Productivity Measurement and its Relationship to Quality in a South African Minting Company.

A Research Report

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MASTERS DEGREE IN BUSINESS LEADERSHIP,

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by

MM MTOTYWA

30 November 2007

To my fiancée, Vuyi and our daughter Gqwesa

ABSTRACT

The aim of this study was to investigate a productivity measurement at the South African Minting Company and evaluate the relationship between productivity and quality.

Special emphasis was given to profit-linked total factor model as the tool for measurement. This was encouraged by their ability to separate productivity, profitability and price recovery. Three models were selected and evaluated. These models American Productivity Center (APC) Model, “Profitability = productivity + price recovery” (PPP) model and multi-factor productivity measurement model (MFPMM). APC model was selected as the suitable model because of its simplicity, easy to set up, its ability to produce both financial and non financial data, and allow for route cause analysis with expert system, and more insight for the manager with Microsoft Excels’ *What if analysis* “Goal seek”.

APC model was set up for four periods, from 1 April 2004 to 30 September 2007. The overall profitability results of the circulation coins profit center show an overall positive contribution. There was a break-even of the price recovery for 2006 financial year (period 2). In 2007 financial year (period 3), there was a negative contribution, and this improved to almost break-even in the six month period during this 2008 financial year (period 4). This means there was much more inflation on input resources and the recovery was not fully realised in the price of goods sold.

Individual input costs show that the negative price recovery is culminating from material, labour and energy costs contributions. There is a plausible explanation for material and labour, but not for energy. The metal volatility is the underlying cause of the price variation. Labour variation was a company strategy to adjust employee to higher percentiles.

Productivity was always positive with the highest contribution in the current financial year (period 4). This means that the profitability at SA Mint has been driven by productivity in the past two financial years.

Survey of the questionnaire shows average scores for productivity and quality. It is noteworthy, that the lowest mean score for productivity is for the statement “Products are produced in error-free process”. This is a productivity quality measure. In addition, the same variable shows r^2 value of 0.42. A conclusion is that even though productivity and quality are highly correlated and show a highly positive relationship, there is a concern on quality in the company. A link can be made that low price recovery becomes more difficult when the quality is not always good. Defective product is a cost, because the product does not reach the customer and if the product is reworked it is still a cost, though low, but more importantly it decreases the available capacity.

This study was successful in setting up APC model and producing data that is worthy to the company and academic world. Finally, this study was successful in its quest to establish the relationship between productivity and quality.

***Keywords**: Productivity, Quality, APC model, Correlation*

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My ancestors.....

OoZulu, ooMchenge, ooNgwenyankomo, ooHlombe, ooShoba, ooZaphalala, ooCutshwa, ooMarhonono, ooVumbalempongo into ZikaPakade into zika Ndoyiya, into ZikamaGoqwana, ngamaTolo kelawo.....

My creator, God.....

Who gave me the opportunity and ability to complete this study

DECLARATION

I declare that Productivity Measurement and its Relationship to Quality in a South African Minting Company is my own work and all the sources that I have used or quoted have been indicated and acknowledged by means of complete references. It is submitted in partial fulfilment of the requirements for the Masters degree in business leadership at the University of South Africa

_____ 30 November 2007

Dr Matolwandile Mzuvukile Mtotywa

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CHAPTER 1

ORIENTATION OF STUDIES

1.1 INTRODUCTION

The South African Mint Company (SA Mint) has two profit-centers, circulations coins and numismatics. The mandate of the company from its shareholder, South African Reserve bank (SARB) is as follows:

- To drive unit costs for South African circulation coins. This should enable the company to sell coins to SARB at cost effective prices.
- To maximise the profit with exports, utilising the remaining capacity of the circulation coins factory, which currently amounts to 20% and;
- To maximise profit from the numismatics division. This profit center constitutes 30% of the total business.

In their quest to continually achieve the mandate the company should find a suitable measurement of productivity.

Halachimi, (2002) argued that:

If you cannot measure it, you do no understand it; and if you cannot understand it, you cannot control it; and if you can't control it, you cannot improve it.

According to 27th survey of the CEOs profit margin and productivity are the most important performance indicators (Steven, 1998).

1.1.1 Background

As a point of departure, it is important to understand that productivity is a component of performance, not a synonym for it. Productivity need to be viewed as one of the performance measures. It represents a critical component of performance equation and mangers are faced with a task of developing measures, evaluation, control and improvement systems for this performance criterion. Productivity can be measured

with intent to distinguish acceptable from unacceptable levels of performance (Sink *et al* 1984).

Profitability does not have a direct impact when it comes to improvement purposes, since it is a result of, rather than a contributor to, the actions and processes in operations. Profitability in organisations can change for reasons that have little to do with productivity; external conditions like price inflation or cost may bear no relationship to the efficient use of resources (Stainer, 1997).

On the other hand, productivity is strongly connected to the creation of value. Traditionally, productivity measurements were used for an end to control in a company. However, emerging views are that productivity measurements can be regarded as means to learning (Mohanty, 1998). In regard of the emerging view, a need for a suitable productivity measurement is required in the South African Minting (SA Mint) as a learning tool and a performance indicator. Furthermore, measurement is part of the diagnosis and analysis process of identifying where improvement activity should be prioritised. It is important to measure as a basis for analysis, and also to track change and progress during an improvement program (Grünberg, 2004).

Pollit (2005) explained that a manufacturer of coins, bill and cashless vending machines managed to boost productivity and achieve a saving of around £90,000 a year by employing continuous improvement and modern manufacturing techniques.

World-class manufacturers recognise the importance of manufacturing as a strategic weapon and demonstrate an extremely strong commitment to manufacturing excellence (Gilgeous and Gilgeous, 1999). World class manufacturing companies utilise manufacturing as a central role in creating and sustaining customer satisfaction (Flynn *et al*, 1999; Terziovski, 2006). According to Mohanty (1998), productivity is regarded as value addition and quality is value enhancement. These measures can be regarded as the key performance measure for the company (Mohanty, 1998).

An important conclusion is that waste must be eliminated in order to improve productivity, since waste is the opposite of what productivity symbolises (Tangen,

2005). Eliminating defective product is one of the main drivers of eliminating waste, because bad quality product results in either scrap, which is a cost (inefficient use of resources) or rework (which utilises double the capacity for the same product).

Lee *et al* (2007) and Kontoghiorghes and Gudgel (2004) investigated the relationship between productivity and quality. A positive relationship was established between productivity indicators and quality indicators. Mohanty (1998) confirmed the linkage between quality and productivity. Selladurai (2002) proposed an integrated model which clearly shows that a high performance organisation should result from a combination of high productivity and high profitability, which are the result of improved customer satisfaction among others.

This dissertation investigates a suitable method of productivity measurement (which results in decomposition of productivity, price recovery and profitability for the SA Mint. This measurement should be able to link productivity with cost using profit-linked models. The relationship between the results of profit-linked model with quality should also be evaluated in the minting company.

1.1.2 Industry Landscape

There is generally a very low growth rate in the circulation coins industry because it is a mature industry (Mvinjelwa, 2007). Therefore, there are two principal implications for competitive advantage: firstly, a reduction in the number of opportunities for establishing competitive advantage; secondly, shifts in these opportunities from differentiation-based factor to cost based factors (Grant, 2005). The tenders in this industry are mainly awarded based on price. Although, the price is the main determinant, quality product and its on-time delivery are also regarded as key factors.

There has been generally an oversupply of circulation coins in this industry, with the installed capacity exceeding the demand. This situation has since improved in the past few years, because some minting companies especially privately owned, including Birmingham Mint (Britain), Westhaim (Canada) and VDN Euro Coin (Germany) have since closed down. Demand especially of low denomination (circulation coins), is influenced primarily by inflation, which is in turn influenced by the political and economic uncertainties.

The circulation coins business has two major inherent risks, *i.e. ditto* political instability and economic instability. Money is low risk; it is a “safe” asset in low inflation rate time. Political and economic instability tend to lead to a high inflation rate in a country. This in turn forces the use of higher denomination currency. Circulation coins are usually used for lower-valued units, and banknotes for the higher values; also, in most monetary systems, the highest value coin is worth less than the lowest-value bank note.

Economic growth stimulates the demand, in a low inflation country. This was evident in South Africa, where the inflation rate has been low and the economy has been growing. Despite the growing use of technologically advanced payment alternatives in the second half of 1990s, currency in circulation has increased noticeably; this is also true for circulation coins (Gumata *et al*, 2006).

1.1.3 Company Background

The SA Mint Company is a medium-sized enterprise situated in Pretoria, South Africa. The SA Mint together with the Royal Canadian Mint and the Royal British Mint among others, are official minting companies that are owned by their respective countries’ central banks / reserve banks. However, some of these countries’ central banks do not own minting companies, and this offers business opportunities for minting companies like SA Mint (for example export business). This business currently constitutes 20% of the SA Mint circulation coins business. In addition to the official mints, there are also privately owned minting companies. The SA Mint Company is made up of two manufacturing divisions or profit-centers; the circulations coins and numismatics.

The circulation coins division constitutes 70% of the total business at SA Mint. The company supplies circulation coins for South Africa (RSA-5^{c}, 10^{c}, 20^{c}, and 50^{c}, R1, R2 and R5). Figure 1-1 shows the order by SARB as per demand of the circulation coins in the past four years. This demand for circulation coins shows a variable increase. The amount of currency in circulation depends on the public's demand for currency.

Demand largely results from the use of currency in transactions and is influenced primarily by prices for goods and services, income levels, and the availability of

alternative payment methods. The SARB using its forecasting model, orders a year demand of the circulation coins from the SA Mint. All the finished goods are transported from the SA Mint production facilities to Sabvest Limited (SBV) on behalf of the SARB.

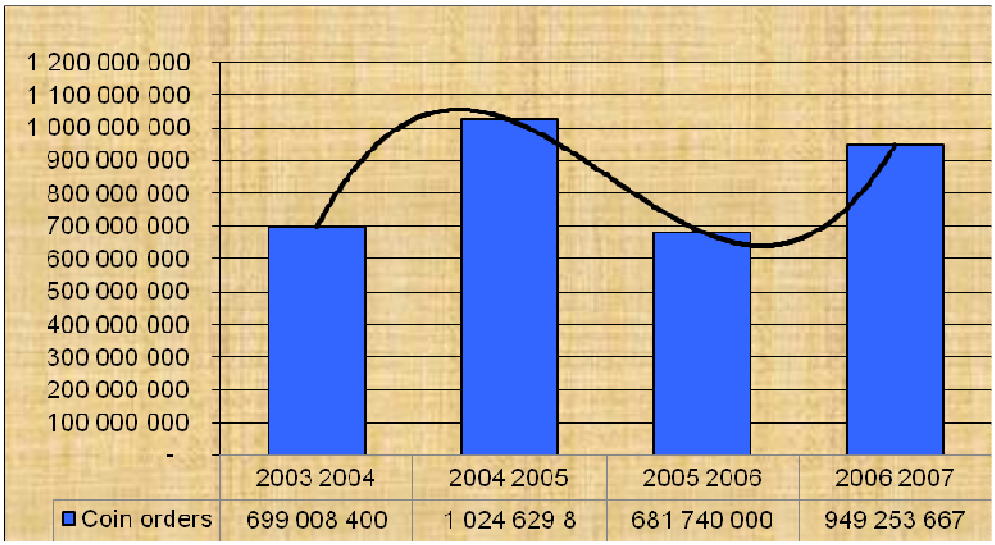

Figure 1-1 RSA order as produced by SA Mint Company for financial year 1995/1996 to 2006/2007

In addition to the order of the SARB, SA Mint competes in the international market, by tendering to produce circulation coins for Africa, Europe, Asia and South America. In the past four years, the SA Mint has produced coins for several countries (for example, Swaziland, Rwanda, Botswana, Mauritius, Namibia, Venezuela, Canada).

The circulation coins production at SA Mint is susceptible to commodity variations, and this tends to contribute towards the price of coin unit production. Steel, copper and nickel are the key metals during the production of circulation coins. Figure 1-2 shows the variation in the price of steel, which is the main raw material for the circulation coins production. The steel price has increased by $122 /metric ton since September 2005. This equates to ~21% increase in the past two years.

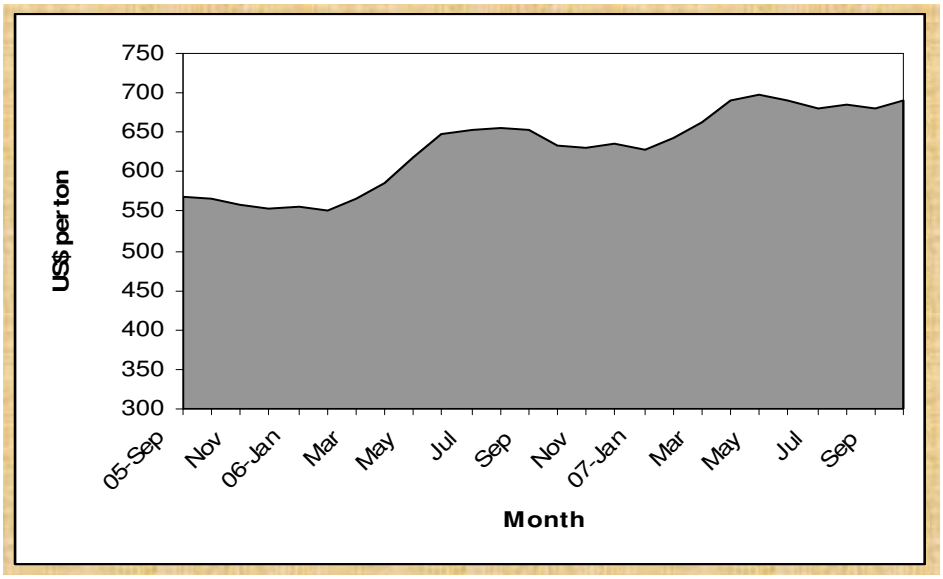

Figure 1-2 Average price of steel per metric ton from September 2005 to September 2007

An increase in copper and nickel prices has also been observed in the past three years, more so in the past two years as depicted in Figures 1-3 and 1-4. The data in these figures is adapted from InfoMine.com (http//www.infomine.com). The price of copper price increased sharply from October 2005 to April 2006, and then small changes from April 2006 until September 2007. The nickel increase has been worse compared to copper (Figure 1-4). This variation means that hedging is not always effective in minimising commodity risk. Overall, the input material has a major influence on the bottom line. This further affirms the need for a profit-linked measurement, since it should take away the market mechanism when measuring the productivity of the company (Rao, 2006).

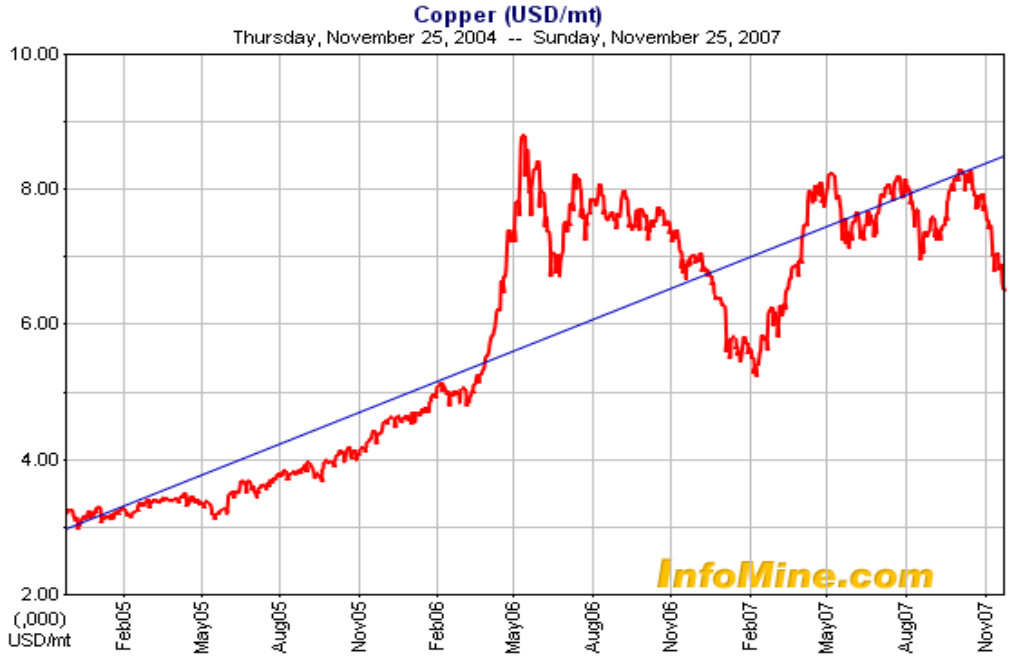

Figure 1-3 Monthly average spot price of copper per pound from November 2004 to November 2007

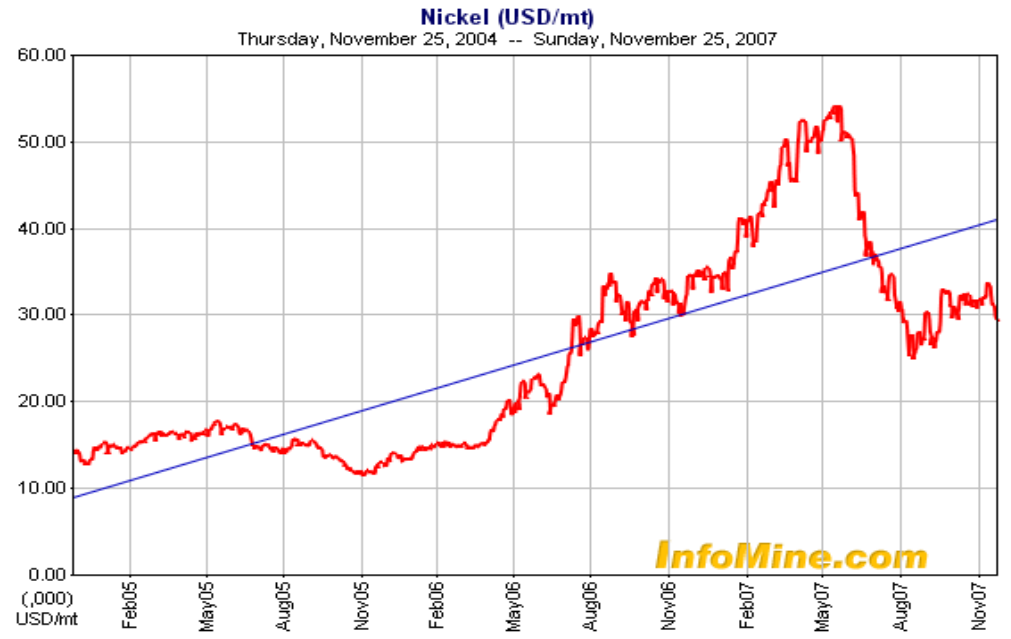

Figure 1-4 Monthly average spot price of nickel per pound from November 2004 to November 2007

Numismatics products form about 30% of the business. There are 45 product offerings of the numismatics division. The Protea series commemorates various aspects and important events in the history of South Africa, Nobel Peace Prize Winners of South Africa; Chief Albert Luthuli, Archbishop Desmond Tutu, Former Presidents Nelson Mandela and FW de Klerk. The natural gold coin features several themes, i.e. Giants of Africa like the hippopotamus, giraffe, and eland. Peace Park series commemorates South Africa's greatest achievement, the Kruger Rand conceived in 1964, where legal tender gold coin linked to daily gold price. This coin is regarded as the giant in the coin industry. In addition, other series include the Heritage series, International Poyer year medallions and selected jewellery is manufactured. Further discussion of this will study focus on circulation coin center (see delimitation of scope of study in section 1.4).

1.2 OBJECTIVE OF STUDY

The SA Mint, like most official minting companies is virtually assured of high volumes of orders from the SARB. It then becomes less difficult to achieve full capacity, as opposed to other manufacturing companies. However, profitability is not easily distinguishable in this company. In this regard, a study of performance measurement is very critical. This in critical in view of the company mandate which is different for different clients, viz. strive for low unit price for shareholder, and increase shareholders' wealth. This should enable the productivity to be the primary measure for achieving high performance so that the company can fulfil its mandate.

The relationship exists between productivity and quality (this is also a point of interest in this study with regards to the SA Mint).

The objectives of this study are outlined below:

- To effectively measure productivity at the SA Mint, using profit-linked productivity model.
- To investigate the relationship between productivity, price recovery and profitability and determine the main driver of profitability between productivity and price recovery at the SA Mint company.

- To investigate the relationship between productivity and quality at the SA Mint company.

1.3 IMPORTANCE OF STUDY

This study should allow SA Mint to continuously strive to achieve its mandate, by having a tangible measurement. Firstly, the evaluation of the productivity should enable the company to remove the market mechanisms. This should assist the company since increasing profitability is not the only mandate of the company from its shareholder. Secondly, there is prediction of a possible increase in demand of low denomination currency (coins) until end of 2009, with possibility of continuation of this trend beyond 2010. In this regard, resource utilisation to ensure maximum throughput is imperative for the company to meet the demand. Quality impacts of capacity utilisation, and input costs. Finally, the Chinese minting industry has developed substantially in the past few years. This raises a concern for the export market of minting firms, since the Chinese have proved in all sectors that they have an ability to be the market leader. Therefore high productivity is not an option but a prerequisite for all firms participating in this industry.

1.4 DELIMITATION OF SCOPE OF THE STUDY

This study is limited to circulation coins production at an official minting company in South Africa, i.e. ditto the South African Mint Company. Furthermore, it only focuses on tangible measurement; intangible measurement like employee morale does not form part of this study.

In the circulation coin side of the business, which forms about 70% of the total business, the following assumptions are made:

- The main customer is the SARB.
- The order is confirmed at the beginning of the year.
- Issues pertaining to customer service and responsiveness are low.
- The remaining capacity, which is usually, no more than 20% is filled by tenders, and the business situation is assessed before a tender is submitted.

1.5 PLAN OF STUDY

The dissertation is set out as follows: In Chapter 2, alternative theories which are the foundation of this study on performance, productivity and profitability are discussed. These concepts are defined and all the relevant links are explained. Relevant profit linked productivity models, the APC model, Multi-factor Productivity Measurement Model (MFPMM) and "Profitability = Productivity + Price Recovery" (PPP) are evaluated. In this regard, Chapter 2 becomes a logical consequence of the statement of the problem, which follows in chapter 3. Based on the problem statement, four hypotheses are formulated. These hypotheses are based on the suitability of the models discussed in Chapter 2 on measuring productivity, profitability and performance at the South African Mint Company, and the existence of a positive relationship between productivity and quality.

In chapter 4 an exposition of the methodology followed is given. The following aspects are covered: research approach, sampling, measuring instrument and data analysis. This study is quantitative with data collected for setting up the model and the survey conducted on the company in view of the relationship between productivity and quality. The results of the study are tabulated in Chapter 5, and discussed in Chapter 6. In this chapter the conclusions of the study are drawn, and the recommendations are made. Finally, the bibliography and appendices follow Chapter 6.

CHAPTER 2

FOUNDATION OF STUDY

2.1 INTRODUCTION

This chapter presents the theoretical foundation of this study. This should provide invaluable information that should ensure that the statement of the problem, which follows in chapter 3, is a logical consequence of the underlying theory. The usefulness of available productivity measurement models arises from the fact that they consists of a large number of important production factors (Ray and Sahu, 1992).

Productivity measurement models can be classified in various ways. Singh *et al* (2000) classified them as index measurement models, linear-programming based productivity models and econometric productivity models. Sink *et al* (1984) classified them as partial-factor, total factor and surrogate measures. The criterion for selection of suitable model is normally based on unit of analysis (for example, individual to national level) and scope of measurement or time frame (from minutes to years) (Roa and Miller, 2004).

As explained in chapter 1, this study is limited to firm-level productivity measurement. In general, total factor models are more appropriate to measure productivity at firm-level (Roa and Miller, 2004). There are four most commonly used total factor models. These are total productivity model (TPM), American Productivity Center now, known as American Productivity and Quality Center model (APC), multi-factor productivity measurement model (MFPMM) and "Profitability = Productivity + Price Recovery" (PPP) model (Roa and Miller, 2004). APC, MFPMM and PPP models are regarded as more appropriate measuring models, since they link productivity performance directly to the bottom line of the firm. This feature is not found in TPM, and therefore, the evaluation and selection of suitable model for SA Mint should be done from the three profit-linked models (APC, MFPMM and PPP).

These profit-linked models should present a report where it is clear of how much of the profit is attributed to productivity. This is imperative to SA Mint as discussed in chapter 1, in that the mandate of the company is not just to increase shareholders wealth, so lower profit margins does not necessary mean that the shareholder's wealth is being destroyed. Furthermore Mohanty (1998) argues that productivity is regarded as value addition and quality is value enhancement so positive relationship exists. A decomposed productivity value from profitability value when evaluating performance measurement should allow for the investigation of the relationship between productivity and quality.

The layout of this chapter starts by first discussing the terms; performance, productivity, profitability and quality, followed by the theoretical foundation of three models that link performance, productivity and profitability. The most suitable one is selected. After which, the relevant links are made in order to make sense of the results obtained from the models.

2.2 CONCEPTS DEFINED

2.2.1 Profitability

Profitability is the result of interaction of controllable and uncontrollable factors. The uncontrollable factors entail economic and political environment, market growth or decline and inflation among others (Alsyouf, 2007).

The term profitability is the overriding goal for the success and growth of any business; it can be defined as the ratio between revenue and cost (Tangen, 2005).

$$\text{Profitability} = \frac{\text{Output volume X output unit price}}{\text{Input volume X unit cost}}$$

Profitability is a useful complementary or countermeasure to performance and productivity. It helps to identify the effects of monetary effects like inflation, price changes, devaluation and currency effects and distinguish them from "true" performance and productivity changes. A company can increase its profit margin and at the same time decrease productivity, because of these monetary effects. If both

productivity and profitability are measured, the true reasons for increased profits can become clearer (Grünberg, 2004).

2.2.2 Productivity

Productivity is a multi-dimensional term, with a meaning that can vary, depending on the context within which it is used. However, there is a common characteristic to the term (Tangen, 2005). In industrial Engineering, productivity is general defined as the relation of output (i.e. produced goods) to input (i.e. consumed goods) in manufacturing transformation process (Sumath, 1994). Mathematical definitions, on the other hand can be used as the basis of performance measures, where the major aim is to improve (not to explain) productivity.

Broman (2004) suggested that it is necessary to have a clear distinction between a concept and a particular mathematical definition attached to the concept in order to effectively evaluate the characteristics of the mathematical definition. Bernolak (1997:204) provided a useful verbal explanation of productivity that is related to manufacturing:

Productivity means how much and how well we produce from the resources used. If we produce more or better goods from the same resources, we increase productivity. Or if we produce the same goods from less resource, we also increase productivity. "Resources" means all human and physical resources i.e. people who produce the goods or provide the services, and the assets with which the people can produce the goods or provide the services.

This definition captures two important characteristics. Firstly, productivity is closely related to the use and availability of resources. In short, this means that a company's productivity is reduced if resources are not properly used or if there is a shortage of them. Secondly, productivity is also strongly connected to the creation of value. Thus, high productivity is achieved when activities and resources in the manufacturing transformation process add value to produced goods.

The productivity measures can be divided into three types (Stainer, 1997); total productivity; total factor productivity; and partial productivity measures.

Productivity is a relative concept, it cannot be said to increase or decrease unless a comparison is made; either in variation of standard at a certain point in time or of changes over time. Misterek *et al* (1992) argues that productivity can be increased or decreased, base on the differences in the relationships.

2.2.3 Performance

Performance covers overall economic and operational aspects. Discussing and measuring performance has two main aims - firstly to connect company goals and objectives to improvements and secondly to set targets for improvement activity. Together, these help focus energy and activity and increase the impact of any improvement initiative.

Goals are usually considered as high level, generally not expressed in numeric form. They are translated at "the next level down" into objectives that are clearly measurable. Both should be demonstrably linked to the company's mission, which is the fundamental reason for a company's existence. Productivity and profitability of the organization can be tracked using total-factor productivity models (Rao, 2006).

2.2.3 Quality

Quality is defined as the degree to which a company meets customers' perceptions on a variety of characteristics of the delivered products/services, and is often expressed and managed using a variety of technical quality factors such as percentage of defect goods (Slack *et al*, 1998). Juran (1974) defined quality as fitness for purpose and excellence. Sink *et al* (1984) argue that quality is a measure of performance on the input side, with respect to the transformations of input and also on the out put side. According to Grant *et a*l (1994) quality is a form of perfection that has intrinsic value.

2.3 OVERVIEW OF THE MODELS

The purpose of productivity measures is either a trend analysis, comparison analysis or goal analysis. Profit-linked total factor productivity measurement models are used for trend analysis (Roa, 1993).

2.3.1 American Productivity Center (APC) Model

The first approach to model productivity using profit linked factor model is the American Productivity model developed by American Productivity and Quality Center (previously known as American Productivity Center). This model is based on the premise that a firm generates profits from two sources, productivity and / or price recovery improvements. Productivity is a measure of real growth changes in physical input and output quantities, whereas price recovery is the extent to which input costs or price increase is passed on to the customer (i.e. the extent to which inflation is recovered through sales price increases) (Miller and Roa, 1989).

The attraction of this productivity measurement model to the business community is that it uses readily available accounting data and provides performance results in dollars as opposed to abstract indexes. Companies can easily implement the model with the assistance of popular spreadsheet software such as Microsoft Excel.

Computation

According to Roa (1989), the profitability contribution is calculated in the APC model "by subtracting each input [Value] change ratio from total output change ratio and multiplying the resulting number by the input's value in period 1 (Roa, 2000). Here, Period 1 is the base period (Roa, 1993).

Mathematically, profitability contribution can be expressed as follows:

$$\textit{Profitability} = (S_t C_B - S_B C_t)/S_B$$

where: C_B = Costs in base period;
C_t = Costs in period t;
S_B = Sales in base period and;
S*t* = Sales in period *t.*

The productivity contribution in this model is expressed as follows:

$$\textit{Productivity} = C_B\,[(S_t^D / S_B) - C_t^D / C_B]$$

where: C_B = Costs in base period;

C_t^D = Cost in period t deflated to the base period;

S_B = Sales in base period and;

S_t^D = Sales in period t deflated to the base period.

The APC model utilises a single step deflation, when deflating the units of x ~~X~~ and y; the total deflation expression is as follows:

$$\textit{Value}_t^D = Q_{x1}P_{xB} + Q_{y1}P_{yB}$$

where: Q = Quantity; P = Price; B = base period and; t = period t

APC model utilises several ratios without a financial orientation. One main consequence of this is that management's buy-in and; use of a productivity measurement tool is facilitated when that tool is couched in financial language (Miller and Roa, 1989).

Microsoft Excel Spreadsheet

The APC model can be implemented using Microsoft excel spreadsheet. The required data for APC model is any two of the following: quantities, prices and values. Value is the product of quantity and price (Roa, 2006)

If the quantities and prices are entered the costs and revenue can be calculated. Along with the cost and revenue, deflated values can be calculated for the second period to the last selected period with the price of period 1 (base period). This is necessary to remove the price effect of the input and output so that productivity within the periods can be measured.

Change ratios should then be calculated, volume, quantity or price of period two, divide to those of period one.

Following these ratio calculations, performance indexes are calculated as shown below (Roa, 2000):

$$\text{Productivity index} = \frac{\text{Quantity change ratio of total output}}{\text{Quantity change ratio of input}}$$

$$\text{Price recovery index} = \frac{\text{Price change ratio of total output}}{\text{Price change ratio of input}}$$

$$\text{Profitability index} = \frac{\text{Value change ratio of total output}}{\text{Value change ratio of input}}$$

The final step is to convert performance results in terms of productivity and price recovery contributions to profitability in dollar or rand terms.

Microsoft Excel has an added advantage because it can provide answers to some questions using “Goal Seek” and ‘Solver” features. APC model can be regarded as a simple measurement that managers can use easily and frequently (Roa, 2000).

2.3.2 Ethyl Corporation (PPP) Model

The second approach used to model the productivity is Profitability = Productivity + Price recovery (PPP) model developed by Miller (1984). The motivation behind the development of this model was to devise a procedure whose calculations and theory would readily be understood by a financially orientated manager (Miller and Roa, 1989).

The PPP model generates information by measuring changes in profits beyond what they would be if a given profitability standard or goal is realized. This procedure then dissects this change into contributing amounts, either from changes in productivity performance or net price recovery (net increase in sales price over increases in price of labour, raw material, energy and other resources (Millller, 1984).

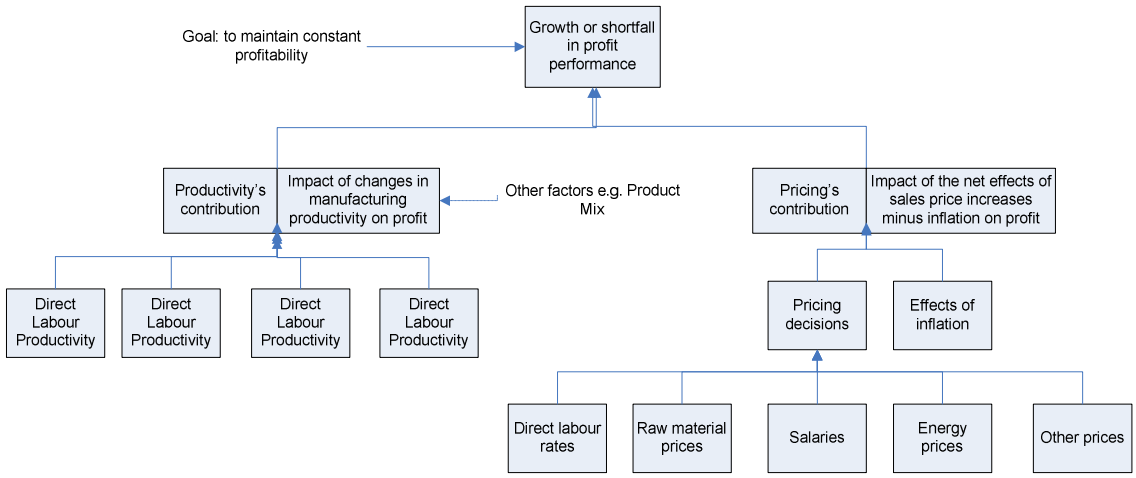

Figure 2-1 Productivity and price recovery flow chart

The flow chart indicates that the overall company productivity is affected positively by efficient use of manufacturing resources such as material, labour and energy. In turn, these changes in productivity affect the company's ability to generate profits. By the same token, increases in the sales price can compensate for rising resource costs due to inflation.

Like APC model, PPP model is also based on the premise that a company generates profits from productivity and/ or price recovery.

This model utilized mathematical of the additive profitability relationship, with input data, labour, material and energy resulting in computation dollar or rand value of profitability, productivity and price recovery in a given period. Unlike other profit-linked approaches, PPP procedure starts with and maintains dollar figures throughout its derivation of the final productivity performance results. During computation of productivity, this model uses cumulative deflation method to re-instate current figures to the base year. PPP incorporates the relation between current productivity period levels and the productivity levels of all previous periods.

Computation

In this approach, "the actual gross profit realized in a period is compared with the gross profit that would have been realized had the company's profit margin (its gross profit divided by its net sales revenue) remained unchanged" (Miller 1984a).

$$\textit{Profitability} = = (S_t C_B - S_B C_t)/S_B$$

The PPP model defines a "deflated margin" which is the profit margin in period t stated in base period dollars or prices. The productivity effect is calculated in the same manner as the profitability gain or shortfall but using only the real (or deflated) value of revenues and costs. That is:

$$\textit{Productivity} = S_t^D[(S_t^D - C_t^D)/S_t^D - ((S_B - C_B)/S_B)]$$

According to Miller (1984), the PPP model uses a cumulative deflation. The period-to-period price changes are "chained together to produce a cumulative price deflator. The Implied Deflator is the ratio of total current period value in previous period prices (deflated value). It provides an inflation factor for the price movement from period t-1 to period t.

$$\text{Value}_t^D = \frac{\text{Value } (Q_{xt}P_{xt-1} + Q_{yt}P_{yt-1})(Q_{xt-1}P_{xt-2} + Q_{yt-1}P_{yt-2})....}{(Q_{xt-1}P_{xt-1}\text{-t} + Q_{yt-1}P_{yt-1}).....}$$

The PPP model uses dollar or rand term throughout its derivation and accumulative deflations methods.

2.3.3 Multi-factor Productivity Measurement Model (MFPMM)

MFPMM was developed by the American Productivity Center in 1977, currently known as the American Productivity and Quality Center for measuring productivity and price recovery, and for explicitly relating these results with profitability at the organizational/functional levels (Phusavat and Photaranon, 2006). This model's primary focus is on a manufacturing/production unit with tangible outputs and inputs. It is suitable for a process that is stable, implying not-so-often changes in products

being offered (Sink and Tuttle, 1989). Finally, the MFPMM can easily adapt the data from a typical accounting system for its major components, Figure 2.2.

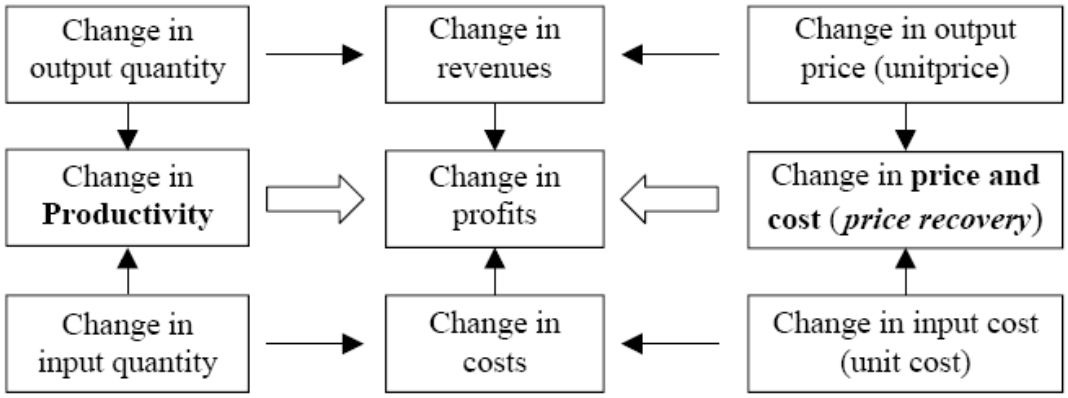

Figure 2-2 Nine components of multi-factor productivity measurement model

To elaborate more on the MFPMM, it is essential to highlight its other key features. For example, the MFPMM combines the concepts of the opportunity gain/loss, and the dynamic/static ratios in both single-, and partial-formats (Phusavat and Photaranon, 2006).

Computation

Based on Sink (1985) the calculations can be done, by calculating value of period 1 as the quantity of outputs produce (Q_{i1}) and / or sold multiply by output unit price and the input's unit cost (P_{i1}) or unit cost. This is similar to APC model in this regard. For period two the same quantification applies with quantity output (Q_{i2}) and unit price (P_{i2}).

Price –weighted and base period price indexed changed – quantities (both unit price and cost remained constant at period 1, yield the following:

$$\frac{\sum_{i=1}^{n}(Q_{i2})(P_{i1})}{\sum_{i=1}^{n}(Q_{i1})(P_{i1})}$$

The quantity-weighted and current period indexed changes – unit prices and costs (both output and input quantities remained constant at period 2):

$$\frac{\sum_{i=1}^{n}(Q_{i2})(P_{i2})}{\sum_{i=1}^{n}(Q_{i2})(P_{i1})}$$

When depicting profitability indexes, reflecting the rates of change on both the quantity produced / consumed and unit price/cost:

$$\frac{\left.\sum_{i=1}^{n}(O_{i2})(P_{i2})/\sum_{i=1}^{n}(O_{i1})(P_{i1})\right\}\text{Rate of change on output value}}{\left.(I_{ij2})(P_{i2})/(I_{ij1})(P_{i1})\right\}\quad\text{Rate of change on input value}}$$

Indicating the impacts of opportunity gained or loss from productivity changes

$$[(I_{ij1})(P_{i1})]\left[\left(\frac{\left[\sum_{i=1}^{n}(Q_{i2})(P_{i1})\right]}{\sum(Q_{i1})(P_{i1})}\right)-\left(\frac{(I_{ij2})(P_{i1})}{(I_{ij1})(P_{i1})}\right)\right]$$

Finally, the total impact on profits from productivity / price recovery can be calculated as follows:

$$[(I_{ij1})(P_{i1})]\left[\left(\frac{\left[\sum_{i=1}^{n}(Q_{i2})(P_{i2})\right]}{\sum(Q_{i1})(P_{i1})}\right)-\left(\frac{(I_{ij2})(P_{i2})}{(I_{ij1})(P_{i1})}\right)\right]$$

2.5 LINKING PRODUCTIVITY TO PROFITABILITY

Organisations should combine productivity and profitability ratios, so that the true reasons for increased profits can become clearer.

The major drawback with monetary units in productivity measurement is that they need to be deflated, *i.e.* adjusted for price changes. This involves difficulties when calculating the measures. In fact, often an approximation of the price changes needs

to be made to make the calculations easy to handle. Many researchers, for example, Wolff (1990) and Lofsten (2000), point out this problem and recommend adjusting for price variations of the input factors when calculating productivity. However, this price-change issue is a source of "error" for productivity calculations and, suggests that monetary units should be avoided in productivity calculations in order to measure true productivity. For improvement work, it is strongly recommended that monetary units are kept separate from the productivity ratios.

Partial productivity measures relate to one single output and normally to one single input (Hannula, 1999; Stainer, 1997).

The strength of partial productivity measures is that they allow the design of specific measures for smaller areas, functions or divisions in a company. These measures are often suitably responsive, *e.g.* it is often easier to pin-point a problem using a partial productivity measure as a diagnostic tool. A total productivity measure operates at a "higher" level and does not permit the same level of "focus". On the other hand, a partial productivity measure does not cover all operational areas or cost categories of a company; this is why both kinds of measures are needed.

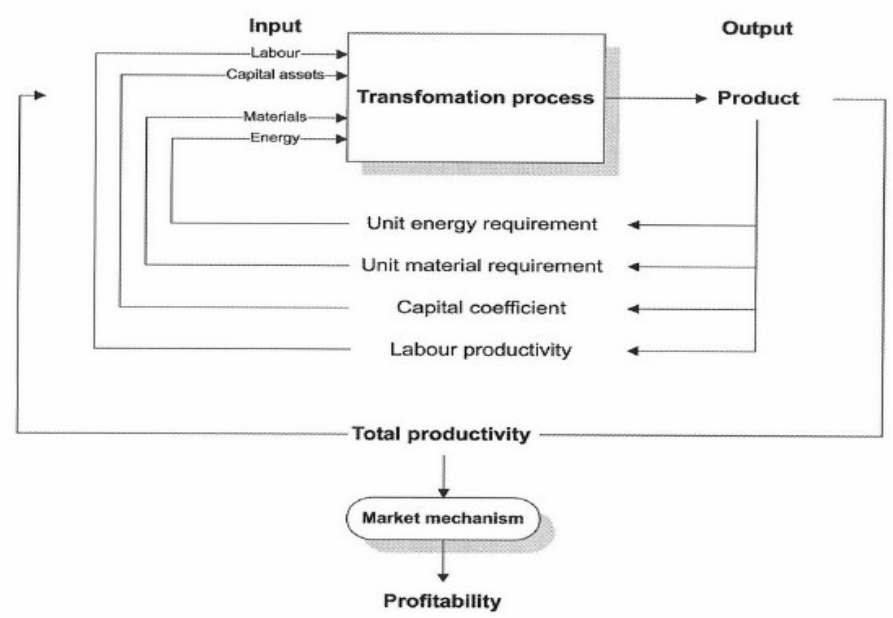

Figure 2-3 Transformation process and productivity model

Thus at simple level, total and total factor productivity measures are more suited for monitoring purposes and partial productivity measures are more useful for diagnosis.

Figure 2.3 shows the transformation and productivity model. This curve shows a separation on productivity from profitability by market mechanism (inflation) (Tangen, 2005)

2.6 LINKING PERFORMANCE, PRODUCTIVITY AND PROFITABILITY

The measures used to evaluate a company's performance have historically been financial ones, such as the monetary value of sales and profits or percentage return on monetary investment. Because external groups place a strong emphasis on such financial measures, the internal performance measurement systems used within companies have also tended to be financial, usually focusing on costs [1]. Although the literature provides a wealth of possible measures to choose from, it indicates how to select from among those measures (White, 1996).

There are two main views on the relationship between, productivity, profitability and performance. These are the hierarchical view and subset view. The hierarchical classification of measurement support monitoring and pin-pointing measures, where the monitoring measures are of a more general kind and can be used as indicators of problems (Figure 2.4). However, it is difficult to get information on the specific causes of problem when information is not sufficiently detailed. The subset view provides information on how to relate the different measures (Grunberg, 2004).

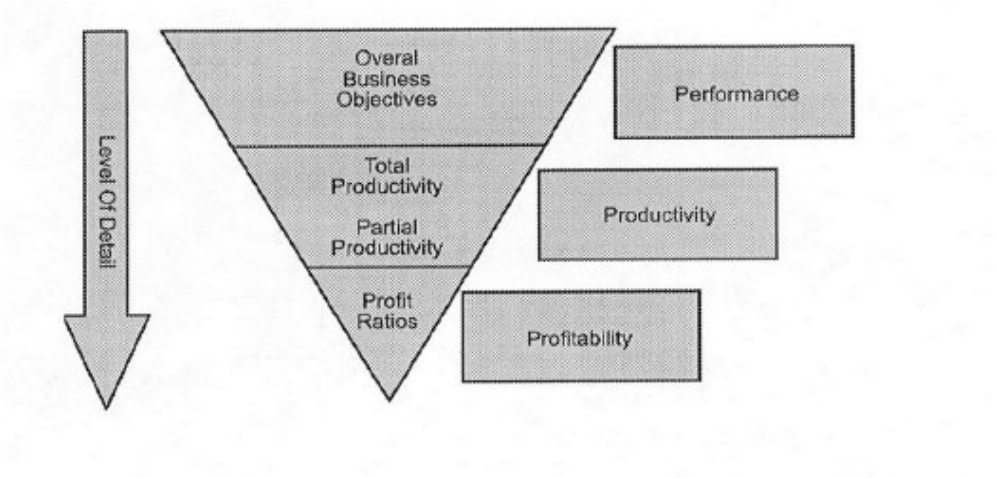

Figure 2-4 A hierarchal view of the terms, performance, productivity and profitability

It may be important, especially in particular types of operation, to connect quality to productivity measures. This can be done with a quality multiplier factor to the productivity ratio (Al-Darrab, 2000).

Two main views of the relationships between the terms are presented here, a hierarchical view and a subset view. The hierarchical classification of measurements supports monitoring and pin-pointing measures, where the monitoring measures are of a more general kind and can be used as indicators of problems. However, it is difficult to get information on the specific causes of a problem when information is not sufficiently detailed. The subset view provides information on how to relate the different measures.

Performance and productivity can be viewed as a company's ability to provide customer value. As PPP is often described as ratios, the generic description could be summed up to customer value/resources. However, this ratio is extremely broad and needs to be divided into smaller concepts for use in improvement work. These concepts are described later.

The measurements of PPP can also input into ongoing control processes helping the organisation to focus on the important characteristics of operations. (The influence of a measurement system is extensive, but difficult to predict. This paper does not explicitly address this topic, but it is important to understand that measurement systems have both intended and unintended consequences).

2.4 LINKING PRODUCTIVITY TO QUALITY

Mohanty (1998) identified similar ideologies between productivity and quality as depicted in Table 2-1. The criteria for culture and responsibility are the same and objectives and priorities are similar and complementary. Principles of quality and productivity owe their origins to general systems theory (GST). Quality and productivity management are operationalised to maximise profitability in the organisations (Mohanty, 1998).

Table 2.1 Similarities in ideologies between quality and productivity.

Criteria	Quality	Productivity
Definition	Customer-driven	Orientation driven
Objective	Minimise wastage	Maximise resource utilisation
Decision	How to be competitive?	How to be competent
Priority	To win competition	To reduce inputs
Responsibility	Total organisation	Total organisation
Culture	Team work	Team work

Maskell (1989) listed as world-class the quality considerations are incoming quality from suppliers, production quality (including the use of statistical process control charts and direct measures of the customer's satisfaction).

2.7 SUMMARY AND CONCLUSION

In this chapter, three profit-linked factor productivity models; APC, PPP and MFPMM are discussed. There are several similarities between these models,

Assessing the impact of productivity on profitability using such measures as output per worker-hour has been difficult. A simple method of calculating productivity's contribution to profitability is presented which several corporations have successfully used. The method allows a firm to calculate the effects of sales pricing strategies on profitability. Profitability is defined as being equal to productivity plus price recovery. Profit change is measured as the actual profit a company achieved during a period, compared to the gross profit that was anticipated. Productivity's contribution to profitability is measured by the deflated gross profit margin for the period, minus a baseline profit margin, multiplied by deflated net sales for the period. The price recovery measure indicates how well increases in sales prices were able to buffer the firm's profits from inflation.

Even though productivity has become an everyday word, it remains one of the most elusive concepts in business and economic literature, remaining so because of the lack of definitive theoretical work, mainly at the firm level. The American Productivity

Center (APC) has undertaken the challenge to develop the firm-level productivity measures. The APC productivity measurement model is addressed. The approach taken was to develop a total factor productivity measurement system including all factors of input, not just labour. Other factors included are capital, materials, energy, *etc*. Besides considering all factors of input, it measures the effect of productivity on profits and isolates the effect of inflation on profits. For maximum benefits, the APC model must be interrelated with a firm's budgetary and accounting systems (Miller, 1984).

There is an existence of a relationship between quality and productivity and this relationship is further explored in chapter 3 during the formulation of hypothesis.

CHAPTER 3

PROBLEM STATEMENT

3.1 INTRODUCTION

Chapter 2 has evaluated the profit-linked factor productivity model, with APC model selected as the suitable one for the South African minting company. In addition to the use of both indexes and rand values, this model allows for easy computation with Microsoft Excel spreadsheet. Furthermore, the links between productivity and quality are established. This argues well for this chapter and paves way for both the problem statement and the research questions of this study.

3.2 PROBLEM STATEMENT

Based on the foundation of study presented in Chapter 2, the problem of this study is formulated as follows:

American Productivity Center (APC) profit-linked model is suitable for measuring productivity at the SA Mint Company, and a relationship exists between productivity and quality.

3.3 HYPOTHESES

3.3.1 Profit-linked Measurement

The American Productivity Center (now known as American Productivity and Quality Center (APC) model is a simple model and has been utilised in a manufacturing environment as a productivity measure. The number of publish paper on this model is somewhat limited. Roa (2006)'s view on it is that the data required to set up and measure the model is not always readily available since it requires operations information of an organisation.

Roa (2006) utilised the APC model to measure productivity, profitability and performance of Harlingen waterworks. This study was able to prove that the APC measure is able to assist Harlingen waterworks in better understanding their problem areas, and thus the focus of improvement. It also showed that this model can be used independently in a company or in conjunction with balance score cards. In addition, the managerial implications were evaluated using goal seek.

Hypothesis I

American Productivity Center (APC) can distinguish productivity and profitability and thus, a suitable measuring tool for measurement of productivity at SA Minting Company

Hypothesis II

The productivity contribution is the key driver of profitability at the SA Minting Company.

3.3.2 Relationship Quality / Productivity

Hayes and Wheelright (1984) argue that within an industry, different companies differ in emphasis given to each competitive priority, thus creating their own unique strategic profile. Hayes and Wheelright (1984) explicitly advise against the pursuit of multiple competitive priorities. They state that it is difficult if not impossible and potentially dangerous for a company to try to compete by offering superior performance along all of these dimensions (cost, quality, dependability, flexibility and on-time delivery) simultaneously. This is because; the company might end up second best to all of them. Instead, they suggest that the company must attach clear set of priorities among the dimensions, which is supported over time by various decisions about resource allocation, rewards and competitive profiles.

In chapter 2, section 2.6. the existence of the relationship between productivity and quality is discussed. There are several assertions regarding the relationship of productivity and performance measures. The desired outcome is to provide customer with highest quality product, on time delivery at lowest possible costs. This is in line with company mission which is as follows:

Credible and sustainable supply of circulations coins and related product delivered on time in a cost effective manner for local and international clients.

Quality and productivity management practises are being pursued in most companies either in isolation or in an absolutistic fashion. Today, there is a growing realisation that both practises should be integrated by breaking boundaries of absolutism for mobilisation of all internal resources towards a common goal (i.e. for creation of value) (Mohanty, 1998).

There was always separate emphasis between the objectives of quality management and productivity management and they were thus, viewed as being contradictory. Research recently indicates that quality and productivity should have a positive relationship (Lee *et al*, 2007).

Quality and Productivity were regarded as mutually conflicting. Kaydos (1991) states that

"It is reasonable to think that lowering quality standards will increase productivity because the amount of good product made will increase slightly".

Darst (1990) further re-iterated this negative relationship between quality and productivity. It was argued that the program to improve quality causes disruptions and delays, and that result in reduced output. Butts (1984) in his article on the relationship of quality to productivity describe poor quality as:

"A vampire-like creature which takes bite after bite out of productivity"

According to Mohanty (1998) productivity which is regarded as value addition and quality, which is value enhancement are the main determinants of competitiveness. To remain competitive, organisations need to integrate and synergize both productivity and quality.

Kontoghiorghes and Gudgel (2004) investigated the correlation between the productivity and quality indicators (Table 3-1). The analysis showed a positive relationship between all quality and productivity indicators in the two selected manufacturing companies. The correlation ranged from 0.29 to 0.74, with an average of 0.46. Internal process satisfaction and the extent, to which work output by peers is consistently delivered accurately, show the highest and second highest correlation, respectively with productivity indicators. This implied that if the organisation places an emphasis on the quality of work output, a more efficient and on-time operation should result, and this in turn should have a positive influence on productivity.

These quality indicators are similar to those of companies pursuing world class status suggested by Maskell (1989), which are incoming quality (material), statistical process control (SPC), customer satisfaction and inventory accuracy.

Table 3-1 Quality and productivity indicators

Quality Indicators	Productivity Indicators
Internal processes	Amount of work output by peers exceed expectations
Work output by peers is consistently delivered accurately	Inputs are received from others in a timely fashion
External customer satisfaction	Products or services are produced in a cost-effective manner
Work output by peers is consistently delivered complete	
Satisfied with quality of peer work output	
No change or rework needed after the final products are produced	
Produced products / service meet specifications	
On time delivery of products / services	
External customer loyalty	
Employees react quickly to resolve unexpected problems	
No scrap produced	

The third hypothesis of this study can be formulated as follows:

Hypothesis III

There is a positive relationship between productivity and quality indicators at the South African Minting Company.

3.5 CONCLUSION

After the data have been generated by the APC model, interpretation of the results follows. A correlation of relationship at the SA Mint between the productivity measurement results and quality is done. The literature has indicated that there is a positive correlation between productivity and the performance indicators. All the relevant hypotheses were formulated based on the literature review.

CHAPTER 4

RESEARCH METHODOLOGY

4.1 INTRODUCTION

This chapter builds upon previous chapters, and outlines the research methodology utilised to complete this study. There are three basic worlds of research; they are pragmatic interest (everyday life), epistemic interest (science) and critical interest (meta-science). This study belongs to the epistemic interests, which include scientific knowledge, scientific discipline and scientific research (Strasheim, 2007).

The research process includes a problem statement – design-methodology-conclusions. The methodological approach to this research can be a quantitative paradigm (structured), qualitative paradigm (Verstehen) or participatory paradigm

(action research) (Strasheim, 2007). In this study the productivity measurement is a quantitative analysis using a profit-linked model. Furthermore, the correlation analysis and regression analysis are done on the quantitative data obtained from the survey questionnaire.

The steps that were followed in this study are depicted in Figure 4-1. Firstly, the topic of interest is discussed, and objectives are re-iterated. Secondly, research design is discussed, and this includes types of research (exploratory or conclusive), source of data, population, data collection and approach methods and finally construct and pre-test questionnaire (relevant for the survey part of the study).

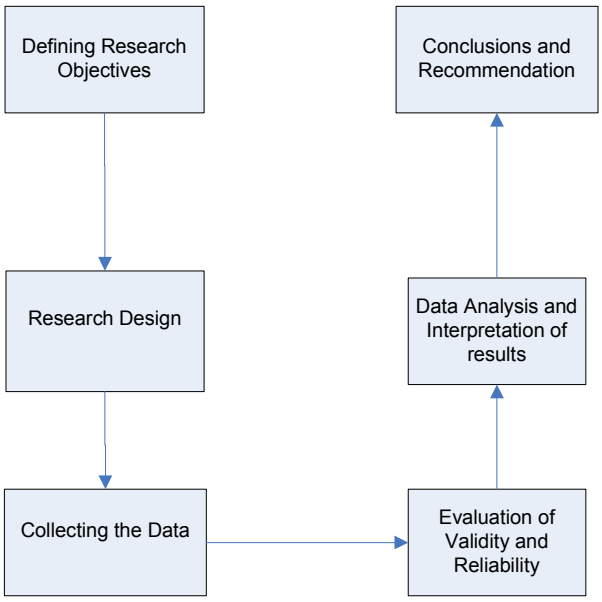

Figure 4-1 Research process.

4.2 TOPIC OF INTEREST AND OBJECTIVES

The main topic of interest is to investigate and recommend suitable tools for productivity measurement in the South African Minting Company, and evaluate the relationship between productivity and quality. The objectives as discussed in Chapter 1 which are;

- To effectively measure productivity at the SA Mint, using profit-linked productivity model.
- To investigate the relationship between productivity, price recovery and profitability and determine the main driver of profitability between productivity and price recovery at the SA Mint company.
- To investigate the relationship between productivity and quality at the SA Mint company.

4.3 RESEARCH DESIGN

4.3.1 Phase of Research

Research design can be classified into two broad bands, exploratory and conclusive research:

- Exploratory - exploratory research is to understand the general nature of the problem, the possible decision alternatives available and the relevant variables that need to be considered. Furthermore, there is little prior knowledge of the problem. It allows for the use of secondary data sources, literature reviews, observations, unstructured individual and group interviews with knowledgeable persons as well as case studies (Brummer, 2005).
- Conclusive - it can be sub-classified to causal and descriptive. Casual is normally used to obtain evidence of cause and effect relationship. This type of research is conducted by controlling various factors in order to determine which variable is the cause of what is being predictable. In contrast, the objective of descriptive research is to describe certain variables.

Generally this study followed exploratory research, since there is little knowledge on the problem, prior information is readily available and secondary is utilised for the set up of profit-linked APC model. Furthermore, an attempt was made to achieve causal part of the conclusive phase using the relationship between productivity and quality with an assistance of a questionnaire.

4.3.2 Determine source of data

There are two types of information available to the researcher, primary and secondary source. Primary data include data collected specifically for the research problem at hand, while secondary includes data and information already published, collected for purpose other than the specific research needs under investigation (Diamantopolous and Schegelelmilch, 2005). (For the study, a mixture of primary and secondary information was solicited.

The backbone of this research was the use of profit-linked model to measure and compare the productivity and profitability in last 3 financial year and the half year results of the current year at the SA Mint ending in September 2007. Academic sources were consulted for establishing and evaluating the relationship between productivity and quality.

4.3.3 Define the population

The population of this research included individuals across the company, from top management to operator level. It was decided that surveying everyone in the company was uneconomical and tedious, and thus, a sample of about one third of the organisation, which is 100 individuals were chosen.

In this study probability sampling procedure is used. In this sampling procedure each element in the population had a known non zero-probability of being included in the sample. The probability method used for sampling is stratified sampling, were sample members are chosen randomly from different segments or strata of the overall organisation (Diamantopolous and Schegelelmilch, 2005). The strata were the level in the organisation, team members which included operators and analysts, team leaders or supervisors included assistant foremen and foremen. The other strata are middle management, senior management and specialists like Engineer,

Accountant, HR officer, Metallurgist and Chemists. Each stratum was sampled according to its size, with more participants in operator level and least at senior management level.

4.4 COLLECTION OF DATA

There are several data collecting approaches in the literature (Mouton, 2001), these include:

- Observation through experimental recording
- Testing like psychometric testing
- Selecting and analyzing through textual analysis, discourse and historical analyses.
- Survey / Interviewing through a self- administered questionnaire and structured

Regardless whether data come from within or outside an organization, we can differentiate between two types of data: subjective and objective, Subjective measures are based on opinion or estimates, while objective measures are based on independently-observable facts. Much of the information gathered from within a company - and especially the information that has historically been collected for performance measurement - can be obtained in the form of objective data (Emory, 1980).

4.4.1 Collection of APC model data

In this study, an objective data was collected for the measurement of the productivity with profit-linked model; data regarding the output or sales was obtained from the financial statements, while the input resources were obtained from the records in the Financial Department of SA Mint. This data was obtained for the financial year 2005 (1April 2004 to 31 March 2005), financial year 2006 (1 April 2005 to 31 March 2006), financial year 2007 (1 April 2006 to 31 March 2007) and half financial year 2008 (1 April 2007 to 30 September 2007).

4.4.2 Collection of Relationship Data

The data for the establishment of the relationship between productivity and performance indicators was collected using a questionnaire, of which the questionnaire was distributed and collected either through e-mail or personal.

The questionnaire was formatted in terms of structured questions (see Appendix A). These questions were statements based on the literature review pertaining to productivity and quality. A Likert scale (1-5) was used to evaluate the statement, with 1-strongly disagree, 2-disagree, 3-neither agree nor disagree, 4-agree and 5-strongly agree.

4.5 DATA ANALYSIS

Data analysis for productivity measurement was performed in Microsoft Excel by set up a model with series of calculations:

- Calculation of vales
- Calculation of deflated values
- Calculation of change ratios
- Calculation of productivity, price recovery indexes and profitability
- Calculation of rand value contribution of productivity, price recovery and profitability.

After calculations all the relevant trends were drawn, which made it possible to compare the different periods.

The data analysis from the questionnaire was analysed using statistical program, *Analyse-it*. Computation of summary statistics, Pearson product correlation and linear regression was conducted to ascertain the relationship between productivity and quality.

The correlation between two variables (productivity and quality) reflects the degree to which the variables are related. The most common measure of correlation is the Pearson Product Moment Correlation Pearson's correlation reflects the degree of linear relationship between two variables. It ranges from +1 to -1. A correlation of +1 means that there is a perfect positive linear relationship between variables, -1 means there is a perfect negative correlation and 0 means there is no correlation

(.Diamantopolous and Schegelelmilch, 2005). In addition to correlation a relationship between linear regression curves were constructed to further model the relationship between a dependent variable and independent variable. Average quality was regarded as the indipendent variable while productivity was the depended variables.

4.6 VALIDITY AND RELIABILITY OF THE RESEARCH

The data gathered in a research survey should be valid and reliable, if the survey results are to be credible. Validity measures indicates the extent to which a particular measure is free from both systematic and random error, while the reliability measure the extent to which a measure is free from random error (Diamantopoulos and Schegelmich, 2005).

In this study, the validity was achieved through pre-testing the questionnaire with 5 individuals from Production Engineering Department at the SA Mint. The comments made on the questionnaire led to minor adjustment being made, after which it was distributed to the respondents included in the sample. No validity was made on the data for setting up the model since it was an authentic data from the financial statement, account receivables, manufacturing account among others.

The reliability of the data for setting up the model was not questioned and not evaluated, although some cross check were conducted (for example manufacturing account and cost of sales).

4.7 ETHICS

South African Mint Company employees have an obligation to maintain the confidentiality of information entrusted to them regarding the company's operations and activities. The confidential or proprietary information may not be disclosed to others except when disclosure is authorized. All information related to the company's business should be considered confidential unless it has been released in public documents.

Research participants were informed about the nature of these studies and given the choice to either participate or not. The researcher promise to uphold the participant’s

right to privacy; under no circumstance the report will be presented in such a way that others will become aware of how a participant has responded.

CHAPTER 5

RESULTS OF THE STUDY

5.1 INTRODUCTION

In Chapter 4, the research methodology that was followed in this study was discussed. This included the computation of the APC model utilising Microsoft Excel Spreadsheet, which assisted in formulating the results of the first research question one and two. This is the American Productivity Center (APC) model that can distinguish productivity and profitability and thus, a suitable measuring tool for measurement of productivity at the South African Minting Company. The results are tabulated in this chapter, and then discussed in chapter 6.

Furthermore, the statistical analysis using *Analyse-it* was conducted to ascertain the relationship between productivity and the quality. These results are also tabulated and interpreted in this chapter. They address the research question three, which is; the existence of a positive relationship between productivity and quality at the SA Mint.

5.2 CHARACTERISTICS OF DATA

5.2.1 Data for the Model

The data for setting up the APC model was obtained from the financial statements and company operations system (SAP, ERP). This data made it possible to calculate the deflated values, change ratios, performance ratios and performance contributions. Quantities; prices and/or values of both input and output were obtained. The period selected was last financial year 2005 (1April 2004 to 31 March 2005), financial year 2006 (1 April 2005 to 31 March 2006), financial year 2007 (1 April 2006 to 31 March 2007) and half financial year 2008 (1 April 2007 to 30 September 2007). This period is in line with the time the company, started the world class manufacturing journey.

5.2.2 Respondents

The sampling frame of this study consisted of 100 employees of South African Mint Company using probability sampling procedure presented in chapter 4. This represents about a third of the total permanent staff. Of the 100 employees given 83 survey questionnaires were returned. This equates to 83% of the selected sample.

The sample was made up of 41 team members, which are operators and analysts, 21 team leaders, which are supervisors, foremen and assistant foremen. These two groups constituted, about 75% of the returned survey sample. The rest was made of middle management, senior management and specialist, which were 12, 4 and 5, respectively (Figure 5-1).

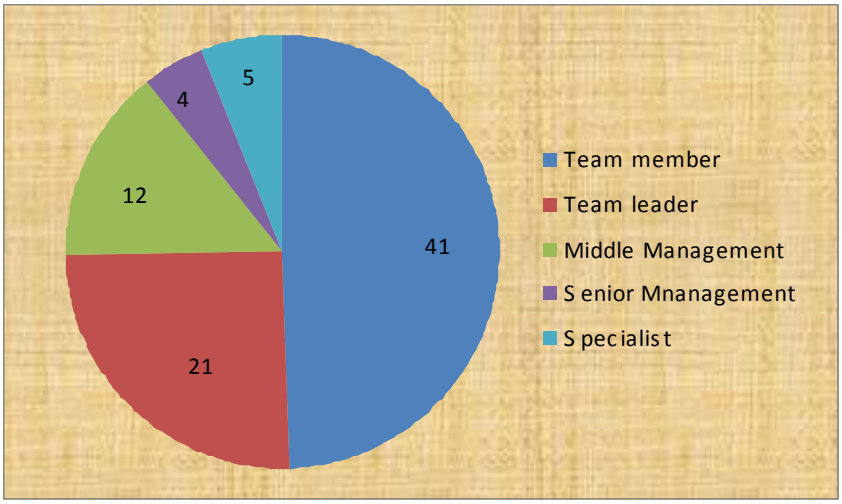

Figure 5-1The positional distribution of the survey respondents

Figure 5-2 depicts the distribution of the respondents as per department; ~55.4% of the survey was from production, 22.9% were service providers (laboratory, quality, safety) and 8.5% engineering department. The rest of the correspondents were from HR, Finance and others (Executives and Production Engineering).

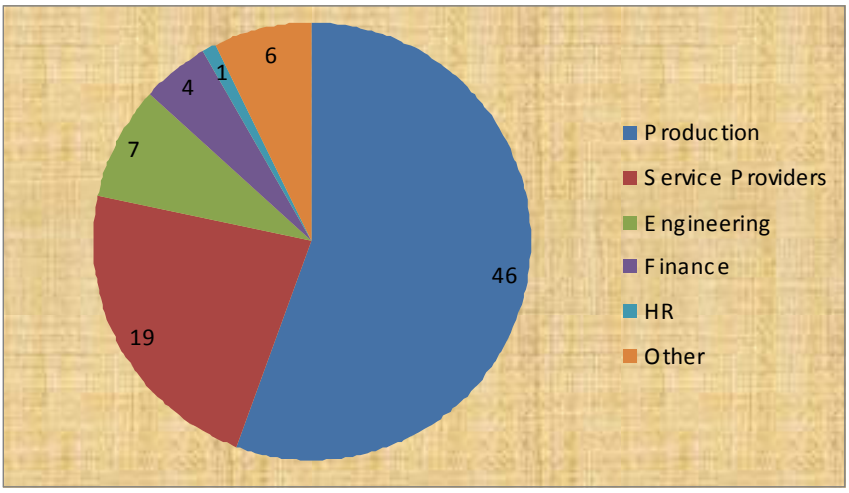

Figure 5-2 The departmental distribution of the survey respondents

5.3 RESEARCH RESULTS

5.3.1 APC Model Results

Performance data was gathered from the company's historical records. The data was from financial year starting from 1 April 2004, to 30 September 2007 (half year of financial year 2008). All required quantity, price and value of both the outputs and inputs were obtained or calculated from any of the two available variables.

The outputs were the manufactured products (product A-K), and the inputs were material, labour, energy, capital and miscellaneous. The material utilised for manufacturing were the casting material, plating material and the base material, which was to be electroplated during circulation coins' production. The labour was calculated collectively across the production area, the data was not separated into employees. The energy items which directly affect production are gasses and fuel, which are required in the furnaces. In that regard, the gas and fuel was the computed item for energy input. The capital selected was direct depreciation and the miscellaneous costs were risk control costs like refuse removal.

A Series of calculations were followed during the set up of the APC model using Microsoft Excel. As a point of departure; deflated values (VL) were calculated from the values, and the results are tabulated in Tables 5-1 to 5-4, for financial year 2005, 2006, 2007 and 2008, respectively.

Table 5-1 Quantity, price, value and deflated values of input and output during financial year 2005.

		2005			
OUTPUTS	**Product Name**	**Q1**	**P1**	**V1**	**VL1**
	Product A	29,344,000	1.300	38,138,843	38,138,843
	Product B	54,927,000	0.343	18,843,818	18,843,818
	Product C	51,474,000	0.300	15,449,424	15,449,424
	Product D	43,924,000	0.146	6,423,885	6,423,885
	Product E	113,038,000	0.129	14,551,164	14,551,164
	Product F	196,000,000	0.100	19,513,175	19,513,175
	Product G	534,176,000	0.154	82,229,132	82,229,132
	Product I	-	0.380	-	-
	Product J	-	0.238	-	-
	Product K	-	0.066	-	-
	Other Sales				
TOTAL OUTPUT		**1,022,883,000**		**195,149,442**	**195,149,442**
INPUTS					-
	Plated Metal	4,486,460	5.528	24,800,860	24,800,860
	Casting Metal A	1,050,557	17.770	18,668,397	18,668,397
	Casting Metal B	105,004	106.520	11,185,050	11,185,050
	Plating Metal A	224,000	17.770	3,980,480	3,980,480
	Plating Metal B	58,500	106.520	6,231,420	6,231,420
	Chemicals	1,087,485	6.460	7,025,174	7,025,174
TOTAL MATERIAL		**7,012,006**		**71,891,379**	**71,891,379**
LABOUR	Coin Producer	44,643	774.3589141	34,569,705	34,569,705
TOTAL LABOUR	Coin Producer	44,643	774.3589141	**34,569,705**	34,569,705
GASS AND FUEL	Fuel and Gases	1,451,073	0.786488236	1,141,252	1,141,252
TOTAL ENERGY		**1,451,073**		**1,141,252**	**1,141,252**
CAPITAL	Depreciation direct	126,338,240	0.1	12,633,824	12,633,824
TOTAL CAPITAL		**126,338,240**		**12,633,824**	**12,633,824**
MISCELLANEOUS	Risk Control A	140	2,023.80	283,332	283,332
	Risk Control B	5,919	36.05085318	213,385	213,385
TOTAL MISC		**6,059**		**496,717**	**496,717**
TOTAL INPUT				**120,732,877**	**120,732,877**
GROSS PROFIT (%)				**38.13**	**38.13**
DEFLATED MARGIN (%)				**38.13**	

In financial year 2005, seven products were produced by the circulation coins profit center, as denoted by product A to G in Table 5-1. In this period, 1,022 billion coins were made and sold for a value of ZAR195, 2 million. The total manufacturing cost in this period was ZAR 120.7 million, which culminated in a gross profit of 38%. The deflated value (VL1) is the same as the (V1) because financial year 2005, was selected as the base period.

Table 5-2 tabulates the results of financial year 2006. In the results the gross profit was 34.0%, with the total revenue of ZAR 180.2 million from sales of 709, 2 million coins. The product range during this period consisted of eleven different types of circulation coins products. These products were both RSA and export business products.

Table 5-2 Quantity, price, and value and deflated values of input and output during 2006 financial year

		2006			
OUTPUTS	**Product Name**	**Q2**	**P2**	**V2**	**VL2**
	Product A	35,584,000	1.434	51,026,363	46,249,066.41
	Product B	13,500,000	0.625	8,442,000	4,631,447.96
	Product C	20,640,000	0.477	9,837,857	6,194,896.81
	Product D	28,608,000	0.224	6,398,531	4,183,920.00
	Product E	57,680,000	0.177	10,235,670	7,425,035.11
	Product F	90,720,000	0.130	11,775,695	9,031,812.63
	Product G	435,008,000	0.173	75,348,919	66,963,566.97
	Product I	12,109,000	0.380	4,600,539	4,600,539.04
	Product J	9,000,000	0.238	2,140,650	2,140,650.00
	Product K	6,336,000	0.066	421,096	421,095.63
TOTAL OUTPUT		**709,185,000**		**180,227,319**	**151,842,030.56**
INPUTS					
	Plated Metal	4,062,340	6.312	25,641,475	22,456,351.78
	Casting Metal A	827,018	18.210	15,060,003	14,696,114.84
	Casting Metal B	149,568	90.030	13,465,642	15,932,024.94
	Plating Metal A	162,974	18.210	2,967,757	2,896,047.98
	Plating Metal B	22,950	90.030	2,066,189	2,444,634.00
	Chemicals	788,024	9.309	7,335,987	5,090,650.25
TOTAL MATERIAL		**6,012,874**		**66,537,052**	**63,515,823.78**
LABOUR	Coin Producer	29,586	1220.847698	36,120,000	22,910,182.83
TOTAL LABOUR	Coin Producer	29,586	1220.847698	**36,120,000**	22,910,182.83
GASS AND FUEL	Fuel and Gases	1,365,664	1.13427168	1,549,034	1,074,078.67
TOTAL ENERGY		1,365,664		**1,549,034**	**1,074,078.67**
CAPITAL	Depreciation direct	71,270,500	0.200	14,254,100	7,127,050.00
TOTAL CAPITAL		**71,270,500**		**14,254,100**	**7,127,050.00**
MISCELLANEOUS	Risk Control A	87	3186.241379	277,203	176,070.60
	Risk Control B	6,323	33.22238811	210,065	227,949.54
TOTAL MISC				**487,268**	**404,020.14**
TOTAL INPUT				**118,947,455**	**95,031,155.43**
GROSS PROFIT (%)				**34.00**	**37.41**
DEFLATED MARGIN (%)				**37.41**	

The sales of ZAR180.2 million when deflated using the price of financial year 2005 result in sales of ZAR151.8 million. There is a similar deflation for the total input resulting in a decrease of about ZAR 23 million from ZAR118.9 to ZAR95.0 million. The net effect of deflated gross profit is an increase from 34.0% to 37.4%. In Table 5.3, the results of financial year 2007 shows a deflated percentage margin of 39.95%, and a 15.4% increase from the normal gross margin which is made up of ZAR140.9 cost of goods sold and ZAR187.0 million sales revenue.

Table 5-3 Quantity, price, value and deflated values of input and output during 2007 financial year

	2007			
OUTPUTS	**Q3**	**P3**	**V3**	**VL3**
	13,328,000	1.864	24,847,367	17,322,604
	1,001,000	0.731	731,327	343,413
	9,360,000	0.663	6,203,512	2,809,314
	54,942,400	0.203	11,152,415	8,035,326
	41,592,000	0.174	7,224,080	5,354,058
	145,920,000	0.139	20,312,320	14,527,360
	703,968,000	0.159	111,667,241	108,366,302
	6,144,000	0.322	1,978,161	2,334,273
	4,000,000	0.238	951,400	951,400
	18,664,000	0.105	1,964,581	1,240,424
TOTAL OUTPUT	**998,919,400**		**187,032,405**	**161,284,475**
INPUTS				
	5,678,210.00	5.363	30,454,105	31,388,776
	635,177.29	31.040	19,715,903	11,287,100
	90,539.41	93.660	8,479,921	9,644,258
	265,069.00	31.821	8,434,777	4,710,276
	12,109.50	93.660	1,134,176	1,289,904
	1,105,100.08	8.133	8,988,215	7,138,971
TOTAL MATERIAL	**7,786,205.28**		**77,207,096.83**	**65,459,285**
LABOUR	29882	1397.838163	41770200	23,139,393
TOTAL LABOUR	29882	1397.838163	**41,770,200**	**23,139,393**
GASS AND FUEL	1,553,194	1.260	1,957,102	1,221,569
TOTAL ENERGY			**1,957,102**	**1,221,569**
CAPITAL	64,790,000	0.3	19,437,000	6,479,000
TOTAL CAPITAL			**19,437,000**	6,479,000
MISCELLANEOUS	102	3251.794118	331,683	206,428
	9,553	29.04640532	277,480	344,394
TOTAL MISC			**609,163**	**550,821**
TOTAL INPUT			**140,980,562**	**96,850,069**
GROSS PROFIT (%)			**24.62**	**39.95**
DEFLATED MARGIN (%)			**39.95**	

In the six-month period ending 30 September 2007, 611 million circulation coin units were produced resulting in sales revenue of ZAR140.5 million (Table 5-4). The gross profit was found to be 14.61%, and increased to 25.06%, when using the deflated values.

After obtaining all the gross profits and the deflated values using 2005 financial year as the base period, the change ratios were calculated, and the data is tabulated in Table 5-5. Table 5-5 shows the calculations for change ratios of values (V_n/V_1, n = 2, 3 or 4), price (P_n/P_1, n = 2, 3 or 4) and quantity (Q_n/Q_1, n = 2, 3 or 4) were conducted from the data presented in Tables 5-1 to 5-4.

Table 5-4 Quantity, price, value and deflated values of input and output during first six months of 2008 financial year

		2008			
OUTPUTS	**Product Name**	**Q4**	**P4**	**V4**	**VL4**
	Product A	4,816,000	1.807	8,702,174.02	6,259,429
	Product B	18,000,000	0.787	14,167,578.97	6,175,264
	Product C	24,000,000	0.576	13,825,473.65	7,203,368
	Product D	35,904,000	0.212	7,624,875.78	5,250,960
	Product E	56,000,000	0.172	9,640,842.07	7,208,772
	Product F	88,320,000	0.132	11,659,789.40	8,792,876
	Product G	352,128,000	0.163	57,236,244.19	54,205,318
	Product I	4,800,000	0.355	1,703,738.88	1,823,651
	Product J	15,000,000	0.147	2,197,800.00	3,567,750
	Product K	12,222,000	0.161	1,967,909.01	812,284
	Other Sales			11,731,750.00	-
TOTAL OUTPUT		**611,190,000**		**140,458,176**	**101,299,671**
INPUTS					-
	Plated Metal	4235620	5.738337575	24,305,417	23,414,232
	Casting Metal A	486808.5	49.50999991	24,101,889	8,650,587
	Casting Metal B	71848.59	244.1800003	17,543,989	7,653,312
	Plating Metal A	132336	25.94	3,432,796	2,351,611
	Plating Metal B	52222	116.3600191	6,076,553	5,562,687
	Chemicals	789303.989	9.28920771	7,332,009	5,098,921
TOTAL MATERIAL		**5,768,139.08**		**82,792,652.38**	**52,731,350**
LABOUR	Coin Producer	24854	992.7317937	24673356	19,245,916
TOTAL LABOUR	Coin Producer	24854	992.7317937	**24,673,356**	19,245,916
GASS AND FUEL	Fuel and Gases	1,063,275	1.352	1,437,021	836,253
TOTAL ENERGY				**1,437,021**	836,253
CAPITAL	Depreciation direct	25,913,250	0.4	10,365,300	2,591,325
TOTAL CAPITAL				**10,365,300**	2,591,325
MISCELLANEOUS	Risk Control A	92	4454.163043	409,783	186,190
	Risk Control B	8,834	29.29001585	258,748	318,473
TOTAL MISC				**668,531**	**504,663**
TOTAL INPUT				**119,936,860**	**75,909,508**
GROSS PROFIT (%)				**14.61**	**25.06**
DEFLATED MARGIN (%)				**25.06**	

The change ratios for individual inputs and outputs are easy to compute, but the ones for total sales, material, labour, capital energy and miscellaneous, require a different way of calculation. Q_n/Q_1 for total sales is computed using the ratio of deflated sales in period n (n= 2, 3 or 4) to the sales in period 1. The deflated sales remove the effect of price change, enabling Q_n/Q_1 to be viewed as a quantity-to-quantity ratio.

The change ratio for prices (P_n/P_1) of sales is the ratio of sales in period n to the deflated sales in period n. This ratio is essential to remove the effect of quantity change by using period n quantities at period 1 and period n prices.

The change ratios for V_n/V_1 are calculated easily using the value of the n period divided by the value of period 1. The same formulation is employed for other aggregates.

In general, there is an increase in the change ratio on pricing for the total inputs from period 2 to period 4. Periods 2, 3 and 4 had a price ratio of 1.2517, 1, 4557 and 1.5800, respectively with respect to period 1. Quantity ratio and value ratio increase between financial year 2006 and 2007, but decreased in financial year 2008. This is hardly surprising considering that financial year 2008 results are only for six months as opposed to full year for other periods. The same trend is observed in the total output or sales.

Table 5-5 Change ratios of circulation coins profit center for period 1April 2004 to 30 September 2007.

		Change Ratios								
OUTPUTS	**Product Name**	**Q2/Q1**	**Q3/Q1**	**Q4/Q1**	**P2/P1**	**P3/P1**	**P4/P1**	**V2/V1**	**V3/V1**	**V4/V1**
	Product A	1.2126	0.4542	0.1641	1.1033	1.4344	1.3903	1.3379	0.6515	0.2282
	Product B	0.2458	0.0182	0.3277	1.8228	2.1296	2.2942	0.4480	0.0388	0.7518
	Product C	0.4010	0.1818	0.4663	1.5881	2.2082	1.9193	0.6368	0.4015	0.8949
	Product D	0.6513	1.2509	0.8174	1.5293	1.3879	1.4521	0.9961	1.7361	1.1870
	Product E	0.5103	0.3679	0.4954	1.3785	1.3493	1.3374	0.7034	0.4965	0.6625
	Product F	0.4629	0.7445	0.4506	1.3038	1.3982	1.3260	0.6035	1.0410	0.5975
	Product G	0.8144	1.3179	0.6592	1.1252	1.0305	1.0559	0.9163	1.3580	0.6961
	Product I	-	-	-	1.0000	0.8474	0.9342	-	-	-
	Product J	-	-	-	1.0000	1.0000	0.6160	-	-	-
	Product K	-	-	-	1.0000	1.5838	2.4227	-	-	-
	Other Sales	-	-	-	-	-	-	-	-	-
TOTAL OUTPUT		**0.7781**	**0.8265**	**0.5191**	**1.1869**	1.1596	1.3866	0.9235	0.9584	0.7197
INPUTS										
	Plated Metal	0.9055	1.2656	0.9441	1.1418	0.9702	1.0381	1.0339	1.2279	0.9800
	Casting Metal A	0.7872	0.6046	0.4634	1.0248	1.7468	2.7862	0.8067	1.0561	1.2911
	Casting Metal B	1.4244	0.8622	0.6842	0.8452	0.8793	2.2923	1.2039	0.7581	1.5685
	Plating Metal A	0.7276	1.1833	0.5908	1.0248	1.7907	1.4598	0.7456	2.1190	0.8624
	Plating Metal B	0.3923	0.2070	0.8927	0.8452	0.8793	1.0924	0.3316	0.1820	0.9751
	Chemicals	0.7246	1.0162	0.7258	1.4411	1.2590	1.4380	1.0442	1.2794	1.0437
TOTAL MATERIAL		**0.8835**	**0.9105**	**0.7335**	**1.0476**	1.1795	1.5701	0.9255	1.0739	1.1516
LABOUR	Coin Producer	0.6627	0.6694	0.5567	1.5766	1.8052	1.2820	1.0448	1.2083	0.7137
TOTAL LABOUR	Coin Producer	**0.6627**	**0.6694**	**0.5567**	**1.5766**	1.8052	1.2820	1.0448	1.2083	0.7137
GASS AND FUEL	Fuel and Gases	0.9411	1.0704	0.7328	1.4422	1.6021	1.7184	1.3573	1.7149	1.2592
TOTAL ENERGY		**0.9411**	**1.0704**	**0.7328**	**1.4422**	1.6021	1.7184	1.3573	1.7149	1.2592
CAPITAL	Depreciation direct	0.5641	0.5128	0.2051	2.0000	3.0000	4.0000	1.1282	1.5385	0.8204
TOTAL CAPITAL		**0.5641**	**0.5128**	**0.2051**	**2.0000**	**3.0000**	4.0000	1.1282	1.5385	0.8204
MISCELLANEOUS	Risk Control A	0.62143	0.7286	0.6571	1.5744	1.6068	2.2009	0.9784	1.1707	1.4463
	Risk Control B	1.06825	1.6140	1.4925	0.9215	0.8057	0.8125	0.9844	1.3004	1.2126
TOTAL MISC		**0.8134**	**1.1089**	**1.0160**	**1.2060**	**1.1059**	**1.3247**	**0.9810**	**1.2264**	**1.3459**
TOTAL INPUT		**0.7871**	**0.8022**	**0.6287**	**1.2517**	**1.4557**	**1.5800**	**0.9852**	**1.1677**	**0.9934**
GROSS PROFIT (%)										
DEFLATED MARGIN (%)										

Appendix A1-A3 and Figures 5-2 to 5.14 present the results of performance indicators in both indexes and in rand (ZAR) for period 2, 3 and 4. The performance index results were calculated by computing the quantity change ratio of total output divided by the output or total input. The same computation was done for the price recovery index and profitability index. The rand contributions of productivity and profitability were calculated by subtracting change ratio of the input from the change ratio of the output, and then multiplying by the price of the input in the base period (viz. period 1). The rand contribution for price recovery is the difference between the profitability contribution and the productivity contribution.

Figure 5-3 shows the productivity, price recovery and profitability chart of the base metal denoted as plated metal. Although the trend shows a positive price recovery, the productivity and the profitability are negative. There was a dip in productivity from period 2 (financial year 2006) to period 3 (financial year 2007). Although, productivity remained negative there was stability with a marginal increase from period 3 to period 4 (financial year 2008).

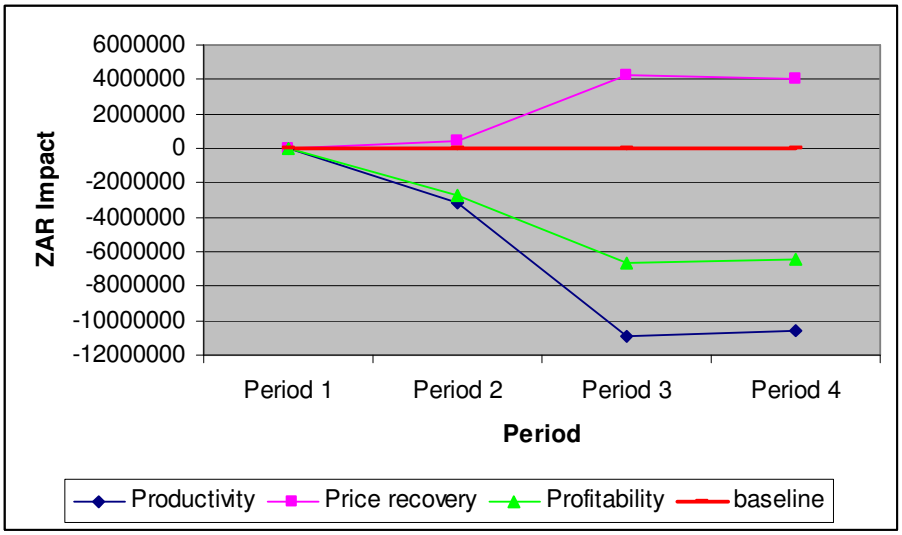

Figure 5-3 Plated metal productivity, price recovery and productivity chart

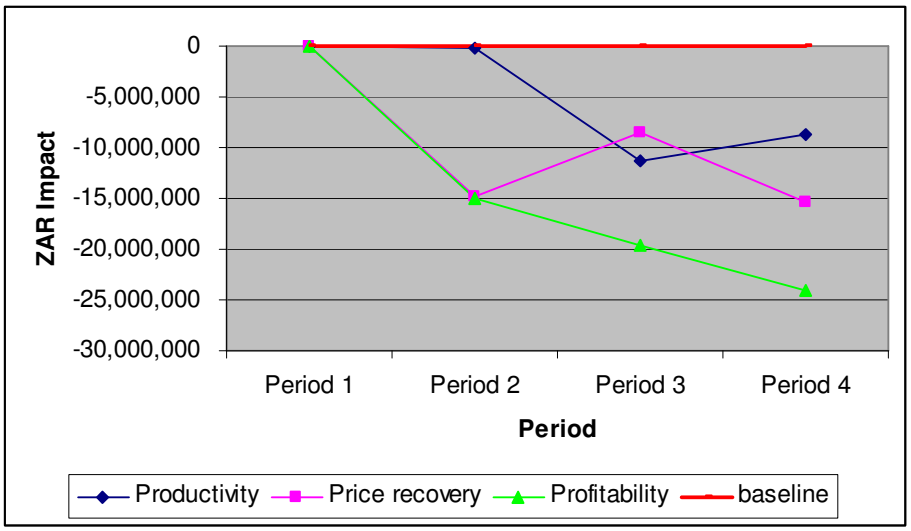

Figure 5-4 Casting Metal A productivity, price recovery and productivity chart

The casting material, copper, in Figure 5-4 shows a negative trend for productivity, price recovery and profitability. The price recovery was -ZAR 15 million in period 2, and then there was an improvement of more than 30% in price recovery in period 3, after which a further decline was observed in period 4. However, productivity and profitability are negative, and improvement is shown in productivity between periods 3 and 4. The impact of this improvement is not felt by profitability at this stage.

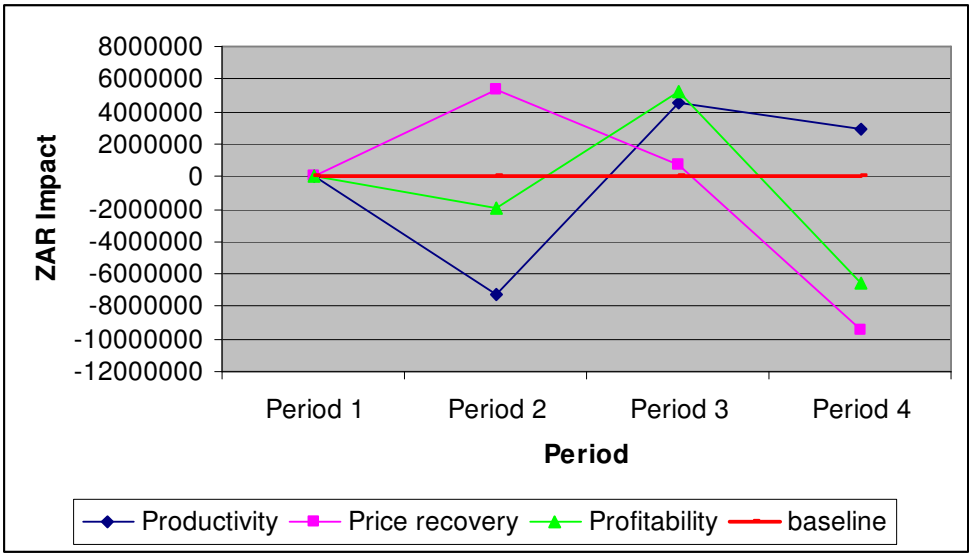

Figure 5-5 Casting Metal B productivity, price recovery and productivity chart

There other casting material (casting metal B), which is nickel is showing a negative price recovery and profitability even though the productivity has been positive after period 2 (Figure 5-5).

The performance of plating metal A and B, are depicted in Figures 5.6 and 5.7. The price recovery has been fairly good for all the periods except for financial year 2007 (period 3). Although productivity was negative for the last two periods; the profitability remained positive (Figure 5-6). In the plating metal B chart (Figure 5-7), the productivity increased, since the base period, except in financial year 2008. Overall the profitability was positive for plating metal B (Figure 5-7).

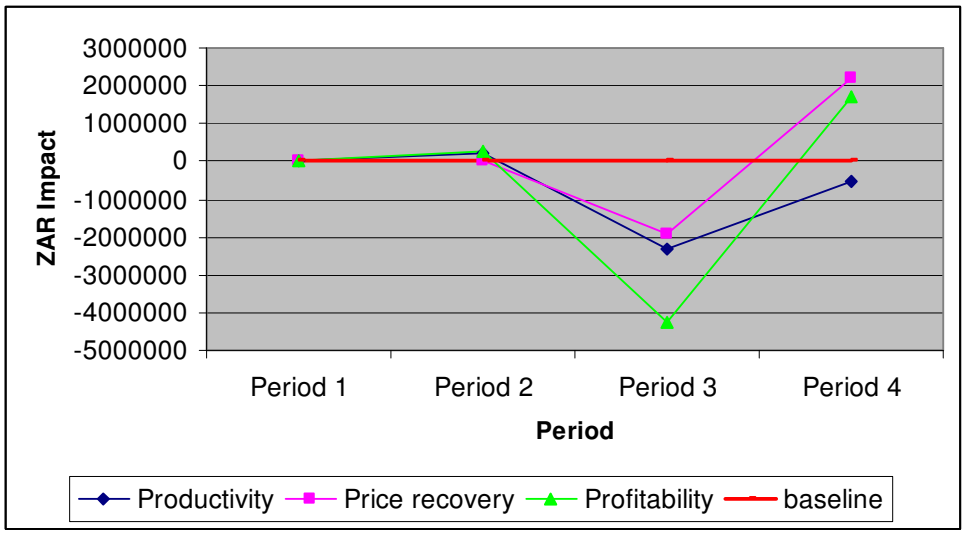

Figure 5-6 Plating Metal A productivity, price recovery and productivity chart

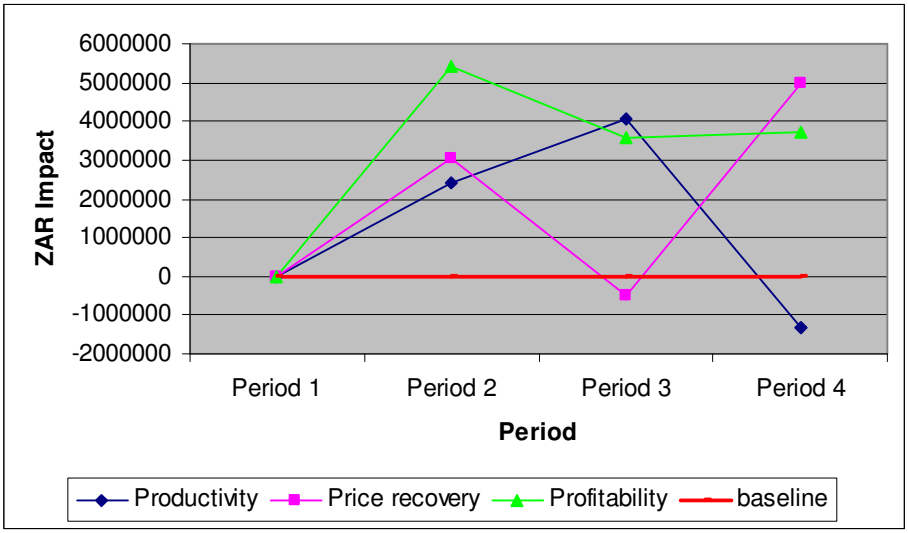

Figure 5-7 Plating Metal B productivity, price recovery and productivity chart

Figure 5-8 depicts the trends of productivity, profitability and price recovery of chemicals. Price recovery is shown as the main determinant of the profitability, with productivity having a limited impact. The trends are varying for this material with the highest positive rand impact, realised in financial year 2007.

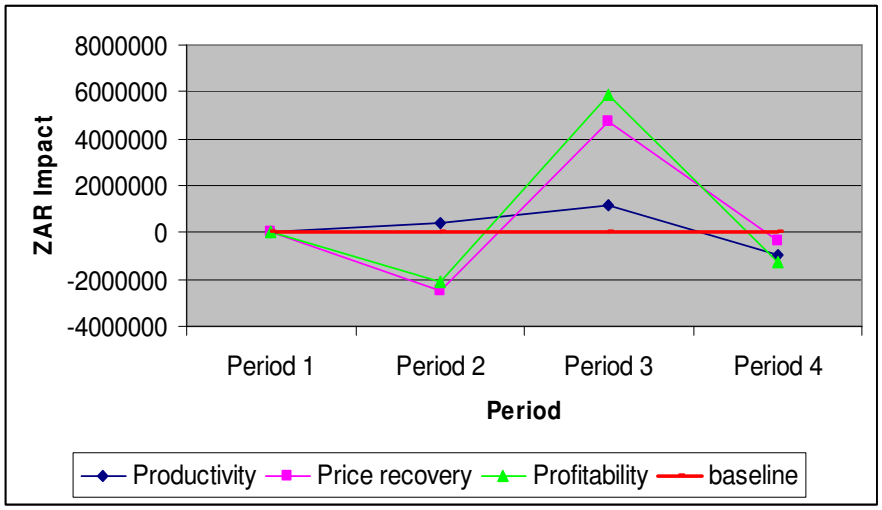

Figure 5-8 Chemicals productivity, price recovery and productivity chart

Figure 5-9 shows the overall material productivity, price recovery and profitability. The overall trend for productivity shows a break-even in period 2 when compared to period 1, after which an increase from period 3 and further increase in period 4. The

price recovery is a cause for concern, although in period 2 and 4 there is almost a break even. There is a poor price recovery in period 3. It is clear from the chart (Figure 5-9) that the overall profitability was good.

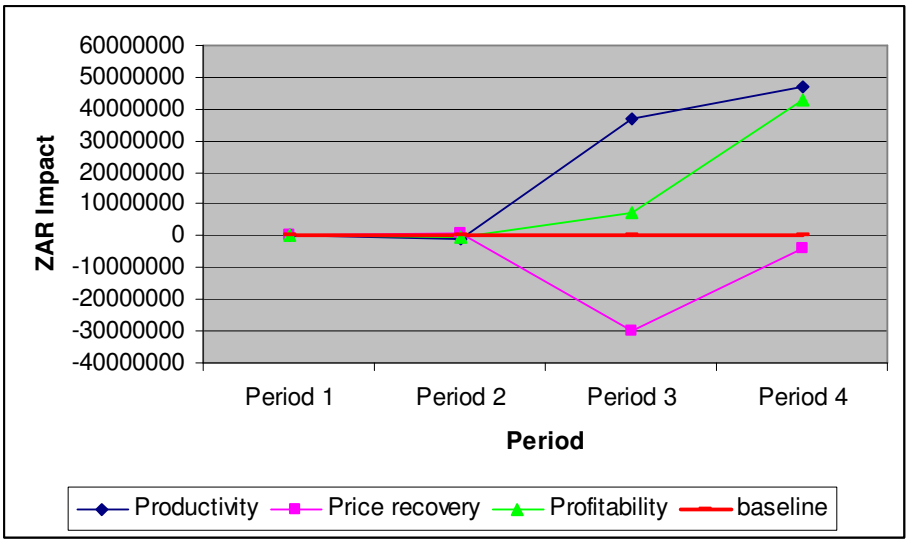

Figure 5-9 Total Metal productivity, price recovery and productivity chart

The overall profitability and price recovery of labour (Figure 5-10) has been negative in period 2 and 3, and has since picked up and became positive in period 4. The productivity was been always positive from period 2 to period 4, with highest peak at in period 3. This means there was a change in the period 2 and 3 (see section 6.2).

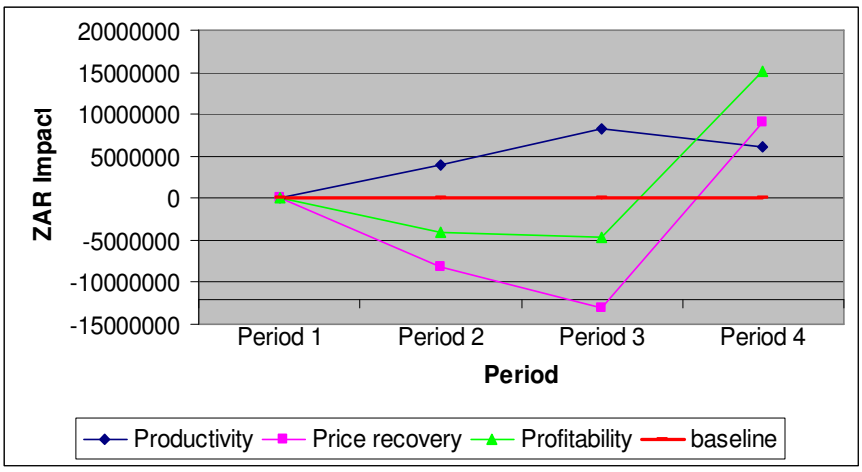

Figure 5-10 Labour productivity, price recovery and productivity chart

Gas and fuel shows poor productivity, price recovery and profitability, all being negative, with the worst price recovery and productivity in period 4 and 3, respectively (Figure 5-11). Period 4 show a slight difference in profitability impact, with productivity positively counter acting the poor price recovery during this period

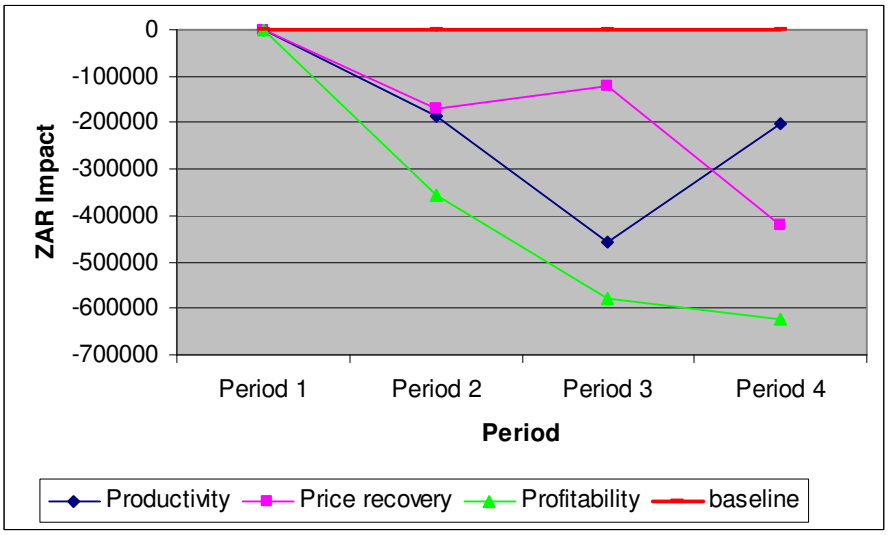

Figure 5-11 Energy productivity, price recovery and productivity chart

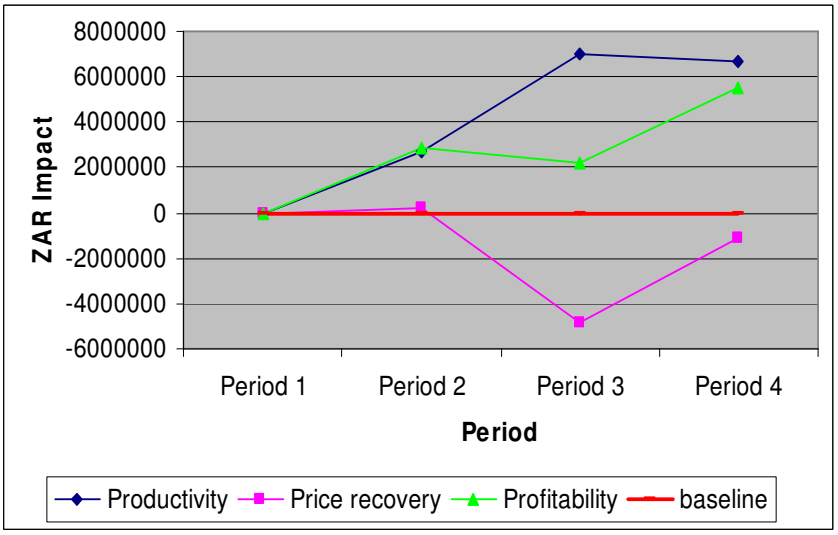

Figure 5-12 Capital productivity, price recovery and productivity chart

Capital productivity and profitability shows a positive impact, while price recovery shows a negative impact. It is encouraging to find out that productivity has offset the negative impact of price recovery (Figure 5-12).

There were two miscellaneous costs which were computed (Figure 5-13 and 5-14). The costs selected directly impact on the cost of goods sold (*viz*. waste removal), as per SA Mint manufacturing account denoted by risk control A and risk control B. In both miscellaneous costs, the productivity and profitability are negative. The price recovery is positive for risk control B, but negative for risk control A.

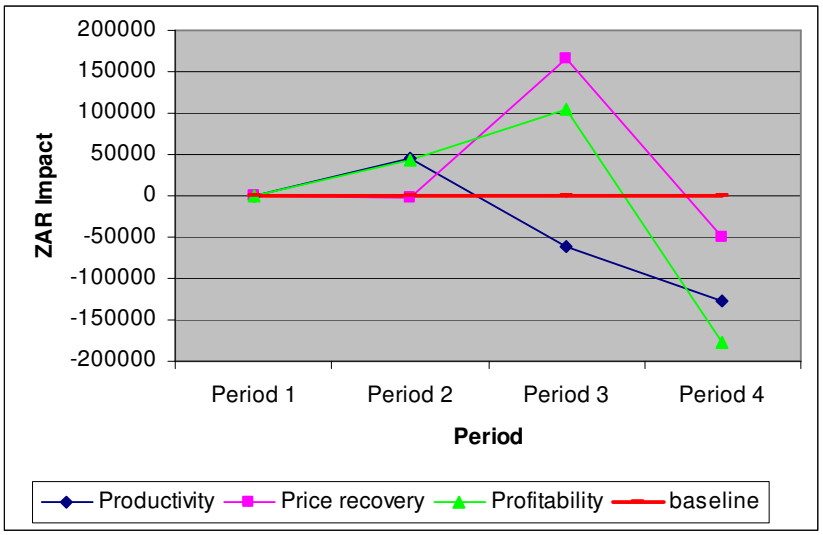

Figure 5-13 Risk control A productivity, price recovery and productivity chart

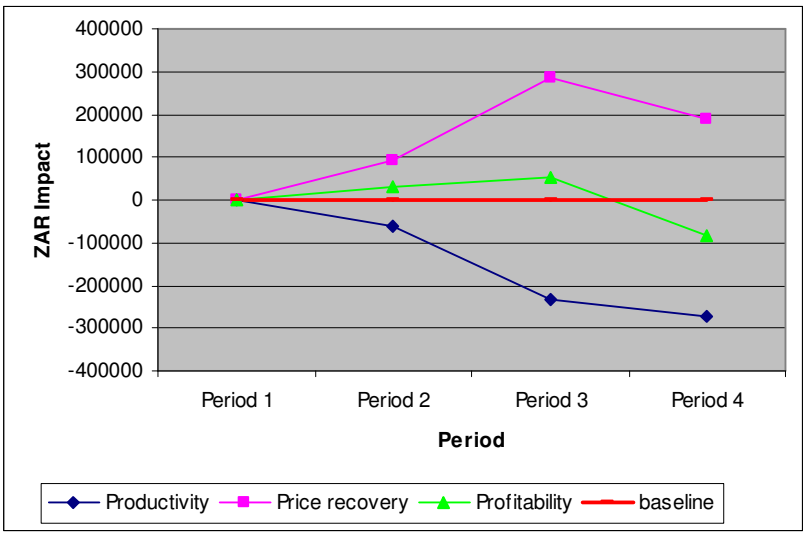

Figure 5-14 Risk control B productivity, price recovery and productivity chart

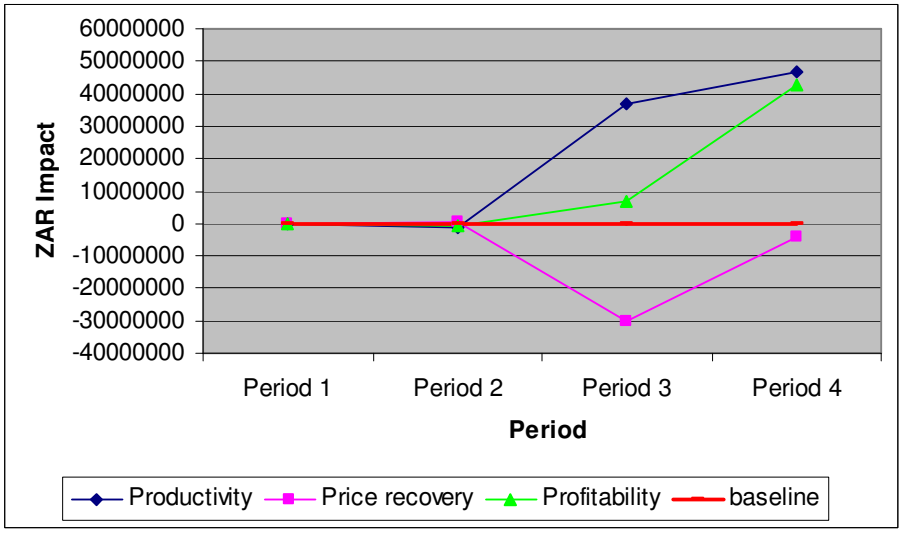

Figure 5-15 Overall circulation coin profit center profitability, productivity and price recovery

The overall profit center performance is showing good productivity and profitability, and a price recovery that is negative for periods 3 and 4 (Figure 5-15). The merits of this are discussed in chapter 6, considering the mandate of the SA Mint as discussed in chapter 1.

5.3.2 Quality / Productivity Results

Table 5-6 Summary statistics of the productivity variables.

VARIABLE	Work output by peer exceed expectation	Inputs received in timely fashion	Cost effective production of products	Product are produced in error-free process	Operations are reliable
n	83	83	83	83	83
Mean	2.92	2.51	2.37	2.27	2.58
Standard Deviation	0.90	0.69	0.89	0.56	0.73
Minimum	2.00	1.00	1.00	1.00	1.00
Q1	2.00	2.00	2.00	2.00	2.00
Median	3.00	2.00	2.00	2.00	3.00
Q3	4.00	3.00	3.00	3.00	3.00
Maximum	5.00	4.00	5.00	4.00	4.00
Skewness	0.37	0.55	0.55	0.39	0.29
Kurtosis	-1.20	-0.18	0.06	0.31	-0.38
Mode	2.00	2.00	2.00	2.00	2.00

The results of the summary statistics for both quality and productivity are given in Tables 5-6 and 5-7, respectively. There were 83 respondents as denoted by n, with mean values for productivity ranging from 2.27 to 2.92, while the ranges for quality scores were 1.64 to 4.31. As discussed in chapter 4, Likert scale was used with 1 being strongly disagree, 2- agree, 3- neither agree or disagree, 4- agree and 5 strongly agreeing.

In the productivity statistics products produced in error-free process and products produced in cost effective manner had lowest means, while process flexibility had a highest mean. The frequency distribution for all five variables is asymmetrical meaning they are positively skewed (0.37, 0.55, 0.55, 0.39, and 0.29). This means that the large frequencies are towards disagreeing end with the survey statements. Smaller frequency is towards the agreeing end with the survey statements. Quality results (Table 5-6) shows mixed skewness, with most frequencies distribution towards the disagreeing end than agreeing end.

Table 5-8 tabulates the Pearson product correlation between quality and productivity. There was a total of 65 indicators were correlation was performed. The correlations ranged from 0.77 to -0.11. As shown, all quality indicators were found to be positively correlated to productivity indicators except for 2 which show negatively correlation. 5

of the 63 positively correlated indicators showed a correlation of less than 0.1, and were regarded as non-correlation. Two-tailed significance p-test was employed at α =0.01 (99%). In these results more than 55% have significance of 99% or above, 74%, have significance of 95% and above. The remaining 26% have significance of less than 95%.

The quality indicators which was found to exhibit the highest correlation to productivity indicators were “incoming material of acceptable quality”, SPC charts widely used and “employee react quickly to solve a problem”. The lowest correlation between quality and productivity indicators were “external customer are loyal”, and “levels of inventory is 95% accurate”.

Table 5-7 Summary statistics of the quality variables

VARIABLE	Incoming material of acceptable quality	SPC is widely used	Level of inventory is 95% accurate	Internal processes are satisfactory	Work output always delivered accurately	external customers are satisfied	Work output consistently delivered complete	Satisfied with quality of peer work output	No change or rework needed after final product	produced products always meet specification	External customers are loyal	Employee react quickly to solve unexpected problems	No scrap is produced
n	83	83	83	83	83	83	83	83	83	83	83	83	83
Mean	2.98	2.96	3.01	2.35	2.49	2.78	2.43	2.11	1.92	2.13	4.31	2.47	1.64
Standard Deviation	0.91	0.98	0.55	0.76	0.77	0.70	0.86	0.81	0.91	0.88	0.76	0.61	0.69
Minimum	2.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	2.00	2.00	1.00
Q1	2.00	2.00	3.00	2.00	2.00	2.00	2.00	2.00	1.00	1.50	4.00	2.00	1.00
Median	3.00	3.00	3.00	2.00	2.00	3.00	2.00	2.00	2.00	2.00	4.00	2.00	2.00
Q3	4.00	4.00	3.00	3.00	3.00	3.00	3.00	3.00	2.00	3.00	5.00	3.00	2.00
Maximum	5.00	5.00	4.00	4.00	5.00	5.00	4.00	4.00	5.00	4.00	5.00	4.00	3.00
Skewness	0.25	0.15	-0.44	1.05	0.84	-0.11	0.69	0.22	1.25	0.39	-0.77	0.94	0.62
Kurtosis	-1.33	-0.79	2.15	0.53	0.60	1.16	-0.38	-0.60	2.01	-0.52	-0.28	-0.10	-0.72
Mode	2.00	2.00	3.00	2.00	2.00	3.00	2.00	2.00	2.00	2.00	5.00	2.00	1.00

Table 5-8 Pearson product correlation between quality and productivity

QUALITY	**PRODUCTIVITY**				
	Work output by peer exceed expectation	Inputs received in timely fashion	Cost effective production of products	Product are produced in error-free process	Operations are reliable
Incoming material of acceptable quality	0.77 (< 0.0001)	0.33 (0.0022)	0.30 (0.0066)	0.61(<0.0001)	0.29 (0.0068)
SPC is widely used	0.45 (<0.0001)	0.32 (0.0035)	0.25 (0.0214)	0.39(0.0003)	0.42 (<0.001)
Level of inventory is 95% accurate	0.15 (0.1778)	0.27 (0.0125)	0.16 (0.1387)	0.26(0.0161)	0.28 (0.0094)
Internal processes are satisfactory	0.33 (0.0023)	0.17 (0.1202)	0.29 (0.0074)	0.38(0.0004)	0.29 (0.0077)
Work output always delivered accurately	0.31 (0.0048)	0.28 (0.0098)	0.21 (0.0605)	0.37 (0.0006)	0.18(0.1064)
External customers are satisfied	0.34 (0.0017)	0.33 (0.0021)	0.23 (0.0374)	0.33 (0.0021)	0.37 (0.0007)

N = 83 $\alpha = 0.01$ 2 - tailed p in parenthesis

Cont…..

QUALITY	**PRODUCTIVITY**				
	Work output by peer exceed expectation	Inputs received in timely fashion	Cost effective production of products	Product are produced in error-free process	Operations are reliable
Work output consistently delivered complete	0.19 (0.0852)	0.12 (0.2817)	0.15 (0.1701)	0.34 (0.0017)	0.24 (0.0320)
Satisfied with quality of peer work output	0.35 (0.0013	0.27 (0.01209)	0.16 (0.1431)	0.44 (<0.0001)	0.34 (0.0015)
No change or rework needed after final product	0.30 (0.0054)	0.36 (0.0008)	0.34 (0.0018)	0.23 (0.0341)	0.24 (0.0467)
Produced products always meet specification	0.32 (0.0030)	0.31 (0.0042)	0.06(0.5878)	0.27 (0.0129)	0.18 (0.1000)
External customer are loyal	0.02 (0.8494	0.02 (0.8605)	0.01 (0.9630)	**-0.11 (0.3223)**	**-0.11 (0.3246)**
Employee react quickly to solve unexpected problems	0.69 (<0.0001)	0.41 (0.0001)	0.43 (<0.0001)	0.48 (0.0001)	0.26 (0.0193)
No scrap is produced	0.30 (0.0053)	0.26 (0.0170)	0.24 (0.0281)	0.37 (0.0005)	0.20 (0.0690)

N = 83 α = 0.01 2 - tailed p in parenthesis

Table 5-9 Linear regression outputs for productivity and quality relationship chart

Average Quality	Work output by peer exceed expectation	Inputs received in timely fashion	Cost effective production of products	Product are produced in error-free process	Operations are reliable
n	83	83	83	83	83
R^2	0.45	0.26	0.17	0.42	0.22
SE	0.7	0.6	0.8	0.4	0.7

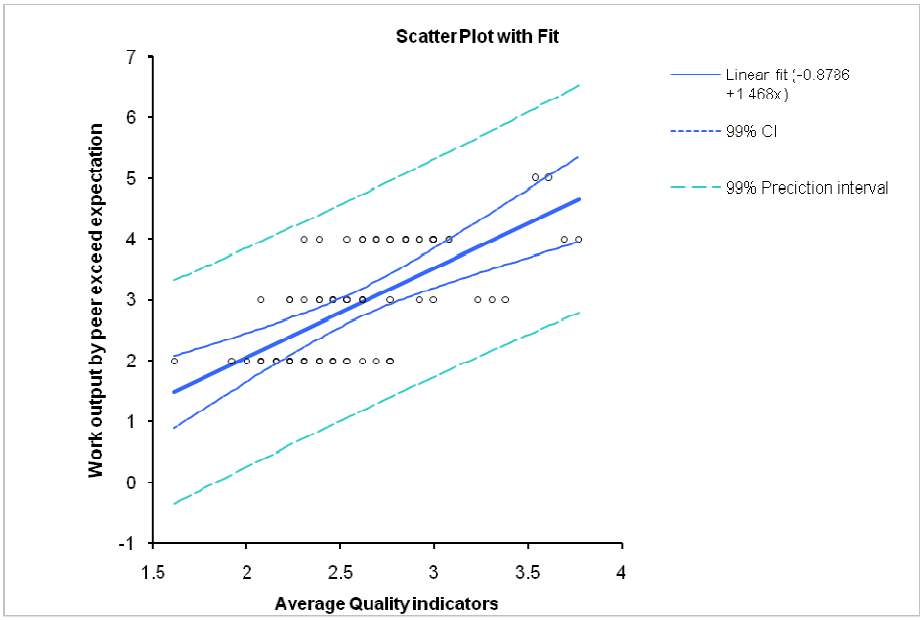

Figure 5-16 The linear regression of work output by peers exceed expectations vs. average quality indicator.

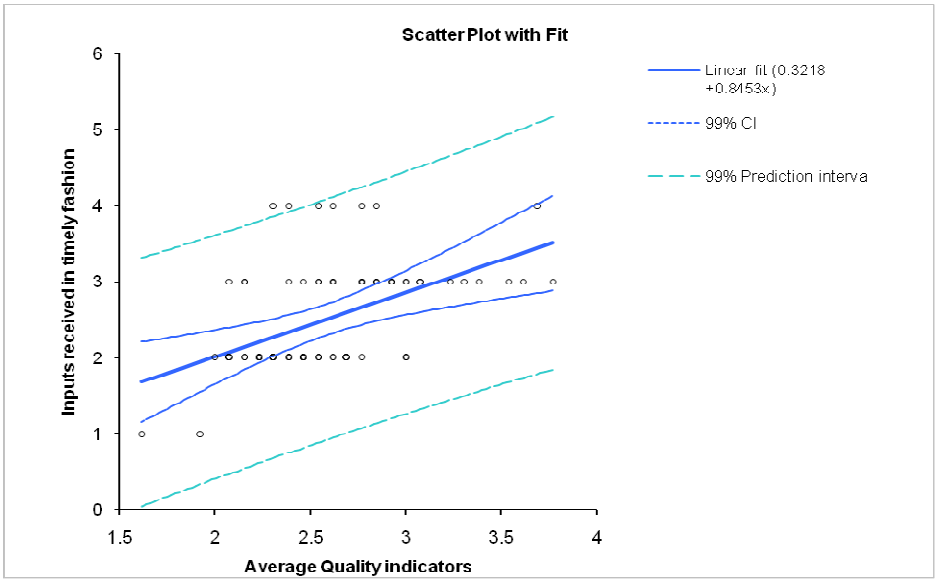

Figure 5-17 The linear regression of input received in timeos fashion by peers vs. average quality indicator.

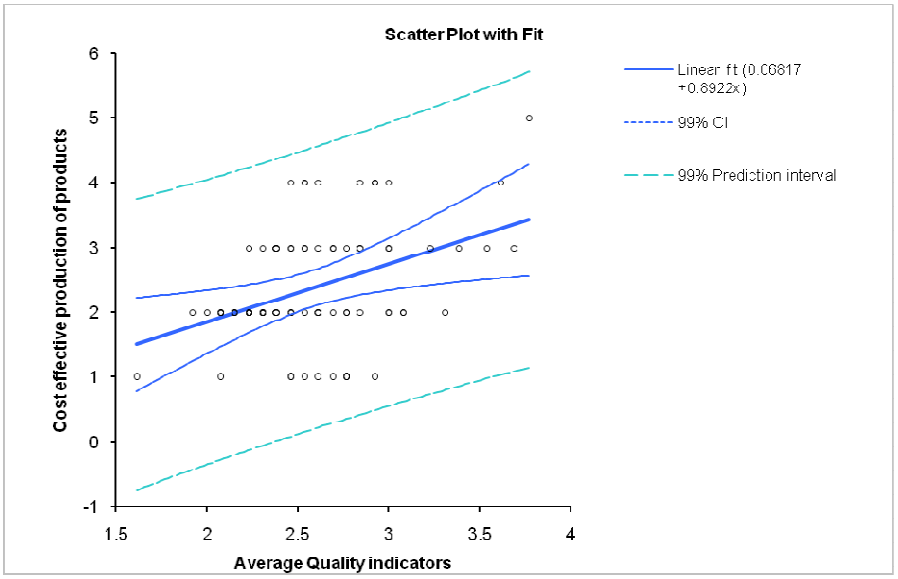

Figure 5-18 The linear regression of cost effect production of products vs. average quality indicator.

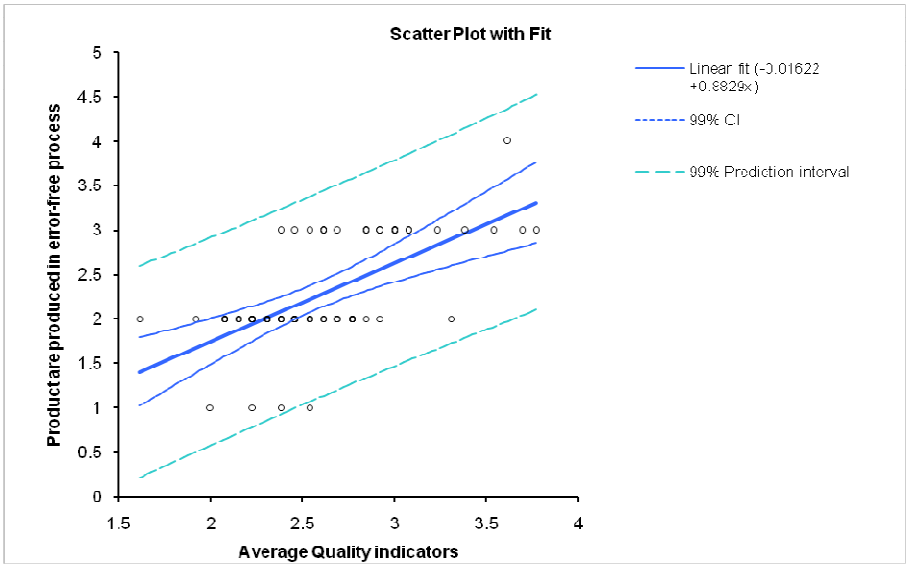

Figure 5-19 The linear regression of products are produced in error-free process vs. average quality indicator.

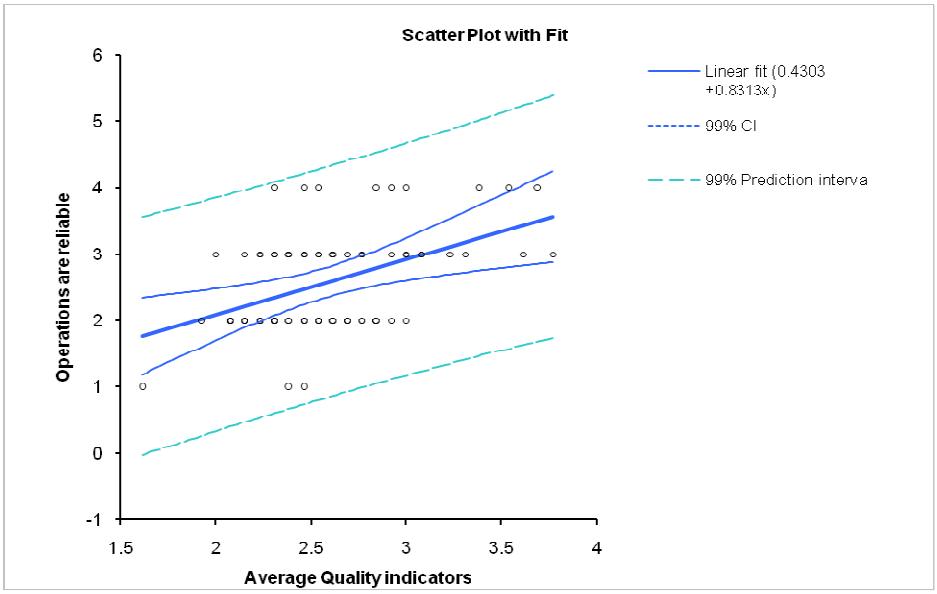

Figure 5-20 The linear regression of operations are reliable vs. average quality indicator.

Figures 5-16 to 5-20 illustrate the linear regression curves and the positive relationship between productivity and quality. The highest relationship denoted by r2 was found for “work output by peer exceed expectation”, while the least correlation was found for “cost effective production of products”. This means there is weak relationship between cost effectiveness and productivity. In summary, the interpreted results show a positive correlation between productivity and quality.

CHAPTER 6

DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

6.1 INTRODUCTION

Having reviewed the literature on profit-linked productivity measurement and having collected the data and setup the APC model; it was apparent that this model provides invaluable information about productivity and profitability in the South African Minting Company. This information allowed for the evaluation of the relationship between quality and productivity using a questionnaire. All these results are tabulated and interpreted in Chapter 5. This chapter is thus the culmination of all stages of the research process, which were undertaken in order to achieve the primary objectives of this study, which was elucidated in chapter 1, and reaffirmed as the problem statement in chapter 3.

The primary objective of this study was as follows:

To setup a profit-linked productivity models to measure productivity in the SA Mint Company, and investigate its relationship to quality in the company.

6.2 DISCUSSION OF RESULTS

6.2.1 APC Model

Profit-linked total factor productivity measurement models are used for trend analysis (Roa, 1993). Productivity and profitability can be analysed in two ways. Firstly, they can be measured as comparisons of variations from competitors or other standard, at one point in time. Secondly, they can be measured as productivity or profitability changes over time in index form (Bernolark, 1997). This study adopted the second approach, although the American Productivity and Quality Model, afforded an opportunity to compute the rand contribution of productivity, price recovery and profitability. This study computed all the trends as tabulated and interpreted in chapter 5.

The results tabulated in Table 5-1 to 5-4 in chapter 5, were used to depict the overall gross profit and the deflated gross profit at the SA Mint. It is clear that there is continuously a decrease in gross profits (Figure 6.1). It is worthwhile to note that the gap between gross profit and deflated profit is not consistent, with highest found in period 3, and lowest in period 2, since period one is ignore because it is the base period. The decrease in gross profits can be attributed to either lower sales or high cost of sales. The sales are made up of price and quantity.

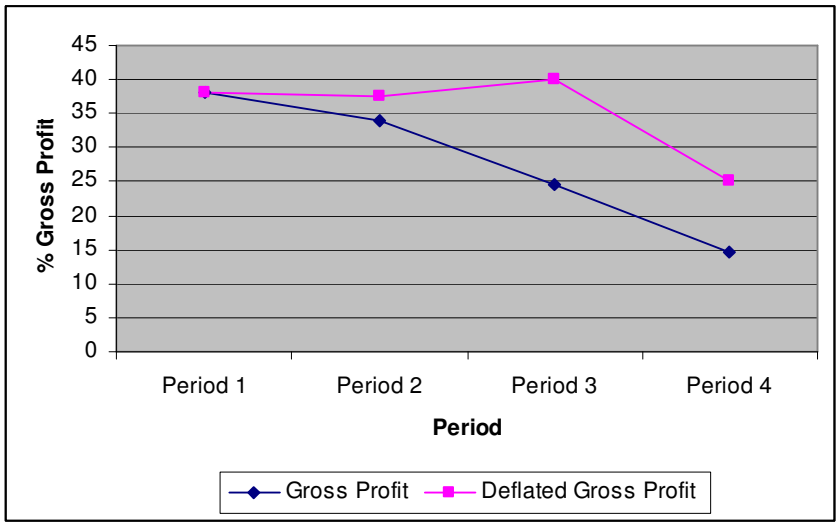

Figure 6-1 The change in gross and deflated gross profit from 2005 financial year to 2008 financial year

When evaluating table 5-1 to 5-4 in chapter 5 it is clear that some of the products were sold at a lower price in 2008 financial year, compared to 2007 financial year. For example, product C was sold at 15.1% lower than previous year; same applies to Product A, which was sold at 3.2% less, and product E was sold at 1.2% less than the previous year. In addition, increases of some product price were marginal, even lower than the inflation rate. Moreover, the export business, where the profit is maximised as per mandate (see section 1.1 in chapter 1) contributed 20% less in the sales revenue of 2008 financial year, compared to the previous year financial period.

Figure 6-2 depicts the increase in price of material which shows an increase of less than 1% from period 2 (financial year, 2006) compared to period 1 (financial year, 2005). When evaluating period 3 compared to period 2, and period 4 compared to period 3, an increase of 4.2% and 17.7% is observed. This increase in material price

is attributed to market mechanism, mainly the increase in raw material (see Figure 1-2 to 1-4, section 1.1 of chapter 1).

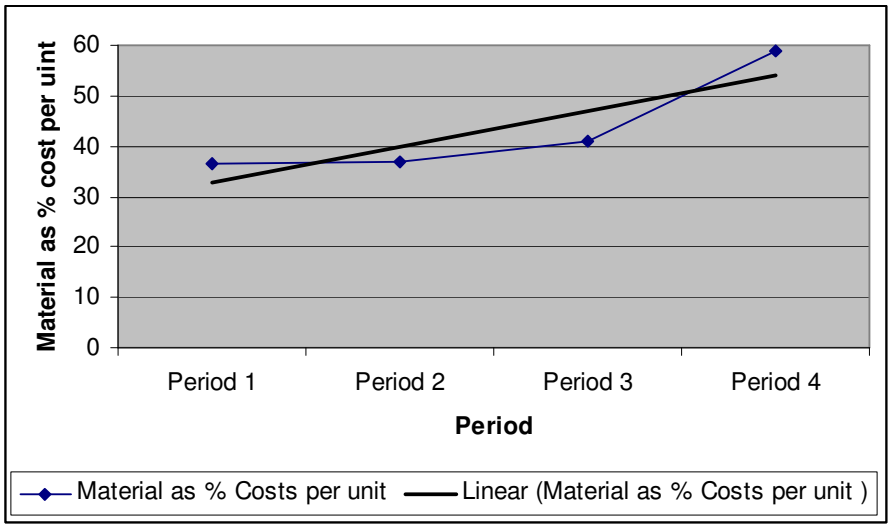

Figure 6-2 Material as percentage cost per unit produced during financial year 2005 to financial year 2008.

A conclusion drawn from the two scenarios shown above is that, there is definitely a need for a productivity measurement at the South African Minting Company, which can decompose profitability to productivity and price recovery. This is the measure which can objectively measure productivity at the SA Mint.

American Productivity and Quality Center (APQC) formerly known as APC developed the model used in the study. All the relevant theoretical background is presented in section 2.3.1 of chapter 2. Of importance is that profitability is the product of productivity and price recovery. The material which is one of the main cost input, ranges from 36 - 59% of the total input costs. This significance resulted in the main material being decomposed, resulting in six components (plated metal, casting metal A, casting metal B, plating metal A, plating metal B and chemicals). The results of the productivity, price recovery and profitability were depicted and interpreted in Figures 5-3 to 5-8 in chapter 5.

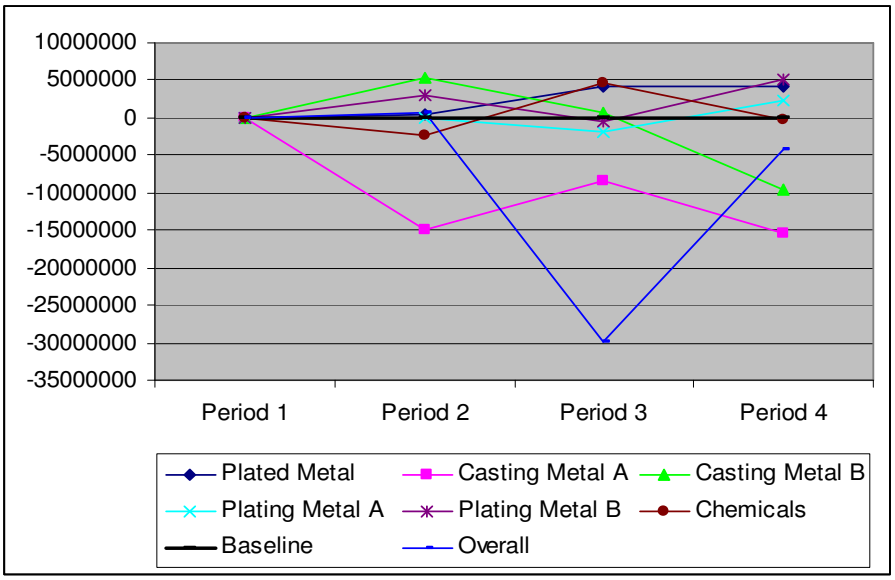

Figure 6-3 Recovery price of components of the material during financial year 2005 to financial year 2008.

Figure 6-3 shows that the company price recovery is mixed, with positive price recovery for plated metal A and B, in the current financial year. This means that there room for inefficiencies and waste is non existent for the company, due to agreed pricing with the SARB and the profit margin obtained from a mature industry.

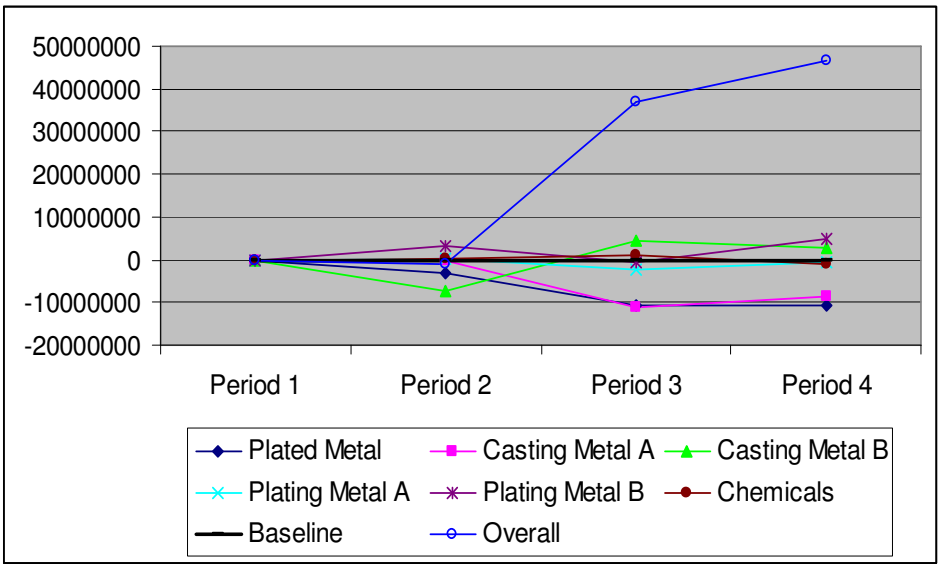

Figure 6-4 Productivity of components of the material during financial year 2005 to financial year 2008.

In chapter 2, Bernolak's (1997) view on productivity is presented, where he states that productivity means how much and how well products are from the resources used. If more or better goods are produced from the same resources, the productivity is increased. Or if same goods are produced from less resource, the productivity is also increased.

Overall productivity for material is high (Figure 6-4), although casting metal A and plated metal is on the negative side. The labour productivity is also highly positive as depicted in Figure 5.10 (section 5.2 in chapter 5). These two input costs form up to 88% of the total input cost, and thus have an overall impact on the total productivity chart. Steel price (plated steel) was not the main contributor towards the negative profitability as all the costs were recovered during period 2 to period 4.

As explained in chapter 2, profitability is the result of interaction of controllable and uncontrollable factors. According to Alsyouf (2007), the uncontrollable factors are economic and political environment, market growth or decline and inflation. These uncontrollable factors could impose significant positive or negative impact on profitability. In this study, the overall profitability of circulation coins profit center is highly positive. This is mainly attributed to productivity and much less to the price recovery (Figure 5-15 in chapter 5).

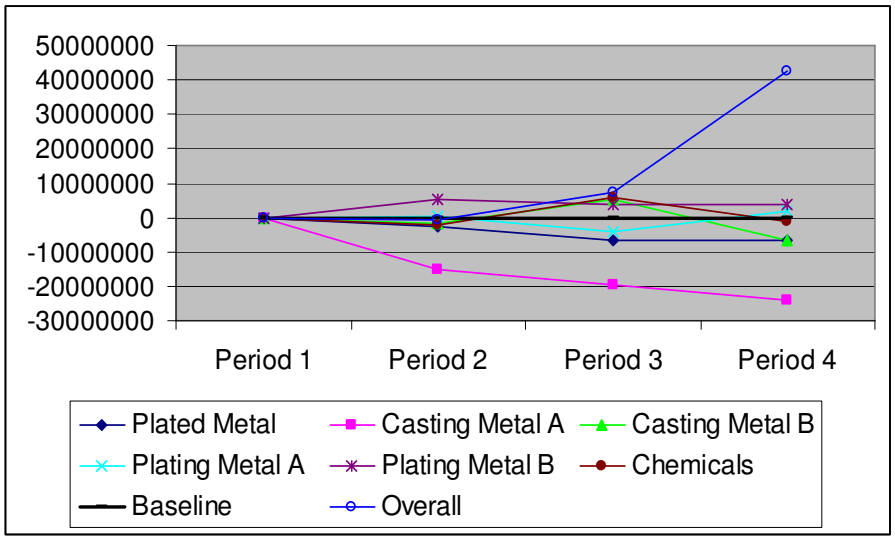

Figure 6-5 Profitability price of components of the material during financial year 2005 to financial year 2008.

6.2.2 Productivity / Quality

As explained in chapter 4, there is a relationship between productivity and quality. The results tabulated the in chapter 5, shows that using both Pearson correlation and linear regression there is a positive relationship between productivity and quality. This study confirms the studies of Kontoghiorghes and (Gudgel, 2004) and findings of Mohanty in 1998.

The statements "Work output exceeds expectation" and "Products are produced in error-free process" show highest correlation with average quality scores, r^2 of 0.45 and 0.42, respectively.

6.3 CONCLUSIONS

The aim of this study as explained in chapter 1 was to investigate the most suitable productivity measurement models, and establish the relationship between the measurement and quality at the SA Mint.

To achieve this, it was deemed necessary to investigate the appropriate productivity measurement models, of which four of them were considered. These models were the total productivity model (TPM), American productivity center model (APC), multifactor productivity measurement model (MFPMM), and "Profitability = Productivity + Price Recovery" (PPP) model.

Of these four models TPM was eliminate early as it did not provide an option of linking productivity to profitability. This elimination was conducted on the basis that circulation coin profit center (where the study was conducted), has mandate of maximising profit, and only recover costs depending on the client.

This means that low profit margin do not necessary mean the shareholder's value is being destroyed. APC model was finally selected as the appropriate model based on its simplicity; easy to set up using Microsoft Excel. Furthermore, this model is suitable for both financial (rand contribution) and non-financial (indexes) personnel. They can be to utilise it, and interpret its results without any difficulty. An attempt was made to try and explain the results obtained from this model, and a relationship was established between productivity and quality.

The following conclusions were made on this study:

- APC model is the most suitable model to measure productivity at the SA Mint as it allows for the decomposition of profitability to productivity and price recovery.
- APC model can be set up easily by using Microsoft Excel as seen and discussed in chapters 2 (see section 2.3.1) and chapter (see section 4.5).
- APC model's suitability is further enhanced by its ability compute the productivity, price recovery and profitability contributions in both indexes and rand, allowing for a non financial and financial measurement as seen on results in chapter 5, see section 5.3.1.
- Results revealed that overall price recovery is a concern for the company, with largely negative price recovery mainly in material, labour, and energy. Material price recovery was mainly attributed to volatility in the market and labour price recovery to SA Mint strategy to adjust employee remuneration to higher percentiles.
- Productivity was shown to be the main driver of profitability in the circulation coins profit center. Good productivity was achieved on the overall material, labour and capital. Few concerns were evident in energy and miscellaneous. Although, there are concerns energy and miscellaneous forms less than 2% of the total costs.
- Survey of the questionnaire shows average scores for productivity and quality. A mean range of 2.27 to 2.92 for productivity and 1.64 to 4.31 for quality (see section 5.3.2 in chapter 5). It is noteworthy, that means score of 2.27 on productivity is for the statement "Products are produced in error-free process". This is a productivity quality measure, which point more towards the quality.
- The survey concluded that there is a positive relationship between productivity and profitability. This is in agreement with several authors as presented in see 3.3.2 in chapter 3.
- This study can be regarded as successful in meeting its objectives as stipulated in section 1.2 of chapter 1, proving the hypothesis formulated in chapter 3

6.3 LIMITATION OF STUDY

The limitation this study was the availability of the published information on APC model in real world situation. Most of the information was academic in work and few articles published data from company.

6.4 SUMMARY AND RECOMMENDATIONS OF STUDY

6.4.1 Recommendations

The impetus for this study arose from the review of the literature on importance of productivity measurement, and its relationship with quality. This literature review revealed that productivity can be measured by a profit-linked model, and this model can be set up and computed using Microsoft Spreadsheet. American Productivity Center (APC) Model was found to be the most suitable; it allows for measure of both non-financial (indexes) and financial (rand) during computation. The non financial and financial measurement allows both line manager and financial manager to use the model for measuring productivity and profitability in the company.

The computation of the model in Microsoft Excel makes it possible for the manager to get further insight by conducting *What if Analysis* using “Goal seek” feature. Furthermore, the results of the model from Microsoft Excel can be assessed from other software such as expert systems. This system can interpret the results, determine the causes and recommend solutions. Microsoft Excel *What if Analysis* using “Goal seek” and expert systems were not used in this study as this would be going beyond the scope of this study.

In addition the literature revealed productivity which is regarded as value addition and quality, which is value enhancement, are the main determinants of competitiveness. To remain competitive, companies need to integrate and synergize both productivity and quality.

Based on the review of literature the main objectives of this study were formulated as follows:

- To effectively measure productivity at the SA Mint Company, using profit-linked productivity model.

- To investigate the relationship between productivity, price recovery and profitability and determine the main driver of profitability between productivity and price recovery at the SA Mint company.
- To investigate the relationship between productivity and quality at the SA Mint company.

In accordance with the aforementioned objectives, a literature study APC model was set up and productivity, price recovery and profitability were computed. The relationship between productivity and quality at the SA Mint was also investigated using a survey questionnaire. All the findings then yielded the following recommendations:

Recommendation 1

It is recommended that the company review its metal risk management strategy and buffer for both internal and external uncertainties, to ensure total recovery of costs is achieved.

This study reveals that the overall circulation coins profit center shows a negative recovery during this evaluated period. This negative recovery is mainly attributed material and labour costs. The material costs are mainly due to market variation as revealed in the study, while the labour cost as improving, the dip was due to company strategy to adjust salaries for the employees to higher percentiles.

Recommendation 2

It is recommended that the results of the survey which generally show a perception that the quality in the company is average should be communicated to the employees, and measures should be put in place to address quality issues from both process and human point of views.

The results of the survey questionnaire reveal that there is a positive association between quality and productivity. However, the scores for the score for quality are average and need improvements. This is necessary in light of volatility in the metal price and as scrap cost more, than it would normally cost, because of risk management strategy (for example “hedging”). Quality improvement can be

regarded as a “hanging fruit” which can be leverage with minimal capital resource utilisation.

Recommendation 3

It is recommended that the company trend the cost of quality and link it impact to productivity.

This study revealed a positive relationship between productivity and quality. This means that good quality has a positive impact on productivity, and the reverse is also true.

Recommendation 4

The APC model should be set up for both the circulation coins and numismatics profit centers. This model should measure productivity, price recovery and profitability at business unit levels in the circulation coins profit centers. These business levels are Processing, Plating and Final Products.

It was apparent in this study that APC is easy to set up and no additional capital resources are required because Microsoft spread sheet is readily available at the SA Mint. This model gives an insight on the contributions of both productivity and price recovery for both financial and non financial managers. In presence of this model the managers can measure and improve productivity. This measurement should allow the management of the company to drive a strategy around using productivity as the main contributor towards profitability. This is necessary in view of the company mandate (drive costs for South Africa circulation coins, maximise profits from export circulation coins’ business and maximise profit from numismatics profit center) discussed in this study and the operating industry (mature industry).

Recommendation 4

Manager at the SA Mint should familiarise themselves with Microsoft “Goal seek”. This should allow the manager to set and review target on productivity through an efficient use of resources and ensures that the profitability is not negatively affected by their respective operations.

Literature revealed that What if analysis using “Goal seek” allow the manger to obtain relevant information and set target based on measurable targets.

6.4.2 Concluding Remarks

Although this study could be classified as being successful because a suitable productivity measurement was computed and contribution of profitability were decomposed to productivity and price recovery, this was not the main contribution of the work to productivity and management. The fact that APC model APC can be set up easily using a widely used Microsoft Excel enable more confidence on the model from the productivity and management community. This might assist in Prof Mohan Roa in his quest to have more publishable work done on the profit-linked models.

Lastly, this study is agreement with international community that productivity and quality have a positive association, and effort to improve quality should have a positive impact on productivity.

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APPENDICES

APPENDIX A

QUESTIONAIRRE ON PRODUCTIVITY AND QUALITY AT S.A. MINT COMPANY

Dear Participant

A statement is given on productivity and performance at SA Mint Company, please answer it, with you best of your ability by ticking or crossing in the box 1- 5, as shown below:

1 - Strongly Disagree 2 - Disagree 3 - Neither agree or disagree 4 - Agree 5 - Strongly Agree

	SECTION A	1	2	3	4	5
	PRODUCTIVITY					
1	The amount of work output by peer exceed expectations					
2	Inputs are received from others in a timely fashion					
3	Products are produced in a cost effective manner					
4	The products are produced in error-free processes					
5	The operations are reliable					

	QUALITY	1	2	3	4	5
1	All the incoming material is of acceptable quality					
2	Statistical process Control (SPC) is widely used as a method for controlling the quality of the manufacturing process					
3	Level of inventory is at least 95% accurate					
4	Internal processes are satisfactory					
5	Work output by peers is always delivered accurately					
6	External customers are satisfied					
7	Work output by peers is consistently delivered complete					
8	Satisfied with quality of peer work output					
9	No change or rework is needed after final product produced					
10	Produced products always meet specification					
11	External customers are loyal					
12	Employees react quickly to resolve unexpected problems					
13	No scrap is produced					

	SECTION B	1	2	3	4	5
	Your position is					
	Team member (e.g. Operator, Analyst, Clerk)	1				
	Team leader / Supervisor (Foreman, Ass. Foreman)	2				
	Middle Management (e.g. Area manager, line manager)	3				
	Senior Manager (executive, MD)	4				
	Specialist (Engineer, Accountant, HR officer)	5				
	Your Department is					
	Production (Factory, Gold room)	1				
	Service Provider (IT, Lab, Quality, Safety)	2				
	Engineering (Mechanical, Electrical)	3				
	Finance	4				
	HR	5				
	Sales and Marketing	6				
	Others (specify)	7				
	THANK YOU FOR YOUR ASSISTANCE!!!					

APPENDIX B

Appendix B-1

		Performance ratio			Period 2		
		Productivity	Price recovery	Profitabilit	Productivity	Price recovery	Profitability
TOTAL OUTPUT							
INPUTS							
	Plated Metal	0.8593	1.040	0.8933	-3159280	422264	-2,737,016
	Casting Metal A	0.9884	1.158	1.1448	-170594	-14889409	-15,060,003
	Casting Metal B	0.5463	1.404	0.7671	-7229153	5327673	-1,901,480
	Plating Metal A	1.0694	1.158	1.2387	201087	42254	243,341
	Plating Metal B	1.9833	1.404	2.7853	2403914	3031882	5,435,796
	Chemicals	1.0738	0.824	0.8844	375502	-2473678	-2,098,176
TOTAL MATERIAL		0.8807	1.133	0.9979	-7578523	-35121083	-42,699,606
LABOUR	Coin Producer	1.1741	0.753	0.8839	3987840	-4008672	-20,832
TOTAL LABOUR	Coin Producer	1.1741	0.753	0.8839	3987840	-8112818	-4,124,978
GASS AND FUEL	Fuel and Gases	0.8267	0.823	0.6804	-186093	-170510	-356,602
TOTAL ENERGY		0.8267	0.823	0.6804	-186093	-170510	-356,602
CAPITAL	Depreciation direct	1.3793	0.593	0.8186	2703086	190848	2,893,933
TOTAL CAPITAL		1.3793	0.593	0.8186	2703086	190848	2,893,933
MISCELLANEOUS	Risk Control A	1.2521	0.754	0.9440	44385	-1919	42,466
	Risk Control B	0.7284	1.288	0.9381	-61919	92605	30,686
TOTAL MISC		0.9566	0.984	0.9414	-17534	19255	1,721
TOTAL INPUT		0.9885	0.948	0.9374	-1091224	579995	-511,229

Appendix B-2

		Performance ratio			Period 3		
		Productivity	Price recovery	Profitability	Productivity	Price recovery	Profitability
TOTAL OUTPUT							
INPUTS							
	Plated Metal	0.6530	1.195	0.7805	-10,891,697	4206886	-6,684,811
	Casting Metal A	1.3669	0.664	0.9075	-11,287,100	-8428803	-19,715,903
	Casting Metal B	0.9585	1.319	1.2641	4,511,905	742805	5,254,711
	Plating Metal A	0.6984	0.648	0.4523	-2,303,638	-1927309	-4,230,947
	Plating Metal B	3.9926	1.319	5.2657	4,083,110	-492948	3,590,162
	Chemicals	0.8133	0.921	0.7491	1,174,225	4724149	5,898,374
TOTAL MATERIAL		0.9077	0.983	0.8924	-50,577,770	-13544435	-64,122,204
LABOUR	Coin Producer	1.2347	0.642	0.7932	11,990,288	-9530983	2,459,306
TOTAL LABOUR	Coin Producer	1.2347	0.642	0.7932	8,337,374	-12981752	-4,644,378
GASS AND FUEL	Fuel and Gases	0.7721	0.724	0.5589	-457,667	-120473	-578,140
TOTAL ENERGY		0.7721	0.724	0.5589	-457,667	-120473	-578,140
CAPITAL	Depreciation direct	1.6116	0.387	0.6230	7,043,946	-4815540	2,228,406
TOTAL CAPITAL		1.6116	0.387	0.6230	7,043,946	-4815540	2,228,406
MISCELLANEOUS	Risk Control A	1.1344	0.722	0.8187	-61,127	165347	104,220
	Risk Control B	0.5121	1.439	0.7370	-234,964	285774	50,810
TOTAL MISC		0.7453	1.049	0.7815	250,858	-214103	36,755
TOTAL INPUT		1.0303	0.797	0.8208	37,033,516	-29949810	7,083,706

Appendix B-3

		Performance ratio			Period 4		
TOTAL OUTPUT		**Productivity**	**Price recovery**	**Profitability**	**Productivity**	**Price recovery**	**Profitability**
INPUTS							
	Plated Metal	0.5498	1.336	0.7344	-10,540,412	4085332	-6,455,079
	Casting Metal A	1.1202	0.498	0.5575	-8,650,587	-15451302	-24,101,889
	Casting Metal B	0.7586	0.605	0.4589	2,906,377	-9488757	-6,582,381
	Plating Metal A	0.8786	0.950	0.8346	-507,130	2213345	1,706,215
	Plating Metal B	0.5815	1.269	0.7381	-1,298,871	4996433	3,697,562
	Chemicals	0.7152	0.964	0.6896	-948,549	-324898	-1,273,446
TOTAL MATERIAL		0.7077	0.883	0.6250	11,444,917	-24132878	-12,687,962
LABOUR	Coin Producer	0.9324	1.082	1.0084	5,845,021	5561212	11,406,234
TOTAL LABOUR	Coin Producer	0.9324	1.082	1.0084	6,110,493	9027845	15,138,338
GASS AND FUEL	Fuel and Gases	0.7084	0.807	0.5716	-200,887	-421591	-622,478
TOTAL ENERGY		0.7084	0.807	0.5716	-200,887	-421591	-622,478
CAPITAL	Depreciation direct	2.5308	0.347	0.8773	6,666,121	-1123388	5,542,733
TOTAL CAPITAL		2.5308	0.347	0.8773	6,666,121	-1123388	5,542,733
MISCELLANEOUS	Risk Control A	0.7899	0.630	0.4976	-128,075	-49251	-177,326
	Risk Control B	0.3478	1.707	0.5936	-274,706	191027	-83,678
TOTAL MISC		0.5109	1.047	0.5348	236,678	-302896	-66,218
TOTAL INPUT		0.8256	0.878	0.7245	46,754,698	-4197279	42,557,419