**Improving Competitiveness Through the Application of Cost Estimation Models**

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## Declaration

I hereby declare that this study is my own work and it does not contain material that has been published already or written by another student or researcher. This material has not been previously submitted for any award or degree at Durban University of Technology or any other educational institution. Furthermore, I declare that the academic content of this thesis is my own creation of work. The support given or contribution made by the company in this study has been clearly acknowledged.

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My family, my parents – Lallie and Cedric Naicker and my sister Priyesca Naicker. Thank you for helping me to realize one of my greatest dreams – I hope this will inspire others to realize theirs.

# ABSTRACT

Optimal costing decisions are required in order to ensure that organisations are globally competitive. The case study company is a global affiliate based in Durban, KwaZulu-Natal, South Africa and is involved in the manufacture and assembly of automobiles and automotive components. It was noticed that cost estimation models were only introduced at an advanced stage in the project life cycle. The concept of cost estimation and its application to improve various factors of a business has been investigated previously and existing evidence could be utilised to support further study in the field. Therefore, the aim of the study was to improve the quality of sourcing decisions by means of the introduction of a parametric cost estimation model and business process re-engineering. A case study approach was adopted.

The first objective was to develop an overview of the current sourcing processes and understand the factors which influenced sourcing decisions. The methods used included the generation of a Standard Operating Procedure (SOP) for the current sourcing process, an online survey and interviews. It was concluded that there was a need to develop a detailed SOP which identified and included all impacted departments.

The second objective was to redesign the sourcing process. It was concluded that the current sourcing processes did not take cost estimates into account at the early stages of the project life cycle and the inability to accurately predict costs consequently negatively impacted the cost competitiveness of the organisation.

The third objective was to develop and implement a parametric cost estimation model. The model was created using Microsoft Excel. The results revealed that the Parametric Cost Estimation Model (PCEM) needed to focus on small injection moulded components as they were the highest contributor to the high Cost Index Manufacturing (CIM), which made the organisation globally uncompetitive. The results revealed that with the introduction of the PCEM and the revised sourcing process, the selected component was competitively priced.

Recommendations were made for continuous process improvement and a roadmap for the further introduction of cost estimation models. Further research could also be conducted to develop an optimal cost estimation model based on analogous costing techniques or to develop a comprehensive database for other complex commodities.

# PUBLICATIONS

- Conference paper:

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**List of Acronyms**

| | |
|---|---|
| GDP | Gross Domestic Product |
| SOP | Standard Operating Procedure |
| MFG | Manufacturing |
| RMBSS | Request for Make vs. Buy Supplier Selection |
| TSAM | The Selected Automotive Manufacturer |
| TMC | Toyota Motor Corporation |
| PEPD | Purchasing, Engineering & Planning Division |
| OEM | Original Equipment Manufacturer |
| WARP | World-wide Automotive Real Time Purchasing |
| PSM | Purchasing Strategy Management |
| SPE | Supplier Purchasing Engineering |
| R&D | Research & Development |
| PE | Production Engineering |
| QCE | Quality Control Engineering |
| PCLD | Production Control & Logistics Department |
| BBB-EE | Broad Based Black Economic Empowerment |
| TPS | Toyota Production Systems |
| PDCA | Plan Do Check Act |
| DTM | Design Team Meeting |
| RFQ | Request for Quotation |
| CIM | Cost Index Manufacturing |

| | |
|---|---|
| CEM | Cost Estimation Model |
| PCEM | Parametric Cost Estimation Model |
| TCM | Target Cost Management |
| JIT | Just In Time |
| TME | Toyota Motors Europe |
| SIPOC | Suppliers, Inputs, Processes, Outputs and Customers |
| TQM | Total Quality Management |
| QC | Quality Control |

# CHAPTER 1 : INTRODUCTION

## 1.1 Introduction

The automotive industry in South Africa appears to be 20% more expensive than Western Europe and is 30%-40% more expensive than China and India (Rathilall and Singh 2018). For South Africa to remain globally competitive in the automotive industry, this gap must be reduced.

The automotive industry in South Africa is a key contributing sector in terms of GDP, hence it is important to ensure the survival and continued expansion of this sector. Currently the automotive sector constitutes 7% of the South African GDP but only 0.7% of the global vehicle output (Barnes and Morris 2008). Bearing these facts in mind, the research will focus on key factors to ensure the survival and potential expansion of the automotive industry in South Africa.

Through globalisation many companies are now able to source components from a wide range of suppliers worldwide. Through the introduction of an optimal sourcing process, purchasing specialists can procure a component at the optimum price, thereby ensuring that the organisation remains competitive in the global market. It is therefore imperative that organisations continually investigate available options to improve their competitiveness.

The research will focus on utilising cost estimation models to improve the competitiveness of a Durban-based automotive manufacturer with key focus on the application of cost estimation models to assist with improving the quality of sourcing decisions. It was imperative that good sourcing decisions were made early in the project as good purchasing strategies could lead to effective cost saving if implemented correctly (Wei and Chen 2008). When information was limited at the early stages of the project, it was shown that parametric cost models could be extremely useful to generate accurate cost estimates (Dysert 2001). These cost estimation models are often used to ensure that when a component is sourced, it is sourced at the optimum cost level.

This chapter outlines the problem statement, the aim of the study and its significance as well as the structure of the dissertation.

## 1.2 Problem Statement

The Durban-based automotive manufacturer aims to be a globally competitive affiliate. However, due to poor sourcing decisions the automotive manufacturer is not currently competitive. The current sourcing processes do not allow for accurate cost estimation at the onset of a project. This places cost engineers at a disadvantage due to the fact that costs can only be negotiated after the final sourcing decision has been made. Cost estimates are generally based on the processes involved in the manufacturing of the part and rely on the knowledge of the cost engineer, and this often lengthens the lead time to generate an accurate cost estimate.

Should the organisation remain uncompetitive, it will be at risk in terms of future production volumes. If the organisation is not able to become competitive, it will not be allocated production volumes for future models, which may ultimately result in the downsizing of the manufacturing facility in Durban, leading to job losses and a contraction of the South African automotive industry.

This problem has also been highlighted by Roy *et al.* (2011) where it was identified that the automotive industry was operating in a highly competitive market and the controlling of product costs was a key factor to improve competitiveness. The authors also indicated that the introduction of accurate cost estimation models could positively impact the product costs.

## 1.3 Aim of the Study

The aim of this study was to improve the competitiveness of the automotive manufacturer by applying cost estimation models and to improve the quality of sourcing decisions moving forward by visualizing the current sourcing process, restructuring it and introducing the application of parametric cost estimation models.

## 1.4 Specific Objectives

The specific objectives of this research were:

- To outline the current process for the sourcing of components to identify factors influencing sourcing decisions and resulting in the high cost of parts, and to redesign the sourcing process to allow for optimal sourcing.

- To develop and implement a parametric cost estimation model for early cost estimation.

## 1.5 Research Methods

The case study research strategy was adopted for this study. The methodology that was adopted included the development of a Standard Operating Procedure (SOP) for the current sourcing process. The redesign of the sourcing process was conducted utilising material and information flow diagrams and flowcharts. The research methods used for the study were as follows:

- For objective one, observations were completed to gain an understanding of the steps involved in the sourcing process from the receipt of the Request for Make vs. Buy Sourcing Selection (RMBSS) to the sourcing of the component and consequently a mapping out of the process flow for the sourcing process at the case study company. The method used was an ishikawa diagram that was developed through observation and engagement with the purchasing specialists to identify areas of the root cause of the high parts cost and the 5 why analysis, which was utilised in order to determine which areas in the sourcing process needed improvement.

- For objective two, the method used was the Pareto analysis to determine which components urgently required the application of a cost estimation model. The model was developed utilising secondary information from TMC manuals and was created using Microsoft Excel.

## 1.6 Research Scope and Limitations

The research scope embraced the current sourcing process for automotive components and was limited to the case study company based in South Africa.

## 1.7 Significance of the Study

The case study company continually strives to implement continuous improvements in order to become the leading automotive manufacturer in South Africa. However, the improvement activities are mainly focused on the production section of the automotive manufacturer. By expanding the focus of continuous improvement to all activities, the case study company may experience some benefits. This research will also add more information to the body of knowledge regarding the sourcing of components in the automotive industry.

## 1.8 Dissertation format

**Chapter One – Introduction**: This chapter focuses on presenting the study outline, which consists of the study background, research problem, aim of the study, research objectives, research scope and limitations, significance of the study and the dissertation format.

**Chapter Two – Literature Review**: This chapter provides a theoretical concept base, supporting continuous improvement tools and techniques.

**Chapter Three – Case Study Company Background**: This chapter presents the background of the company and further describes the sourcing processes.

**Chapter Four – Research Methods**: This chapter focuses on the adopted methodology for the study as well as ethics considerations.

**Chapter Five – Results and Discussion**: This chapter focuses on the results and a discussion of the research. The key elements discussed include sourcing process flow value added analysis, SOP and the cost estimation model generation.

**Chapter Six – Summary and Conclusion**: This chapter provides the summary and conclusion of the study, makes recommendations and outlines the roadmap for the revised sourcing process and the expansion of cost estimation models.

## 1.9 Conclusion

This chapter has outlined the research framework and the problem statement and given the background to the study. The key elements of the study included the research objectives, the research methods, the research scope and its limitations, the significance of the study and the dissertation format of the study. In this chapter the research problem has been clearly defined as the lack of cost estimation in the early stages of projects to support accurate sourcing decisions. In order to address the identified research problem, this research will aim to clarify and revise the current sourcing process to include cost estimation in the early stages of projects. A key focus area for the research will be to develop a tool to facilitate early and accurate cost estimation. Through the introduction of the cost estimation model and a revised sourcing process, the Durban-based automotive manufacturer would be able to secure the production volume for the next passenger vehicle by ensuring that the pricing of the vehicle was globally competitive, thereby mitigating the negative impact of production volume loss and the contraction of the automotive industry in South Africa. The following chapter gives a detailed literature review on globalisation, kaizen and cost models.

# CHAPTER 2 : REVIEW OF COST ESTIMATION TECHNIQUES

## 2.1 Introduction

This chapter reviews the background literature on the theory and understanding of the foundational concepts of cost estimation with regard to manufacturing systems. The principles of cost estimation focus on the accurate prediction of costs through the use of various models, which is aligned to the purpose of this research. This chapter commences with a focus on kaizen principles; it then deals with the tools and techniques of kaizen, and concludes with a focus on manufacturing complexity and cost modelling.

## 2.2 The Impact of Globalisation

Rapid industrial globalisation has placed immense pressure on manufacturing companies to ensure their competitiveness and survival in a global market. In 2011, while investigating the types of data and information required for accurate cost estimating, Roy *et al*. (2011) initially identified that there was a need to control costs due to the highly competitive global market where a competitive edge was a necessity to ensure survival. Additionally, it was also mentioned that one of the main economic factors which influenced competitiveness in an automotive company was product cost and therefore a need for accurate cost estimates arose.

A similar study was conducted in Turkey by Kabak *et al.* (2014)., which highlighted the importance of cost estimation as a response to the expanding global economy. It was noted that competition at an international level had become increasingly important due to the globalisation of the economy. The authors defined competitiveness as a set of institutions, policies and relevant factors which determined the productivity of a country. The research utilised a three-step methodology, which included problem structuring, quantification of causal relationships, and developing policy structures to assist policy makers in their decisions to enhance the competitiveness of the Turkish automotive industry. The research focused on developing a decision-making tool to support policy makers regarding their decision to improve the competitiveness of certain industries. The model was then applied to the Turkish automotive industry to evaluate how to enhance the competitiveness of the industry and was able to identify important criteria for the Turkish automotive industry to focus on. The study concluded that the research provided satisfactory outputs with regard to providing guidelines on cost estimation. Furthermore, the research recommended that user-friendly software be developed to facilitate the calculations used in the methodology.

In Brazil, the competitive environment was changing due to globalisation – many domestic companies faced the threat of global competition, thus driving the need for companies to identify priorities, including selling price, manufacturing quality, delivery time, product range and flexibility, to ensure their competitiveness. Lucato *et al.* (2012) conducted research into factors affecting the competitiveness of an organisation and, after consulting the available literature, the following factors were deemed most relevant to be considered in the development of a model to measure competitiveness – design, modularity, price, kaizen, lean, proximity, management and finance. According to Table 2.1 shown below, the relevant factors were identified and selected for the study based on the number of citations.

**Table 2.1 Relevant competitive factors for an auto parts manufacturer – literature summary**

| Reference | Dsn | Qly | Mod | Prc | CIm | Lean | Ltm | Prx | Loc | Mgm | Fin | Tcn | Col |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Abraham (1998) | ✗ | | ✗ | | | ✗ | | ✗ | | | | | |
| Arkader (2001) | ✗ | | ✗ | ✗ | | ✗ | | | | ✗ | | | |
| Bedê (1996) | ✗ | ✗ | | ✗ | ✗ | ✗ | | | ✗ | | ✗ | | |
| Branchini (1998) | ✗ | | ✗ | ✗ | | ✗ | ✗ | ✗ | ✗ | | ✗ | ✗ | |
| Carvalho (2008) | | | | ✗ | ✗ | ✗ | | ✗ | | ✗ | | ✗ | |
| Consoni (2004) | ✗ | | ✗ | | | | | ✗ | | ✗ | | | |
| Corswant and Fredriksson (2002) | | | ✗ | ✗ | | | | ✗ | | | | | |
| Costa and Queiroz (2000) | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ | | ✗ | ✗ | ✗ | ✗ | | |
| Cousins and Stanwix (2001) | | | | ✗ | ✗ | | | ✗ | | | | ✗ | |
| Coutinho and Ferraz (1994) | ✗ | ✗ | | ✗ | ✗ | ✗ | | ✗ | ✗ | ✗ | ✗ | | |
| Fleyry and Salerno (1998) | ✗ | | ✗ | | ✗ | ✗ | | | | | | ✗ | |
| Grisi and Ribeiro (2004) | ✗ | | ✗ | ✗ | ✗ | ✗ | | ✗ | | ✗ | | | ✗ |
| Gunasekaran and Chung (2004) | ✗ | | | | ✗ | | | | ✗ | ✗ | ✗ | | ✗ |
| Humphrey and Salerno (2000) | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ | | ✗ | | ✗ | ✗ | | |
| Lakshman and Parente (2008), | | | ✗ | ✗ | | | | ✗ | ✗ | | ✗ | | |
| Lau (2002) | ✗ | ✗ | | ✗ | | ✗ | | | | ✗ | | | ✗ |
| Lee and Wilhem (2010) | | | ✗ | | ✗ | | | ✗ | ✗ | | ✗ | | ✗ |
| Mitteldorf (1996) | ✗ | | ✗ | | ✗ | ✗ | ✗ | | | | | | |
| Posthuma (1997) | ✗ | | ✗ | | ✗ | ✗ | | ✗ | | ✗ | | | |
| Quadros Carvalho and Queiroz (1997) | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ | | ✗ | | ✗ | ✗ | | |
| Sako (2000) | ✗ | | ✗ | | | ✗ | | | | | | | |
| Salerno *et al.* (2001) | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ | | ✗ | ✗ | ✗ | |
| Salerno *et al.* (2002) | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ | | ✗ | ✗ | ✗ | |
| Salerno *et al.* (2003) | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ | | ✗ | ✗ | ✗ | |
| Silva (2002) | ✗ | | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ | | ✗ | ✗ | | |
| Vijayasarathy (2010) | | | | | | | ✗ | ✗ | ✗ | | | | ✗ |
| Womack *et al.* (1992) | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ |
| Yang *et al.* (2010) | ✗ | | ✗ | | ✗ | ✗ | | ✗ | | | | | |
| Citation of each factor | 22 | 10 | 21 | 18 | 19 | 21 | 8 | 21 | 9 | 16 | 15 | 8 | 6 |
| Selected factors | ✗ | | ✗ | ✗ | ✗ | ✗ | | ✗ | | ✗ | ✗ | | |

Key to abbreviations: Dsn, effective participation in product design; Qly, quality certifications; Mod, modularity; Prc, capacity to meet target prices; CIm, continuous improvement practices; Lean, lean manufacturing techniques; Ltm, lead time reduction; Prx, proximity; Loc, plant location; Mgm, updated management techniques; Fin, financial strength; Tcn, own technology development; Col, supplier collaborative work.

Source: Lucato *et al*. (2012)

The authors then created a mathematical model to measure the degree of the competitiveness of an organisation. The model was then validated by applying it to three automotive suppliers. The results showed that the model generated produced competitive positions similar to those perceived in the market. While the research provided a measurement of the competitiveness of the organisation and potential areas for improvement, it did not specify any particular method to enhance the competitiveness of an organisation.

In India, Singh *et al.* (2007) noted that the automotive component sector, which formed a core segment of the Indian economy, was under pressure due to the expanding global economy. Singh *et al.* (2007) analysed aspects of the competitiveness of the sector in relation to a globalised economy. The authors identified various pressures and constraints on the Indian automotive component sector via the use of surveys and data analysis. From the analysis it was determined that the need to reduce costs was causing the most pressure on the sector. A correlation analysis was also completed to determine the relationship between pressures, constraints, strategies, performance and competitiveness. It was concluded that strategies for investment, quality, cost and competency were significantly correlated with the competitiveness of an organisation. This research indicated that results could be improved by including areas of strategy development such as an organisation’s culture, flexibility, suppliers, and human capital. The literature provided an understanding of the pressures that had arisen and contextualized the need for holistic, accurate cost estimation moving forward.

While global pressure has mounted on organisations, the requirement for Target Cost Management has prevailed. Much research has been conducted in terms of the origin of and requirement for Target Cost Management. Baharudin and Jusoh (2015) stated that in a competitive global market, organisations were under pressure to provide the right products at the right price. According to the authors, the Japanese utilised target cost management as a serious competitive tool as it allowed companies to manage costs early on in the design phase and this allowed them to estimate the cost correctly and set the right price, thereby reducing the risk of not generating sufficient profit.

Baharudin and Jusoh (2015) stated that it was this concept which allowed the Japanese to manage their strategies and operate speedily at a profitable margin. Through this research the authors determined that while calculating the product’s estimated cost, the Japanese made their cost estimation based on project assumptions. These assumptions included foreign exchange rates and processes – it was also noted that Japanese automotive suppliers relied heavily on their suppliers. Through further research, the authors found that Japanese companies broke down the target cost into each cost and major functions, such as engine, transmission and audio system. Then, cost engineers for each design group separated the target cost from the group component and parts level to set the target cost of each purchased part. The authors used a case study approach to compare the methods of implementing TCM in companies in Japan versus Japanese affiliated companies. The study identified a local supplier in Malaysia operating in a joint venture with a Japanese company. After the study it was determined by the authors that there were vast differences between how TCM was implemented in Japan versus how it was implemented in Malaysia. Upon validation of the research, it was noted that as the study was a single case study and based in a single industry, the findings could not be generalised and could not holistically describe TCM implementation in Malaysia; however, future researchers could utilise the information provided to serve as a foundation to gain further insight into TCM implementation outside of Japan.

The reviewed literature has indicated that organisations around the world identified the need to improve their competitiveness through various methods, including cost estimation, due to the ever-increasing pressure caused by globalisation. The concept of Kaizen has been introduced by multiple companies to assist with the improvement of competitiveness.

## 2.3 Kaizen Philosophy to Improve Competitiveness

Through a systematic review of literature relating to Kaizen costing, Miranda *et al.* (2020) identified that the kaizen model originated in Japan, where continuous improvement formed the basis for all business operations. The etymology of kaizen was further explained as a combination of the Japanese characters “kai”, which means change, and “zen”, which means improvement. According to Miranda *et al.* (2020), the Kaizen Institute stated that five principles had to be met in order to ensure the successful implementation of a kaizen project, namely:

- Know Your Customer
- Let It Flow
- Go to Gemba
- Empower people
- Be Transparent.

Miranda *et al.* (2020) stated that according to Sani and Allahverdizadeh (2012), kaizen essentially tried to ensure that everyone in the company continually reconsidered the methods used to complete tasks in order to identify whether there was a better way to complete the task. It encouraged the use of intelligent and shared thought and action through work teams to search for improvements. It was determined through research that kaizen focused on improving the performance of production processes, reducing costs, increasing production, and improving quality of service and customer satisfaction. Of the forty articles reviewed, thirty percent of them focused on alternate kaizen application methods in industries such as service sectors, including the health, education, hospitality, project management and auditing sectors. The research further identified that kaizen was often coupled with other continuous improvement tools such as PDCA, MUDA, Six Sigma, Lean Manufacturing, Lean Thinking, JIT, cycle time, lead time, quality management and benchmarking. The articles reviewed showed that 12 of the 40 authors utilised a case study approach to investigate the effects of kaizen application, while eight of the authors utilised a questionnaire. The study concluded that kaizen could be successfully implemented in the service sector; however, success was largely dependent on management buy-in and support, effective use of resources and assertive planning.

When analysing kaizen strategy and the drive for competitiveness, Smadi (2009) stated that the idea of Kaizen was propagated in the western world by Masaaki Imai, who defined kaizen as “the process of continuous improvement in any arena of one’s life, be it personal, social, home or work”. Imai also outlined five principles to guide kaizen implementation. The five principles included:

- Process improvements through PDCA
- Putting quality first through cross-functional teams
- Hard data versus hunches and feelings
- Viewing the next process as the customer
- Visual management.

Additionally, Smadi (2009) provided evidence from previous studies where kaizen had been utilised to improve business operations, realise cost reduction and improve an organisation’s competitive position in the market. A study of the TMC and the implementation of the Toyota Way found that the company was able to harness the benefits of a visual factory, eliminate waste and establish a strong culture of continuous improvement. In TME, kaizen helped to improve productivity by 30%, reduced line work by 10% and freed up 25% of floor space. The Boeing Commercial Airplane Company used kaizen as a strategy and was able to reduce costs and improve efficiency. It was concluded that the kaizen strategy had been recognised as a major factor in the success of Japanese businesses and when implemented, even in Western companies, the strategy yielded favourable results which manifested as cost savings and improved competitiveness.

Kaizen can be implemented through the “Plan Do Check Act” (PDCA) cycle. The logic and benefits of kaizen for every improvement must be carefully assessed before implementation. In order to avoid unjustifiable changes to the system, it is important to utilise the 5 why concept to ensure that each improvement action is comprehensible and justifiable.

Advantages of kaizen include:

- Teamwork, increased efficiency, employee satisfaction, and improved safety
- Kaizen philosophy improves: quality of product, capital usage, production capacity, utilization of space, and communication.
- Kaizen provides speedy outcomes.

## 2.4 Lean Principles and Tools

When applied correctly, Lean manufacturing tools can be utilised to improve competitiveness. The implementation of lean tools eases the identification and elimination of waste through the supply chain. Sharma *et al.* (2013) discussed Lean tools and stated that each tool contains a unique approach to waste elimination. Lyons *et al.* (2013) listed the key Lean manufacturing principles as the alignment of production to demand, waste elimination, supplier integration and the innovative participation of the labour force in continuous improvement activities.

The Lean tools and techniques related to the task of this thesis are discussed below. The concepts which will be discussed include the 5 why analysis, the fishbone diagram, flow charts, Pareto analysis and Gemba.

### 2.4.1 5 Why Analysis

In their research relating to Six Sigma, Ashok Sarkar *et al.* (2012) identified the 5 why analysis as a method where the question "why" was asked five times and it was then accepted that the answers would identify the root cause (Andersen and Fagerhaug 2002).

### 2.4.2 The Fishbone Diagram

According to Ashok Sarkar *et al.* (2013), Professor Kaoru Ishikawa developed this tool in 1943 to sort the potential causes of a problem while arranging the causal relationships. Through a cause-and-effect diagram, all potential causes (or inputs) for a single effect (or output) were explored and a depiction of the root cause analysis was made as per their natural association. The cause-and-effect diagram is popularly associated with Lean Six Sigma implementation as it relates several causes to an effect. The steps followed are:

1. Conducting a brainstorming session to identify ideas/ symptoms/ causes that are related to the effect.
2. Identifying the potential causes from the ideas/ symptoms
3. Grouping the causes by their natural association, popularly under the four Ms, i.e., man-material-machine-method.

### 2.4.3 Flowcharts

PMI states that flowcharts are also referred to as process maps because they display the sequence of steps and the branching possibilities that exist for a process that transforms one or more inputs into one or more outputs. Flowcharts show the activities, decision points, branching loops, parallel paths, and the overall order of processing by mapping the operational details of procedures that exist within a horizontal value chain. One version of a value chain is known as a SIPOC (suppliers, inputs, process, outputs and customers) model. Flowcharts may prove useful in understanding and estimating the cost of quality for a process. When flowcharts are used to represent the steps in a process, they are sometimes called process flows or process flow diagrams and they can be used for process improvement as well as identifying where quality defects can occur or where to incorporate quality checks.

Figure 2.1 below provides a graphical example of the detail behind the SIPOC value chains utilised in the new product introduction process.

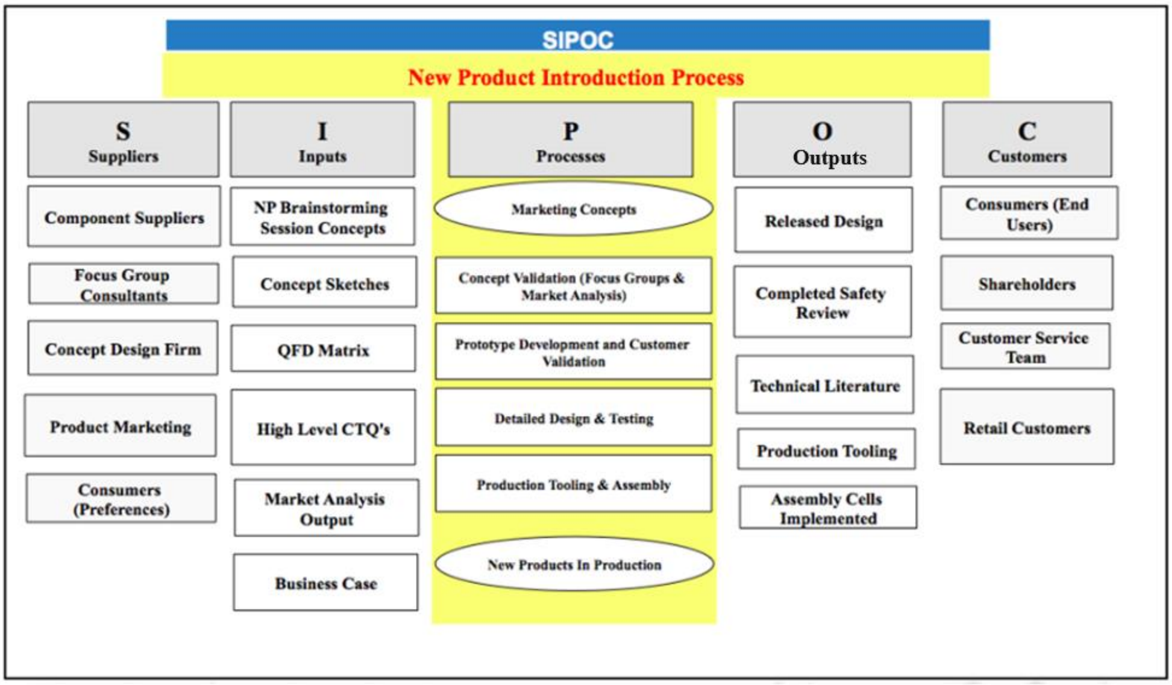


**Figure 2.1: SIPOC Example**
Source: (Anon. 2021)

### 2.4.4 Pareto Analysis

In their research relating to the critical success factors of TQM, Karuppusami and Gandhinathan (2006) defined the Pareto analysis as a QC tool which ranked data classifications in descending order from the highest to the lowest frequency of occurrence. The total frequency was equated to 100 percent. The “vital few” items occupied a substantial amount (80 percent) of the cumulative percentage of occurrences, and the “useful many” items occupied only the remaining 20 percent of occurrences. The “vital few” items were then prioritised and became the focus point for future improvements.

### 2.4.5 GEMBA (Workplace Investigation Method)

In some instances the investigator may need to further investigate by visiting the pertinent operations to check on compliance with the rules so that appropriate corrective measures can be taken to resolve the problem caused by any identified non-conformance. This type of study could be termed the GEMBA, or workplace investigation method (Sarkar and Mukhopadhyay 2012).

Together with the implementation of kaizen as a response to globalisation, it has been noticed that manufacturing complexity in organisations is increasing, which could further complicate the requirements for accurate cost estimation. The drivers of manufacturing complexity and details regarding cost modelling are explained below.

## 2.5 Manufacturing Complexity

It was found that in a manufacturing organisation, the systems were under a great deal of pressure to adapt to changes rapidly due to increasing global competition and frequent, unpredictable market changes; therefore, organisations had to design systems which not only allowed for the manufacture of high-quality goods at low cost, but also for a rapid response to changing market needs and consumer requirements (Koren and Shpitalni 2010). While operating in an uncertain environment, increasing complexity was one of the most prominent challenges facing the manufacturing industry (Waguih *et al.* 2012). Due to the inherent complexity and dynamics associated with manufacturing systems, it became difficult to estimate, control and monitor costs without making errors (Agyapong-Kodua *et al.* 2011). A system was defined as complex if it had many parts, or components, with many connections between them (Waguih *et al.* 2012).This is highlighted in Figure 2.2.

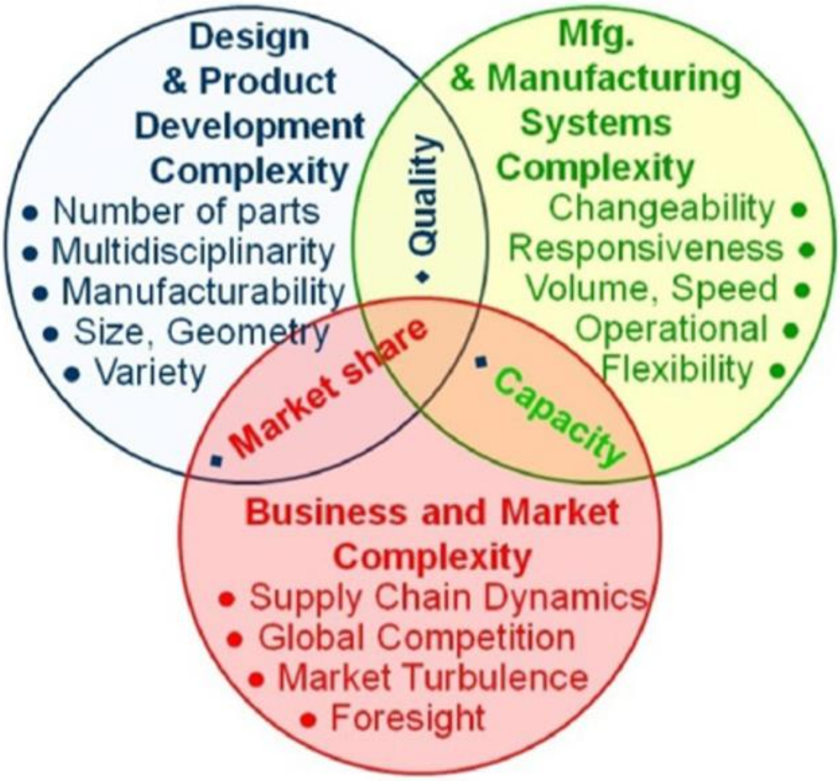


**Figure 2.2: Complexity of design manufacturing and business with examples of related subtopics**

Source: (Waguih *et al.* 2012)

Waguih *et al. (2012)* illustrated the drivers of complexity in manufacturing systems that included economic, social and technological factors, as seen in Figure 2.3.

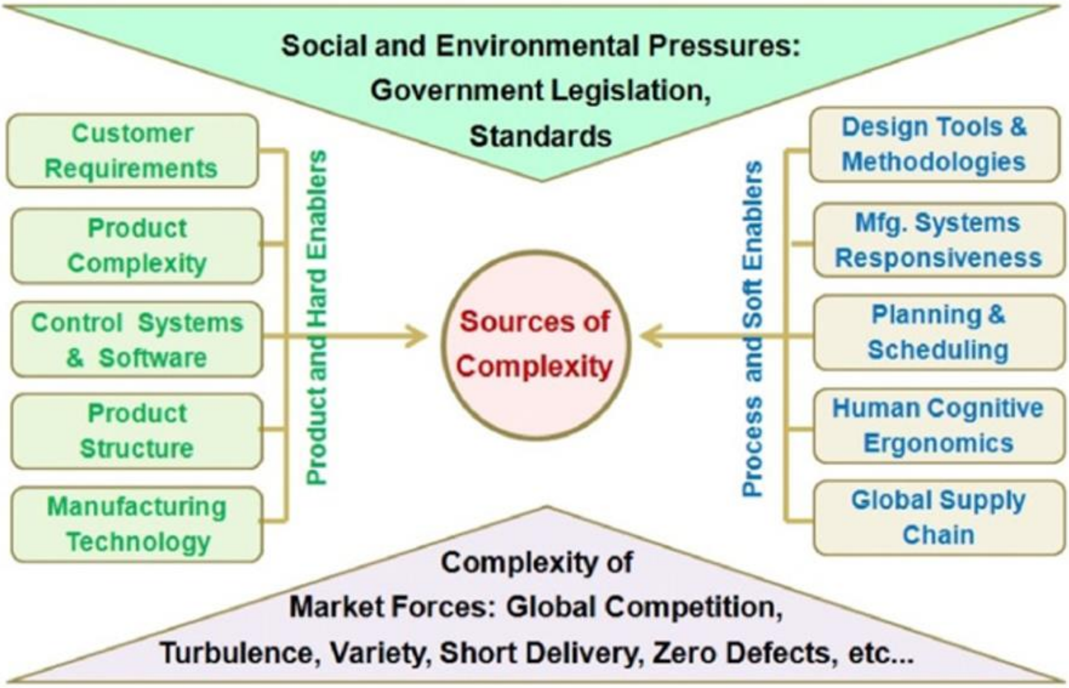


**Figure 2.3: Drivers of manufacturing complexity**
**Source: ( Waguih *et al.*:2012)**

The complexity of manufacturing systems rendered the use of traditional accounting practices unsuitable for the dynamic manufacturing environment. Hence it was proposed that cost modelling be utilised to manage the risk, uncertainty, change and complexity associated with dynamic manufacturing systems (Agyapong-Kodua *et al.* 2011).

## 2.6 Cost Modelling

Cost modelling provided the platform on which cost estimation and project planning could be built (Agyapong-Kodua *et al.* 2011).

In his extensive research on expert estimation, Usman (2018) cited and offered further explanation on the techniques identified by Boehm for cost estimation. The techniques are listed below:

1. Parametric
2. Expert judgement

3. Analogy
4. Parkinson
5. Price to win
6. Top Down
7. Bottom-up.

The techniques were later analysed by researchers such as Huang et. al (2011) and Curran *et al*. (2004), who stated that while Boehm's classification was representative of the cost modelling techniques, the Parkinson method could not be considered as a cost estimation model but should rather be considered as a management technique which strove to define the project scope. Other research has broadly classified cost modelling techniques under four main categories: intuitive, parametric, variant-based and generative (Shebab and Abdalla 2001). The methodology of cost modelling has been discussed in great detail and it has been noted that activities should be focused on quantitative cost-modelling techniques as qualitative methods only indicated whether an alternative was better or worse without any absolute values. The quantitative and qualitative methods were expanded upon by Salmi *et al.* (2016) as per Figure 2.4.

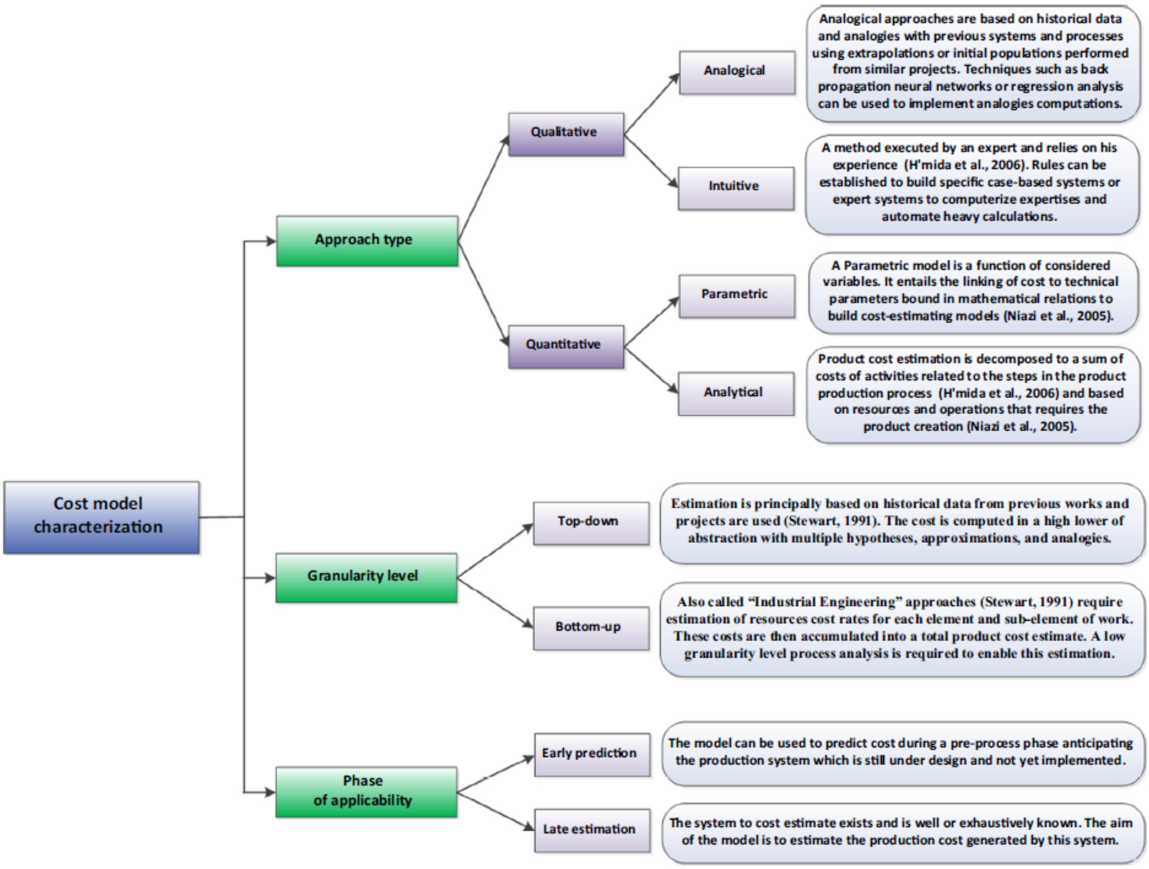


**Figure 2.4: Cost approaches to literature classifications methods**

Source: ( Salmi *et al*. 2016)

Some researchers such as Aseidu *et al*. 2000; Layer *et al.* 2002; and Caputo and Pelagagge 2008, have further defined quantitative cost modelling methods as:

1. Statistical
2. Analogous
3. Generative or Analytical
4. Feature Based.

It was also discussed that statistical models should adopt statistical criteria in order to identify causal links and correlate cost and product characteristics to obtain a parametric function with one or more variables. Generating cost models often required the use of various skills due to the requirements of multi-disciplinary knowledge

(Agyapong-Kodua *et al.* 2011). The skills required for cost modelling are described in Figure 2.5.

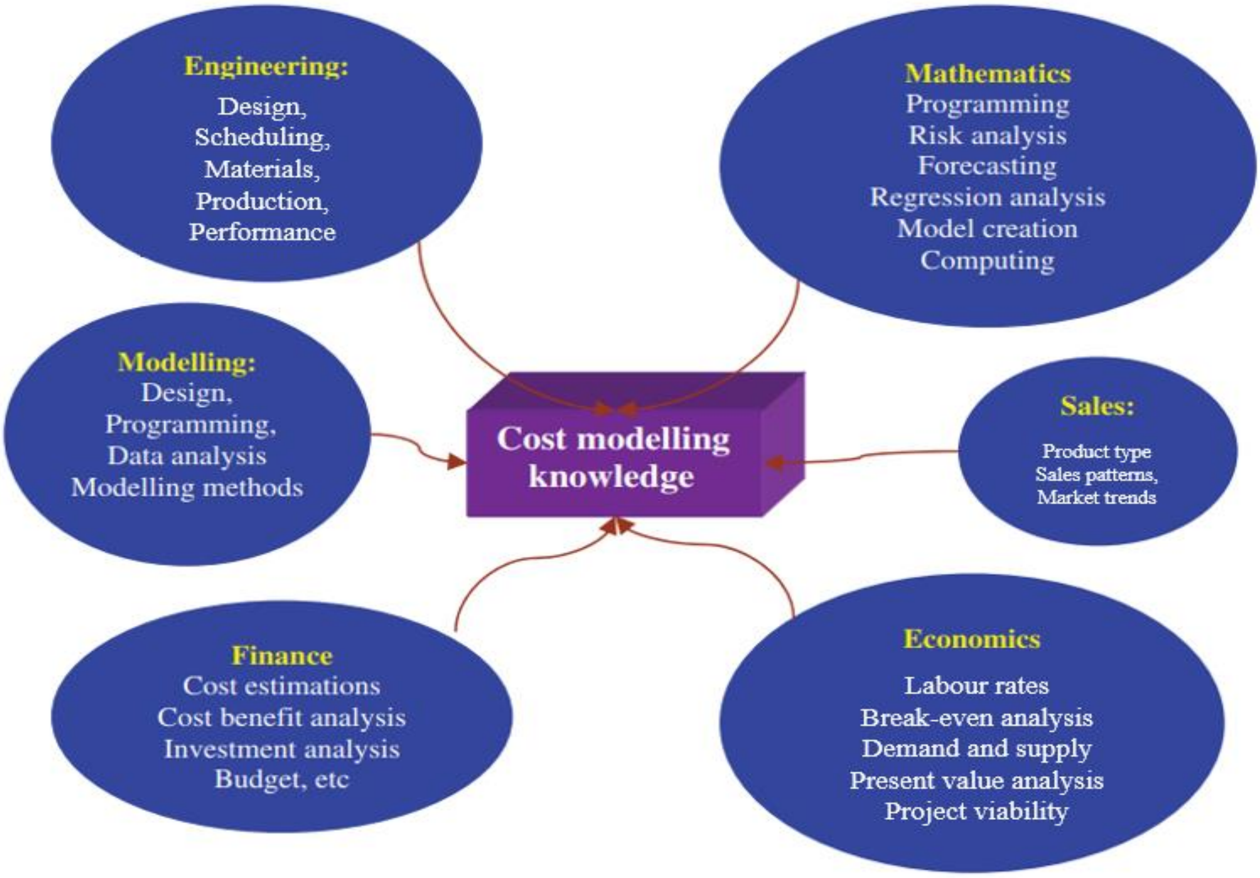


**Figure 2.5: Skills and Knowledge required for cost modelling**

Source: ( Agyapong-Kodua *et al.* 2011)

While cost modelling requires a high skills level and is a labour-intensive process, the benefits have far outweighed the required input. Some of the benefits include:

- Increasing the understanding of cost drivers
- Measuring the performance of suppliers, employees and the production system
- Facilitating a cross-functional approach linked via costs
- Justifying investment where required
- Cost reduction and management through the entire business structure.

Additionally, cost models provide other benefits to organisations relating to gaining active executive support and developing integrated data management systems and co-operative supplier relations. The introduction of cost models has also been associated with the propagation of the kaizen mindset (Fitzgerald 2002; Handfield 2000).

The current cost models assist organisations in terms of providing the benefits discussed previously. However, the current structure of cost models has some limitations – the most significant being the fact that the current models only take into consideration the cost factor and do not consider the impact of other product values such as weight, quality and performance. The existing cost estimation models did not incorporate an analysis or understanding of the current manufacturing capability of organisations therefore errors could be made in the cost estimation (Wasim *et al*. 2012). Additionally, limitations such as the inability of models to be applied outside their database range and the requirement of constant adjustments to reflect any change in the environment hindered the application of cost models in the manufacturing industry (Agyapong-Kodua *et al.* 2011).

In terms of the abovementioned research on costing methods and cost modelling, it has been shown that there have been several advancements in the methods of costing and the development of models for cost estimation purposes; however, there has not been an effort to apply the methods, or models to the manufacturing industry holistically. Cost-modelling techniques can generally be defined as shown in Figure 2.6 and in most instances literature has defined these modelling methods as product based.

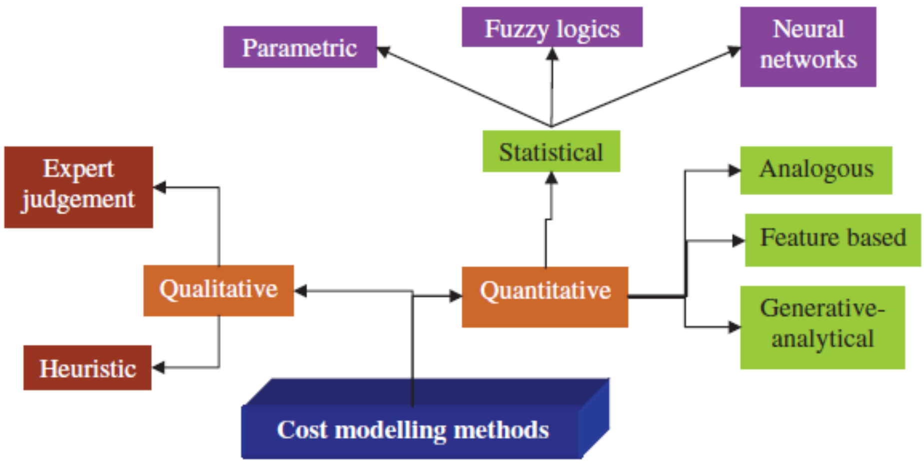


**Figure 2.6: Classification of cost modelling methods**

Source: ( Agyapong-Kodua *et al.* 2011)

The methods discussed in the literature reviewed for this study often considered cost as independent of other metrics. It has also been noted that the existing models remained largely qualitative and were subject to the opinions of experts. In essence, the problems experienced by the manufacturing industry could be attributed to increasing complexity, which originated from the ongoing complexity involved in the current markets. Ultimately, the onus now lies with cost engineers to develop models to support critical decision making – to ensure that "make" or "buy" decisions are made accurately, thereby ensuring the survival of a business in a complex and dynamic market.

## 2.7. Research Gap

While reviewing the literature, it was noticed that while much focus has been placed on the generation and application of cost estimation models, there has been limited research with regard to the relationship between the application of cost estimation models and the effect on the overall competitiveness of the organisation. Additionally, in the automotive industry there has been inadequate research regarding the impact of cost estimation models on the overall sourcing process. This research will aim to establish the impact of the application of cost estimation models to the sourcing process for automotive components.

## 2.8. Conclusion

This chapter focused on the background to the study and the theory of the foundational concepts was presented to provide the reader with a better understanding of the research objectives. This chapter commenced with an overview of the impact of globalisation and proceeded to elucidate kaizen. It then further looked at manufacturing complexities and the current methods applied in cost modelling. Due to the nature of the research project, most of the tools outlined in the literature review were adopted to support the research. The research implemented the PDCA approach while utilising tools such as the 5 why analysis, the fishbone diagram, Pareto analysis, flowcharts and GEMBA. The next chapter outlines the background to the company and the sourcing processes utilised.

# CHAPTER 3 : CASE STUDY COMPANY BACKGROUND

## 3.1 Introduction

This chapter outlines the background to the case study company and its sourcing processes. The study was conducted on the sourcing of level one components which are used in the assembly of automobiles. The main products include resin parts, press parts and functional parts. The sourcing processes take place at the RMBSS (Request to Make/Buy Strategy Sheet) stage of the project life cycle.

The case study company based in Durban, South Africa is an international automotive manufacturer. The company focuses on the assembly of passenger vehicles and multipurpose vehicles. Based on the flexibility of the new generation productions, the case study company forms part of an optimised global supply chain where component sourcing is flexible and driven by competitiveness and reliability.

## 3.2 PEPD Division Overview

Figure 3.1 shows an organogram for PEPD, which is the division tasked with ensuring that components are sourced optimally with regard to cost and design specifications. Highlighted in blue are the areas which are actively involved in leading the sourcing of components.

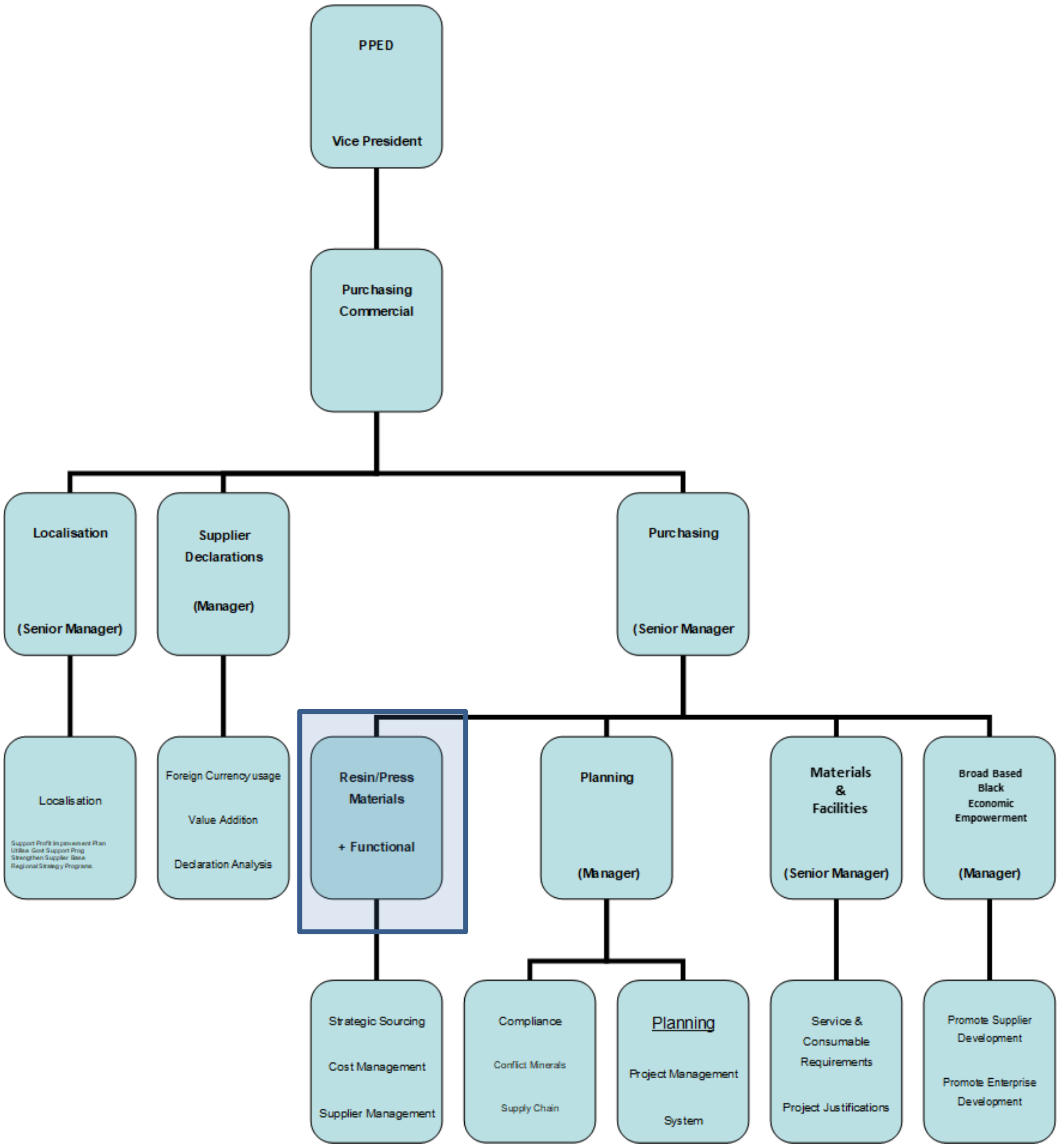


**Figure 3.1: Organogram for PEPD**

(Source: Developed by author)

### 3.2.1 Role of Purchasing

Purchasing's mission is to build a supplier base that has the respect and trust of the community while remaining competitive, thus securing the long-term, stable procurement of the best products at the best prices within the best timeframe. At each stage of the project (vehicle development, production preparation and production), purchasing carries out operations in cooperation with other functional divisions such as engineering or manufacturing. Additionally, the role of purchasing is to build solid relationships with suppliers to ensure that the case study company's philosophy and practical approaches are understood and applied consistently. It is also the responsibility of purchasing to convey the requests of suppliers throughout the organisation and actively ensure that all corporate functions are completed timeously and accurately to ensure that orderly business interactions with suppliers are maintained. Figure 3.2 provides a summary of the role of purchasing within the case study company.

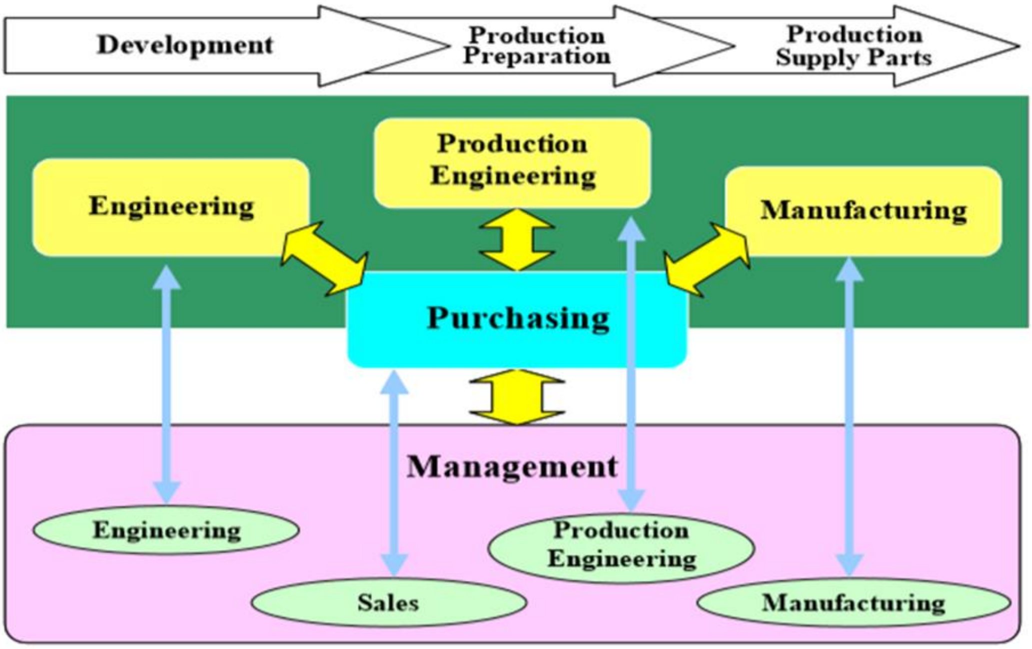


**Figure 3.2: Role of purchasing within the case study company**

(Source: Developed by author)

### 3.3 Sourcing Process

The sourcing process commences with the identification of components which are eligible for sourcing via an automated system. Triggers are sent from TMC to the purchasing specialists to notify the affiliate that the sourcing process can formally begin.

Once these triggers are received, the specialists are encouraged to download and evaluate the RMBSS and available drawing information. For this process, the specialists will utilise their own experience and knowledge of the commodity to identify high level change points and determine potential suppliers for the identified component.

The RMBSS and drawing information is then reviewed by the design team, which is constituted of members from all relevant departments. The design team meeting is used as a forum to evaluate the supplier's suitability with regard to the supply of the identified part. Factors which are discussed include current cost competitiveness, capacity, compliance with OEM targets and corporate responsibility, as well as the location and the infrastructure and logistics in place. The design team then agrees on the suppliers who will be approached for quotations and the specialist is then tasked with issuing the RFQ to the supplier.

The RFQ is shared along with all other available relevant information including the drawings, exchange rates and annual volumes. The suppliers are given two weeks to evaluate this information and respond with costs. The costs are shared with the case study company where the design team reconvenes to finalise the sourcing based on the costing received.

Upon receipt of the costs, the purchasing specialist will present the cost information to the design team to gain consensus and sign-off in respect of the selected supplier. It is imperative that all departments are included in this meeting and are made aware of the selected supplier. Consequently, the purchasing specialist will conclude the sourcing of the component via WARP and liaise with the engineering department to generate a list of sourced parts. The sourced parts will then be shared with the supplier on a Letter of Intent, which triggers the supplier to begin the tooling preparation, parts preparation, parts evaluation, parts approval and parts supply to the automotive manufacturer. Figure 3.3 gives a detailed overview of the sourcing process.

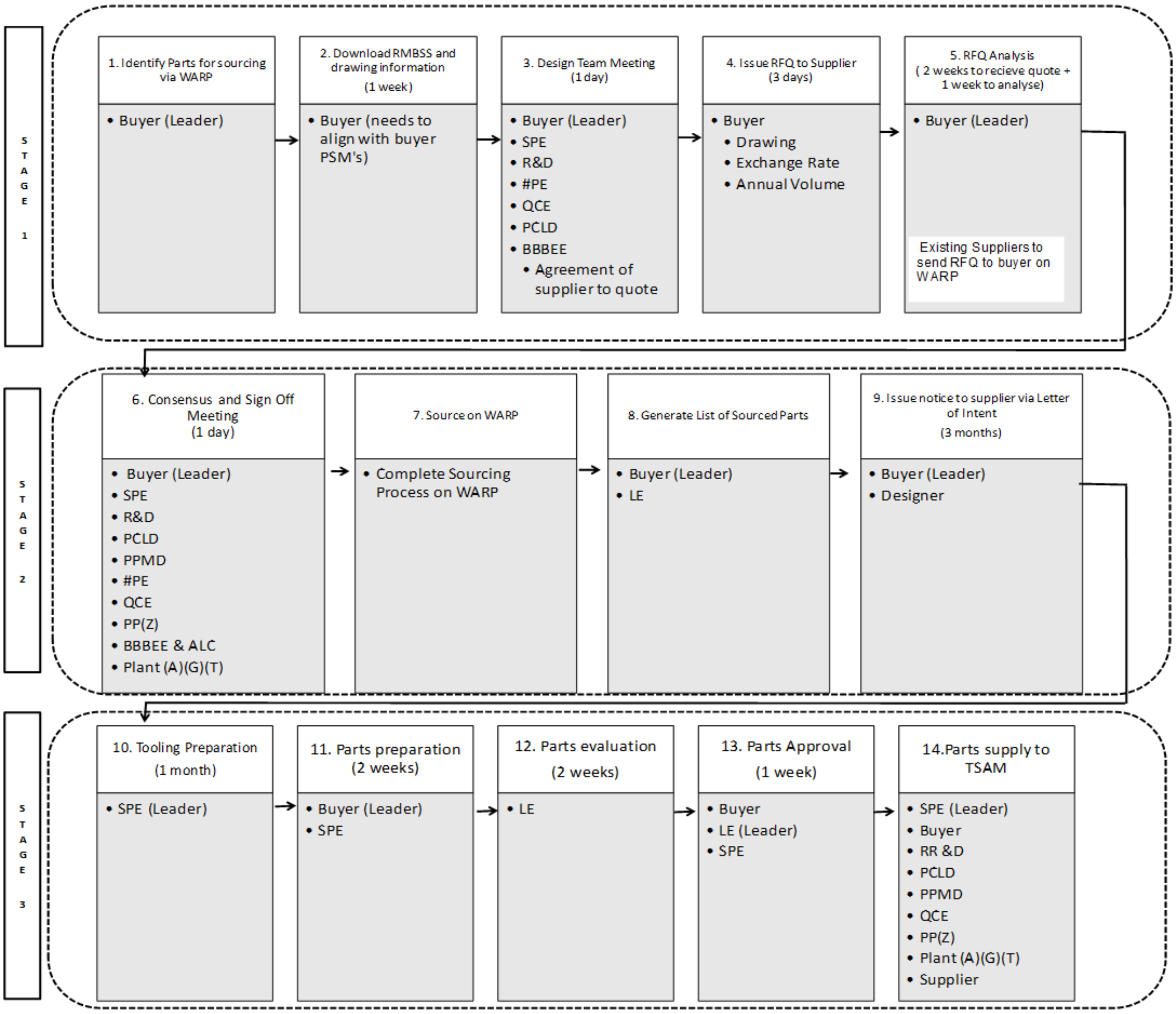


**Figure 3.3: Overview of the Sourcing Process**

(Source: Developed by author)

## 3.4 Sustainability of Continuous Improvement in the Case Study Company

The case study company places high focus on the implementation of continuous improvement techniques and striving towards excellence. By continually implementing the principles of TPS and lean manufacturing, the company aims to achieve lean excellence and ensure that the company is a market leader in respect of cost, quality and innovation.

### 3.4.1 Guiding Principles at the Case Study Company

The guiding principles at the case study company include the following:

- Open and fair corporate activities
- Provide clean and safe products and enhance the quality of life
- Create and develop advanced technologies
- Pursue growth in harmony with the global community through innovative management.

### 3.4.2 Continuous Improvement Strategy at the Case Study Company

The strategy at the case study company shown in Figure 3.4 consists of two key pillars: continuous improvement and respect for people. Continuous improvement guides employees to challenge themselves, implement kaizen and Genchi Genbutsu, while respect for people focuses on respect and teamwork.

Challenges encourage long-term vision when they are met with resolve and creativity to realize goals. It is imperative that employees create value through the manufacturing and delivery of products and services, embrace the spirit of challenge and ensure that long-term perspective is applied along with thorough consideration in decision-making.

The implementation of kaizen means that the company will continuously focus on improving business operations and strive for innovation and evolution. The case study company promotes the kaizen mind-set and innovative thinking, building lean systems and structures and promoting organisational learning.

Genchi Genbutsu is a concept where employees are encouraged to embark on a fact-finding mission to identify the source in order to make the correct decisions, build consensus and achieve goals with speed and accuracy.

Respect for people highlights the requirement for employees to make a considerable effort to understand each other and build mutual trust through sincere communication and taking responsibility.

Teamwork reflects how the company stimulates personal and professional growth through shared developmental opportunities and maximised individual and team performance.

Figure 3.4 provides an overview of the case study company's continuous improvement strategy.

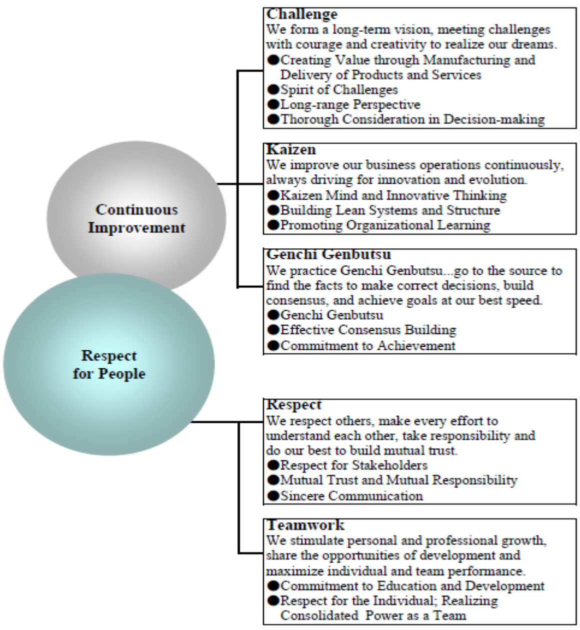


**Figure 3.4: Continuous Improvement Strategy at Case Study Company**

(Source: Developed by Case Study Company)

### 3.4.3 Approach to Establish a Competitive Supplier Base

The main factors that have to be considered in the successful establishment of a competitive supplier base include:

- Mutual trust and benefit
- Two-way communication
- Building quality into processes.

As shown in Figure 3.5, all focus areas must be attended to in order to ensure that the supplier base is competitive and responsive.

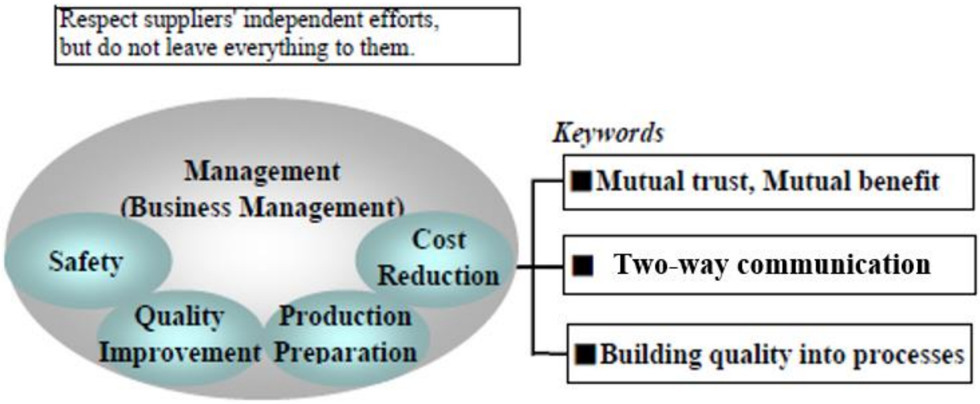


**Figure 3.5: Management Approach to Establish a Competitive Supplier Base**
(Source: Developed by Case Study Company)

### 3.4.4 Best Sourcing Approach

The case study company's approach to ensure best sourcing is characterised by the following activities:

- Open and fair interaction: consider suppliers as partners and always maintain openness and honesty.
- Long and stable procurement: choose suppliers who have a shared vision and commitment.

- Multiple sourcing: enables the case study company to maintain a competitive relationship and diversify risks.

- Effective supply chain: eliminate Muda in the supply chain below by considering geographical implications.

- Benchmark costing: grasp global impact and act decisively.

- "Should-Be" costing: develop a logical well-reasoned desired price and work on cost reduction in the early stages of the project.

- Genchi Genbutsu: go to supplier's production sites to determine how the cost of production is determined.

- Persistent Kaizen efforts: constantly identify areas for improvement.

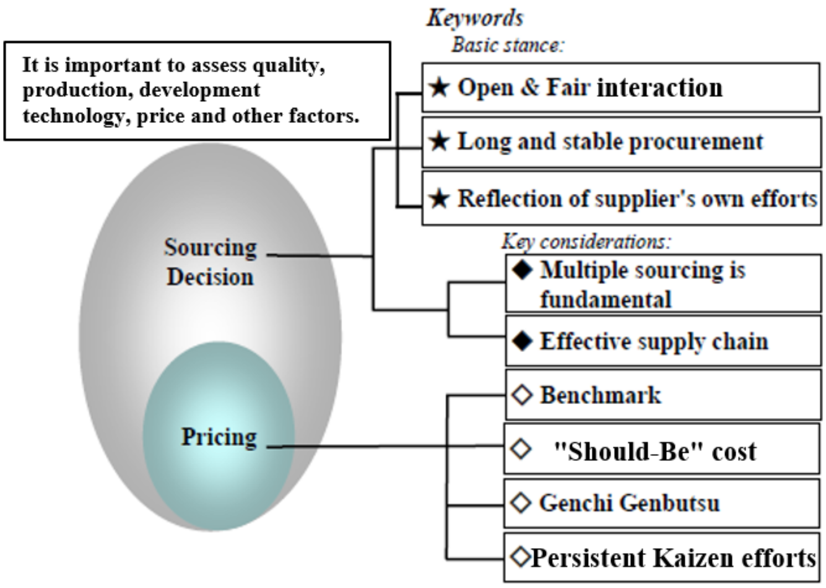


**Figure 3.6: Best Sourcing Approach**

(Source: Developed by Case Study Company)

### 3.5 Conclusion

The aim of this chapter was to outline the background to the case study company and also to give the reader an understanding of the sourcing processes. The research was conducted on the sourcing of components and all processes relating to sourcing were explained. It was noted that the implementation of continuous improvement principles was critical in order to improve the quality of sourcing decisions. It was also found that the continuous improvement principles guide all employees to strive for excellence and ensure that the company remains competitive and relevant in an ever-expanding global market.

# CHAPTER 4 : RESEARCH METHODS

## 4.1 Introduction

This chapter focuses on the methodology that was used for the study. The fundamental aspect of the methodology consists of understanding the various methodologies which were applied to achieve the desired research objectives.

## 4.2 Research Design

For this study the case study research strategy was adopted. In order to achieve the research objectives, the methodology that was adopted included the generation of the current sourcing process, the identification of areas for potential improvement, the development of an improved sourcing process and an accompanying cost estimation model. The first step in the methodology focused on detailing the current sourcing process in order to develop an understanding of the steps involved from the introduction of the component to the final sourcing. The standard operating procedure which was generated is unique to the case study company and takes into account the general operations and constraints experienced there. In order to complete the research and evaluate the impact of it holistically, the PDCA (Plan, Do, Check, Act) approach was adopted. The approach is outlined in Figure 4.1.

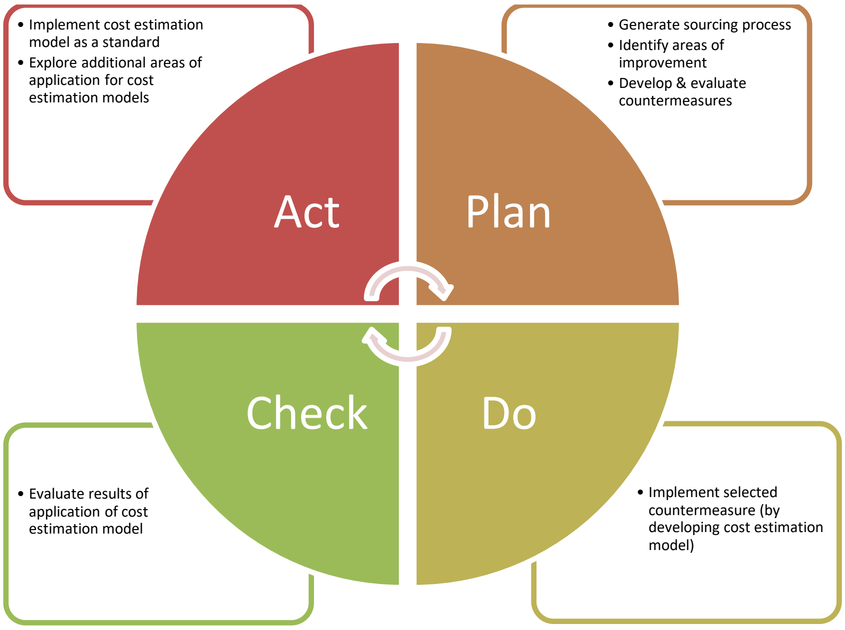


**Figure 4.1: Diagrammatic Representation of PDCA Approach**

(Source: Developed by Author)

Through the research and evaluation of various methods, it was deemed appropriate to proceed with a convergent research design.

The natural progression of the research led towards the selection of appropriate research methods. Much of the literature reviewed focused on improving the competitiveness of various industries and organisations throughout the world. It was noticed that 69% of the literature reviewed from 2007 to 2018 utilised surveys, questionnaires and interviews to collect data. However, to obtain accurate and reliable results, it was determined that a single case study approach would be used to determine the impact of a cost estimation model on the sourcing decisions made at the automotive manufacturer and its relation to the competitiveness of the organisation. The case study would thus focus on the impact of the cost estimation model at an organisational level at the automotive manufacturer.

The research utilised primary data collected from individuals currently employed at the automotive manufacturer and the application of the developed cost estimation model with regard to a specific commodity. The data was collected in two stages, focusing on collecting data from employees via an online survey using Microsoft online forms and through interviews. The responses from the interviews were documented as field notes.

The results from the online survey and the results from the interviews were compared and conclusions were drawn regarding the factors which could influence the competitiveness of the automotive manufacturer and whether the application of a cost estimation model could potentially impact its competitiveness. The data was then analysed and interpreted using the descriptive statistic method.

Guided by the information gathered from the interviews, the survey and the literature review process, the optimal cost estimation model was developed, verified and implemented. The results of the implementation were then analysed, which concluded the research.

It was identified that the automotive manufacturer's most uncompetitive commodity was resin parts. Currently, the automotive manufacturer purchases local components at an average CIM of 1.80 – meaning that on average the automotive manufacturer is paying 80% more for local resin components than other global affiliates. In order to be globally cost competitive the automotive manufacturer identified that a component CIM of 1.15 had to be achieved, meaning that, locally, there needed to be a 65% reduction in the cost of resin components.

In order to magnify the impact of the research, it was deemed appropriate to focus the study on resin components manufactured at an emerging resin supplier, Supplier A, located in Stanger, KwaZulu-Natal. The cost estimation model to be developed and applied to resin components supplied by Supplier A and its impact would be evaluated accordingly. The implementation of the cost estimation model would be in respect of the sourcing process for the next passenger vehicle produced by the automotive manufacturer with the intent of reaching the specified CIM target in order to secure a global production volume of 30 000 units per annum.

## 4.3 Research method for objective 1

The first research objective was to develop an overview of the current sourcing process and understand the factors which were influencing sourcing decisions and resulting in the high cost of parts. The method that was used to address the first research objective was to observe the process followed by the purchasing specialists from the introduction of the part into the sourcing system to the final sourcing of the component, and then generating a comprehensive process flow for sourcing at the case study company. Additionally, the purchasing specialists were asked to complete an online survey regarding the factors which influenced sourcing and the current applicability of cost models to the process. Similar questions were posed to the management team at Purchasing through interviews to verify that the information gathered from the purchasing specialists was aligned to the overall departmental objectives and best practices. Appendix 1 shows the interview guide for the questions posed to the participants. Additionally, the research focused on redesigning the sourcing process in order for the optimal sourcing process to be implemented. An ishikawa diagram was used to determine the root cause of the high cost of parts, and the 5 why analysis provided a guide as to which factors needed to be improved through the revised sourcing process. A process flow diagram was completed in order to provide a visual representation of the process.

### 4.3.1 Sourcing Process Flow

This section addresses the first research objective, which was to develop a comprehensive SOP for the current sourcing process and to understand the factors which influenced the sourcing decisions. Figure 4.2 shows the full sourcing process flow at the case study company. It details the steps involved from the identification of available parts for sourcing up to the supply of the parts.

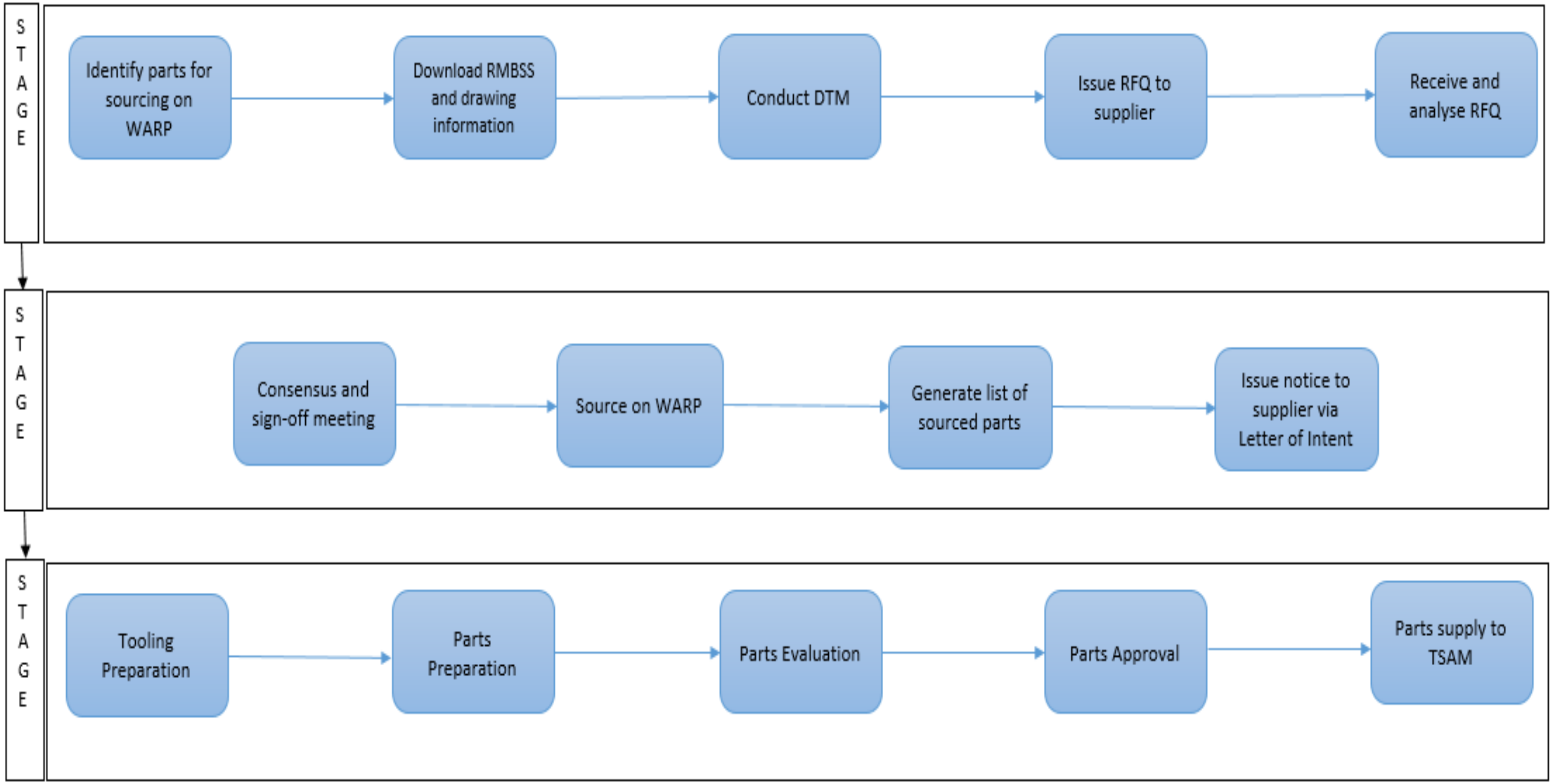


**Figure 4.2: Full Sourcing Process Flow**

### 4.3.2 Sub-production Process Flow for Stage 1

The process flow diagram in Figure 4.2 shows the sub-production process flow for Stage 1 of the sourcing process. This is the first stage of the sourcing process, and during this phase the purchasing specialist downloads the RMBSS and any available drawing information to determine the change points from the current part. The company is able to identify any determining factors regarding sourcing and cost. Key determining factors include the entity responsible for the design of the part (the supplier or the case study company), the part's weight, the part's dimensions, and the materials and processing required. These key determining factors are discussed at the DTM, which is a discussion between purchasing, engineering, process development and logistics to ensure that the suppliers have the capability and capacity to supply the part being studied. After the DTM, the RFQ is issued to the selected supplier – the supplier then studies the information and sends the quotation to the purchasing specialist who analyses the quotation to ensure that any applied cost movement is justified.

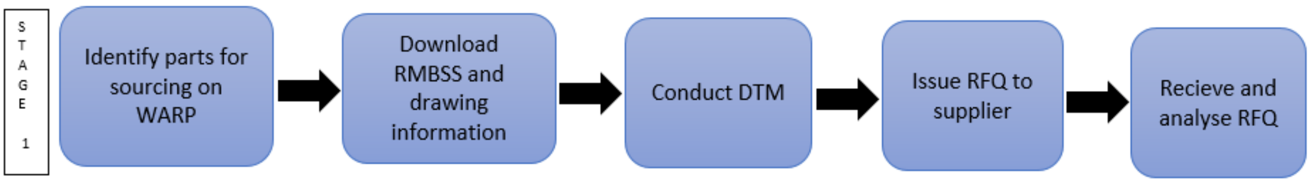


**Figure 4.3: Sub-production Process Flow: Stage 1**

(Source: Developed by author)

### 4.3.3 Sub-production Process Flow for Stage 2

Figure 4.3 shows the sub-production process flow for Stage 2 of the sourcing process, which is the second step of production. This phase is completed to gain consensus on the selected supplier for sourcing and to notify the supplier that there is a requirement to supply the identified part. A consensus meeting is held between the departments involved in the DTM and this meeting ensures that all the departments have the same understanding regarding the selected supplier and that all activity moving forward is aligned to the agreed sourcing decision. The parts are then sourced by the purchasing specialist on a system called WARP, after which a list of production parts is generated by the purchasing specialist and the relevant engineer and shared with the selected supplier via a Letter of Intent.

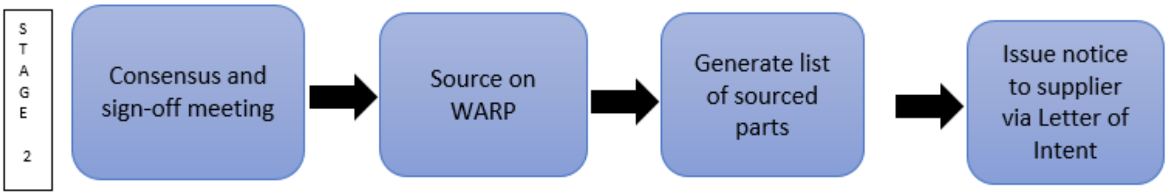


**Figure 4.4: Sub-production Process Flow: Stage 2**

(Source: Developed by author)

### 4.3.4 Sub-production Process Flow Stage 3

Figure 4.5 shows the sub-production process flow for Stage 3 of the sourcing process. Throughout this phase the supplier is managed by a group of specialists to ensure that there is adequate preparation and evaluation to confidently fit the part to the vehicle. This phase ensures that the tooling used to manufacture the part is compliant with all stipulated standards. The focus then shifts to the preparation, evaluation and approval of parts prior to the supply of parts to the manufacturing line.

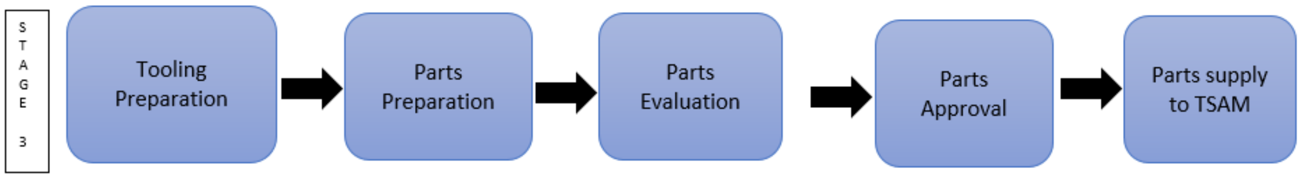


**Figure 4.5: Sub-production Process Flow: Stage 3**

(Source: Developed by author)

### 4.3.5 Online Survey Process

The previous section outlined the detailed sub-production process flows that characterized the sourcing process and addressed the first phase of the first objective, which was to map out the current sourcing process. This section will provide the detail in respect of the second phase of the first objective where the research focuses on identifying the factors which influence sourcing decisions via an online survey and through interviews with the management team at Purchasing Commercial.

The online survey was sent to 30 employees who were involved in Purchasing Commercial activities at the Durban-based automotive manufacturer. These employees were actively involved in the sourcing processes where CIM levels are calculated and analysed to make a decision regarding the sourcing of components. The survey was completed by 23 respondents, yielding a response rate of 76.67%.

The survey was designed with four phases: the first phase focused on personal questions relating to the respondents' years of experience in their current positions and their educational qualifications; the second phase focused on job specific questions; the third phase related to cost estimation models and the fourth phase related specifically to cost competitiveness at the automotive manufacturer. The survey posed the following questions to respondents:

1. Do you currently work at the Durban-based automotive manufacturer in the Purchasing Commercial department?
2. What is your current position?
3. How many years of professional experience do you have?
4. How many years have you been working in your current position?
5. What is the highest educational qualification you have completed?
6. Which purchasing team do you belong to?

7. How many suppliers do you manage?
8. What commodities do you purchase?
9. Which factors influence your sourcing decisions? Please select all applicable factors.
10. Do you use a cost estimation model when completing sourcing decisions?
11. If you have answered Yes to Question 10, please select the cost estimation model that you are currently using.
12. If you have answered No to Question 10, do you think the application of a cost estimation model would assist in making your sourcing decisions quicker and more accurate?
13. Please list three factors which you believe influence the cost of local parts at the automotive manufacturer.
14. Please list three ways in which you believe the automotive manufacturer could improve its cost competitiveness.

### 4.3.6 Interview Process

Further to the online survey, interviews were conducted to understand more fully how sourcing decisions were made and the factors which influenced them. The interviews were conducted with various members of management within the Purchasing Commercial department to understand which factors were taken into account regarding sourcing activities at management level and to determine what were the key factors influencing the cost of local components and methods which could be used to improve the automotive manufacturer's cost competitiveness.

The interviews followed a similar format to the online survey to allow for the easy comparison of results. Questions asked related to the participants' professional experience, job specific functions, cost model utilisation and cost competitiveness.

In addition five members from the Purchasing Commercial department management team were interviewed, utilising a semi-structured interview style where open-ended questions were posed.

Each participant was asked to respond to the following questions:

1. What is your current position at the automotive manufacturer?

2. How many years of professional experience do you have and how long have you been working in your current position?

3. What does your function entail?

4. Which commodities are you responsible for?

5. How do your teams make sourcing decisions?

6. Is a cost estimation model being utilised by your teams?

7. Do you believe the application of a cost estimation model could improve the cost competitiveness of the automotive manufacturer, and if so, how?

8. Please list three factors which you believe influence the cost of local components.

9. Please list three ways in which the automotive manufacturer could improve its cost competitiveness.

Each response was documented through field notes and the results are expanded upon and discussed in Chapter 5.

Through observation and additional engagement with purchasing specialists an ishikawa diagram and 5 why analysis were completed in order to identify the root causes for the high cost of local parts.

## 4.4 Research method for objective 2

The second research objective was to develop and implement a parametric cost estimation model. The cost estimation model was generated using Microsoft Excel. A case study approach was then used to determine the impact and effectiveness of the developed cost estimation model.

The parametric model was designed to target resin components. A Pareto analysis was used to determine the parts most contributing to the high CIM. The Pareto analysis was conducted on 3860 parts supplied by 16 suppliers, all of which were identified as contributing to the high CIM. The parts were categorised according to the commodity supplied and were then analysed in terms of percentages to determine which were the highest contributors. The table below details the data used to generate the Pareto graph and it is followed by the Pareto graph showing that 64% of the parts which had a CIM greater than 1.13 were small resin components.

| Company | Number of parts CIM > 1.13 | Part Type Supplied | Percentage |
|---|---|---|---|
| Supplier A | 213 | Functional Components | 6% |
| Supplier B | 96 | Functional Components | 2% |
| Supplier C | 414 | Functional Components | 11% |
| Supplier D | 5 | Functional Components | 0% |
| Supplier E | 333 | Press Components | 9% |
| Supplier F | 216 | Press Components | 6% |
| Supplier G | 81 | Press Components | 2% |
| Supplier H | 18 | Press Components | 0% |
| Supplier I | 3 | Press Components | 0% |
| Supplier J | 706 | Small Resin Components | 18% |
| Supplier K | 637 | Small Resin Components | 17% |
| Supplier L | 431 | Small Resin Components | 11% |
| Supplier M | 354 | Small Resin Components | 9% |
| Supplier N | 328 | Small Resin Components | 8% |
| Supplier O | 12 | Small Resin Components | 0% |
| Supplier P | 14 | Small Resin Components | 0% |
| Grand Total | 3860 | | |

**Table 4.1 Data used for Pareto analysis**

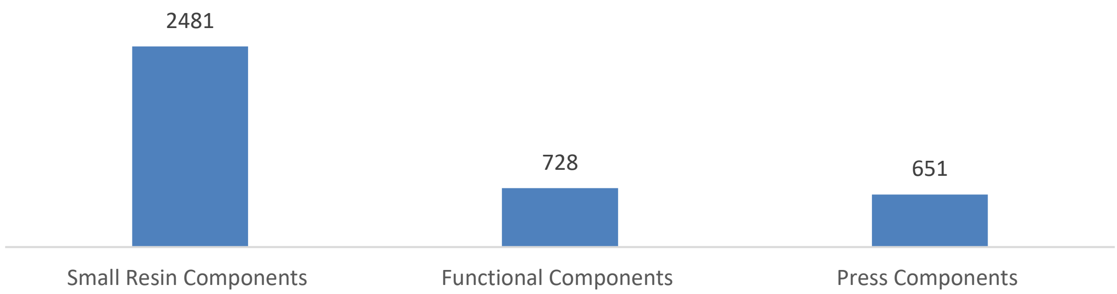


**Figure 4.6: Pareto graph – Number of parts with CIM greater than 1.13**

(Source: Developed by author)

## 4.7 Research framework

Figure 4.7 shows a diagrammatic representation of the applied research framework which was used to develop a roadmap for improving the competitiveness of the case study company through the application of cost estimation models.

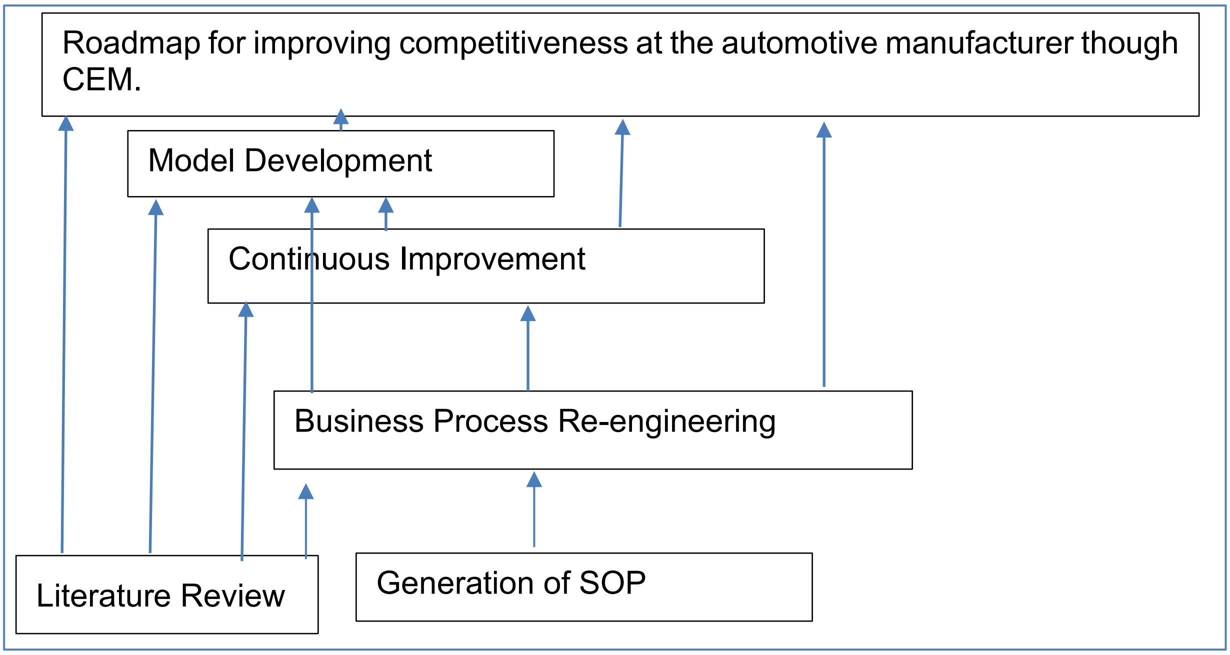


**Figure 4.7: Diagrammatic Representation of Research Framework**

(Source: Developed by Author)

## 4.8 Ethical considerations

The division of applied ethics has clearly defined a set of guiding principles and laws which define the conduct for research ethics. Research ethics is crucial when conducting research and stipulates that the researcher must protect their research participants, data and information. Appendix 2 provides the ethics clearance certificate, which shows that the researcher was cognisant of all the ethical issues prior to conducting the study.

Shapiro and Stefkovich (2016) commented that human beings generally find ethical decisions challenging. However, this study embraced the required ethics and incorporated the concept into academic writing. It was deemed vital to maintain research ethics in accordance with the Durban University of Technology's policy where a post-graduate student is required to submit the thesis through Turnitin software to check for plagiarism. The requirement is for students to conform to 20% or less plagiarised material to gain acceptance for the research database. Appendix 4 details a Turnitin report with a 15% similarity index, which is acceptable as per the institution's requirements.

## 4.9 Conclusion

This chapter focused on the methodology adopted for the study and the associated ethical considerations. For this study the case study research strategy was adopted. To achieve the research objectives, the methodology that was adopted included the generation of an SOP for the sourcing process, the identification of areas in need of improvement, the redesigning of the sourcing process and the development of a cost estimation model. The next chapter focuses on the presentation of the results and discusses them.

# CHAPTER 5 : RESULTS AND DISCUSSION

## 5.1 Introduction

This chapter focuses on the presentation and discussion of the research results. The key issues highlighted in this chapter include the sourcing process flow, online survey results, flow diagrams, the Pareto analysis for the selected components and the application of the parametric cost estimation model.

## 5.3 Online Survey and Interview Results

### 5.3.1 Online Survey Results

With regard to the first phase of the survey, the survey posed questions relating to the number of years of experience the respondent had in their current position and their highest completed educational qualification. It also requested respondents to confirm that they were based in the Purchasing Commercial department and their role in the department.

From the responses it was noted that 100% of the respondents worked in the Purchasing Commercial department and 22 of the 23 respondents identified as Purchasing Specialists and 1 out of 23 respondents identified as a Purchasing Manager. The results relating to the years of experience in the current position and the highest completed qualification are shown below in Figure 5.1.

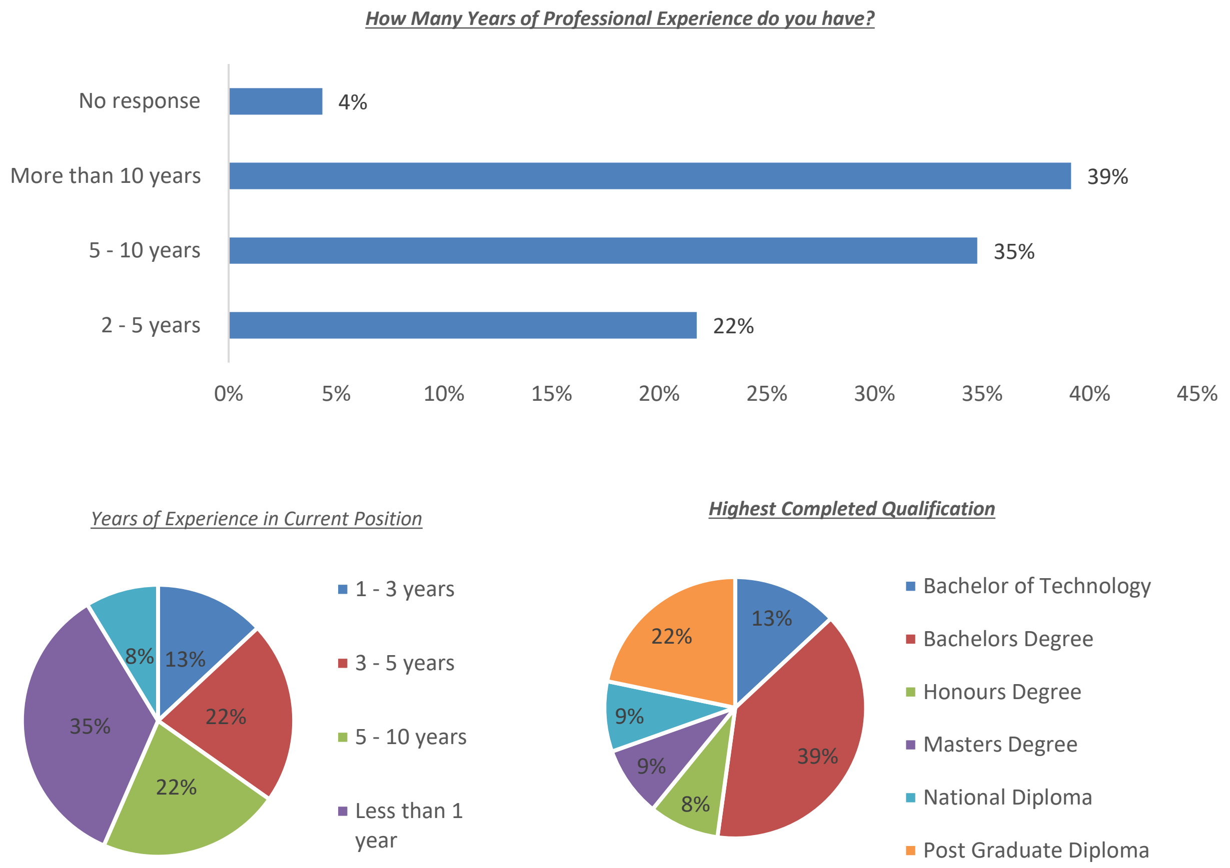


**Figure 5.1: Response to Questions 3, 4 & 5**

Based on the above figure, it was apparent that whilst the majority of the respondents had more than ten years of professional experience, 35% of the respondents indicated that they had less than one year of experience in their current position. It was also noted that the most prominent educational qualification obtained was a Bachelor's degree, followed by a Postgraduate Diploma and then a Bachelor of Technology, a Master's Degree and a National Diploma. These results indicated that while the Purchasing Commercial department had experienced, knowledgeable members, there might be a problem regarding specialists who had been employed in their current position for less than one year.

The second phase of the survey posed job specific questions so as to identify the placement of respondents as well as their key areas of impact with regard to commodities and the supplier base. Figure 5.2 below shows the number of respondents from each buying team.

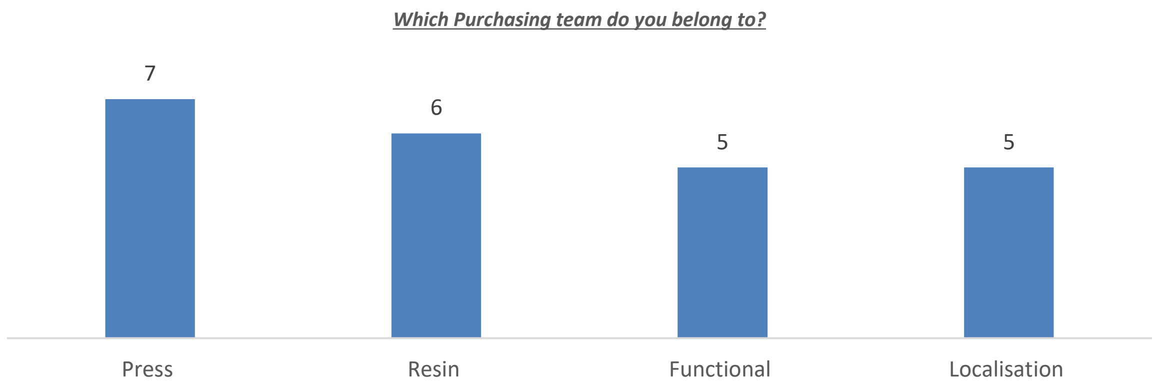


**Figure 5.2: Response to Question 6**

When evaluating the impact of each purchasing specialist with regard to the supplier base, the team responsible for localisation was excluded from this activity due to the nature of their function which involved activity with all suppliers. When analysing the responses from all the other respondents it was found that, on average, each purchasing specialist managed approximately five suppliers with commodities ranging from various functional components including shock absorbers, springs, headlamps and airbags to resin and press components. By completing this analysis, it was possible to provide a holistic representation of the supplier base in respect of the research. The suppliers were then requested to select applicable factors which influenced their sourcing decisions. It was shown that all respondents took the cost consideration into account when sourcing, whereas only 26% of the respondents took other factors into account. The results can be seen in Figure 5.3 below.

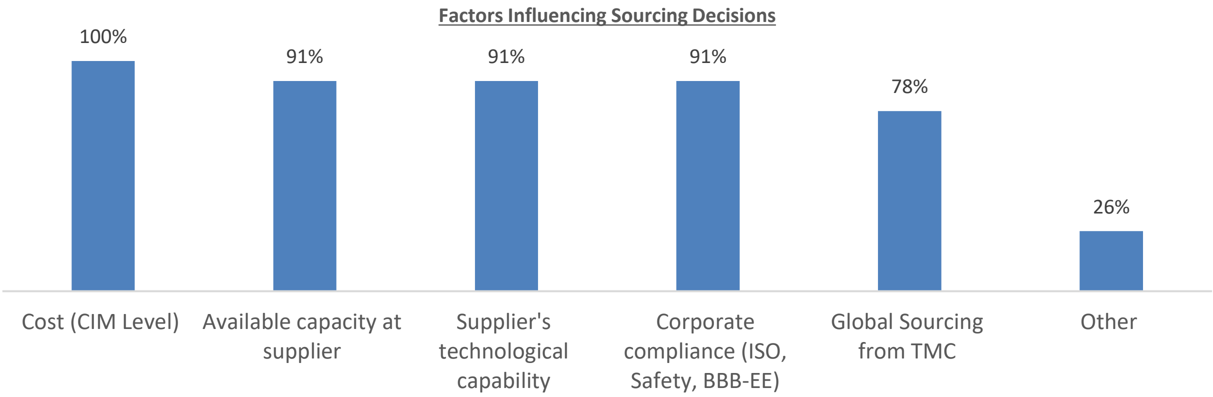


**Figure 5.3: Response to Question 9**

The survey then explored the application of cost models within the Purchasing Commercial department and posed questions regarding whether or not a cost estimation model was utilised, the type of cost estimation model utilised and what the impact would be if a cost estimation model was to be introduced. The response indicated that 69.57% of the respondents currently utilised a cost estimation model, whereas 30.43% of the respondents did not utilise a cost estimation model, and of the 30.43% who did not utilise a cost estimation model, 85.71% agreed that the implementation of a cost estimation model would increase the speed and accuracy of their sourcing decisions. Of the 69.57% of respondents who utilised a cost estimation model, it was determined that 30.43% used engineering techniques, 21.74% used parametric models and 17.39% used analogy-based techniques. Figure 5.4 details the responses to questions about the use of a cost estimation model. Engineering techniques are based on processes which can only be determined at a later stage in the project; therefore the engineering techniques cannot be easily applied at the sourcing stage when the process has not yet been defined. Additionally, analogy-based techniques do not provide the highest accuracy levels and therefore it was recommended that a parametric model be utilised for sourcing activities.

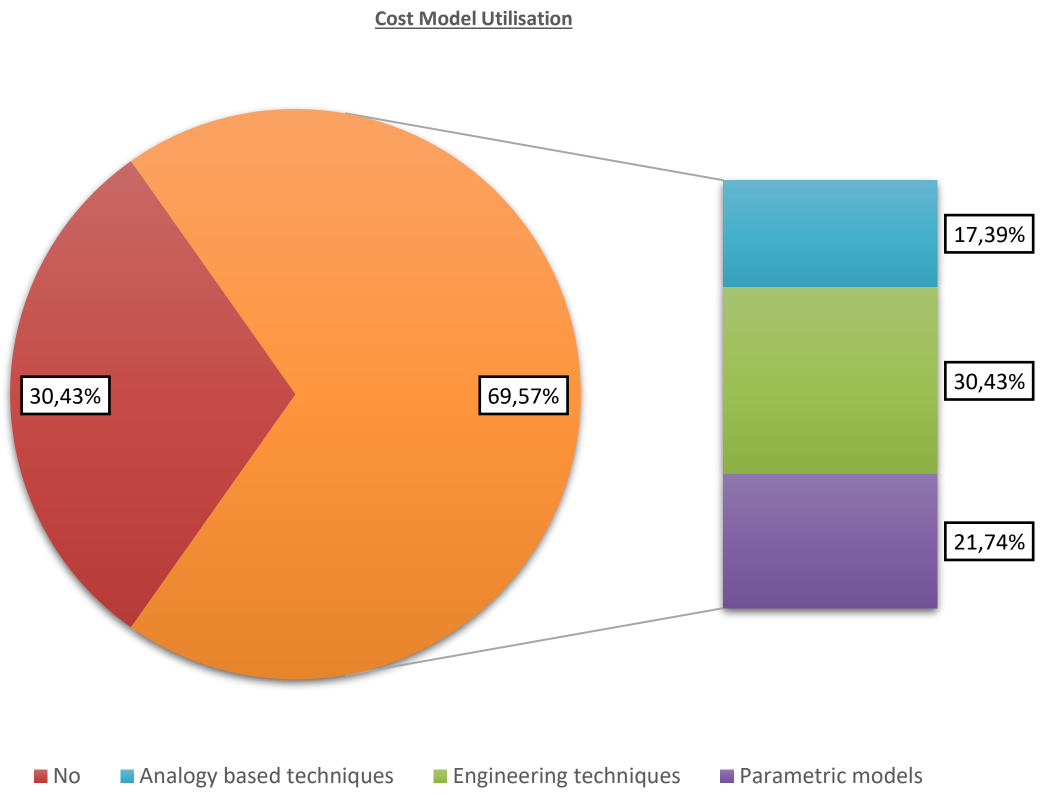


**Figure 5.4: Responses to Question 10 & 11**

Subsequently, the survey requested respondents to provide factors which they believed influenced the cost of local components and methods which could be used to improve the cost competitiveness of the automotive manufacturer. The responses are detailed in Table 5.1.

**Table 5.1: Factors influencing cost of local components**

| Survey Response | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Purchasing Team | F | P | R | F | P | L | L | F | L | L | F | P | R | R | P | P | P | P | R | L | F | R | R | |
| Economics | X | | | | | | | | | | X | | | | | | | | | | | X | | 3 |
| Material | X | | | X | | X | X | | | | | X | X | X | | | X | | | X | | | X | 10 |
| Profit | X | X | | | | | | | | | | | | | | | | | | | | | | 2 |
| Labour Costs | | X | X | | | | | X | | | | | X | X | | X | X | | | | X | | | 8 |
| Volume | | X | | | X | | | | | | | | | X | | | | X | | | | | | 4 |
| Exchange Rates | | | X | | | | | | | | | | | | | X | | X | | | | | | 3 |
| Component Prices | | | X | X | | | | | | | | | | | | | | | | | | | | 2 |
| Overhead Costs | | | | X | | | | | | | | | X | | | X | X | | X | | | | | 5 |
| Plant Location | | | | | X | | | | | | | | | | | | | | | | | | | 1 |
| Long Lead Time | | | | | X | | | | | | | | | | | | | | | | | | | 1 |
| Quotation Inaccuracy | | | | | | X | | | | | | | | | | | | | | | | | | 1 |
| Inefficient supply chain | | | | | | X | | | | | | | | | | | | | | | | | | 1 |
| Process | | | | | | | X | | X | | | X | | | | | | | | | | | | 3 |
| High investment | | | | | | | X | | X | | | | | | | | | | | | | | X | 3 |
| Imported Material | | | | | | | | X | X | X | X | | | | | X | | | | | | | | 5 |
| Monopoly suppliers | | | | | | | | X | | | | | | | | | | | | | | | | 1 |
| Tier 2 Instability | | | | | | | | | | X | X | | | | | | | | | | | | | 2 |
| Poor cost Estimation at Suppliers | | | | | | | | | | X | | | | | | | | X | | | | | | 2 |
| Complexity | | | | | | | | | | | | X | | | | | | | | | | | | 1 |
| Technival Know How | | | | | | | | | | | | | | | X | | | | | | | | | 1 |
| Costing Procedures | | | | | | | | | | | | | | | X | | | | | | | | | 1 |
| Logistics | | | | | | | | | | | | | | | | | | | X | X | | | | 2 |
| Supplier Capability | | | | | | | | | | | | | | | | | | | X | | X | | | 2 |
| Supplier Capacity | | | | | | | | | | | | | | | | | | | | X | | | | 1 |
| Duty & Royalty Payments | | | | | | | | | | | | | | | | | | | | | X | | | 1 |
| Supplier Margins | | | | | | | | | | | | | | | | | | | | | | X | | 1 |
| Variation in specification | | | | | | | | | | | | | | | | | | | | | | X | | 1 |
| Supplier Location | | | | | | | | | | | | | | | | | | | | | | | X | 1 |

Through these results it was determined that the key influencing factors for the cost of local components were material, labour costs, overhead costs and imported material. The most selected influencing factor was material (43,47%), followed by labour (34,78%), overhead costs (21,73%) and imported material (21,73%). This indicated that, according to the purchasing specialists, the cost of a local component was most influenced by the material cost. While the material cost was governed by the requirements indicated on the engineering drawing, at the automotive manufacturer the material cost was considered a controllable cost as it was largely dependent on the accuracy of the process and the suitability of the equipment utilised to manufacture the component. Through effective analysis of the process, it was believed that the material cost could be reduced via scrap reduction and optimal tooling specifications.

The respondents were then asked to provide methods through which the automotive manufacturer could improve its competitiveness. The results are documented in Table 5.2.

**Table 5.2: Response to Question 14 – Methods to improve cost competitiveness**

| Factors to Improve Competitiveness | % of responses |
|---|---|
| Increase Local Content | 22.03% |
| Accurate Cost Estimation | 8.47% |
| Increase volumes | 6.78% |
| Manufacturing Improvement | 6.78% |
| Negotiation | 5.08% |
| Benchmarking | 1.69% |
| Carry-over designs | 1.69% |
| Centralised Purchasing & Logistics | 1.69% |
| Commonize material to increase volume | 1.69% |
| Competitive bid | 1.69% |
| Consolidate the business | 1.69% |
| Develop capable R&D skill to allow for supplier selection autonomy | 1.69% |
| Forex policy | 1.69% |
| Global Best Source Activity | 1.69% |
| Improved employee morale | 1.69% |
| Improved commodity information | 1.69% |
| Increase in-house capability | 1.69% |
| Increase supplier base | 1.69% |
| Increase training | 1.69% |
| Increased understanding of commodities | 1.69% |
| Increasing the local supplier base | 1.69% |
| Locate suppliers closer to manufacturing plant | 1.69% |
| Mind-set change | 1.69% |
| More stringent material control | 1.69% |
| New suppliers | 1.69% |

| | |
|---|---|
| Optimise tooling | 1.69% |
| Overhead cost analysis | 1.69% |
| Pursue in-sourcing | 1.69% |
| Recycle waste | 1.69% |
| Reduce the number of suppliers | 1.69% |
| Relaxation in specifications | 1.69% |
| Remove overhead cost as a negotiable item | 1.69% |
| Solar energy | 1.69% |
| Synergies | 1.69% |
| VA/VE | 1.69% |
| Grand Total | 100.00% |

The responses indicated that the most commonly suggested factor to improve cost competitiveness was to increase local content, closely followed by accurate cost estimation. For the purpose of this research, it was important to note that the automotive manufacturer had successfully introduced a rigorous and successful localisation programme, thus making it productive to focus on cost estimation as a method to improve the competitiveness of locally manufactured parts.

### 5.3.2 Interview Results

With regard to Question 1, three of the participants identified as Senior Managers and the remaining two identified as Managers for various portfolios.

For Question 2, the results are shown in Figure 5.5.

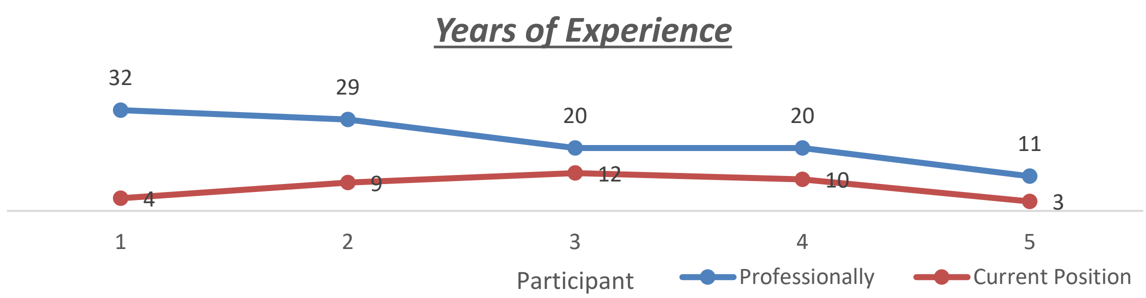


**Figure 5.5: Response to Interview Question 2**

(Source: Developed by author)

Through this response it was found that 80% of the participants had twenty or more years of professional experience, whereas only 40% of respondents had ten or more years of experience in their current position.

When asked about their function, all the participants indicated that their function revolved around the management of and support for buying functions in the Purchasing Commercial department relating to various commodities including resin components and materials, press components and materials, and functional components.

The participants were then required to explain how their respective teams made sourcing decisions. The results were sorted and it was found that 100% of the participants used Cost, Safety, Quality, Delivery and Compliance to guide their decisions. The remaining factors are shown in Table 5.3.

**Table 5.3: Response to Interview Question 5**

| Cost Safety Quality Delivery Compliance | Supplier Capability | Competitive Bid | Part complexity | Supplier Capacity | TMC Approval |
|---|---|---|---|---|---|
| X | | | | | |
| X | | | | | |
| X | X | X | | | |
| X | X | | X | | |
| X | X | X | | X | X |
| 100% | 60% | 40% | 20% | 20% | 20% |

The interview then sought to determine how cost models were utilised in the department. Eighty percent of the participants responded that their teams were utilising a cost estimation model; however, there were varying responses regarding the type of cost estimation model which was utilised. Table 5.4 delineates the responses.

**Table 5.4: Responses to Interview Question 6**

| Participant | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| **Cost Model Utilised?** | Yes | Yes | No | Yes | Yes |
| **Additional Commentary** | Largely based on buyer knowledge | Manual Process | Part Complexity does not allow for CEM | Process based costing | Process based costing |

It was found that the majority (80%) of the buying teams did utilise a cost estimation model; however, it must be noted that of this 80%, 50% indicated a process-based model, and 25% indicated that they were utilising a manual process and that the process was largely dependent on the buyer's knowledge.

All the participants indicated that the application of a cost estimation model could improve the cost competitiveness of the automotive manufacturer. Sixty percent of the participants indicated that cost competitiveness could be improved by improving the accuracy of quotations and sourcing decisions and the remaining 40% indicated that cost competitiveness could be improved by providing specialists with more negotiating power.

The participants were then requested to list key factors which influenced the cost of local components and methods and through which the automotive manufacturer could improve cost competitiveness. These identified factors and their relevant percentages are shown in Table 5.5.

**Table 5.5: Response to Interview Question 8**

| Cost Influencing Factor | Percentage |
|---|---|
| Material | 80% |
| Labour | 60% |
| Supplier Capability | 40% |
| Available Technology | 40% |
| Local Economics | 20% |

| | |
|---|---|
| High Investment | 20% |
| Unregulated Machine Rates | 20% |
| Logistics | 20% |
| Volume | 20% |
| Incentives | 20% |

Material cost was found to be the most commonly identified influencer of local component costs, followed by labour costs, supplier capability, available technology and other factors.

Lastly, the participants were requested to propose methods to improve the cost competitiveness of the automotive manufacturer. A variety of methods was proposed, with the centralisation of purchasing being the most common factor as recommended by 60% of the participants, closely followed by optimisation of tooling, increasing of local content and better cost estimation, which saw 40% of participants recommending these factors. All the recommended methods and their relevant percentages are shown in Figure 5.6.

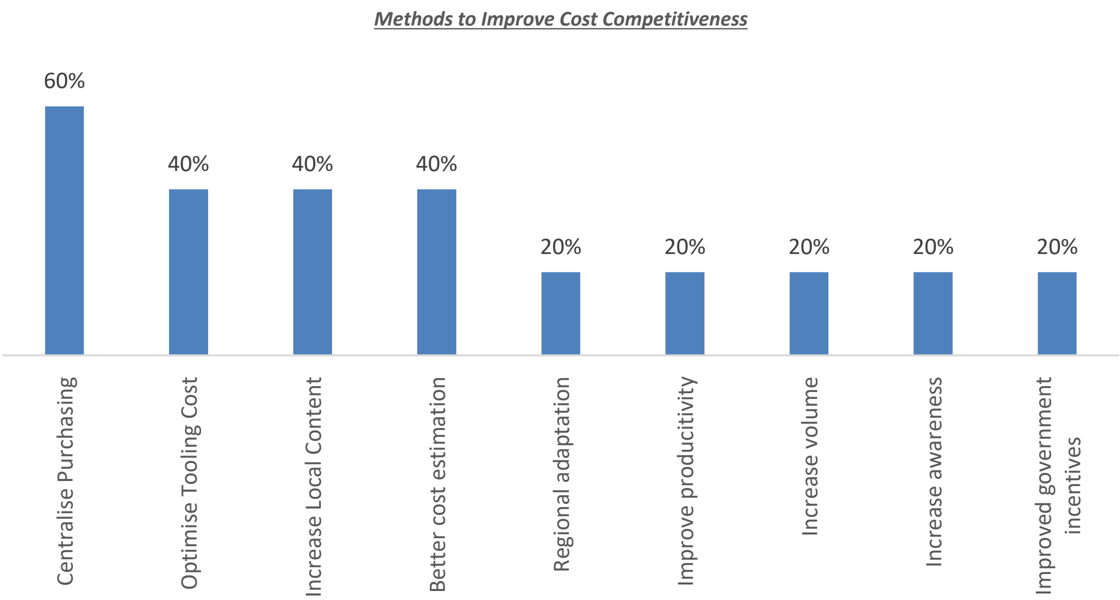


**Figure 5.6: Response to Interview Question 9**

### 5.3.3 Discussion of Survey and Interview Results

To increase the accuracy of the results of this research, data was collected from two different sources, the first being the online survey directed at Purchasing Specialists and the second being the interviews directed at Purchasing Management. By collecting data from different sources, potential weaknesses in the data could be overcome (Mishra and Rasundram 2017).

In order to fully verify the information from both sources, the responses to questions directly related to the study objectives will be documented in a tabular format. This will allow confirmed conclusions to be drawn from the study.

**Table 5.6: Online Survey vs. Interview Responses**

| Key Factors | Online Survey Results | Interview Results |
|---|---|---|
| To make Sourcing Decision | Cost | Cost |
| Which Influence Cost of Local Components | Material<br>Labour<br>Overheads<br>Imported Material | Material<br>Labour<br>Supplier Capability |
| To improve Cost Competitiveness | Increase Local Content<br>Accurate Cost Estimation<br>Increased Volumes | Centralise Purchasing<br>Optimise Tooling Cost<br>Increase Local Content<br>Better Cost Estimation |

Based on the results from both the online survey and the interviews, it could be concluded that cost was the most important factor when making sourcing decisions and, additionally, the cost of local components was largely influenced by material and labour costs. It is imperative to note that while there were differences in the recommendations to improve cost competitiveness, the issue of improved cost estimation techniques was present and prominent through both the online survey and the interviews. It was also determined through the interviews that there was a requirement for accurate cost estimation to be completed early on in the project life cycle before making the sourcing decision. The interviews, survey and generation of the SOP for the sourcing process revealed that the current sourcing process was not inclusive and did not provide specialists with ample information to negotiate the cost sufficiently.

This was due to the following reasons:

- The information provided by the RMBSS and preliminary drawings was limited.
- The technical skills and expert knowledge, which are attained through years of experience and on the job training, were lacking in the case study company's purchasing department due to many specialists occupying the position for only three years or less.
- The current cost estimation model used was generally based on engineering techniques, which could only be applied at a much later stage in the project once the manufacturing process had been agreed and approved.

## 5.4 Revised Sourcing Process

To achieve the first objective, it was necessary to identify the root cause of the high parts cost and identify the areas which needed to be improved through the revised process. The root cause analysis was completed using an ishikawa diagram shown in Figure 5.7 and the 5 why analysis shown in Figure 5.8.

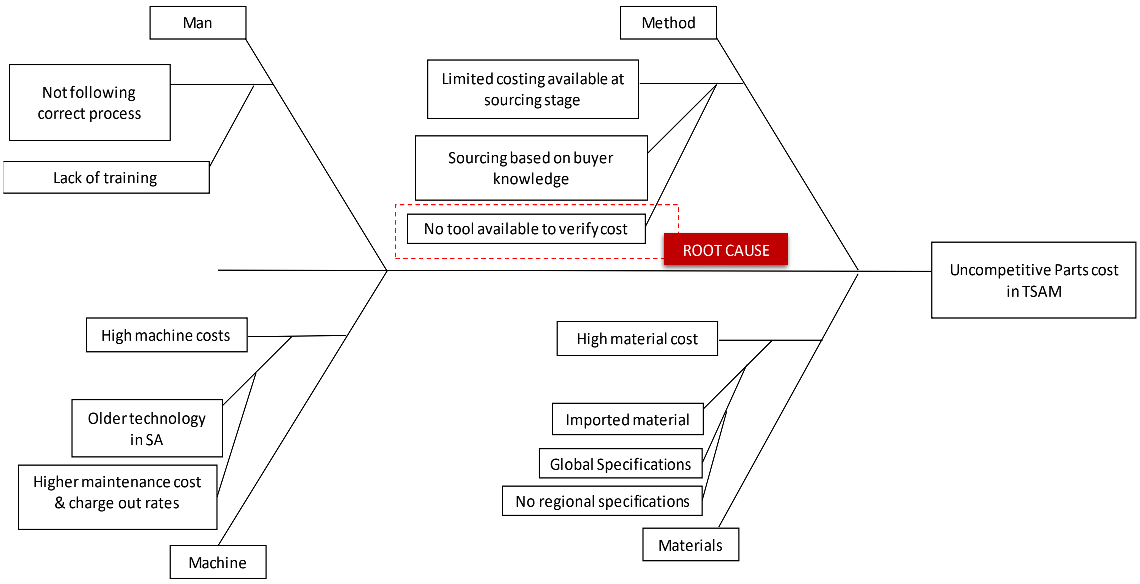


**Figure 5.7:Ishikawa Diagram**

(Source: Developed by author)


**Figure 5.8: 5 Why Analysis**

(Source: Developed by author)

The 5 why analysis revealed that due to limited information at the early stages of the project, sourcing decisions were based on the buyer's knowledge and experience. This could result in high costs being submitted at a later stage in the project, by which time the source of supply would be fixed and could not be changed due to the impact it would have on the system.

In order to strengthen the current process, it was recommended that when Purchasing Specialists were negotiating costs and agreeing to tentative costs, the process should be completed with the use of costs generated from a cost estimation model, hence making the negotiation easier, improving the accuracy of the costing and ensuring that there were fewer adjustments later on in the project. Therefore, it was proposed that the sourcing process be revised in order to improve the cost competitiveness at the automotive manufacturer. The proposed sourcing process is shown in Figure 5.9.


**Figure 5.9: Revised Sourcing Process**

(Source: Developed by author)

With these requirements in mind, a parametric cost estimation model for injection moulded resin models was created based on the global training manuals provided by TMC and which provided guidance on how to calculate material, process, tooling and overhead costs. With regard to the overhead cost, the cost calculated was in relation to one part only, hence it was not possible to utilise activity-based costing for the purpose of this research. The model was generated on Microsoft Excel, requiring minimal input from the Purchasing Specialist to generate the cost estimate. The model was then validated by generating cost estimates for existing local components and then measuring the accuracy levels.

### 5.5 Model Adoption

The model was formulated according to guidelines provided in training manuals from TMC, which provided mathematical formulas for the calculation of the material cost, process cost, overhead cost and tooling cost for injection moulded resin components. The training manuals also provided general guidelines regarding the cost of materials, which was adjusted globally according to the relevant exchange rates.

The model was created using the Microsoft Excel computer program. This program was selected for various reasons including ease of use for new users, increased accessibility for users and feasibility, since many software programs which focus on the generation of cost estimates are specialised and require licences, which can be very costly. Hence, Microsoft Excel was used to provide a cost-effective solution to generate cost estimates early on in the project life cycle.

The model created a separate tab for each component of the part cost. The model contained the following tabs:

Tab 1: Material Cost

Tab 2: Process Cost

Tab 3: Overhead Cost

Tab 4: Tooling Cost.

Each tab used the relevant formula to generate the estimate based on the guidelines and cost tables provided. The following formulas were applied to each cost component (Kooanantkul and Yensudjai 2018: 1-28):

Material Cost = {Product Mass (kg) x 1.01 x Material Unit Price} + {Runner Mass (kg) x Recycle Cost}

Process Cost = Injection Cost Per Shot/ No. of Cavities

Overhead Cost = (Material Cost + Process Cost) x 0.15

Tooling Cost = Mould Cost + Checking Fixture Cost

Figures 5.10 – 5.13 show the construction of the model using Microsoft Excel.

In Figure 5.10 the tab detailing the material cost is shown. For the material cost, there are various factors which need to be taken into consideration. These factors include the product mass, the material type, the runner mass and the recycle cost.

The user is required to input the product mass (which is highlighted in yellow) – this information can easily be obtained from the part drawing or the RMBSS. The user is then required to select the runner mass from a drop-down menu (which is highlighted in yellow). Additionally, the user will also be required to indicate the material type, which can also be selected from the drop-down menu which lists various materials generally used in the automotive industry. Based on the information provided by the user, the tab will utilise the applied formula to calculate the material cost for the component.

**Material Cost** {Product Mass (kg) x 1.01 x Material Unit Price } + {Runner Mass(kg) x Recycle Cost}

| | | | | |
|---|---|---|---|---|
| Product Mass | 0.094 | 1.01 | Recycle Cost | 15 |

**Material Cost R 9.37**

| Product Material | | | | |
|---|---|---|---|---|
| | TMAP -EM Price (R/kg) | | **Material Cost** | |
| ABS-1 | R | 100.00 | R | 9.49 |
| ABS-2A | R | 115.00 | R | 10.92 |
| ABS-2B | R | 120.00 | R | 11.39 |
| ABS-2C | R | 130.00 | R | 12.34 |
| ABS-3 | R | 80.00 | R | 7.60 |
| ABS-4A | R | 122.00 | R | 11.58 |
| ABS-4B | R | 122.00 | R | 11.58 |
| ABS-5 | R | 95.00 | R | 9.02 |
| PC | R | 160.00 | R | 15.19 |
| PP-1 | R | 48.00 | R | 4.56 |
| PP-2 | R | 52.00 | R | 4.94 |
| PP-2 | R | 52.00 | R | 4.94 |
| PP-2 A2564GT-BT | R | 64.25 | R | 6.10 |
| PP-3A | R | 75.00 | R | 7.12 |
| PP-3B | R | 70.00 | R | 6.65 |
| PP-4 | R | 75.00 | R | 7.12 |
| PP-5 | R | 96.50 | R | 9.16 |
| POM-1 | R | 100.00 | R | 9.49 |
| POM-2 | R | 120.00 | R | 11.39 |
| PA6 | R | 150.00 | R | 14.24 |
| PA66 | R | 185.00 | R | 17.56 |
| PA12 | R | 120.00 | R | 11.39 |
| PMMA | R | 142.00 | R | 13.48 |
| PE-1 | R | 50.00 | R | 4.75 |

| | | |
|---|---|---|
| PP-5 | **R** | **9.16** |
| Product Cost | R | 9.16 |

| Runner Material | | |
|---|---|---|
| Less than 25g | 15% | 0.0141 |
| 25g or more | 8% | 0.0075 |
| 500g or more | 6.5% | 0.0061 |
| 1000g or more | 4% | 0.0038 |
| 2000g or more | 3.5% | 0.0033 |
| 3000g or more | 2.5% | 0.0024 |

| | | |
|---|---|---|
| Runner Mass | Less than 25g | 0.0141 |
| Runner Cost | 0.2115 | |

**Figure 5.10: CEM – Material Cost**

Following the calculation of the material cost, the user will then proceed to the second tab which will calculate the process cost for the identified component as shown in Figure 5.11. The user will be required to input the material type, the part dimensions and the number of cavities per tool. The calculation takes into account the minimum die clamping force and the product size guidelines to determine the tonnage required for the component. Based on the required tonnage and the material type, a cost per injection shot is calculated and divided by the number of cavities to provide an accurate process cost.

**Process Cost** = **Injection Cost Per Shot** / **No. of Cavities**

| | | |
|---|---|---|
| **Process Cost** | **R** | **2.40** |
| *Check for Special Case 1&2 | | |

| Minimum Die Clamping Force Pressure Co-efficients | |
|---|---|
| PP | 0.3 |
| TSOP | 0.3 |
| PE | 0.3 |
| PA | 0.4 |
| PVC | 0.4 |
| POM | 0.4 |
| PP-GLASS FIBER | 0.4 |
| ABS | 0.45 |
| TPR | 0.45 |
| ABS-2C | 0.6 |
| PC | 0.6 |
| PMMA | 0.6 |
| Acrylic Resin | 0.6 |

| | |
|---|---|
| PP | 0.3 |
| **Minimum Die Clamping Force** | **99 Tons** |
| **Final Machine Tonnage** | **99 Tons** |
| **Closest Table Value** | **150** |

| Dimensions in cm | |
|---|---|
| L | 30 |
| W | 11 |
| Surface Area | 330 |

| Product Size Guidelines (mm) | Tonnage |
|---|---|
| 370 x 370 | 40 |
| 420 x 420 | 80 |
| 520 x 520 | 150 |
| 560 x 560 | 200 |
| 630 x 630 | 250 |
| 650 x 650 | 300 |
| 710 x 710 | 350 |
| 800 x 800 | 400 |
| 900 x 850 | 500 |
| 950 x 930 | 600 |
| 1100 x 950 | 700 |
| 1120 x 1000 | 800 |
| 1400 x 1150 | 1000 |
| 1550 x 1250 | 1300 |
| 1850 x 1400 | 1600 |
| 1850 x 1600 | 2000 |
| 2000 x 1600 | 2500 |

| | |
|---|---|
| 370 x 370 | **40 Tons** |

Process Cost TDEM (Should Be)

| Machine Tonnage | Molding Cost Per Shot | |
|---|---|---|
| 50 | R | 1.12 |
| 80 | R | 1.55 |
| 150 | R | 2.40 |
| 200 | R | 2.68 |
| 520 | R | 3.55 |
| 300 | R | 4.47 |
| 350 | R | 5.65 |
| 400 | R | 6.25 |
| 500 | R | 8.68 |
| 600 | R | 12.64 |
| 700 | R | 14.45 |
| 800 | R | 15.84 |
| 1000 | R | 23.01 |
| 1300 | R | 31.94 |
| 1600 | R | 39.18 |
| 2000 | R | 49.84 |
| 2500 | R | 60.37 |

| Special Case 1 : Inj Cost x 1.1 | | |
|---|---|---|
| ABS - 2B | R | 2.64 |
| ABS - 2C | R | 2.64 |
| PPO | R | 2.64 |
| PC/ABS | R | 2.64 |
| ASG | R | 2.64 |
| PVC | R | 2.64 |
| PP-Talc | R | 2.64 |
| PP-Glass | R | 2.64 |
| PA6 +GF (Nylon-Glass) | R | 2.64 |
| TPR | R | 2.64 |
| EVA | R | 2.64 |

| Special Case 1 : Inj Cost x 1.2 | | |
|---|---|---|
| PMMA | R | 2.88 |
| PC | R | 2.88 |

| | | | | |
|---|---|---|---|---|
| Rand Per Shot | R | 2.40 | No. of cav | 1 |

**Figure 5.11: CEM – Process Cost**

The material cost and process cost are then used to calculate the overhead cost. The guidelines indicate that the accepted overhead cost for the component is 15% of the material and process costs. For this particular tab the user is not required to input any information as the cost is automatically displayed and calculated. This calculation can be seen in Figure 5.12.

| **Overhead Cost** | **(Material Cost + Process Cost ) x 0.15** | |
|---|---|---|
| | | |
| Material Cost | R | 9.37 |
| Process Cost | R | 2.40 |
| | | |
| Sub Total | R | 11.77 |
| | | |
| **Overhead Cost** | **R** | **1.77** |

**Figure 5.12: CEM – Overhead Cost**

To generate an accurate cost it is imperative that the tooling costs are calculated and factored into the cost of the component. The fourth tab of the model focuses on generating the tooling by utilising information provided by the user relating to the usage of the component and the number of slides (this can be obtained from the part drawing). The calculation of the tooling cost can be seen in Figure 5.13. The calculation of the tooling cost is the final step in the calculation process. The model will then accumulate all costs (material, process, overhead and tooling) to generate a “should be” cost for the identified component. The generated cost will then form the basis for negotiation regarding the costs for the identified component with the recommended supplier.

| | | | | |
|---|---|---|---|---|
| **Tooling Cost** | **Mould Cost + Checking Fixture Cost** | | | |
| **Tooling Cost** | **R** | **370 755,00** | Usage Per Month | 8 862 |
| *Check for Special Case | | | | |
| **Tooling Cost (SC)** | **R** | **-** | | |
| **Tooling Cost Per P** | **R** | **1,74** | | |
| Mold Cost | Machine Clamping Force x 3500 | **346 500** | Machine Tonnage | 99 |
| Checking Fixture Cost | 7% of Mold Cost | **24 255** | | |

| Special Cases: | Add to Tooling Cost | |
|---|---|---|
| Product Surface Area (cm) | | 330 |
| **Plating and Painting** | **R** | **20 460** |
| **Graining** | **R** | **49 500** |
| **Hot Runner** | **R** | **150 000** |
| **Total Slide Cost** | **R** | **350 000** |

1 *150 000 Multiplied by number of hot runners

| | | | |
|---|---|---|---|
| No. of slides | | | 0 |
| **Slide Cost** | | 30 - 39 | **R 350 000** |

| Slide Length | | Rand/Pcs |
|---|---|---|
| 40 or more | R | 400 000 |
| 30 - 39 | R | 350 000 |
| 20 - 29 | R | 250 000 |
| 15 - 19 | R | 150 000 |
| 10 - 14 | R | 100 000 |
| 5 - 9 | R | 70 000 |
| 4 | R | 60 000 |
| 3 | R | 50 000 |
| 2 | R | 40 000 |
| Less than 2 | R | 30 000 |

**Figure 5.13: CEM – Tooling Cost**

### 5.5.1 Model Validation

Two methods of validation were utilised. The first method involved testing the model in relation to the current set of components in order to verify the accuracy level of the model. To do this, the model was applied to a currently used small injection moulded component supplied by Supplier A, the generated cost estimates were compared to the current price, and an accuracy level was determined.

Additionally, the model was presented to all Purchasing Specialists in the automotive manufacturer through a platform known as the Purchasing Education Program which creates a platform for discussion surrounding new ideas.

During the trial the model was used to generate a cost estimate for a relay block cover, utilising the part dimensions' weight and material. The model generated a cost estimate of R13.93. The actual price of the component was recorded at R13.78. This means that there was only a 1.45% variance between the estimate and the real-world price. Currently, Supplier A supplies these components at a competitive CIM of 1.05 – meaning that the model is able to generate accurate, competitive cost estimates for small injection moulded parts.

The discussion with the specialists yielded excellent results where the specialists indicated that the model was user friendly and could be used in order to enhance their negotiating abilities.

Based on this validation the model was applied to the sourcing for the next passenger vehicle at the automotive manufacturer.

### 5.5.2 Model Application

Despite their current competitive CIM, when quoting for the next passenger vehicle the identified case study company's initial quotation for components resulted in a CIM of 1.74. This meant that they were 74% more expensive than other global affiliates. In line with the requirements, the automotive manufacturer must ensure that components are sourced at a CIM of 1.15 or less to ensure that the company is globally competitive and able to secure the required volume for the next passenger vehicle. In order to evaluate the impact of the developed cost estimation model, the model was applied to the Proposed Sourcing Process. The process is documented below.

Step One: RMBSS for Cover Relay Block received by purchasing specialist.

Step Two: RMBSS requirements evaluated with regard to volume and specifications.

Step Three: Case Study Company identified as a suitable supplier with sufficient capacity and capability.

Step Four: A cost estimate was generated using the cost model to provide a cost at a CIM of 1.05. The relevant parameters such as weight, length, width, material and annual volume were entered into the model. Based on the model, a cost estimate of R8.27 was calculated.

Step Five: This costing was discussed with the supplier who initially had proposed a cost of R13.60. The supplier was then requested to re-evaluate the costing based on the cost estimate provided.

Step Six: The supplier provided a revised costing and agreement was reached with the buyer on the final cost. The initial costing was reduced by R4.71 and a new price of R8.89 was agreed.

Step Seven: The sourcing process was completed.

The CIM results from this activity are detailed in Figure 5.14.

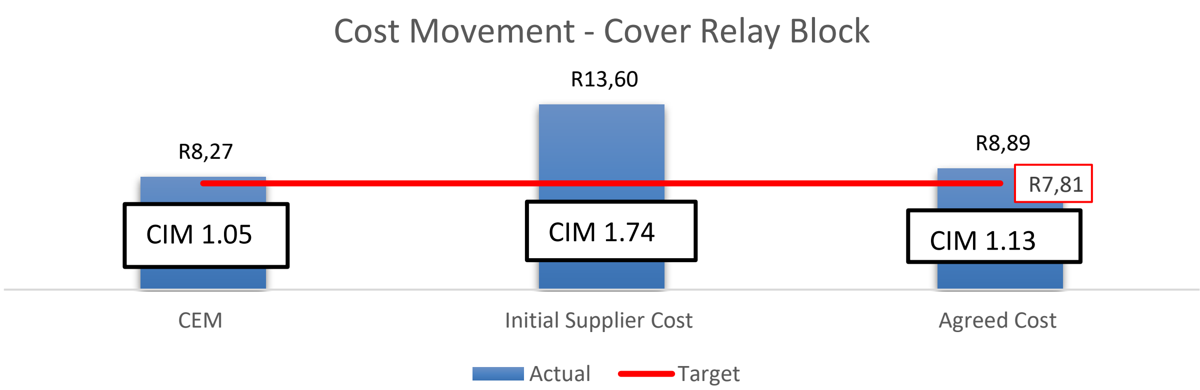


**Figure 5.14: CEM – Application at Case Study Company Results**

(Source: Developed by author)

With the implementation of the revised sourcing process and the application of a parametric cost estimation, a significant reduction in CIM was achieved and the case study company was able to meet the stipulated targets in order to ensure that the production volume for the next passenger vehicle was secured. The case study company was able to reduce the CIM on the cover relay block by 61% while achieving and exceeding the target CIM of 1.15.

## 5.6 Conclusion

This chapter detailed the current state of the sourcing process and the improvements made in order to improve the sourcing process moving forward. The improvements comprised of revising the sourcing process in line with recommendations from purchasing specialists and the introduction of a cost estimation model which could be applied prior to the conclusion of the sourcing activity. Applying the revised process and the generated cost estimation model yielded excellent results and the case study company was able to achieve the desired targets and secure the required production volume for the next generation passenger vehicle. The next chapter focuses on the recommendations and the conclusion of the study.

# CHAPTER 6 : RECOMMENDATIONS AND CONCLUSION

## 6.1 Introduction

The previous chapter highlighted the sourcing process flows influencing factors relating to sourcing and the trial implementation of a revised sourcing process. Several Kaizen points were noted based on the current process flow. Continuous improvement is an improvement initiative focusing on reducing failure in the system and increasing success. Continuous improvement can be governed by worker perception, team effort, adapting easily to change, engagement of management, and motivation (Sundar, Balaji and Kumar 2014). This chapter focuses on the recommendations for improvement and provides a conclusion to the research. Recommendations and a road map for continuous improvement of the sourcing process are also discussed.

## 6.2 Conclusions relating to objective 1

Through an evaluation of relevant literature and engagement with purchasing specialists and managers, the researcher was effectively able to outline the current process for the sourcing of components and identify factors which influenced sourcing decisions and resulted in high costs.

Through this engagement it was determined that cost, supplier capacity and capability were the key factors which were influencing the sourcing decisions, whereas material and labour were provided as the main factors which influenced product costs.

Based on the feedback provided from the purchasing specialists and managers, it was decided that the key focus area to improve the quality of sourcing decisions would be costs.

Through the generation of an ishikawa diagram and 5 why analysis, it was determined that the current sourcing processes needed to be redesigned to incorporate a tool to allow for early cost estimation. The literature reviewed indicated that in order to accurately estimate costs at the early stages of the project life cycle, a parametric cost estimation model would be the most suitable model type. The process was then redesigned introducing the application of a parametric cost estimation model and presented to the purchasing specialists to obtain buy-in, and was then applied to the sourcing of a new component.

### 6.3 Conclusions relating to objective 2

Whilst reviewing the literature, it was determined that the most applicable cost estimation model would be a parametric cost estimation model. The parametric cost estimation model was generated using Microsoft Excel and based on formulas and costing provided in the global training manuals from TMC. The model was then applied to the revised sourcing process for a new component, where it was noticed that there was a 61% reduction in the CIM of the component as a result of the purchasing specialist using the generated cost estimate as a negotiation tactic.

### 6.4 Recommendations

The following recommendations are aligned to the first objective, which was to redesign the sourcing process. As highlighted in Chapter 3, sustainability of continuous improvement initiatives was seen as imperative and could be achieved through the continuous implementation of TPS, lean principles and kaizen.

#### 6.4.1 Improvement Opportunities for Cost Estimate Generation by the Buyer

It was determined through the mapping of the current process flow that opportunity for improvement existed in the sequence of operations relating to the sourcing process. Purchasing Specialists were not able to generate cost estimates prior to the submission of the quotation from the supplier, which meant that there was no basis for strong price negotiation. By ensuring that the Purchasing Specialist was able to accurately predict the cost prior to submission, the supplier would then be more amenable to a cost reduction or an alignment to the expected cost. By redesigning the process, the quality of sourcing decisions was improved.

### 6.4.2 Improvement Opportunities from the Development and Implementation of a PCEM

After understanding the factors which influenced sourcing decisions and the timing required to accurately predict costs through surveys and interviews, the PCEM was developed. The PCEM provided a cost-effective method for the Purchasing Specialist to accurately understand the cost impact of sourcing decisions without having access to advanced information. It is important to note that the implementation of the PCEM resulted in a significant reduction of the CIM. Through this activity and its further implementation, the case study automotive manufacturing company was able to reduce the CIM, become globally competitive and secure the desired production volume for the next passenger vehicle.

## 6.5 Conclusion

The first objective of this research was to outline the sourcing process flow for the sourcing of automotive components and to redesign the sourcing process. An overview of the production flow was provided and this was seen as critical for the subsequent analysis of value and non-value adding activities. Kaizen points were identified and implemented. The second objective of this research was to develop and implement a PCEM for resin parts. It was established that the purchasing specialist was not able to generate a cost estimate at the sourcing stage of a project. Therefore, it was important to redesign the sourcing process to allow for an accurate cost estimation at the early stages of the project. Through this research it was determined that a cost estimation model could lead to improved competitiveness. For future research it is recommended that PCEMs are created for other commodities, including forged components, casted components, press components and electrical components.

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# APPENDICES

## Appendix 1: Ethics Clearance Certificate


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