 | 183.0 | 356.0 | 990.2 | 0.223 |
| Mar-96 | 87,157.0 | 85 | 30.0 | 37,416.1 | 583.0 | 186.6 | 396.4 | 1,025.4 | 0.224 |
| Apr-96 | 75,082.0 | 95 | 36.7 | 43,533.2 | 392.3 | 155.8 | 236.5 | 790.3 | 0.251 |
| May-96 | 76,594.0 | 115 | 44.6 | 61,686.0 | 583.0 | 218.0 | 365.0 | 666.0 | 0.207 |
| Jun-96 | 117,474.0 | 117 | 35.0 | 63,361.5 | 561.0 | 153.4 | 407.6 | 1,004.1 | 0.178 |
| Jul-96 | 67,840.0 | 117 | 51.0 | 70,529.5 | 583.0 | 329.3 | 253.7 | 579.8 | 0.277 |
| Aug-96 | 60,805.0 | 115 | 32.9 | 29,841.7 | 583.0 | 228.8 | 354.2 | 528.7 | 0.263 |
| Sep-96 | 90,856.0 | 113 | 52.1 | 98,784.9 | 561.0 | 376.0 | 185.0 | 804.0 | 0.321 |
| Oct-96 | 66,983.0 | 110 | 47.4 | 60,397.2 | 583.0 | 318.2 | 264.8 | 608.9 | 0.287 |
| Nov-96 | 95,435.0 | 110 | 42.7 | 71,045.0 | 561.0 | 300.7 | 260.3 | 867.6 | 0.307 |
| Dec-96 | 56,664.0 | 110 | 49.8 | 56,322.5 | 517.0 | 233.6 | 283.4 | 515.1 | 0.227 |
| Jan-97 | 66,320.0 | 110 | 39.1 | 42,536.0 | 583.0 | 278.0 | 305.0 | 602.9 | 0.291 |
| Feb-97 | 91,483.0 | 110 | 22.8 | 27,061.7 | 517.0 | 156.7 | 360.3 | 831.7 | 0.234 |
| Mar-97 | 40,044.0 | 111 | 40.8 | 27,596.1 | 583.0 | 133.9 | 449.1 | 360.8 | 0.136 |
| Apr-97 | 56,951.0 | 108 | 28.8 | 23,043.1 | 561.0 | 155.8 | 405.2 | 527.3 | 0.198 |
| May-97 | 54,734.0 | 107 | 37.1 | 32,244.2 | 583.0 | 220.8 | 362.2 | 511.5 | 0.238 |
| Jun-97 | 69,780.0 | 107 | 24.5 | 22,691.7 | 561.0 | 226.8 | 334.2 | 652.1 | 0.305 |
| Jul-97 | 40,449.0 | 107 | 54.6 | 48,706.7 | 583.0 | 252.4 | 330.6 | 378.0 | 0.196 |
| Aug-97 | 49,778.0 | 97 | 40.5 | 33,840.0 | 583.0 | 106.8 | 476.2 | 513.2 | 0.109 |
| Sep-97 | 42,088.0 | 97 | 56.9 | 55,616.7 | 561.0 | 353.5 | 207.5 | 433.9 | 0.271 |
| Oct-97 | 43,359.0 | 97 | 52.1 | 47,067.0 | 583.0 | 216.2 | 366.8 | 447.0 | 0.178 |
| Nov-97 | 40,900.0 | 101 | 52.1 | 44,468.5 | 561.0 | 254.3 | 306.7 | 405.0 | 0.217 |
| Dec-97 | 39,380.0 | 101 | 46.7 | 34,550.0 | 539.0 | 201.6 | 337.4 | 389.9 | 0.199 |
| Jan-98 | 37,022.0 | 101 | 46.5 | 32,159.7 | 583.0 | 253.9 | 329.1 | 366.6 | 0.233 |
| Feb-98 | 29,706.0 | 101 | 37.9 | 18,127.8 | 517.0 | 161.5 | 355.5 | 294.1 | 0.194 |
| Mar-98 | 25,670.0 | 101 | 37.6 | 15,488.9 | 583.0 | 164.7 | 418.3 | 254.2 | 0.176 |
| Apr-98 | 29,827.0 | 100 | 37.7 | 18,021.1 | 561.0 | 137.5 | 423.5 | 298.3 | 0.153 |
| May-98 | 34,763.0 | 97 | 42.3 | 25,535.7 | 572.0 | 192.5 | 379.5 | 358.4 | 0.194 |
| Jun-98 | 31,397.0 | 97 | 45.5 | 26,229.3 | 561.0 | 135.4 | 425.6 | 323.7 | 0.132 |
| Jul-98 | 47,624.0 | 97 | 38.0 | 29,196.6 | 583.0 | 290.7 | 292.3 | 491.0 | 0.309 |
| Aug-98 | 44,830.0 | 92 | 21.6 | 12,353.3 | 583.0 | 202.0 | 381.0 | 487.3 | 0.272 |
| Sep-98 | 64,748.0 | 86 | 38.7 | 40,893.3 | 561.0 | 332.0 | 229.0 | 752.9 | 0.363 |
| Oct-98 | 43,381.0 | 81 | 36.6 | 25,002.2 | 583.0 | 280.9 | 302.1 | 535.6 | 0.306 |
| Nov 98 | 55,480.0 | 83 | 34.6 | 29,410.0 | 561.0 | 265.4 | 295.6 | 668.4 | 0.309 |
| Dec 98 | 53,073.0 | 85 | 30.5 | 23,315.4 | 517.0 | 214.7 | 302.3 | 624.4 | 0.289 |

*Sources for raw data:*
*Daily and Weekly Production and Quality Control Reports and Records, Monthly Personnel and Management Account Reports and Records, 1995-9*
*(a) Calculated with equation (3.21)*

## Annex VI.3: Yarn Production Process

The spinning process is the transformation of raw fibres, natural or synthetic, into yarn. In the case of company 3, the use of natural fibres is exclusively dominated by cotton. The production of yarn involves several preparatory processes before the final spinning stage. These processes, illustrated in Figure VI-6, are described below.

a) Opening, cleaning and lap formation
In this first stage, the bales of incoming raw fibres are opened up, cleaned of dust particles, seed coats and other natural trash, and blended. The blend ratio of different cotton qualities is dependent upon the required quality of the yarn. The blended bale fibres are then transformed into laps (or sheets) that can be used in the next stage, called carding. The amount of lap is measured in weight and length. During this process the blowing and scutching machines are used. The laps of cotton that go to carding still contain partially unopened fibres together with some dirt.

b) Carding
Carding is meant to reduce the laps of fibre into slivers by the removal of the remaining impurities and excessively short fibres, separating the fibres and making them parallel. For higher grade and finer yarns, the carding sliver is subjected to a combing process. The purpose of combing is to obtain a high quality yarn that contains fewer short fibres and that is more even than the carded yarn. The two processes are carried out by the carding and combing machines.

c) Drawing
The drawing process is aimed at reducing the variation in weight of the sliver by further straightening of the fibres and reduction of the size of carding sliver as it passes between successive sets of rollers. Each of the sets of rollers moves at a speed higher than that of the preceding set. The reduction of weight (per metre) of the sliver is called the draft. This term is also used in the roving and spinning processes.

d) Roving
The sliver from the drawing process is taken to the roving process where it is made thinner by the same principle of increasingly fast rollers employed in the drawing process. The sliver is also twisted slightly to increase its strength. The roving process that produces the roving as its end product is omitted if the sliver is fed to an open-end spinning process.

e) Spinning
Spinning is meant to reduce the number of fibres in the roving per metre by drafting and twisting the previously parallel strands into a spiral. This process enables the strands to stick together and give the end product of this process - yarn, enough strength to stand greater stresses resulting from succeeding operations. The yarn is wound onto bobbins and its thickness is called its count. In company 3, there are two types of spinning processes. These are the ring spinning and open-end spinning. In ring spinning, the yarn being spun is twisted as the spindle travels more quickly than the front drafting roller. The number of twist per inch is given by the ratio of the number of rotations of the spindle per turn of the front roller. In open end spinning, instead of rotating the entire bobbin of yarn (or package of yarn) to obtain the twist, an open-end of the yarn is rotated around the axis of the yarn. The main benefits of open-end spinning are that yarn formation proceeds at a faster rate

than in ring spinning and that the roving process can be skipped entirely. The ring spinning, on the other hand, has a relatively lower investment cost per spinning unit (i.e. spindle) and can be used for almost all yarn-products. For example, low and high yarn counts, and all blends of natural and synthetic fibres can be produced using ring spinning. Open-end spinning systems are suitable for low counts. The most popular spinning technology is ring spinning.

f) Twisting and winding

The spinning cycle often includes other preparatory stages for the weaving (or knitting) process after the spinning of the yarn. Company 3’s spinning mills also take up some of this preparation by performing some twisting and winding of the produced yarn. Twisting several yarns is carried out to obtain different specific final products. Removing faults in the yarn and winding it on larger cones is a process that facilitates further use of the yarn. Several machines, such as autoconers, assembly winders and twisters, are employed to combine the winding and spinning process.

A layout of two production plants is given in Figure VI-7.

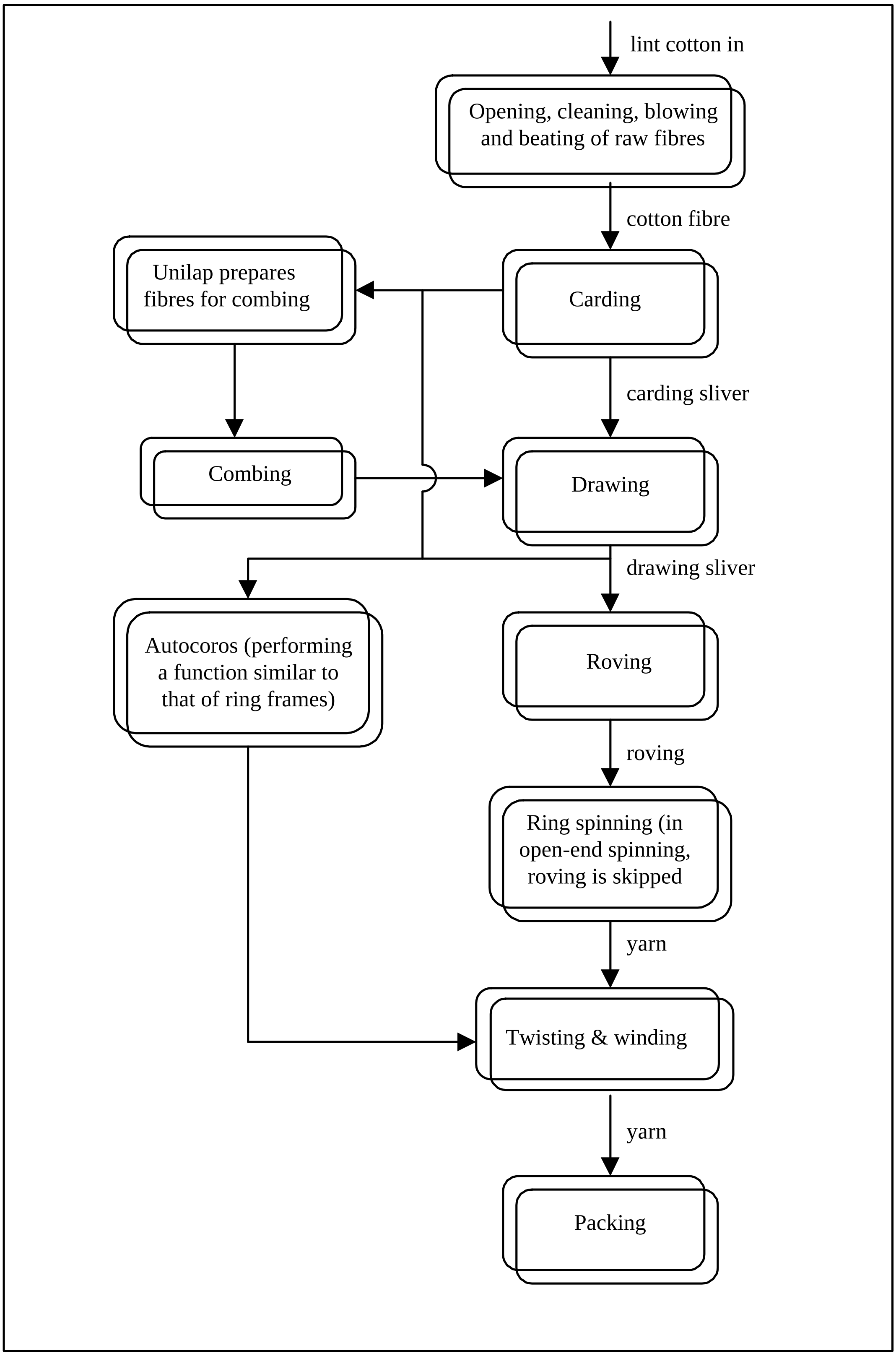


**Figure VI-6: Yarn production process**

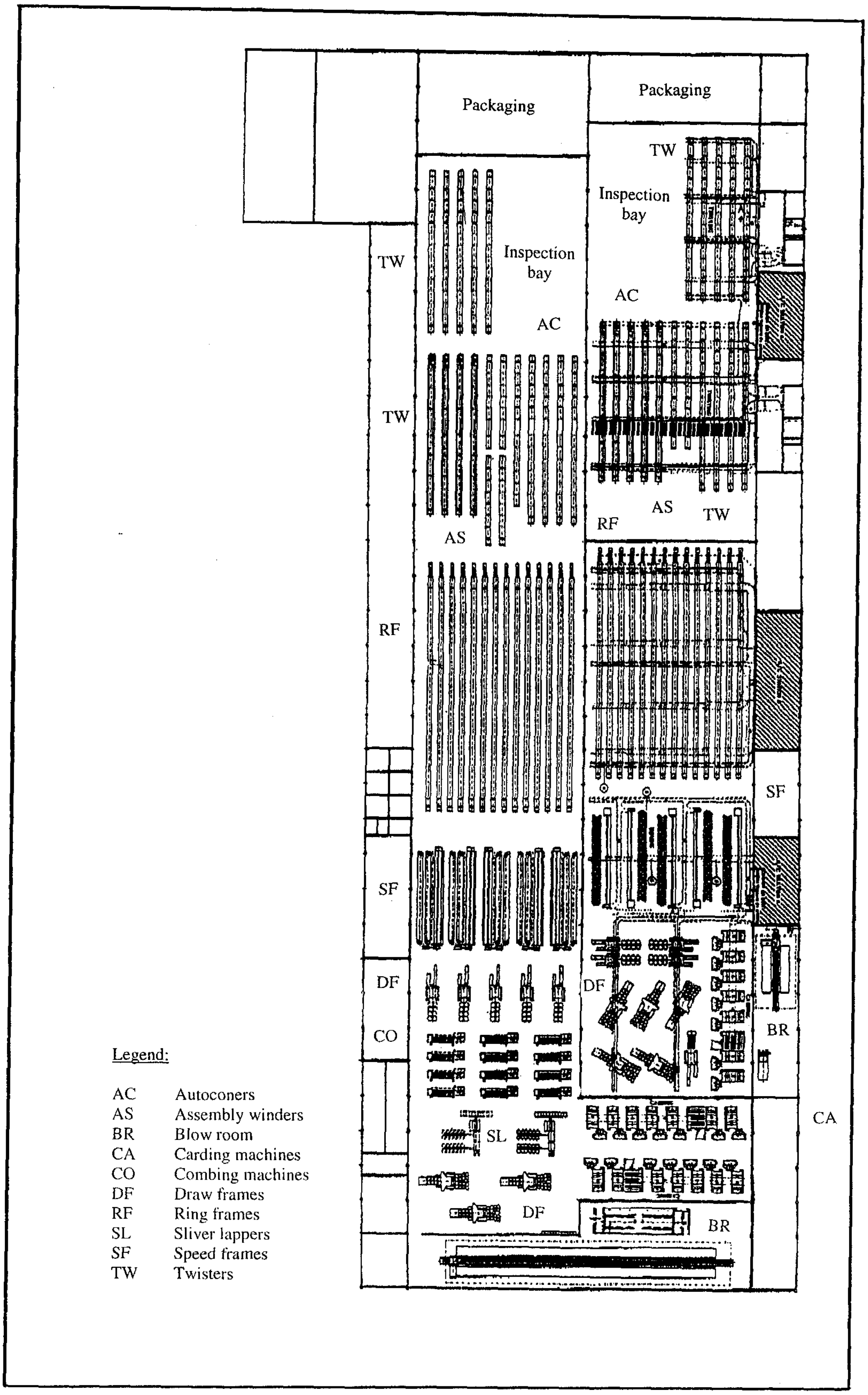


**Figure VI-7: Layout of two of the five yarn plants (side by side)**

**Table VI.4: Monthly output, labour, qualified gross output per worker and transformation efficiency for company 3, January 1995-December 1998**

| | 1<br>Qualified gross output<br>(kilograms) | 2<br>Employment<br>(persons) | 3<br>Percentage of disqualified products<br>(%) | 4<br>Total yarn disqualified<br>(kilograms) | 5<br>Considered period<br>(hours) | 6<br>Total effective time<br>(hours) | 7<br>Total lost time<br>(hours) | 8<br>Qualified gross output per person engaged<br>(kg/worker) | 9<br>Production system transformation efficiency<br>(a) |
|---|---|---|---|---|---|---|---|---|---|
| Jan-95 | 501,233.2 | 688 | 11.0 | 61,968.2 | 776,736.0 | 732,178.0 | 44,558.0 | 728.5 | 0.839 |
| Feb-95 | 477,743.4 | 693 | 8.2 | 42,413.8 | 701,568.0 | 666,562.0 | 35,006.0 | 688.9 | 0.873 |
| Mar-95 | 536,571.4 | 699 | 7.6 | 44,269.6 | 776,736.0 | 747,324.0 | 29,412.0 | 767.7 | 0.889 |
| Apr-95 | 516,870.3 | 704 | 6.5 | 36,067.4 | 751,680.0 | 713,827.0 | 37,853.0 | 733.8 | 0.888 |
| May-95 | 561,858.5 | 710 | 4.7 | 27,897.2 | 776,736.0 | 754,847.0 | 21,889.0 | 791.6 | 0.926 |
| Jun-95 | 546,110.9 | 715 | 3.7 | 20,910.3 | 751,680.0 | 732,890.0 | 18,790.0 | 763.5 | 0.939 |
| Jul-95 | 501,966.7 | 721 | 11.1 | 62,435.3 | 776,736.0 | 750,593.0 | 26,143.0 | 696.5 | 0.859 |
| Aug-95 | 535,255.9 | 726 | 6.9 | 39,489.3 | 776,736.0 | 737,631.0 | 39,105.0 | 737.1 | 0.884 |
| Sep-95 | 527,348.9 | 732 | 10.3 | 60,799.0 | 751,680.0 | 721,670.0 | 30,010.0 | 720.8 | 0.861 |
| Oct-95 | 554,106.9 | 737 | 8.8 | 53,768.9 | 776,736.0 | 722,627.0 | 54,109.0 | 751.7 | 0.848 |
| Nov-95 | 558,250.7 | 743 | 9.9 | 61,479.6 | 751,680.0 | 718,103.0 | 33,577.0 | 751.8 | 0.861 |
| Dec-95 | 505,390.3 | 748 | 10.2 | 57,459.9 | 701,568.0 | 662,330.0 | 39,238.0 | 675.7 | 0.848 |
| Jan-96 | 536,327.1 | 781 | 6.5 | 37,255.8 | 751,680.0 | 723,273.0 | 28,407.0 | 686.7 | 0.900 |
| Feb-96 | 512,011.4 | 814 | 9.3 | 52,706.7 | 726,624.0 | 674,687.0 | 51,937.0 | 629.0 | 0.842 |
| Mar-96 | 569,271.3 | 867 | 11.0 | 70,383.3 | 776,736.0 | 748,152.0 | 28,584.0 | 656.9 | 0.857 |
| Apr-96 | 577,659.7 | 919 | 9.1 | 57,542.6 | 754,032.0 | 728,973.0 | 25,059.0 | 628.4 | 0.879 |
| May-96 | 688,072.6 | 972 | 13.0 | 102,549.4 | 787,152.0 | 759,563.0 | 27,589.0 | 708.0 | 0.840 |
| Jun-96 | 724,875.6 | 1,024 | 10.2 | 82,102.8 | 761,760.0 | 735,345.0 | 26,415.0 | 707.6 | 0.867 |
| Jul-96 | 763,176.5 | 1,077 | 10.2 | 86,958.5 | 787,152.0 | 741,268.0 | 45,884.0 | 708.6 | 0.845 |
| Aug-96 | 789,087.2 | 1,114 | 8.8 | 76,551.1 | 787,152.0 | 727,852.0 | 59,300.0 | 708.6 | 0.843 |
| Sep-96 | 726,014.1 | 1,150 | 7.5 | 58,868.4 | 776,736.0 | 601,855.5 | 174,880.5 | 631.2 | 0.717 |
| Oct-96 | 649,342.9 | 1,187 | 14.0 | 105,363.5 | 751,680.0 | 623,868.8 | 127,811.2 | 547.1 | 0.714 |
| Nov-96 | 653,023.0 | 1,224 | 8.5 | 60,335.3 | 776,736.0 | 732,613.1 | 44,122.9 | 533.7 | 0.863 |
| Dec-96 | 667,463.5 | 1,260 | 15.6 | 123,482.4 | 751,680.0 | 711,087.6 | 40,592.4 | 529.7 | 0.798 |
| Jan-97 | 879,354.2 | 1,297 | 13.3 | 135,277.2 | 747,264.0 | 711,569.0 | 35,695.0 | 678.1 | 0.825 |
| Feb-97 | 865,155.6 | 1,333 | 13.1 | 130,188.0 | 715,008.0 | 687,052.7 | 27,955.3 | 648.8 | 0.835 |
| Mar-97 | 1,060,836.2 | 1,370 | 7.9 | 90,550.2 | 791,616.0 | 759,110.0 | 32,506.0 | 774.3 | 0.884 |
| Apr-97 | 991,574.4 | 1,370 | 12.2 | 137,934.9 | 766,080.0 | 740,622.0 | 25,458.0 | 723.8 | 0.849 |
| May-97 | 1,034,755.4 | 1,366 | 6.7 | 74,026.0 | 791,616.0 | 764,776.0 | 26,840.0 | 757.5 | 0.902 |
| Jun-97 | 1,034,114.7 | 1,246 | 7.1 | 78,524.8 | 766,080.0 | 733,289.0 | 32,791.0 | 829.9 | 0.890 |
| Jul-97 | 1,064,931.0 | 1,238 | 8.9 | 104,065.7 | 791,616.0 | 769,056.0 | 22,560.0 | 860.2 | 0.885 |
| Aug-97 | 1,049,071.4 | 1,275 | 8.1 | 92,484.0 | 791,616.0 | 757,893.0 | 33,723.0 | 822.8 | 0.880 |
| Sep-97 | 1,023,986.6 | 1,253 | 8.9 | 100,234.2 | 766,080.0 | 745,780.0 | 20,300.0 | 817.2 | 0.887 |
| Oct-97 | 1,073,628.1 | 1,267 | 6.6 | 76,221.0 | 791,616.0 | 769,567.0 | 22,049.0 | 847.4 | 0.908 |
| Nov-97 | 1,005,675.5 | 1,263 | 3.3 | 34,101.4 | 766,080.0 | 740,603.0 | 25,477.0 | 796.3 | 0.935 |
| Dec-97 | 953,881.8 | 1,247 | 12.2 | 132,049.7 | 740,544.0 | 687,805.0 | 52,739.0 | 764.9 | 0.816 |
| Jan-98 | 968,407.2 | 1,205 | 10.7 | 116,393.1 | 754,356.3 | 690,345.3 | 64,011.0 | 803.7 | 0.817 |
| Feb-98 | 880,733.6 | 1,223 | 6.4 | 59,918.8 | 681,247.0 | 662,939.7 | 18,307.3 | 720.1 | 0.911 |
| Mar-98 | 972,268.3 | 1,228 | 7.9 | 83,150.0 | 753,555.4 | 726,708.9 | 26,846.4 | 791.7 | 0.888 |
| Apr-98 | 1,012,021.3 | 1,233 | 6.3 | 68,254.7 | 730,328.5 | 715,216.7 | 15,111.8 | 820.8 | 0.917 |
| May-98 | 963,105.2 | 1,238 | 5.5 | 55,960.7 | 752,548.5 | 743,098.9 | 9,449.6 | 778.0 | 0.933 |
| Jun-98 | 948,215.9 | 1,238 | 6.6 | 67,533.1 | 729,123.3 | 711,772.2 | 17,351.1 | 765.9 | 0.911 |
| Jul-98 | 952,720.8 | 1,238 | 10.1 | 107,472.8 | 753,029.0 | 743,587.6 | 9,441.4 | 769.6 | 0.887 |
| Aug-98 | 1,002,648.6 | 1,259 | 6.3 | 67,136.8 | 754,493.6 | 737,290.0 | 17,203.6 | 796.4 | 0.916 |
| Sep-98 | 1,034,186.6 | 1,255 | 6.8 | 75,530.5 | 729,436.1 | 718,038.0 | 11,398.1 | 824.1 | 0.917 |
| Oct-98 | 1,129,282.4 | 1,238 | 5.8 | 69,811.3 | 754,081.7 | 743,476.5 | 10,605.2 | 912.2 | 0.929 |
| Nov 98 | 1,006,302.3 | 1,248 | 8.4 | 92,182.3 | 730,443.0 | 710,489.7 | 19,953.3 | 806.3 | 0.891 |
| Dec 98 | 918,824.0 | 1,244 | 6.2 | 60,576.2 | 657,398.7 | 646,363.6 | 11,035.1 | 738.6 | 0.922 |

*Sources for raw data:*
*Daily and Weekly Production, Quality Control and Downtime Summary Reports and Records, Monthly Personnel Reports and Records, 1995-98*
*(a) Calculated with equation (3.21)*

## Annex VI.4: Mining Implements Production Process

Various metal working processes are used to manufacture engineering products at company 4. These include machining of alloy steels, grinding and heat-treatment. The production processes are organized in unit shops dedicated to specific product ranges. The general product flow is illustrated in Figure VI-8. Mining implements are made in four main stages: the incoming raw materials are cut to suitable sizes and may undergo initial heat treatment before proceeding to the next production stage. After the initial stage, the prepared raw materials are subjected to various forming processes depending on the type of the mining implement. Forming stresses are relieved through heat treatment. Heat treatment is also used to impart the required operational properties to the implements. Assembly and coating constitute the last stage of the implement manufacture. Figure VI-9 presents a layout of the machine shop.

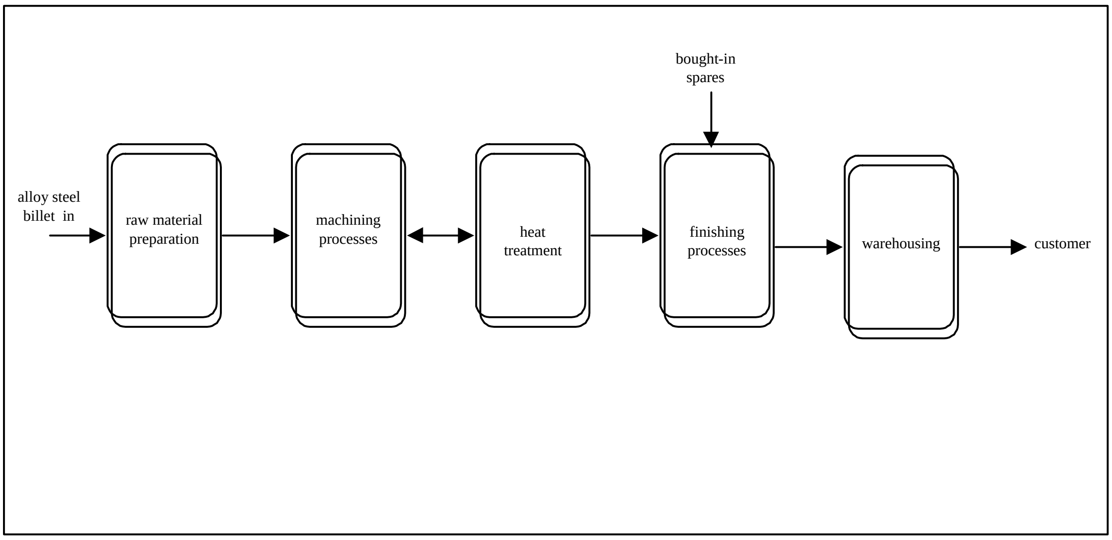


**Figure VI-8: Typical mining implements production flow chart**

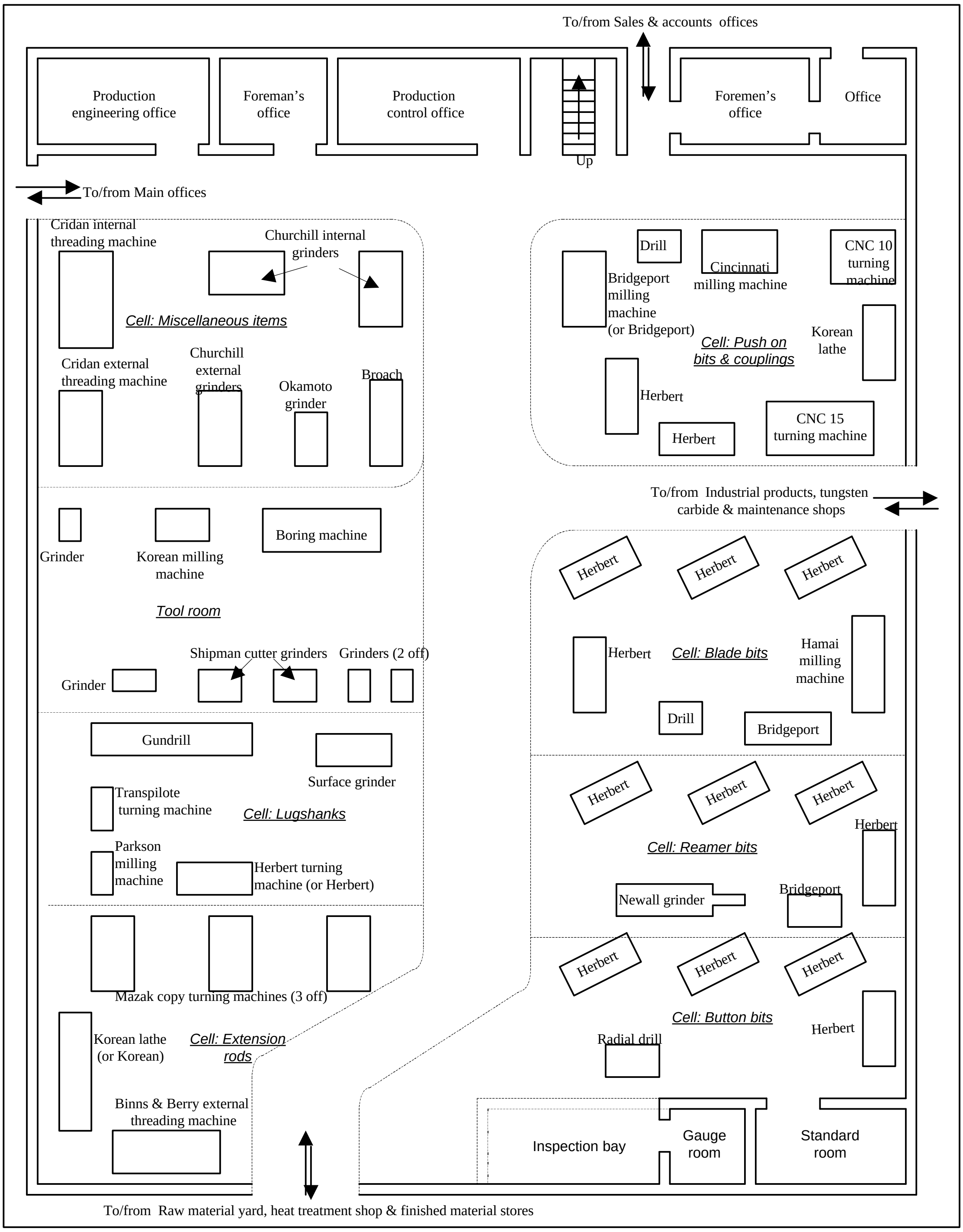


**Figure VI-9: Layout of machine shop**

In principle, the company initially uses the conglomerate's technology, redesigns some products for Zambian needs, and mining implement parts are manufactured and assembled in the shops. For some products, the company still has to go through the difficult process of developing new products by its own efforts in a cost-effective manner.

**Table VI.5: Monthly output, labour, qualified gross output per worker and transformation efficiency for company 4, January 1995-December 1998**

| | 1<br>Qualified gross output (at 1990 prices)<br>(ZK million) | 2<br>Employment<br>(persons) | 3<br>Percentage of disqualified products<br>(%) | 4<br>Disqualified products (at 1990 prices)<br>(ZK million) | 5<br>Considered period<br>(hours) | 6<br>Total effective time<br>(hours) | 7<br>Total lost time<br>(hours) | 8<br>Qualified gross output per person engaged (at 19990 prices)<br>(ZK 000/ worker) | 9<br>Production system transformation efficiency (a) |
|---|---|---|---|---|---|---|---|---|---|
| Jan-95 | 20.0 | 272 | 42.9 | 15.0 | 7,992.0 | 3,601.4 | 4,390.7 | 73.5 | 0.257 |
| Feb-95 | 32.6 | 272 | 38.4 | 20.3 | 7,940.4 | 3,578.1 | 4,362.3 | 119.8 | 0.278 |
| Mar-95 | 25.6 | 273 | 37.0 | 15.0 | 7,941.4 | 3,578.6 | 4,362.8 | 93.8 | 0.284 |
| Apr-95 | 31.7 | 273 | 32.4 | 15.2 | 7,938.3 | 3,577.2 | 4,361.2 | 116.1 | 0.304 |
| May-95 | 32.0 | 271 | 34.9 | 17.1 | 8,042.2 | 3,624.0 | 4,418.2 | 118.2 | 0.294 |
| Jun-95 | 25.0 | 271 | 40.6 | 17.1 | 8,018.6 | 3,613.3 | 4,405.2 | 92.4 | 0.268 |
| Jul-95 | 27.1 | 272 | 35.6 | 15.0 | 7,916.9 | 3,567.5 | 4,349.4 | 99.5 | 0.290 |
| Aug-95 | 32.6 | 269 | 32.9 | 16.0 | 8,031.8 | 3,619.3 | 4,412.5 | 121.2 | 0.302 |
| Sep-95 | 30.3 | 269 | 29.9 | 12.9 | 7,950.8 | 3,582.8 | 4,368.0 | 112.8 | 0.316 |
| Oct-95 | 28.8 | 270 | 35.5 | 15.8 | 8,266.8 | 3,725.2 | 4,541.6 | 106.7 | 0.291 |
| Nov-95 | 29.5 | 270 | 36.5 | 17.0 | 8,254.1 | 3,719.5 | 4,534.6 | 109.3 | 0.286 |
| Dec-95 | 20.8 | 268 | 27.6 | 7.9 | 7,936.2 | 3,576.2 | 4,360.0 | 77.5 | 0.326 |
| Jan-96 | 42.0 | 264 | 31.7 | 19.5 | 7,930.4 | 3,681.8 | 4,248.6 | 159.2 | 0.317 |
| Feb-96 | 31.1 | 264 | 42.6 | 23.1 | 8,542.5 | 4,057.6 | 4,484.9 | 117.7 | 0.273 |
| Mar-96 | 25.1 | 264 | 39.4 | 16.3 | 7,449.5 | 3,619.2 | 3,830.3 | 95.0 | 0.295 |
| Apr-96 | 24.8 | 261 | 39.2 | 16.0 | 7,331.9 | 3,421.4 | 3,910.5 | 95.2 | 0.284 |
| May-96 | 29.5 | 257 | 42.2 | 21.5 | 8,814.8 | 4,056.1 | 4,758.7 | 114.6 | 0.266 |
| Jun-96 | 30.1 | 258 | 36.9 | 17.6 | 8,039.3 | 3,844.0 | 4,195.4 | 116.7 | 0.302 |
| Jul-96 | 31.9 | 256 | 35.7 | 17.7 | 8,073.7 | 3,698.4 | 4,375.3 | 124.5 | 0.295 |
| Aug-96 | 27.8 | 255 | 38.0 | 17.0 | 7,776.1 | 3,528.6 | 4,247.5 | 108.9 | 0.281 |
| Sep-96 | 30.1 | 244 | 36.8 | 17.5 | 8,006.4 | 3,670.8 | 4,335.6 | 123.2 | 0.290 |
| Oct-96 | 29.5 | 186 | 31.2 | 13.4 | 8,134.0 | 3,623.6 | 4,510.4 | 158.8 | 0.306 |
| Nov-96 | 22.0 | 186 | 38.6 | 13.8 | 7,326.3 | 3,396.8 | 3,929.5 | 118.1 | 0.284 |
| Dec-96 | 22.4 | 187 | 41.1 | 15.6 | 8,135.0 | 3,493.2 | 4,641.9 | 119.8 | 0.253 |
| Jan-97 | 16.2 | 185 | 37.9 | 9.9 | 7,289.9 | 3,231.5 | 4,058.4 | 87.8 | 0.275 |
| Feb-97 | 15.7 | 185 | 44.3 | 12.5 | 7,094.1 | 3,017.7 | 4,076.3 | 84.9 | 0.237 |
| Mar-97 | 17.0 | 185 | 37.8 | 10.3 | 7,443.0 | 3,262.6 | 4,180.4 | 91.7 | 0.273 |
| Apr-97 | 22.2 | 186 | 38.9 | 14.1 | 7,500.4 | 3,266.3 | 4,234.1 | 119.1 | 0.266 |
| May-97 | 23.5 | 181 | 39.8 | 15.5 | 7,559.2 | 3,161.1 | 4,398.0 | 129.6 | 0.252 |
| Jun-97 | 26.5 | 181 | 40.7 | 18.2 | 7,811.5 | 3,276.2 | 4,535.3 | 146.7 | 0.249 |
| Jul-97 | 27.7 | 182 | 37.7 | 16.8 | 7,543.1 | 3,076.6 | 4,466.5 | 152.4 | 0.254 |
| Aug-97 | 22.2 | 181 | 38.5 | 13.9 | 7,838.0 | 3,218.2 | 4,619.7 | 122.9 | 0.253 |
| Sep-97 | 24.5 | 180 | 36.0 | 13.8 | 7,503.8 | 3,009.4 | 4,494.4 | 136.0 | 0.256 |
| Oct-97 | 18.5 | 177 | 35.6 | 10.2 | 7,253.3 | 3,023.0 | 4,230.3 | 104.3 | 0.268 |
| Nov-97 | 19.1 | 185 | 35.7 | 10.6 | 7,444.7 | 3,069.0 | 4,375.7 | 103.1 | 0.265 |
| Dec-97 | 27.4 | 183 | 39.7 | 18.0 | 7,769.1 | 3,312.6 | 4,456.4 | 149.5 | 0.257 |
| Jan-98 | 15.3 | 183 | 38.4 | 9.5 | 7,640.5 | 3,597.3 | 4,043.2 | 83.6 | 0.290 |
| Feb-98 | 12.5 | 183 | 36.8 | 7.3 | 7,166.8 | 3,580.1 | 3,586.8 | 68.5 | 0.316 |
| Mar-98 | 8.3 | 182 | 38.4 | 5.2 | 7,237.2 | 3,867.0 | 3,370.2 | 45.8 | 0.329 |
| Apr-98 | 10.3 | 177 | 33.0 | 5.1 | 7,221.1 | 3,705.0 | 3,516.1 | 58.5 | 0.344 |
| May-98 | 7.4 | 174 | 38.3 | 4.6 | 7,581.0 | 3,756.6 | 3,824.4 | 42.6 | 0.306 |
| Jun-98 | 11.1 | 174 | 35.4 | 6.1 | 7,726.6 | 3,543.1 | 4,183.4 | 63.9 | 0.296 |
| Jul-98 | 14.8 | 171 | 42.7 | 11.0 | 7,535.8 | 3,569.9 | 3,965.9 | 86.4 | 0.272 |
| Aug-98 | 15.9 | 171 | 40.9 | 11.0 | 7,597.6 | 3,581.7 | 4,015.9 | 93.1 | 0.279 |
| Sep-98 | 16.8 | 169 | 42.1 | 12.2 | 7,394.7 | 3,380.7 | 4,014.0 | 99.2 | 0.265 |
| Oct-98 | 18.8 | 171 | 32.9 | 9.2 | 7,687.2 | 3,847.8 | 3,839.4 | 109.9 | 0.336 |
| Nov 98 | 10.9 | 121 | 41.1 | 7.6 | 7,544.5 | 4,072.8 | 3,471.6 | 90.1 | 0.318 |
| Dec 98 | 16.8 | 120 | 43.1 | 12.7 | 7,666.9 | 3,504.0 | 4,162.9 | 139.9 | 0.260 |

*Sources for raw data:*
*Daily and Weekly Production, Quality Control and Shop Performance Reports and Records, Monthly Personnel Reports and Records, 1995-98*
*Sources for deflators:*
*CSO data base on Index Numbers of Wholesale Prices 1966=100 (by Industrial Activities)*
*(a) Calculated with equation (3.21)*

# Glossary of Important Terms

Binary comparison: A price or quantity comparison between two countries that draws upon data only for those two countries.

Constant returns to scale: Exist when long-run average cost is independent of the level of output.

Economic efficiency: In regard to production, economic efficiency implies production at least cost.

Elasticity of supply: The percentage increase in quantity supplied of a good produced that occurs as a result of a 1 percent increase in its price, holding constant all other factors that affect quantity supplied.

Fisher, or "ideal," index: The more usual definition is the geometric mean of the own-weighted and base-country-weighted indexes.

Growth rate: The percentage rate of increase per year of any variable over a specified period of time.

International dollars: Dollars with the same purchasing power over total US GDP at the US dollar in a given year, but with a purchasing power over subaggregates and over detailed categories determined by average international prices rather than by US relative prices.

Marginal analysis: Seeking the optimal value of some variable by comparing the costs and benefits that would be produced by small changes in that variable.

Marginal cost: The increase in total cost a firm must incur to produce 1 more unit of output.

Marginal product: The addition to a firm's output obtained by employing an additional unit of some particular variable input.

Own weights: The term is used, for example, to refer to the weights of the country other then the US in a binary comparison in which the US is the base country.

Purchasing power parity (PPP): The number of currency units required to buy goods equivalent to what can be bought with one unit of the currency of the base country, usually the US dollar in the present study.

Real product or real quantity: The final product or quantity in two countries that is valued at common prices and, therefore, valued in comparable terms internationally.

Technical efficiency: A method of production is technically efficient if there is no other method that uses less of at least one input and no more of any other input to produce a given level of output. Technical efficiency is required for but does not imply least-cost (economically efficient) production.

Technical progress: Occurs whenever it becomes possible, with given input prices, to produce a given level of output at lower cost. Produces increases in productivity.

Unit value ratio (UVR): The ratio of the unit values for each matched product in a bilateral comparison. Unit values are derived by dividing ex-factory output values by produced quantities for each product in each country.

# About the author

Francis K. Yamfwa is a PhD candidate in Industrial Engineering and Management Science at the Eindhoven University of Technology, Eindhoven, The Netherlands. He received his Bachelor's degree in Mechanical Engineering from the University of Zambia, Lusaka, Zambia in 1986, and his Master of Science degree in Computer Integrated Manufacture from the University of Strathclyde, Glasgow, UK in 1991. Before embarking on his PhD research, he was a lecturer in Mechanical Engineering at the University of Zambia. During this time he carried out research and industrial consultancy activities of which several reports were published. He also worked in various key capacities in the Engineering Department of the Luanshya Mine Division of the Zambia Consolidated Copper Mines Limited. He is a member of the Engineering Institution of Zambia (Zambia), the Institute of Industrial Engineers (USA), the Institution of Mechanical Engineers (UK), and the South African Institution of Mechanical Engineering (South Africa).

He is married and has two adorable and loving children.

# Stellingen

behorende bij het proefschrift

# Improving Manufacturing Performance in LDCs
**the case of Zambia**

van

**Francis K. Yamfwa**

2 oktober 2001

I

The common explanation for the lack of growth among firms in African LDCs is the market failure, to be rectified by policy interventions. This contradicts the findings of this study *(This thesis).*

II

The (economic) decline of Africa is partly rooted in the international environment. The most important factor in the decline of Africa, however, is the lack of proper economic management of resources and development activities *(Yamfwa, 1997).*

III

Even for the lowest income countries, openness to external trade and investment is a necessary first step to solid and sustainable industrial development *(This thesis and Yamfwa, 1997).*

IV

Globalisation stresses the importance of economic efficiency and competitiveness, thereby diminishing the effectiveness of industrial support policies based only on the national identity of an industry *(Yamfwa, 1997).*

V

Investment in a well designed and proven production process that reflects a widespread emphasis on simplicity and reliability of the technology of the plant operations helps compensate for the lack of industrial, maintenance and repair experience on the part of the large majority of the work force at a textile company *(This thesis).*

VI

Industrial performance improvement demands repeatedly asking ‘why?’ and a stubborn refusal to give up the search for the best single way *(This thesis).*

VII

The novel solution of “happy hour” at a beer manufacturing company improves productivity *(This thesis).*