

**PRODUCTIVITY MEASUREMENT IN SMALL MANUFACTURING
ENTERPRISES IN THE STEEL AND ENGINEERING INDUSTRY
OF SOUTH AFRICA**

by

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A special word of thanks to a strong
mentor and determined leader - Prof. Ghyoot

To Michael McDonald
Head: Economics Division
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To all the entrepreneurs and small businessmen
who have taken the challenge to create
their own futures.

To Yvonne, Dean, Chantel & Shirley.

SUMMARY

The South African economy desperately requires an injection from small manufacturing enterprises that are productive and highly organised - hence the need to identify suitable productivity measurement approaches for use in these enterprises.

The following research question was formulated:

Which productivity approach(es) is (are) generally most suitable for small manufacturing enterprises in the steel and engineering industry of South Africa?

The following directions of research were identified:

- (1) A literature search revealed 12 productivity measurement approaches. The theory of each is discussed in detail.
- (2) An empirical search was performed to establish the requirements of industry.
This process is fully discussed.

The results of both the literature and empirical searches were used to develop a list of criteria. These criteria were compared with each of the approaches, and only three were found to conform to these requirements.

The results of this comparison provided the answer to the research question.

Keywords

Productivity measurement approaches

Productivity measurement

Productivity measurement models

Productivity in small enterprises

Small enterprise productivity measurement

Manufacturing productivity

Applying value added to measure productivity

Profitability through productivity

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CHAPTER 1

INTRODUCTION AND BACKGROUND

1.0 INTRODUCTION

Productivity, which is expansively measured as the relationship between output and input and recorded as a percentage, is currently receiving increased attention in the steel and engineering industry of South Africa. The researcher who is involved in this sector of industry has concentrated on the problem facing small enterprises when determining productivity in their own specific enterprise. A need has also developed from negotiations between unions and employer organisations to arrive at suitable approaches to determine productivity for the purpose of wage bargaining. This dissertation comprehensively investigates various productivity approaches and their application, with the intention of assisting management with the development of a suitable approach for use in the small manufacturing enterprise.

1.1 BACKGROUND TO THE RESEARCH PROBLEM AND STATEMENT OF THE RESEARCH QUESTION

South African businesses, trying to come to grips with local issues such as the RDP (Reconstruction and Development Programme), affirmative action, corporate governance and disclosure, international competition and opportunity, also face another new set of challenges. The worldwide business environment is undergoing permanent and fundamental structural change.

Enterprises are re-engineering, restructuring, focusing on core competencies and products, outsourcing and downsizing. These tactics and strategies were designed to cope with economic recession, and function well in these situations. They are now being used to provide the competitive edge in growth economies.

The result is that millions of employees can no longer take secure and long-term employment for granted. Careers are being cut short as companies, even as they grow,

continue to retrench or limit employment. This phenomenon may create future problems in many Third World countries in particular. There is a possibility that in South Africa it will become a major dilemma within the next 10 years (P-E Corporate Services 1995:2). Overseas enterprises and investors are showing interest in our markets and new investments promise a temporary boost in job creation. If this is to be sustained, South African businesses need to become far more competitive.

Enterprises throughout South African are being scrutinised closely at present and the objectives of the RDP will influence the business sector in various ways in the future. The RDP Base Document refers to five key programmes (*Government Gazette* 1994) as follows:

- meeting basic needs
- developing our human resources
- building the economy
- democratising the state and society
- implementing the RDP

Of these five key programmes, the one that directs the most attention to business is the programme entitled "Building the Economy". The first two paragraphs of this programme as stated in the *Government Gazette* clearly point to certain shortcomings in the economy and the business sector. The content of these paragraphs follow (*Government Gazette* 1994):

The economy is in bad condition. The benefits of its strengths in mining, manufacturing and agriculture are delivered mainly to the small wealthy sector. Its weaknesses are seen in the low levels of investment in productive enterprises, in low productivity and high costs. The poor majority of the people carry the burden of unemployment, bad housing, poor health - in short, of the poor performance of the economy. The RDP is committed to reversing the distortions of the economy.

The economy also suffers from other barriers to growth and investment, such as government dissaving and a comparatively high proportion of our gross domestic product (GDP) absorbed in government consumption expenditure. Other barriers include falling rates of return, capital outflows, low exports and high import propensity, and stagnating productivity.

When considering the content of these two paragraphs, the problem of poor productivity, together with high costs and the burden of unemployment, is clear.

The need for productivity improvement has been confirmed by the Monitor Company (McDonald 1994a) which was commissioned by the state to conduct a study of various business sectors in South Africa. Discussions with Monitor (Green 1995) confirmed that there is a definite need for productivity improvement.

Lawlor provides five compelling reasons why productivity should receive serious and continuing attention (Lawlor 1985:5):

The world's markets have become very competitive, with survival consequently dependent upon maintaining the right balance between price, quality and delivery.

Manufacturing industry has now been redistributed to include the Third World. This means that the older industrialised countries must compete with their new low-cost competitors or else design and make entirely new products.

The economic and social well-being of people, and in turn the peace of the world, depend upon organisations of all kinds making effective use of the limited resources at their disposal. This includes generating sufficient income to meet daily needs and a surplus, which may be called wealth, for investment in the future.

An appropriate social infrastructure (e.g. education, health provision and public transport) necessitates the generation by industry of sufficient income and wealth to support it. Moreover, because this section of economies, especially in the Western World, now consumes significant proportion of national incomes, these public organisations also have a responsibility to manage their productivity more effectively.

The undesirable effects of inflation can be reduced by the efficient production of an adequate supply of goods and services by the industrial and public sectors for everyone, including the employed and unemployed, retired people and the young.

The function of productivity in business has also become a point of increased interest in recent discussions between unions representing employees and SEIFSA representing employers in the Steel and Engineering Industries Federation of South Africa (SEIFSA 1994:1).

SEIFSA agrees that productivity inefficiencies have resulted from the distorted economic system and defines these inefficiencies as follows (McDonald 1994:1):

The unit of cost of labour, which measures the productivity of labour in manufacturing as part of the total cost of a product, became expensive. ... The high cost of labour was caused less by high wage costs than by poor labour productivity ...

Capital costs, the cost of machinery and equipment, were also high because such equipment was not maximally utilised ...

Over the sanctions years, because of the severe depreciation in the value of the Rand, imported machinery became very expensive. Also sanctions denied South Africa access to the latest manufacturing technology. Furthermore, the recessionary conditions in South Africa and the inability to export, caused spare capacity to go unutilised.

Because of limited local and export demand (which was, nevertheless, being serviced even with the use of outdated machinery), there was no need to buy new and better machinery or to make technological innovations which would allow for improved efficiencies.

McDonald's document made a contribution to the development of a framework document on productivity bargaining to be agreed between SEIFSA and 13 recognised trade unions by the end of 1994. These negotiations were not completed in 1994, but they have progressed and are nearing finality. Matters under consideration are as follows (*Business Day* 1994):

- Implementing broadbanding and multi-skilling arrangements;
- selection criteria for worker education and training and related production;
- job security relating to introducing multi-skilling and broadbanding;
- efficiency gains, productive performance and a more flexible approach to work organisation and production;
- increased worker participation;
- and worker representative feedback and communication facilities.

The purpose of the document is to promote productivity improvements, assist interested companies to enter into voluntary productivity agreements with trade unions and to provide guidance on the nature and scope of agreements. SEIFSA stressed that

agreements would only be entered into on a voluntary basis, but NUMSA (National Union of Metalworkers of SA) wants to make productivity bargaining compulsory (*Business Day* 1994).

This framework document is compelling small manufacturing enterprise management to identify the correct approach in measuring productivity. In fact, Basson (*Engineering Week* 1994) warns that limited managerial skills and technological capacity in small and medium enterprises (SMEs) have resulted only in small contributions to the economy. This can be attributed to the high rate of inefficiency experienced in SMEs.

Singh (*Engineering News* 1994), a director of the National Small Industries Corporation of India (NSIC) stated that if South Africa did not look after small business, the country's economy would be doomed. He points out that in India, there is legislation in which, the government has identified 600 products that have to be purchased from the small industries sector.

According to Basson, at present, the government in South Africa has no legislation of this kind, although a lobby is gaining momentum in a bid to force government and big business to source at least some of their requirements from the SME sector (*Engineering News* 1994).

A definite move is being made in this area. The Ministry of Trade and Industry has published a draft bill on strategies for the development of an integrated policy and a support programme for small, medium and micro-enterprises (SMMEs) (JCCI 1994:3 and SEIFSA 1996). The document is in support of the RDP and stems from the need to build the economy. Four different types of enterprise are identified and defined in this paper as follows:

- (1) *Survivalist enterprises*. This sector results from the activities of people unable to find suitable employment, who do anything to create an income.
- (2) *Micro-enterprises*. These are very small businesses consisting of no more than the owner and at most two employees.

(3) *Small enterprises*. A full definition of the small enterprise is given in appendix A.

(4) *Medium enterprises*. A full definition of the medium enterprise is given in appendix A.

It is clear from the Ministry of Trade and Industries Bill and the requirements of the RDP to build the economy, that there is, a need to research the function of productivity in all enterprises. However, since small enterprises are seen as the vehicle to providing considerable improvement in South Africa's economy in the future, research is directed at productivity in small enterprises. Taking these selection criteria further across the spectrum of small enterprises ranging from retailing, mining, construction to service industry and manufacturing, the study is directed at manufacturing enterprises. But when considering manufacturing, the industry is diverse, and covers pharmaceuticals, petrochemicals, plastics, paper, food, textiles and numerous forms of manufacturing. Because of the researcher's involvement in the steel and engineering industry, this study will focus on that section.

According to SEIFSA (McDonald 1995) the total steel and engineering industry comprises 9 000 enterprises. Of these, 2 700 are affiliated to SEIFSA through their membership of one of the SEIFSA associations. McDonald (1995) states that out of the 2 700 enterprises, 70 percent can be considered as small manufacturing enterprises since they employ no more than 50 people.

Thus a large sector of small manufacturing enterprises are affected and will benefit from this research.

The abbreviation "SME" to define small and medium enterprises has become popular as the accepted industry norm and for this reason it is more suitable to refer to the small manufacturing enterprise in full throughout this dissertation.

Considering the background that has been discussed, a question concerning the application of productivity measurement approaches in small manufacturing enterprises arose. This question was formulated as follows:

Research question

Which productivity approach(es) is (are) generally most suitable for small manufacturing enterprises in the steel and engineering industry of South Africa?

1.2 THE OBJECTIVES OF THE RESEARCH

The first objective of the research is to describe the productivity measurement approaches located in the literature. Each approach has its own method of evaluating and measuring productivity, and it is the objective of the researcher to detail these methods systematically in order to provide the basis for their comparison and discussion.

Secondly, the list of criteria that industry and the stakeholders in South Africa require from a productivity approach must be established and detailed in a well-structured format. This list of criteria will provide the basic information, and each of the approaches described in the literature will be compared to these criteria to evaluate their suitability.

The final objective is to determine which approaches are suitable for use in small manufacturing enterprises in South Africa. It will be possible to draw up a list once the comparison between the criteria and approaches has been completed. The suitable approach or approaches will be the result of this study.

1.3 THE RESEARCH METHODOLOGY

After conducting an extensive literature search, the author has determined that no previous studies of this nature have been undertaken in South Africa. This, in turn, has led the author to trace all approaches described in the literature in various types of industry and in different countries. Approaches described in the literature were traced in the United States of America, the United Kingdom, Switzerland, Japan, the Philippines, South Africa and Zimbabwe. Although the number of countries researched is not exhaustive, the literature obtained makes adequate reference to most of the economically active nations as well as several emerging nations and therefore provides a sound basis for the research.

There is limited reference to small manufacturing enterprises in the literature, but extensive reference to manufacturing enterprises. These approaches have been combined to develop a body of knowledge on productivity measurement.

The research is exploratory by nature, and to ensure its validity, it was necessary to consult all the key stakeholders in the South African steel and engineering environment. Consultation was in the form of direct interviews, telephonic discussions and written communication with high-ranking officials who represent a respective contributor to the steel and engineering industrial sector. Contributors include individual enterprises, employer associations, the International Labour Office (ILO) in various countries, the Small Business Development Corporation (SBDC), the Small Business Development Bureau (SBDB) and banking institutions supporting the small manufacturing sector.

The suitability of each approach described in the literature was checked against the requirements of South African small manufacturing enterprises functioning in the steel and engineering industrial sector.

1.4 OUTLINE OF THE DISSERTATION

Chapter 1: Introduction and background

This chapter provides background to the research problem, the objectives of the study and the research method that will be followed.

Chapter 2: Productivity measurement approaches described in the literature

In chapter 2, the productivity approaches that have been located in the literature search are described and detailed systematically.

Chapter 3: Current practices and requirements of the steel and engineering industry

With the aid of an empirical search, this chapter determines the criteria of industry regarding its individual expectations of a productivity measurement approach. These criteria are used to identify suitable approaches for application in a small manufacturing enterprise in the steel and engineering industry of South Africa.

Chapter 4: Recommendation and conclusion

In this chapter, the approaches discussed in chapter 2 are compared to the requirements resulting from the questionnaires. The conclusion concerning the suitability of each approach are stated in this chapter. These are followed by the recommended solution to the problem and the answer to the research question.

1.5 CHAPTER SUMMARY

The South African economy desperately requires an injection from small manufacturing enterprises that are productive and highly organised to contribute to the country's gross domestic product and to satisfy the reconstruction and development programme. This, as well as the problem facing small manufacturing enterprise owners who are involved in

wage negotiations, has led to the need to identify suitable productivity measurement approaches for their small manufacturing enterprise.

A three-stage study is proposed:

- (1) The productivity measurement approaches described in the literature should be traced and analysed. This is the subject of chapter 2.
 - (2) A survey of the current practices and requirements of small manufacturing enterprises in the steel and engineering industry of South Africa should be conducted. This is the subject of chapter 3.
 - (3) From the requirements of industry, and the literature, a list of criteria to be met by the productivity measurement approaches in small manufacturing enterprises in the steel and engineering industry of South Africa, should be drawn up. Evaluation of the various approaches described in the literature against these criteria will indicate which approach(es) are suitable for use by small manufacturing enterprises in the steel and engineering industry of South Africa. This is the subject of chapter 4.
-

CHAPTER 2

PRODUCTIVITY MEASUREMENT APPROACHES DESCRIBED IN THE LITERATURE

2.0 INTRODUCTION

Various approaches are used to determine the level of productivity in an enterprise, each approach providing its own form of information to management for their use and benefit. Before discussing the approaches, it is necessary to grasp the meaning of productivity to ensure a precise understanding of the task at hand.

The NPI define productivity as follows (NPI 1987:7):

Productivity is the ability to combine and convert inputs of labour, material, capital and other resources into goods and services of an acceptable quality.

Productivity incorporates the efficient and effective use by management of all production resources to ensure maximum output at minimum cost.

It is measured as the ratio between the (physical) output of products and services and the (physical) input of labour, capital, material and energy resources as shown in equation 2.1

$$\text{Productivity} = \frac{\text{Output}}{\text{Capital} + \text{Labour} + \text{Energy} + \text{Materials (inputs)}} \quad (2.1)$$

Van Loggerenberg's definition follows (Van Loggerenberg 1990: PAA-1):

Productivity refers to the ability to achieve production. Simply defined, productivity is measured as shown in equation 2.2

$$\text{Productivity} = \frac{\text{Product quantity (output)}}{\text{Resource quantity (input)}} \quad (2.2)$$

The ILO define productivity as (Prokopenko 1990:2):

the relationship between the output generated by a production or service system and the input provided to create this output. Thus productivity is defined as the efficient use of resources in the production of various goods and services.

Productivity can also be defined as the relationship between results and the time it takes to achieve them. The less time taken to achieve the desired results, the more productive the system.

Thus, the basic productivity concept is always the relationship between the quantity and quality of resources used to produce them.

$$\text{Therefore:} \quad \frac{\text{Output}}{\text{Input}} = \text{Productivity} \quad (2.3)$$

At the outset it is necessary to understand a number of misconceptions about productivity determination in order not to lose focus in the task at hand. The task is to measure the productivity of small manufacturing enterprises in the steel and engineering industry of South Africa. The following misconceptions need to be dispelled:

- (1) Productivity is not only labour efficiency or labour productivity because the latter is also an input into the greater productivity formula - although not the sole determinant.
- (2) Judging an enterprise simply by its output is not a determinant of productivity. An enterprise's output may increase, but if the input costs of production are not controlled, an increase in output does not constitute an improvement in productivity.
- (3) Productivity and profitability are often confused. Profit per se in an enterprise can be increased through improved price recovery, irrespective of a simultaneous decline in productivity.

- (4) Productivity is often confused with efficiency. Efficiency means producing high quality goods in the shortest possible time. Thus, if the goods are not needed and they have been produced for nothing, then the enterprise has been counterproductive.
- (5) Cost cutting in the enterprise does not always contribute to an improvement in productivity. Indiscriminate cost cutting can lead to long-term difficulties for an enterprise.
- (6) Productivity can only be applied to a manufacturing enterprise. This is incorrect. Whilst this study is concerned with the manufacturing enterprise, there are service functions within these enterprises such as a drawing office providing a service, that require control and assessment. These are typically, financial functions, engineering support, procurement divisions, human resources management and public relations (Prokopenko 1987:4).

The ILO state that a general understanding of productivity is a comprehensive measure of how an enterprise can satisfy the following criteria (Prokopenko 1987:6; Prokopenko 1990:2):

- Objectives: the degree to which they are achieved.
- Efficiency: how effectively resources are used to generate useful output.
- Effectiveness: what is achieved compared with what is possible.
- Comparability: how productivity performance is recorded over time.

This is confirmed by Lawlor, (1985:36), although he adds a fifth criterion, namely:

- Trends: the productivity performance record over time, that is, the decline, static or growth aspects.

Lawlor (1985:30) also confirms that good productivity information is the first most important step in convincing management that productivity improvement, in its widest sense, is a necessity in an enterprise.

2.1 PRODUCTIVITY MEASUREMENT APPROACHES

The approaches discovered in the literature are now discussed in detail and the theory of each provided. An effort has been made to discuss each approach in the same sequence and manner. However, on account of the diversity of these approaches, it has not always been possible to maintain a precise discussion pattern. The productivity approaches discussed in this chapter are the following:

Section 2.2	Productivity measurement and evaluation system (ProMES)
Section 2.3	Deterministic productivity accounting (DPA)
Section 2.4	The National Productivity Institute (NPI)
Section 2.5	Theory of constraints (ToC)
Section 2.6	The total productivity model (TPM)
Section 2.7	Alan Lawlor's approach (Lawlor)
Section 2.8	Applied productivity - Gold's approach (Gold)
Section 2.9	Operation function analysis (OFA)
Section 2.10	International Labour Organisation - (ILO)
Section 2.11	Quick productivity appraisal (QPA)
Section 2.12	Kurosawa and Goshi - Japan Productivity Center (Kurosawa)
Section 2.13	Multifactor productivity measurement model (MFPMM)

2.2 PRODUCTIVITY MEASUREMENT AND EVALUATION SYSTEM (ProMES)

2.2.1 Background

Motivational issues are used in the measurement of productivity by means of the ProMES

system. The issues of separating effects of factors that personnel can control from those they cannot control distinguishes ProMES from other productivity approaches.

The ProMES productivity measurement approach is used to provide feedback to increase productivity through the behaviour of organisational personnel. Increases in productivity occur through changes in motivation, where motivation is broadly defined to include amplitude, persistence and direction of behaviour (Pritchard, Jones, Philip, Stuebing & Ekeberg 1989:73).

The basic model for developing a productivity measurement and improvement programme begins with a clear statement of the enterprise's objectives. Once these objectives have been identified, measures that accurately track progress toward these objectives are carefully developed. Performance on these measures is then fed back to personnel by means of reports, which are used to discuss how to improve productivity within the enterprise. As productivity improves on each measure, objectives are more completely achieved. The ProMES approach follows this sequence (Pritchard, Weiss, Goode & Jensen 1990:257).

2.2.2 ProMES methodology

2.2.2.1 Step 1: Identifying the enterprise's products

An enterprise is expected to perform a number of activities or realise a number of objectives. In ProMES these objectives are renamed and called products. The ability of the enterprise to fulfil the requirements of these products is nothing more than a measure of productivity, and as the generation of each product improves, so does productivity.

A team of employees is selected from the ranks of shopfloor workers, supervisory and production personnel. This team is called the design team and is responsible for the development of the products.

Depending on the type of enterprise, the products relate to the kind of goods manufactured as well as the processes that lead to their output. In an enterprise producing a specific item repeatedly, typical products may be:

Product 1: Manufacture optimal quality goods

Product 2: Maintain a high level of throughput

Any number of measurable products can be selected to cover the full spectrum of manufacture. Once the product listing is completed, the team proceeds to the next step.

2.2.2.2 *Step 2: Developing indicators to measure these products*

Since the products need to be measurable the indicators will show how well the enterprise is generating the products listed under step 1.

There may be one or several indicators for a given product. Some indicators will already be available; others will need to be developed. The resulting indicators of the products listed might look as follows:

Product 1: Manufacture optimal quality goods.

Indicator A: Rework rate:

Percentage of items returned to the shopfloor because of poor quality during manufacture.

Indicator B: Return rate:

Percentage of items returned that did not function after despatch to customers.

Product 2: Maintain a high level of throughput.

Indicator A: The standard output per shift is required.

After completing the product list with its indicators, the design team will present this information to senior management for approval and fine tuning.

2.2.2.3 Step 3: Establish contingencies

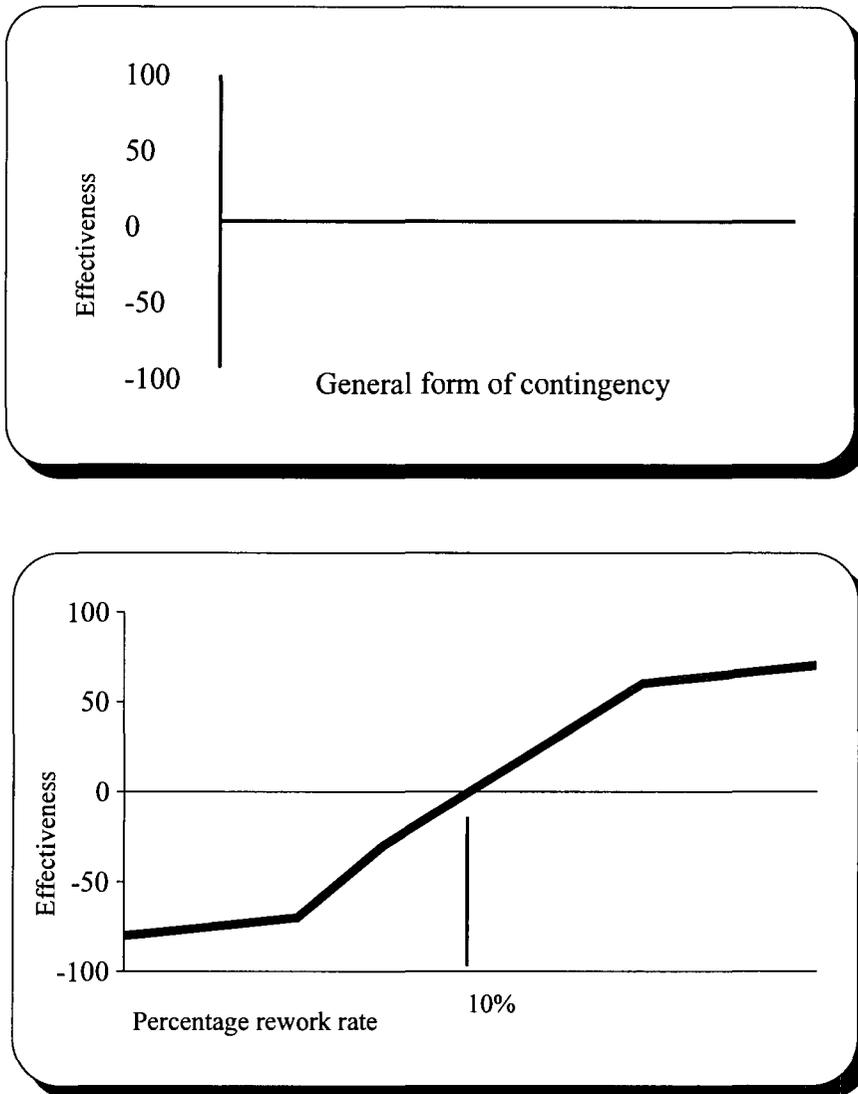
The term "contingency" does not mean the relationship between behaviour and a reinforcer as understood in the opinion of a behaviourist. The term means that the level of evaluation of an outcome is contingent on the amount of that outcome. A contingency is specifically the relationship between the amount of the indicator and the effectiveness of that amount (Pritchard et al 1989:75). This is best explained by means of a graphic representation as provided in figure 2.1 below.

A contingency is of importance to the enterprise when assessing how differing amounts of the indicator contribute to the enterprise's overall product. Figure 2.1 shows the general form of a contingency. The horizontal axis (X axis) represents the amount of the indicator and ranges from its worst feasible level to the best level that is realistically possible.

The vertical axis (Y axis) measures the effectiveness of the various levels of the indicator. This scale ranges from +100 (maximum effectiveness) to -100 (minimum effectiveness). The zero point represents the level of effectiveness expected. It is the level of the indicator that is neither especially good nor especially bad (Pritchard et al 1990:259).

Contingency graphs are developed for all the products. The design team determines the effectiveness values that correspond to the maximum and minimum indicator levels. Applying this to the rework rate indicator selected in step 2, the design team now decides on the best rework rate possible. Assume that 2 percent is selected. Now the worst possible rework rate is selected - assume that this is 20 percent. After the best and worst conditions have been established, the team's task is to identify the actual function that relates the amount of the indicator to effectiveness. The zero point of the indicator must first be determined. This is the point at which the level is neither good nor bad. A point is placed on the figure at the intersection of the zero point of the Y axis and the level of the neutral point on the X axis. In the lower graph shown in figure 2.1 the zero point is at a 10 percent rework rate.

Figure 2.1: Example of the rework contingency



Source: Pritchard et al (1989:78); Pritchard et al (1990:260)

Once the zero points have been identified and the effectiveness values of the maximums and minimums for all the contingencies established, the remainder of the points in the function are developed by the design team. Group discussion is continued until consensus is reached.

Assume that the design team allocates the lowest rework rate an effectiveness of -80 and for the highest rework rate an effectiveness of +70. The contingency for the percentage rework rate would then be similar to that of the lower graph in figure 2.1. By going above

the neutral point of 10 percent, a positive condition is attained. However, for a lower rate than 10 percent the effectiveness becomes poor. The situation for a point lower than 16 percent, which is already bad, declines at a slower rate. Once at this point the decrease is not proportionally as poor. A similar condition occurs for increases in effectiveness above that of 6 percent.

Each indicator will have its own contingency and a full complement of contingencies will exist after the team has completed the exercise.

Pritchard et al (1990:261; Pritchard et al 1989:79) state the following:

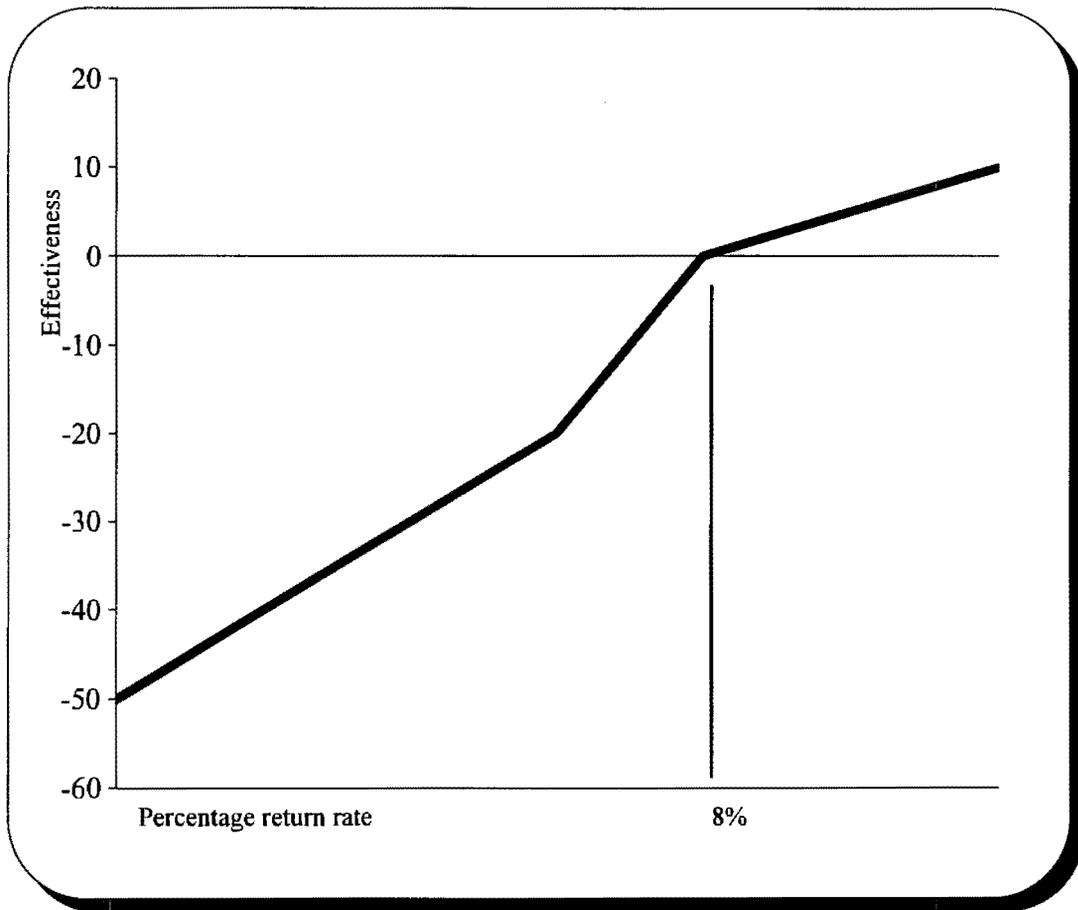
Two things are particularly noteworthy about contingencies. First, the overall slope of the contingency expresses the relative importance of the indicator. Therefore the slopes (angle of inclination) are representative of indicators that are very important to the functioning of the unit. This is because steep slopes imply that small variations in the amount of the indicator result in large variations in effectiveness. Indicators with shallow slopes are much less important to the functioning of the unit because variation in these indicators will have less of an impact on total effectiveness. Thus, the variations in importance of the tasks of the unit are reflected by the contingencies.

The second important aspect of contingencies is their non-linearity. This is important because, for example, a given amount of improvement at the low end of the measure may not have the same effect as at the high end of the measure. It is very common for improvements in the middle range of the indicator to result in large improvements in effectiveness, while improvement at the high end of the indicator result in less of an improvement in effectiveness. In other words a point of diminishing returns is reached.

The point can be likened to a point of saturation. After reaching this point, it is no longer feasible to put an effort into achieving further improvement because of the limited benefit achieved. The enterprise's attention needs to shift to more important needs among the other indicators.

It has been argued that an enterprise's effectiveness measures cannot be linear continuous functions (Seashore & Campbell quoted in Pritchard et al 1989:79). The contingencies in the ProMES system capture this nonlinearity, thus providing a more accurate picture of the enterprise's functioning.

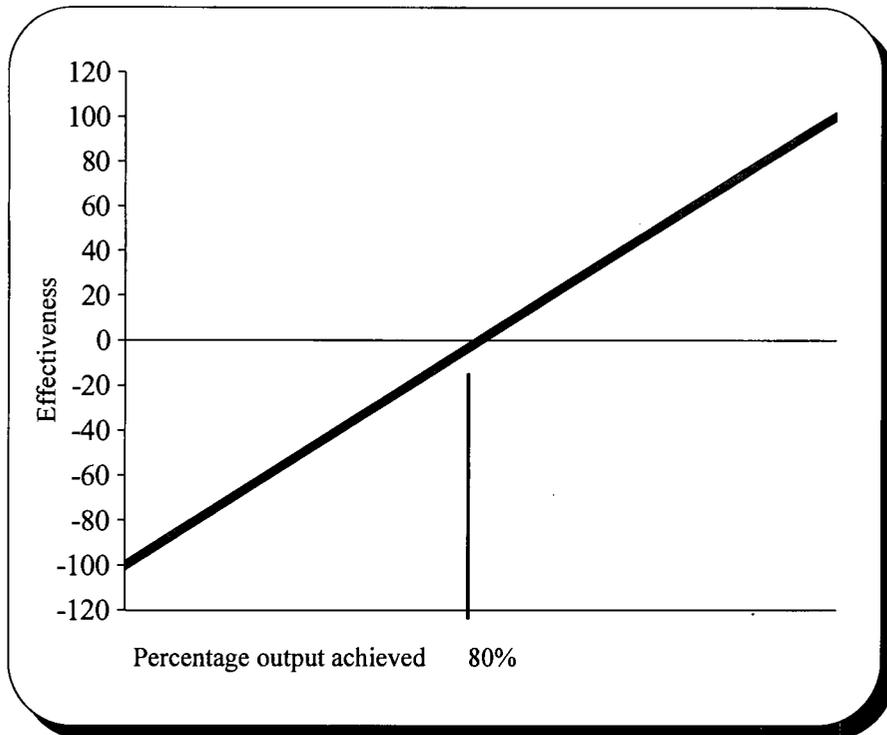
Figure 2.2(a): Return rate contingency for a small manufacturing enterprise



Source: Pritchard et al (1989:78); Pritchard et al (1990:260)

For the two products described together with each one's indicator, the contingency for the small manufacturing enterprise will include the rework rate indicator at the bottom of figure 2.1 as well as the two indicators in figures 2.2(a) and 2.2(b). The number system applied to figures 2.2(a) and 2.2(b) have been used to link the diagrams together.

Figure 2.2(b): Output contingency for a small manufacturing enterprise



Source: Pritchard et al (1989:78); Pritchard et al (1990:260)

2.2.2.4 Step 4: Creating a formal feedback report

The system needs to be put together to provide feedback to management of the enterprise's level of productivity. All the indicator data must be gathered over a specified period of time. This period may be either a month, a quarter or six months. To enable effective control, the length of time between feedback must be restricted to prevent slow reaction.

A table of indicator measures is formulated similar to that in table 2.1. Each product with its indicator, or indicators, is represented in the table. In cases where more than one indicator is provided, the total effectiveness of the combined indicators is determined by a summation of the respective indicator. Each effectiveness score has a distinct meaning. A score of zero means that the enterprise is meeting expectations - that is, its productivity is neither particularly good nor bad. For a more positive score, the better expectations are

being exceeded. In the case where a more negative score is recorded, below expectation results have been recorded.

Table 2.1: Feedback report

	Indicator data: Month	Effectiveness score
Productivity: SBU Date:		
Product 1: Optimal quality goods		
Indicator:		
A: Rework	6%	60
B: Return rate	4%	5
Product 2: High level of throughput		
Indicator:		
A: Standard output/shift	70%	-50
Total effectiveness: Throughput		-50
Overall effectiveness		15

Source: Pritchard et al (1989:81); Pritchard et al (1990:263)

Overall effectiveness is now determined by summing the effectiveness score for each

product. The ability to simply sum effectiveness scores is one of the major advantages of the ProMES system (Pritchard et al 1989:81).

The feedback report can be a record of the effectiveness of the total small manufacturing enterprise or of a specific SBU (strategic business unit) depending on the diversity of the enterprise.

Finally, there is a maximum possible overall effectiveness score. This is the overall effectiveness score the unit would receive if it were at the maximum possible value on each indicator (Pritchard et al 1989:81).

Considering the information in table 2.1, the maximum effectiveness score will be as follows:

		Maximum effectiveness
Product A:	Indicator 1	70
	Indicator 2	10
Product B:	Indicator 1	75

Therefore the maximum possible effectiveness score = $70 + 10 + 75$
= 155

It is then possible to determine an overall effectiveness (productivity) by calculating the percentage of the achieved overall effectiveness in relation to the maximum possible effectiveness.

$$\text{Productivity} = \frac{15 \times 100}{155} = 9,68 \%$$

The closer the enterprise is to the maximum score, the closer it is to the best possible productivity.

Two other unique features of ProMES need to be considered, namely:

- (1) priorities
- (2) aggregation across SBUs

2.2.3 Priorities

ProMES is capable of generating priorities for improving productivity. These priorities come directly from the feedback table, since a given time period (eg a month) is recorded in this report and the actual amount of each indicator achieved for that period together with the effectiveness value. It is a simple task to look at the data for each indicator and calculate the effectiveness gain that would occur if the enterprise or SBU were to increase by one increment on each of the indicators. The associated increase of effectiveness for each indicator can be determined. This is followed by a priority listing of the changes from highest to lowest. This listing communicates exactly what should be done to achieve maximum productivity.

Table 2.2: Productivity improvement priorities

Change	Gain in effectiveness
Priorities for the following period	
Percentage output achieved from 70% to 80%	25
Percentage rework rate from 6% to 5%	5
Percentage return rate from 4% to 3%	1,25

Source: Table 2.2 has been developed from the information provided in figures 2.1, 2.2(a), 2.2(b) and table 2.1.

A word of caution about using the ProMES system to develop priorities: the number of

increments used for the different indicators should be similar in quantity. The problem is that if the number of increments differs considerably, an increase of one increment in one indicator will be a much greater percentage of the total possible range than an increase of one increment in the other indicator.

2.2.4 Aggregation across SBUs

ProMES is able to aggregate across strategic business units (SBUs) and therefore to aggregate the measurement system of larger enterprises. If an enterprise were to consist of five SBUs it would be possible to combine the five measures into a single measure for the entire enterprise. This is not possible in most productivity measurement systems since measurement varies from one SBU to the next (Pritchard et al 1989:83).

Each SBU is measured on a common basis, for example, the overall effectiveness of each business unit. This can be regarded as the overall contribution that each SBU makes to the enterprise. Once again it is possible to add the overall effectiveness of each SBU to obtain a measure of overall effectiveness for the enterprise provided the following additional step is taken, namely normalisation.

By adding the different SBU values, one is essentially assuming that each SBU contributes equally to the effectiveness of the enterprise. Although possible, it is not safe to make this assumption. Often one particular SBU is more critical than another and contributes more to the effectiveness of the enterprise.

It is necessary to adjust the scale of the contingencies across the enterprise. This is achieved by allocating the highest possible level of the most important indicator for each SBU with an effectiveness value of +100. This is true because when the contingencies were developed, the highest level of the most important indicator in each SBU was arbitrarily defined as having an effectiveness value of +100. Thus each of the five SBUs in the same enterprise will have at least one indicator value of +100. This can be thought of as the best possible performance level of the most important indicator for each SBU.

All the +100 indicator levels from the five SBUs are then shown to the management of the enterprise, as well as managers from various levels of supervision in the enterprise. It is their responsibility to rescale the five levels. This is achieved by ranking the five levels in terms of overall contribution to the enterprise. They are asked which of the five outcomes they would most value for the overall effectiveness of the enterprise. This is discussed and consensus reached. Once a final set of ratings is agreed upon, the next step is to rescale the individual contingencies for each of the SBUs. This is done by reducing the effectiveness score of each level of each indicator by the same percentage as its own maximum indicator was reduced in the rescaling.

A similar process is followed for the negative levels of the indicators. The most negative level of the most important indicator is listed for each of the SBUs. These levels are ranked and then rated. The negative values of each level of the indicators are adjusted by the percentage that the original minimum indicator level was reduced. This rescaling process has the effect of adjusting the effectiveness score of the different SBUs in the enterprise for any differences in importance. Once it has been finished, the overall effectiveness values from the SBUs can be added to produce the overall effectiveness of the entire enterprise.

2.3 DETERMINISTIC PRODUCTIVITY ACCOUNTING (DPA)

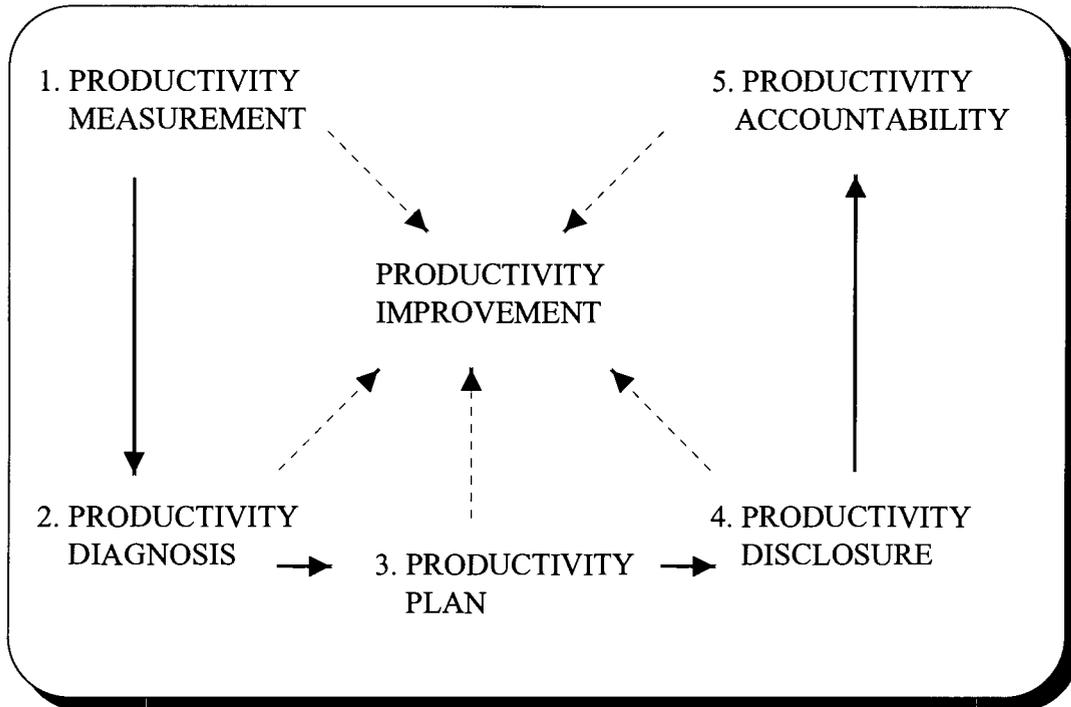
2.3.1 Background

When administering the social science methods related to price theory (microeconomics), the study of product price to quantity is addressed. A related approach is that of deterministic productivity accounting (DPA). DPA utilises the price and quantity concept in respect of products and resources. It considers productivity as a derivative of the economic principle that equates maximum output to minimum input - that is, maximum financial income to minimum financial expenditure. This leads to the maximisation of both productivity as well as price recovery, and when combined, maximises profitability.

2.3.2 DPA methodology

Van Loggerenberg (1990:PAC-1) proposes a process which will result in productivity improvement by the application of five sequential steps as shown in figure 2.3.

Figure 2.3: Productivity management process



Source: Van Loggerenberg (1990:PAC-1)

2.3.2.1 Step 1: Productivity measurement

The purpose of all productivity measurement is control, yet good productivity measurement has more demanding characteristics. Van Loggerenberg (1990:PAB-8) states that productivity measurement in a small manufacturing enterprise must apply full accounting principles. It must:

- provide simple and unambiguous signals to improve profits;
- break down change in profit into the underlying contributions from each resource used in production (i.e. materials, energy, labour and capital);
- break down the productivity term into a capacity utilisation term and an

efficiency term, (i.e. differentiate short term uncontrollable from short term potentially controllable factors);
 use the price recovery term to evaluate whether productivity loss or productivity gain for a given resource is appropriate;
 transform the above measures of change in profit into corresponding measures for change in profitability, change in cost per unit of output, and change in performance index numbers (i.e. productivity index numbers) and;
 provide consistent signals for profit improvement regardless of the units in which the measure is expressed.

Productivity measurement as the first step in the process for productivity improvement is recognised by DPA as having the following accounting identity that applies to revenue, cost and capital (Van Loggerenberg 1990:PAC-1):

$$\begin{array}{l} \text{Value} \quad = \quad \text{Quantity} \quad \times \quad \text{Price} \quad \quad \quad (2.4) \\ \text{(in rand)} \quad \text{(in units)} \quad \quad \quad \text{(in rand/unit)} \end{array}$$

The function of productivity measurement is used to provide remote monitoring and information on the financial standing of the enterprise, resulting from changes in productivity over a period of time, say, from one month to the next or one financial quarter to the next. Productivity measurement is aimed at the objective of changing human behaviour in order to change productivity (Van Loggerenberg 1990:PAC-5).

Development of the DPA approach

The development of the DPA approach starts with equation 2.4 above. It is used to develop the following equations:

$$\begin{array}{l} \text{Value} \quad = \quad \text{Quantity} \quad \times \quad \text{Price} \quad \quad \quad (2.4) \\ \text{(in rand)} \quad \text{(in units)} \quad \quad \quad \text{(in rand/unit)} \end{array}$$

$$\text{Productivity} \quad = \quad \frac{\text{Product quantity}}{\text{Resource quantity}} \quad \quad \quad (2.5)$$

$$\text{Price recovery} = \frac{\text{Product price}}{\text{Resource price}} \quad (2.6)$$

The equation for profitability is developed from the equations for productivity and price recovery (Van Loggerenberg 1990:PAC-2):

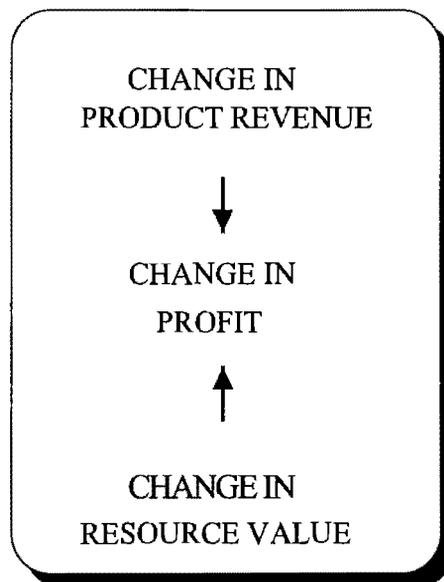
$$\frac{\text{Product value}}{\text{Resource value}} = \frac{\text{Product quantity}}{\text{Resource quantity}} \times \frac{\text{Product price}}{\text{Resource price}}$$

Therefore:

$$\text{Profitability} = \text{Productivity} \times \text{Price recovery} \quad (2.7)$$

Equations 2.4, 2.5 and 2.6 lead to the development of further financial functions concerning the changes in product revenue to changes in resource value as shown in figure 2.4.

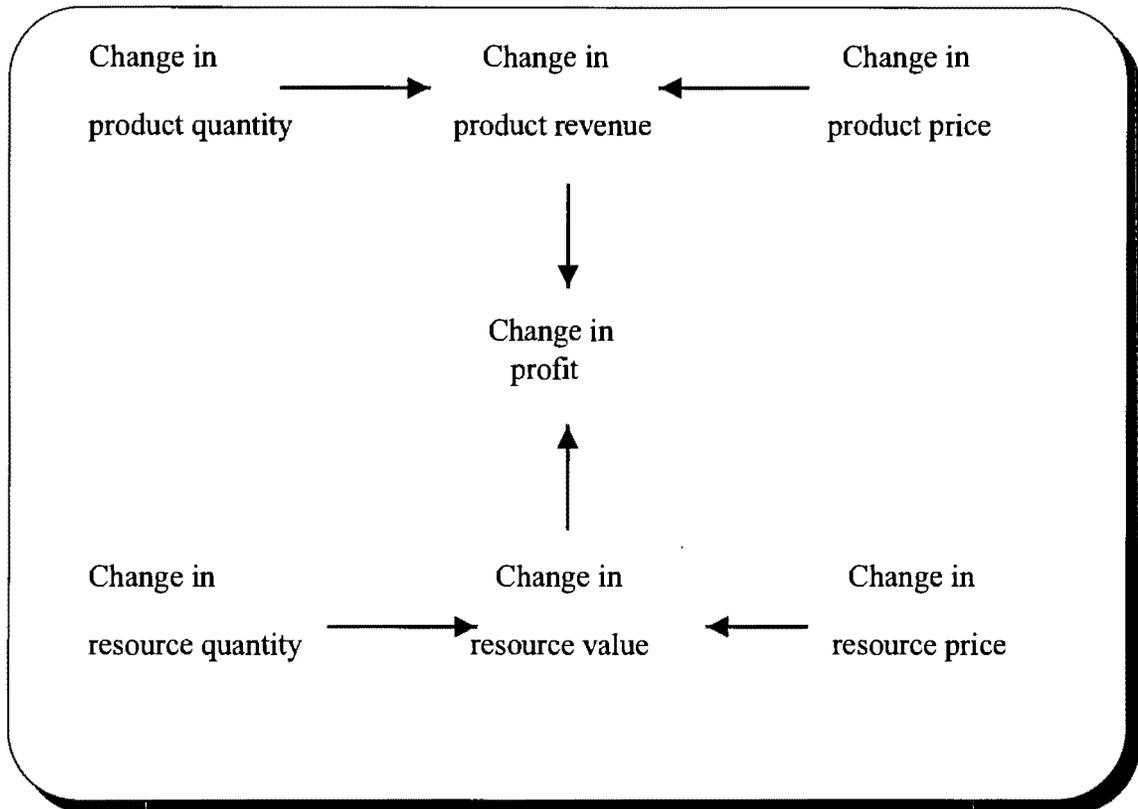
Figure 2.4: Change in profit - example 1



Source: Van Loggerenberg (1990:PAD-2)

Figure 2.4 shows the traditional financial approach to evaluating information provided in the enterprise's income statement. Whilst the financial function provides useful information, it is lacking in information about the effects of quantity and price change. Figure 2.5 provides further insight into this shortcoming.

Figure 2.5: Change in profit - example 2



Source: Van Loggerenberg (1990:PAD-3)

Figure 2.5 shows how prices can influence profit from two perspectives:

- (1) Price change of the product
- (2) Price change of the resources

It also shows how quantity variation can do precisely the same to profit variation in the following two instances:

- (1) Quantity change of the product

(2) Quantity change of the resource

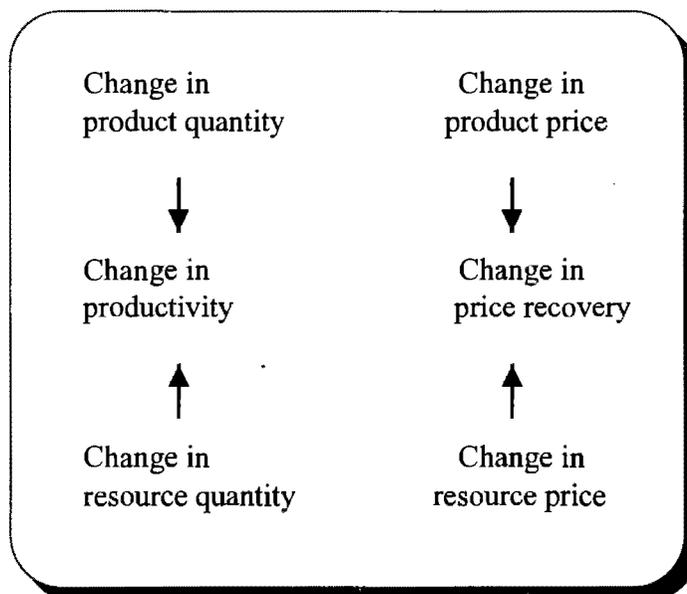
When there is a change in the price or quantity of the product, a variation occurs in the product revenue. Similarly, when there is a change in the price or quantity of the resource, a variation occurs in the resource value results. The net result on profit is either an increase or a decrease in profit.

Figure 2.5 fails to provide information on productivity and price recovery - hence the development of figure 2.6.

Figure 2.6 presents the situations in which:

- (1) A change in productivity results from a change in product quantity which is not proportional to a simultaneous change in resource quantity.
- (2) A change in price recovery results from a change in product price which is not proportional to a simultaneous change in resource price.

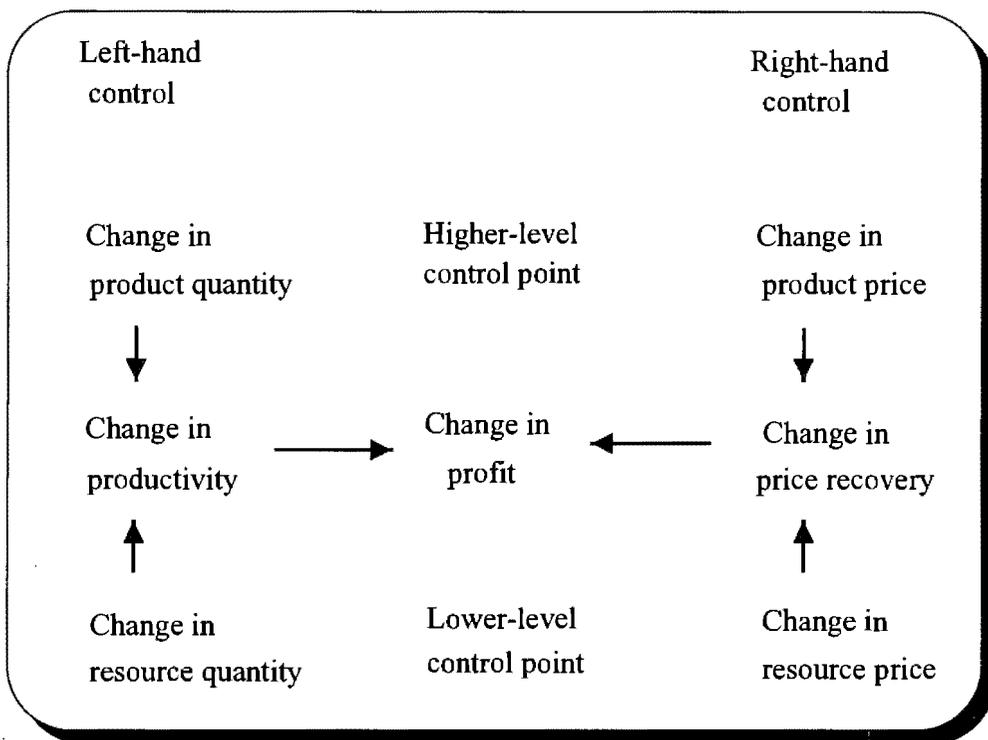
Figure 2.6: Change in productivity and price recovery



Source: Van Loggerenberg (1990:PAD-3)

Figure 2.6 shows that these relationships can be measured for each resource used in the enterprise, thus making it possible to measure the change in profit as shown in figure 2.7. Figure 2.7 shows that it is possible to measure the bottom-line impact of change in productivity and change in price recovery for each resource used in the enterprise. This provides management with a control method to gauge the bottom-line rand effect of a change in the allocation of individual resources (Van Loggerenberg 1990:PAD-4).

Figure 2.7: Change in profit: higher-level and lower-level influences



Source: Van Loggerenberg (1990:PAD-4)

The level related to the product is called the higher-level control point. At this level, decisions are made on both production and product pricing, and management are able to trade productivity variance off against price recovery. This is brought about by a price reduction in favour of an increase in product demand.

The lower-level control points influence profit when less resource quantity is utilised for a constant quantity of product. This results in an increase in productivity. Similarly, when the price of a resource can be controlled and reduced compared to a constant product

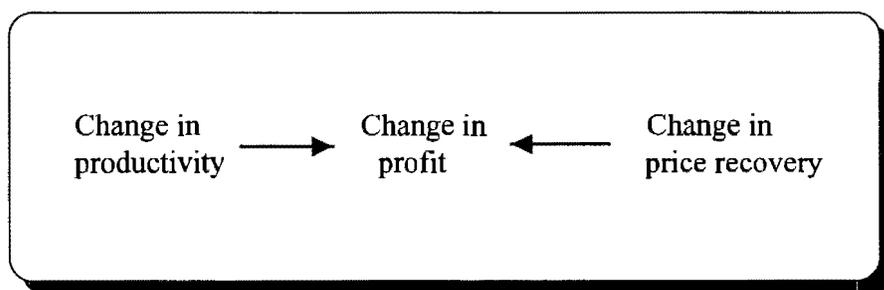
price, the price recovery improves. The combination of both productivity and price recovery gain, results in an increase in profit.

An additional perspective is that of the left-hand and right-hand control points, each of which influence the profit of the enterprise.

- (1) **Left-hand control point.** This area relates the output to input ratio of product quantity to resource quantity - an equation used to measure productivity.
- (2) **Right-hand control point.** This area provides information on the effectiveness of the price recovery variance per resource. When an unfavourable contribution to price recovery occurs, it is possible to direct productivity growth objectives to the resource causing the less than favourable recovery.

The ability to measure each resource's contribution to change in productivity and change in price recovery, to that of a change in profit, suggests that their aggregation allows one to explain the origin of change in profit in the income statement, as described in figure 2.8.

Figure 2.8: Profit change: income statement

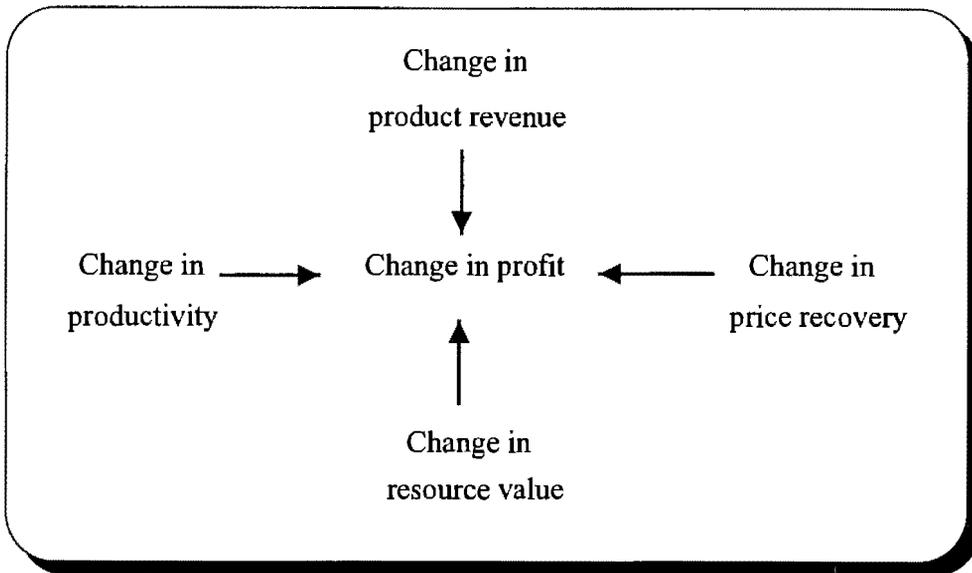


Source: Van Loggerenberg (1990:PAD-5)

Figure 2.8 suggests that it is possible to explain a change in the income statement by administering the horizontal function in the figure in lieu of the vertical method utilised in figure 2.4. A combination of figures 2.4 and 2.8 results in a single figure which provides added control insight.

Figure 2.9 is the result of this combination:

Figure 2.9: Profit change: the combined result



Source: Van Loggerenberg (1990:PAD-6)

Reviewing the development of the change in profit resulting from the various influences as tabulated from figure 2.4 to figure 2.9, a summation of all the concepts is presented in figure 2.10.

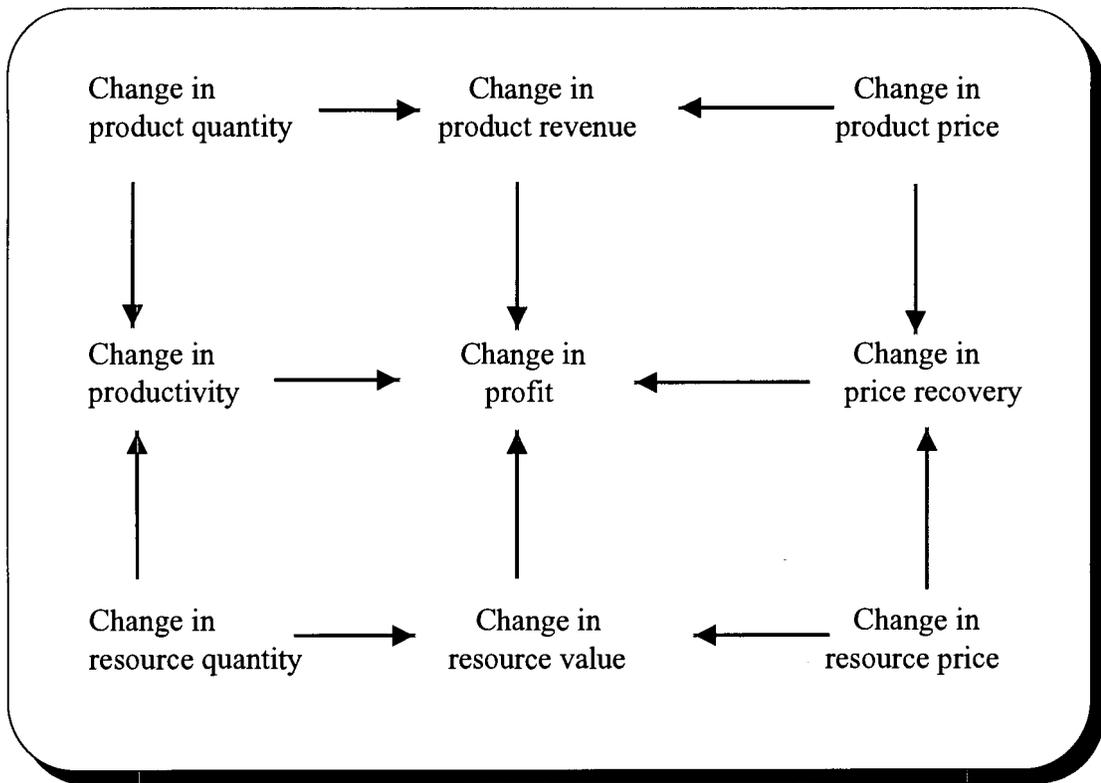
It is important to note that figures 2.4 to 2.10 are conceptual rather than definitional. This can be explained by considering the accounting approach to determining a change in profit as follows:

$$\text{Profit (rand)} = \text{Revenue (rand)} - \text{Cost (rand)} \quad (2.8)$$

a Productivity and price recovery levels

Productivity is influenced in various ways due to changes in product quantity and resource quantity. Similarly, insight is also required into the influence on price recovery resulting from a change in product price and resource price. The following productivity measurement situations and price recovery situations clarify these influences of change:

Figure 2.10: The DPA model



Source: Van Loggerenberg (1990:PAD-6)

Consider a manufacturer of steel tables. During the previous period the manufacturer produced 20 tables; in the current period 30 tables have been produced.

$$\begin{aligned}
 \text{Product quantity relative} &= \frac{\text{New product quantity}}{\text{Old product quantity}} && (2.9) \\
 &= \frac{30 \text{ tables}}{20 \text{ tables}} \\
 &= 1,5 \text{ dimensionless}
 \end{aligned}$$

Now consider the resource situation if a variation occurs as follows:

In the previous period, 40 square metres of steel were consumed. In the current period, 50 square metres were consumed. Thus:

$$\begin{aligned}
 \text{Resource quantity relative} &= \frac{\text{New resource quantity}}{\text{Old resource quantity}} & (2.10) \\
 &= \frac{50 \text{ square metres of steel}}{40 \text{ square metres of steel}} \\
 &= 1,25 \text{ dimensionless}
 \end{aligned}$$

The resultant influence on productivity on account of the two relative relations is shown in the following equation:

$$\begin{aligned}
 \text{Steel productivity relative} &= \frac{\text{New steel productivity level}}{\text{Old steel productivity level}} & (2.11) \\
 &= \frac{30/50 \text{ tables per square metre of steel}}{20/40 \text{ tables per square metre of steel}} \\
 &= \frac{0,6}{0,5} \\
 &= 1,2 \text{ dimensionless}
 \end{aligned}$$

The steel productivity relative can be derived by using the product quantity relative and resource quantity relative as follows (Van Loggerenberg 1990:PAG-3):

$$\begin{aligned}
 \text{Steel productivity relative} &= \frac{\text{New steel productivity level}}{\text{Old steel productivity level}} & (2.12) \\
 &= \frac{\text{New product quantity} / \text{New resource quantity}}{\text{Old product quantity} / \text{Old resource quantity}} \\
 &= \frac{\text{New product quantity} / \text{Old product quantity}}{\text{New resource quantity} / \text{Old resource quantity}} \\
 &= \frac{\text{Product quantity relative}}{\text{Resource quantity relative}} \\
 &= \frac{1,5}{1,25} = 1,2
 \end{aligned}$$

When defining productivity relative as the product quantity relative divided by resource quantity relative, a common base for deriving their slopes on a graph occurs. This signifies that safe inferences on productivity can be drawn from the slopes of the product quantity relative and resource quantity relative. The inferences will provide information in the form of an increase in productivity or a state of constant productivity, and finally, a condition of a decline in the level of productivity.

2.3.2.2 *Step 2: Productivity diagnosis*

Productivity diagnosis is the step that evaluates and assesses the reason or reasons for changes in productivity. Management's cooperation is essential to ensure a satisfactory outcome to the questions posed in this step (Van Loggerenberg 1990:PAC-2).

2.3.2.3 *Step 3: Productivity plan*

This step represents what are termed, "soft components" and "hard components". A productivity plan is developed from the information gained during the diagnostic step. When this plan is implemented, its key objective must be the improvement of productivity from the current level, to a forecast level in line with the enterprise's budget.

The soft components in this step include, but are not limited to, the following:

- ♦ paradigm shift
- ♦ education
- ♦ training
- ♦ culture
- ♦ reorganisation of the enterprise's structure

The hard components will include, but are not limited to, the following:

- ♦ machinery acquisition or sale
- ♦ value engineering
- ♦ engineering excellence
- ♦ MRP - material requirements planning
- ♦ PERT/CPM - critical path methods
- ♦ linear programming

2.3.2.4 *Step 4: Productivity disclosure*

Productivity disclosure involves the divulgence of index numbers to internal and external parties obtained from profit and/or cost performance-related reports. The internal disclosure of this data brings about an increased awareness of the productivity concept in the enterprise (Van Loggerenberg 1990:PAC-3).

In the case of small manufacturing enterprises, it is unlikely that this information will be divulged to outside parties. However, Van Loggerenberg encourages the idea of disclosure to external parties since it is considered that disclosure represents the acid test of management's commitment to productivity improvement (Van Loggerenberg 1990:PAC-3).

2.3.2.5 *Step 5: Productivity accountability*

Productivity accountability relates to both actual and planned productivity performance. In the case of actual productivity performance, actual productivity in a specific period of time is related to actual productivity in an earlier period or to budget for the same accounting period. Planned productivity performance relates the planned productivity performance in a given budget to an earlier accounting period or another budget for an earlier period (Van Loggerenberg 1990:PAC-4).

2.3.2.6 *The outcome: productivity improvement*

Productivity improvement is identified through productivity measurement and the outcome communicated to the relevant parties involved in the productivity improvement process. All the components of the five steps of the process must be merged together to achieve productivity improvement (Van Loggerenberg 1990:PAC-4).

2.4 THE NATIONAL PRODUCTIVITY INSTITUTE (NPI)

2.4.1 Background

It is appropriate to consider the current mission statement of the NPI in order to obtain an overview of their policies and objectives. The NPI (1996) states:

The NPI's mission is to make a significant contribution to the improvement of the standard of living and quality of life of all people in South Africa and to the creation of employment opportunities by taking and evoking action that will result in the more productive use of all resources.

In line with its mission the NPI's function is to promote productivity. They do this by assisting organisations through consulting activities, by offering productivity training, and promoting productivity at a national level. They also host an annual productivity competition to determine the most productive enterprises in the South African economy.

Since their services are predominantly of a consulting nature their methods are not freely available. In addition the publication of specific case studies has been reduced and only older sources are available. The sources consulted date back to as early as 1973 where a similarity is noted in the methodology applied as recently as 1987. The publication, *Productivity study of the pharmaceutical manufacturing industry in South Africa*, has no date of publication, but the study spans the period 1985 to 1987.

When an evaluation is done in an enterprise, the NPI first considers the macro-environment and its influence on the enterprise. This coincides with its long-term view that only an enterprise that serves the needs of its society effectively and efficiently will survive (NPI sa:5).

The methodology of evaluating an enterprise is consistent, and can be divided into the following five segments (NPI 1973; NPI 1977; NPI sa):

- General management
- Financial management
- Marketing
- Personnel and labour
- Production

Only the sections within these five segments that specifically deal with an objective method of determining productivity are included in this discussion. Several subjective measures are used in the segments dedicated to background information, general management, marketing management and personnel management. This leaves financial and production management as the key segments requiring consideration.

2.4.2 NPI methodology

2.4.2.1 Step 1: Financial productivity measurement

The objective is to measure the total productivity performance of the enterprise. A relationship must be found between the output value generated by the enterprise and the input value. This can take the form of the net output or value added to the input value.

Value added is defined as the value generated by a manufacturer through the production process (NPI 1973:29). Consider the case where a raw material is purchased for the purpose of manufacturing a finished product for sale. Certain costs are added to this raw material to convert it into a saleable product. These costs take the form of wages, salaries,

overheads, administrative expenses, selling expenses, finance expenses and net profit before tax. The sum of all these costs equals the value added to the raw material. It is a key objective of the enterprise to increase the amount of value added to all input materials therefore resulting in an increase in productivity.

It is possible to simplify the calculation of value added by applying the following equation:

$$\text{Value added} = \text{Sales} - \text{Outside material purchases} \quad (2.13)$$

In other words, value added is calculated by subtracting the cost of raw materials used in the manufacturing process from the value of sales. This represents the output of the enterprise. Total productivity is measured by dividing the value added by the sum of the yield on capital combined with the yield on labour (NPI 1973:51). This ratio is made up of a combination of two further ratios, namely:

- (1) Labour productivity
- (2) Capital productivity

a *Labour productivity*

Labour productivity indicates the value added for each R 1,00 spent on the yield of labour (NPI 1973:51; NPI 1977:274).

$$\text{Labour productivity} = \frac{\text{Value added (Net output)}}{\text{Total salaries}} \quad (2.14)$$

An enterprise's wage policy and pricing policy may to some extent influence this ratio, but it provides a comparable measure of labour productivity.

In enterprises with a high capital/labour ratio where plant and machinery (capital) are not underutilised, it is normal for these enterprises to have a high labour productivity ratio.

If one considers this ratio in relation to the capital/labour ratio presented above, it is clear that when an enterprise has a high capital/labour ratio, it is more capital intensive and therefore the value added divided by a proportionally smaller labour component is relatively greater than in a case when an enterprise's capital/labour ratio is low.

b *Capital productivity*

Capital productivity indicates the value added generated for each R 1,00 spent on the after tax yield (NPI 1973:51; NPI 1977:275).

$$\text{Capital productivity} = \frac{\text{Value added}}{\text{After-tax yield on operating assets}} \quad (2.15)$$

The after-tax yield can also be a predetermined percentage expected to be received on the value of the operating assets. That is, if a 6 percent after-tax yield is required for an operating asset base of R2 million, then the after-tax yield on operating assets is calculated as follows:

$$\begin{aligned} \text{After-tax yield} &= \frac{6}{100} \times \text{R } 2\,000\,000 \\ &= \text{R } 120\,000 \end{aligned}$$

The age of the plant and the enterprise's pricing policy may affect this ratio, but it does permit comparison between various enterprises.

A high capital (or operating asset) productivity can be expected in an enterprise having a low capital/labour ratio. This is due to high utilisation of labour. Similarly a low capital ratio occurs when a high capital/labour ratio exists in the enterprise.

It holds that where the capital/labour ratio is low, the company is more labour intensive, with the result that if value added is divided by a proportionally smaller capital

component, the value added for each rand spent on the yield of capital would be relatively higher than in a case where an enterprise's capital/labour ratio is high.

2.4.2.2 *Step 2: Total productivity*

To obtain an overall yardstick of performance for one or more enterprises within an industry, the NPI combines the measures of labour productivity and capital productivity in the development of the total productivity ratio (NPI 1973:53; NPI 1977:276):

$$\text{Total productivity} = \frac{\text{Value added}}{\text{Salaries} + \text{Yield on capital}} \quad (2.16)$$

An additional list of productivity ratios used in conjunction with the financial ratios are as follows (NPI sa:62):

- Growth in sales (over period of years)
- Real growth in sales (inflation adjusted)
- Sales per employee
- Growth in sales per employee
- Real sales per employee
- Growth in real sales per employee
- Value added to sales ratio (%)
- Value added per employee
- Growth in value added per employee
- Growth in assets
- Capital employed per employee
- Growth in capital employed per employee

All the growth aspects listed above are compared with previous performances during preceding years.

In addition to productivity measures, attention is focused on various financial ratios which cover the following categories:

- ♦ Profitability analysis

- ♦ Income, expenses and profit structure
- ♦ Asset utilisation
- ♦ Asset and liability structure
- ♦ Short-term planning and information systems

2.4.2.3 Step 3: Profitability ratios

The key objective to achieve success in the enterprise is clearly stated by the NPI (sa:49):

A business enterprise exists because the owners expect a return on their capital. The main objective of such a business should therefore be to maximise the return on capital in a manner consistent with long-term balanced growth and acceptable to the society in which the business or enterprise operates.

The NPI makes use of a specific method to analyse the financial results of an enterprise. They point out that an enterprise's return on operating assets (operating profit/operating assets) depends on two relationships namely, that between its operating profit and its sales (operating profit/sales) and that between its sales and its operating assets (sales/operating assets) (NPI 1973:52).

The method used to determine the return on assets (ROA) is clearly detailed in the combination of the following ratios (NPI 1973:6):

$$\text{Return on operating assets} = \frac{\text{Operating profit}}{\text{Operating assets}} \quad (\text{Ratio 1}) \quad (2.17)$$

The operating profit margin considers only income produced by the enterprise through sales minus material cost, wages, salaries, administration and other operating expenses. This equates earnings before interest and tax (EBIT) to sales (Unisa 1984:53):

$$\text{Therefore: Operating profit margin} = \frac{\text{EBIT}}{\text{Sales}} \quad (\text{Ratio 2}) \quad (2.18)$$

$$\text{and Turnover of operating assets} = \frac{\text{Sales}}{\text{Operating assets}} \quad (\text{Ratio 3})$$

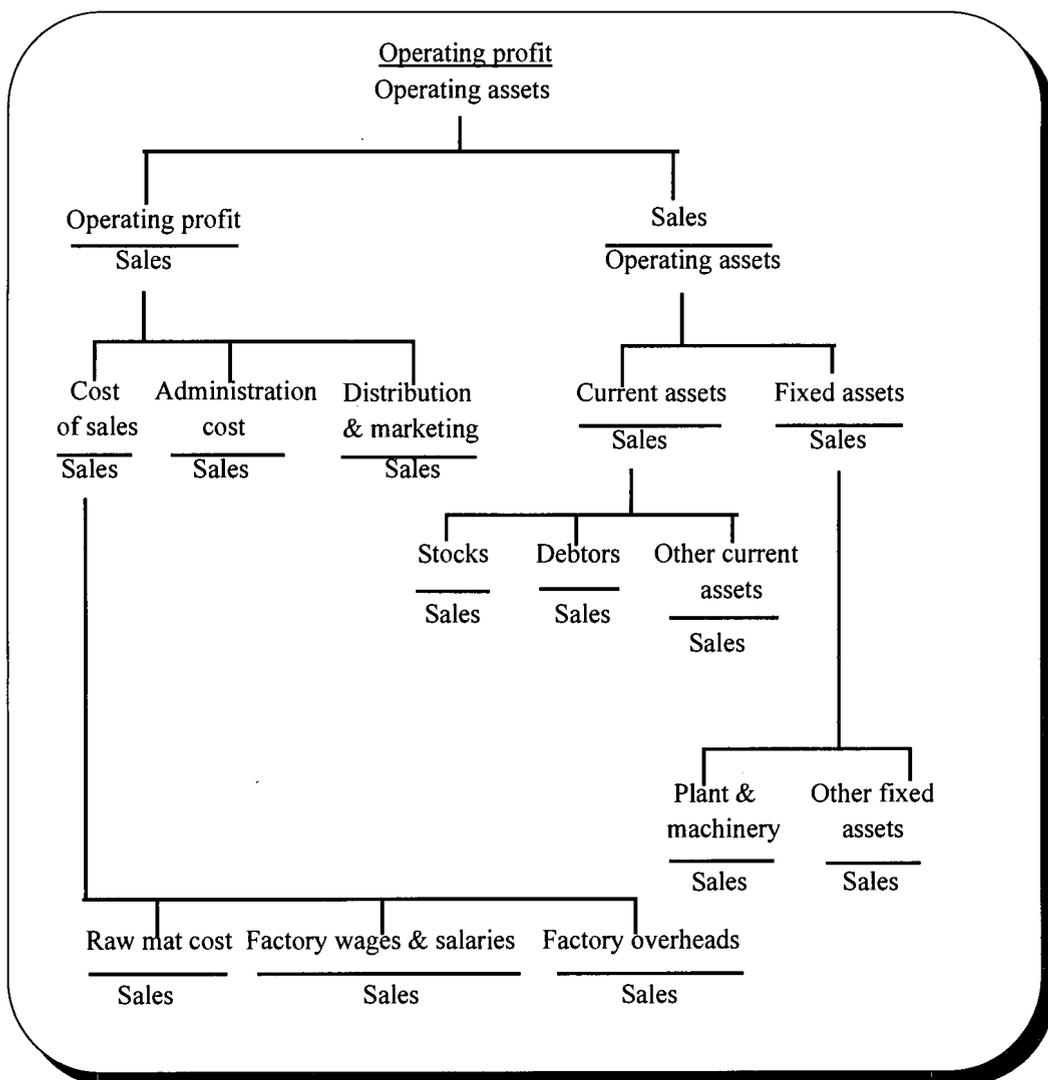
Substituting these ratios into ratio 1:

$$\text{ROA} = \frac{\text{EBIT}}{\text{Sales}} \times \frac{\text{Sales}}{\text{Operating assets}} \quad (2.19)$$

$$\text{Ratio 1} = \text{Ratio 2} \times \text{Ratio 3}$$

This can be expanded on to include a number of additional ratios as detailed in figure 2.11:

Figure 2.11: Sales-related ratios



Source: NPI (1973:54)

2.4.2.4 Step 4: Income, expenses and profit structure

This information is presented in three ways (NPI 1973:17; NPI 1977:28; NPI sa:53):

Individual items are expressed as a percentage of sales, for example, overheads as a percentage of sales.

Individual items are expressed as a value per employee and are given the abbreviation REA (rand per employee per annum) unit value (NPI 1973:17; NPI 1977:28).

Individual items are expressed in rand per R 1 000 invested in operating assets. This obtained by dividing each item by the value of the total operating assets divided by R 1 000 (NPI 1973:23):

Annual sales	R 250 000		
Total operating assets	R 120 000		
Therefore:	$= \frac{120\,000}{1000}$	=	120
and rand value of sales per R1 000 of assets		=	$\frac{250\,000}{120}$
		=	2 083,33

This value can be used to compare one enterprise with another when the relevant data are available on other enterprises in the same industry.

When considering the income, expense and profit ratios of the enterprise, four ratios are determined with reference to sales (NPI 1973:24; NPI sa:57):

Cost of sales / sales
 Gross profit / sales
 Period cost / sales
 Operating profit / sales

Various other cost items are expressed in relation to total cost. This process eliminates the influence of prices and their associated margins.

These ratios can be tabulated in the following way for these various cost items:

Cost of sales / total cost

- ♦ Materials used / total cost
- ♦ Factory labour / total cost

Administration cost / total cost

Marketing cost / total cost

- ♦ Selling cost / total cost
- ♦ Distribution cost / total cost
- ♦ Other marketing costs/ total costs

2.4.2.5 *Step 5: Asset utilisation*

To evaluate the utilisation of assets, it is possible to divide this sector into two types of asset utilisation:

- (1) Operating asset utilisation
- (2) Other indicators of asset utilisation

a *Operating asset utilisation*

A study is carried out to determine the amount of investment the enterprise requires in operating assets to generate R 1 000 of sales. The lower the amount of investment, the better the assets are utilised (NPI sa:65).

A table providing this information over a period of time can be developed. The enterprise is able to compare its utilisation over a time period to ensure that a balance is maintained. If information is available from a source of central statistics, similar enterprises are able to compare their performance to other enterprises in their field of activity.

These data can be tabulated in the format shown in table 2.3:

Table 2.3: Asset utilisation

Operating asset item	Year n Rand	Year n+1	Year n+2	Average
1. Fixed operating assets	416	397	340	377
1.1 Land & buildings	358	330	258	309
1.2 Plant & machinery	80	73	69	73
1.3 Motor vehicles	40	38	46	41
1.4 Office equipment	27	22	29	23
2 Current assets	765	708	533	618
2.1 Debtors	428	298	231	298
2.2 Stocks	443	434	419	430
- Finished goods	206	231	189	194
- Work in progress	118	101	110	85
- Raw materials	178	171	147	150
2.5 Total assets	1 107	978	839	887

Values on R 1 000s

Source: NPI (sa:66)

b Other indicators of asset utilisation

A number of additional assets are considered in the form of ratios and are recorded in a method similar to the operating assets in table 2.4.

The following ratio applies in determining the collection period for total debtors (Gitman 1985:121):

$$\text{Debtors' collection period} = \frac{\text{Accounts receivable (debtors)}}{\text{Annual sales} / 360} \quad (2.20)$$

Table 2.4: Other indicators of asset utilisation

Ratio	Year n	Year n+1	Year n+2	Average
Debtors' collection (days)				
- Total debtors	156	109	84	109
- Trade debtors	91	78	83	78
Stockholding days (cos)*				
- Finished goods	75	84	69	71
- Work in progress	43	37	40	31
- Raw materials	65	62	54	55
- Packaging materials	15	14	18	15
- Total stock	162	158	153	157
Business cycle (days)	279	258	195	226
Current ratio	4,73	5,88	6,97	5,48
Quick ratio	2,60	1,88	2,24	1,70

* cos = cost of sales

Source: NPI (sa:69)

The following ratio is used to determine the age of stock (Gitman 1985:120):

$$\text{Inventory turnover} = \frac{\text{Cost of goods sold (cost of sales)}}{\text{Inventory}} \quad (2.21)$$

$$\text{Average age of stock} = \frac{360}{\text{Inventory turnover}} \quad (2.22)$$

The value for inventory can be altered to suit finished goods, work in progress and raw materials as required.

The business cycle is calculated by adding together total stockholding in days and the debtors' collection period in days (NPI sa:68).

The current ratio gives an indication of how many times current liabilities are covered by current assets. A general guideline is that this ratio should not be below two.

$$\text{Current ratio} = \frac{\text{Current assets}}{\text{Current liabilities}} \quad (2.23)$$

The quick ratio or acid test is similar to the current ratio except it excludes inventory from current assets. Inventories are excluded since they are the least liquid current asset. A quick ratio of one or greater is recommended (Gitman 1985:119).

$$\text{Acid test ratio} = \frac{\text{Current assets} - \text{inventory}}{\text{Current liabilities}} \quad (2.24)$$

2.4.2.6 Step 6: *Asset and liability structure*

The asset structure provides the percentage of each asset to the total assets and is tabulated accordingly. The liability structure follows the same format in table form as described in table 2.5:

Table 2.5: Asset structure as a percentage of total assets

Asset structure	Year n Rand	Year n+1	Year n+2	Average
1 Fixed assets	49,47	41,10	39,09	41,58
1.1 Land & buildings	36,39	32,81	29,42	32,14
1.2 Plant & machinery	10,17	9,47	8,74	9,16
1.3 Motor-vehicles	4,63	3,36	2,11	3,26
1.4 Office equipment	3,70	3,49	8,19	5,13
2 Current assets	89,47	90,92	90,94	90,50
2.1 Debtors	37,63	38,23	30,97	32,86
2.2 Stocks	73,74	73,77	72,94	73,44
2.3 Cash & deposits	12,13	14,11	23,99	15,61
2.4 Other	4,40	18,43	13,67	11,64
3 Other assets	29,29	18,89	19,86	22,41
4 Total assets	100	100	100	100

Source: NPI (sa:71)

Similarly, the liability structure takes on a similar format to the asset structure table as follows:

Table 2.6: Liability structure as a percentage of total liabilities

Liability structure	Year n	Year n+1	Year n+2	Average
1 Fixed liabilities	86,04	84,77	87,33	83,79
1.1 Shareholders' equity	71,89	75,77	79,89	72,14
1.2 Long-term loans	20,85	18,32	20,83	20,04
1.3 Other	2,84	14,77	6,30	8,85
2 Current liabilities	66,94	67,09	71,03	68,54
2.1 Creditors	66,94	67,09	71,03	68,54
2.2 Bank overdraft	28,49	22,64	16,63	17,30
2.3 Short-term loans	5,96	17,31	10,01	9,90
2.4 Other	10,74	13,44	21,11	14,25
3 Total liabilities	100	100	100	100

Source: NPI (sa:72)

2.4.2.7 *Step 7: Production*

Three major factors make up the input factors of the production function, namely materials, labour and machinery. A combination of each input produces an output in the form of a product.

Since the relationship between output and input forms the basis of productivity measurement, an evaluation of the production function is vital to any holistic productivity study (NPI sa:98).

Three divisions of manufacturing productivity are measured in this section, namely:

- (1) Material productivity
- (2) Labour productivity
- (3) Equipment and machine productivity

a *Material productivity*

The percentage of material used as the input in the total product is often high in proportion to other inputs. This emphasises the need to measure and control the productivity of materials to prevent excessive influence on the price build of the product due to poor productivity.

The following aspects of material productivity are investigated:

- i Material yields
- ii Material wastage
- iii Inventory analysis

i *Material yields*

The quantity of material consumed to produce a product can be compared to the

standard quantity which is defined as the required amount for the product. This provides a measure of material yield.

$$\text{Material yields} = \frac{\text{Material output quantity}}{\text{Material input quantity}} \quad (2.25)$$

ii *Material wastage*

The overrequirement of materials to produce the product may be the result of poor control of material issues, bad workmanship, poor machine setting or obsolescence. All these causes of material wastage must be categorised and monitored to ensure that they are minimised at all times.

The major factors adversely affecting material yields resulting in wastage may include the following (NPI sa:101):

- Poor and/or incorrect setting of production machines
- Rejects and rework
- Poor production volumes
- Residue in production equipment (extrusion machines)
- Environmental material losses, that is, steam, excessive extraction or evaporation
- Poor control of production process

iii *Inventory analysis*

Various ratios are used to provide productivity information on the inventory function. These have been covered in section 2.4.2.5 which deals with the use of assets. They are repeated here for ease of discussion and reference as follows:

- (1) The ratio of raw materials to the cost of sales given as a percentage.
- (2) If imported materials are used, it is appropriate to measure them the same way as a ratio of imported raw materials to the cost of sales given as a percentage.

(3) The age of stock is determined with the ratio (Gitman 1985:120):

$$\text{Average age of stock} = \frac{360}{\text{Inventory turnover}} \quad (2.22)$$

where:

$$\text{Inventory turnover} = \frac{\text{Cost of goods sold (cost of sales)}}{\text{Inventory}} \quad (2.21)$$

The value for inventory can be altered to suit finished goods, work in progress and raw materials as required.

b *Labour productivity*

Labour utilisation is defined as the time spent on productive work as a percentage of time available (NPI sa:108). It can best be expressed by means of the following equation:

$$\text{Labour utilisation} = \frac{\text{Productive hours worked}}{\text{Hours available}} \times 100 \quad (2.26)$$

The labour improvement potential of an enterprise can be determined by means of the following equation (NPI sa:110):

$$\text{Labour improvement potential} = \frac{\text{Target level} - \text{Present average level}}{\text{Present average level}} \times 100 \quad (2.27)$$

The present average level can be determined over a period of time for the individual enterprise or it can be taken from an industry norm.

A further method of labour measurement is that of labour efficiency which is defined as the time required to do the work at a standard work pace, expressed as a percentage of the actual time taken to do the work. It is presented in the following equation (NPI sa:112):

$$\text{Labour efficiency} = \frac{\text{Hours required at standard work pace}}{\text{Hours required at actual work pace}} \times 100 \quad (2.28)$$

This equation leads to the development of the labour productivity equation which represents the time spent by the workers on productive work, multiplied by the efficiency at which this work is performed, expressed as a percentage of the time available to these workers (NPI sa:112).

The equation takes the following form:

$$\text{Labour productivity} = \frac{\text{Productive hours worked} \times \text{Efficiency}}{\text{Hours available}} \times 100 \quad (2.29)$$

c *Equipment and machine productivity*

One essential aspect needs to be considered with regard to equipment and machinery, namely utilisation. It is explained in the following section.

i *Machinery utilisation*

Two types of measurement are used when considering the fixed plant or capacity, namely: Capacity efficiency and capacity utilisation.

Capacity efficiency

Efficiency is the ratio of actual output to effective capacity (Stevenson 1986:177).

$$\text{Capacity efficiency} = \frac{\text{Actual output}}{\text{Effective capacity}} \quad (2.30)$$

Where:

Actual output, is the rate of output actually achieved. It is not possible for actual output to exceed effective capacity and it is often less than effective capacity due to breakdowns, defective output or shortages of materials (Stevenson 1986:177).

Effective capacity, is the maximum possible output given a product mix, scheduling difficulties, machine maintenance and factors concerning quality (Stevenson 1986:177).

Capacity utilisation

Utilisation is the ratio of actual output to design output as follows:

$$\text{Capacity utilisation} = \frac{\text{Actual output}}{\text{Design capacity}} \quad (2.31)$$

Where:

Design capacity is the maximum output that can possibly be achieved from the machinery in use (Stevenson 1986:177).

2.5 THEORY OF CONSTRAINTS (ToC)

2.5.1 Background

In recent years, the NPI has promoted the work of Goldratt and Cox (1992) as a philosophy which should be induced in the thoughts of management who function in manufacturing enterprises.

The subject emphasised by Goldratt and Cox (1992) is the key objective of the enterprise in the form of its goal, or as they term it, "the goal".

2.5.2 Theory of constraints methodology

2.5.2.1 Step 1: Define the enterprise's goal

The initial objective is to define the enterprise's goal. For the manufacturing enterprise, this has been defined as the goal to make money (Goldratt & Cox 1992:40). Yet the broad statement of making money requires refinement, and can be appropriately

subdivided into three measurements which will lead to the achievement of the goal (Goldratt & Cox 1992:49):

- (1) Net profit
- (2) Return on investment
- (3) Cash flow

Clearly the goal is to make money by increasing net profit, while simultaneously increasing the return on investment and simultaneously increasing cash flow. These measures express the goal of making money perfectly well but also permit management to develop operational rules enabling them to manage and control the enterprise.

2.5.2.2 *Step 2: Operational measurement*

There are three operational measurement rules in the manufacturing enterprise (Goldratt & Cox 1992:59).

Throughput
Inventory
Operational expenses

a *Throughput*

Throughput is the rate at which the system generates money through sales. Throughput should not be confused with production. If the enterprise produces something but is unable to sell it, it is not categorised as throughput. Only when the product is sold and money received can it be classified as throughput.

b *Inventory*

Inventory is all the money that the system has invested in purchasing things it intends to

sell. The value added is not considered in the valuation of inventory, that is, where labour costs are added to a component prior to booking it into stock. In this way any confusion is eliminated and prevents the idea that a rand spent is either considered as an investment or an expense.

c Operational expense

Operational expense is all the money the system spends in order to turn inventory into throughput.

In each of these measurements, the enterprise is considered as a whole and not as various strategic business units. Local optimums are not part of the consideration, that is, where each individual division of the enterprise is optimised (Goldratt & Cox 1992:60).

A quick method to evaluate an enterprise's attainment of its goal would be to ask the following questions:

Have more products been sold due to the excess capacity available in the plant? - Throughput.

Have reductions been made in the workforce? - Operational expense.

Have stocks been reduced? - Inventory.

Each of these measures maintains the emphasis on money (Goldratt & Cox 1992:72):

When throughput increases, the amount of money coming into the enterprise increases.

Inventory refers to the money tied up in the enterprise - static.

Operational expense is a consumer of money which is paid out in order to achieve throughput.

With these forms of measurement available, the goal can be stated in the following way (Goldratt & Cox 1992:66):

To increase throughput while simultaneously reducing both inventory and operating expenses

2.5.2.3 *Step 3: Balancing the plant*

A balanced plant is a plant in which the capacity of each and every resource is balanced exactly with demand from the market (Goldratt & Cox 1992:84).

Two phenomena cause difficulty when trying to balance a plant (Goldratt & Cox 1992:86):

Dependent events
Statistical fluctuations

a *Dependent events*

A dependent event occurs when an event or a series of events, must take place before another can begin. The subsequent event depends upon the ones before it. This means that one operation has to be completed before a second can be performed.

It often happens in manufacturing that components are made in a sequence of steps. Machine A has to finish Step 1 before Worker B can proceed with Step 2. All the components must be completed before the final product can be assembled and ultimately packed before delivery.

b *Statistical fluctuations*

Fluctuations occur in manufacturing time at different points in the production process. This occurs specifically in a queuing environment in which components move from one machine to another in order to arrive at the assembly point. Take the example of a build of the final product where 80 percent of the components pass through production line X,

whilst the remaining 20 percent are supplied by another production line Y. Let us assume that line X is short and the processing time is 10 minutes whilst the production time for line Y is 15 minutes. When the first component reaches the assembly point after passing through line X, it has to wait five minutes before the first component off line Y is ready for assembly. Now when the second component comes off line X, the total production time for the two components off line X is 20 minutes, but in the case of the first two off line Y the total production time is 30 minutes. The variance is now 10 minutes because of the delay on line Y. This variance is called the statistical fluctuation in the plant.

2.5.2.4 *Step 4: Categorising the resources*

Once dependent events and statistical fluctuations have been identified, the next step is to investigate each of the production lines and distinguish between the following two types of resources (Goldratt & Cox 1992:138):

bottlenecks
nonbottlenecks

a *Bottlenecks*

A bottleneck is a resource whose capacity is equal to less than the demand placed upon it. It is simple to locate a bottleneck in the plant since large amounts of inventory will be found there waiting to be processed.

b *Nonbottlenecks*

A nonbottleneck is any resource whose capacity is greater than the demand placed on it.

i *The relationship rules regarding bottlenecks and nonbottlenecks*

Certain rules express the relationship between bottlenecks and nonbottlenecks as follows:

- (1) Capacity should not be balanced with demand, but the flow of products through the plant should be balanced with the demand from the market (Goldratt & Cox 1992:138).
- (2) An hour saved on a bottleneck is an hour saved on the entire system (Goldratt & Cox 1992:229).
- (3) The level of utilisation of a nonbottleneck is not determined by its own potential, but by some other constraint in the system. A plant in which everyone works all the time, is extremely inefficient because inventories are built up between machines resulting in an increase in the money tied up in the system (Goldratt & Cox 1992:204). The number of components produced through nonbottlenecks should be based on the constraints of the system.
- (4) Activating a resource and utilising a resource are not synonymous Utilising a resource means making use of the resource in a way that moves the system towards the goal. Resources include machinery and productive processes that make up the system which produces the enterprise's products.

A resource is activated when a nonbottleneck machine is run indiscriminately and no benefit is derived from its output. The loss of benefit is caused by the build-up of work in progress because the next operation is unable to process these materials.

Goldratt and Cox (1992:209) express this approach as follows:

... activating a nonbottleneck to its maximum is an act of maximum stupidity.

Thus a resource must be utilised as and when it is required rather than activated without discretion.

- (5) An hour saved on a nonbottleneck is a mirage. Since components off a nonbottleneck machine need to be balanced with the flow through the bottleneck, there is no benefit in saving time on a nonbottleneck. This approach provides more time to permit setups on nonbottlenecks (Goldratt & Cox 1992:229).

- (6) The use of an economic manufacturing quantity (EMQ) system is not suitable when trying to balance bottlenecks and nonbottlenecks. More setups can be permitted and batch sizes reduced (Goldratt & Cox 1992:229).

Economic manufacturing quantity is determined by the following formula (Schonberger 1985:253):

$$EMQ = \sqrt{\frac{2DS}{(IC)(1-D/P)}} \quad (2.32)$$

where:

D is the demand required over a period of time, for example, a year.

S is the cost of a setup.

IC is the cost to carry one unit for one year.

P is the production rate measured in the same units as D. The value of

P must be greater than D in order to satisfy demand.

There are situations in which this process of identifying and addressing bottlenecks will not work in a plant. They are firstly, if there is no demand for the products the enterprise manufactures, and secondly, if the management of the enterprise are unwilling to change their production methods and policies.

ii *Processing work through bottlenecks*

Since a bottleneck in the production line delays all the components presented to it, it is necessary to ensure that it does not stop at any time. Two principal themes should be focused on when considering bottlenecks (Goldratt & Cox 1992:158):

Make sure the bottleneck's time is not wasted.

Increase the capacity of a bottleneck by taking the load off it and supplying this load to a nonbottleneck capable of manufacturing the component.

Prioritising orders through the bottleneck should be in the form of the oldest customer orders first, followed in descending order until the newest orders are reached. All the components that need to be processed by the bottleneck should be tagged with, say, a red tag so that all the operators are aware of this requirement. To improve the flow through the bottleneck, it is necessary to ensure that only good components are supplied to the bottleneck machine. To ensure this, the products before the bottleneck should be inspected and if they pass inspection should be labelled with, say, a yellow tag. These components should be treated like gold (Goldratt & Cox 1992:181).

2.5.3 The rules to apply when defining constraints

The word "bottleneck" is not the correct term to use when considering the market or the system of material release and should be replaced by the word "constraint". Applying this to the methodology utilised when defining and solving constraints the procedure can be reduced to five sequential steps as stated by Goldratt and Cox (1992:303) as follows:

- Identify the system's constraint(s)
- Decide how to exploit the system's constraint(s)
- Subordinate everything else to the above decision
- Elevate the system's constraint(s)
- Warning! If in the previous steps a constraint has been broken, go back to step one, but do not allow inertia to cause a system's constraint

In conjunction with these steps, it is essential to use the IF and THEN approach to each question. This can be achieved by asking the following three simple questions at each step in the process (Goldratt & Cox 1992:333):

- (1) What to change?
- (2) What to change to?
- (3) How to cause the change?

2.6 THE TOTAL PRODUCTIVITY MODEL (TPM)

2.6.1 Background

The TPM model is a holistic approach to measuring the enterprise's productivity. All the factors of capital, labour and energy are included in the model, resulting in a total measure of productivity.

The role of the worker and his/her importance to the enterprise is also considered in this approach. Union leaders and employees are beginning to accept the importance of improvement in productivity in enterprises to maintain market share. Job security also increases on account of employees' increased competence and cooperation with management (Sumanth 1984:21). Two favourable management strategies are the result of improving total productivity, namely (Sumanth 1984:42):

- (1) the ability to reduce the selling price of a product without sacrificing the present profit margin
- (2) the profit margin of the enterprise increases without an increase in the selling price

When the first strategy is implemented, three benefits occur:

- (1) The consumer will benefit through a reduction in the purchase price of the enterprise's products, whilst obtaining the same quality or even better quality in some cases.
- (2) The enterprise will probably gain market share resulting in an increase in revenue

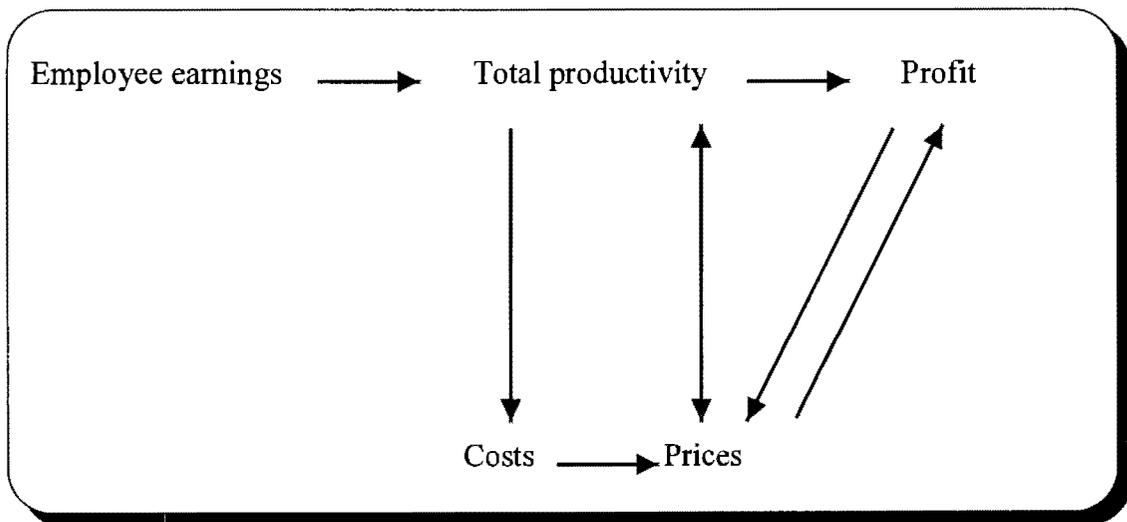
and in so doing, provide opportunities to take advantage of the economies of scale.

(3) Employees will benefit in an enterprise using a productivity bonus scheme.

If the second strategy is followed, the benefit goes to the owner of the enterprise through an increase in profit. Furthermore, increased retained earnings can be used for research and development therefore broadening the enterprise's market.

When total productivity in an enterprise improves, the nation as a whole benefits. This is brought about by the sharing of profits with employees in individual enterprise. Those employees with the potential to increase their earnings are motivated to work harder at improving productivity in the enterprise. This cycle then leads to a strong and healthy economy. Sumanth developed the productivity benefit model from this theory as summarised in figure 2.12.

Figure 2.12: Productivity benefit model



Source: Sumanth (1984:43)

When an enterprise is involved in an on-going productivity improvement programme, at a given time, it will be seen to be involved in one of four stages or phases:

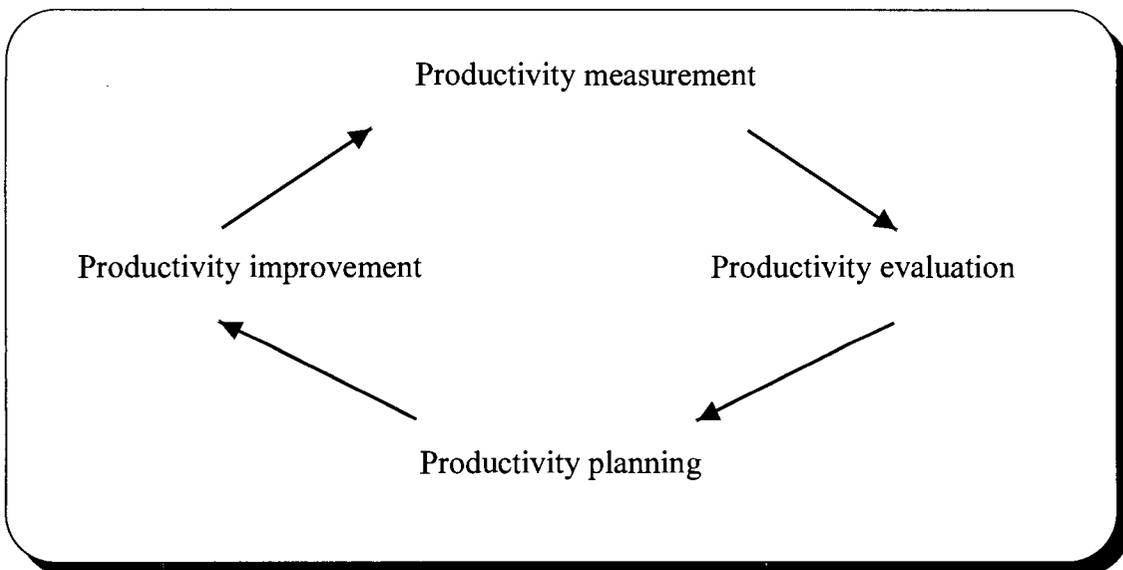
- (1) Productivity measurement
- (2) Productivity evaluation
- (3) Productivity planning
- (4) Productivity improvement

These stages have been defined as the MEPI phases (Sumanth 1984:47) where:

M	represents measurement
E	represent evaluation
P	represent planning
I	represent improvement

These four stages of a productivity programme are the key steps in the productivity cycle as shown in figure 2.13.

Figure 2.13: The productivity cycle



Source: Sumanth (1984:47)

The sequential order of the cycle is first, measurement followed by evaluation, planning and improvement as defined in the MEPI phases. The TPM model lends itself to

productivity evaluation, productivity planning and improvement in a scientific manner (Sumanth 1984:109).

2.6.2 Total productivity methodology

2.6.2.1 Step 1: The (basic) total productivity model

TPM is based on a set of five partial productivity measures and can be applied in any manufacturing enterprise. It is simply defined as follows (Sumanth 1984:153) :

$$\text{Total productivity} = \frac{\text{Total tangible output}}{\text{Total tangible input}} \quad (2.33)$$

where :

$$\begin{aligned} \text{Total tangible output} = & \text{value of finished units produced} \\ & + \text{value of partial units produced} \\ & + \text{dividends from shares} \\ & + \text{interest from investments} \\ & + \text{other income} \end{aligned} \quad (2.34)$$

and

$$\begin{aligned} \text{Total tangible input} = & \text{value of (human + material + capital} \\ & + \text{energy + other expenses) inputs used} \end{aligned} \quad (2.35)$$

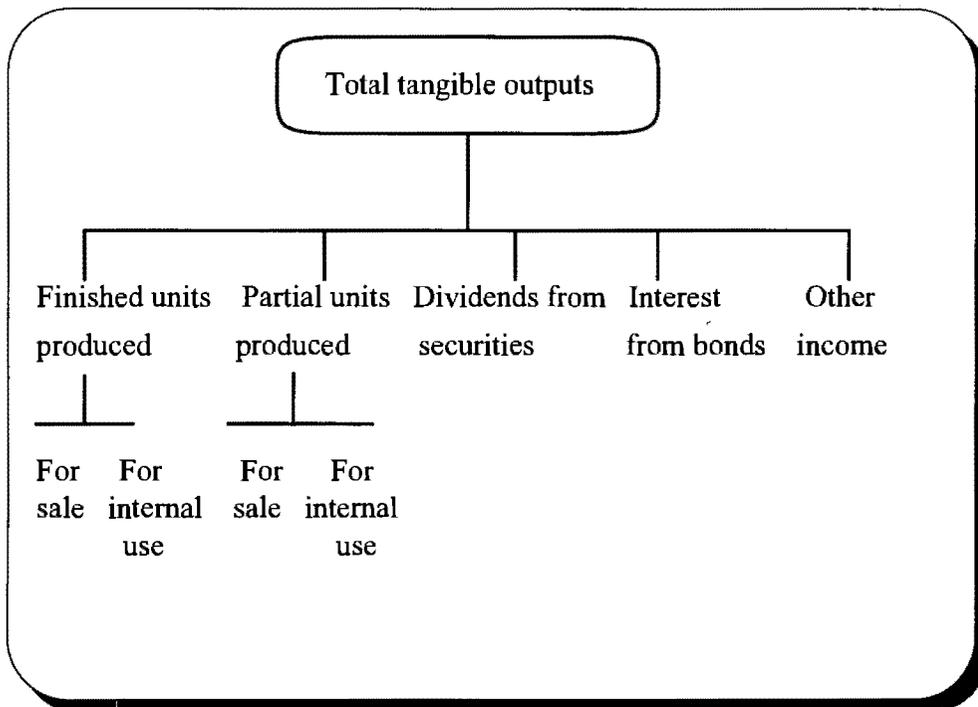
2.6.2.2 Step 2: Define tangible outputs

Tangible means directly (or inherently) measurable - that is, the number of motors manufactured or the number of sheets perforated. These are tangible output. Intangible outputs would include the amount of pollution created or goodwill generated by an enterprise. The intangible elements are relatively small and can be ignored for practical purposes. Tangible outputs therefore include all output produced, expressed in constant monetary terms of a base (reference) period. This is visible when considering the

enterprise that manufactures more than one product, that is, steel (in tons) and shoes (in pairs) - it is not possible to add tons to shoes.

The output elements considered in the total productivity model are easily followed by consulting figure 2.14.

Figure 2.14: Output elements considered in the total productivity model



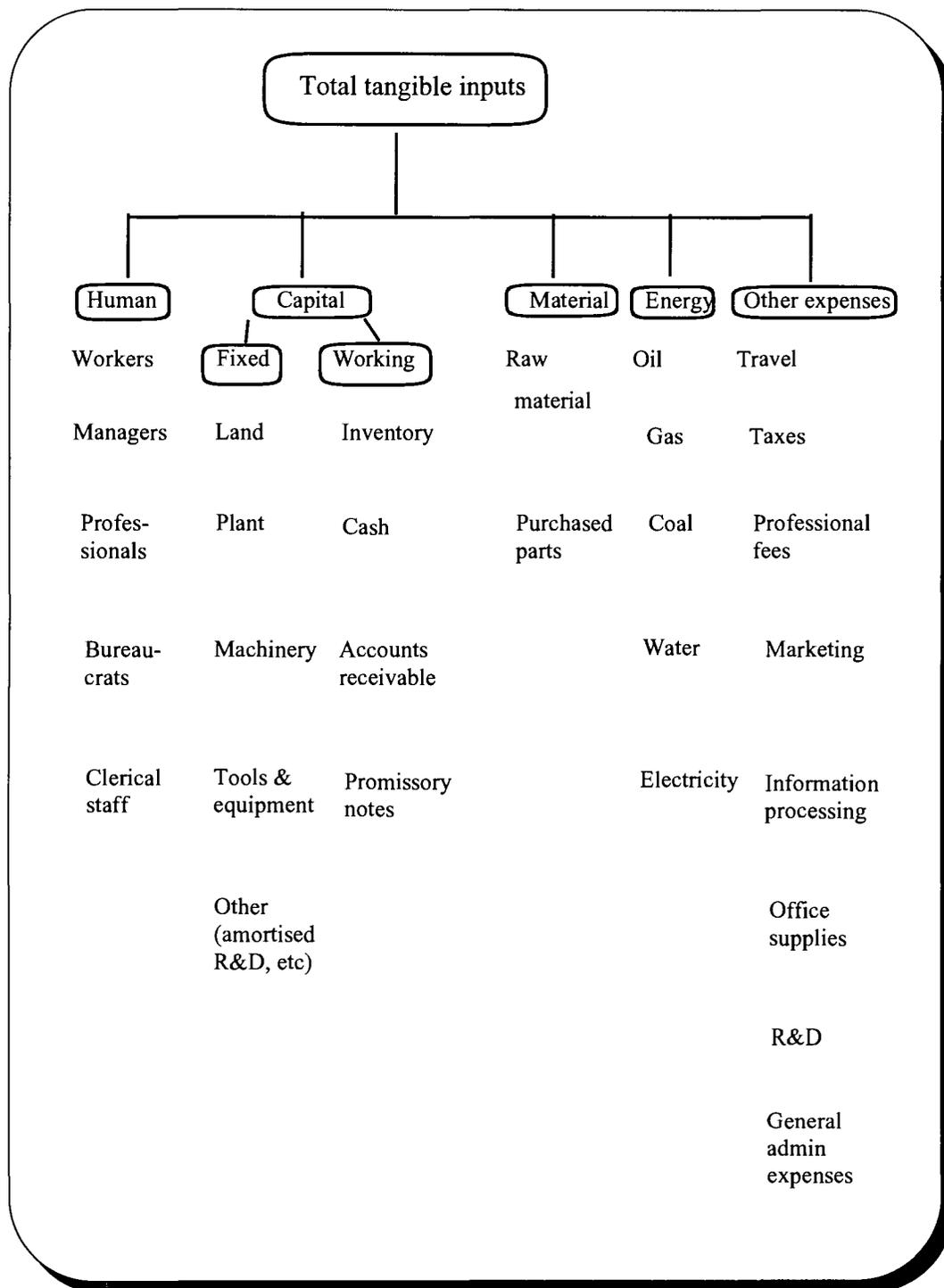
Source: Sumanth (1984:153)

2.6.2.3 Step 3: Define tangible inputs

Tangible inputs, like outputs, are expressed in value terms because all input elements are not the same. An example is the input of man-hours for labour (human) resources and kilowatt hours for energy.

Similarly, tangible inputs can be more easily understood when referring to figure 2.15.

Figure 2.15: Input elements considered in the total productivity model



Source: Sumanth (1984:154)

The usefulness of an exclusively enterprise level of measurement is limited, because it does not inform the management of shortcomings in the enterprise. When a certain product is experiencing a decline in sales, this is not noted through a single measure.

A productivity measurement system that indicates the productive health of the enterprise is required. This measure should also indicate an increase or decline in the productivity of the enterprise's products. TPM is such a productivity measurement system and has a number of salient features as stated by Sumanth (1984:155):

It provides both aggregate (firm-level) and detailed (operational unit-level) productivity indices.

It points out which operational units are profit making and which are not.

It shows which particular input resources are being utilised inefficiently so that corrective action can be taken.

It lends itself to mathematical treatment so that sensitivity analysis and model validation become relatively easier.

It is integrated with evaluation, planning and improvement phases of the productivity cycle. That is to say, the TPM offers, for the first time, a way of not only measuring but also evaluating, planning and improving the overall productivity of an organisation as a whole as well as its operational units.

It offers the advantages of management by exception by providing a means to more tightly control the total productivity of major operational units, while providing a routine control for the less critical operational units.

It provides valuable information to strategic planners in making decisions related to diversification and phase-outs of products or services.

TPM uses the term "operational units" to refer to the product or service provided by an enterprise. However, it can also be used in a broader sense when referring to a plant in a division, a division in a corporation or a profit centre in an enterprise (Sumanth 1984:155). What it is not intended to be is a department within an organisation. This can best be explained by considering a manufacturer of computers. There may be several functional departments that make up the enterprise, such as electronic shop, printed circuit board shop, cabinet making shop, assembly, coating and quality control. All these

departments have one objective - to produce top quality computers at the right price and time. Should they individually attempt to measure total productivity and compete with each other, even at the expense of not achieving the objective of producing computers, the plant may face excessive costs, poor quality and low morale. TPM provides an indirect opportunity for an enterprise to develop teamwork and ultimately to be goal oriented.

2.6.3 Notation for the total productivity model

The notation used in the model by Sumanth (1984:156) follows:

TPE	= Total productivity of the enterprise =	$\frac{\text{Total output of the enterprise}}{\text{Total input of the enterprise}}$	(2.36)
TP_i	= total productivity of product i	$\frac{\text{Total output of product } i}{\text{Total input of product } i}$	
PP_{ij}	= partial productivity of product i with respect to input factor j		
$\{j\}$	= { H, M, C, E, X }		
H	= human input (includes all employees)		
M	= material and purchased component input (raw materials are included)		
C	= capital input (includes the uniform cost of both working and fixed capital)		
E	= energy input		
X	= other expenses		
i	= 1, 2, 3, ... ,N		
N	= total number of products manufactured in the period under consideration (current period)		
O_i	= current period output of product i in value terms (rand)		
OE	= total current period output of the enterprise in value terms (rand) $= \sum_i O_i$		
I_i	= current period input for product i in value terms (rand) $= \sum_j I_{ij} = I_{iH} + I_{iM} + I_{iC} + I_{iE} + I_{iX}$		
I_{ij}	= current period input of type j for product i in value terms		
IE	= total current period input used by the enterprise in value terms $= \sum_i I_i = \sum_i \sum_j I_{ij}$		

If 0 and i represent subscripts corresponding to the base period and current period, respectively, then:

$$TPE_t = \frac{OE_t}{IE_t} = \frac{\sum_i O_{it}}{\sum_j I_{it}} = \frac{\sum_j O_{it}}{\sum_i \sum_j I_{ijt}} \quad (2.37)$$

$$TPE_0 = \frac{OE_0}{IE_0} = \frac{\sum_j O_{i0}}{\sum_i I_{i0}} = \frac{\sum_i O_{i0}}{\sum_i \sum_j I_{ij0}} \quad (2.38)$$

This leads to the definition of the total productivity index for the enterprise in period t , $(TPIE)_t$, as follows:

$$(TPIE)_t = \frac{TPE_t}{TPE_0} \quad (2.39)$$

Similarly, the total productivity index for a product i in period t , $(TPI)_{it}$, is given by:

$$TPI_{it} = \frac{TP_{it}}{TP_{i0}} \quad (2.40)$$

2.6.4 Application of the total productivity model

To implement TPM in a small manufacturing enterprise it is necessary to first identify the number of operational units involved in the enterprise. This helps to define the number of partial measures that must be applied when determining total productivity. In an enterprise producing two products, N will equal 2 and can be denoted as Product 1 and Product 2.

Consider the situation of a small manufacturing enterprise manufacturing gates (Product 1) and wheelbarrows (Product 2). During a one-week period, the following are recorded:

Product 1	Human input	=	R 1 000	=	I_{1H}
	Material input	=	R 3 000	=	I_{1M}
	Capital input	=	R 2 500	=	I_{1C}

Energy input	=	R 300	=	I_{1E}
Other expenses input	=	R 200	=	I_{1X}
Output	=	R 7 200	=	O_1

Product 2	Human input	=	R 1 500	=	I_{2H}
	Material input	=	R 3 200	=	I_{2M}
	Capital input	=	R 2 200	=	I_{2C}
	Energy input	=	R 200	=	I_{2E}
	Other expenses input	=	R 250	=	I_{2X}
	Output	=	R 8 020	=	O_2

The total productivity of the enterprise is determined as follows:

$$\text{TPE} = \frac{O_1 + O_2}{I_1 + I_2}$$

where: $O_1 = R 7 200$
 $O_2 = R 8 020$

and $I_1 = \sum_j I_{1j} = I_{1H} + I_{1M} + I_{1C} + I_{1E} + I_{1X}$
 $= 1 000 + 3 000 + 2 500 + 300 + 200$
 $= R 7 000$

$$I_2 = \sum_j I_{2j} = I_{2H} + I_{2M} + I_{2C} + I_{2E} + I_{2X}$$

$$= 1 500 + 3 200 + 2 200 + 200 + 250$$

$$= R 7 350$$

hence $\text{TPE} = \frac{7200 + 8020}{7000 + 7350}$
 $= R 1,06 / \text{rand of total input}$

The total productivity of the enterprise is given as rand of output to rand of input. Provided the value of TPE is more than one, then the enterprise is productive as well as

profitable. To ensure that the enterprise is keeping within a set standard, the present total productivity of the enterprise during period t is compared with the total productivity during period 0 as follows:

If, during period 0, the total productivity recorded was $TPE_0 = R 1,10$, then the total productivity index for the enterprise in period t is determined by applying formula (2.39):

$$\begin{aligned} (TPIE)_t &= \frac{1,06}{1,10} \\ &= 0,96 \end{aligned}$$

Similarly, the productivity index for products can be determined in the same manner by application of formula (2.40) and the respective product data.

The method of determining the enterprise's total productivity by means of its partial productivity permits management to assess specific areas requiring productivity improvement.

2.7 ALAN LAWLOR'S APPROACH (Lawlor)

2.7.1 Background

Lawlor's (1985:22) approach addresses three questions:

Where are you now? This concerns how efficiently resources are currently being used and the suitability of equipment, products and organisation structure.

How much better could you be? Even though answering the first question may have revealed such deficiencies as low order books and outdated plant, improvements in performance are still possible.

Where should you be? For survival and prosperity in the longer term drastic alterations in the way organisations function will be necessary.

Questions 1 and 2 represent what Lawlor calls second-wave methods or organisations, while question 3 represents a bridge to the future. Lawlor refers to these questions as stages in productivity improvement (Lawlor 1985:22). The difference between stage 1 and stage 3 is called the performance gap and relates to the current position of an enterprise compared to where it should be.

These three questions and how they relate to the enterprise changing from the methods used during the Industrial Revolution to the methods that should be used up to the year 2000 and beyond are presented in figure 2.16.

Figure 2.16: The basics of productivity improvement

Company potential - What is ultimately possible?		
>>>>>> HOW TO GET THERE? >>>>>>>		3
	2	Where should you be? - making radical changes in markets, products, processes and the use of total resources
1	How much better could you be? - even with current markets but making better use of all resources	
Where are you now? - operating with existing constraints of resources and markets		
2nd-wave organisations		3rd-wave organisations
Current efficiency	Medium-term capability	Long-term potential
The three stages of productivity improvement		

Source: Lawlor (1985:23)

Lawlor confirms that good productivity information is the first most important step to convincing management that productivity improvement, in its widest sense, is a necessity in the enterprise (Lawlor 1985:30).

2.7.2 Lawlor's methodology

The introduction to this chapter provides a definition of productivity. Five aims of a productivity measurement approach are provided by the ILO and Lawlor, and are detailed in the introduction. For convenience Lawlor's definition which was stated in the introduction is repeated in this section. Lawlor (1985:36) states that productivity is a comprehensive measure of how efficiently and effectively enterprises satisfy the following five aims.

- (1) Objectives: the degree to which principal objectives are achieved;
- (2) Efficiency: how efficiently resources (inputs of labour materials, purchased services and capital) are used to generate useful outputs, useful in the sense that goods made or services provided are actually needed;
- (3) Effectiveness: what is achieved in output and input terms compared to what is potentially possible;
- (4) Comparability: how productivity compares with other organisations, industries and countries;
- (5) Trends: the productivity performance record over time, that is, the decline, static or growth aspects.

2.7.2.1 Step 1: Achievement of objectives

It is essential to know whether the enterprise's main objectives are achieved. In a small manufacturing enterprise, the key objective will normally relate to maximisation of profit. In addition, there are other competing aims such as paying satisfactory wages to employees, meeting the payments to outside suppliers and setting aside a fund for wear and tear of plant for later replacement.

Adam Smith the father of private enterprise states the following as quoted in Lawlor (1985:36):

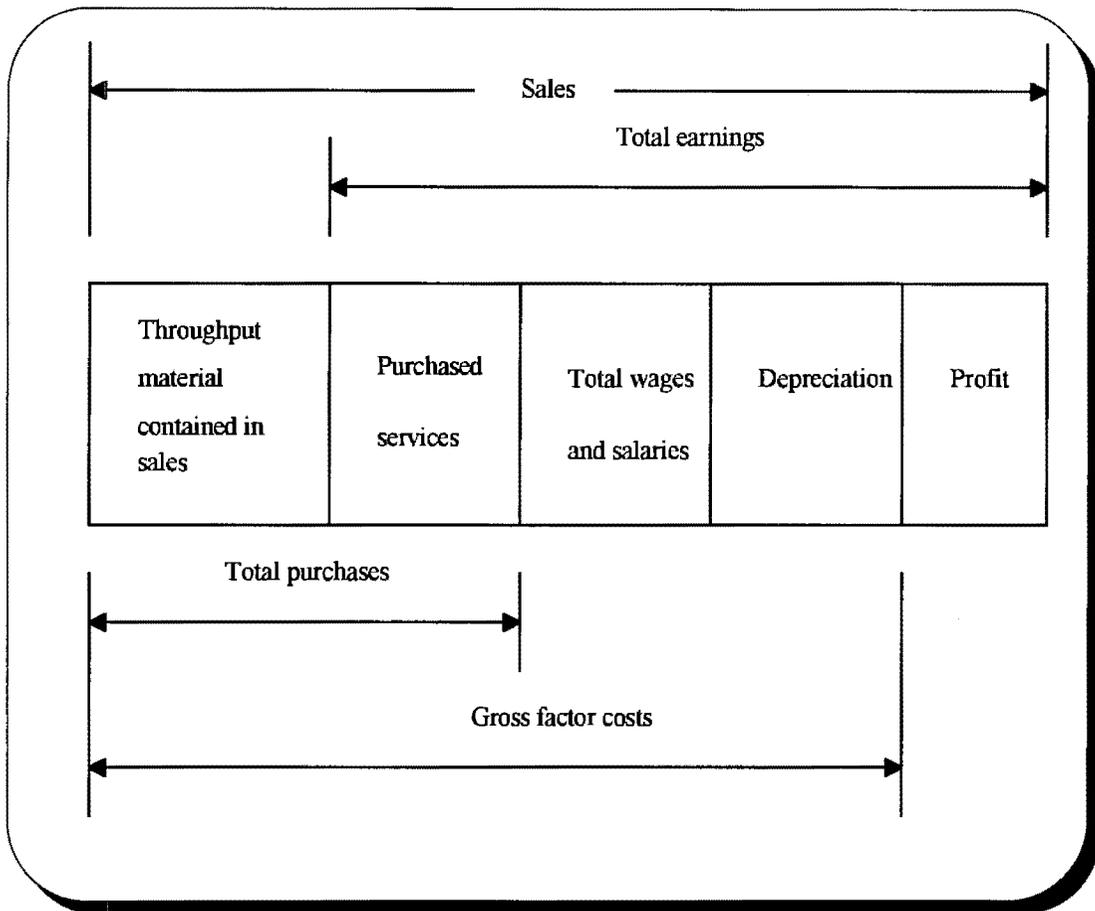
... the sole end purpose of any organisation is to make a viable living for everyone involved in it and to sustain its fixed and circulating income.

It has been argued that profit is only a form of interest, and enterprises do not fail in the short term when they cease to make a profit, but when losses have so reduced their working capital that they cannot pay the wages and creditors (Lawlor 1985:36).

To prevent this from occurring it is necessary to provide adequate funding to meet all the demands of the enterprise. This funding is called total earnings and forms the basis of Lawlor's productivity measurement approach. Total earnings is best explained in figure 2.17.

2.7.2.2 *Step 2: Measurement of efficiency*

In figure 2.16, the first basic requirement to achieve productivity improvement is given as a question; Where are you now? When considering efficiency, an answer is provided to this question. Efficiency is a measurement of the way an enterprise is currently using the resources at its disposal. This is an "actuality" or what an enterprise is managing to do now, with its existing resources, under existing constraints (Lawlor 1985:37).

Figure 2.17: Total earnings and sales

Source: Lawlor (1985:37)

Efficiency measurements should reveal two broad aspects of the existing enterprise's performance as follows (Lawlor 1985:38):

The output to input relationship, that is, the output generated by available inputs, bearing in mind whether the output is useful in the sense of being outputs should play an important part in productivity, especially in manufacturing and retailing concerns.

The utilisation of resources or the quantity of inputs utilised compared to the total capacity available.

An important aspect of efficiency that should be noted is that engineers and accountants have different methods of considering this ratio. Engineers never have a systems efficiency that measures more than 100 percent because in engineering one cannot get more than one has put into the system when referring to energy. An accountant, on the other hand, always expects to achieve an efficiency in excess of 100 percent. The following equations are given to simplify the explanation:

$$\text{Engineer's concept} \quad \text{Efficiency} = \frac{\text{Input} - \text{Losses}}{\text{Input}} \times 100$$

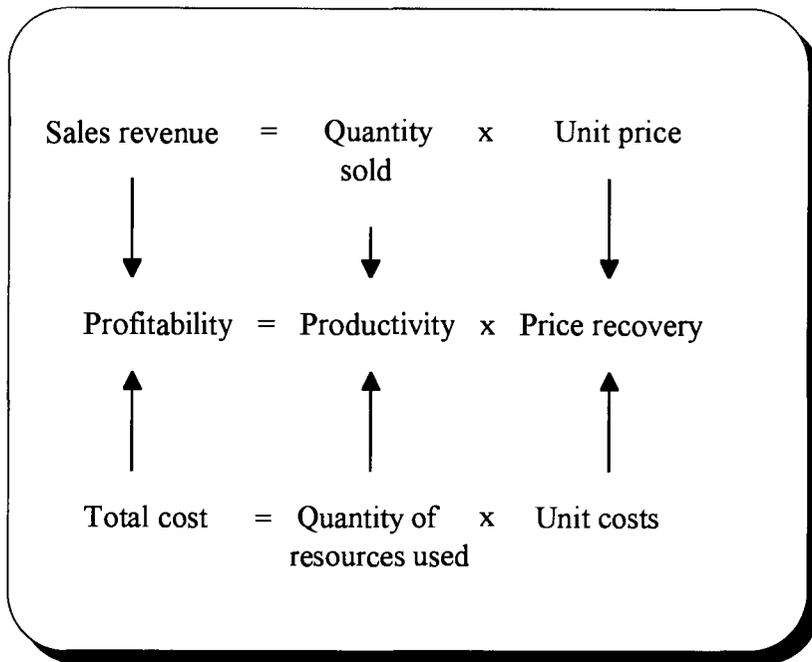
$$\text{Accountant's concept} \quad \text{Efficiency} = \frac{\text{Output}}{\text{Input}} = \frac{\text{Input} + \text{Profit}}{\text{Input}} \times 100$$

The positive and negative link between these two viewpoints can be shown as:

$$\frac{\text{Output} - \text{Input}}{\text{Input}} = \frac{\text{O} - \text{I}}{\text{I}} = \frac{\text{O}}{\text{I}} - 1 \quad (2.41)$$

This shows that the "I" deducted from the productivity ratio of $\frac{\text{O}}{\text{I}}$ gives the profit productivity ratio (Lawlor 1985:39).

Performance measurement in small manufacturing enterprises will be influenced in varying degrees by the profit-oriented financial indicators of the accountant and the more physical indicators of the engineer. The American Productivity Center has addressed this issue and their method of dealing with it is presented by Lawlor in figure 2.18. It will be noted that this relationship between productivity and price recovery is the same as the deterministic productivity accounting approach which was previously presented by Van Loggerenberg in equation 2.7.

Figure 2.18: Profitability and productivity

Source: Lawlor (1985:39)

2.7.2.3 Step 3: *Effectiveness potential*

Effectiveness and efficiency are related, but are different aspects of productivity measurement. Effectiveness compares what could be done with the enterprise's resources, while efficiency determines the existing state of affairs. When effectiveness is used in this way it includes an output target to be reached, achieving a new standard of performance, or a more idealistic potential that would be possible if all constraints were removed. Lawlor therefore provides two levels of organisational effectiveness (Lawlor 1985:39):

Reaching improved standards of performance through better organisation and the use of management techniques, that is, work study. The target is to make use of the full capability of resources such as plant, a design department, a piece of land or a hospital. Even with the current constraints of unsatisfactory resources and a low level of demand, could we be better if we really worked at it?

Aiming for an ideal potential if constraints, both internal and external, were removed. As Russell Ackoff points out, all organisations should pursue goals which may at the time seem unattainable.

As an equation, the relationship of output/input is shown as follows:

$$\frac{\text{Output}}{\text{Input}} = \frac{\text{Effectiveness (what can be achieved)}}{\text{Resources consumed}} \quad (2.42)$$

As a rule, enterprises have many levels of effectiveness combined with just as many degrees of resource consumption. To explain this concept in detail consider the following example:

Alpha Enterprises, a small manufacturing enterprise, is currently achieving an annual rate of stock turn of four based on a cost of sales for the year of R 600 000 and total average stock of R 150 000. If Alpha wishes to match the average Japanese enterprises having eight stock turns per annum, what are the effectiveness possibilities it can follow?

Four basic ratios can be used in this example:

(1) Firstly, where are they now?

$$\frac{\text{Output}}{\text{Input}} = \frac{600\,000}{150\,000} = 4$$

(2) A higher output can be divided by the same amount of input.

$$\frac{1\,200\,000}{150\,000} = 8$$

(3) The actual output can be divided by a reduced amount of input.

$$\frac{600\,000}{75\,000} = 8$$

(4) The highest level of effectiveness occurs when maximum output is divided by minimum input, that is, where they should be.

This is a combination of increased sales and reduced stock, as follows:

$$\frac{800\ 000}{100\ 000} = 8$$

Whichever option is adopted, the lesson will be twofold as stated by (Lawlor 1985:41):

Current levels of efficiency must be assessed and targets of effectiveness determined.

Productivity improvement involves trade-offs; each part of an organisation affects the rest; it is a total problem.

2.7.2.4 *Step 4: Comparability of performance*

It is always good to compare the performance of one enterprise with another. A very good productivity ratio in itself does not tell the enterprise owner much. Only when these values are compared to other enterprises in a similar industry they become meaningful. Difficulty arises when trying to do this comparative work in the private sector because publication of these figures is not mandatory.

It is not only the comparison between enterprises that requires attention. Because of international trade, a comparison should also be made with world players. Fierce international competition has developed because of the expanding communication network.

Interenterprise comparison is also a measurement of effectiveness since the enterprise is exposed to the standards of other enterprises. This will provide new aims for the enterprise.

2.7.2.5 *Step 5: Trends*

Trends in productivity over time are an essential part of any measurement system. The

comparison of current performance with that of last month or the previous year will reveal whether any growth has taken place.

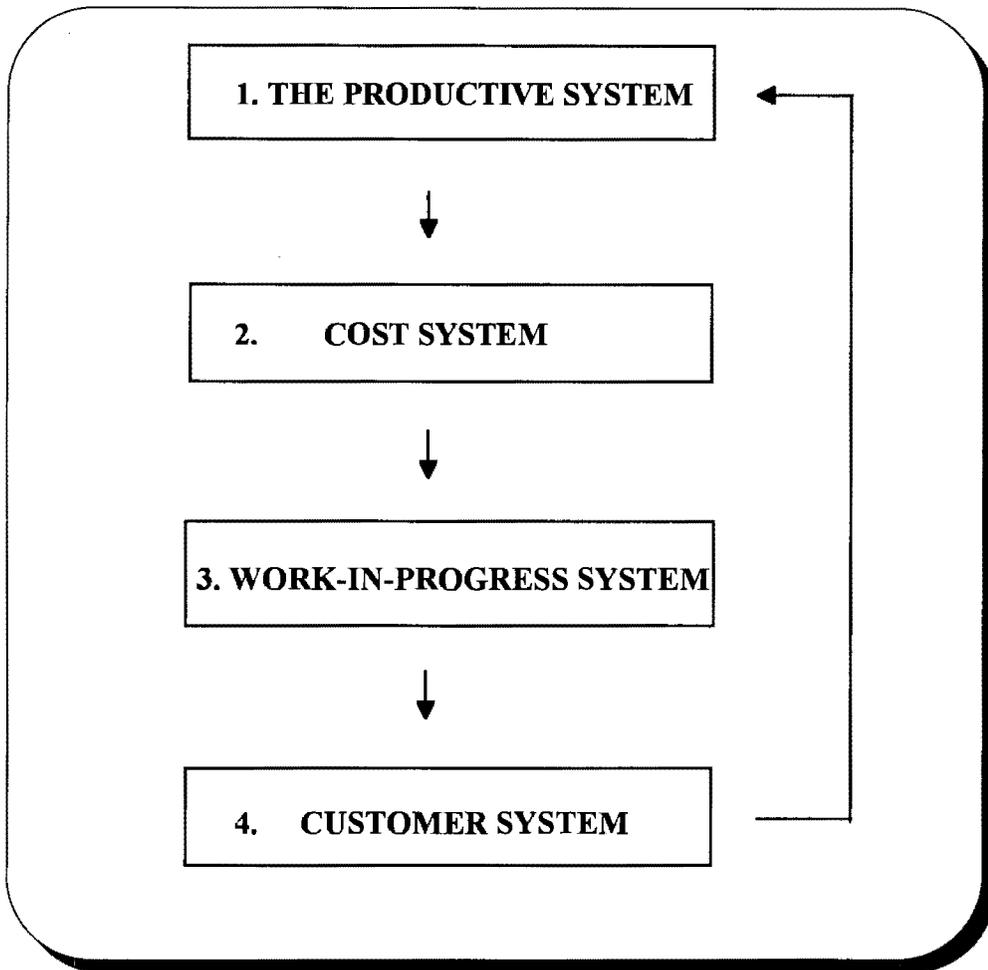
However two cautions when using trend comparison over time periods: firstly allow for price increases and the effects of inflation, and secondly consider different mixes of output and inputs (Lawlor 1985:42).

Now that the aims have been discussed it is possible to progress to the measurement of productivity.

2.7.3 Productivity measurement

The measurements required to complement the five steps of productivity are captured in the model presented by Lawlor. However, to facilitate understanding of the model it is subdivided into two figures, namely 2.19 and 2.20.

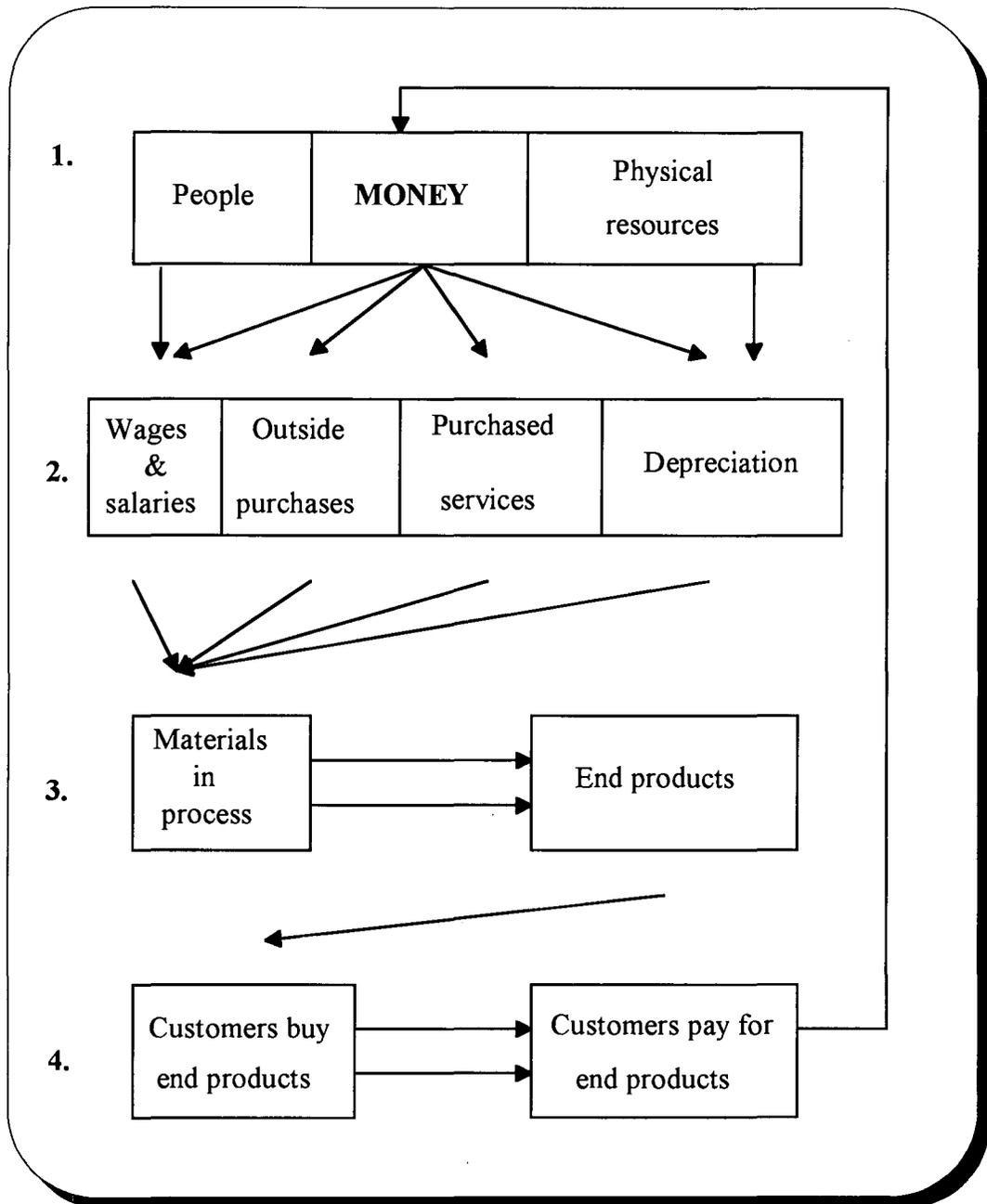
Each stage of the productive system as described in figure 2.19 represents the flow of money in the enterprise. It is stated that to ensure the successful future of an enterprise, working capital should be increased, or at very least, an effort should be made to ensure that it is not eroded (Lawlor 1985:74).

Figure 2.19: Lawlor's productivity model

Source: Adapted from Lawlor (1985:75)

Figure 2.20 subdivides the four stages into further categories that either absorb or produce money as follows:

Figure 2.20: Subdivisions of Lawlor's productivity model



Source: Adapted from Lawlor (1985:75)

Stage 1: The productive system

The subdivision as detailed in figure 2.20 can be expanded to improve the understanding of the productive system as follows:

- ◆ **People** consist of all personnel associated with production, services, professional, clerical, supervision and management.
- ◆ **Money** relates to liquid working capital, cash in hand and bank.
- ◆ **Physical resources** include plant, tools, transport and land.

Stage 2: The cost system

The cost system can be explained as follows:

- ◆ **Wages and salaries** refer to people conversion costs and are given the notation W.
- ◆ **Outside purchases** refer to materials as well as parts that are purchased to manufacture products. They are given the notation M.
- ◆ **Purchased services** include all services required in the conversion process and are denoted by PS.
- ◆ **Depreciation** refers to the costs of wear and tear, and is denoted by k.

Stage 3: Work-in-progress system

- ◆ **Material in process** refers to the adding of processing costs to materials to produce end products of increased value.
- ◆ **End products** are fully converted materials with increased value. The total increased value is the system's total earnings, T.

Stage 4: The customer system

- ◆ **Customers buy end products**, or useful output. These products are sold at prices representing increases in value above conversion costs.
- ◆ **Customers pay for end products**. This entails reimbursing the liquid working capital fund.

Taking the application of this approach further, a number of measurement equations become necessary.

2.7.3.1 *Primary productivity measurement*

As previously stated, the primary objective of the enterprise is to increase its total earnings for the following reasons (Lawlor 1985:76):

Total earnings is the basic fund which meets all of the demands on any organisation.

Ensuring a flow of total earnings above conversion costs is necessary for a healthy working capital fund.

Total earnings gives equal priority to all claimants (that is, employees, suppliers, shareholders and tax collectors) and is therefore more socially acceptable.

It is appropriate to any kind of organisation, private, public, commercial and non-profit making alike; all of these enterprises should aim for total earnings above their operating costs. Moreover, while it may be difficult to measure outputs in non-commercial undertakings, the inputs inherent in total earnings are common to all kinds of organisation.

Figures 2.19 and 2.20 show that a high level of total earnings ensure a healthy enterprise. At the same time, if the rate of generation of total earnings (T) per unit of conversion cost (C) is also high, the enterprise is productive as well. Consequently the primary total earnings productivity (E) is:

$$E = \frac{\text{Total earnings}}{\text{Conversion cost}} = \frac{T}{C} \quad (2.43)$$

Since profit (P) is total earnings minus conversion cost, or T - C, a secondary profit productivity E_p index can be derived where:

$$E_p = \frac{P}{C} = \frac{T - C}{C} \text{ or } \frac{T}{C} - 1 = E - 1 \quad (2.44)$$

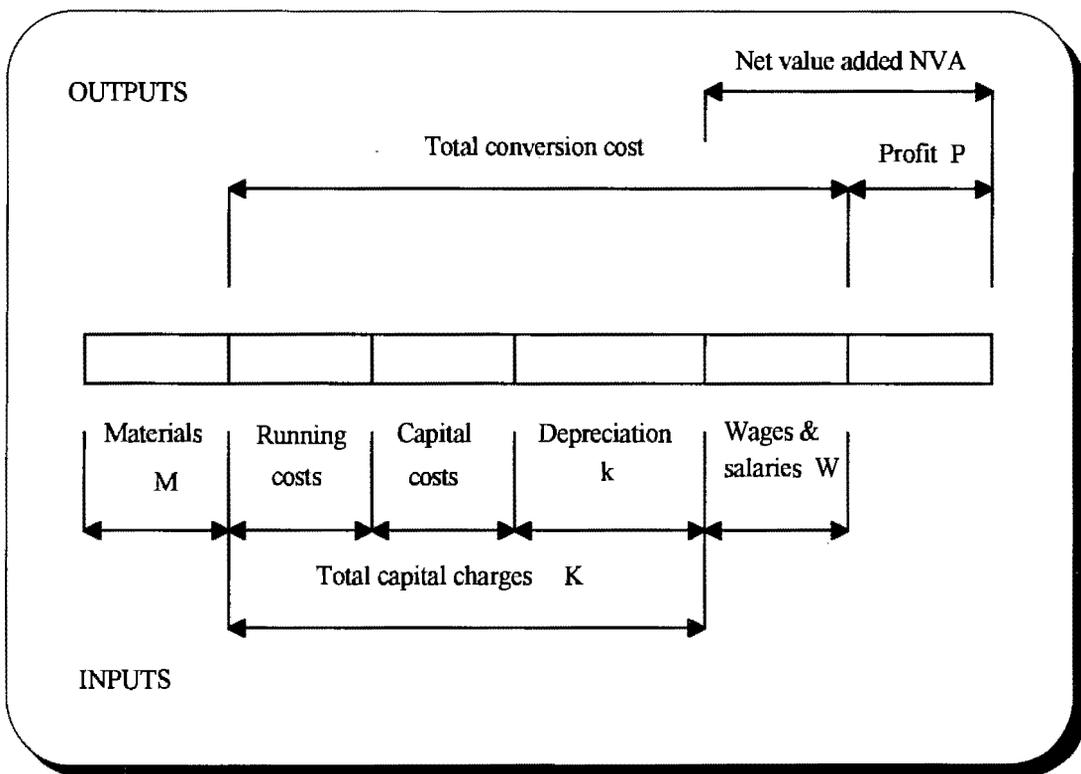
When one is deducted from the primary total earnings productivity E, then E_p equals profit productivity. Consider the following example: if the total earnings for a particular month are R 100 000 and the conversion costs for the same month are R 75 000, determine the total earnings and profit productivity?

$$E = \frac{100\,000}{75\,000} = 1,33$$

$$E_p = \frac{100\,000 - 75\,000}{75\,000} = 0,33 \text{ or } 1,33 - 1 = 0,33$$

This means that for every R 1,00 of conversion cost, R 1,33 of total earnings and R 0,33 of profit have been generated. Productivity and profitability are therefore linked. If productivity increases, then profit will also increase. In conventional accounting practice, profit includes allowance for changes in stock value. This concept of profit may be described as conversion profit. It is the surplus or profit remaining after allowing for the costs of converting the materials used during the period/month in question. Figure 2.21 below explains this concept fully.

Figure 2.21: Defining conversion costs



Source: Adapted from Lawlor (1985:53)

This can be reduced to a simpler form where:

- ♦ total earnings = T
- ♦ sales = S
- ♦ throughput materials = M
- ♦ total wages and salaries = W
- ♦ total purchased services = PS
- ♦ total outside purchases = X (including M and PS)
- ♦ depreciation or wear and tear cost = K

- ♦ added value = AV

$$\begin{aligned} \text{Thus: } T &= S - M && (2.45) \\ AV &= S - X \\ &= T - PS \end{aligned}$$

Added value is used extensively for comparisons of productivity between countries (Lawlor 1985:78). An additional equation is used to provide the cost accountant's view of contribution margin CM. Relating CM to total earnings,

$$\begin{aligned} CM &= S - V \\ &= T - CV \end{aligned}$$

where:

$$V = M + CV$$

and CV is the portion of conversion costs which varies in direct proportion to the level of output activity.

2.7.3.2 *Secondary productivity measurement*

Total earnings productivity (E) reveals a primary or overall measurement of efficiency for most types of enterprise, and also provides three other aspects of conversion efficiency as stated by Lawlor (1985:78):

- The rate at which input generates output
- The quantity of inputs used to generate a given output
- The potential output which could be obtained from a given input

Total earnings productivity answers the question: "Where are you now"? In other words, total earnings are obtained for different input efficiencies; some equipment may have high utilisation while other items of equipment are used less. Value is added or output produced, only to the extent that available resources are utilised to convert inputs into

outputs - that is, the ratio of utilised resources to the total costs of all available resources is a secondary measure of productivity. As a result, the total conversion cost includes two main divisions (Lawlor 1985:79):

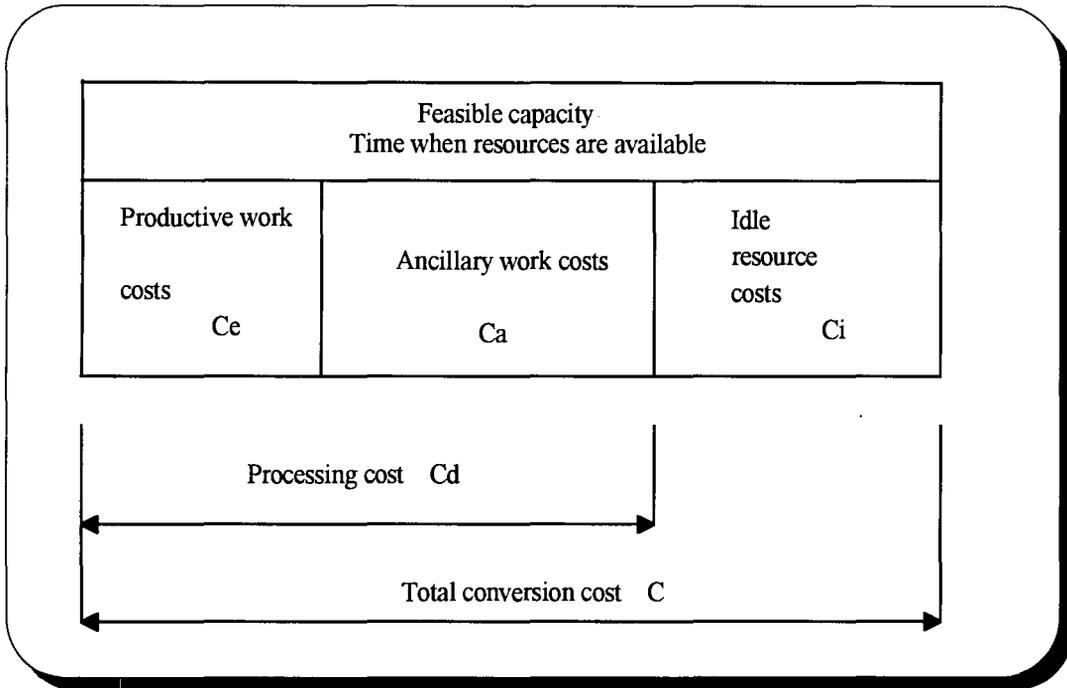
The costs incurred when resources (people and equipment) are productively utilised. These costs can be further subdivided into productive work costs and ancillary work costs. The sum of both costs will be called processing costs, prefix C_d , with productive work costs being prefixed C_e and ancillary work C_a .
Un-utilised or idle resource cost C_i , when people and equipment are wholly idle.

These divisions and subdivisions are detailed in figure 2.22, and resource or conversion utilisation productivity can be indicated as follows:

$$\frac{\text{Time or costs incurred on productive and ancillary work}}{\text{Total time available or total conversion costs, including idle time}} = \frac{C_d}{C} \quad (2.46)$$

Another basic resource productivity indicator is to relate pure productive work C_e to total conversion costs as follows:

$$\frac{\text{Time or costs incurred on purely productive work}}{\text{Total time available or total conversion costs, including ancillary work and idle time}} = \frac{C_e}{C} \quad (2.47)$$

Figure 2.22: Divisions of conversion cost

Source: Lawlor (1985:80)

Two other measurements fall under the general heading of secondary measurements, namely working capital and inventory productivity. Manufacturing enterprises cannot ignore the key aspect of working capital. The productivity of working capital is given as:

$$\frac{\text{Total earnings}}{\text{Throughput materials} + \text{conversion costs}} = \frac{T}{M + C} \quad (2.48)$$

This provides the total earnings per unit of working capital employed or the rate of turnover of working capital. One can use sales or profit as the output relative to working capital. The following equations result:

Sales as a ratio to working capital employed:

$$\frac{\text{Sales}}{M + C} \quad (2.49)$$

Profit as a ratio to working capital employed:

$$\frac{\text{Profit}}{M + C} \quad (2.50)$$

The productivity of inventory is similar to working capital, but must include the carrying cost of keeping materials for a period of time. Therefore inventory productivity is indicated as follows:

$$\frac{\text{Total earnings}}{\text{Throughput material} + \text{carrying cost}} = \frac{T}{M + C_{inv}} \quad (2.51)$$

The accepted method used to measure inventory productivity is the rate of stock turns, which is defined as follows (Gitman 1985:120):

$$\text{Inventory turnover} = \frac{\text{Cost of goods sold}}{\text{Average inventory}} \quad (2.52)$$

The efficient use of working capital and inventory should be high on the list of managerial priorities for the manufacturing enterprise. Similarly, the relationship between profitability and productivity should be understood, as well as the working capital and money aspects. It is futile for an enterprise to be profitable and productive, if it has no money to manage its daily affairs (Lawlor 1985:81).

2.7.3.3 *Productive potential*

It is necessary to consider the potential of an enterprise to maximise its total earnings. The potential total earnings can be achieved when all inputs are fully utilised and no idle capacity costs occur. This will occur when all resources are engaged in productive and ancillary work, that is, when "Cd" and "C" are equal. In practice, it is highly unlikely that this will be achieved. However, to measure potential total earnings, the approach below is used. If all conversion costs are utilised on "Cd" work, the potential total earnings "Tpot" are:

$$T_{pot} = \frac{T}{\text{Total Cd}} \times C \quad (2.53)$$

Consider the example where the total earnings for a period equal R 100 000, the total conversion costs R 75 000, processing costs R 48 000 and productive work costs R 30 000. The following result is obtained:

$$\text{Utilisation productivity} = \frac{C_d}{C} = \frac{48\,000}{75\,000} = 0,64$$

This means that under two-thirds of the resources are occupied productively and nearly one-third are idle. The existing and potential total earnings are therefore :

$$\begin{aligned} \text{Existing total earnings} &= \text{R } 100\,000 \\ \text{Potential total earnings} &= \frac{T}{C_d} \times C = \frac{100\,000}{48\,000} \times 75\,000 \\ &= \text{R } 156\,250 \end{aligned}$$

Lawlor (1985:82) points out that productive work has a big lever effect on total organisational productivity, with a similar effect on profit. He further emphasises that even more dramatic results are obtained if all resources are utilised on productive work only. This can be achieved by technological improvements to reduce setup time to zero minutes. This is presently the key objective in Japanese enterprises.

In the above example, the potential total earnings with all resources being occupied on purely productive work "Ce" would be:

$$\frac{100\,000}{30\,000} \times 75\,000 = \text{R } 250\,000$$

This shows that only 40 percent of the conversion costs are utilised solely on productive work, and is determined as follows:

$$\frac{30\,000}{75\,000} \times 100 = 40\%$$

If the remaining 60 percent were used in the same way, the total earnings would increase by two-and-a-half times. This is determined as follows:

$$\frac{250\,000}{100\,000} = 2,5$$

2.7.3.4 *Interenterprise comparison*

It is possible to apply these formulae to various enterprises with similar characteristics in order to assess their productivity.

The indicators, total earnings $\frac{T}{C}$, profit $\frac{P}{C}$ and productivity minus idle costs can be tabulated as follows:

Table 2.7: Interenterprise productivity comparisons

Enterprise	1	2	3	4	5
code	Overall enterprise productivity		Productivity less idle costs		Range 3 ÷ 1
	T/C	P/C	T/Cd	P/Cd	
A	1,70	0,70	3,60	2,60	2:1
B	1,66	0,66	2,16	1,16	1,3:1
C	1,61	0,61	1,92	0,92	1,2:1
D	1,42	0,42	1,93	0,93	1,4:1
E	1,39	0,39	1,93	0,93	1,4:1
Averages	1,56	2,78	2,31	1,31	1,48:1

Source: Lawlor (1985:83)

The use of this comparative approach is limited since a strong similarity must exist between the enterprises under consideration. However, such a system has great potential. Potential output analysis is concerned with measuring the effectiveness of an enterprise. As

stated previously, the basic measurement of potential productivity can never exceed unity - productive work costs cannot be greater than total conversion cost and neither can processing costs. The analysis makes use of costs, although it is also possible to make use of units of time. In other words, in the equation $\frac{Cd}{C}$, C would be the total feasible time available and Cd the total time that resources are occupied on productive and ancillary work. These basic measurements of utilisation and productivity can be used at three levels of the enterprise, as stated by Lawlor (1985:84):

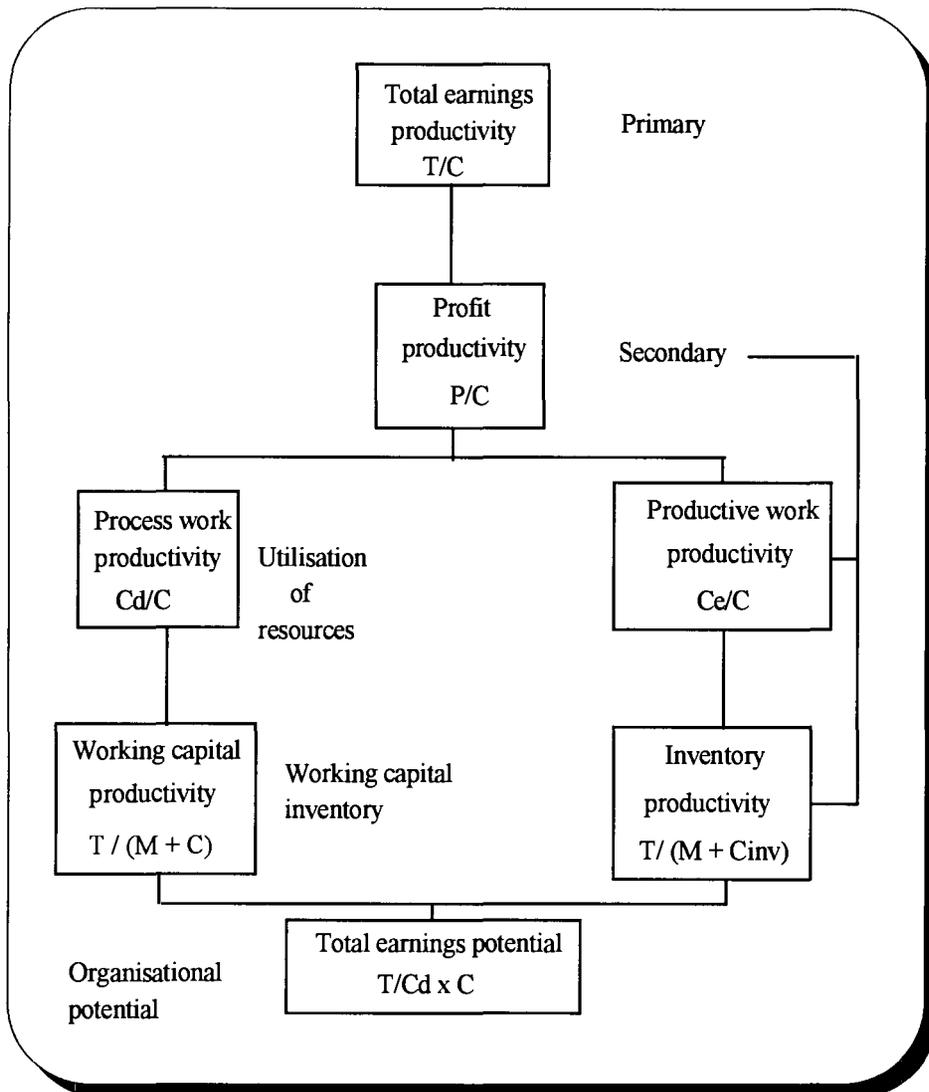
For the organisation as a whole, that is:

$$\frac{\text{Total of all times/costs on processing work}}{\text{Total conversion costs}}$$

At individual departments or section levels

For specific items of plant, work groups or for individuals

All the measurements that have been discussed in this section to maximise productivity are incorporated in a single framework as detailed in figure 2.24 below.

Figure 2.23: Framework of measurements

Source: (Lawlor 1985:86)

2.8 APPLIED PRODUCTIVITY - GOLD'S APPROACH (Gold)

2.8.1 Background

The ILO states that Gold's approach (Prokopenko 1987:41) focuses on the rate of return on investment and attributes profit to five specific elements of performance, namely :

product prices
unit costs

use of facilities
 productivity of facilities
 allocation of resources between fixed and working capital

Gold emphasises that the significance of given input-output ratios depends not only on the analytical relevance of the categories used, but also on five additional requirements whose instinctive recognition of categories in simple production systems has often been overlooked in other applications (Eilon, Gold & Soesan 1976:19).

Two of these concern the qualitative stability of each input and output category through time and the ability to measure those criteria being applied in the process. The first requirement emphasises that changes in the inputs or outputs may confuse the interpretation of the noted changes in quantitative input-output relationships. In other words, if a product is composed of more than one element, variations may occur in the quantity of one element compared to the next, each time it is manufactured. The second requirement warns of the dangers of quantifying peripheral rather than core aspects of input and output flows. In other words, if a product is sold according to weight and the composition of the material is changed during manufacture, the outcome is a smaller financial income because of the reduced weight.

The three remaining requirements are that the numerator and denominator of productivity ratios:

- (1) should relate to congruent sectors of activity
- (2) should relate to properly linked time periods
- (3) and the contribution of the input should be absorbed into and affect the output

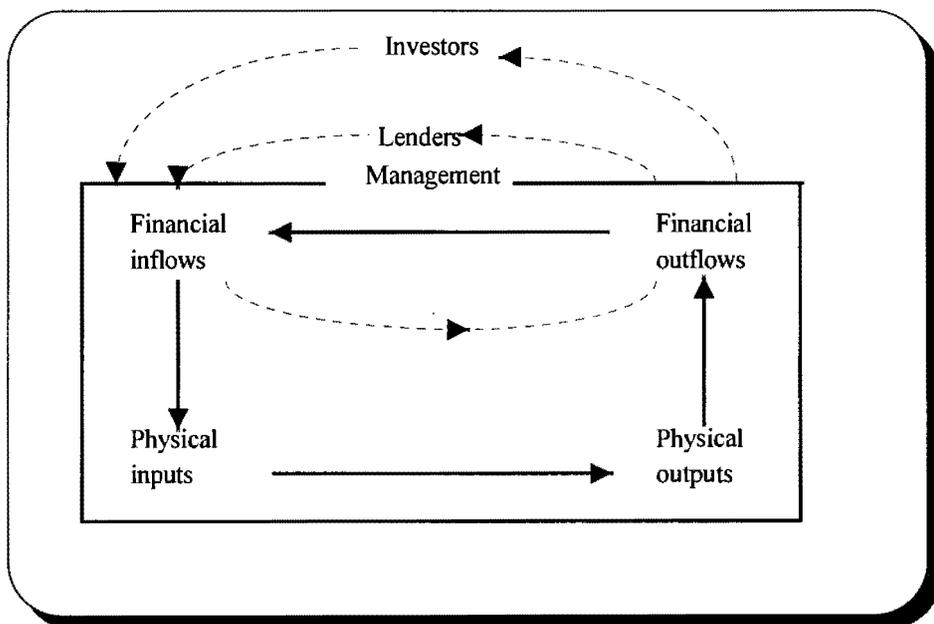
The first of the requirements merely tries to prevent errors such as comparing all of the inputs of a plant with only part of its output. The second is to prevent the use of input and output data for the same period unless all the input is absorbed into the output within that period. The third requirement implies that outputs should be compared with input measurement covering all of the factors that can be substituted for each other.

Finally, it should be noted that the uses made of productivity findings may generate additional requirements with a bearing on the design of effective measures. Put differently, if appraisal efforts are directed towards the managerial objectives of improvement and control, the productivity measures may be redesigned in order to separate data relating to management's requirements from data that do not meet these requirements.

2.8.2 Gold's methodology

In a manufacturing enterprise, the primary responsibilities centre around the adjustment of the level and composition of the physical inputs and outputs through which financial inflows are converted into larger financial returns. Figure 2.24 depicts this as follows:

Figure 2.24: Physical and financial resource flows within the firm



Source: Eilon et al (1976:21)

Business is shown as a four-stage process consisting of inflows of financial resources from investors and lenders; the conversion of these into physical inputs; the transformation of these input into physical outputs; and the conversion of physical goods

and services through sales into financial outflows, which are allocated to lenders and investors and fed

back into the enterprise (Eilon et al 1976:21). The dotted lines indicate the financial flow.

Management require an elaboration of this network at various levels of activity to distinguish between short-term and long-term contributors to total performance, as well as internally controlled and externally imposed adjustments. In addition, management require the extension of such an integrated structure of performance criteria to lower levels of activity in the enterprise.

The result is the primary measure of total performance being regarded as the rate of profit on investment. Gold, however, disagrees with this approach (Eilon et al 1975:22), and states that the areas of decision making that affect this objective are identified as follows by five simple steps of analysis:

2.8.2.1 *Step 1: Profit compared with investment*

The before tax profit (PBT) to total investment may be determined by the ratio of PBT to physical output and by the ratio of output to total investment:

$$\frac{\text{PBT}}{\text{Total investment}} = \frac{\text{PBT}}{\text{Output}} \times \frac{\text{Output}}{\text{Total investment}} \quad (2.54)$$

2.8.2.2 *Step 2: Profit compared with output*

Since profit is determined by the difference between the average gross receipts per unit of output (ie, the average realised price) and average total costs per unit of output, then:

$$\frac{\text{PBT}}{\text{Output}} = \frac{\text{Value of products}}{\text{Output}} - \frac{\text{Total costs}}{\text{Output}} \quad (2.55)$$

(average price) (average unit cost)

2.8.2.3 Step 3: Output compared with investment

Changes in the ratio of output to total investment may be regarded as being determined by the ratios of output to productive capacity, of productive capacity to fixed investment and of fixed investment to total investment:

$$\frac{\text{Output}}{\text{Total investment}} = \frac{\text{Output}}{\text{Capacity}} \times \frac{\text{Capacity}}{\text{Fixed investment}} \times \frac{\text{Fixed investment}}{\text{Total investment}} \quad (2.56)$$

(utilisation rate) (productivity of fixed investment) (internal allocation of capital)

Therefore the changes in the ratio of PBT to total investment may be attributed to five areas of performance as stated by Gold (Eilon et al 1976:23):

product prices	-- Total product value / output
unit costs	-- Total costs/output
utilisation of facilities	-- Output/capacity
productivity of facilities and equipment	-- Capacity/fixed investment
the allocation of investment resources	
capital goods and working capital	-- Fixed and total investment

These ratios then form the equation Gold uses to determine the primary measure of total performance of the enterprise.

2.8.2.4 Step 4: Total performance

$$\frac{\text{PBT}}{\text{Total investment}} = \left(\frac{\text{Product value}}{\text{Output}} - \frac{\text{Total costs}}{\text{Output}} \right) \times \frac{\text{Output}}{\text{Capacity}} \times \frac{\text{Capacity}}{\text{Fixed investment}} \times \frac{\text{Fixed investment}}{\text{Total investment}} \quad (2.57)$$

2.8.2.5 Step 5: Comparison to equity

The ratio of profit to equity investment is used when decisions are required concerning financial structure.

$$\frac{\text{PBT}}{\text{Equity investment}} = \frac{\text{PBT}}{\text{Total investment}} \div \frac{\text{Equity investment}}{\text{Total investment}} \quad (2.58)$$

2.9 OPERATION FUNCTION ANALYSIS (OFA)

2.9.1 Background

OFA is a process describing the knowledge work aspects in an enterprise. Although this topic does not form part of this discussion, there are a few points that relate to the manufacturing enterprise. OFA will therefore not be discussed in detail and only relevant points will be considered.

It is argued that traditional time study as well as work measurement methods and similar authoritarian approaches developed in the past for routine, manual work are inadequate for knowledge work (Bumbarger 1984:6). This has resulted in the need to develop new methods for the following reasons:

- (1) Knowledge workers are involved workers.
- (2) Knowledge work is not repetitive.
- (3) Knowledge activities are organisationally complex.

For many years, productivity improvement was largely authoritarian. In recent times, however, it has become apparent that participation in productivity improvement methods is essential. This has led to the first rule for OFA productivity improvement in the professional, knowledge office area (Bumbarger 1984:9):

- Rule 1. Lasting productivity improvement must come from within and cannot be effectively imposed from the outside.

This emphasises that people throughout the enterprise should be involved in the productivity improvement process if it is to be successful. The answer to OFA's success lies in rule 2 (Bumbarger 1984:20):

- Rule 2. Real, lasting productivity improvement requires change. And change requires creativity, innovation.

Once the people aspects are dealt with, attention the focus shifts to the demands made on the enterprise to meet customer requirements and handle pressure exerted by other enterprises. The principal challenge in improving productivity is to eliminate unnecessary work, not just to speed it up. This leads to the third rule of productivity improvement in the professional knowledge office namely, (Bumbarger 1984:46):

- Rule 3. The productivity of an organisation is determined by the characteristics of the demands placed on it - more than by any other factor.

Since the best way to effect major improvements is a change in demand, the following steps are required (Bumbarger 1984:49):

Identify the unnecessary work in each function.
 Identify the demand that drives each function and the characteristics or features of that demand that cause the unnecessary work.
 Modify and simplify the demand, removing the offending features so as to eliminate the unnecessary work.
 Change the work flow to meet the new, simplified demand and gain lasting structural improvements.

2.9.2 OFA methodology

To implement OFA in the enterprise, the definition of a function must first be understood. A function is a group of related operations performed to meet a single demand. Every enterprise is unique and has its own set of functions (Bumbarger 1984:59).

In a manufacturing enterprise, functions are divided into three categories:

- ♦ Preliminary processes
- ♦ Mainline processes
- ♦ Supporting processes

2.9.2.1 *Preliminary processes*

These functions are future oriented - they prepare the enterprise for mainline activities.

2.9.2.2 *Mainline processes*

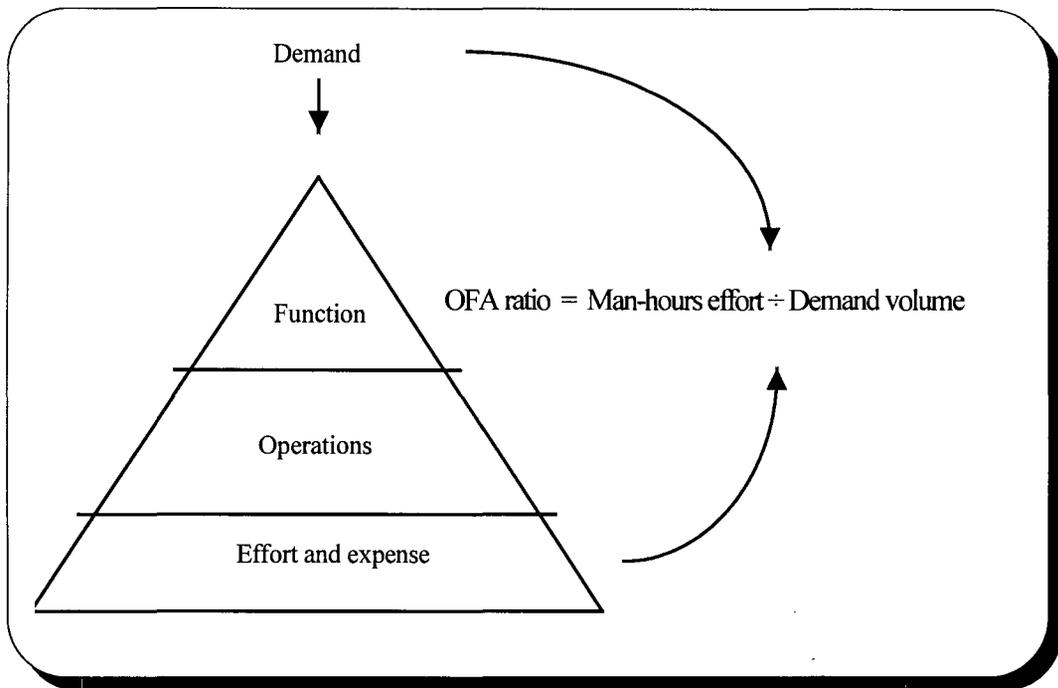
These functions relate to the receiving of orders, the transfer of these data to engineering and manufacturing, as well as, the delivery of goods to customers, the supply of service parts and the financial functions associated with this mainline process.

2.9.2.3 *Supporting processes*

Although they are not a part of the mainline activities themselves, these comprise the functions performed so that the mainline processes can take place.

2.9.3 The OFA ratio - a basic performance measure

The OFA ratio is not the same as a burden allocation ratio generally used in some productivity measurement approaches but is in fact the driving demand for that function. It is purported not to be a convenient statistically related variable (Bumbarger 1984:59). Figure 2.25 explains the ratio.

Figure 2.25: The OFA ratio

Source: Bumbarger et al (1984:70)

The following example shows how this ratio is applied. In an enterprise, 1 540 man-hours are used per month to perform the function of order editing 120 orders. The OFA ratio is determined as follows:

$$\begin{aligned} \text{OFA ratio} &= \frac{1\,540}{120} \\ &= 12,83 \text{ man-hours/order} \end{aligned}$$

From the enterprise's accounts it is possible to determine the cost of order processing by applying the hourly overhead rate to the answer obtained in the calculation.

Therefore if the overheads per hour are R 148,00, then the cost to process one order is:

$$\begin{aligned} \text{Cost} &= 12,83 \times 148 \\ &= \text{R } 1\,898,84 \end{aligned}$$

Variations of the OFA ratio with reference to all the defined functions in the enterprise can be applied to provide a basis for comparison.

The last rule for productivity improvement by means of the OFA approach in the professional knowledge office sector is as follows (Bumbarger 1984:72):

Rule 4. What appears to be a major problem in an organisation, often is only a symptom of an even greater problem in another organisation.

An example of this rule often occurs in a small manufacturing enterprise dependent on external suppliers. Consider the situation where a manufacturer of a specific product, like a stapler, makes use of an external source for the supply of the two springs required for this unit. The internal manufacturing line becomes aware of a problem when its requirements for these springs are not met by the inventory department. This internal problem appears to become an even greater one when an enquiry is made in the procurement department. The enquiry reveals that the suppliers have fallen behind schedule with their despatches on account of material shortages at their end. The internal problem of the staple manufacturer now becomes less of a problem but more a symptom of their suppliers' manufacturing difficulties and their inability to manufacture on time.

2.10 INTERNATIONAL LABOUR ORGANISATION (ILO)

2.10.1 Background

A number of references were researched containing information of the work performed by the ILO. Most relate to productivity measurement and improvement in small manufacturing enterprises. It was noted that several of the key approaches discussed in this chapter are used by the ILO namely, Lawlor, Gold, Quick Productivity Appraisal and Kurosawa (Prokopenko 1987:31; Prokopenko 1990:4; and Prokopenko 1994:22).

The ILO agrees with Lawlor that productivity can be regarded as a comprehensive measure of how enterprises satisfy the following criteria (Prokopenko 1990:2):

Objectives;
 efficiency;
 effectiveness and
 comparability

2.10.2 ILO methodology

The ILO states that productivity measurement and analysis are indispensable for productivity improvement. In addition, a clear understanding by all parties concerned of why productivity measurement is important for the effectiveness of the enterprise is also essential (Prokopenko 1990:3). The parties concerned include management, workers, trade unions and government institutions.

The ILO specifies two types of productivity ratios that measure productivity at all economic levels.

$$\text{Total productivity} = \frac{\text{Total output}}{\text{Total input}} \quad (2.59)$$

$$\text{Partial productivity} = \frac{\text{Total output}}{\text{Partial input}} \quad (2.60)$$

The ratio for total productivity can be expanded, as detailed in the following equation:

$$P_t = \frac{O_t}{L + C + R + Q} \quad (2.61)$$

where:

P_t = total productivity

O_t = total output

- L = labour input factor
- C = capital input factor
- R = raw material and purchase parts input
- Q = miscellaneous goods and services input factor

The ILO consider productivity to be the average of labour and capital productivity weighted and adjusted to price fluctuations (Prokopenko 1990:3).

Two approaches are used to measure labour productivity namely, labour-time and a financial method. The labour-time method considers the value added per worker, as shown in the following equation:

$$\text{Net output per employee} = \frac{\text{Added value per annum}}{\text{Total number of employees}} = \frac{VA}{Ly}$$

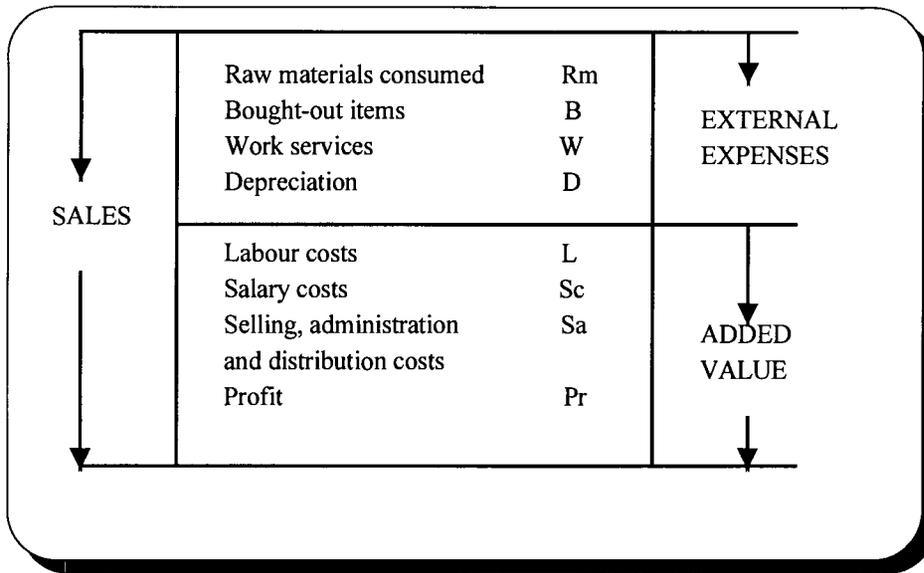
where:

- VA = value added to materials by the production process
- Ly = the number of employees or work-hours completed

and VA = total sales - external expenses

$$VA = S - X \quad (2.62)$$

This equation is the same as (2.45) in Lawlor's approach, and the method of determining total productivity can be clearly compared to figure 2.21 as shown in figure 2.26:

Figure 2.26: Elements of output used in calculating total productivity

Source: Prokopenko (1990:4)

2.10.2.1 Step 1: Measurement of objectives

On account of the need to maximise objectives in the enterprise, the principle of increasing total earnings is applied, and is determined as follows:

$$\begin{aligned} \text{TE} &= \text{sales} - \text{materials} \\ &= S - M \end{aligned} \quad (2.63)$$

The total earnings are used to buy services, pay wages and salaries and to invest in fixed capital, profit and taxes.

2.10.2.2 Step 2: Measurement of efficiency

To determine how efficient the enterprise is, it is necessary to apply the following formula:

$$\frac{\text{Output}}{\text{Input}} = \frac{\text{Input} + \text{Profit}}{\text{Input}}$$

or

$$\frac{O}{I} = \frac{I+P}{I} = 1 + \frac{P}{I} \quad (2.64)$$

where

$$\frac{P}{I} = \text{Profit productivity ratio}$$

2.10.2.3 Step 3: Measurement of effectiveness

Effectiveness compares present achievement with what could be done if resources were managed more effectively (Prokopenko 1990:5). This concept includes an output target of what can be achieved:

$$\frac{\text{Output}}{\text{Input}} = \frac{\text{Effectiveness (what can be achieved)}}{\text{Resources consumed}} \quad (2.65)$$

2.10.2.4 Step 4: Measurement of comparability

The method used in this case provides three levels of comparison as detailed by Prokopenko (1990:5):

Comparison of present performance with a historical base performance

...

Comparison of performance between one unit - an individual, a job, a section, a process - and another ...

Comparison of actual performance with a target ...

2.10.2.5 Step 5: Measurement of trends

It should be the enterprise's aim to achieve a progressive improvement and therefore a trend. This approach requires two levels of productivity measurement within the enterprise. These are primary and secondary levels of productivity measurement.

The primary level deals with total earnings of productivity E which are:

$$\begin{aligned}
 E &= \frac{\text{Total earnings}}{\text{Conversion cost}} & (2.66) \\
 &= \frac{T}{C}
 \end{aligned}$$

where:

$$C = \text{total wages and salaries } W + \text{total purchased services } P_s + \text{depreciation } K$$

The secondary level of profit productivity E_p is obtained by means of the following equation:

$$\begin{aligned}
 E_p &= \frac{P}{C} = \frac{T - C}{C} \\
 &= \frac{T}{C} - 1 & (2.67)
 \end{aligned}$$

or

$$E_p = E - 1 \quad (2.68)$$

The ILO follows exactly the same approach as Lawlor, as detailed in equations 2.46 to 2.52 inclusive. These equations will not be repeated in this section, and can be referred to in the section dealing with Lawlor's approach.

2.10.3 The ILO OD/PIP approach

The ILO organisation development and performance improvement planning approach (OD/PIP) represents the collective experience of ILO management trainers and consultants, gained on field assignments (Prokopenko 1990:10). Since this is not a form of measurement but an improvement technique, it will be discussed only briefly. The OD/PIP approach is a cyclical process, and normally has five components or phases, namely (Prokopenko 1990:11):

- Preliminary diagnosis
- Orientation to OD/PIP
- Organisation diagnosis and action planning
- Implementation
- Review and revision

2.10.3.1 Preliminary diagnosis

During this phase, the health of the enterprise is assessed by management and consultants. They jointly explore possible approaches for improving organisational performance and results. A brief management audit or survey may form part of this phase.

2.10.3.2 Orientation to OD/PIP

Top management should be oriented to OD/PIP, to give them a chance to test the applicability of the approach. A two-day or three-day orientation programme is presented for this testing. This phase is designed to give the parties involved direct exposure to the philosophy, methodology and possibilities of the OD/PIP process.

2.10.3.3 Organisation diagnosis and action planning

This phase requires the running of several one-day or two-day management workshops, to

ensure the identification of the enterprise's objectives, performance indicators and problems, the factors associated with these problems and the hindering forces. The duration of this phase may be anything from one week to several months, depending on the enterprise's commitments and work pressures. Strategies will also be developed as well as action programmes for performance improvement, and arrangements made for their implementation.

2.10.3.4 *Implementation*

Part of the implementation process can start during the preceding phase of diagnosis and action planning workshops, particularly if they are prolonged. Performance improvement objectives and planning are translated into specific operational objectives and targets for units and individuals in the enterprise.

2.10.3.5 *Review and revision*

During the last phase, when results are reviewed and plans revised, the entire performance improvement plan and implementation effort are reviewed. This will include assessment of performance indicators and the rate of attainment of objectives and action programmes. This review of progress should take place at least twice a year, preferably on a quarterly basis during the first year of the OD/PIP effort. Data from these performance reviews are then used to revise or establish new objectives, performance indicators and action programmes. This ensures that the organisation will be sufficiently flexible to meet new demands (Prokopenko 1990:11).

2.11 QUICK PRODUCTIVITY APPRAISAL (QPA)

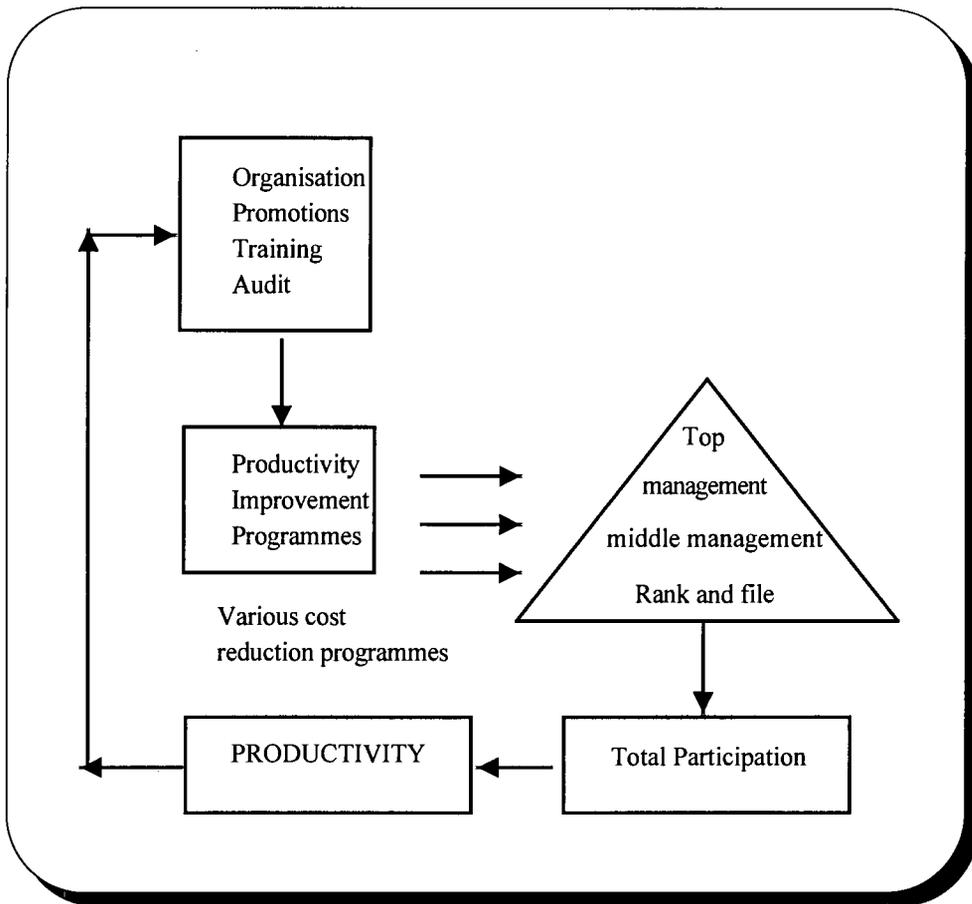
2.11.1 Background

Quick productivity appraisal (QPA) is the result of two years of research undertaken by Elena Avedillo-Cruz with a sponsorship from the Asian Productivity Organisation in Japan. During this period, Avedillo-Cruz was working for the Productivity and Development Centre in the Philippines, a branch of the ILO.

It was discovered that the realisation of maximum productivity improvement in the enterprise requires the integration of all productivity improvement programmes into one effective programme. This programme should be directed towards promoting the total involvement of everyone in the organisation. Such a programme comes together in a corporate-wide productivity improvement programme (CWPIP).

CWPIP is an organised approach to a continuous and integrated productivity improvement programme. It involves the systematic assessment of productivity needs and total participation of every level in the enterprise (Avedillo-Cruz 1989:1). A framework of a CWPIP is provided in figure 2.27.

A study of this figure shows clearly that pure measurement is not the only requirement for optimum productivity in a CWPIP. However, this discussion is solely directed at productivity measurement and this falls into the sphere of the audit cycle in the framework. The audit component involves both diagnosis and monitoring. Productivity indicators are established in the diagnosis phase to determine priority areas for improvement.

Figure 2.27: CWPIP Framework

Source: Avedillo-Cruz (1989:2)

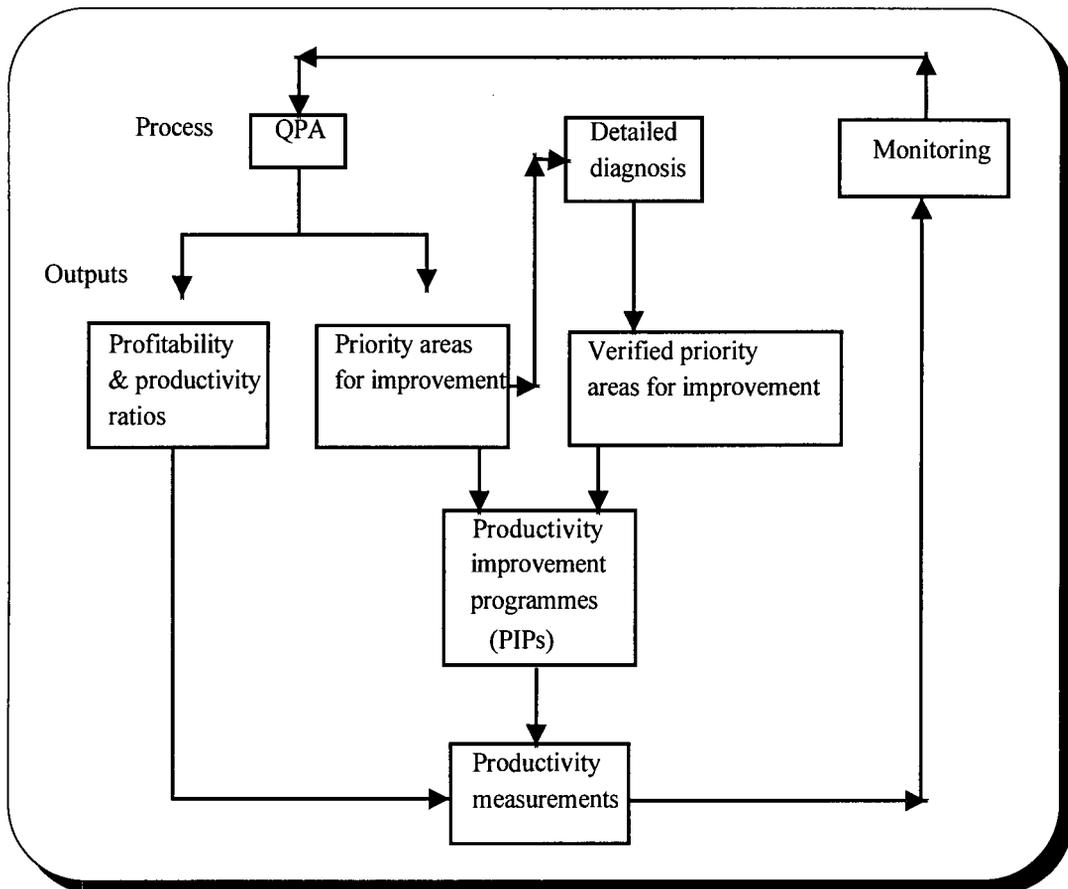
These indicators are then incorporated into the monitoring system whereby periodic checks are made between actual productivity levels and productivity targets. Figure 2.28 provides a clear description of the productivity audit cycle.

Two steps are followed when conducting a diagnosis:

- (1) Firstly, a preliminary diagnosis is made to consider all the factors that affect the enterprise both internally and externally. This diagnosis should be brief yet comprehensive to ensure that the appropriate action is instituted immediately - hence the need to conduct a quick productivity appraisal (QPA).

- (2) Secondly, after identifying the priority areas by means of the QPA, a detailed analysis is conducted for further analysis and verification of these priority areas. Results of this diagnosis will be used to identify the appropriate productivity improvement programme that should be implemented in the enterprise.

Figure 2.28: Productivity audit cycle



Source: Avedillo-Cruz (1989:3)

2.11.2 QPA methodology

QPA is a systematic assessment of productivity needs in the enterprise based on an analysis of its profitability, productivity performance, inherent strengths and weaknesses and the performance of the industry in which the enterprise belongs.

QPA has a twofold purpose (Avedillo-Cruz 1989:4):

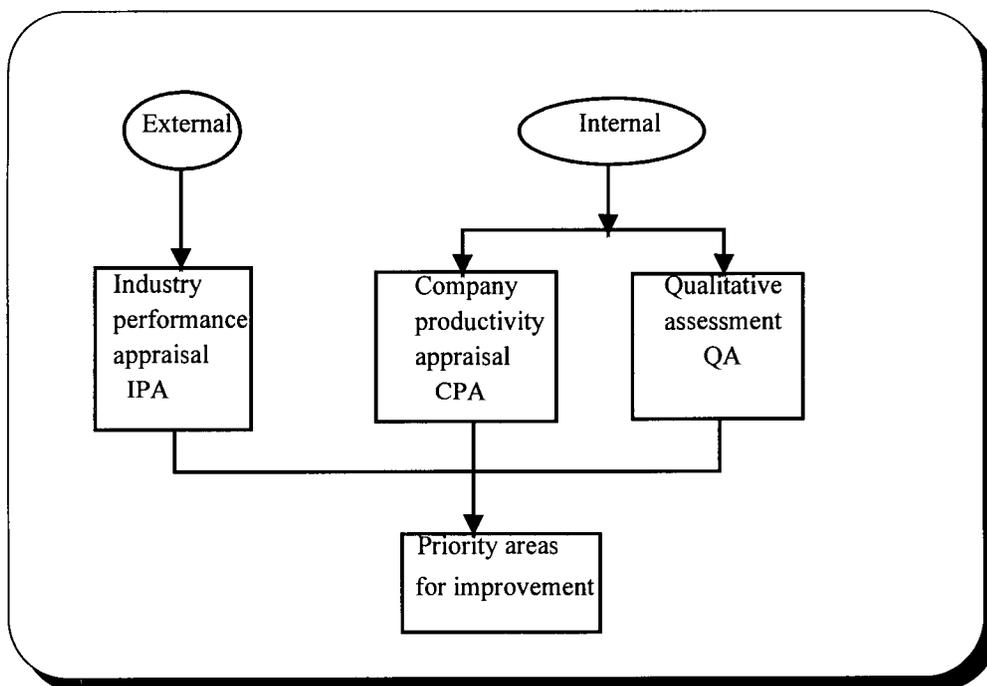
- (1) to identify and isolate problem areas requiring improvement
- (2) to establish productivity indicators for use in the entire enterprise

QPA comprises three components, namely:

- (1) Company performance appraisal (CPA)
- (2) Qualitative assessment (QA)
- (3) Industry performance appraisal (IPA)

Together they provide the means of identifying the priority areas requiring attention as shown in figure 2.29.

Figure 2.29: Components of quick productivity appraisal



Source: Avedillo-Cruz (1989:4)

The foremost of the three components of QPA is company performance appraisal. Past financial statements, profitability and productivity ratios are computed, and the

corresponding trends analysed. The results of CPA will be the priority areas requiring improvement.

2.11.2.1 CPA methodology

Company performance appraisal (CPA) is a quantitative approach to diagnosis. It entails a study of the general trends of specific profitability and productivity ratios derived from financial statements for the past three periods or more. A period may cover a year, a quarter, a month or even a shorter period (Avedillo-Cruz 1989:5).

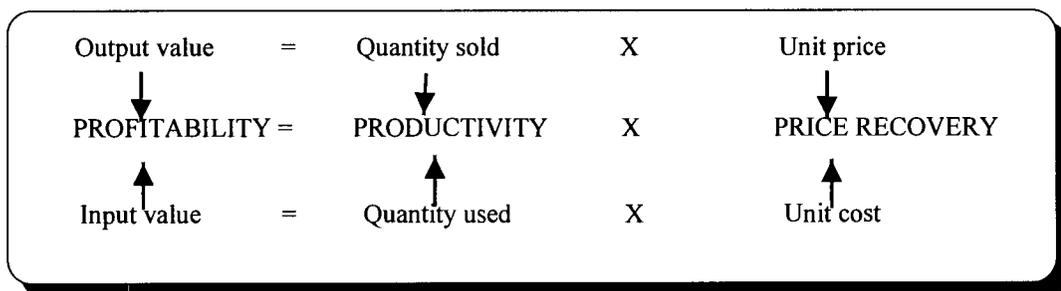
When conducting CPA two basic comparisons may be made, namely:

- (1) between current performance and a historical base performance
- (2) between actual performance and set targets of achievement

The latter comparison is preferable because historical performance does not necessarily mean they were acceptable (Avedillo-Cruz 1989:5). In the first case, it is possible only to provide an indication of improvement or decline measured against previous achievements.

Since the CPA approach makes use of productivity and profitability, the relationship between them must be established. This is best presented in the figure 2.30:

Figure 2.30: The relationship between profitability and productivity



Source: Avedillo-Cruz (1989:7)

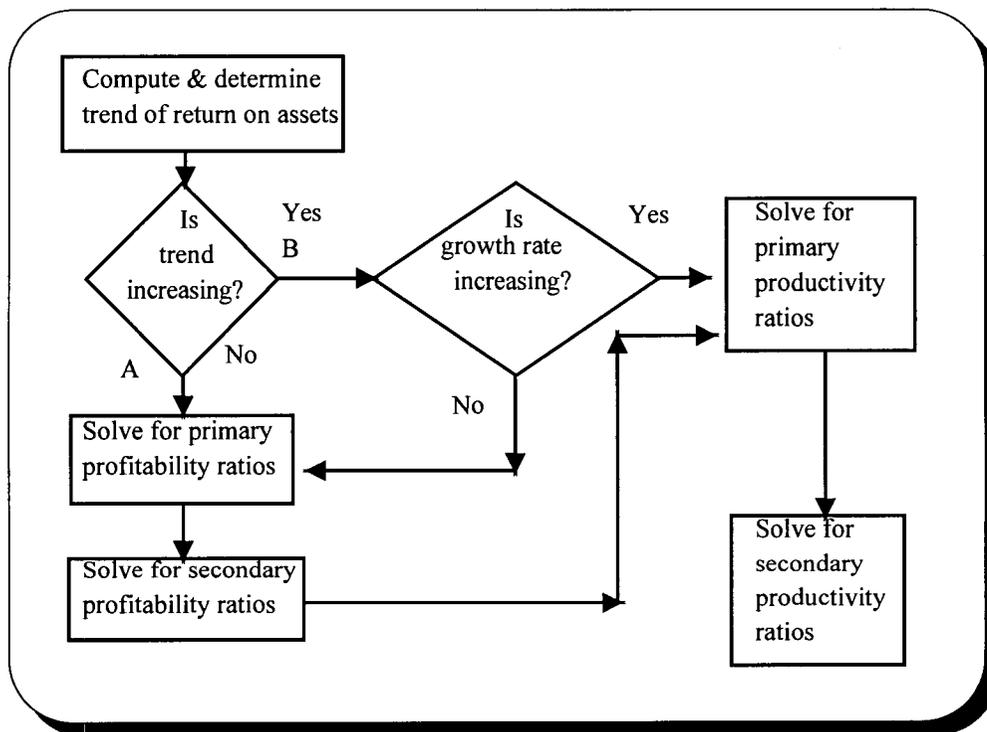
Note that this equation is first mentioned in the section on deterministic productivity accounting in equation 2.7. It occurs again in Lawlor's approach in figure 2.18.

In effect, what needs to be computed are performance ratios classified into:

- (1) change in profitability
- (2) change in productivity
- (3) change in price recovery

The steps used to perform this task are shown in figure 2.31 as follows:

Figure 2.31: Flow chart of company performance appraisal (CPA)



Source: Avedillo-Cruz (1989:11)

2.11.2.2 Step 1: Determine return on assets

Return on assets is determined by dividing net profit by total assets. Net profit may be before tax, as long as consistency is maintained. The period must be specified and kept

consistent - that is, if a monthly cycle is decided on, it must remain the effective period for all future determinations of return on assets.

2.11.2.3 *Step 2: Determine the trend of return on assets*

Depending on the trend, either productivity ratios only or both productivity and profitability ratios are determined. Trend refers to the general behaviour of the ratios determined. The three main classifications of trends used in CPA are increasing, decreasing or constant. Although the trends may actually be fluctuating, what is considered, is its approximation to the general behaviour.

If the trend exhibited by return on assets is decreasing or constant, it is necessary to solve for primary and secondary profitability ratios prior to solving for primary and secondary productivity ratios.

A constant trend requires the computation of the same ratios as a decreasing trend because there is a greater tendency for the constant trend to become a decreasing one.

If the trend of return on assets is increasing, then it undergoes the second test. The growth rate of return on assets is computed to determine whether or not it is increasing.

2.11.2.4 *Step 3: If the trend is decreasing or constant*

The growth rate of return on assets is computed as follows:

$$GR = \frac{ROA_{\text{present}} - ROA_{\text{preceding}}}{ROA_{\text{preceding}}} \times 100 \% \quad (2.69)$$

If the trend of the growth rate on return on assets is decreasing or constant, then the process of determining profitability and productivity ratios must be followed. This is branch A as shown in figure 2.30.

If ROA trend is decreasing or constant:

- (1) Calculate primary profitability ratios.
- (2) Determine trends.
- (3) Calculate secondary profitability ratios.
- (4) Determine trends.
- (5) Perform step 6.

2.11.2.5 *Step 4: If the trend is increasing*

If the trend is increasing, calculate the growth rate of return on assets. There is no need to solve for profitability ratios, since it has been established by the trend that, in terms of profitability, the enterprise is performing well. Only productivity performance needs to be checked.

2.11.2.6 *Step 5: If the growth rate of return on assets is decreasing or constant*

Perform step 3.

2.11.2.7 *Step 6: If the growth rate of return on assets is increasing*

Follow branch B as detailed in figure 2.31.

- (1) Calculate primary productivity ratios.
- (2) Determine trends.
- (3) Calculate secondary productivity ratios.
- (4) Determine trends.

2.11.3 Schedule of profitability ratios

Since the profitability ratios are divided into primary and secondary ratios, the following lists apply:

Primary ratios

$$(1) \text{ Net profit to net sales} = \frac{\text{Net profit}}{\text{Net sales}} \quad (2.70)$$

$$(2) \text{ Cost of goods sold ratio} = \frac{\text{Cost of goods sold}}{\text{Net sales}} \quad (2.71)$$

$$(3) \text{ Operating expenses to sales} = \frac{\text{Operating expenses}}{\text{Net sales}} \quad (2.72)$$

$$(4) \text{ Interest expenses to sales} = \frac{\text{Interest expenses}}{\text{Net sales}} \quad (2.73)$$

Secondary ratios

$$(1) \text{ Total assets turnover} = \frac{\text{Net sales}}{\text{Total assets}} \quad (2.74)$$

$$(2) \text{ Accounts receivable turnover} = \frac{\text{Net sales}}{\text{Accounts receivable}} \quad (2.75)$$

$$(3) \text{ Inventory turnover} = \frac{\text{Net sales}}{\text{Total inventory}} \quad (2.76)$$

$$(4) \text{ Fixed assets turnover} = \frac{\text{Net sales}}{\text{Fixed assets}} \quad (2.77)$$

The primary ratios are based on data available from the income statement, whereas the secondary ratios require data from both the income statement and the balance sheet.

2.11.4 Schedule of productivity ratios

Since the productivity ratios make repetitive use of the value-added concept, a full definition is provided before the ratios are discussed. Figure 2.32 provides the details.

Figure 2.32: Components of value added

Sales of finished product	Value of inputs bought from outside	<ul style="list-style-type: none"> * Raw materials * Semiprocessed products * Semifinished products * Merchandise * Supplies * Packaging materials * Energy * Subcontracting services * Etc
	Value added	<ul style="list-style-type: none"> * Salaries & wages * Bonus, commissions * Depreciation * Interest on loans & bonds * Taxes & public charges * Insurance * Net profit

Source: Avedillo-Cruz (1989:59)

Productivity ratios, like profitability ratios, are also divided into primary and secondary ratios. The following lists apply:

Primary ratios

$$(1) \text{ Total productivity} = \frac{\text{Value added}}{\text{Labour} + \text{Capital inputs}} \quad (2.78)$$

(2) Labour productivity	(a)	$\frac{\text{Value added}}{\text{Total man-hours worked}}$	(2.79)
	(b)	$\frac{\text{Value added}}{\text{Number of employees}}$	(2.80)
	(c)	$\frac{\text{Value added}}{\text{Salaries \& wages}}$	(2.81)
(3) Capital productivity	(a)	$\frac{\text{Value added}}{\text{Tangible \& intangible assets}}$	(2.82)
	(b)	$\frac{\text{Value added}}{\text{Tangible \& fin capital}}$	(2.83)
	(c)	$\frac{\text{Value added}}{\text{Tangible assets}}$	(2.84)
	(d)	$\frac{\text{Value added}}{\text{Fixed assets}}$	(2.85)
	(e)	$\frac{\text{Value added}}{\text{Machinery \& equipment}}$	(2.86)

The following are examples of possible secondary ratios:

Secondary ratios

(1) Labour productivity classification according to:

type of worker	(a)	$\frac{\text{Value added}}{\text{No of direct workers}}$	(2.87)
----------------	-----	--	--------

		$\frac{\text{Value added}}{\text{No of indirect workers}}$	(2.88)
--	--	--	--------

shift	(b)	$\frac{\text{Value added}}{\text{Man-hours worked on first shift}}$	(2.89)
-------	-----	---	--------

$$\frac{\text{Value added}}{\text{Man-hours worked on 2nd shift}} \quad (2.90)$$

$$\frac{\text{Value added}}{\text{Man-hours worked on 3rd shift}} \quad (2.91)$$

function (c) $\frac{\text{Value added}}{\text{Salaries \& wages of production dept}} \quad (2.92)$

$$\frac{\text{Value added}}{\text{Salaries \& wages of finance dept}} \quad (2.93)$$

(2) Capital productivity classification according to:

(a) tangible and intangible assets, that is, marketable securities, cash, accounts receivable, notes receivable, land, buildings and structures

$$\frac{\text{Value added}}{\text{Marketable securities}} \quad (2.94)$$

(b) tangible and financial capital, that is, cash, accounts receivable, notes receivable, land, buildings and structures

$$\frac{\text{Value added}}{\text{Accounts receivable}} \quad (2.95)$$

(c) tangible assets, that is, inventories, land, buildings and structures

$$\frac{\text{Value added}}{\text{Inventories}} \quad (2.96)$$

(d) fixed assets, that is, land, buildings and structures, machinery and equipment, furniture and office equipment, transportation

$$\frac{\text{Value added}}{\text{Machinery \& plant}} \quad (2.97)$$

(e) Machinery and plant, that is, perforating presses, guillotines, lathes

$$\frac{\text{Value added}}{\text{Perforating presses}} \quad (2.98)$$

The selection of which capital input to use depends on the availability and accuracy of suitable accounting reports. In addition, the type of enterprise and the nature of its business influences the selection of the correct capital inputs.

In addition to the listed productivity ratios, it is important to compute the capital-labour ratios and determine the trend of these ratios. The relationship between capital and labour can explain why, for example, labour productivity is increasing. This may be the result of having more productive workers or because of the acquisition of new machinery. Unless all the relationships between capital and labour are determined it will not be possible to define the corrective action required. Table 2.8 provides eight different cases regarding capital and labour.

The computation of all the profitability, productivity and capital-labour ratios will provide adequate information to management to enable corrective decisions to be made and implemented.

Table 2.8: Capital-labour cases

Case	IF			THEN	
	Labour productivity	Capital productivity	Capital / labour ratio	What happens	What should be done
1	Increasing	Increasing	Increasing	Good productivity performance	Maintain or increase productivity further
2	Increasing	Increasing	Decreasing	Good productivity performance	Maintain or increase productivity further
3	Increasing	Decreasing	Increasing	Unfavourable productivity performance	Increase capital productivity
4	Decreasing	Increasing	Increasing	Satisfactory productivity performance	Increase labour productivity by: (1) Developing / identifying other jobs for displaced labour (2) Retraining displaced labour for other jobs
5	Decreasing	Decreasing	Increasing	Poor productivity performance	First, increase capital productivity, then increase labour productivity. Adapt available human resources to machines
6	Increasing	Decreasing	Decreasing	Satisfactory productivity performance	Increase capital productivity
7	Decreasing	Increasing	Decreasing	Unfavourable productivity performance	Increase labour productivity
8	Decreasing	Decreasing	Decreasing	Poor productivity performance	First, increase labour productivity, then increase capital productivity

Source: (Avedillo-Cruz 1989:26)

2.12 KUROSAWA AND GOSHI - JAPAN PRODUCTIVITY CENTER (Kurosawa)

2.12.1 Background

The Japan Productivity Center was developed after the Second World War and the defeat of the Japanese nation. The essential purpose of the centre was to assist industry during the rebuilding of Japanese industry. The main shortcoming identified was that their products were of inferior quality and productivity was extremely poor (Goshi 1995).

Goshi (1995) states that a national decision was taken to coincide with the ILO's Philadelphia Charter of 1944 and the three management principles developed in support of this Charter after 1955, namely:

- (1) the provision of job security
- (2) the recognition of unions
- (3) a profit-sharing scheme

The Japanese nation took these three principles further and formulated new national standards after 1955 as follows:

- (1) to provide lifetime employment
- (2) to empower the unions and provide a company base for them
- (3) to develop productivity based bonus schemes

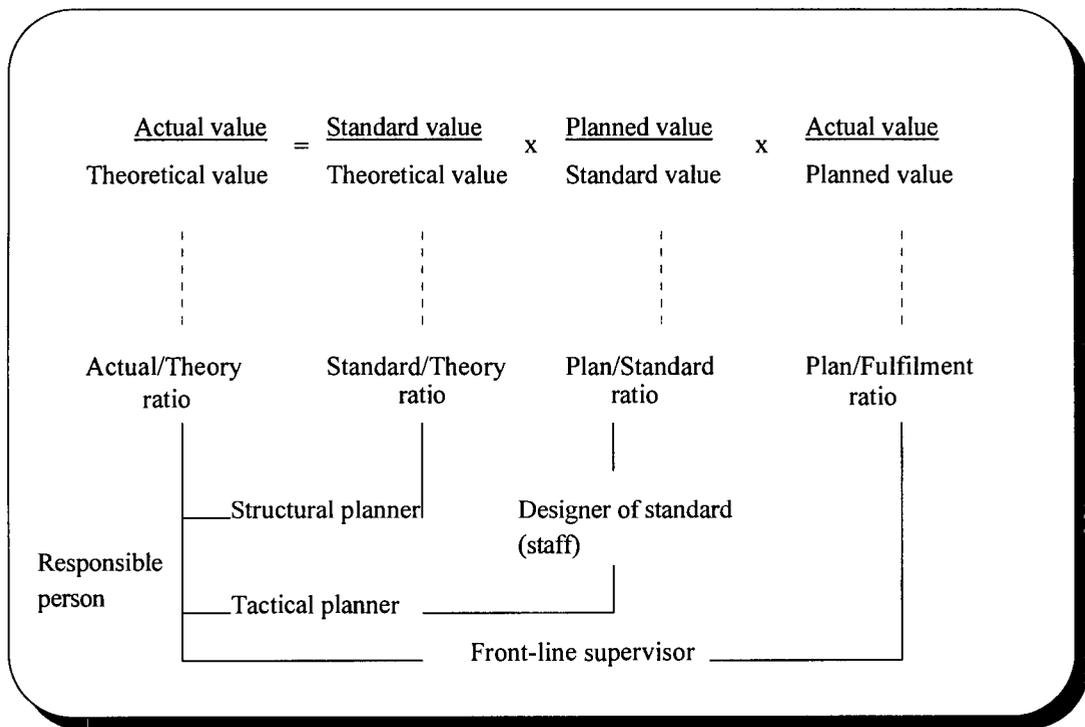
Goshi has dedicated his life to the field of study relating to the second standard of empowering the unions. He names this approach "Joint Consultation" which clearly defines the need to create a forum for discussion between unions and employers. Within the procedures of his approach, no form of productivity measurement is defined since it is left to the Joint Consultation Committee to develop and implement these measures. While Goshi's approach can contribute to a total productivity approach which includes liaison requirements, it does not fall within the scope of this discussion.

Kurosawa, a colleague of Goshi, spent his time developing productivity measurement techniques and has implemented many of these measures in consultation with the ILO and the Asian Productivity Organisation (Prokopenko 1994:22).

2.12.2 Kurosawa's methodology

Kurosawa focuses on the structure of the enterprise. His concept follows the approach of analysing the past, which makes possible the planning of new activities. The idea is to set up information systems for monitoring operations. Hence it is important that productivity measurement be built according to a decision-making hierarchy, similar to the one depicted in figure 2.33.

Figure 2.33: Fundamental framework of productivity measurement

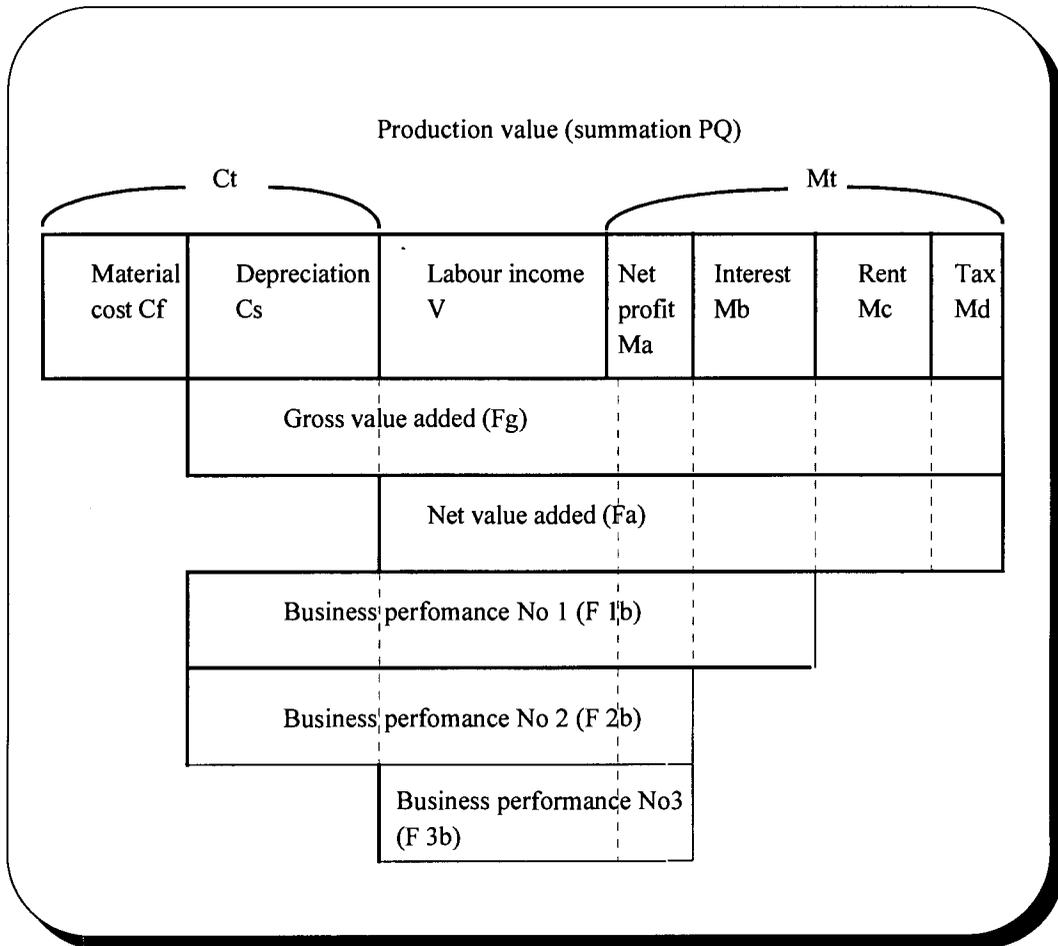


Source: Prokopenko (1994:22)

According to Kurosawa (Prokopenko 1994:22), after a period of applying this equation, an interlinked index system can be developed. He also makes use of value-added productivity measurement in combination with various physical parameters as well as

other related variables. Kurosawa provides a structure of production value and production value-added variants in figure 2.34:

Figure 2.34: Structure of production value and value-added variants



Source: Prokopenko (1994:23)

The real values added are determined by means of equation 2.99 as follows:

$$\text{Real value added} = \frac{\sum P_i Q_i}{I_p} - \frac{\sum S_i I_i}{I_s} \quad (2.99)$$

where:

- $\sum P_i Q_i$ = gross output for current period in current prices
- $\sum S_i I_i$ = industrial cost for current period at current prices
- P_i = market prices
- Q_i = quantity of items sold
- S_i = price of the "i" item of intermediate input factor

- I_i = quantity consumed of the "i" item of intermediate input factor
 I_p = price index number of products
 I_s = price index number of intermediate input

In routine business activities, value added is usually evaluated at current prices. Value added at constant prices is estimated more for analytical purposes. This approach is applied at constant intervals to determine the trend within the enterprise.

2.13 MULTIFACTOR PRODUCTIVITY MEASUREMENT MODEL (MFPMM)

2.13.1 Background

The multifactor productivity measurement model has been known as the "total factor productivity model," as well as the APC model (named for the American Productivity Center, which promoted the approach in 1977), or most generally as a "price-weighted", "indexed" and "aggregated multifactor productivity measurement model". It originated from research performed by Hiram Davis and was first published in Davis's book titled *Productivity accounting* during 1955 (Sink 1985:141). °

The MFPMM approach is a consultative, data base/accounting system and is not people driven since it utilises only ratios and indexes to measure productivity.

According to Sink (1985:142), the model can be and is being utilised to do the following:

- obtain an overall, integrated measure of productivity for the firm;
- to provide an analytical audit of past performance;
- for budget control of current performance;
- for common-price financial statements;
- to assess and evaluate bottom-line impact on specific profitability as a result of productivity shifts;
- to track the results of specific productivity improvement efforts, such as quality circles, quality control, incentive systems and technological innovation;

to measure initial distribution of benefits flowing from gains and/or losses in the productivity of the firms;
and to assist with setting productivity objectives and general strategic planning with regard to capacity utilisation, marketing efforts, cost management, staffing, quality management and pricing strategies.

Three additional uses of MFPMM have been stated by Van Loggerenberg and Cucchiaro in (Sink1985:146):

To monitor historical productivity performance and measure how much, in dollars, profits were affected by productivity growth or decline.

Evaluate company profit plans to assess and determine their acceptability and reasonableness or productivity changes to those plans.

Measure the extent to which the firm's productivity performance is strengthening or weakening its overall competitive position relative to its peer group(s).

Davis's approach has been influenced and altered in a number of ways since its initial publication, and the American Productivity Center made the following specific changes (Sink 1985:144):

Capital has been removed as an input variable in the model. Hence, the model to be presented is accurately labelled multifactor.

Variance analysis, which is presented in both the Davis and the APC versions of the model, has been removed.

A "what-if" simulation routine has been added to the model to allow the analyst/manager to forecast prices, costs and quantities for future periods and to analyse the effect of these changes.

Capital has been left out of the approach since this is one of the resources that is best managed in an enterprise.

2.13.2 MFPMM methodology

The net profit figure alone is an inadequate basis for judgement as to whether manufacturing is being performed at its most productive level. For this reason, by using the basic accounting data to calculate revenues and costs it is possible to apply MFPMM to gain additional and more significantly detailed insight into what is driving profits.

Once again the relationship between productivity and price recovery is used as in previous discussions where:

$$\text{Profitability} = \text{Productivity} \times \text{Price recovery} \quad (2.100)$$

or

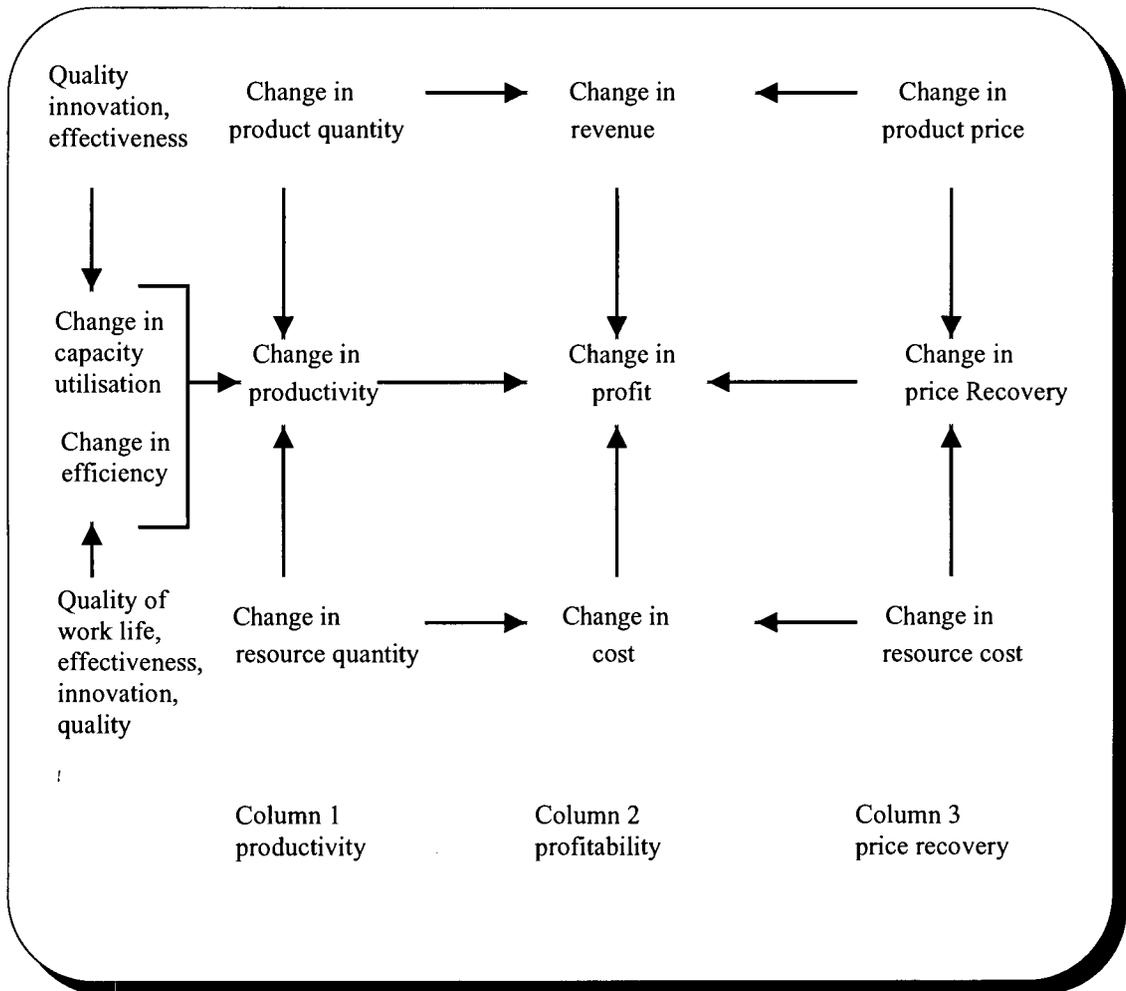
$$\text{Change in cost} = \text{change in resource quantity} \times \text{change in costs (price)}$$

This conforms to the approach recommended by Van Loggerenberg (fig 2.10) as repeated in figure 2.33 with a few additional comments by Sink.

Column 1 in figure 2.35 depicts the basic productivity index relationship, a change in output quantities divided by a change in resource quantities. In each enterprise, there is a unique productivity index for each resource.

Column 2 reflects the profitability index, a change in revenues divided by a change in costs. Note that if all other factors are held constant, namely prices and costs, a positive change in the productivity index will cause or translate into a positive change in profits. Similarly, if quantities are held constant and the price recovery index is positive, then profits, at least in the short run, will be positive.

Column 3 depicts what is called a "price recovery index." The price recovery index is a change in output prices divided by a change in resource costs (prices).

Figure 2.35: Basic factors and interrelationships contributing to performance

Source: Sink (1985:150)

Adapted from Van Loggerenberg & Cucchiaro (1981)

2.13.3 The MFPMM format

Productivity accounting is used in the process, but the data must be devalued or revalued prices and costs. Constant value sales are utilised as output in the model and constant value costs for "all" resources consumed are used as input. The process of devaluing is clearly described in the table which is used in the application of MFPMM. The basic outline is presented in table 2.9:

Table 2.9: MFPMM format

	Period 1			Period 2			Weighted change ratio			Cost / revenue ratio		Productivity ratios		Weighted performance indexes			Rand effects on profits		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Outputs																			
Summation of outputs																			
Inputs																			
Labour																			
Material																			
Energy																			
Investment																			
Services																			
Other																			
Summation of all inputs																			
Difference																			

Source: Sink (1985:151)

For clarity of information, all the outputs making up the rows of the table will firstly be given per product, followed by a summation of the values. The inputs follow the same policy. All the individual values are inserted, followed by a summation of each category - that is, all labour costs, then material and energy.

For a better understanding this procedure for columns 1 to 19, each is discussed individually.

Column 1

Column 1 records the data from accounting statistics and comprises the quantity of outputs the enterprise produced and/or sold as well as the quantities of input resources consumed in order to produce those outputs for period 1. Period 1 will be the base period of the approach. The symbol given to these values is Q_{i1} .

Column 2

This column represents the unit price for outputs and unit cost for inputs during period 1 (base period). Its symbol is P_{i1} .

Column 3

The value (quantity x price) determined from the multiplication of columns 1 and 2 is recorded in this column and is given the symbol, $(Q_{i1})(P_{i1})$.

Columns 4 to 6

Precisely the same data as those recorded in columns 1 to 3 are recorded in these columns, but for period 2. The respective symbols are Q_{i2} ; P_{i2} ; $(Q_{i2})(P_{i2})$.

Columns 7 to 9

These three columns are titled "Weighted change ratios."

Column 7

The price-weighted and base period price indexed changes in quantities are determined. This column partials out or holds constant the effect of prices and examines the price-weighted changes in quantities of output and inputs. Its formula and equation are as follows:

$$\frac{Q_2 P_1}{Q_1 P_2}$$

Column 8

This column determines the quantity-weighted and current period indexed changes in unit prices and unit costs. It partials out or holds constant the changes in quantities of outputs and inputs and examines the changes in unit prices and unit costs from period 1 to period 2. Its formula and symbols are:

$$\frac{Q_2 P_2}{Q_2 P_1}$$

Column 9

This column examines the simultaneous impact of changes in price and quantity from period 1 to period 2 for each row in the model. Its formula and symbols are as follows:

$$\frac{Q_2 P_2}{Q_1 P_1} \quad \text{or simply column 7} \times \text{column 8}$$

Columns 10 and 11

These two columns are labelled "Cost/Revenue ratios". They indicate the ratio of input row elements for columns 3 and 6. The formulae for these two columns are as follows:

$$\frac{I_{ij1}}{\sum (O_{i1})(P_{i1})} \quad \text{and} \quad \frac{I_{ij2}}{\sum (O_{i2})(P_{i2})}$$

$$\text{or } \frac{\text{Input elements, column 3}}{\text{Total, column 3}} \quad \text{and} \quad \frac{\text{Input elements, column 6}}{\text{Total, column 6}}$$

Columns 12 and 13

These two columns are labelled "Productivity ratios". Column 12 reflects the output-to-input ratios for period 1, while column 13 reflects the output-to-input ratios for period 2. The formula for each is:

$$\text{Column 12} = \frac{\text{Total, column 3}}{\text{Input elements, column 6}}$$

$$\text{Column 13} = \frac{\text{Base period price weighted total, column 6}}{\text{Base period price weighted input elements, column 6}}$$

Columns 14 and 16

These two columns are labelled "Weighted performance indexes". Column 14 reflects price-weighted productivity indices. Column 15 represents quantity, weighted price recovery indices and column 16 depicts profitability indices. The respective formulae are as follows:

$$\text{Column 14} = \frac{\text{Column 7 for total outputs}}{\text{Column 7 for each individual input}} \quad \text{Productivity}$$

$$\text{Column 15} = \frac{\text{Column 14}}{\text{Column 12}} \quad \text{Price recovery}$$

$$\text{Column 16} = \frac{\text{Column 9 for total outputs}}{\text{Column 9 for each input}} \quad \text{Profitability}$$

Columns 17 and 19

These columns reflect the rand equivalents of the corresponding cells in columns 14 to 16 - that is, these columns indicate what impact an increase in productivity or price recovery has on profit. The total impact on profit by productivity and price recovery is indicated in column 19. The respective formulae are:

$$\text{Column 17} = \text{Column 7 for total outputs} - \text{Column 7 for each input}$$

Column 18 = Column 19 - Column 17

Column 19 = Column 9 for total outputs - Column 9 for each input

This completes the description of MFPMM.

2.14 CHAPTER SUMMARY

Productivity has been defined clearly in this chapter to ensure that the subject of productivity measurement in the small manufacturing enterprise is adequately explained. A general understanding of productivity is given as a comprehensive measure of how an enterprise can satisfy the following criteria:

- ♦ objectives
- ♦ efficiency
- ♦ effectiveness
- ♦ comparability
- ♦ trends

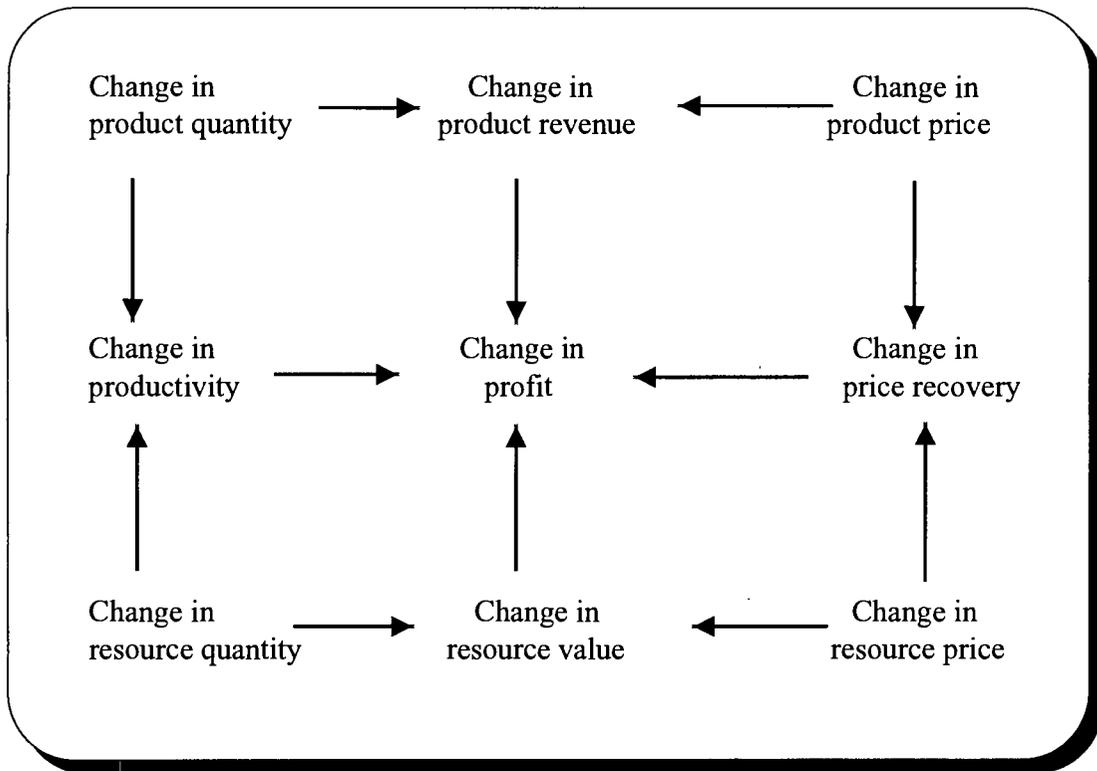
Clarity is provided on partial and absolute measures of productivity as well as the key criteria for a correct productivity measurement approach. Twelve measurement approaches have been discussed in detail, ranging from pure quantitative techniques to techniques requiring comments from individuals on humanistic issues.

When considering these approaches two elements have emerged strongly and repeatedly:

- ♦ the relationship between profitability, productivity and price recovery
- ♦ the application of value added

(1) *The relationship between profitability, productivity and price recovery*

This relationship is first mentioned by Van Loggerenberg in equation 2.7. Thereafter he proceeds to develop a very complex set of equations which lead up to the deterministic productivity accounting approach in figure 2.10. This figure is repeated below.

Figure 2.10: The DPA model

Source: Van Loggerenberg (1990:PAD-6)

This first presentation of the relationship is followed by additional uses of the same ratio. Sumanth presents his productivity benefit model in figure 2.12, and on close examination, it is noted that his approach presents the above ratio.

Lawlor and Avedillo-Cruz also refer to this ratio in the same format as Van Loggerenberg. Finally, the multifactor productivity measurement model in equation (2.100) presents the ratio and provides an additional deduction of it as follows:

$$\text{Change in cost} = \text{change in resource quantity} \times \text{change in cost (price)}$$

(2) *The application of value added*

The second element that goes hand in hand with the first is the use of the value-added concept to determine various ratios. The National Productivity Institute uses value added when evaluating labour and capital productivity. Lawlor in turn provides a method of

determining net value added in figure 2.21. The ILO in figure 2.26 makes use of value added to determine total productivity.

The author who makes the most use of value added is Avedillo-Cruz. She uses it extensively in her quick productivity appraisal approach which considers profitability ratios as well as productivity ratios. In each instance when determining the primary and secondary productivity ratios, value added is used as the numerator in the equation.

Finally, a point repeatedly emphasised in several of the approaches is the use of an enterprise's financial statements and data as the input information in the measurement of productivity. It is therefore essential that full accounting principles are applied in the small manufacturing enterprise to make possible an accurate and correct determination of productivity.

The discussion dealt with in this chapter completes the requirements of the first objective as stated in chapter 1, namely, to document all the productivity measurement approaches obtained during the literature search.

CHAPTER 3

CURRENT PRACTICES AND REQUIREMENTS OF THE STEEL AND ENGINEERING INDUSTRY

3.0 INTRODUCTION

The research procedure described in chapter 1 indicated that the investigation would have two aspects, firstly the literature review to ascertain what methods are available, and secondly the need to determine, through empirical research, the current practices and requirements of industry. Chapter 2 covers the first aspect in detail by discussing the 12 productivity measurement approaches found in the literature.

The second aspect is the subject of this chapter. Primary research is required to confirm that the research problem as defined in chapter 1 does in fact exist. The research problem is twofold: firstly, to identify whether there is a need for productivity measurement in small manufacturing enterprise in the steel and engineering industries of South Africa; and secondly, to determine the current practices and requirements in industry. This includes the question whether managers are able to apply productivity measurement in their enterprises. As stated in chapter 1, section 1.1, the survey will be confined to small manufacturing enterprises in the steel and engineering industry of South Africa. A small manufacturing enterprise is defined in Appendix A.

3.1 RESEARCH PROCEDURE

Information about the current practises and requirements of industry was collected by means of a questionnaire. Two types of questionnaires are used in practice. The first is a structured questionnaire that makes use of closed-ended questions requiring a "yes"; "no" or "uncertain" response. The second type of questionnaire is unstructured, and poses open-ended questions requiring sentence-type responses. The questionnaire may be administered by means of the postal service, telefax, telephone or face to face interviews.

Most of the questions that need to be asked in this survey are more suited to the closed-ended type of reaction. Only in certain instances, where additional information was required on specific topics, were open-ended questions used.

3.2 THE RESEARCH POPULATION DEFINED AND SELECTING THE SAMPLE

Small manufacturing enterprises in the steel and engineering industry are extremely diverse and difficult to locate. This is because they are able to function almost anywhere with limited resources. They are found in the most unlikely places and can function in back yards or small sheds. Often telephone numbers are not listed under the enterprise's name and most of them do not advertise in the yellow pages. It was necessary to locate a suitable source of information that could provide a list of these enterprises without much difficulty. A typical provider would be an association or federation to which these enterprises belong. In the steel and engineering sector of industry it was decided that a suitable sample could be obtained from the Steel and Engineering Industries Federation of South Africa (SEIFSA).

The subject of the research was discussed with the head economist (McDonald 1995) and it was agreed that both parties (SEIFSA and the researcher) would benefit from collaboration during the research survey. The population and sample were determined with the assistance of SEIFSA's economic department. SEIFSA has a total membership of approximately 2 700 enterprises at any one time. The economic department regarded 70 percent (1890) of these members as small enterprises. Once the definition of a small manufacturing enterprise as detailed in appendix A was brought to their attention, their opinion changed. The definition of a small manufacturing enterprise was compared with their data bank and it became clear that only 1 072 (40%) members satisfied this definition. These members constitute the research population. The author decided to send the questionnaire to all 1 072 enterprises.

3.3 QUESTIONNAIRE DESIGN

The complete questionnaire is provided in appendix B for reference. During its development, the steps as described by Boyd, Westfall and Stasch (Ghyoot 1994:22) were followed. They are:

- Determine what information is required.
- Decide how the questionnaire will be administered.
- Decide on the content of individual questions.
- Determine the type of question to use.
- Decide on the wording of questions.
- Decide on the question sequence.
- Precode the questionnaire if computer processing is to be used.
- Decide on the layout and reproduction of the questionnaire.
- Pre-test the questionnaire.

Leedy (1993:188-189) provides additional information that should be considered when developing the questionnaire:

- Be courteous.
- Simplify. Make the instrument as simple to read and to respond to as possible.
- Think of the other person. Put yourself in the place of the respondent.
- Concentrate on the universal. Try to address your questions to universals rather than to specifics ...
- Make it brief.
- Check for consistency.

These guidelines were followed, and because the questionnaire was to be administered through the post, specific attention was paid to simplicity. This was to prevent any doubt or ambiguity from creeping into the questionnaire. When completing the questionnaire, respondents were asked to place a tick in the block accompanying each response. The

simpler questions constitute the first section of the questionnaire and are followed by the more complex ones towards the end (Ghyoot 1994:24).

When administering questionnaires, one should not include questions that will result in the poor cooperation of respondents. Poor cooperation may occur in several ways, for instance, once a respondent has been offended by a question he or she may refuse to continue, or answer the remaining questions inaccurately. The worst case scenario is when the respondent fails to return the questionnaire. Kerlinger (1973:486) defines two types of questions:

Leading questions, which suggest an answer to the respondent, and
Socially loaded questions, which for example are directed at a
particular race within the economy.

The questionnaire consists of 24 questions each of which is precoded in numerical sequence. Where descriptive responses are anticipated, specific titles are allocated to make possible grouping of the replies. A total of 127 codes are allocated to the possible responses to each of the questions. In a few instances, these questions are subdivided into other questions for clarity of information.

The questionnaire is divided into four categories as follows:

- (1) identification of respondents
- (2) requirements of a productivity measurement approach
- (3) use of output information
- (4) respondents' perceptions in general

(1) *Identification of respondents.* This section consists of five questions (1 - 5) directed at establishing the size and type of enterprise as well as whether a productivity measurement approach is used in the enterprise.

- (2) *Requirements of a productivity measurement approach.* In this section 12 questions (6 - 17) are posed. It is the researcher's intention to establish the respondents' knowledge of the subject of productivity measurement as well as determining whether they are familiar with any of the approaches discussed in chapter 2. In addition, it is necessary to identify the respondent's needs and expectations.
- (3) *Use of output information.* Only one question is presented in this section (18). It is subdivided into four responses that attempt to establish management's use of the output data.
- (4) *Respondents' perceptions.* The fourth section of the questionnaire consist of six questions (19 - 24). The perceptions of respondents regarding the advantages and disadvantages of using a productivity measurement approach are established in this section.

Finally, the respondents' opinions regarding the need for a specific productivity measurement approach in the steel and engineering industry of South Africa were obtained. This response is required to confirm that a problem does exist within small manufacturing enterprises as suggested in the statement of the problem in chapter 1.

3.4 ADMINISTRATION OF THE QUESTIONNAIRE

The method of approaching enterprises for assistance with a survey is of utmost importance. The covering letter should be carefully and thoughtfully structured. It should stress the concerns of the person receiving the letter rather than the selfish interests of the sender (Leedy 1985:146).

Since the enterprises being approached are all members of SEIFSA, the appropriate method is to utilise existing communication systems. The most appropriate system is the regular newsletter directed solely at the small manufacturing enterprise within the membership spectrum. This newsletter titled "Small Talk" proved to be a suitable

instrument to use for the distribution of the questionnaire. A copy of the title page is included as Appendix C. A short request is made to members on this page for assistance in the survey by completing the attached questionnaire (Appendix B).

The benefit of using this approach was that respondents were assured of their confidentiality because replies were to be returned to SEIFSA and the names of enterprises were omitted. One disadvantage was that the researcher could not exercise direct control. For example, in the event of a low response rate, it was not possible to use follow-up letters to request a response.

3.5 PRETESTING

To ensure that the questionnaire would be understood by respondents, the researcher decided to conduct a pretest by carrying out a pilot study. This study was carried out by means of telephone surveys directed at 10 enterprises selected from the membership list of the Light Engineering Industries Association. This Association is a member association of SEIFSA. Its members are a subset of the research population because they are part of the 1 072 enterprises that make up the research population. The sample frame used was the membership list of the Association. Ten enterprises were selected at random from this sample frame.

The respondents who were contacted were most cooperative and provided adequate responses to all the questions posed. In two instances, respondents were unwilling to supply information relating to the total asset value and total annual turnover of their respective enterprises.

Only one question required additional refinement (question 12). The purpose of this question is to establish whether a single-digit index is required to report the level of productivity in the enterprise. This index can be in the form of a percentage for total productivity.

One question was eliminated since the information requested was duplicated elsewhere.

3.6 QUESTIONNAIRES DISTRIBUTED AND RETURNED

The research population was defined earlier in section 3.2. It was noted that 1 072 enterprises conformed to the definition of a small manufacturing enterprise. The newsletter "Small Talk" which provided the function of the covering letter, was mailed to each of these enterprises. The total number of returns received via the mail and telefax equalled only 64 of the original research population of 1 072. Thus, a 6 percent response rate was achieved.

3.7 REPRESENTATIVENESS OF THE RESPONSES

An important problem that faces researchers is whether the information gleaned from the survey is representative of the population. Thus the 6 percent response rate experienced in this survey merits comment. Stopher and Meyburg (1979:112) state that the greatest problem facing the self-administered research survey is nonresponse. According to the authors, the nonresponse rate for this type of research may exceed 70 percent.

Kerlinger (1988:380) comments as follows:

Responses to mail questionnaires are generally poor. Returns of less than 40 or 50 percent are common. Higher percentages are rare.

The 6 percent response rate in this survey is obviously low, but because the research population was extremely homogenous, a great deal of validity can be attached to the information obtained. Franzen and Lazarfeld (1945:293) state that the more homogenous the respondents are, the less important is the requirement for a large response rate. The answers to question 1 confirmed that the target research population had been reached and therefore all 64 of the returned questionnaires could be used.

3.8 DATA PROCESSING

Before the analysis of the data can proceed, the data must be prepared. This involves editing, coding and entering data into a computer. Under the heading of editing, Nel, Rädell and Loubser (1988:332) specify the details that should be checked:

3.8.1 Editing

Editing requires that the following should be checked:

- (1) Adherence to sample requirements
- (2) Relevance
- (3) Completeness
- (4) Legibility
- (5) Comprehensibility
- (6) Consistency
- (7) Uniformity

(1) *Adherence to sample requirements.* The questionnaire distribution was planned and administered to ensure that only small manufacturing enterprises were approached. This is confirmed by and controlled through the reaction received to questions 1 to 5 respectively.

(2) *Relevance.* The questions that were posed needed to be relevant with reference to the data required to achieve the research objectives. Each question was checked to ensure that its response would lead to the achievement of these objectives.

(3) *Completeness.* Some respondents omitted one or more questions. However, the extent of this occurrence did not influence the outcome. A possible reason for their nonresponse is that they did not have the information to hand to enable them to respond correctly.

- (4) *Legibility*. In one instance, difficulty with legibility occurred. A respondent provided an answer to a open-ended question but it was illegible. This response was discarded during the analysis.
- (5) *Comprehensibility*. The responses were checked to ensure that they made sense. Because of the large number of closed-ended questions asked, comprehensible responses were received.
- (6) *Consistency*. The majority of questions were answered adequately and only one questionnaire appeared inconsistent. The respondent appeared to have lost interest in completing the questionnaire midway and started to insert inaccurate responses. Only the consistent responses in this questionnaire were taken into account - the rest were discarded.
- (7) *Uniformity*. The same unit of measurement (percentages of the total research population) was used throughout when recording the answers. This made comparability of the responses possible and ensured uniformity.

3.8.2 Coding

The coding of the questionnaire was attended to during its preparation. Seven open-ended questions were included in the questionnaire to gather specific data. An anticipated reaction was provided for each question. This was structured in such a way that if a statement relating to profit was anticipated, a code was reserved for this purpose.

Two wild codes were allocated to questions 87 and 121. Wild codes are applied in cases where an anticipated response has not been predetermined or assumed. Depending on the specific type of answers provided to the question, a description will be provided thereafter. Both these codes had a zero response and were not used.

3.9 DATA ANALYSIS

In every instance in which a percentage is stated, it has been determined with reference to the 64 returned questionnaires.

3.9.1 Identification of respondents

This section comprised questions 1 to 5.

Question 1

Type of enterprise:

Total employed Do you employ 50 or less people in total?

(including staff) Do you employ 51 or more people in total?

A total of 64 respondents answered this question:

50 or less	83%
51 or more	17%
Total	100%

Total asset value Is the total asset value of your enterprise
equal to R 2 million or less?

Is the total asset value of your enterprise
more than R 2 million?

A total of 62 respondents answered this question:

R 2 million or less	66%
R 2 000 001 or more	31%
Response not given	03%
Total	100%

Total turnover *Is the total annual sales turnover of your enterprise equal to R 5 million or less?*

Is the total annual sales turnover of your enterprise more than R 5 million?

A total of 64 respondents answered this question:

R 5 million or less	62,5%
R 5 000 001 or more	37,5%
Total	100%

Are you a manufacturer in the steel and engineering sector? Yes / No
(Manufacturing includes repair related work in which value is added to an item.)

A total of 64 respondents answered this question:

Yes	89%
No	11%
Total	100%

Is your enterprise owned by its management?

Yes/ No/ Uncertain/

A total of 64 respondents answered this question:

Yes	87,5%
No	12,5%
Uncertain	0%
Total	100%

If not, is it part of a large corporation?

Yes/ No/ Uncertain/

A total of 64 respondents answered this question:

Yes	12,5%
No	87,5%
Uncertain	0%
Total	100%

Question 1 was subdivided into short questions and is coded from 1 to 14. It was essential to establish that the respondents represent the desired industry as well as small manufacturing enterprises as defined in appendix A. The results of the 64 returned questionnaires confirm that the survey did reach the correct people.

The number of positive responses from enterprises that have the desired qualifications and fall into the category of the small manufacturing enterprise in the steel and engineering industry are as follows:

Enterprises employing 50 or less people in total	83%
Enterprises with assets equal to R 2 million or less	66%
The total annual sales of R 5 million or less	62,5%
Owner managed	87,5%
Enterprises that are not part of larger organisations	87,5%
Enterprises that manufacturer in the steel and engineering sector	89%

Comparison of this table with the definition of a small manufacturing enterprise in appendix A confirms that the correct enterprises were approached. It is further evident that a homogenous sample completed the questionnaire.

Question 2

Is productivity measurement necessary in your organisation?

A total of 63 respondents answered this question:

Yes	59%
No	27%
Uncertain	12,5%
Response not given	1,5%
Total	100%

A "yes" response has been given to this question despite the number of uncertain responses. It is clear that a need does exist for productivity measurement in the small manufacturing enterprise.

Question 3

Do you use any form of productivity measurement at present?

A total of 64 respondents answered this question:

Yes	41%
No	59%
Total	100%

The above question is structured to obtain a definite "yes" or "no" response and does not permit the option of an uncertain answer. It is clear from the percentage of negative responses that the respondents who indicated a need for productivity measurement in question 2 are not all implementing productivity measurement in their enterprise.

Question 4

If not, go to question 9. If "yes", do you use a specific measurement approach or model?

A total of 27 respondents answered this question:

Yes	19%
No	23%
Response not given	58%
Total	100%

Of the 27 responses given to this question, less than half apply a specific measurement approach.

Question 5

If "yes", which one?

A total of 12 respondents answered this question:

This question is open ended and an appropriate description has been given to each response.

Time and motion studies	8%
Profit	2%
Cost-related controls	8%
The human factor (attitudes)	2%
Response not given	80%
Total	100%

The low response rate makes this a poor indication of the use of specific measurement approaches in small manufacturing enterprises.

3.9.2 Requirements of a productivity measurement approach

Questions 6 to 17 comprise this section.

Question 6

Does your method make use of price recovery and profit?

It should be remembered that in chapter 2, the author concluded that the application of price recovery and profit is an essential requirement of any productivity measurement approach.

A total of 26 respondents answered this question:

Yes	23%
No	14%
Uncertain	3%
Response not given	60%
Total	100%

(where: $\text{price recovery} = \frac{\text{change-in-product-price}}{\text{change-in-resource-price}}$ and

$$\text{profit} = \frac{\text{change-in-product-revenue}}{\text{change-in-resource-value}})$$

When enquiring whether the respondent's measurement approach applies to both aspects, 23 percent of the respondents answered "yes" to the question. This confirms that the systems presently used lack the application of price recovery and profit-related principles.

Question 7

Does your present method satisfy your requirements?

A total of 26 respondents answered this question:

Yes	20%
No	9%
Uncertain	11%
Response not given	60%
Total	100%

Although the "yes" response is dominant in terms of the number of answers, it is not possible to assume that the industry is satisfied with present methods on account of the small number of responses.

Question 8

If "no", why not? Please specify.

This question is open ended and a code was assigned to each anticipated response.

A total of four respondents answered this question:

Inadequate information	5%
Cumbersome	0%
Time consuming	0%
Poor conveyance of data	2%
Response not given	93%
Total	100%

On account of the small number of responses, the result is inconclusive and does not provide adequate information of shortcomings experienced with present measurement approaches.

Question 9

Do you know any of the following approaches?

An abbreviation has been allocated to each approach. This enables the answer to the question to be presented in a table format.

Productivity measurement and evaluation system (ProMES)

Deterministic productivity accounting (DPA)

The National Productivity Institute (NPI)

Theory of constraints (ToC)

The total productivity model (TPM)

Alan Lawlor's approach (Lawlor)

Applied productivity - Gold's approach (Gold)

Operation function analysis (OFA)

International Labour Organisation - (ILO)

Quick productivity appraisal (QPA)

Kurosawa and Goshi - Japan Productivity Center (Kurosawa)

Multifactor productivity measurement model (MFPMM)

A total of 63 respondents answered each of the subsections of this question:

	Yes	No	Uncertain	Response not given	Total
ProMES	2%	86%	11%	1%	100%
DPA	5%	88%	6%	1%	100%
NPI	19%	72%	8%	1%	100%
ToC	6%	86%	6%	2%	100%
TPM	6%	89%	3%	2%	100%
Lawlor	2%	92%	5%	1%	100%
Gold	0%	95%	3%	2%	100%
OFA	2%	94%	3%	1%	100%
ILO	6%	89%	3%	2%	100%
QPA	5%	92%	2%	1%	100%
Kurosawa	3%	94%	2%	1%	100%
MFPMM	0%	95%	3%	2%	100%
	Average	89%			

No doubt exists in this instance of the industry's knowledge of various productivity measurement approaches. It can safely be assumed that these approaches are unknown because of the high percentages recorded for the "no" response. An 89 percent average was recorded for the "no" response.

Question 10

Do you know of any other approaches not mentioned above?

A total of 63 respondents answered this question:

Yes	3%
No	95%
Response not given	2%
Total	100%

This question confirms the outcome of question 9. Only a small number of the respondents claim to know of other approaches.

Question 11

If "yes", please name them.

Nil responses were given to this question.

Although a small number claimed to know of other approaches in question 10, it is now evident that they are unable to provide more information on these approaches.

Question 12

Do you require a single-digit index of productivity?

(For example, a percentage for the total productivity level in the enterprise.)

A total of 62 respondents answered this question:

Yes	38%
No	33%
Uncertain	27%
Response not given	2%
Total	100%

Owing to the high percentage of uncertain responses, this question is not conclusive. However, the answers given to question 14 will provide more information.

Question 13

Do you need partial measures of productivity?

This question is used to determine whether a single value of productivity is required or a number of subdivisions. These subdivisions are termed "partial measures" and they can be added together to obtain a total measure of productivity.

A total of 61 respondents answered this question:

Yes	30%
No	33%
Uncertain	28%
Response not given	9%
Total	100%

It is noted that the answers to this question show the same degree of uncertainty as the answers to the previous question.

Question 14

How should the productivity index be communicated to you?

A total of 64 respondents answered this question:

Graphically	63%
In a table	33%
Other	4%
Total	100%

All the respondents answered this question and preference is given to the use of a graphical presentation.

Question 15

If "other", please specify.

No responses were given to this question.

A small number of responses to question 14 requested that another format of communication should be provided. Yet it is noted in this question that a zero response is given. Those respondents who suggested a different method of communication in question 14 were now unable to provide a suitable recommendation.

Question 16

What must be the source document of the approach?

The enterprise's profit and loss statement and balance sheet

A total of 53 respondents answered this question:

Yes	58%
No	14%
Uncertain	11%
Response not given	17%
Total	100%

Job floor measurement, that is time and method study

A total of 53 respondents answered this question:

Yes	59%
No	8%
Uncertain	16%
Response not given	17%
Total	100%

Other

A total of 21 respondents answered this question:

Yes	5%
No	14%
Uncertain	14%
Response not given	67%
Total	100%

This question is subdivided into three sections. Fifty three 53 responses are logged against the first two subsections and 21 against the last section. From these results it is observed that respondents prefer to acquire information from two sources:

- (1) the enterprise's profit and loss statement and balance sheet
- (2) from the job floor by means of time and method studies

Neither source has sufficient support to enable the selection of one in preference to the other. However, one should remember that in the literature discussed in chapter 2, there was a definite preference for the use of company financial statements.

Question 17

If "other", please specify.

Only two respondents answered this question, both indicating a preference for physical activities over production records.

On account of the low response rate, it is not possible to identify other input sources.

3.9.3 Use of output information

Question 18

Do you ...

- *pay bonuses based on productivity?*

A total of 60 respondents answered this question:

Yes	27%
No	66%
Uncertain	2%
Response not given	5%
Total	100%

- *determine wage increases based on productivity?*

A total of 61 respondents answered this question:

Yes	16%
No	78%
Uncertain	2%
Response not given	4%
Total	100%

- *do long-term planning with this information?*

A total of 61 respondents answered this question:

Yes	22%
No	59%
Uncertain	14%
Response not given	5%
Total	100%

- *compare your level of productivity with other companies in your industry?*

A total of 59 respondents answered this question:

Yes	19%
No	70%
Uncertain	3%
Response not given	8%
Total	100%

In this question it was found that bonuses and wage increases are not determined according to productivity. In addition, this information made a limited contribution to long-term planning. Finally, small manufacturing enterprises tend to neglect a vital aspect in the comparison of enterprises.

If one compares the answers in this question to the answer given in question 2, a significant variance is evident. The need to measure productivity was indicated by the majority of responses to question 2. However, if one now considers the response to question 18, it is clear that the respondents would not know what to do with the information if they had it.

3.9.4 Respondents' perceptions

Questions 19 to 24 are used to assess the respondents' perception of implementing productivity measurement, as well as their requirements for a productivity measurement approach.

Question 19

What problems have you or will you experience when implementing a productivity measurement approach in your organisation?

A total of 90 responses were given to this question because it was possible to provide more than one response.

This question is subdivided into four responses. One or more responses may be given and the percentage outcome is therefore determined with reference to the 64 total returns and not the number of responses.

Union resistance	20%
Staff resistance	33%
Unsuitable methods	28%
Inadequate knowledge of the subject	59%

The largest response clearly indicates that inadequate knowledge of the subject is the major deterrent in the implementation of a productivity measurement approach in the small manufacturing enterprise.

Question 20

If "other", please specify.

Only two respondents answered this question.

The answers referred to human problems during implementation and the lack of competency.

Question 21

Do you see any benefits in using a productivity measurement approach in your enterprise?

A total of 61 respondents answered this question:

Yes	63%
No	17%
Uncertain	16%
Response not given	4%
Total	100%

The number of positive responses are a clear indication in favour of the use of a productivity measurement approach in the small manufacturing enterprise.

Question 22.

If "yes", please specify.

A total of 27 respondents answered this question:

This was an open-ended question and a few additional benefits were suggested, namely:

Profit improvement	31%
An improved ability to plan capacity	5%
Increased accuracy in costing and pricing	3%
Strategic planning will benefit	2%
The ability to target problem areas improves	2%
Response not given	57%
Total	100%

Only 27 responses are given to this question. The majority (20 or 31% of the total sample) are of the opinion that profit will increase in the enterprise if a productivity measurement approach is implemented.

Question 23

Is there a need for a productivity measurement approach/model specifically developed for small manufacturing enterprises in the steel and engineering industry of South Africa?

A total of 60 respondents answered this question:

Yes	59%
No	8%
Uncertain	27%
Response not given	6%
Total	100%

This is a key question in this study. The problem detailed in chapter 1 states that a need exists for the development of a productivity measurement approach in small manufacturing enterprises. The number of positive responses clearly confirms that such a need does exist.

Question 24

Must this approach/model be computerised?

A total of 61 respondents answered this question:

Yes	47%
No	14%
Uncertain	34%
Response not given	5%
Total	100%

Owing to the large number of uncertain responses, consideration should be given to the development of a manual system together with a computerised approach.

This completes the discussion of the survey findings.

3.10 CHAPTER SUMMARY

On completion of the discussion of the theory in chapter 2, an assessment of the industry's needs was required. The population was defined by locating a federation with a large complement of members falling into the category required by the research. A questionnaire was developed to perform the empirical search. This questionnaire was pretested and corrected prior to its application. The empirical search was performed by sending the questionnaire to 1 072 enterprises, all of which are members of SEIFSA. A total of 64 responded to the questionnaire. Because of the homogenous nature of the sample, the findings should be regarded as valid despite a small response rate. The questions, together with their respective percentage responses, are recorded in the chapter. Some of the major responses include the following:

- (1) There is a definite need for a productivity measurement approach developed for small manufacturing enterprises in the steel and engineering industry of South Africa.
- (2) There is a severe lack of knowledge on the topic of productivity measurement.

- (3) The source information should be taken from shopfloor measurements and the companies' financial statements.

In chapter 2, the author emphasised in several of the productivity measurement approaches that an enterprise's financial statements and financial data are essential to these approaches. This information is used as input information in the measurement of productivity. It is therefore imperative that full accounting principles should be applied in the small manufacturing enterprise to ensure that productivity is determined accurately and correctly.

- (4) Approaches applying profitability and price recovery are not used in industry.

In chapter 2, this was shown to be an important requirement of a productivity measurement approach together with financial statements.

- (5) The respondents were not sure what to do with the information obtained from productivity measurement.

These findings will be interpreted in chapter 4.

CHAPTER 4

RECOMMENDATION AND CONCLUSION

4.0 INTRODUCTION AND PROBLEM SUMMARY

This chapter briefly summarises and comments on the literature review. Similarly, the requirements of local industry are discussed. This leads to the development of a list of criteria to which productivity measurement approaches should conform. The approaches described in the literature are then compared to these criteria, and the approaches best suited to the small manufacturing enterprise in the steel and engineering industry of South Africa are identified.

In order to clarify the focus of this chapter, it is necessary to review the objectives of the research study.

The first objective of the research is to describe the productivity measurement approaches located in the literature. Each approach has its own method of evaluating and measuring productivity. It is the objective of the researcher to detail these methods systematically, and this will provide the basis for comparison and discussion. This aspect has been fully dealt with in chapter 2.

Secondly, the list of criteria that industry and the stakeholders in South Africa require from a productivity approach need to be established and detailed in a well-structured format. This list of criteria will provide the basic information, and each of the approaches will be compared with these criteria to evaluate their suitability. The empirical research performed and reported on in chapter 3 covers the basic requirements of this objective leading up to the list of criteria. This chapter deals with the development of the list of criteria.

The third and final objective is to determine which approaches are suitable for use in small manufacturing enterprises in South Africa.

The achievement of the last two objectives concludes the research and provides the answer to the research question.

Research question:

Which productivity approach(es) is (are) generally most suitable for small manufacturing enterprises in the steel and engineering industry of South Africa?

4.1 THE LITERATURE REVIEWED

The literature search identified twelve productivity measurement approaches which were discussed in chapter 2. Each approach requires specific input information to enable it to function and provide an outcome. The essential elements of each approach are reviewed below. An imperative part of the review is to compare each approach with the key determinants in chapter 2. In chapter 2, the author emphasised in several of the productivity measurement approaches that an enterprise's financial statements and financial data are essential to these approaches. This information is used as input information in the measurement of productivity. It is therefore mandatory that full accounting principles should be applied in the small manufacturing enterprise to enable an accurate and correct determination of productivity.

In addition, a great deal of emphasis has been placed on price recovery and value added. These factors combined with the need to improve profitability, are essential requirements of any productivity measurement approach.

The approaches discussed are the following:

- ◊ Productivity measurement and evaluation system (ProMES)
- ◊ Deterministic productivity accounting (DPA)
- ◊ The National Productivity Institute (NPI)
- ◊ Theory of constraints (ToC)

- ◊ The total productivity model (TPM)
- ◊ Alan Lawlor's Approach (Lawlor)
- ◊ Applied productivity - Gold's approach (Gold)
- ◊ Operation function analysis (OFA)
- ◊ International Labour Organisation - (ILO)
- ◊ Quick productivity appraisal (QPA)
- ◊ Kurosawa and Goshi - Japan Productivity Center (Kurosawa)
- ◊ Multifactor productivity measurement model (MFPMM)

4.1.1 Productivity measurement and evaluation system (ProMES)

The measurement of productivity by means of the ProMES system is based on motivational issues. The process of separating the effects of factors that personnel can control from those they cannot control distinguishes ProMES from other productivity approaches.

The ProMES productivity measurement approach is used to provide feedback to increase productivity through the behaviour of organisational personnel. Increases in productivity occur through changes in motivation, where the latter is broadly defined to include amplitude, persistence and direction of behaviour.

ProMES makes use of four steps as follows:

- (1) identifying the enterprise's products
- (2) developing indicators to measure these products
- (3) establishing contingencies
- (4) creating a formal feedback report

The application of these steps is easily followed and implemented in the enterprise. But if this approach is to work effectively and if the enterprise is to derive the most from it, it is essential that products (objectives) of the approach should include critical control elements. These critical control elements should include the list of criteria identified both in the literature and the empirical research.

Because ProMES does not dictate the use of specific ratios or formulae it does not satisfy the application of price theory, value added and profitability. In addition, an enterprise's financial statements are not considered to be an essential requirement in ProMES.

The flexibility and involvement of personnel in the application of the model are positive features. This improves the likelihood that productivity measurement will succeed in the enterprise because employees will want it to work.

4.1.2 Deterministic productivity accounting (DPA)

DPA utilises the price and quantity concept with reference to products and resources. It considers productivity as a derivative of the economic principle which equates maximum output with minimum input - that is, maximum financial income to minimum financial expenditure. This leads to the maximisation of both productivity as well as price recovery, and when combined, produces maximisation of profitability.

The process is divided into five steps, namely:

- (1) productivity measurement
- (2) productivity diagnosis
- (3) productivity planning
- (4) productivity disclosure
- (5) productivity accountability

The purpose of all productivity measurement is control, although good productivity measurement has more demanding characteristics. Full accounting principles must be applied, a fact that the DPA approach takes cognisance of.

This model is extremely complex and difficult to follow. For it to succeed in the small manufacturing enterprise, a special individual needs to be trained and placed in control of its functioning. The interpretation of the results will not be totally understood by all

concerned, and much of the emphasis will be lost. The model does, however, comply with most of the criteria defined by the research.

4.1.3 The National Productivity Institute (NPI)

In line with its mission the NPI's function is to promote productivity. They do this by assisting organisations through consulting activities, by offering productivity training, and promoting productivity at a national level. They also host an annual productivity competition to determine the most productive enterprises in the South African economy.

Since their services are predominantly of a consulting nature their methods are not freely available. This resulted in the need to search for older publications. After assessing the sources obtained during the literature search a similarity was noted between the methodology applied in the NPI's approach.

When an evaluation is done in an enterprise, the NPI first considers the macroenvironment and its influence on the enterprise. This coincides with its long-term view that only an enterprise serving the needs of its society effectively and efficiently will survive.

The methodology of evaluating an enterprise is consistent and can be divided into the following five segments:

- ◊ general management
- ◊ financial management
- ◊ marketing
- ◊ personnel and labour
- ◊ production

Only the sections dealing specifically with an objective method of determining productivity have been included in the discussion, and include financial and production management as the key segments requiring consideration.

The process is divided into six steps which, in certain instances, require additional subdivisions as follows:

- (1) Financial productivity measurement
 - ◊ Labour productivity
 - ◊ Capital productivity
- (2) Total productivity
- (3) Income, expenses and profit structure
- (4) Asset utilisation
 - ◊ Operating asset utilisation
 - ◊ Other indicators of asset utilisation
- (5) Asset and liability structure
- (6) Production
 - ◊ Material productivity
 - ◊ Labour productivity
 - ◊ Equipment and machine productivity

The objective is to measure the total productivity performance of the enterprise. A relationship must be found between the output value generated by the enterprise and the input value. This may take the form of the net output or value added to the input value. Value added is applied in two specific areas, namely, labour and capital productivity.

Under the heading of labour productivity, value added is related to total salaries when determining the efficiency of the labour resource. Capital productivity aspects include a number of ratios that apply value added. These include total productivity, profitability ratios, income and expense.

The utilisation of assets is also evaluated. This covers both aspects of operating and other assets.

The NPI's approach makes use of value added, yet neglects aspects of price recovery.

4.1.4 Theory of constraints (ToC)

The theory of constraints approach has a key objective called "*the goal*". This approach to productivity improvement is based on a philosophy of achieving the goal in the enterprise. In a manufacturing enterprise the goal is clearly to make money.

Four steps have been identified as the procedure leading to the theory of constraints:

- (1) define the enterprise's goal
- (2) operational measurement
- (3) balancing the plant
- (4) categorising the resources

In each instance there are subdivisions. In terms of defining the enterprise's goal the following subdivisions may apply:

- ◊ improvement of net profit
- ◊ return on investment
- ◊ cash flow control

Moving to operational measurements the subdivisions may include the following:

- ◊ increased throughput
- ◊ just-in-time inventory control
- ◊ control of operational expenses

The aspects relating to the balancing of the plant can be subdivided into two factors:

- ◊ dependent events
- ◊ statistical fluctuations

In the categorisation of resources, it is necessary to distinguish between two subdivisions of resources, namely:

- ◊ Bottlenecks
- ◊ nonbottlenecks

The rules relating to bottlenecks and the processing of work through them were dealt with in chapter 2.

The ToC approach leaves many decisions to management and does not dictate any requirements for ratio analysis. It does not adopt the value added and price recovery concepts.

4.1.5 The total productivity model (TPM)

The TPM model is a holistic approach to measuring productivity in the enterprise. It addresses all the factors of capital, labour and energy in a total productivity model. The worker's role and his/her importance in the enterprise is also considered in this approach.

Two favourable management strategies are identified as being the result of improving total productivity, namely:

- (1) the ability to reduce the selling price of a product without sacrificing the present profit margin
- (2) the profit margin of the enterprise increases without an increase in the selling price

Four stages have been defined in the model called the MEPI phase where:

- | | |
|---|------------------------|
| M | represents measurement |
| E | evaluation |
| P | planning |
| I | improvement |

The MEPI phase is achieved when the three steps of the total productivity model are implemented in the enterprise. These three steps are as follows:

- (1) applying the (basic) total productivity model
- (2) defining tangible outputs
- (3) defining tangible inputs

The total tangible outputs are defined in such a way that purchases are excluded - hence the output value can be compared to that of the value-added definition. Similarly, the equations applied can also be likened to the equation described in price theory. TPM is a complex approach, and like DPA, requires an individual with specific skills to implement it. It is difficult to apply in a job shop environment, and a number of partial measures of productivity will result. This approach does not totally coincide with the criteria defined.

4.1.6 Alan Lawlor's approach (Lawlor)

Lawlor considers three questions in his approach:

- (1) Where are you now?
- (2) How much better could you be?
- (3) Where should you be?

Lawlor calls the first two questions, 2nd-wave organisations. This relates to current efficiency and medium-term capability. The third question relates to long-term potential which is the real objective in any enterprise - that is, not only achieving current productivity improvements but also long-term improvements.

Lawlor (1985:36) states that productivity is a comprehensive measure of how efficiently and effectively enterprises satisfy the following five aims:

Objectives: the degree to which principal objectives are achieved;

Efficiency: how efficiently resources (inputs of labour materials, purchased services and capital) are used to generate useful outputs, useful in the sense that goods made or services provided are actually needed;

Effectiveness: what is achieved in output and input terms compared to what is potentially possible;

Comparability: how productivity compares with other organisations, industries and countries;

Trends: the productivity performance record over time, that is, the decline, static or growth aspects.

Five steps are applied in Lawlor's model to achieve productivity in terms of the requirements defined, namely:

- (1) achievement of objectives
- (2) measurement of efficiency
- (3) effectiveness potential
- (4) comparability of performance
- (5) trends

These aspects cover all the requirements of value added, price recovery and profitability ratios. Lawlor's approach appears to be well suited for use in small manufacturing enterprises. It is also possible to compare the results of different enterprises when using this approach. In this approach, several job floor measures that relate to throughput materials and wages paid are considered.

4.1.7 Applied productivity - Gold's approach (Gold)

Gold's approach focuses on the rate of return on investment and attributes profit to five specific elements of performance namely:

- ◊ product prices
- ◊ unit costs
- ◊ use of facilities

- ◊ productivity of facilities
- ◊ allocation of resources between fixed and working capital

It is possible to implement this approach in a manufacturing enterprise because the primary responsibilities centre around the adjustment of the level and composition of the physical inputs and outputs. The use of financial inflows are converted into larger financial returns and constitute the five steps of Gold's approach:

- (1) profit compared with investment
- (2) profit compared with output
- (3) output compared with investment
- (4) total performance
- (5) comparison to equity

The equations applied do not apply value-added or price recovery concepts in their methodology.

4.1.8 Operation function analysis (OFA)

The OFA approach does not fall into the category of a manufacturing productivity measurement approach. It is strictly designed for office environments and addresses the tasks performed by "*knowledge workers*". This term relates to the kind of operators it is designed to measure. There is a need to include this approach in the research since all manufacturing enterprises have office-related tasks. A hybrid developed from combining this approach with one of the other discussed approaches may produce an interesting new approach.

This method obviously does not lend itself to value-added or price recovery concepts. Similarly, shopfloor measurement and the communication of findings using a graph are not possible.

4.1.9 International Labour Organisation (ILO)

The ILO has extensively researched the topic of productivity measurement in small manufacturing enterprises and has published many manuscripts in this field. It agrees with Lawlor that productivity may be regarded as a comprehensive measure of how enterprises satisfy the following criteria:

- ◊ objectives
- ◊ efficiency
- ◊ effectiveness
- ◊ comparability

The ILO states that productivity measurement and analysis are indispensable to productivity improvement. In addition, a clear understanding by all parties concerned of why productivity measurement is important for the effectiveness of the enterprise is also essential. The parties concerned include management, workers, trade unions and government institutions.

A total of five steps are used in the ILO's approach:

- (1) measurement of objectives
- (2) measurement of efficiency
- (3) measurement of effectiveness
- (4) measurement of comparability
- (5) measurement of trends

Value-added concepts are definitely a subject of the ILO's approach, although the latter does not include price recovery considerations. It lends itself to application in shopfloor situations.

4.1.10 Quick productivity appraisal (QPA)

Quick productivity appraisal has been specifically developed with the small manufacturing enterprise in mind. It follows the concept that for the realisation of maximum productivity improvement in the enterprise, the integration of all productivity improvement programmes must be grouped into one effective programme. This programme should be directed towards promoting the total involvement of everyone in the organisation. Such a programme comes together in a corporate-wide productivity improvement programme.

To achieve this corporate-wide programme it is clear that pure measurement is not the only requirement for optimum productivity. However, only the relevant productivity measurements are covered in this discussion, and these are categorised as the company performance appraisal method.

Six steps cover this section of the programme, namely determine:

- (1) the return on assets
- (2) the trend of return on assets
- (3) if the trend is decreasing or constant
- (4) if the trend is increasing
- (5) if the growth rate of return on assets is decreasing or constant
- (6) if the growth rate of return on assets is increasing

All these steps are covered in a schedule of profitability and productivity ratios. A very definite use of value-added and price theory concepts is applied in this approach. This is a holistic approach and considers every area of the enterprise. Shopfloor measurements contribute fully to the approach. Ratios are determined with the use of direct labour content, man-hours worked and wages paid. This approach fully satisfies the criteria that industry requires.

4.1.11 Kurosawa and Goshi - Japan Productivity Center (Kurosawa)

The approach presented by Goshi is not a measurement method of productivity but an attitudinal approach. It originated through negotiations with union members and the decision to empower them. Application of this mindset to small manufacturing enterprises, will improve the level of cross-communication and make a positive contribution to productivity.

Kurosawa, in turn, specialises in the measurement aspect of productivity. His model takes into account value-added aspects yet excludes price theory concepts. It considers only the cost of labour and not the shopfloor environment.

4.1.12 Multifactor productivity measurement model (MFPMM)

The MFPMM approach originated from research performed by Hiram Davis. The American Productivity Center promoted the approach and called it the "total factor productivity model". It has also been referred to as "price-weighted", "indexed" and "aggregated multifactor productivity measurement model".

The MFPMM approach is a consultative, data base/accounting system. It is not people driven since it utilises only ratios and indexes to measure productivity. Since its initial publication, it has been changed in several ways.

Capital has been left out of the approach since this is one of the resources that is best managed in an enterprise.

The model can be and is being utilised to do the following (Sink 1985:142):

- obtain an overall, integrated measure of productivity for the firm;
- to provide an analytical audit of past performance;
- for budget control of current performance;
- for common-price financial statements;

to assess and evaluate bottom-line impact on specific profitability as a result of productivity shifts;
 to track the results of specific productivity improvement efforts, such as quality circles, quality control, incentive systems and technological innovation;
 to measure initial distribution of benefits flowing from gains and/or losses in the productivity of the firms;
 and to assist with setting productivity objectives and general strategic planning with regard to capacity utilisation, marketing efforts, cost management, staffing, quality management and pricing strategies.

Three additional uses of MFPMM have been stated (Sink 1985:146):

To monitor historical productivity performance and measure how much, in dollars, profits were affected by productivity growth or decline.

Evaluate company profit plans to assess and determine their acceptability and reasonableness or productivity changes to those plans.

Measure the extent to which the firm's productivity performance is strengthening or weakening its overall competitive position relative to its peer group(s).

Because the net profit figure on its own is an inadequate basis for judging whether manufacturing is being performed at its most productive level, MFPMM applies basic accounting data to calculate revenues and costs. It is possible through MFPMM to gain additional and more significantly detailed insight into what is driving profits.

The relationship between productivity and price recovery is prominent in the application of this approach. Value added is also a requirement of the approach. This is a very complete approach albeit a totally quantitative technique.

This concludes a brief review of the productivity measurement approaches researched during this study.

4.2 LOCAL INDUSTRY REQUIREMENTS

4.2.1 General

The empirical section of the research required a survey to be conducted to determine the requirements of local industry. This was successfully performed by the application of a questionnaire directed at 1 072 participants in the steel and engineering sector of industry. A 6 percent response rate was received, and although this can be regarded as small, it is undoubtedly a valid response since a homogenous sample was approached. The majority of the respondents were manufacturers in the steel and engineering industry and also conform with the requirements of the definition of a small enterprise as detailed in appendix A.

4.2.2 Need for productivity measurement

It is significant that 59 percent of the respondents provided an affirmative response, namely that productivity measurement is necessary in their enterprise (12,5% were uncertain). This information was obtained by means of question 2. In question 21, a similar question was posed, and 63 percent considered it not only as necessary but also beneficial that productivity measurement be applied in their enterprise (16% were uncertain). However when asked what they would do with the information, many respondents were uncertain. This strongly indicates that there is a lack of knowledge about productivity measurement in this industry. This statement was reinforced by the responses received to question 19, where there was a 59 percent response to the question concerning inadequate knowledge of the subject.

A 59 percent "yes" (27% uncertain), response confirms that a productivity measurement approach specifically designed for small manufacturing enterprises in the steel and engineering industry of South Africa is required.

The author also established that 74 percent (20 out of 27 responses) of those who responded to question 22, anticipated that profitability in their respective enterprises would improve if a productivity measurement approach were implemented.

From responses to the questionnaire it was possible to establish a list of productivity measurement criteria that can be compared to the literature for the selection of the suitable approaches.

4.2.3 Productivity measurement criteria defined

The following criteria have been identified from the responses to the research questionnaire as well as the key requirements repeatedly stated in the literature:

- (1) In chapter 2 it was emphasised in several of the productivity measurement approaches that an enterprise's financial statements and financial data are essential to these approaches. This information is used as input information in the measurement of productivity. It is therefore mandatory that full accounting principles should be applied in the small manufacturing enterprise to make possible an accurate and correct determination of productivity.
- (2) In addition, a great deal of emphasis has been placed on price recovery and value added. These factors combined with the need to improve profitability are essential requirements of any productivity measurement approach.

The above two requirements are key criteria defined by the literature. By incorporating them into the list of requirements obtained during the empirical search, the following list of criteria is formulated (an abbreviation to be used in a tabular summary is given in brackets):

- * The approach must be suitable for use in small manufacturing enterprises in the steel and engineering industry (SM Ent).

- * The financial accounts of the enterprise are an essential requirement for the provision of information as input to a productivity measurement approach (Accounts).
- * The need to use shopfloor information as a source of input data was also given as a requirement by the respondents to the questionnaire (Shop).
- * The productivity measurement approach should make use of the concept of profitability and price recovery (Recovery).
- * The application of value added should be incorporated into a productivity measurement approach (Value).
- * The approach should provide adequate information to management to enable them to take corrective steps (Info).
- * The approach should improve the users' knowledge of the subject and importance of productivity measurement (Know).
- * The output information should be presented in a graphic and/or tabular format (Graphic).
- * A computer-generated system is preferable, but it should be easy to adapt for manual application (Comp).
- * The measurement approach should help to improve profitability (Profit).
- * The approach should not be so difficult for the user to follow, thus preventing him or her from applying it. It should be easy to understand (Easy).

4.3 CONCLUSION AND RECOMMENDATIONS

When the 12 approaches described in the literature are evaluated against the criteria formulated in the preceding section the matrix in table 4.1 results. An "X" indicates that an approach meets a specific criterium. The highlighted columns correspond to the three essential requirements defined in chapter 2 and discussed in chapter 3 as well as section 4.1 in this chapter.

If only these three requirements were considered, then six (50%) of the 12 approaches are suitable for use. However, it is best to select those approaches that meet all the criteria in the schedule. This reduces the selection to three (25%) of the discussed approaches as being the most suitable for use in a small manufacturing enterprise. The three approaches are:

- (1) Alan Lawlor's approach
- (2) The International Labour Organisation
- (3) Quick productivity appraisal (QPA)

Table 4.1: Comparison matrix

	S M E N T	A C O P U N T S	S H C O P O V E R Y	R E C L O U E	V A N N O W P P H I C	I N F O R M A T I O N	K N O W L E D G E	G R O U P P R E S E N T A T I O N	C O M P A R I S O N	P R O P O S I T I O N	E V A L U A T I O N	T O T A L
ProMES	X		X			X	X	X		X	X	7
DPA		X		X	X	X		X	X	X		7
NPI		X	X		X	X	X		X	X		7
ToC	X	X	X			X				X	X	6
TPM		X		X	X	X	X		X	X		7
Lawlor	X	X	X	X	X	X	X	X	X	X	X	11
Gold		X				X	X	X	X	X		6
OFA	X					X	X			X		4
ILO	X	X	X	X	X	X	X	X	X	X	X	11
QPA	X	X	X	X	X	X	X	X	X	X	X	11
Kurosawa		X			X	X	X		X	X		6
MFPMM		X		X	X	X	X	X	X	X		8

These three methods compare favourably with the literature as well as the criteria specified by industry. Their selection answers the research question, namely:

Which productivity approach(es) is (are) generally most suitable for small manufacturing enterprises in the steel and engineering industry of South Africa?

The comparisons in table 4.1 provide essential guidance in the selection of the appropriate productivity measurements approaches. The fact that certain approaches do not meet all the requirements does not suggest that these approaches are inferior, but merely that they are unsuitable for this application.

4.4 SUGGESTED HYBRID

It is possible that a hybrid could be developed from one or more of the approaches in order to achieve an optimum approach. Likely combinations could be a hybrid of the ProMES approach, theory of constraints and the International Labour Organisation. The reason for this selection is because the ProMES approach is people driven, and lacks certain essential formulae. These criteria will be met by the ILO approach. The combination of the ToC approach will increase the application of shopfloor information in the final approach. Since the ILO approach satisfies the requirements detailed in table 4.1, the inclusion of ProMES and ToC will turn this approach into an extremely powerful model. However, this hybrid will have to be developed and tested before it can be declared to be an optimum approach. It possess the potential to become a leading approach.

Another typical hybrid could be the ProMES approach and the multifactor productivity measurement model. These two, combined into a single system would mean that the rigidity of the MFPMM approach could be altered to include human influences on the productive process. The MFPMM approach is a consultative, data base/accounting system - it is not people driven since it utilises only ratios and indexes to measure productivity. A study of table 4.1 will show that if these two approaches are combined all the requirements are satisfied.

Similarly, the approach presented by Goshi is well matched well with a strict measurement approach like MFPMM to produce a holistic productivity measurement approach. Goshi's joint consultation method will provide the humanistic features to the approach. Table 4.1 does not comment on Goshi's approach - it only addresses Kurosawa's measurement approach. However, the joint consultation method applied by Goshi will satisfy the requirements of the table if it is combined with the MFPMM approach.

4.5 FUTURE RESEARCH

The research has been exploratory and has covered productivity measurement approaches suitable for small manufacturing enterprise in the steel and engineering industry of South Africa. The literature search presented different approaches dealing with this topic. The researcher realised that an empirical survey was necessary to provide insight into the requirements of industries in this area.

The researcher proposes that a larger more detailed research project be undertaken. It should include other types of manufacturers in other industries. The fact that only manufacturers in the steel and engineering industry were approached leaves many more avenues requiring investigation. Manufacturing industries such as chemicals, plastic, food, wood, agriculture and minerals, to name but a few, will benefit from a study of this nature.

It is possible to develop a new productivity measurement approach by means of one of the suggested hybrids. This new approach could be developed, tested and applied in industry, resulting in the creation of new data. These data could lead to an overall improvement in all enterprises - hence generating national wealth and economic growth.

APPENDIX A

A.1 LIST OF DEFINITIONS

A.1.1 PRODUCTIVITY

Since various productivity definitions require discussion, chapter 2 is dedicated to the discussion of productivity models and measurements together with the appropriate productivity definitions. Hence a definition of productivity is not given in this appendix.

A.1.2 SMALL MANUFACTURING ENTERPRISE

The Ministry of Trade and Industry (MT&I) provides a definition for each of the four categories they have proposed. Their description of a small enterprise is stated as consisting of the bulk of established enterprises with employment between five and 100. These small enterprises are owner-managed or are directly controlled by the owner-community. They function from business or industrial premises, are tax registered and meet all formal registration requirements. Their classification in terms of assets and turnover is not specified in this paper (JCCI 1994:4).

However, a more detailed definition has been provided in the draft bill published in the Government Gazette, volume 366, no 16876 (SEIFSA 1996). Enterprises have been grouped into two categories, namely A and B. Group B includes manufacturing enterprises and states the following characteristics of a small manufacturing enterprise:

Table A.1: Ministry of Trade and Industry definition

Total annual turnover	R 5 million
Total asset value (fixed property excluded)	R 1 million
Total number of full-time employees	5 - 50

Source: Adapted from (SEIFSA 1996)

The Standard Bank of South Africa, Small Business Development and Advisory Department, (SBDAD) defines a small business as follows (SBDAD 1994:1):

An individual, partnership, close corporation, company or a co-operative with total assets worth not more than R 1,5 million, a turnover of up to R 5 million a year, employing up to 100 people, with borrowing requirements up to R 500000 and which is engaged in, or has intentions of engaging in:
a commercial or manufacturing enterprise; or
the provision of a service.

The Small Business Development Corporation (SBDC) classifies small enterprises as enterprises that employ fewer than 50 people and have a turnover of up to R 5 million a year, and total assets up to R 2 million. They are also managed by the owner (Universiteit van Pretoria 1991:2; Basson 1992:4).

Basson, the former chief economist of the Small Business Development Corporation (SBDC) made the following comment (*Engineering News* 1994):

A SME has one or more of the following characteristics: Fewer than 200 employees; total assets of R 5 - million in today's prices; and direct involvement of the owner in the management of the business.

The SBDC refers in their journal, "Courier", to the number of employees active in microenterprises, and small, and medium enterprises. Microenterprises employ fewer than five people, small enterprises fewer than 50 and medium enterprises between 50 and 200 (SBDC 1994:9).

During 1992 the Bureau of Market Research (BMR) at the University of South Africa conducted a study on the definition of the small enterprise, and set the following criteria (Unisa 1992b:49-50):

An enterprise is considered a small enterprise provided it conforms to one compulsory qualitative criteria and two compulsory quantitative criteria:

One compulsory qualitative criteria.

- ◊ The enterprise is privately and independently owned, managed and controlled and may consist of more than one branch.

Two of the following three compulsory quantitative criteria.

- ◊ The enterprise has a total annual turnover of less than R 2,5 million (1992 prices).
- ◊ The enterprise has total assets of less than R 2 million (buildings and land excluded).
- ◊ The enterprise employs fewer than 50 people.

These four definitions have been grouped together in table A.1 for comparison purposes:

Table A.2: Characteristics of small enterprises

Source	No. employees	Annual turnover	Asset base	Management
MT&I	5 ≤ 50	≤ R 5 million	≤ R 1 million excluding land & buildings	Owner/directly controlled by owner
SBDAD	≤ 100	≤ R 5 million	≤ R 1,5 million total assets	Owner
SBDC	< 50	< R 5 million	< R 2 million excluding land & buildings	Association owner and management
BMR	< 50	< R 2,5 million	< R 2 million excluding land and buildings	Private independent

Source: Adapted from the Ministry of Trade and Industry (JCCI 1994:4 and SEIFSA 1996), the Standard Bank of South Africa, Small Business Development and Advisory Department (1994:1), the Bureau of Market Research at the University of South Africa (Unisa 1992b:49-50), the Small Business Development Corporation (Universiteit van Pretoria 1991:2; Basson 1992:4).

For the purpose of this research, the final definition when selecting a small manufacturing enterprise will take the following format as given in table A.2:

Table A.3: Characteristics of a small manufacturing enterprise

No employees	Annual turnover	Asset base	Management
<= 50	<= R 5 million	<= R 2 million excluding land & buildings	Association: owner and management

Source: Adapted from table A.2

The selection of up to 50 employees coincides with the research, but it should be noted that many small manufacturing enterprises are highly labour intensive whilst keeping within the limit of the asset base specified. The higher asset value of R 2 million has been selected to make a wider selection for the research population possible. The application of a small manufacturing enterprise productivity model in enterprises with more than 50 employees and even more assets than R 2 million is not uncommon. The outcome in these enterprises will not differ from that in small manufacturing enterprises.

A.1.3 MANUFACTURING DEFINED

Manufacturing includes any activity which adds value to raw material of any form (solid, liquid or gas) through a conversion (productive) process performed by either a hand or machine operation. This conversion of raw material provides products sold or used for further conversion into other products (Siropolis 1990:66).

The Concise Oxford Dictionary (1964:742) defines manufacturing as:

Making of articles by physical labour or machinery.

Harold Martin (Lawlor 1985:80) provides the following definition of manufacturing :

Manufacturing: productive work is work which changes the shape, physical characteristics or appearance of materials, or which joins (assembles) one material to another, or separates one material from another during the process of converting production materials into (saleable or usable) products.

APPENDIX B

<p align="center">SMALL MANUFACTURING ENTERPRISE PRODUCTIVITY MEASUREMENT SURVEY</p>

TO: Head: Economics Division
SEIFSA
PO Box 1338
Johannesburg 2000

For ease of reply you may wish to send your questionnaire to us by telefax: SEIFSA's
Telefax No is (011) 838-1522.

Kindly place a tick in the box corresponding to the response.

Identify respondent.

1. Type of enterprise:

Total employed	Do you employ 50 or less people in total?	<input type="checkbox"/>	01
(including staff)	Do you employ 51 or more people in total?	<input type="checkbox"/>	02

Total asset value	Is the total asset value of your enterprise equal to R 2 million or less?	<input type="checkbox"/>	03
	Is the total asset value of your enterprise more than R 2 million?	<input type="checkbox"/>	04

Total turnover	Is the total annual sales turnover of your enterprise equal to R 5 million or less?	<input type="checkbox"/>	05
	Is the total annual sales turnover of your enterprise more than R 5 million?	<input type="checkbox"/>	06

Are you a manufacturer in the steel and engineering sector? (Manufacturing includes repair related work in which value is added to an item.)	<input type="checkbox"/> Yes / No <input type="checkbox"/>	07 08
---	--	----------

Is your enterprise owned by its management?	<input type="checkbox"/> Yes/No <input type="checkbox"/> /Uncertain <input type="checkbox"/>	09 10 11
---	--	----------------

If not, is it part of a large corporation?	<input type="checkbox"/> Yes/No <input type="checkbox"/> /Uncertain <input type="checkbox"/>	12 13 14
--	--	----------------

2. Is productivity measurement necessary in your organisation?	<input type="checkbox"/> Yes/No <input type="checkbox"/> /Uncertain <input type="checkbox"/>	15 16 17
--	--	----------------

3. Do you use any form of productivity measurement at present?	<input type="checkbox"/> Yes / No <input type="checkbox"/>	18 19
--	--	----------

4. If not go to question 9 if "yes" do you use a specific measurement approach or model?

Yes / No

20 21

5. If yes, which one?

For office use only			
time	22	cost	24
profit	23	people	25

Requirements of a productivity measurement approach.

6. Does your method make use of price recovery and profit?

Yes/No/Uncertain

26 27 28

(where: price recovery = $\frac{\text{change in product price}}{\text{change in resource price}}$ and

$$\text{profit} = \frac{\text{change in product revenue}}{\text{change in resource value}})$$

7. Does your present method satisfy your requirements?

Yes/No/Uncertain

29 30 31

8. If no, why not? Please specify.

For office use only			
inadequate information	32	time consuming	34
cumbersome	33	poor conveyance of data	35

9. Do you know any of the following approaches?

Productivity measurement and evaluation system (ProMES)

Yes/No/Uncertain

36 37 38

Deterministic productivity accounting (DPA)

Yes/No/Uncertain

39 40 41

The National Productivity Institute (NPI)

Yes/No/Uncertain

42 43 44

Theory of constraints (ToC)

Yes/No/Uncertain

45 46 47

The total productivity model (TPM)

Yes/No/Uncertain

48 49 50

Alan Lawlor's approach (Lawlor)

Yes/No/Uncertain

51 52 53

Applied productivity - Gold's approach (Gold)

Yes/No/Uncertain

54 55 56

- Operation function analysis (OFA) Yes/No /Uncertain
57 58 59
- International Labour Organisation - (ILO) Yes/No /Uncertain
60 61 62
- Quick productivity appraisal (QPA) Yes/No /Uncertain
63 64 65
- Kurosawa and Goshi - Japan Productivity Center (Kurosawa) Yes/No /Uncertain
66 67 68
- Multifactor productivity measurement model (MFPMM) Yes/No /Uncertain
69 70 71

10. Do you know of any other approaches not mentioned above? Yes / No
72 73

11. If yes, please name them.

For office use only		
statistical	74	humanistic 75
		computerised 76

12. Do you require a single digit index of productivity? Yes/No /Uncertain
(For example, a percentage for the total productivity level in the enterprise.)
77 78 79

13. Do you need partial measures of productivity? Yes/No /Uncertain
80 81 82

14. How should the productivity index be communicated to you?
- graphically 83
 - in a table 84
 - other 85

15. If other, please specify.

For office use only	
diagram	86
	87

16. What must be the source document of the approach?
- The enterprise's profit & loss statement and balance sheet Yes/No /Uncertain
88 89 90
- Job floor measurement, ie time and method study Yes/No /Uncertain
91 92 93
- Other Yes/No /Uncertain
94 95 96

17. If other, please specify.

For office use only	
physical activities	97
production records	98

Use of output information.

18. Do you ...

- pay bonuses based on productivity? Yes No /Uncertain
99 100 101
- determine wage increases based on productivity? Yes No /Uncertain
102 103 104
- do long-term planning with this information? Yes No /Uncertain
105 106 107
- compare your level of productivity with other companies in your industry? Yes No /Uncertain
108 109 110

Respondents' perceptions.

19. What problems have you or will you experience when implementing a productivity measurement approach in your organisation:

- union resistance, 111
- staff resistance, 112
- unsuitable methods, 113
- inadequate knowledge of the subject. 114

20. If other, please specify.

For office use only	
human related 115	competence 116

21. Do you see any benefits in using a productivity measurement approach in your enterprise?

- Yes No /Uncertain
117 118 119

22. If yes, please specify.

For office use only	
profit 120	121

23. Is there a need for a productivity measurement approach/model specifically developed for small manufacturing enterprises in the steel and engineering industry of South Africa ?

- Yes No /Uncertain
122 123 124

24. Must this approach/model be computerised?

- Yes No /Uncertain
125 126 127

Thank you for your cooperation.

APPENDIX C



SURVEY ON SMALL BUSINESS PRODUCTIVITY MEASUREMENT

Seifsa has agreed to assist Mr. Tony Webber, Vice Chairman of the Light Engineering Industries Association, with research into the productivity of small- and medium-sized enterprises.

The attached survey questionnaire is aimed at companies employing 50 or fewer employees, and has been devised to ascertain if and how small businesses measure productivity within their organisations. We would be very grateful if you could take the time to fill in and return the questionnaire to the Seifsa Economics Division by fax on (011) 838-1522.

There is no need for companies to identify themselves; complete confidentiality will be maintained.

The findings of the survey will be published in a future edition of Small Talk. It is hoped that the survey will assist in developing practical and reliable methods of measuring productivity in small- and medium-sized companies.

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Hotline: (011) 834-9167

A SEIFSA NEWSLETTER FOR SMALL BUSINESS IN THE METAL AND ENGINEERING INDUSTRY

Supply side measures developed for SMMEs

When it was announced that the current General Export Incentive Scheme (GEIS) would be phased out by the end of 1997, government representatives in the former National Economic Forum (NEF) agreed to channel the savings made from GEIS into new "GATT friendly" supply-side measures. Instead of direct subsidies, exporters were to receive indirect assistance aimed at improving the competitiveness of South African manufacturers and assisting small- and medium-sized businesses in particular.

In the August 1995 edition of Small Talk, details were provided of the proposed government assistance to SMMEs including the establishment of a National Small Business Council (NSBC). A draft National Small Business Bill has now been published which will allow for the creation of the NSBC. R250-million has also been earmarked for the creation of an Enterprise Promotion Agency which will be responsible for establishing local business service centres throughout the country.

A similar amount has been raised for the National Credit Guarantee Fund to provide payment guarantees to companies dealing with SMMEs.

Facilities will also be established for smaller businesses to gain access to pre-shipment and post-shipment financing of exports. Details of this facility were developed in conjunction with the World Bank and National Economic, Development and Labour Council (NEDLAC).

Once these programmes have been finalised, Seifsa, together with the South African Foreign Trade Organisation (SAFTO) and the Industrial Development Corporation (IDC), will arrange seminars to inform members of how small businesses may avail themselves of these facilities.

For further information, please contact Michael McDonald or Kit Wostenholm of Seifsa's Economic Division on Tel: (011) 833-6033 or Fax: (011) 838-1522.

Main Agreement gazetted

Amendments to the Main Agreement finalised between employers and trade unions at the end of July 1995, were published in Government Gazette No. 16782, Notice No. R1642 on Friday 27 October. The amendments become effective and legally binding on 6 November 1995.

The wage increases have been backdated to 1 July 1995. Employers who have not yet awarded the negotiated increases or who have

awarded only a portion of them, must award the full increase or the balance thereof within a 16-week period after 6 November.

As was the case in 1994, small businesses employing no more than 10 scheduled employees may apply for an expedited exemption from the wage-related elements of the Agreement through their Regional Industrial Council. For further information, please contact Seifsa's IR Division on (011) 833-6033.

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