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The perceived global manufacturing competitiveness of the South African autocatalytic converter industry

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The perceived global manufacturing competiveness of the South African autocatalytic converter industry

A research report submitted by
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A research report submitted to the Faculty of Commerce, Law and Management, University of the Witwatersrand, in partial fulfilment of the requirements for the degree of Master of Business Administration

Johannesburg, 2013

ABSTRACT

The South African autocatalytic converter has shown exponential growth during the last decade under the Motor Industry Development Plan (MIDP). Due to calls from the World Trade Organisation (WTO) for free and fair trade it was replaced with a different incentive programme called Automotive Production Development Programme (APDP) at the end of 2012.

This research report aims to investigate the perceived competitiveness of the organisations within the South African autocatalytic converter industry and their readiness for the phasing out the MIDP programme after 2012.

Firstly the perceived competitiveness of the industry was established through a comparative study of organisations within the industry and how they believe they compare to both international recognised operational best practises and their international competitors. The data for this study was gathered through structured interviews where the respondents were asked to subjectively compare themselves against their international competitors.

Secondly a fuzzy cognitive map (FCM) was developed to determine the readiness of the industry for operating under the auspices of the APDP programme. This FCM was enhanced through interviews with industry leaders and finally used to simulate several plausible future scenarios to test the readiness of the industry to operate sustainably under APDP.

This research report revealed that the industry considers itself to be either slightly behind or on the same level as their international competitors with regards to the various individual operational best practises considered in this study. The biggest challenge faced by the local industry is the big location disconnect of the industry to their primary markets in Western Europe and the associated additional transport costs. The simulations from the enhanced FCM revealed the sensitivity of the local autocatalytic converter industry to the global economic environment, external stimulus or support and particularly the economic health of the Western European countries.

DECLARATION

I, Johannes Hendrik Keulder, declare that this research report is my own work except as indicated in the references and acknowledgements. It is submitted in partial fulfilment of the requirements for the degree of Master of Business Administration in the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in this or any other university.

Signed at Johannesburg, South Africa

On the …….. day of …… 2013

DEDICATION

This research report is dedicated to my family.

It's dedicated to my lovely wife Mariaan for her devoted support, unwavering understanding and astounding encouragement throughout my studies and career.

It's dedicated to my two beautiful princesses, Liane and Danika. One look in your eyes and all becomes worthwhile…

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From the initiating and formulation of this thesis, to the final draft, I owe my immense gratitude to my supervisor, Professor Terri Carmichael. Her sound guidance and advice was invaluable in making this study possible.

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I would also like to thank all the respondents and interviewees; without your time and input this research would not have been possible.

Catalytic Converter Interest Group (CCIG), Department of Mineral Resources (DMR) for assisting and making the gathering of data and information a less arduous task.

Finally to my loving wife and two beautiful daughters for supporting me through the long nights..

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CHAPTER 1: INTRODUCTION

1.1 Purpose of the study

The purpose of this research is twofold. Firstly to explore the extent to which the South African catalytic converter industry, as a sub-section of the automotive component industry, has successfully and sustainably implemented world class manufacturing principles throughout their operations. Secondly this research will aim to construct and test a predictive fuzzy cognitive map, based on the perceptions of the major industry players, which could be used to gauge the readiness of the industry for the next phase of the South African government's liberalization programme called the Automotive Production and Development Programme (APDP).

The APDP programme serves as a replacement of the current Motor Industry Development Programme (MIDP) and was introduced at the end of 2012. The intention of the MIDP programme was the re-integration of South Africa's automotive industry into the global economic operating environment and placed strong emphasis on export incentives (Barnes, 1999, 2000a). Under the APDP programme the focus will shift from export support to production support and is more compliant with requirements from the World Trade Organisation (WTO) of which South Africa is a member (Black, 2009). This transition will force suppliers in the automotive component industry to critically review their operational strategies to remain competitive in the global playing field under the new APDP programme.

The first step in the research process is to investigate current literature on the underlying key success factors that are considered to be critical to ensure profitable long term sustainable operations within a manufacturing industry.

The next step will then be to ascertain the degree to which the major role players within the South African catalytic converter industry believe these critical success factors are present within their organisations and then to construct a cognitive model too that could be used to assess the readiness of the industry to operate under APDP.

1.2 Context of the study

Brief discussions on the general trends observed within the automotive industry, of which the catalytic converter industry is a significant subsection, as well as a brief discussion on the impact of tariffs and trade incentives on the South African automotive industry as a whole are provided below:

1.2.1 The Automotive Industry in general and the impact of globalisation on the structure of the Automotive Industry

The modern automotive Industry, both the automotive assembly as well as the automotive component manufacturing sectors are in many ways a reflection of the latest and state-of-the-art in automation technology (Mashilo, 2010).

Mashilo (2010) further describes the automotive industry as a continuous manufacturing process not only within and between the assembly plants but which also transcends the entire automotive supply chain and includes the suppliers of the discreet automotive components. Mashilo (2010) highlights the critical role of logistics as a mode of production in this continuous manufacturing process.

Womack, Jones and Roos (1990) describe how the automotive industry assumes a leading role in effecting changes in the organisation of work, technology and production methods and these transcends to other industries. Their key argument is that in order to become competitive, the automotive industry had to transform work and production organisation from craft production to a mass production regime and then to evolve further to lean production

Womack et al.(1990) highlight the strategic importance of the automotive industry and presents the automotive industry as the bedrock of the manufacturing industry of a country. Barnes (2000a) takes this sentiment further and suggests that the rise of the USA after World War 1 and Japan's rise to its current economic prominence are partly due to the leading role of their automotive industries. Barnes and Hartogh (2009) explain this strategic importance by means of what they refer to as the automotive industry's multiplier effects into a wide range of other manufacturing – and service related industries. This multiplier effect is explained by Mashilo (2010)

as the effect that any changes in the automotive industry will have on industries such as paint production, glass production, iron and steel production, metals engineering, tyre manufacturing and this effect could even transcend into retail, finance and service sectors. He further illustrates this interdependency between the various industries by highlighting that in the 1980s already, the average Japanese automaker's production system contained 170 first-tier, 4700 second-tier, and 31600 third-tier subcontractors [suppliers]

Mashilo (2010) summarises the characteristics of the automotive industry as a whole and highlights that the automotive industry suffers from high operational cost structures, narrow profit margins, fluctuations in customer demands, stiff quality requirements, complex supply chains with multiple levels of suppliers, geographically diverse and expanded operations combined with a wide variety and complex country specific regulations. These inherent characteristics, as described by Mashilo (2010), are clearly recognizable when the business trends within the automotive industry over the past decade, as highlighted by various earlier authors, are analysed. The following general trends were observed and commented on by various earlier researchers:

- Outsourcing of non-core operations to suppliers (Womack et al., 1990; Gereffi, 1999)

- Increasing competitive pressures throughout the supply chain, in general but also towards geographically dispersed networks of plants, affiliates and suppliers (Barnes, 2000b).

- Aggressive cost reduction measures throughout the entire supply chain in the form of contractual prerequisites/requirements placed on suppliers including increased quality requirements as well as more leaner, flexible and enhanced Just In Time (JIT) systems (Barnes and Morris, 2008).

- Global sourcing strategies and rationalisation of suppliers (Barnes and Morris, 2008; Mashilo, 2010)

1.2.2 The history of the South African Automotive Industry.

The first motor vehicle assembly plants were established in 1920 and were heavily protected through trade tariffs (Black and Mitchell, 2002). The domestic industry therefore developed mainly as an assembly industry for the local market, it was inwardly focussed and was characterised by high product variety, low production volumes and as a result high operational cost structures (Black, 2002; Black and Mitchell, 2002). Trade tariffs provided protection to the local assemblers from imports but since the local markets are fairly small, no real economies of scale can be obtained and this resulted in high prices (Black and Mitchell, 2002). Fierce competition based on new product development existed within the local industry and most of the net operating profits were eroded by the high cost associated with new product development (Black and Mitchell, 2002). The South African automotive industry went through rapid growth during the period between 1950 and 1980 mainly as a result of the trade protection (Black, 2002). Cars were mostly still assembled locally from imported components, with according to Black (2002) only 20 percent local content value added in the 1960's. The political isolation and sanctions against South Africa during the apartheid era led to some of the multinational corporations (MNC's) withdrawing their investment from South Africa (Mashilo, 2010) .

1.2.3 The impact of trade policies, incentives and tariffs such as MIDP on the industry

The automotive industry up and till the 1980's has undergone six distinct and structured phases of industry liberalization with the aim to make the industry less inwardly focussed, promote lower operational cost structures and finally making the industry more competitive in the global arena (Black, 2002). The focus of the final Phase VI, from 1990 to 1995 was to rationalize production and in many ways was the first real attempt to address the inward focus of the industry and promote exports of components. It, however, resulted in the proliferation of new domestic models (Black and Mitchell, 2002). Black and Mitchell (2002) believe this was because the effective rate of protection increased as high nominal tariffs rates on built up vehicles were maintained but the protection on the component sector fell sharply as the local

content requirement was relaxed and assemblers were increasingly able to rebate import duties on components.

Dissatisfaction with the results of Phase VI led to the introduction of the MIDP in 1995 (Black, 1998). The key features of MIDP as summarised by Black (2002) were as follows:

- Reduction of tariffs on light vehicles and components, with tariffs being phased down even faster than required by the World Trade Organisation.
- Removal of local content requirements
- Duty-free import of components up to 27% of the wholesale value of the vehicle
- Duty rebate credits to be earned on exports of vehicles and components and were used for the duty-free import of vehicles and components

The continued liberalization and increased pressure from the WTO has resulted in the South African Government since 2003 embarking on a formal review of the MIDP programme and in which future format it will continues, the due date for phasing out and final transition to a new programme was set for the end of 2012 (Flatters, 2005). The South African automotive component industry, as early as 2003 voiced its concern about the uncertainty of any possible new programme and expressed its preference that MIDP continues with minor adaptations to ensure WTO compliance (Flatters, 2005). The South African government has however opted to continue and replace the MIDP programme with a new programme where the focus will be more directly on the development of local automotive production. The new programme, Automotive Production Development Programme (APDP) was developed by the Department of Trade and Industry and implementation has commenced in January 2013. Figure 1 compares the benefits and regulations under the old MIDP programme with that of the new APDP programme. The most significant change will be the industry incentives that will no longer be calculated on “local material used” but rather be calculated on “the value of local production”. This involves a shift from export support to the support of local automotive production. This will mainly impact on the component suppliers that flourished by exporting most of their products.

	MIDP (1995 – 2012)	APDP (2013 – 2020)
Tariffs	The level of protection offered by **tariffs reduced consistently from 65% and 49% for CBUs and CKDs respectively in 1995, to 25% and 20% in 2012**	The level of protection offered by **tariffs will remain constant at 25% and 20% for CBUs and CKDs respectively from 2013 to 2020**
Local OEMs Vehicle Allowance	**DFA (Duty Free Allowance):** 27% of the local assembled vehicle's wholesale price is rebated against the duty payable on imported components that are used in the production of vehicles for the domestic market	**VAA (Volume Assembly Allowance):** 20-18% of local assembled vehicle's wholesale price is rebated against the duty payable on imported components that are used in the production of vehicles, irrespective of where the production is sold, as long as annual units per plant exceed 50,000
Industry incentives	**Export linked duty credits earned:** Benefits calculated on local material used	**Market neutral PI (Production Incentive) in place:** Benefits calculated on local production value. Vulnerable Industries higher benefits
Investment assistance	**PAA (Productive Asset Allowance):** • Only benefits OEM and 1st tier suppliers whose investment is linked to a local OEM • 20% benefit, payable over 5 years (4% per year)	**AIS (Automotive Investment Scheme):** • Benefits OEM and auto component suppliers as long as investment is auto focused • 20-30% benefit, payable over 3 years (6.67% per year)

(Source BMA Intelligent systems)

Figure 1: Comparison of MIDP and APDP schemes

1.2.4 *Description of an autocatalytic converter*

An autocatalytic converter is a device that is fitted into the exhaust system of a motor vehicle/truck and converts all harmful emissions to environmentally friendly gases through a chemical reaction utilizing a combination of Platinum Group Metals (PGM) as catalyst (see appendix C: Description of Autocatalytic Converter). The manufacturing process requires raw material powders, platinum group metals and ceramic substrates from global suppliers. These are then shipped to the local South African manufacturing sites where the formulations are batched up and deposited or coated onto the ceramic substrate as the finished autocatalytic converter. These converters are then fitted into the exhaust systems by the canners which are then finally assembled onto the vehicles.

1.3 Problem statement

1.3.1 *Main problem*

To assess the perceived global manufacturing competiveness of the South African Autocatalytic Converter Industry without the Motor Industry Development Programme (MIDP)

1.3.2 *Sub-problems*

a. **Investigate the applicability of global manufacturing best practices to the South African catalytic converter industry**

The first sub-problem is to establish the applicability and extent to which the key success factors for sustainable operations in a manufacturing industry, as presented in the literature, are present in the South African catalytic converter industry.

b. **Investigate the applicability of external factors to the perceived competiveness of the South African catalytic converter industry without MIDP**

The second sub-problem is to provide a qualitative assessment of possible external factors influencing the international competitiveness of the industry. Different scenarios were simulated to ascertain the readiness of the South African catalytic converter industry to adopt the new APDP programme as a replacement of the current MIDP programme by 2012. The simulation scenarios will be used to determine the extent to which this replacement and anticipated increased global competition are shaping the current operational strategies within the industry.

1.4 Significance of the study

The study fills a gap in the literature in that it aims to provide a qualitative prediction to the degree to which the South African catalytic converter manufacturers will remain competitive under the new APDP programme. The study will aim to provide

insight into which specific areas within the industry are potentially lacking behind global best practises.

The South African automotive catalytic converter industry has shown exceptional growth since 1995 and the implementation of MIDP (De Klerk, 2009). In his study De Klerk (2009) aimed to understand the reason for this growth and investigated the impact of innovation, levels of education and degree of foreign ownership on the success of the industry. The results from his study were inconclusive as to the contribution of these to the growth experienced by the industry. This study will aim to complement his work by investigating the presence of globally identified manufacturing best practises within the South African catalytic converter industry.

As highlighted by authors such as Wonnacott (1996), Black (2001) and Mashilo (2010), when an industry is developed under high levels of protection then the industry is most likely to suffer from high production cost structures. For the South African automotive industry this is apparent through the large number of makes and models being produced at low volumes (Black, 2001). The productivity of the South African automotive industry under MIDP as well as the associated benefits and economic dynamics has been the subject of a number of research reports (e.g.(Barnes, 1999; Black and Mitchell, 2002; Flatters, 2002). These reports mostly included the entire automotive industry with some placing emphasis on the final assemblers or Original Equipment Manufacturers (OEM).

Fick and Buys (2005) in their study focussed on the productivity of the industry and also included first-tier component suppliers in their research scope. The research done by Fick and Buys (2005) has to a large extent served as a basis for this study. However the global economic crisis of 2007, the continued liberalization of the industry since the Fick and Buys report as well as the introduction of the new APDP programme in 2012, are believed to have changed the operational landscape significantly to warrant another study of the productivity of the automotive component industry. In this study, however the emphasis will be solely on the second-tier catalytic converter suppliers as the potential impact of APDP are believed to be of particular significance. The catalytic converter suppliers are part of the major role players within the automotive component industry, most of the catalytic converters are produced for the European markets and the beneficiation of Platinum Group

Metals as key raw materials results in large operational cost structures (Flatters, 2005) . Flatters (2005) continues to say that much of the domestic catalytic converter production could easily be disassembled and moved out of the country and that there is growing evidence that the large scale export of seat covers and catalytic converters that has been fostered by MIDP is not competitive in the global arena without MIDP.

This study is hoped to provide guidance to organisational leaders within the catalytic converter industry as to the extent of any disparity that may exist between their own business practises and the world class business and manufacturing methodologies that are considered critical for sustainable and global competitiveness. An understanding of these disparities could be valuable for reviewing operational strategies.

1.5 Delimitations of the study

This research study will be limited to the South African catalytic converter industry only.

The emphasis is on the first-tier and second-tier suppliers namely the catalytic converter coaters and canners as listed members of the Catalytic Converter Interest Group (CCIG)

Priority has been given to the suppliers according to their proportional contribution to the turnover of the industry.

1.6 Definition of terms

APDP – Automotive Production Development Programme (Mashilo, 2010)

Best Practise – An operational practise that contributes to a successful organisation's competitive advantage and that has been identified by the organisation's peers with the aim to mimic this practise in their operations.

CCIG – Catalytic Converter Interest Group

FCM – Fuzzy Cognitive Map is a graphic illustration of causal relationships between the various events or nodes of a complex system with the aim to simplify concepts and promote greater understanding of the system (Kosko and Dickerson, 1994)Lean Manufacturing – a set of practices intended to remove all waste from the system, striving to minimize and optimise usage of resources (Schonberger, 1986).

MIDP – Motor Industry Development Programme (Black and Mitchell, 2002)

MNC's – Multinational companies (Mashilo, 2010)

OEM – Original Equipment Manufacturer, in this situation it will be the automotive assemblers (Black, 2001).

PGM – Platinum Group Metals (Platinum, Palladium, Rhodium etc.)

World Class Operations (WCO) – An accumulation of best practises in total quality, concurrent engineering, lean production, advanced manufacturing systems, logistics and general organisational practice, with the aim to improve performance and competitiveness (Kasul and Motwani, 1995a)

WTO – World Trade Organisation (Flatters, 2005)

1.7 Assumptions

It is assumed that the respondents of this research will have sufficient knowledge and understanding of these identified world class manufacturing techniques and methods (as highlighted by the most predominant literature resources) to be able to clearly articulate, analyse and draw comparisons to these techniques or any of the possible derivations thereof in their own business practises.

Although the information from the respondents will be subjective, it is assumed that the respondents are adequately informed about the current state of their own manufacturing methods, operational practices and performance measurement systems to reduce any influence or bias that could potentially occur as a result of

their subjectivity; and that their responses would therefore be an accurate reflection of the true state of operations within their organisations.

It is further assumed that the respondents of the in-depth interviews will be knowledgeable on the benefits provided by both the MIDP and APDP programmes.

It is also assumed that respondents will not be influenced by internal and external competition and will be willing to divulge and discuss their business operations without fear of losing competitive advantage.

Although the research is sensitive to the above mentioned assumptions in terms of the quality of data and opinions received; it is believed that these assumptions are reasonable as the respondents will be restricted to industry leaders and senior business officials within the CCIG.

CHAPTER 2: LITERATURE REVIEW

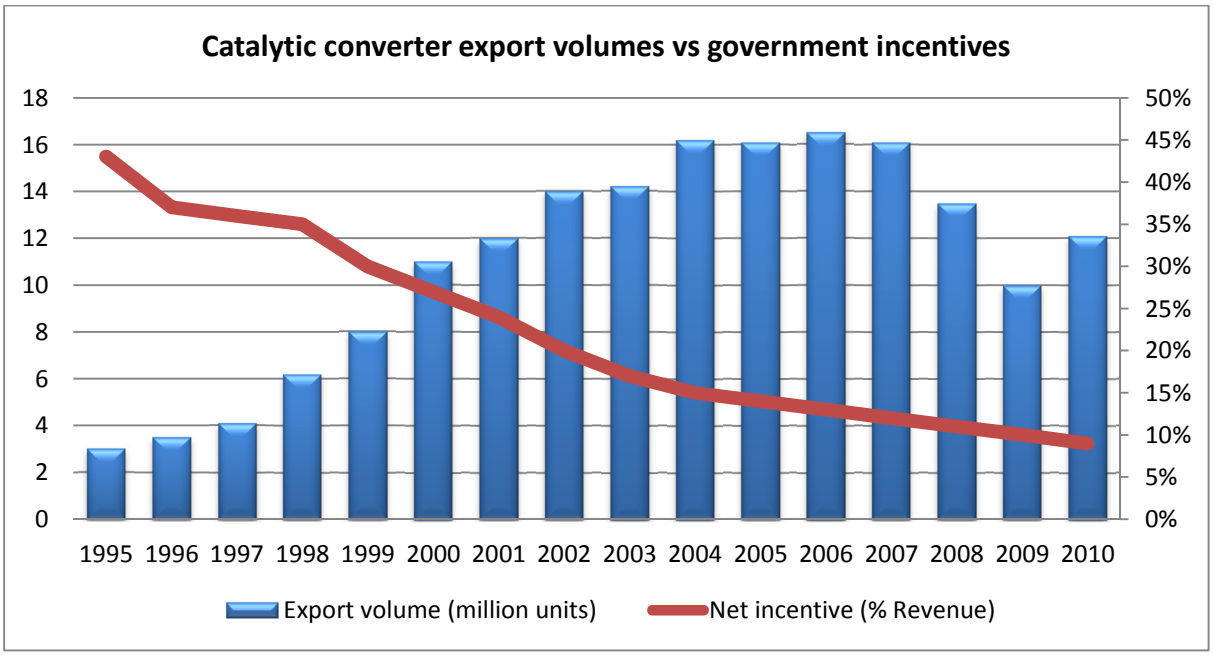
2.1. Introduction

"In the past, national economies were comparatively isolated from each other. Distance, time zones, language, national differences in government regulations, culture and business systems also isolated national economies. There is a movement towards a world in which national economies are merging into a mutually dependent global economic system, commonly referred to as globalisation" (Hill, 2001:4) as cited by Naude (2006).

Globalisation means enhanced competition. The reduction in trade barriers associated with globalisation has forced many formerly protected economies to open up to global competition and to confront the challenge of achieving global competitiveness. This is a problem both for firms in rich countries, and for those in developing countries. In particular producers in high-income countries are increasingly being threatened by imports from low wage economies.

The South African automotive sector was pre-liberalisation characterised as inwardly focussed and heavily protected with a large range of cars produced in small volumes. Given a small and stagnant local market, the scales of production and export levels were low (Black, 1998).

The phased liberalisation of the South African automotive industry only really started to gain momentum with the introduction of MIDP in 1995. The impact of MIDP on the growth seen within the industry are highlighted by authors such as Black (2002) and Flatters (2002). Many believed the prospects of the auto industry at the time of tariff liberalisation to be bleak. The opposite turned out to be true, the automotive industry flourished with a particular impressive growth in export performance. As could be seen in figure 2 the growth in exports in some of the subsectors such as autocatalytic converters were positive, specifically in the period between 1995 (the launch of the MIDP program) and 2006 (when the phasing out of MIDP by the year 2102 was announced)



Source: Catalytic Converter Interest Group (CCIG): Catalytic converter industry beyond 2012

Figure 2: Catalytic converter export volumes vs. Government trade incentive

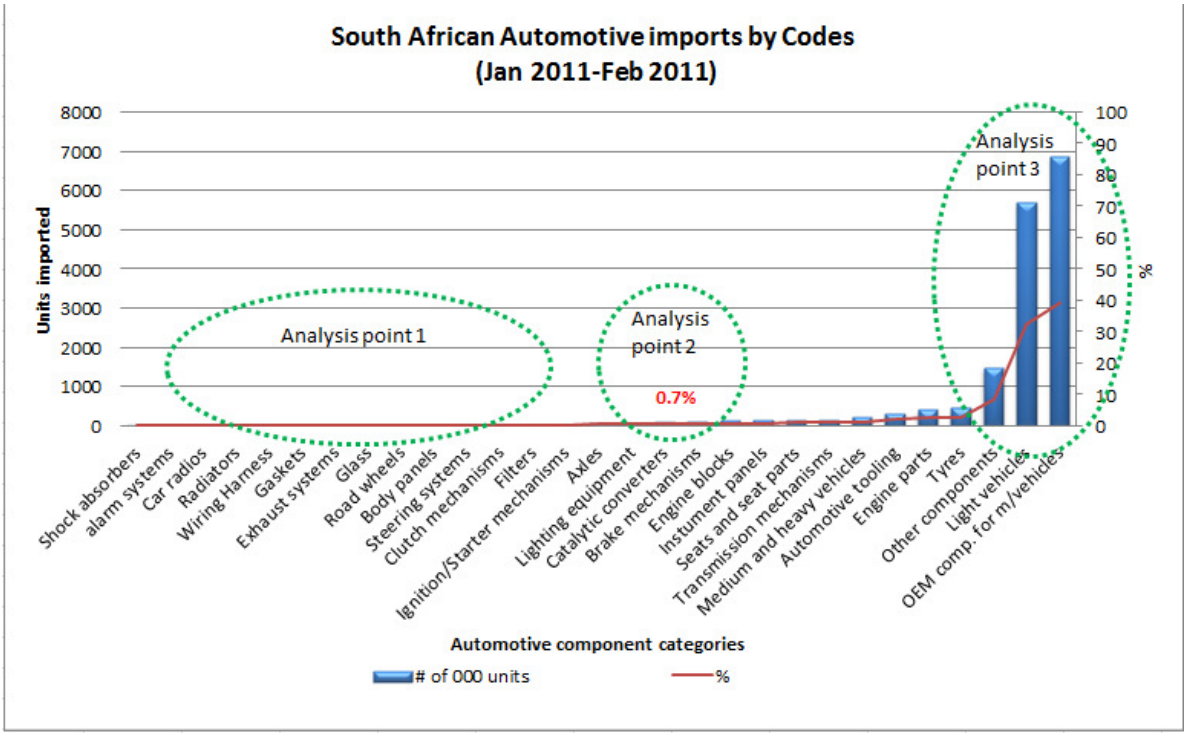
Figure 2 demonstrates the possible impact that government incentives had on the export volumes of catalytic converters from South Africa. Apparent from figure 2 are the dramatic growth seen in the industry with the introduction of government incentives in 1995 as well as the the impact of the incremental reduction of government incentives on the export volumes of autocatalytic converters from 2005 onwards..

During the period 1994 to 1999 the industry saw rapid growth with the share of South African autocatalytic converters imported into the European Union rose from 2.9% to 72.7% and the share of United States imports of catalytic converters rose from nothing to 22.7% in the same period (Black, 2002). Over the past 15 years of existence in South Africa, the catalytic converter industry has achieved an average compound growth of around 14% per annum and by 2008, the industry generated in excess of R22 billion in export revenue. This industry is the largest South African beneficiator (>90%) of locally mined precious metals, representing approximately

17% of PGM mined in South Africa (CCIG, 2011). The industry is also the largest consumer of locally produced stainless steel (50,000 tons/annum), exceeding 38% of local consumption (CCIG, 2011).

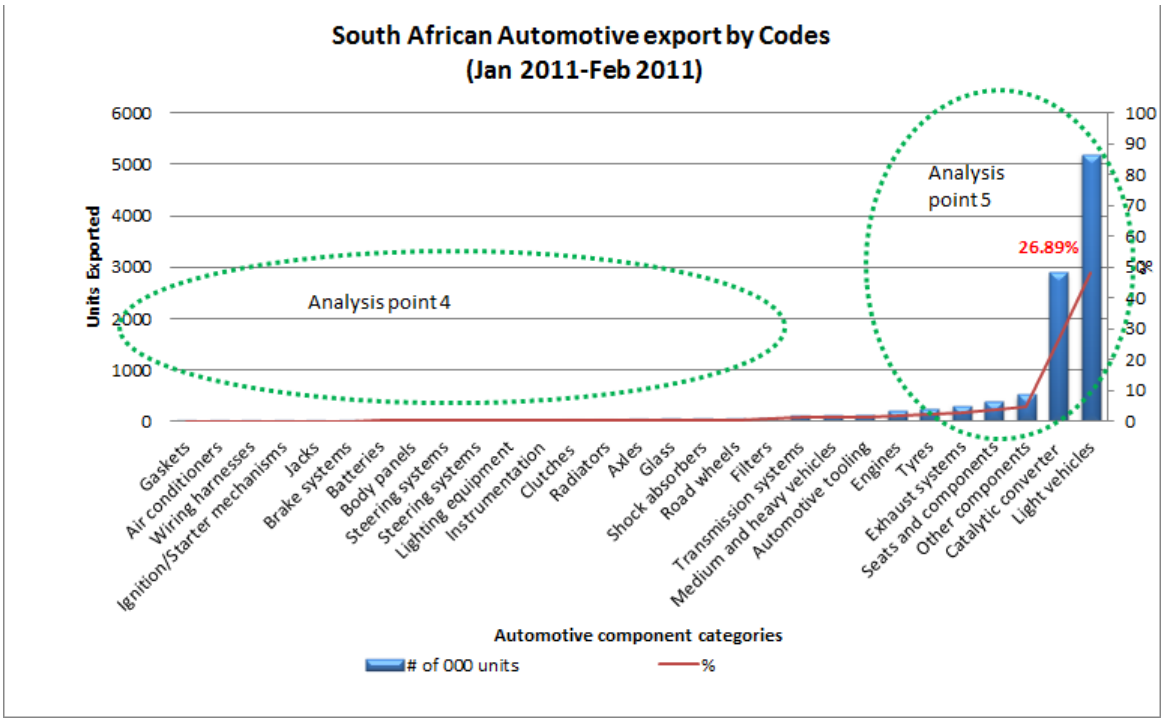
The South African Catalytic Converter Industry is composed largely of global multi-national manufacturers who supply to international vehicle manufacturers (OEMs). The South African autocatalytic converter production facilities were established at the request of the OEMs to take advantage of the benefits offered by MIDP and resulted in a near 100% export focused industry. With figures 3 and 4 the aim is to demonstrate the export orientation of the South African autocatalytic converter industry. The following analysis points with regards to figure 3 and 4 are highlighted:

- Analysis point 1 and 4 – very low levels of automotive components are imported for local assembly as well as very low levels are manufactured locally for export purposes.
- Analysis point 2 and 5 – catalytic converters imported for local assembly comprises only 0.7% total automotive components imported during the period. However locally manufactured catalytic converters are comprises approximately 27% of total automotive components exported. Catalytic converters are the second highest export category.
- Analysis point 3 – importing of fully assembled light vehicles to be sold to local consumers (33%) and the OEM (overseas manufactured) components imported for local assembly (39%) only comprises over 70% of the total automotive components and vehicles imported during the period. It could therefore be concluded that minimal locally manufactured automotive components did find their way into locally assembled vehicles destined for the export market.
- Analysis point 5 – Autocatalytic converters are the only category that exports significant levels of manufactured units. During the period, light vehicles was the category exported the most with just over 5 million units. These light vehicles were assembled locally and limited to OEMs with a local assembly footprint such as Ford, VW, BMW, Toyota etc.



Source: SA Department of Trade and Industry (2011)

Figure 3: Motor vehicles imports by codes 2011Jan-Feb



Source: SA Department of Trade and Industry

Figure 4: Motor vehicles export by codes 2011 Jan-Feb

South Africa has a location disadvantage relative to the primary Western European markets and the associated logistics and financing costs need to be overcome to ensure that the industry remain competitive to European competitors/manufacturers (Barnes, 2008; Black,2009). Under MIDP the incentives or credit rebates were sufficient to offset these additional costs, but this may no longer be the case under APDP and some OEMs have started to award catalytic converter business elsewhere.

The revision of MIDP in 2012 and increased exposure to global competition will require the firms within the industry to re-evaluate their competitive success (Barnes and Morris, 2008). In order to survive, South African automotive component manufacturers/exporters need to remain globally competitive and a reduction of production costs and the improvement in manufacturing efficiencies will be essential. Naude (2006) believes that this will only be achieved through a culture of continuous improvement while Barnes and Morris (2008) are promoting tools from world class manufacturing programmes and adhering to lean production practices.

Many firms are coming to the realization that competitive success in the global arena is dependent on various different factors from both the external environment as well as their internal operations. Their capabilities to manage their production as a premier strategic function will be critical to ensure their global competitive success (Kasul and Motwani, 1995a). This effort will further be made difficult as there is a need for firms to integrate a globalization component into their overall strategy. Almost all firms have global potential, in varying degrees, and need a systematic framework for evaluating which elements to globalize. Being able to develop and implement an effective global strategy is the acid test of a well-managed company (Kasul and Motwani, 1995a).

Chan (1993a) and Voss (1995) share the sentiment on the importance of a well-designed manufacturing strategy and highlight three broad perspectives of a manufacturing strategy. The first of these perspectives argue that a firm should compete through its manufacturing capabilities. This is achieved through aligning the capabilities of the manufacturing function with its corporate and marketing strategies

as well as the competitive requirements of the marketplace. The second perspective is effectively a contingency-based approach and aims to promote internal and external consistency between the business and product context. Finally there are approaches based on the need to adopt practises that has been identified as globally best practises for example “World Class Manufacturing” (Voss, 1995:6). For the purposes of this study a hybrid of the three perspectives on manufacturing strategy will be considered, as it is believed that all three influence the competitiveness of a firm or an industry as a whole.

Figure 5 illustrates the approach taken in this study to assess the global competitiveness of the South African Catalytic converter industry. In Figure 5 it is illustrated that to analyse the economic performance of an industry, one is faced with two distinct problems. Not only is a comprehensive analyses of the internal capabilities of the major industry players required, but also should the external factors or drivers influencing the industry on a macro level be considered. According to figure 5 the internal capabilities are assessed around the following categories as suggested by Richardson, Taylor and Gordon (1985); Ferdows (1990); Chan (1993); Schonberger (1996); Coronado (2002); Davies and Kochhar (2002) and Feigenbaum (2002) :

- Process efficiency
- Process repeatability and reliability
- Process and product quality
- Process flexibility
- Process and product innovation
- Managerial capabilities and the alignment with an effective manufacturing strategy

The assessment of the industry player’s internal capabilities will form the focus of the first sub problem of this research report.

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Figure 5 further illustrates the importance to also understand the external drivers impacting on the industry and this will be the focus of the second sub problem. The external factors investigated in this study, according to authors such as Armstrong (1982); King (1983); Shrivastava (1986); Simkin and Cheng (1997); Valentin (2001);

Palmade (2005), relates to the factors from the external environments that influence the competitive nature of an industry as a whole but also an individual firm within the autocatalytic converter industry. From the external environment, various factors from the political, economic, social, technology, environmental and legal spheres should be considered in any assessment of the factors that will shape the competitive success of the industry.

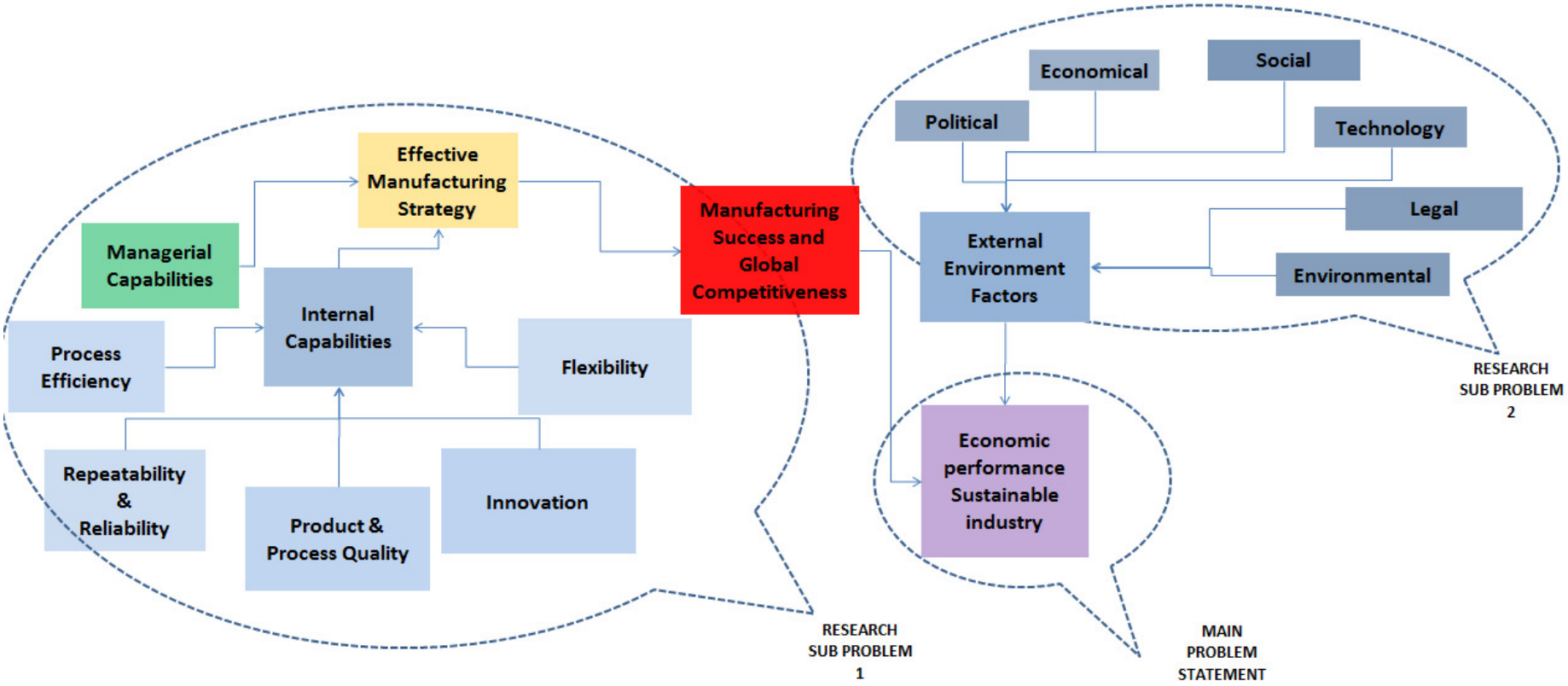


Figure 5: Research flow mind map

As illustrated in figure 5, the first sub problem of this study is focused on the effectiveness of the internal operations and aims to establish the extent to which the key identified global best practises for sustainable operations are present in the South African autocatalytic converter sub industry.

From the internal operations perspective, the factors that will arguably impact the most on the competitive success are the effectiveness of manufacturing performance such as lean production methods (Kojima and Kaplinsky, 2004) and product innovation (Wheelwright and Clark, 1995; Bessant and Caffyn, 1997)

Lean production techniques seem to be a prerequisite for producers with regards to the efficiency of their internal operations. Many literatures are available by a number of authors (Schonberger, 1996; Feigenbaum, 2002; Stalk and Hout, 2003; Kojima and Kaplinsky, 2004; Maskell and Baggaley, 2004; Schonberger, 2007; Womack, Jones and Roos, 2007) that describe the best operating practices such as lean production and flexible specialisation. The common themes from these literatures seem to revolve around waste reduction, process efficiency, repeatability, reliability, product and process quality, innovation and flexibility throughout the entire operations of the firm.

But how can the degree of progress in the adoption of lean production be measured? What factors determine the rate of adoption of lean production? Kojima and Kaplinsky (2004) attempted to construct a Lean Productive Index (LPI) that could be used as a comprehensive quantitative assessment of performance and practice. Their LPI comprised of three sub-indices namely a flexibility index, a quality index and a continuous improvement index. These three indices seem to be aligned with the general themes or overlap arising from literature on lean production and will be the base used in this study to discuss and analyse the degree of lean production.

The final aim of this study and illustrated in figure 5 as the main problem statement will then be to combine the relevant factors from both the internal and external environments as previously discussed and construct a fuzzy cognitive map (FCM) of the South African catalytic converter industry. This FCM could assist in promoting a

greater understanding and predict the impact (if any) of regulatory changes such as the phasing out of MIDP on the perceived global competitiveness of the industry.
Combining the internal competitiveness of the industry together with the relevant external factors that impact on the industry an attempt will be made to construct a fuzzy cognitive map (FCM). This map could potentially be used to explore the possible future of this industry in view of the continued liberalization of the industry

2.2. Background discussion.

In order to be globally competitive a firm or an industry must have reached a level where their internal operations could be considered best practice or "world class". This section explores the manufacturing activities or practises that are generally considered to be "world class" and essential for a firm or industry to be competitive in the global arena. The South African Autocatalytic converter industry will be assessed to the level to which it conforms to these practises and where possible gaps could exist.

The second part of this section will explore the factors that impact on the South African Autocatalytic converter industry from the external environment. With the continued liberalisation of the automotive industry and greater global competition, the role players within the industry should be keenly aware of the factors shaping their industry. This will enable them to strategically better position themselves and respond to their changing environment.

2.3. The internal operational factors or best practises that impact on manufacturing competitiveness

Economic or financial performance indicators are mostly an indication of a firm's past performance and are often largely influenced by external market forces. In reality these indicators only presents the current financial health of the firm and do not reveal much about the firm's ability to meet or to adapt adequately to future customer and industry requirements. The global automotive component industry is described by Barnes (1999) in his research report as an industry that is fundamentally altered

on an ongoing basis, with customers who are increasingly becoming more demanding in terms of quality, price and flexibility.

Barnes (1999) therefore proposes that a measurement of a firm's operational effectiveness and ability to adapt are more meaningful indicators of a firm's future sustainable success in a volatile business environment. In his research of 1999 as well as in his follow up study of 2000 (Barnes, 2000a:8; Barnes and Morris, 2008), he presents six "market drivers" as proxy measures that could be used as an indication on how well a firm is meeting the requirements from its customers or market.
The market drivers as presented by Barnes (1999) focuses on cost control, quality performance, internal and external flexibility, capacity to change (human resource development) and innovation capability.

The approach taken by Roth and Miller (1992) seem to be logical and plausible as it is based on the premise that an industry's effectiveness is largely influenced by what the customers and market deem to be of importance. The drivers as identified by Roth and Miller (1992) seem to be aligned with the general subject literature and incorporate quality, flexibility and innovation. Barnes (1999) complements the study of Roth and Miller (1992) and include the following as equally important factors affecting the industry's effectiveness:

a) the importance of a clearly defined, aligned and communicated manufacturing strategy,
b) manager's and leader's ability to define and execute this strategy and to facilitate an understanding and commitment throughout the entire company
c) the company's ability to align and maintain all the socio-technical factors of production such as human resources as well as the physical assets are the strongest overall predictor of manufacturing strength.
d) and lastly, the degree to which the manufacturing function transcends the traditional boundaries and are directly linked to both suppliers and customers.

Kasul and Motwani (1995a) as well as Wheelwright and Clark (1995) highlight the importance of leadership and claim that when the manufacturing operations function fails to contribute significantly to the creation of sustainable competitive advantage, it is a failure, not of manufacturing management, but of top management.

Voss (1995) state that manufacturing best practices have come from many sources: Materials Requirements Planning (MRP) from the USA, Optimized Production Technology (OPT) from Israel, Flexible Manufacturing Systems (FMS) from the UK, group technology from Russia. The most recent literature on manufacturing best practises however have been dominated by Japanese manufacturing practises and is mainly as a result of the outstanding performances of the Japanese manufacturing industries over the past decades. Just-in-time manufacturing (JIT) (Schonberger, 1986) and total quality management (TQM) (Schonberger, 1994) were arguably the best practises underlying the success of the Japanese manufacturing industries and these evolved into lean production methodologies (Schonberger, 2007).

Many of these best practices have been brought together under the concept of world class manufacturing (WCM) or world class operations (WCO). In essence, WCO is defined by Chan (1993) and Chan, Samson and Sohal (1993) as having best practices in total quality, concurrent engineering, lean production, advanced manufacturing systems, logistics and general organisational practice

In addition Davies (2002) further defines world class manufacturing as having operational performance equalling or surpassing best international companies.

The assumption of “world class operations” (WCO) is that the continuous development of best (world class) practices will lead to superior performance in all areas within the firm and this in turn will lead to increased competitiveness.

Kasul and Motwani (1995a) have done an extensive review of the literature and have identified the critical factors and measures that constitute WCO as well as the organisational requirements for WCO implementation. They have categorised these requirements into the following nine categories:

(1) Management commitment;
(2) Quality;
(3) Customer service;
(4) Vendor and material management;
(5) Advanced technology;
(6) Facility control;
(7) Flexibility;

(8) Price/cost leadership;
(9) Global competitiveness.

Ferdows and De Meyer (1990:169) observed that during the journey of WCO implementation “the Japanese seem to follow a distinct sequence of improvement programs which aim at building one capability upon, and not instead of, another”. Ferdows and De Meyer (1990) argue that certain capabilities are required to be implemented first to facilitate the implementation of subsequent capabilities. They placed greater emphasis on quality capabilities and then rank capabilities in the following areas and order: dependability, speed and cost efficiency. This study will support their argument as it is believed that quality is the market driver mostly demanded by the customers in the automotive industry. It is also believed that quality is a prerequisite for dependability and only once the operations are meeting quality and dependability requirements, can speed and cost be effectively addressed.

The model for a company to reach global manufacturing competitiveness as presented by Kasul and Motwani (1995a) will serve as a base for the development of a new and adapted model. This new model will be suitably adapted with elements from the general literature as highlighted in the preceding paragraphs of this literature review and will be used to assess the global competitiveness of the internal operations of the South African catalytic converter industry.

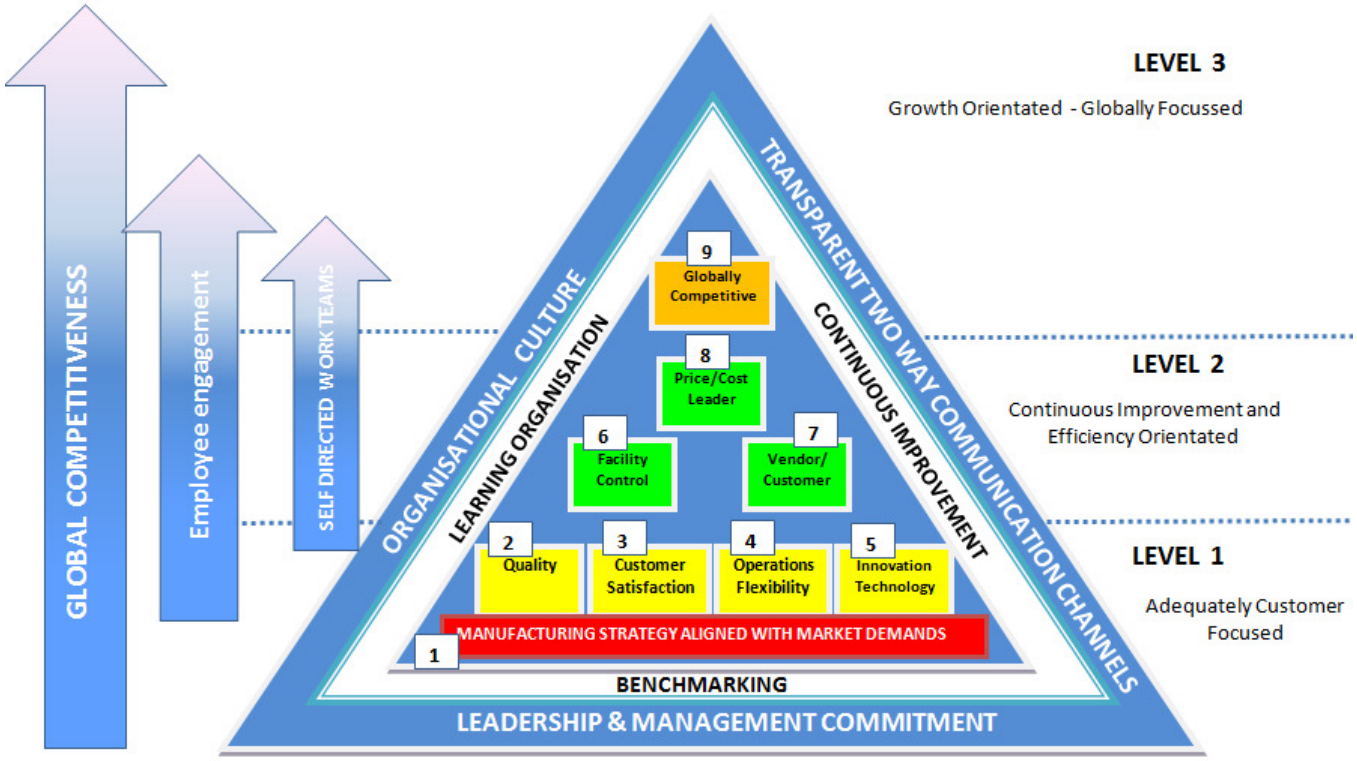


Figure 6: World Class Operations assessment model (adapted from the model proposed by Kasul and Motwani (1995a))

2.3.1 Description of World Class Operations Assessment Model

The WCO assessment model as presented in Figure 6 proposes that the road to global competitiveness could be divided into three distinct levels. During the first two levels of the road map a company develops a more definite customer focus and also evaluates their efficiency as they gain local supremacy. At the third level the company transitions and the focus becomes growth on a global level as they seek global supremacy. A company progresses through the three levels as they implement and master various best practices or WCO factors. These WCO factors serve as building blocks and are presented as a sequential implementation process. It is noted that a large overlap could exist between any of the WCO factors and in reality most companies may implement certain aspects or elements from different WCO factors simultaneously and the implementation progress may also differ for each of the WCO factors. This will result in the position of a company on the roadmap to become blurry and not easy to establish. The model however promotes the sequential progression through the building blocks and argues that the success with which a company will implement the next WCO factor is determined by how they have successfully mastered the previous WCO factor. Following this argument it may explain why companies may still struggle with satisfying their customers as they have not fully mastered quality throughout their operations yet. Likewise a company may not truly become a cost leader as they haven't mastered managing their vendors and customers effectively. The first step on the road map is the defining and alignment of a clear manufacturing strategy with the requirements of the company's customers.

The role of the company's leadership and management are placed together with organisational culture and effective communication channels on the three sides of the encompassing triangle as the presence of all three elements during the entire journey are fundamental for success.

The inner triangle highlights the need of the organisation to become a learning organisation that thrives on continuous improvement and benchmarking their performance against themselves as well as other best performing firms.

The WCO assessment model further illustrates that as a firm progresses towards global competitiveness the level of employee engagement and participation will

increase and there will be a greater tendency towards establishing self-directed work teams or quality circles.

The different WCO factors will be discussed in greater detail below.

a. *Leadership and Management commitment*

Pursuit of world-class status in a global market means constant change. The primary function of a firm's leadership and management is to provide and maintain an enabling environment and culture that is conducive to supporting and facilitating the required operational changes and strategies. Kasul and Motwani (1995a) and Wheelwright and Clark (1995) highlight the importance of the close involvement of top management to ensure that the improvement to the manufacturing operations contributes to a sustainable competitive advantage. Management must set and communicate a clear direction with defined goals and objectives that is aligned with market demands; provide adequate budget and resources as well as monitor the progress closely (Chan, 1993a; Farrell, 2000). Management's commitment to cultivate and nurture the continuous improvement process by empowering people to change and assume greater ownership as well as regularly review and raise the goals and targets are highlighted by Chan (1993b; Farrell, 2000). The degree of visibility and support that management provides in implementing a total quality environment is critical to the success of WCO (Kasul and Motwani, 1995b). The emphasis should be on long-term organizational improvement and development of an attitude and skills for implementing changes; management sends signals that provide the employees with an understanding of the environment within which they work and how they are expected to function within it (Farrell, 2000). He further explains that besides an emphasis on promoting a willingness to accept risk, top managers should also adopt a facilitative or transformational leadership.

b. *Continuous Improvement/ Learning Organisation/ Innovation/Technology*

World class operations (WCO) require that innovation are incorporated into the everyday corporate culture, all employees of the firm should be encouraged to come forward with new ideas, processes, products and solutions (Barnes and Lorentzen; Kasul and Motwani, 1995a). The innovation activities of firms cover both processes and products.

Improvement to operations could come in the form of small increments or in bigger step changes but either form requires throughout the entire firm a structured approach to learning, learning mindset and a culture that promotes problem solving and are tolerant of mistakes. Innovation could originate from formal Research and Development initiatives, which are normally capital intensive, or could also originate from the gradual assimilation of technologies and process improvements and depends on the relative strengths of the company in terms of productive capacity and technological capability (Barnes and Lorentzen, 2006)

Garvin (1993) defines organisational learning as when an organisation is skilled at creating, acquiring and transferring knowledge, and at modifying its behaviour to reflect the new knowledge and insights.

Cooney (1997) points out the link between continuous improvement, enterprise or firm training and employee engagement. Farrell (2000) in his research on Australian firms, has established a positive relationship between organisational learning and business performance and competitiveness.

Koc and Ceylan (2007) in their study of 119 large scale Turkish firms take a slightly different view on the innovation capacity of a firm. In their study they point out that many companies focus on the technology strategy, idea quality, idea generation, technology acquisition and exploitation rather than on the more traditional factors such as teamwork, learning organisation, management participation and delegation as the criteria to develop innovative capacity.

For the purposes of this study the innovation capacity of a firm will be assessed from the basis that innovation is influenced by organisational culture, management

involvement (through practises such as strategic direction, employee selection and deployment, rewards and recognition, support for idea generation and multifunctional teams) as well as the firm's access to new technology (either through internal or external sources) and their ability to exploit these technologies.

c. *Quality*

Quality is defined as the consistent conformance to customers' expectations and is a major influence on the external customer satisfaction but also internally reduce operational costs and increases operational dependability (Slack, Chambers and Johnston, 1995)

Chan (1993b) states that a company must have a quality plan that consist of the following components:

1. A quality policy that contains measured goals and concrete methods to achieve them;
2. Process design measurement techniques,
3. Ensures high reproducibility of the processes and reduce variability in parts;
4. Force suppliers to provide quality products on time;
5. Product designs that reduce the number of redesigns and make quality easy to manufacture;
6. Incorporate training programmes in acceptable quality techniques for all employees;
7. Ensures that the quality department is involved in new product development;
8. Ensure that operators are involved in problem solving and authorized to self-implement solutions.

Quality programmes should measure the percentage or the number of parts that deviate from the acceptable in order to prevent the reoccurrence of a defect (Kasul and Motwani, 1995a). They further mention that quality measurement techniques should also include monitoring supplier quality levels, utilizing statistical process control (SPC) to reduce process variability, and calculating the cost of quality.

With increased competition quality at source programmes such as Total Quality Management (TQM) (Terziovski and Samson, 1999) and Six Sigma (Coronado and Antony, 2002) are becoming more and more relevant.

“TQM is a philosophy that embraces concepts, methods, tools and techniques to form a language which is understood and applied as a business strategy at the ``top-floor'' and as a functional strategy at the ``shop-floor.'''' Terziovski and Samson (1999:229).

This approach assists organisations to integrate business activities in leadership, people, customer orientation, planning, quality assurance of processes, and information and analysis. These activities, when effectively linked together, would lead to sustainable world class performance in customer satisfaction, employee relations, operating performance and business performance. In essence this promote a “zero defect” and a “do it right the first time” attitude towards quality throughout the entire organisation

Some empirical studies as discussed by Park, Hartley and Wilson (2001) also point out the positive impact that quality management practises have on product quality, customer satisfaction and financial improvements. They highlight human resource management and process management as the most promising of the quality management practices.

Regardless of which of the quality management programmes such as TQM, Six sigma or any other structured programme, are followed, what is deemed of importance for a company to be competitive is the presence of a sound quality management process and a strong focus on quality throughout the entire organisation.

d. *Customer satisfaction*

With customer satisfaction is meant the degree to which a firm’s operations are in tune with and responsive to the customer’s requirements. It is the firm’s ability to not only be aware of the customer’s requirements but also to be able to quickly modify their operations to better meet these requirements, this is considered fundamental in WCO (Keiser and Smith, 1994; Stalk and Hout, 2003).

According to Kasul and Motwani (1995a) customer service should be addressed from two main areas:

(1) Internal customer service;

(2) External customer assurance.

They define internal customers as the next user of the product or service such as the next work centre or department and also provide the key components required to ensure internal and external customer satisfaction. Efficient service to internal customers should comprise of the following components:1) establishing a platform to communicate and understand customers' needs accurately, 2) providing timely and dependable deliveries, 3) presenting improvements or cost-saving suggestions, 4) authorizing employees to self-implement solutions, 5) cross-training employees for mastery of more than one job and 6) providing adequate technical training.

External customer assurance focuses on meeting external customer expectations through 1) providing a platform to enable greater understanding of customer requirements, 2) providing customers with timely information and responding quickly to complaints, 3) maintaining a corporate goal to reduce the quantity of questions or complaints, 4) and recognizing all successful efforts in providing outstanding service (Hill, 2005).

Monitoring customer satisfaction could be done through various ways from monitoring the number of late deliveries and customer complaints to measuring the value-added labour that meets the customer's specific needs (Maskell, 1989; Maskell and Baggaley, 2004). Consumer surveys and measuring the percentage of repeat sales to existing customers can also be used to measure customer satisfaction. Great customer service is only possible through equally great support systems and total customer satisfaction will be enhanced through measurements that emphasize the lifetime value of the customer (Peters, 1987)

e. *Operational flexibility*

Operational flexibility means being able to change or adapt the operation in some way or another in terms of what the operation does, when it is done and lastly, how it is done (Slack et al., 1995). They highlight that a flexible operation enhances dependability, speeds up response time and reduces manufacturing time and costs. These translate into four distinct operational flexibilities namely:

a) Product flexibility – ability to introduce new or modified products

b) Mix flexibility – ability to produce a wide variety/ range of products

c) Volume flexibility – ability to change the level of output, quantities or volumes

d) Delivery flexibility – ability to change the timing of deliveries or responsiveness.

Operational flexibility therefore is largely influenced by lead time and has two interrelated parts: the total system lead time from receipt of order to payment for the delivery of the supplied product, and the total research and development lead time that it takes to introduce and successfully ship a new product (Kasul and Motwani, 1995a).

The total system lead time is focused on all the internal functions and activities of the firm to produce the existing products. Process time or manufacturing lead time, is a common measurement in use and the WCO goal is to shorten it as much as possible. Kasul and Motwani (1995a) presents the following techniques to improve total system lead times:

1) Optimum lot or batch sizes to match demand, minimise waste, maximise equipment utilisation
2) Product simplification reducing the number of part numbers that the system must deal with;
3) Implementing a pull schedule system to move materials as needed through the plant;
4) Emphasizing the internal departments and processes as customers;
5) Simplifying the routeings and reducing the inventory control points; storing materials where they are used;
6) Utilizing a Materials Resource Planning (MRP) system to order raw materials.

The total research and development lead time concerns the frequency and speed by which a company responds to the market demand for new products (Kasul and Motwani, 1995a). Measuring innovation could be difficult and could be done through monitoring the number of new products introduced over a time period and also measuring the time taken from concept and design to full scale production and introduction into the market (Maskell, 1989).

f. *Facility control*

Facility control is the factor that is concerned with overhead costs, utility expenses as well as wastage of resources and materials and attempts to bring order and organisation to the work place. An improvement in facility control involves more value-adding activities in less space, less material handling for

employees and efficient and optimum process or factory layouts (Kasul and Motwani, 1995a). They propose the following approaches to improving facility control:

1) Total productive maintenance – efficient and preventive maintenance to prolong the life span of all equipment and minimise manufacturing delays. Maintenance responsibility and ownership should ideally reside with all levels of the company.

2) A flexible cellular layout to manufacturing processes - a cell layout is where all the transforming resources of the manufacturing process are located in one area or cell. The aim is to concentrate all relevant and related manufacturing activities in one area and minimise non-value adding activities such as material and people transfer in-between areas (Slack et al., 1995).

3) Waste elimination and housekeeping – bringing order to and promoting an organised work place that will minimise wastage of materials, resources and time and aim to eliminate wasteful or not needed activities.

The following measures are proposed by Maskell (1989) as potential measures to measure facility control:

1) Number of projects focused on facility cost reduction e.g. re-use of waste, maintenance cost reduction, energy consumption reduction.

2) Number of lost machine time – as a measure of the effectiveness of the equipment maintenance program.

3) Calculating the total distance travelled by the product throughout the manufacturing process as a measure of effectiveness of cellular process layout.

g. *Vendor, customer and material management*

No company can function in isolation and vendor and customer or supply chain management, is the management of the interconnection of firms that relate to each other through upstream or downstream processes that produce value to the ultimate consumer in the form of a product (Slack et al., 1995) All the companies in the chain keep a portion or margin of the end-users money in return for the value it has added. The entire chain is interdependent and should be managed holistically, with each partner not only satisfying its own customer but also the satisfaction of the end-user as confirmed by Park, Hartley and Wilson (2001) in their study of the Korean automotive industry.

Many companies realise the need for greater collaboration with their supply chain partners to improve their own competitiveness (Keiser and Smith, 1994; Holweg, 2005; Singh, Smith and Sohal, 2005). Partnerships with suppliers should be based on a well-defined quality programme and be focused strongly on continuous improvement geared towards improvement of overall dependability and cost reduction across the entire chain. For many companies the greatest appeal in collaborative partnerships are due to the sharing of risks associated with the development of new products (Kasul and Motwani, 1995a).

A material policy across the entire supply chain is critical and according to Kasul and Motwani (1995a) should focus on the following:

1) Reduce inventory levels and increase turnover rates through smaller batch/lot sizes and more frequent deliveries

2) Using fewer suppliers with stronger relationships

3) Emphasising quality and delivery capability or dependability rather than price

4) Eliminating queue space and inventory quantity through continuous materials processing, utilising techniques such as Just-in-time (JIT).

Materials availability or the inverse materials shortage could be simple measurements used to determine the effectiveness and dependability of a firm's supply chain. This combined with monitoring processing lead time across the entire

supply chain as well as the responsiveness of the supply chain to changes in the market could paint a very clear picture on the effectiveness of the entire supply chain.

h. ***Price/Cost leadership***

Low cost is a universally attractive objective as every saving on operational cost directly adds to the profit of the company (Slack et al., 1995). They further highlight that an improvement on any of the manufacturing performance objectives of quality, speed, dependability and flexibility will also affect the associated manufacturing cost. The speed, dependability and flexibility of the operations has an indirect impact on manufacturing costs as it reduces the in-process inventory, reduces the administrative overheads, eliminates operational disruptions and minimise idle time on equipment.

Reitsperger, Daniel, Tallman and Chismar (1993) and Feigenbaum (2002) confirms the link between quality and costs in terms of elimination of waste, rejected product, disruption to internal customers' processes and product reworks (both from a materials and time perspective).

The measure that is most frequently used to indicate how successful an operation is at minimising cost through controlling and optimising its internal operations, is productivity (Slack et al., 1995). There are various different productivity measures but essentially productivity is defined as the ratio of what was produced to what was required to produce that specific output (Kasul and Motwani, 1995a; Slack et al., 1995). Productivity could therefore be improved through reducing the costs associated with inputs (either/both transforming and transformed resources) while maintaining the same or higher levels of output. It is also clear that cost reduction initiatives can no longer be restricted to internal operations any longer and should transcend beyond the firm's borders into the firm's supply chain.

For the purposes of this study the catalytic converter industry will be assessed on the basis of:

- whether a definite focus on operational cost reduction exists,

- whether there is a pro-active and clear link between all continuous improvement/innovation initiatives and unit costs and
- whether the firm is benchmarking its productivity performance against its global competitors.

2.3.2 Conclusion

Literature suggests that in order for a manufacturing company to be considered globally competitive without any trade protection or incentive, it must have achieved "world class" status. An assessment model for "World Class Operations" was constructed from the predominant themes from available literature. Although this model may not be absolute, it is believed that it is comprehensive enough to provide a fair indication of the key elements that constitute "World Class Operations".

2.3.3 Proposition 1

The South African Autocatalytic converter industry has developed adequately in terms of "World Class Operations" in order for the industry to be considered globally competitive.

2.4. Factors from the external environment that impact on the South African Catalytic converter industry

No company or industry operates in isolation and can't only rely on its internal operations to ensure a long term sustainable competitive advantage. A company is also influenced by many factors from the external environment and the company's ability to recognise the impact of these influences, and its ability to suitably adapt its operational strategies accordingly, are key prerequisites for long term success (Armstrong, 1982; Alexander, 1985). This section will aim to explore the most significant external factors impacting on the South African autocatalytic converter industry's long term prospects.

The external business environment analysis will be done utilising Porter's Five Forces model (Porter, 1996) as well as scanning the political, economic, social,

technological, environmental and legal environments (PESTLE), related to the autocatalytic converter industry. Both Porter's five forces model and the PESTLE model are well known strategic tools utilised in the literature to gain a better understanding of a company's external environment (Shrivastava, 1986; Simkin, 1997; Valentin 2001; Hunger, 2003). These models are by no means considered to be without flaws and completely comprehensive, but for the purposes of this study, will be considered as sufficient to gain a conceptual understanding of the external influences impacting on the South African autocatalytic converter industry.

The South African Autocatalytic converter industry is mostly export orientated and exports over 80% of the converters to the Western European regions , it is therefore largely dependent on influences from the European markets (CCIG, 2011).

2.4.1 Supply Side Factors

The South African Autocatalytic converter industry imports the majority of the raw materials used in their manufacturing processes from overseas markets with the exception of the platinum group metals which are sourced from the rich South African reserves. Because of the geographical disadvantages and distances to the primary markets in Western Europe, the South African Autocatalytic converter industry experiences additional transport costs which negatively impacts their global competiveness. The industry therefore has to be extra mindful of minimising operational costs and how these costs are influenced by external factors.

- ***Platinum reserves***

Platinum is an extremely scarce resource. The annual global supply of platinum is approximately about 200Mg (metric ton) of which over 60% is consumed by autocatalytic converter applications; jewellery accounts for about 25% and other industrial uses account for the remainder (Johnson Matthey, 2009a). In most of the industrial applications Platinum is irreplaceable without a significant compromise to performance of the catalytic converter and could in most occasions only be replaced with other PGMs (Platinum Group Metals) such as Palladium, Rhodium, Ruthenium etc. Over 80% of the world's Platinum is mined in South Africa; Russia is the second largest supplier and contributes around 10% with some deposits in Zimbabwe (Yang,

2009). According to a report by Gordon, Bertram and Graedel (2006) geologists don't expect significant further PGM deposits to be discovered in the world. Therefore not only is the total available reserves of Platinum limited but according to Yang (2009) the demand exceeds the supply with limited inventory holding. This results in a very thin market which is very sensitive to changes and fluctuations in both supply and demand. Yang (2009) further highlights that future demand is expected to increase significantly as a result of both diesel propulsion and fuel cell propulsion technologies that require higher Platinum loadings compared to conventional automotive propulsion technologies. The potential use of fuel cells as a replacement of lithium batteries in electronic appliances will further increase the demand for Platinum. Yang believes that if not managed carefully, this could result in a global supply crisis.

- ***Energy costs – Electricity***

NERSA (The National Energy Regulator for South Africa) at the time of conducting this research has recently granted Eskom (the national electricity provider) the right to increase electricity prices by an average of 25% over the next three years. This will significantly impact on the manufacturing costs of autocatalytic converters, as the manufacturing processes are quite energy intensive. The industry will have to find innovative means to reduce their electricity consumption as the additional cost could not simply be passed onto the customers without affecting the competitiveness of the industry.

- ***Imports from low labour cost countries such as China & India***

Many manufacturing operations are moved from developed countries with high labour costs to developing countries with low labour costs such as China and India (Saran and Guo, 2005). Labour costs contribute largely to the manufacturing costs of South African autocatalytic converters as many of the manufacturing processes have not been fully automated yet. This poses a significant threat to the South African Autocatalytic converter industry as European markets may choose to source their converters from countries such as China or India where labour costs and ultimately unit costs are lower.

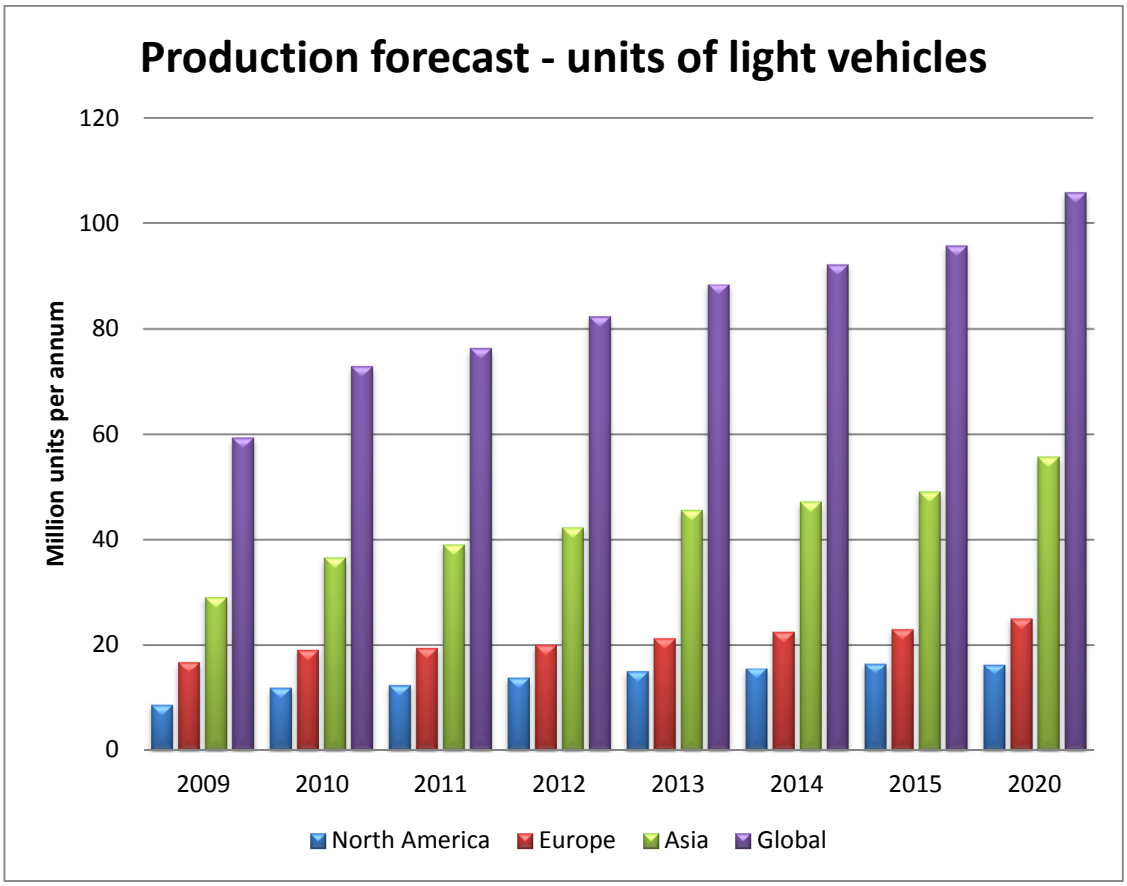
- ***Stainless steel as major input raw material***

The South African Autocatalytic converter industry is the largest consumer of locally produced stainless steel (50,000 tons/annum), exceeding 38% of local consumption (CCIG, 2011). The profitability of the South African autocatalytic converter industry is therefore largely dependent on the price and availability of stainless steel and the factors influencing this commodity.

2.4.2 Demand Side Factors

- ***Projected sales forecast for car sales in Europe***

With the primary markets for South African produced autocatalytic converters being the Western European Markets, it is critical to base any assessment of the South African autocatalytic converter industry on the expected growth in car sales in Western Europe.



Source: Adapted from IHS Global Insight (December 2010); Johnson Matthey – Report to Analysts (February 2011);

Figure 7: Forecasted regional production for light duty vehicles

Although the expected growth in global light or passenger car sales as indicated in figure 7 seems to be healthy and the number of units produced in 2009 is expected to be nearly doubled by 2020. Most of this growth is however limited to the Asian region with the growth in Europe and North America significantly lower and almost stagnant.

- ***Production overcapacity in the world***

Majority of the world's automobiles are still being manufactured in developed countries such as North America, Europe and Japan. Developing economies such as China, India, Korea, Thailand and Brazil only recently gained prominence in the global auto manufacturing arena (Barnes and Morris, 2008). They further claim that a global production overcapacity of around 25% exists and that automotive assemblers struggle to fill their plant and earn a reasonable return on their current investments. Therefore between the well-established operations within the developed countries and the rapid rise of production within the Asian tigers (developing Asian countries with very large local markets and very low cost production capabilities), very few options for market growth beyond their own borders exist for the remainder of the developing economies such as South Africa. In most developing countries the automotive and automotive component industries are locally significant in terms of political, economic and technological importance but almost insignificant on an international scale. Barnes and Morris (2008) further highlights that the challenges confronting developing economy auto industries are compounded by three key changing dynamics of global automotive value chains:

a) Producer driven value chains that strongly impacts on the nature and structure of operations,

b) Mergers and acquisitions that lead to the establishment of multi-national firms with access to transparent and truly global information flows

c) The intensification of competition throughout the automotive industry, resulting in deteriorating financial performance.

- ***Growth exports into African countries***

Africa is to some extend increasingly regarded as the region for long term investment opportunities. Global investors and businesses are realising the potential purchasing power and size of the African markets (Makholwa, 2011) . The improved sentiment towards Africa has been aided by governance reforms and an improving macroeconomic landscape. The South African Autocatalytic converter industry could leverage their current technology, natural resources and expertise to secure a significant foothold in this potential future market.

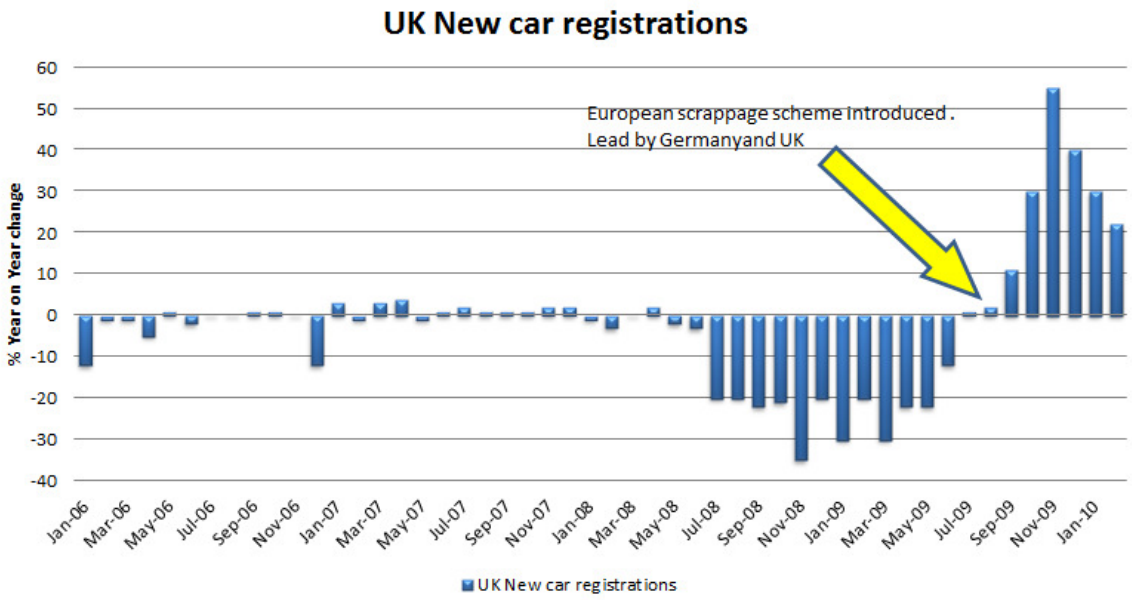
2.4.3 Political and Economic Factors

- ***Exchange rate***

With the South African Autocatalytic converter industry mostly export focussed, it is largely impacted by the exchange rate and the strength of the South African Rand. The stronger the South African currency becomes the more expensive the autocatalytic converters are for the European markets and also less attractive. The South African Rand is expected to strengthen and is projected to stabilise at R6.27 by 2013 (Business monitor 2011)

- ***Economic recessions impact on car sales***

With the primary market being Western Europe, the South African Autocatalytic converter industry was affected by the global recession that particularly hit Europe and the USA hard. Motor vehicles are considered luxury purchases and sales are significantly affected by factors such as availability of credit, cost of credit, flexibility in repayment terms and the spendable income of households. Inflation and interest/lending rates are therefore key determinants of vehicle sales.

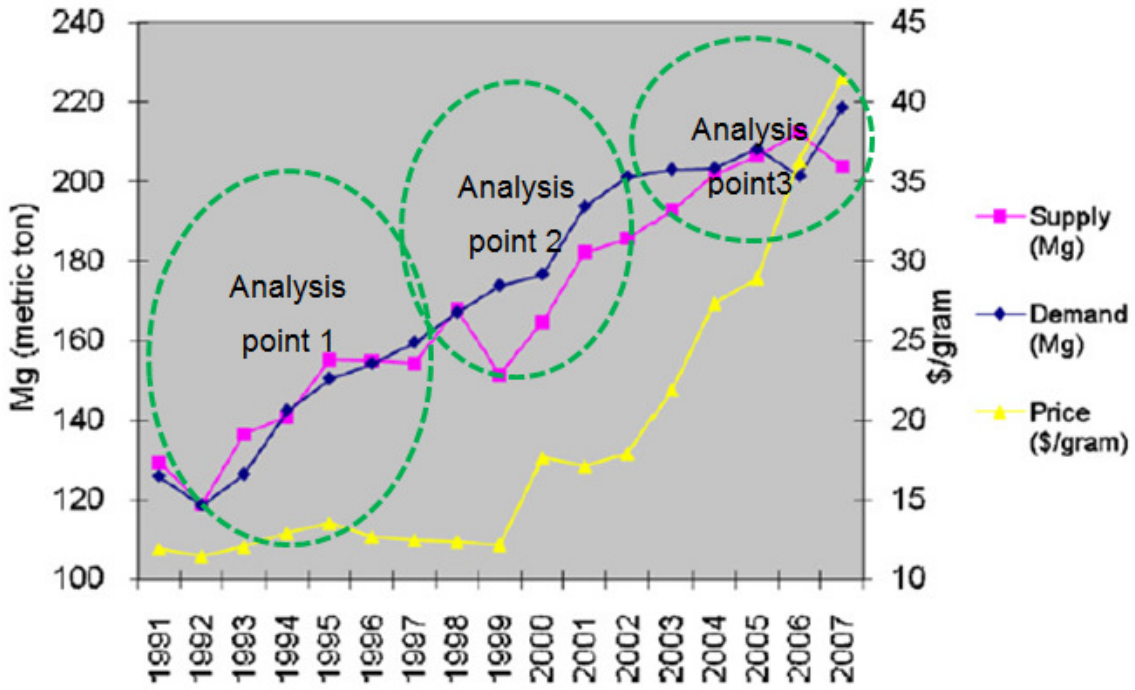


Source: Society of Motor Manufacturers and Traders (2010)

Figure 8: New car registrations in UK

Figure 8 aims to illustrate the effect of the global recession such as during 2008/2009 on the sale/registration of new motor vehicles. In figure 8 is presented the year on year growth/decline in UK new car registration. The dramatic decline in new car registrations as a result of the global economic recession in 2008/2009 is clearly visible. Countries such as Germany and the UK developed and lead during the middle of 2009 on an economic recovery plan with the aim to stimulate new car sales through an incentivised used-vehicle scrappage programme. The impact of these artificially stimulated automotive vehicle sales are illustrated in figure 8 and is further proof of the link between car sales and the economic health of a country.

- ***Platinum price***



Source: (Yang, 2009)

Figure 9: Global supply and demand curves for Platinum vs. Average price of Platinum

Figure 9 aims to illustrate the sensitivity of the PGM (or Platinum) prices towards the demand for platinum. The demand for Platinum exceeds the supply with very low commodity inventory levels. This resulted in the buffer between supply and demand becoming very thin and the price of platinum therefore volatile and quite sensitive to changes in supply or demand (Yang, 2009). Yang (2009) demonstrates this sensitivity through three analysis points:

1) Analysis point 1 – During the period between 1991 and 1999 a number of new uses for platinum became commercial (of which autocatalytic converters technology is one of the biggest consumers). Although the demand for platinum therefore increased during this period, the supply kept up with the increased demand and the price of platinum remained fairly constant

2) Analysis point 2 - During 1999 Russia suspended export of Platinum for almost a year, this resulted in roughly a 10% shortage in supply which resulted in the Platinum price increasing with 50%

3) Analysis point 3 - Electricity outages on the South African Platinum mines during 2007 resulted in a two week halt to all mining operations and an associated 3% reduction in annual supply. This lead to a 40% increase in the Platinum price.

The platinum price is therefore clearly quite sensitive to operational issues in the South African mining sector such as electrical outages or labour strikes that could potentially influence the supply of Platinum. The demand for Platinum is expected to increase over the following years, with no real improvement in mining output (Yang, 2009). This could result in potential increases to the price of platinum group metals. Not only will higher Platinum prices increase the selling price of new cars, it will also indirectly strengthen the case for alternative propulsion technologies.

- ***Fuel / oil price***

The distance between the South African Autocatalytic converter industry and their primary market in Western Europe makes the industry vulnerable to rising fuel costs. The additional transport costs increases the unit costs per converter and therefore the autocatalytic converters from South Africa compare less favourable to the autocatalytic converters from manufacturers in or closer to Europe e.g. United kingdom, Germany and Macedonia (Barnes and Morris, 2008).

Higher fuel prices and fear of global warming could potentially have two different effects on the number and type of vehicles that are sold (Hamilton, 2008).

1. A greater migration towards public transport or buying cars with a smaller engine capacity. This will reduce the demand for catalytic converters or smaller cars require smaller converter with a lower Platinum loading per converter.

2. A potential switch to diesel cars for its higher fuel efficiency. This switch will be beneficial as diesel catalytic converters require a higher platinum loading per converter (Yang, 2009)

- ***Impact of government regulations on the South African autocatalytic converter industry***

The South African government's continued liberalization of the South African automotive industry will have a significant impact on the cost competiveness of the industry (Black, 1998; Naude, 2006; Barnes and Morris, 2008; Black, 2009). The benefits received from MIDP will no longer off set the additional transport costs to the European markets and the industry will have to find innovative ways to reduce their manufacturing costs (Barnes and Morris, 2008)

The following socio-political factors are also believed to impact on the productivity and cost structures of the industry:

- *Changes to export trade tariffs and incentives*
- *Union involvement and power*
- *Ratio of Temporary labour to permanent labour*
- *Skill levels of employees*

2.4.4 Environmental and Technological Factors

- ***Stricter environmental laws***

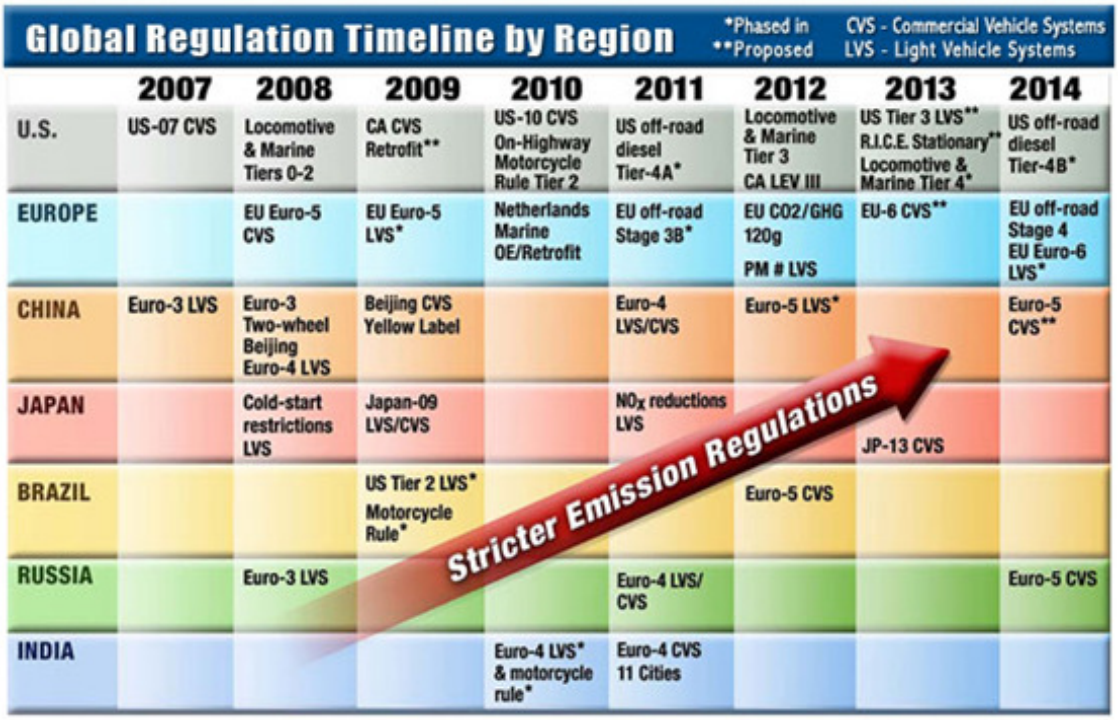
Increasing international awareness and the attention to global warming, specifically the contribution from vehicle exhaust emissions resulted in regular tightening of regulatory emission controls over the past decade. Strict emission control legislation is no longer restricted to developed countries and has been introduced increasingly in the emerging new economies such as China, India and Brazil (CCIG, 2011). The rate of introducing stricter environmental legislation will be arguably significantly slower compared to the introduction rate in the developed countries; if the Asian countries start to accelerate the introduction of stricter environment legislation the sheer size of their automotive industries could place PGM reserves under severe

pressure (Riley, 2002). This however remains unlikely and countries such as Brazil and China are expected to only introduce equivalent legislation to the EU 6 standard only after 2015 (Johnson Matthey, 2009b).

Continued pressure from environmentalist groups have resulted in a continual and increasing demand for catalytic converters for vehicles and the aggressive tightening of legislation in Europe over the past decade contributed greatly to the rapid growth of the South African autocatalytic converter industry. The tightening of emission control legislation requires a new formulation or technology of autocatalytic converter to meet this new emission specification and therefore ensuring a continued demand for future converter technologies but not necessarily an increase in future volumes of converters to be sold (Barnes, 2008). The tightening of regulation will also drive the trend towards cleaner more efficient engines (CCIG, 2011).

The legislation for larger internal combustion engines such as trucks etc. is also intensifying and recently the EU countries started to restrict the emission of soot particles from diesel engines this on the other hand will mean greater future sales volumes as the current market for catalytic soot filters for trucks are still in its infancy (Johnson Matthey, 2009b). This diesel particulate filter converters is expected to be, together with particulate filter converters for gasoline engines, the next growth market for the local industry (CCIG, 2011).

Figure 10 below illustrates the phased introduction of tighter regulations for the different global regions. Of particular importance to the South African industry will be the anticipated introduction of the tighter EU-6 legislation in 2013 within the European region.



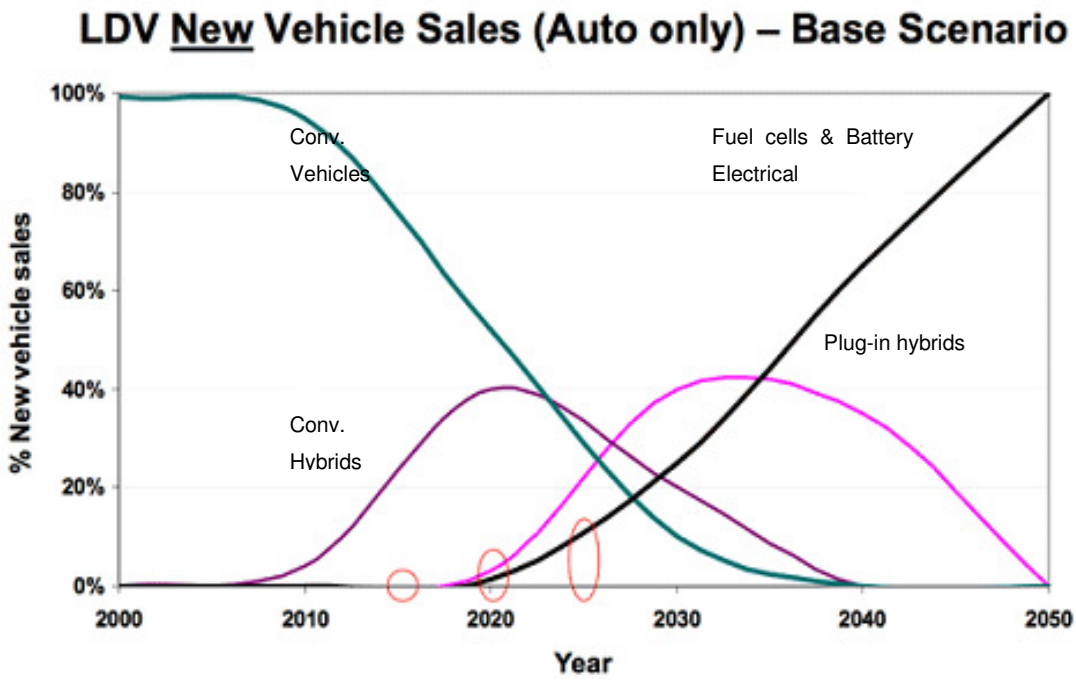
Source: CCIG, The SA Catalytic Converter Industry: Beyond 2012

Figure 10: Global Regulation Timeline by Region (Introduction of new Environmental and emission legislation)

- ***New technologies, fuel cells etc., movement away from PGM's***

Increasing societal awareness of the impact of emissions on the environment is placing pressure on the development of automotive propulsion technologies that is "greener" or less harmful to the environment. Propulsion through an internal combustion engine will ultimately be replaced by technologies such fuel cells (FCV), battery electrical vehicles (BEV) or some hybrid combination thereof (Emadi, Lee and Rajashekara, 2008).

Hybrid (combination between electrical/fuel cell and internal combustion) propulsion technologies will still require a catalytic converter and/or carbon filter, albeit smaller units. Battery electrical vehicles (BEV) and fuel cells (FCV) however do not require a converter (CCIG, 2011).



Source: CCIG, The SA Catalytic Converter Industry: Beyond 2012

Figure 11: Forecasted sales of new Light Duty Vehicles by propulsion technology

According to the CCIG anticipated base scenario demonstrated in Figure 11 the internal combustion engine is in the decline phase of the propulsion technology life cycle. Of the car sales in 2020, 3% is expected to be plug-in hybrids and 1% fuel cells and battery electrical vehicles. Conventional technology and conventional hybrids are expected to be completely phased out by 2040 and by 2050 only fuel cells and battery electrical technology will be used.

Another factor that will impact on the South African catalytic converter industry is the move away from using Platinum Group metals (PGM) as the active catalyst ingredient in emission control technologies. Advanced ceramic technology don't require expensive PGM's and has potential for both stationary (e.g. power stations) and mobile (e.g. vehicles) applications (Johnson Matthey, 2009b).

2.4.5 Conclusion

In summary, literature suggests that the demand for South African Autocatalytic converters is reasonably sensitive to any changes not only in the South African

economic, political, social, technological and environmental context but is also largely affected by changes in the global arena. The extent to which trade incentive schemes such as MIDP protected and shielded the industry in the past against these external forces will be investigated in the advent of revising the MIDP trade incentive scheme in 2012.

2.4.6 Proposition 2

There are causal relationships between events from the South African and global external business environments and the demand for South African autocatalytic converters that will impact on the sustainable future of this industry without the benefits from the current MIDP incentive scheme as implemented by the South African government.

2.5. Conclusion of Literature Review

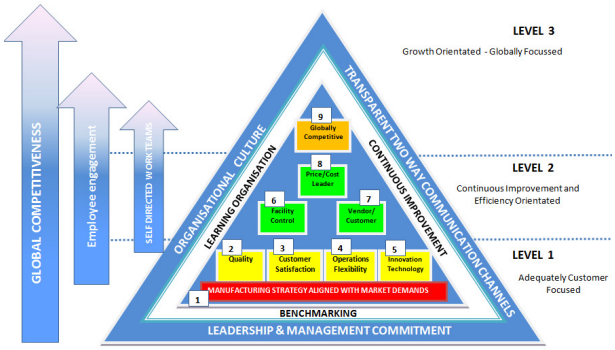
Any kind of exploratory or predictive analysis of the plausible scenarios for the future of the South African autocatalytic converter industry without the protection of MIDP, have to take cognisance of both the current internal operational capabilities of the companies within the industry as well as the sensitivity of the industry to influences from the external macro business environments.

This research will assess the internal operational capabilities of the companies based on the "World Class Operations" assessment model constructed from the predominant operational best practises as identified from available literature.

2.5.1 Proposition 1

The South African Autocatalytic converter industry has developed adequately in terms of "World Class Operations" in order for the industry to be considered globally competitive.

Table 1: Categories and References relating to Sub-problem 1

Category	References (Only main references listed)
• **"World class" internal operation and Globally competitive** Assessment of internal operational capabilities based on the constructed assessment model  "World Class Operations" assessment model: Fig 3 in Chapter 2 of this report.	(Kasul and Motwani, 1995a) (Davies and Kochhar, 2002) (Barnes, 2000a) (Barnes, Bessant, Dunne and Morris, 2001) (Chan, 1993b) (Fick and Buys, 2005) (Maskell, 1989) (Roth and Miller, 1992) (Schonberger, 1996) (Slack et al., 1995) (Stalk and Hout, 2003) (Womack et al., 1990)

The influences from the external macro business environments have been assessed both from a South African context and global context. The main influences affecting the industry centres on two categories namely: 1) factors affecting the cost of the autocatalytic converter and 2) factors affecting the demand for the autocatalytic converters from South Africa.

2.5.2 Proposition 2:

There are causal relationships between events from the South African and global external business environments and the demand for South African autocatalytic converters that will impact on the sustainable future of this industry without the benefits from the MIDP incentive scheme

Table 2: Categories and Reference relating to Sub-problem 2

Category **(Only main items listed)**	**References** **(Only main references listed)**

• **Factors affecting the cost of the autocatalytic converter e.g.**
  ○ Exchange rate
  ○ Import/export costs, regulations
  ○ Manufacturing charges, labour, transport
  ○ Oil/Fuel prices
  ○ PGM prices
• **Factors affecting demand for autocatalytic converters e.g.**
  ○ New car sales in Europe
  ○ Environmental legislation
  ○ Product/ process technology
  ○ New propulsion technologies
	(Barnes, 2000b)
	(Barnes, Kaplinsky and Morris, 2004)
	(Black, 2001)
	(CCIG, 2011)
	(Emadi et al., 2008)
	(Yang, 2009)
	(Riley, 2002)
	(Mashilo, 2010)
	(Barnes and Morris, 2000)
	(Barnes and Morris, 2008)
	(Black, 2009)
	(Flatters, 2005)
	(Johnson Matthey, 2009b)
	(Wonnacott, 1996)

CHAPTER 3: RESEARCH METHODOLOGY

Powell (1997) states that research can't be defined with a single definition since there is more than one kind of research. From the general definitions he concludes that there are two major types of research namely basic research and applied research. Basic research is primarily interested in deriving new knowledge while applied research emphasizes the solving of specific problems in real situations. Research is further defined by the data gathering methodology used and could be either qualitative, quantitative or a mixture of both qualitative and quantitative (Creswell, Plano Clark, Gutmann and Hanson, 2003).

Both qualitative and quantitative researchers are concerned about the individual's point of view, according to Falconer and Mackay (2000) qualitative researchers believe they can get closer to the subject's perspective through detailed interviewing and observation as oppose to the quantitative researchers that are seldom able to capture the subject's perspective because they have to rely on more remote, inferential empirical data. The empirical data produced by the softer, interpretive methods, are regarded by many quantitative researchers as unreliable, impressionistic and not objective. Because all methods of data collection have limitations, the use of mixed methods could potentially not only neutralize some of these limitations but also by capturing both trends and in-depth perspectives and forging a connection between trends and perspectives may add greater value than qualitative or quantitative alone (Creswell et al., 2003)

Falconer and Mackay (1999) define positivist approaches as those that involve establishing cause and effect relationships while interpretive approaches search for underlying trends and highlights that knowledge gained by interpretive methodologies is not necessarily something that can be verified by further positivist research. He argues that interpretative research stands on its own merit and that it has often been viewed by positivist researchers from a positivist perspective. This tends to promote a view of interpretive work as a subordinate or supporting activity; something that might be done prior to or in support of positivist research. A neutral viewpoint allows researchers to see each type of research as philosophically and logically equal and

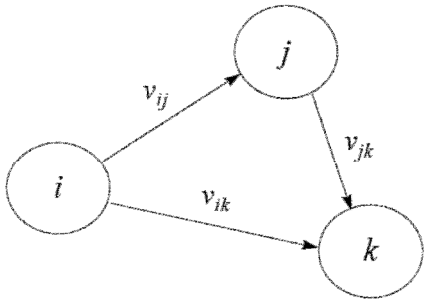
the methodology employed must match the particular phenomenon of interest (Falconer and Mackay, 1999; Falconer and Mackay, 2000).

This research aims to predict plausible scenarios for the future of the South African autocatalytic converter industry, without regulatory protection in the form of MIDP, by finding and analysing causal relationships between the internal and external business environments of companies within the industry. The research paradigm can be considered a mixed method approach making use of both quantitative and qualitative research approaches. A quantitative approach through a Fuzzy Cognitive Map used for simulations of various plausible future scenarios, as well as a qualitative approach through open ended detailed interviews with industry leaders. The interviews explore the perceived global competitiveness of the industry and its internal operations with the intent of developing causal patterns to predict the future of the industry.

3.1 Research methodology /paradigm

The main research methodology employed to simulate scenarios for the South African Autocatalytic converter industry's future without export incentives was Fuzzy Cognitive Mapping (FCM). A FCM links causal relationships between policies or objectives and events or processes in a causal picture or fuzzy dynamic feedback system (Kosko and Dickerson, 1994).

Cognitive mapping is useful as it allows one to abstract from and simplify complex systems by constructing a model that emphasize certain critical features while simultaneously de-emphasize other less critical features or aspects of the system (Kwahk and Kim, 1999). They explain that a cognitive map consists of three constructs: 1) a 'node', called causal concept, 2) a 'link', representing causal connection among causal concepts, and 3) 'strength', specifying causal value of a causal connection. They further claim that there are three kinds of cognitive maps depending on the representation method of the causal value: the simplest form which has either '+' or '-', a weighted map which has a value in the interval and a fuzzy map which employs a fuzzy value such as 'more' or 'some'.



Causal concept: node *i*, node *j*, node *k*
Causal connection: link (*i*, *j*), link (*j*, *k*), link (*i*, *k*)
Causal value: strength v_{ij}, strength v_{jk}, strength v_{ik}

Source: Supporting Business Process re-engineering using cognitive maps (Kwahk and Kim, 1999)

Figure 12: Constructs of a cognitive map

The causal value $v_{i,j}$ is the degree to which the i'th concept (the source concept) influences the j'th concept (destination concept) without any other interference. A positive (+) causal value means a causal increase. A negative (-) causal value means a causal decrease. A FCM could then be constructed from all the different relations (both direct and indirect) and also converted into a matrix. Deciding on a value for the causal link or in other words the magnitude or degree of influence is in most cases the more difficult step in the process of constructing a cognitive map and not necessary which nodes or concepts are connected (Kwahk and Kim, 1999).

Once the FCM is constructed, different simulations are possible for various scenarios whereby the FCM is tested against certain conditions (by activating or deactivating any combination of the start-up nodes) in order to provoke different outcomes and answers to "what if" questions (Taber, 1991). Using matrix algebra the FCM will be a matrix and the conditions tested will be a state vector with the result or outcome then computed by multiplying the state vector by the FCM matrix (Taber, 1991). Kosko and Dickerson (1994) states that a FCM can only "forward chain" to answer what-if questions and not "backward chain" to answer "why" questions.

FCM are a useful research tool to simulate plausible scenarios for the Autocatalytic converter industry as all the factors or concepts both internal and external that could influence the industry in some way or another makes for a very complex system. Mohr (1997) states that FCMs are excellent informal tools that provide a simple and

clear way to represent complex causal relationships. Not only do FCM provide a mental model of the real world but because of its fuzzy logic elements are forgiving of uncertain information and are preferable to quantitative tools especially where hard quantitative measures of influences are not possible or available. The ability to simulate and test different scenario outcomes could provide the industry with valuable insight into the sensitivity of the industry to any eminent future changes. This insight could prove valuable in shaping their strategic responses not only to the changes in government regulations but other external and internal changes as well.

3.2 Research Design

The research has followed both a quantitative and a qualitative approach. The cause and effect relationships of the external business environment have been drawn from the literature to generate a first draft FCM. The internal operations of the firms within the industry have been benchmarked against international autocatalytic converter manufacturers by means of structured and in-depth interviews. These have provided insight into the perceived global competitiveness of the industry and serve as input to the FCM for the start-up conditions of the “internal operational or manufacturing competitiveness” nodes. Thereafter the first draft FCM has been enhanced using industry experts to produce the “enhanced FCM”. The validated FCM are considered an accurate reflection of reality and were used to analyse various plausible future scenarios facing the autocatalytic converter industry.

The testing of the FCM was done through in-depth interviews with subject and industry experts. It involved showing respondents the first draft FCM in person or via email and thereafter incorporating their views to validate or expand the FCM.

The main methods of data gathering and research therefore were in depth interviews and simulation.

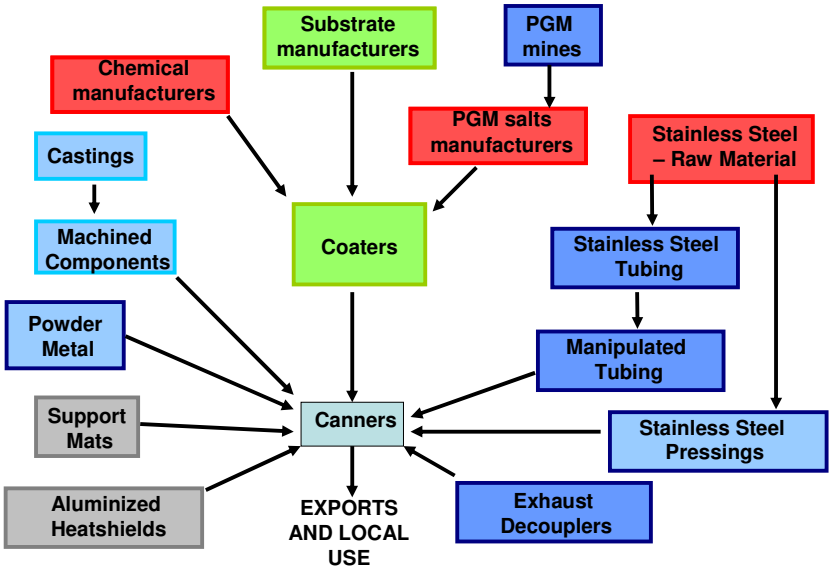
Table 3: Disadvantages and advantages of simulation as research method Mohr, (1997); Oban, (2005)

Disadvantages	Advantages
Subjectivity in the construction of the model could lead to inaccuracies in the simulation	Flexible and allows numerous scenarios on the future demand for South African catalytic converters to be tested under different conditions
Simulation by nature is not tangible.	Simplifies complexity in that FCM allows one to see the big picture and plausible outcomes to potentially complex situations/systems
The results are time bound and sensitive to the validity of the underlying assumptions and constructs. The model needs to be updated and revised if any of the assumptions/constructs relevancy or contribution changes.	Can be modified and refined allowing for more or less detail based on the various different opinions and perceptions of the different readers/investigators.

3.3 Population and sample

3.3.1 Population

The scope of this research was limited to the South African Autocatalytic converter industry and the population has therefore been limited to the members of the Catalytic Converter Interest Group (CCIG).



Source: CCIG membership

Figure 13: Catalytic converter interest group (CCIG) membership

From the members listed in Figure 13 the focus has been limited to the canners, coaters, substrate manufacturers and PGM salts manufacturers as these are considered to be the major role players within the autocatalytic converter value chain. They have limited business interest outside of this specific industry and therefore the members that will mostly be impacted by any changes relevant to this industry.

Coaters / Digesters (PGM Salts Manufacturers):

Johnson Matthey, Umicore Autocat, Umicore Catalyst, BASF, Cataler, Hereaus

Canners:

Faurecia, Tenneco, Eberspacher, Emcon, Toyota, Bosal, Benteler, Magnetti Marelli, Cummins, Cataler, VWSA, Delphi

Substrate Manufacturers:

Corning, NGK

3.3.2 Sample and sampling method

The nature of this research requires a good understanding of global manufacturing best practises, accurate knowledge of own operational practises within the respondents own company and a deep understanding of the automotive component and autocatalytic converter industries as a whole. The respondents were therefore purposefully selected on their experience, authority and business exposure to ensure their ability to provide informed opinions. This type of sampling is referred to by Creswell (2003) as a purposive sampling methodology as oppose to a random sampling methodology. The sample of respondents for the comparative benchmarking of the internal operations was limited to senior line managers (within the population of firms as specified under 3.3.1). The aim was to conduct structured interviews with at least 50% of the 20 firms in the population group.

Table 4: Respondents role map

Respondent position/ Role map	Leadership & Learning	Quality	Customer satisfaction	Operational flexibility	Innovation / Technology	Facility Control	Vendor /Supplier	Cost Leader	Validation of FCM
Quality Manager	x	x	x				x	x	
Sales/Account managers	x		x				x		
Production /Engineering managers	x	x		x	x	x		x	
Manufacturing Managers	x	x		x	x	x		x	
Process Engineering Managers				x		x			
Human Resource Managers	x				x				
Operational Directors	x				x		x	x	x
Managing Directors	x								x
Industry experts									x

Table 5: List of respondents

Name	Company & position in value chain
Senior Management	Johnson Matthey , Coater and PGM Salt manufacturer
Board members	Catalytic Converter Interest Group (CCIG)
Senior Management	BASF, Coater and PGM Salt manufacturer
Senior Management	UMICORE, Coater and PGM Salt manufacturer
Senior Management	Faurecia, Canner
Senior Management	Tenneco, Canner
Senior Management	Emcon, Canner
Senior Management	Eberspacher, Canner
Senior Management	NGK, Substrate supplier

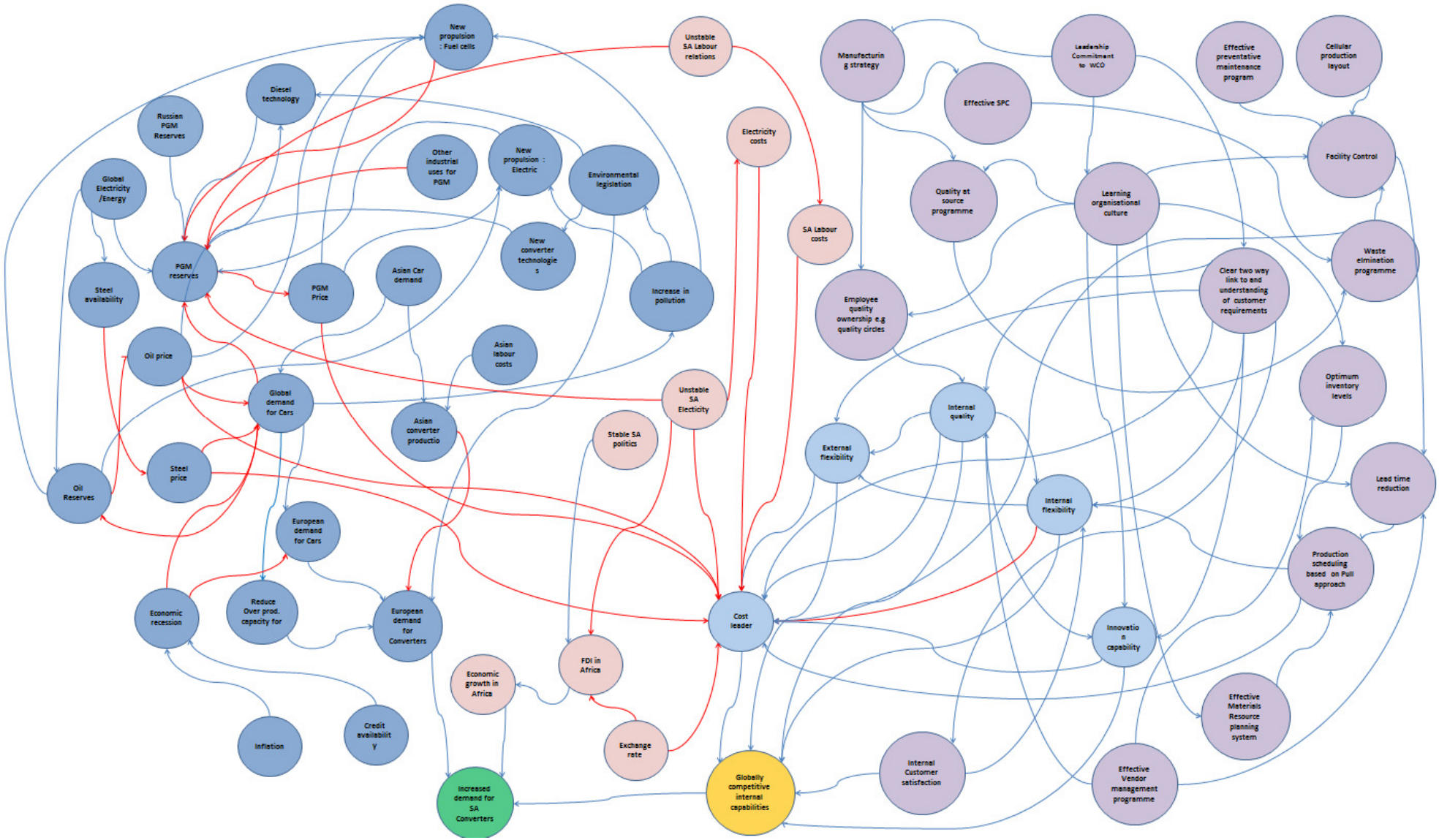
3.4 The research instruments

3.4.1 The Structured Interview Questionnaire

The data regarding the level to which the internal operations of the South African Autocatalytic converter industry have adopted “world class operations” have been gathered through qualitative and structured in-depth interviews. The interview questionnaire was constructed with the aim that the interviews could be concluded within 40-60min. The interview has addressed operations around the key performance areas and best practises as highlighted by the “World Class Operations” assessment model constructed in chapter two of this report. The interview further included questions around the perceptions of the respondents on the importance of each of the best practises to their own specific operations as well as how they believe they compare to international standards.

The following draft FCM has been constructed from literature. It has formed the basis upon which industry experts were interviewed to verify the links and nodes and add to the FCM. Upon analysing the interview results the draft FCM were adapted to produce the enhanced FCM.

Figure 14: Draft fuzzy cognitive map (FCM) – next page


New propulsion : Fuel cells
Unstable SA Labour relations
Manufacturing strategy
Leadership Commitment to WCO
Effective preventative maintenance program
Cellular production layout
Diesel technology
Effective SPC
Russian PGM Reserves
Electricity costs
Facility Control
Other industrial uses for PGM
New propulsion : Electric
Environmental legislation
Quality at source programme
Learning organisational culture
Global Electricity /Energy
SA Labour costs
New converter technologies
Waste elimination programme
PGM reserves
PGM Price
Asian Car demand
Increase in pollution
Clear two way link to and understanding of customer requirements
Steel availability
Employee quality ownership e.g quality circles
Asian labour costs
Optimum inventory levels
Oil price
Global demand for Cars
Unstable SA Electicity
Internal quality
Asian converter productio
Stable SA politics
External flexibility
Steel price
Lead time reduction
Oil Reserves
Internal flexibility
European demand for Cars
Production scheduling based on Pull approach
Economic recession
Reduce Over prod. capacity for
European demand for Converters
Cost leader
Innovation capability
FDI in Africa
Economic growth in Africa
Effective Materials Resource planning system
Inflation
Credit availability
Exchange rate
Internal Customer satisfaction
Effective Vendor management programme
Increased demand for SA Converters
Globally competitive internal capabilities

1

From	To	Positive	Negative
Global Electricity/Energy costs	Steel availability	X	
Steel availability	Steel Price		X
Steel price	Global Demand for cars		X
Global Electricity/Energy costs	Oil Reserves	X	
Global Electricity/Energy costs	PGM reserves	X	
PGM Reserves	PGM Price		X
PGM Price	New propulsion: Electric	X	
PGM Price	New propulsion: Fuel Cells	X	
Oil Reserves	Global Demand for cars		X
Oil Reserves	Oil Price		X
Oil Price	New Propulsion: Fuel Cells	X	
Oil Price	Diesel technology	X	
Oil Price	Global Demand for cars		X
Oil Reserves	New propulsion: Fuel cells	X	
Oil Reserves	New propulsion: Electric	X	

From	To	Positive	Negative
Global Demand for cars	Reduce Over prod. Capacity for converters	X	
Reduce Over prod. Capacity for converters	European demand for Converters	X	
European demand for Converters	Increased demand for SA Converters	X	
Global demand for cars	European demand for cars	X	
European demand for cars	European demand for Converters	X	
Inflation	Economic recession	X	
Economic Recession	Global Demand for Cars		X
Credit availability	Economic recession	X	
Economic Recession	European demand for cars		X
Global demand for Cars	PGM Reserves		X
FDI in Africa	Economic growth in Africa	X	
Economic growth in Africa	Increased demand for SA Converters	X	
Russian PGM Reserves	PGM Reserves	X	

From	To	Positive	Negative
Global demand for cars	Increase in pollution	X	
Increase in pollution	New propulsion: Fuel Cells	X	
New propulsion: Fuel Cells	PGM Reserves		X
Increase in pollution	Environmental legislation	X	
Environmental legislation	Diesel Technology	X	
Diesel Technology	PGM Reserves	X	
Increase in pollution	New propulsion: Electric	X	
New propulsion: Electric	PGM Reserves	X	
Environmental Legislation	European demand for converters	X	
Environmental Legislation	New converter technology	X	
New converter technology	PGM Reserves	X	
Other industrial uses for PGM	PGM Reserves		X
Asian Car Demand	Global Demand for Cars	X	
Asian Car Demand	Asian converter production	X	
Asian converter production	European demand for converters		X

From	To	Positive	Negative
Asian Labour cost	Asian converter production	X	
Exchange Rate	Increased demand for SA converters		X
INTERNAL OPERATIONAL CAPABILITIES			
Exchange Rate	Cost leader		X
Steel Price	Cost leader		X
Oil Price	Cost leader		X
PGM Price	Cost Leader		X
Unstable SA Electric Supply	Cost Leader		X
SA Electricity Costs	Cost Leader		X
SA Labour Cost	Cost Leader		X
External Flexibility	Cost Leader	X	
Clear Two way communication and understanding of customer requirements	Cost Leader	X	
Internal quality	Cost Leader	X	
Waste elimination program	Cost Leader	X	

From	To	Positive	Negative
Internal flexibility	Cost Leader		X
Innovation capability	Cost Leader	X	
Production scheduling based on pull approach	Cost Leader	X	
Cost Leader	Globally competitive	X	
External Flexibility	Global Competitive	X	
Internal quality	Global Competitive	X	
Internal flexibility	Global Competitive	X	
Innovation Capability	Global Competitive	X	
Internal Customer Satisfaction	Global Competitive	X	
Global Competitive	Increased demand for SA Converter	X	
Exchange rate	FDI in Africa		X
Unstable SA electricity supply	FDI in Africa		X
Stable SA Politics	FDI in Africa	X	
Unstable SA Electricity supply	PGM Reserves		X

From	To	Positive	Negative
Unstable SA Electricity supply	Electricity cost	X	
Unstable SA labour relations	PGM reserves		X
Unstable SA labour relations	SA Labour Costs		X
Internal quality	External flexibility	X	
Internal quality	Internal flexibility	X	
Internal quality	Innovation capability	X	
Internal flexibility	External flexibility	X	
Internal customer satisfaction	Internal flexibility	X	
Reaction scheduling based on pull approach	Internal flexibility	X	
Learning organisational culture	Quality and source program	X	
Learning organisational culture	Employee quality ownership example quality circles	X	
Learning organisational culture	Optimum inventory levels	X	
Learning organisational culture	Lead time reduction	X	
Learning organisational culture	Effective material resource planning system	X	

From	To	Positive	Negative
Learning organisational culture	Innovation capability	X	
Learning organisational culture	Facility control	X	
Quality at source program	Waste elimination program	X	
Manufacturing strategy	Effective SPC	X	
Manufacturing strategy	Quality at source program	X	
Manufacturing strategy	Employee quality ownership	X	
Leadership commitment to WCO	Manufacturing strategy	X	
Leadership commitment to WCO	Learning organisational culture	X	
Leadership commitment to WCO	Clear Two way communication and understanding of customer requirements	X	
Effective SPC	Waste elimination program	X	
Effective preventative maintenance program	Facility control	X	
Cellular production layout	Facility control	X	
Waste elimination program	Facility control	X	
Facility control	Lead time reduction	X	

From	To	Positive	Negative
Effective vendor management program	Internal quality	X	
Effective vendor management program	Lead time reduction	X	
Effective vendor management program	Optimum inventory levels	X	
Lead time reduction	Production scheduling based on pull approach	X	
Effective materials resource planning system	Production scheduling based on pull approach	X	
Optimum inventory levels	Production scheduling based on pull approach	X	
Clear Two way communication and understanding of customer requirements	Innovation capability	X	
Clear Two way communication and understanding of customer requirements	Internal Flexibility	X	
Clear Two way communication and understanding of customer requirements	Internal customer satisfaction	X	
Clear Two way communication and understanding of customer	External flexibility	X	

From	To	Positive	Negative
requirements			
Clear Two way communication and understanding of customer requirements	**Internal quality**	**X**	
Employee quality ownership	**Internal quality**	**X**	

3.5 Procedure for data collection

The internal operations of the companies have been benchmarked on their perceived global manufacturing competitiveness and the data for this exercise have been collected via the structured in-depth qualitative interviews with senior management. The insights gained from this benchmark exercise have served as the start-up input to the various internal operations nodes on the FCM.

The construction of the preliminary or draft FCM was solely from literature on the South African autocatalytic converter industry as well as literature on globally accepted “world class” manufacturing best practises. The FCM therefore incorporates the most pertinent influences from both the internal and external business environments.

Once the draft FCM was constructed it was validated by industry experts through further in-depth interviews. The FCM was emailed and either discussed telephonically or in person with the respondents. The email also contained a cover letter describing what fuzzy cognitive mapping is, the aim of the study and instructions on how to proceed.

Each respondent was asked to comment on the following: 1) relevancy of the nodes of the draft FCM, 2) whether the FCM is adequately comprehensive to be a fair portrayal of the relevant forces at play within the industry, 3) outlining whether they

agreed or disagreed with the direction of the causal link and 4) subjectively weigh the strength of the causal link on a sliding scale from -1 to +1.

3.6 Data analysis and interpretation

The first step was to conduct structured interviews to ascertain the level to which the firms adhere to certain WCO best practises and validate the causal links represented by the draft FCM. The next step was to revise and incorporate the recommendations from the interviews to construct the final FCM.

The final FCM was used to simulate and predict specific scenarios around the changes in the government trade incentive MIDP and how this will impact on the industry after 2012. From the various scenario outcomes certain inferences could be made regarding the sensitivity of the industry towards these changes.

3.7 Limitations of the study

The research methodology used was simulation and the weakness of this as a research method is the subjectivity of model/tool/map that is used. The FCM that was constructed is subject to the thoughts and interpretation of the researcher. Although every effort has been made to make the FCM as comprehensive as possible and validate causal relationships and influences through available literature and real life observations, readers may have different thoughts and perceptions especially to the relative contribution strengths of the various causal relationships. The outcomes from the various scenarios should therefore not be interpreted as absolute, but should rather be seen as plausible outcomes given certain specific conditions. Simulation as research method therefore is flexible in that the reader can adopt the model to suit his/her own perceptions.

Qualitative interviews by nature will provide subjective information. The interviews have therefore be restricted to senior management level to try and ensure that the perceptions of the respondents are as informed and unbiased as possible, but some degree of subjectivity will be remain.

3.8 Validity and reliability

3.8.1 External validity

External validity is the ability of the research to be generalised across persons, settings and times.

This research although specifically focused on the Autocatalytic converter industry, could to a large extent be generalized to most manufacturing industries with regards to the internal “world class” operational capabilities. Other industries may however not be affected by the same or to the same extent by influences from the external environments. The extent to which these external influences impact on the industry could also vary over a prolonged time.

3.8.2 Internal validity

Face validity may be weak as many of the concepts or elements from WCO may be interpreted or understood differently by different respondents and their responses will be largely subjective. This research will aim to improve face validity through the data gathering method of using in-depth interviews rather than sending surveys to give the researcher an opportunity to gauge the interpretation of the respondents on the various topics.

Predictive validity is also considered low as simulation accuracy is compromised by the subjectivity of the research tool used. Predictive validity is improved by evaluating and revising the FCM by a panel of industry leaders to review any scenario that were simulated.

Concurrent and construct validity is improved by basing all the causal relationships of the FCM and performance measures on recommendations from available subject literature.

3.8.3 Reliability

In terms of stability and equivalence, this research is considered fairly stable and not strong on equivalence. It is believed that the opinions of the various individual industry leaders and predominant literature are unlikely to change drastically but their opinions on the relative contributing strength in a causal relationship may change over time and in different circumstances. In this research to improve the stability, the contribution strength of the different causal relationships will be based on an average rating from the various interview respondents. This is believed to be more robust. Due to the subjectivity of the respondents, equivalence is believed to be low as the interpretation and opinion will differ if another sample of respondents were chosen. To improve equivalence the sample respondents will be carefully selected to include the relevant senior managers and industry leaders that will be best informed about the current levels of operations and status of the industry.

CHAPTER 4: PRESENTATION OF RESULTS

4.1 Introduction

The summarised results (Table 6) from the in-depth interviews on how well the South African Autocatalytic Converter industry has implemented the various elements of the WCO model (as presented in Chapter 2 of this report). The detailed breakdown of the interviewees' responses is presented as bar charts within appendix E.

From the respondents interviewed, the draft FCM was supported in that it conveyed the underlying mechanisms which drive the demand for South African autocatalytic converters as well as the key WCO elements that an organisation must consider to remain competitive in the global business environment. During the interview process certain recommendations were made with the aim to enhance the draft FCM, analysing the various nodes both from a relevancy perspective but also the weighted contribution of the links between the various nodes. There were two main criticisms on the draft FCM from the respondents. The first criticism is that it did not explicitly highlight the impact that the location disconnect between Southern Africa and the main markets in Europe have on the demand for South African converters. The second criticism is that it did not adequately incorporate the potential benefits from the APDP government program as well as the potential benefits from the South African Government's new Mineral Beneficiation program that may be extended to the Autocatalytic Converter industry.

These two criticisms were incorporated into the FCM to enhance it to a state where it is a true and comprehensive presentation of the drivers for the demand for South African Autocatalytic converters. The enhanced FCM is presented under paragraph 4.4 of this chapter. The enhanced FCM was subsequently used to simulate various different scenarios to predict a possible future outcome for the industry after the replacement of the MIDP program at the end of 2012. These simulations will be discussed in chapter 5 of this report.

4.2 Demographic profile of respondents

The nature of this research requires a good understanding of global manufacturing best practises, accurate knowledge of own operational practises within the respondents own company and a deep understanding of the automotive component and autocatalytic converter industries as a whole. The respondents were therefore purposefully selected on their experience, authority and business exposure to ensure their ability to provide informed opinions

The sample of respondents for the comparative benchmarking of the internal operations was limited to senior line managers (within the population of firms as specified under 3.3.1). The aim was to conduct structured interviews with at least 50% of the 20 companies in the population group.

Sixteen interviews in total were conducted and included respondents from:

- Two PGM salt manufacturers
- Two substrate suppliers
- Three coaters
- Three canners
- Six additional interviews with various industry leaders and senior management from above mentioned companies and industry groups such as CCIG, NAAMSA and CATSA.

4.3 Results pertaining to Proposition 1:

The South African Autocatalytic converter industry has developed adequately in terms of "World Class Operations (WCO)" in order for the industry to be considered globally competitive.

The various respondents were interviewed to establish their perception on the level of implementation on each of the WCO elements within their own organisation and how they believe they compare to their international counter parts. The most popular categories chosen by the respondents for each of the interview questions are presented below in table 6 and 7. A more detailed breakdown of the responses from the various respondents is presented as bar charts in appendix E.

Table 6: Interview results - Implementation of the WCO elements in the South African Autocatalytic Converter Industry

WCO ELEMENT	INTERVIEW QUESTIONS	Most popular Response category selected by Respondents	# of responses in this category
Quality at source programme	Degree to which a quality at source programme has been implemented and contributing to a measured cost saving.	No sustainable and structured quality at source program	5
	Rate the importance of an effective quality at source programme in your organisation	Critical	9
	Rate your perception on how your organisation compare against your international competitors on Quality at source	Far below their level	5
Cellular facility layout	Degree to which your production systems follow a cellular arrangement	Initial attempts to improve organisation of production systems	4
	Rate the importance of a cellular approach to production in your organisation	Not important	8
	Rate your perception on how your organisation compare against your international competitors on Cellular production systems	Same level	9
Production following a Pull approach	Degree to which your production scheduling follow a pull approach	Formal attempts to implement material flow through organisation of production systems	4
	Rate the importance of a Pull approach to production scheduling in your organisation	Critical	6

WCO ELEMENT	INTERVIEW QUESTIONS	Most popular Response category selected by Respondents	# of responses in this category
	Rate your perception on how your organisation compare against your international competitors on following a Pull approach to production scheduling	Same level	5
Statistical process control	Degree to which a Statistical Process Control (SPC) has been implemented and contributing to a measured cost saving.	Attempted to implement an SPC system. System not fully robust yet	6
	Rate the importance of an effective SPC in your organisation	Important	7
	Rate your perception on how your organisation compare against your international competitors on SPC	Outperforms competitors	5
Quality control	Degree to which employees are involved in quality control and improvement initiatives such as quality circles and contributing to a measured cost saving.	Structured employee involvement in quality programmes is fully implemented Cost savings quantifiable Ownership still with management	5
	Rate the importance of an effective employee involvement in quality programme in your organisation	Important	6
	Rate your perception on how your organisation compare against your international competitors on employee involvement in quality control	Same level	6
customer management	Degree of focus on optimising the frequency of deliveries to customers and measuring the associated cost saving.	Delivery frequency measured but no structured optimisation initiative in place	5
	Rate the importance of an effective delivery frequency management approach	Not important	9
	Rate your perception on how your organisation compare against your international competitors optimum delivery frequency: Customers	Same level	9
Customer management	Degree of focus on optimising the reliability of deliveries to customers and measuring the associated cost saving.	Definite structured initiative to optimise delivery reliability	6
	Rate the importance of reliability in customer deliveries within in the industry	Critical	9
	Rate your perception on how your organisation compare against your international competitors on reliability of customer deliveries: Customers	Same level	6
Supplier management	Degree of focus on optimising the frequency of deliveries from suppliers and measuring the associated cost saving.	Delivery frequency measured but no structured optimisation initiative in place	4

WCO ELEMENT	INTERVIEW QUESTIONS	Most popular Response category selected by Respondents	# of responses in this category
	Rate the importance of an effective delivery frequency management approach	Important	7
	Rate your perception on how your organisation compare against your international competitors regarding optimum delivery frequency: Suppliers	Same level	8
Supplier management	Degree of focus on optimising the reliability of deliveries from suppliers and measuring the associated cost saving.	No official or structured effort to measure supplier delivery frequency	5
	Rate the importance of an effective delivery reliability management approach	Not important	5
	Rate your perception on how your organisation compare against your international competitors regarding optimum delivery reliability: Suppliers	Same level	5
New product introduction	Degree of focus on optimising the speed of new product/technology introduction and measuring the associated cost saving.	Definite structured initiative to optimise lead time for new product introduction	5
	Rate the importance of the speed of new product introduction.	Important	8
	Rate your perception on how your organisation compare against your international competitors regarding the speed with which new products are introduced.	Same level	10
Material flow management	Degree to which internal processes are capable to handle materials on a Just In Time basis to minimise stockholding.	No structured approach to internal materials handling	4
	Rate the importance of a just in time materials flow internal process	Important	6
	Rate your perception on how your organisation compare against your international competitors on just in time	Slightly below their level	6
Changeover improvement	Degree to which there is conscious attempt to improve the changeover from one product to another and measuring the associated cost saving.	Self-sustaining programme to continuously monitor and improve changeover times	6
	Rate the importance of a definite focus on continuously improving change over times in your organisation	Critical	8
	Rate your perception on how your organisation compare against your international competitors on changeover times	Slightly below their level	5
Multi-skilled work force	Degree to which workforce on shop floor are multi skilled.	Can perform different tasks on own production line only	5

WCO ELEMENT	INTERVIEW QUESTIONS	Most popular Response category selected by Respondents	# of responses in this category
	Rate the importance of a work force that is multi skilled across various different functions.	Not important	6
	Rate your perception on how your organisation compare against your international competitors on a work force that is multi skilled.	Same level	9
Operational flexibility	Degree to which workforce or equipment could be increased or reduced according to volatile demand cycles	Make use of some temporary labour, Labour responsive, equipment unresponsive	4
	Rate the importance of flexible operations in terms of capacity throughput.	Not important	8
	Rate your perception on how your organisation compare against your international competitors in terms of flexible capacity throughput	Far below their level	7
Employee involvement in Process improvement	Degree to which entire organisation is involved in continuous improvement and measuring the associated cost saving.	Formal improvement programme implemented good participation from employees	5
	Rate the importance of a formalised improvement culture in your organisation	Critical	9
	Rate your perception on how your organisation compare against your international competitors on self-sustaining improvement culture	Slightly below their level	6
Employee involvement in Process/product quality	Degree to which employees are involved in quality control and improvement initiatives such as quality circles and contributing to a measured cost saving.	Structured employee involvement in CI programmes is fully implemented Cost savings quantifiable Ownership still with management	5
	Rate the importance of an effective employee involvement in improvement in your organisation	Critical	13
	Rate your perception on how your organisation compare against your international competitors on employee involvement in improvement	Slightly below their level	6
Statistical process control	Degree to which a Statistical Process Control (SPC) has been implemented and contributing to a measured cost saving.	SPC fully implemented and system is robust.	6
	Rate the importance of an effective SPC in your organisation	Critical	8
	Rate your perception on how your organisation compare against your international competitors on SPC	Same level	9

WCO ELEMENT	INTERVIEW QUESTIONS	Most popular Response category selected by Respondents	# of responses in this category
Continuous improvement	Degree to which employees are involved in improvement initiatives such as Kaizen teams and contributing to a measured cost saving.	Launched formal and structured employee involvement in improvement programmes	6
	Rate the importance of an effective employee involvement in continuous improvement programs in your organisation	Critical	9
	Rate your perception on how your organisation compare against your international competitors on employee involvement in Continuous improvement	Same level	9
Clear defined business alignment - Leadership	Degree to which the leadership have established and aligned clear and defined goals and objectives, which have been cascaded through all levels of the organisation and progress, are closely monitored by the leadership.	Business goals and objectives have been defined, aligned and cascaded throughout business but is still mostly driven by top management. Not yet flexible and adapting to changes in market conditions	6
	Rate the importance of clear, defined and aligned business goals and objectives in your organisation	Critical	8
	Rate your perception on how your organisation compare against your international competitors on clear, defined and cascaded business goals and objectives	Same level	5
Supplier /customer collaborative relationships	Degree to which collaborative partnerships exist with vendors/customers that involve a quality programme but are also geared towards improving the dependability and reducing cost across the entire supply chain.	Relationships with customer/vendors exists but are limited to full filling order obligations and transactions as well as handling complaints and deviations to quality but not as a collaborative effort	5
	Rate the importance of collaborative partnerships with your vendors/customers to your organisation	Not important	9
	Rate your perception on how your organisation compare against your international competitors on collaborative vendors/customer relationships	Slightly below their level	7
Facility Control	Degree to which the facility layout has been optimised to minimise material flow and movement as well as maximising the operational life span and productivity of equipment/assets	Some thoughts have been given to minimise movement of materials from one process step to the next. Manufacturing equipment maintained breakdowns less frequent and maintenance function becoming more preventative.	6
	Rate the importance of effective Facility Control in your organisation	Important	8

WCO ELEMENT	INTERVIEW QUESTIONS	Most popular Response category selected by Respondents	# of responses in this category
	Rate your perception on how your organisation compare against your international competitors on Facility control	**Same level**	**7**

In table 7 below is provided a summarised breakdown of the perceived importance the various WCO elements and how the respondents perceive themselves to compare with their international competitors.

Table 7: WCO Element importance and comparison table

WCO ELEMENT	Perceived importance	# of respondents	Perceived Comparison	# of respondents
Employee involvement in Process/product quality	Critical	15	Slightly below the level of international competitors	7
Quality at source programme	Critical	10	Far below International competitor's level	6
Customer management	Critical	10	Same level as international competitors	10
Employee involvement in Process improvement	Critical	10	Slightly below the level of international competitors	7
Continuous improvement	Critical	10	Same level as international competitors	10
Changeover improvement	Critical	9	Slightly below the level of international competitors	6
Statistical process control	Critical	9	Outperforms competitors	6
Clear defined business allignment - Leadership	Critical	9	Same level as international competitors	6
Production following a Pull approach	Critical	7	Same level as international competitors	6

ELEMENTS RANKED AS IMPORTANT

WCO ELEMENT	Perceived importance	# of respondents	Perceived Comparison	# of respondents
New product introduction	Important	9	Same level as international competitors	11
Facility Control	Important	9	Same level as international competitors	8
Statistical process control	Important	8	Same level as international competitors	10
Supplier management	Important	8	Same level as international competitors	9
Quality control	Important	7	Same level as international competitors	7
Material flow management	Important	7	Slightly below the level of international competitors	7

ELEMENTS RANKED AS NOT IMPORTANT

WCO ELEMENT	Perceived importance	# of respondents	Perceived Comparison	# of respondents
Supplier /customer collaborative relationships	Not important	10	Far below International competitor's level	8
Cellular facility layout	Not important	9	Same level as international competitors	10
Operational flexibility	Not important	9	Far below International competitor's level	8
Multi-skilled work force	Not important	7	Same level as international competitors	10

4.4 Results pertaining to Proposition 2

There are causal relationships between events from the South African and global external business environments and the demand for South African autocatalytic converters that will impact on the sustainable future of this industry without the benefits from the MIDP incentive scheme

The three main criticisms from the respondents of the draft FCM were the following:

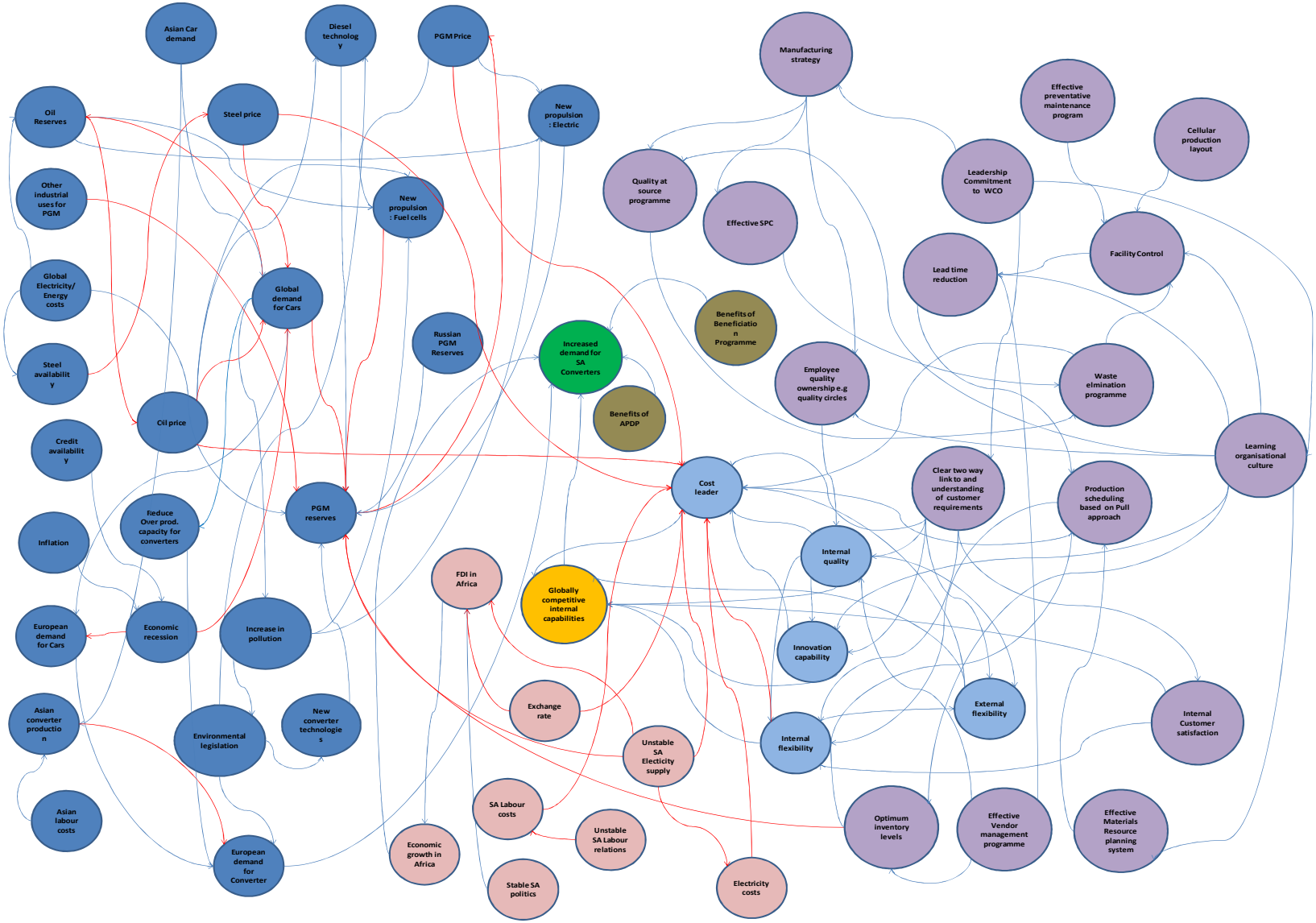
- The draft FCM doesn't explicitly depict the way the demand for South African catalytic converters are affected by the transport costs associated with location disconnect to the European markets.

- The draft FCM doesn't address the purchase contract cycles of the automotive OEMs. The typical OEM purchase contract sources components for a period of the next 5 years, therefore any improvement in the attractiveness of the South African industry could potentially only be seen 5 years later.

- The respondents also highlighted that the impact of South African Government policy and programmes were not comprehensively described in the draft FCM. The new programme APDP will still provide minimal benefits to the Automotive OEMs albeit only limited to the ones with a local assembly footprint within South Africa. These benefits are expected to last another two years after 2012. The South African Government also had introduced a new Beneficiation programme, under which it will be beneficial for companies to beneficiate or add value to locally sourced minerals before exporting to overseas markets. This programme has not yet been officially extended to include the autocatalytic converter industry but the majority of respondents were hopeful that the industry could see significant benefits as one of the prime beneficiators of South African PGMs.

During the interview process the respondents were asked not only to comment on the relevance and validity of the various nodes and causal links but also to provide a relative strength or contribution for each of the causal links. For the enhanced FCM the average strength from the various responses were calculated for each of the causal links. The strength of the various causal links could be any value between and including -1 and +1. If the respondents believed that the causal link between two nodes was strongly inverse then the causal strength would be -1. If the respondents believed that the causal link is strongly re-enforcing then the causal strength would be +1. If there is no causal link between the nodes then the strength would be 0.

Figure 15: Enhanced Fuzzy Cognitive Map (FCM) - next page


Asian Car demand
Diesel technology
PGM Price
Manufacturing strategy
Effective preventative maintenance program
Cellular production layout
Oil Reserves
Steel price
New propulsion : Electric
Quality at source programme
Leadership Commitment to WCO
Other industrial uses for PGM
New propulsion : Fuel cells
Effective SPC
Facility Control
Global Electricity/ Energy costs
Global demand for Cars
Lead time reduction
Russian PGM Reserves
Increased demand for SA Converters
Benefits of Beneficiation Programme
Steel availability
Employee quality ownership e.g quality circles
Waste elmination programme
Oil price
Benefits of APDP
Credit availability
Learning organisational culture
Cost leader
Clear two way link to and understanding of customer requirements
Production scheduling based on Pull approach
Reduce Over prod. capacity for converters
PGM reserves
Inflation
Internal quality
FDI in Africa
Globally competitive internal capabilities
European demand for Cars
Economic recession
Increase in pollution
Innovation capability
Exchange rate
External flexibility
Internal Customer satisfaction
Asian converter production
New converter technologies
Environmental legislation
Unstable SA Electicity supply
Internal flexibility
Asian labour costs
SA Labour costs
Optimum inventory levels
Effective Vendor management programme
Effective Materials Resource planning system
Unstable SA Labour relations
European demand for Converter
Economic growth in Africa
Stable SA politics
Electricity costs

4.5 Summary of the interview results

Some of the common themes that became apparent from the interviews are that the majority of the respondents seem to believe that the South African autocatalytic converter industry are comparing favourably on the majority of the WCO elements to the performance of their international counterparts. The majority of the respondents believed that the South African industry were either on the same level or slightly behind on most of the WCO elements except on the effective use of statistical process control (SPC). Close to a third of the respondents believed they were ahead of their international competitors on the effective use of SPC. They do however seem to agree that the future of the industry is greatly dependent on the industry‘s ability to compete on price; with narrow profit margins already a trade mark of the automotive and components industries; the opportunities to further reduce operational manufacturing costs are limited.

The respondents did also place great emphasis on the impact of macro-economic factors such as economic recessions, exchange rates, currency volatility as well as the availability and costs associated with scarce resources and commodities such as PGMs. It would therefore seem that the fate of the industry is not entirely under its own control and very sensitive to the macro business environment. The detailed breakdown of the respondent’s responses and the weighting they have assigned to each of the causal links of the FCM is provided in appendix B.

The three main criticisms from the respondents with regards to the draft FCM were the following:

- The draft FCM doesn’t explicitly depict the way the demand for South African catalytic converters are affected by the transport costs associated with location disconnect to the European markets.

- The draft FCM doesn’t address the purchase contract cycles of the automotive OEMs. The typical OEM purchase contract sources components for a period of the next 5 years, therefore any improvement in the attractiveness of the South African industry could potentially only be seen 5 years later.

- The respondents also highlighted that the impact of South African Government policy and programmes were not comprehensively described in the draft FCM. The new programme APDP will still provide minimal benefits to the Automotive OEMs albeit only limited to the ones with a local assembly footprint within South Africa. These benefits are expected to last another two years after 2012. The South African Government also had introduced a new Beneficiation programme, under which it will be beneficial for companies to beneficiate or add value to locally sourced minerals before exporting to overseas markets. This programme has not yet been officially extended to include the autocatalytic converter industry but the majority of respondents were hopeful that the industry could see significant benefits since the industry is considered one of the prime beneficiators of South African PGMs.

CHAPTER 5: DISCUSSION OF THE RESULTS

5.1 Introduction

In this chapter the common themes from the in-depth interviews as well as the results of certain scenarios from the FCM were analysed and discussed.

The analyses of the perceived competitiveness of the South African Autocatalytic converter industry have been based on the perceptions of the respondents. The respondents were asked on which WCO elements they believe are critical for the sustained success of their businesses as well as how they believe their businesses compare to their international competitors.

The enhanced FCM attempted then to model the impact of various external influences that may have an impact on the demand for autocatalytic converters manufactured in South Africa. Each interpretation was guided by how the respondents perceived the potential impact and magnitude of the external influence and is hence open for further interpretation.

The testing of the FCM aimed to validate the accuracy and was done based on current and existing conditions and perceptions of the industry in 2012. The outcome of the test was then evaluated to ascertain whether it revealed a valid reflection of the industry.

FCMs allows for many different potential scenarios to be tested and analysed. The complex nature of the interactions within the system may give rise to unintended consequences. It is by analysing these unintended consequences that a greater understanding of the various different levers that drive the performance and sensitivity of an industry could be ascertained. The real value of a FCM therefore lies in the ability of decision makers to gauge the potential impact of decisions and policies may have on the industry as a whole.

5.2 Demographic profile of respondents

The nature of this research requires a good understanding of global manufacturing best practises, accurate knowledge of own operational practises within the respondents own

company and a deep understanding of the automotive component and autocatalytic converter industries as a whole. The respondents were therefore purposefully selected on their experience, authority and business exposure to ensure their ability to provide informed opinions

The sample of respondents for the comparative benchmarking of the internal operations was limited to senior line managers (within the population of firms as specified under 3.3.1). The aim was to conduct structured interviews with at least 50% of the 20 companies in the population group.

Sixteen interviews in total were conducted and included respondents from:

- Two PGM salt manufacturers
- Two substrate suppliers
- Three coaters
- Three canners
- Six additional interviews with various industry leaders and senior management from above mentioned companies and industry groups such as CCIG, NAAMSA and CATSA.

5.3 Discussion pertaining to Proposition 1

The WCO elements mostly regarded as critical by the majority of the respondents centres around employee involvement in quality and process improvement. These trends seem to be aligned with the predominant trends from literature and programmes such as Total quality management (TQM) that were discussed in chapter 2 of this report. The automotive manufacturing world is notorious for the high emphasis placed on both product quality as well as process quality, and many quality standards are enforced by the OEMs throughout the entire supply chain (Barnes and Morris, 2008). The Verband der Automobilindustry or VDA standards as promoted by most German car manufacturers are but one of a whole multitude of standards implemented within the industry (Verband der Automobilindustrie, 2010).

With such a high emphasis already placed on automotive component suppliers, product and process quality could rather be seen as an order qualifier or hygiene factor rather than a source for potential competitive advantage to the South African autocatalytic industry. Close to halve of the respondents believed that they were trailing slightly behind their international competitors and in order for them to win new contracts this could be a potential stumbling block. One of the fundamental aspects of the WCO elements relating to product and process quality is the involvement of the entire workforce in delivering repeatable, reliable high quality products that meet or exceed customer requirements. It is not only important that the end product meet customer expectations but a secondary benefit of a strong focus on process quality, is to ensure that operational waste is also minimised. The reduction in operational cost associated with the minimisation of operational waste could however contribute to making the local industry more competitive on price.

To truly reap the cost reduction benefits it will be critical for companies to evolve from inspecting quality only at intermediate stages during the process to an organisational culture where every employee is a custodian for quality-at-source regardless whether they are an accountant sitting in the accounts office or an operator physically involved in the manufacturing process.

Terziovski and Samson(1999) and Feigenbaum (2002) both emphasised the importance as one of the major pillars of the Total Quality Management (TQM) philosophy that all levels of an organisation must assume responsibility for quality of both product and process yet only a third of the respondents believe that they have succeeded in transferring the ownership of quality from management to their employees. This research only aimed to establish the perception on how companies believe they are comparing to their overseas competitors and not whether there are room for improvement in their own facilities.

The one WCO element that almost one third of the respondents rated as critical and also perceives their performance to be better than that of their international competitors was in the area of the use of Statistical Process Control (SPC). Whether this WCO element on its own will be able to provide a significant competitive advantage is doubtful but what is reassuring is that SPC could be used as an underlying critical building block for any quality and process improvement initiative.

With regards to continuous improvement the majority of respondents rated their own performance compared to the performance of their overseas competitors as either on the same level or slightly below. This is indicative that the respondents have realised the definite need to improve their operations to remain competitive but the level of continuous improvement required to provide a real competitive advantage for the industry remains subjective. From the respondents that have some sort of formal continuous improvement programme implemented, the majority could not clearly quantify or link the implementation of their programme to any significant additional business contracts that was won over the past few years. This is not surprising as Zairi,(1998) also highlighted that many companies claim that the real monetary benefit/return on their continuous improvement investments only became apparent after approximately 3-5 years. Only one respondent believed that a major contributing factor for them winning additional business from a German OEM recently was the fact they had a very structured and systematic continuous improvement programme implemented in their organisation.

It would therefore appear that a definite focus on continuous improvement could also be classified as an order qualifier rather than an order winner with the most benefit for the organisation coming from improvements that reduce operational cost and finally cost per unit.

Production scheduling according to a “pull” approach was also ranked as critical by the respondents with close to one third of the respondents of the opinion that they are on the same level as their overseas competitors. Scheduling according to a pull approach is according to current literature regarded as an important approach to minimise unnecessary high inventory levels and the associated impact of these high inventory levels to an organisation’s working capital. For the South African autocatalytic converter industry this WCO element could be an important focus point to improve their competitiveness considering the increased operational lead time in a supply chain that is in comparison significantly longer than that of European autocatalytic converter suppliers.

The WCO elements considered important but not critical by the respondents were: New product introduction, Facility control and Supplier management. On all these WCO elements the respondents rated themselves as on the same level as the overseas counterparts.

Due to the nature of the automotive industry where OEMs are launching new motor vehicle models every few years combined with stricter global environmental legislation; had made the ability to respond quickly to changing customer requirements and products an essential part of this industry. The introduction of new products or components are tightly controlled by the OEM across the entire supply chain through a process call Advanced Product Quality Planning (APQP). It was the view of the respondents that the South African autocatalytic converter industry has historically performed well with the introduction of new products but also believed that they were on par with their overseas competitors. Some of the respondents were of the opinion that as a result of ever increasing consumer demands for a greater variety of vehicles to be available; the ability to introduce new products efficiently and faster will become more and more important in the future. This could therefore according to them provide a potential competitive advantage in years to come.

Facility control relates to how effectively an organisation utilizes its equipment and facility to manufacture its products. Over half of the respondents rated facility control as important and this could be due to the intensive capital required to actively participate within the automotive supply chains. Although the respondents rated themselves to be on the same level as overseas competitors, very few could demonstrate how they have applied techniques or methods to improve the facility control after the initial erection of the factories and buildings. They admitted that once erected their facilities are not easily changed and therefore careful thought has to be given at the design stage with regards to layout, equipment, process flow and process technology. These they believed were not always considered when the older facilities were first erected.

The WCO elements rated as not important were quite interesting in that over two thirds of the respondents agreed that collaborative supplier/customer relationships were not as important as the other elements. Although some agree that collaborative relationships will play a greater role in future business environments, they admit that they are potentially far behind their overseas competitors.

The supply chains in the automotive industry are very strictly coordinated by the OEMs and customer audits on component supplier's processes are a regular occurrence. Relationships however among first tier, second tier and third tier suppliers seemed to have not fully evolved into a pro-active collaborative effort across the entire supply chain.

These relationships are currently still focused on order fulfilling and reacting to customer complaints. Collaborative supply chain management requires the relevant parties to pro-actively engage in activities that will improve process reliability and dependability as well as minimise operational cost across the entire chain and the benefit not only reaped for some of the individual members of the value chain (Singh et al., 2005; Mashilo, 2010).

This will require a great amount of openness, trust and sharing which many of the respondents still are reluctant to consider. The predominant mind-set still prevailing within the industry is a mind-set where each company is focused solely on its own operations, where little interference from suppliers/customers are sought or tolerated unless the interference are imposed on them from the OEM.

It could be concluded from analysing the expected benefits as alluded to by the relevant literature and the status of the existing relationships within the current value chains; that collaborative relationships could potentially be a source of great competitiveness for the industry as whole. Once the key players break the silo mentality and start to actively get involved in the operations across the entire value chain with the aim to reduce cost and improve quality and to improve their service holistically, then the industry as a whole could become more attractive and ensure greater beneficiation and value add to the end customer.

Another WCO element that surprisingly was not rated as either critical or important was multi-skilled staff. Close to two thirds of the respondents estimated their organisations to be on the same level as their overseas competitors but most admit that their understanding of their competitor's employee skill level may not be accurate. The trade-off between specialisation and multi-skilled staff seem to be a point of debate as many respondents believe that the technical nature of the autocatalytic process requires specialisation of skills and don't leave much room for multi-skilling of staff. The other opinion in the debate centres around the flexibility multi-skilling provides and in a country where specialised skills could be scarce this argument could have merit as well. The respondents that do believe in its importance are making conscious efforts to make use of this as a competitive advantage.

Operational flexibility was another WCO element that was regarded as not as important among the respondents. Operations could be flexible from a resource, capacity, product

range, and process or technology perspective. It was the view of the majority of the respondents that they don't always have significant control over factors influencing operational flexibility and therefore are not aggressively focusing on it.

Resource flexibility with regards to employees is arguably the one area where an organisation could have more control over in terms of the proportion of temporary to permanent staff it chooses to employ. Pressure from labour unions such as Cosatu to minimise and control labour brokers are making it increasingly difficult for organisations to make use of temporary staff. Many companies previously made more actively use of temporary workers to cope with volatile demand cycles. Some of respondents believe that a permanent work force enables better working relations ships, promote skills of work force, employee loyalty and ownership and productivity, aiming to use this as a competitive advantage.

Equipment is usually capital intensive and very few of the respondents really have significant flexibility when it comes to extra capacity on their production lines. Many of the respondents seem to have accepted this as something not as much under their direct control and are therefore not really actively trying to manage and optimise labour and equipment flexibility.

It is the view of the author that operational flexibility could be one of the areas in which the South African autocatalytic converter industry finds ways to improve its competitiveness and attractiveness to foreign markets.

5.4 Discussion pertaining to Proposition 2

To gain a greater understanding of the external factors that influences the competitiveness of the South African Autocatalytic converter industry, the following eight scenarios were modelled on the enhanced FCM:

- Scenario 1: The industry considered competitive and the industry benefits only from the new APDP programme.

- Scenario 2: The industry considered to be competitive and the industry benefits from both the APDP and Beneficiation programmes

- Scenario 3: The industry considered competitive, benefits from both APDP and Beneficiation but in a global recessionary environment
- Scenario 4: The industry considered competitive, but industry only benefits from Beneficiation programmes, no global recession.
- Scenario 5: Industry considered competitive but no real leadership commitment to WCO
- Scenario 6: Industry considered competitive but industry influenced by instability with regards to South African labour relations, politics, and electrical supply.
- Scenario 7: Industry to be considered competitive, no global recession but influenced by global economic factors such as rising energy costs, international PGM reserves
- Scenario 8: Industry considered **not** competitive, but leadership to have real commitment to WCO elements.

Plausible combinations of policies and influences have been combined in each of these scenarios, this stems from the understanding that policies do not operate in isolation but are rather intertwined with other policies.

Scenario 1: The industry considered competitive and the industry benefits only from the new APDP programme.

When this scenario was modelled the current market and industry conditions were considered together with the node for “Benefits of APDP” activated and the output of the FCM is depicted in appendix F. The current market and industry conditions were depicted by the activation of the following nodes:

- Global demand for cars
- Overcapacity for production of autocatalytic converters in Asia regions
- European demand for cars
- Economic growth in Africa

- Increase in pollution
- Environmental legislation
- SA manufacturing globally competitive
- Demand for Diesel Technology
- New converter technologies
- Stable SA politics

To depict the South African autocatalytic converter industry to be competitive all of the WCO nodes have been activated.

The simulation of this scenario on the advanced FCM stabilised after 5 cycles with the node for **"Demand for SA converters"** to be **inactive.**

This scenario therefor seems to illustrate that the benefits expected from APDP may not be sufficient to ensure the continued existence of the SA autocatalytic converter industry in its current format.

APDP is a scheme that aims to stimulate local production of automobiles by allowing manufacturers to claim rebates on import duties paid on components and fully assembled vehicles depending on the number of cars made in South Africa. The intention is to support the industry until 2020 (Parker, 2012).

	MIDP (1995 – 2012)	APDP (2013 – 2020)
Tariffs	The level of protection offered by **tariffs reduced consistently from 65% and 49% for CBUs and CKDs respectively in 1995, to 25% and 20% in 2012**	The level of protection offered by **tariffs will remain constant at 25% and 20% for CBUs and CKDs respectively from 2013 to 2020**
Local OEMs Vehicle Allowance	**DFA (Duty Free Allowance):** 27% of the local assembled vehicle's wholesale price is rebated against the duty payable on imported components that are used in the production of vehicles for the domestic market	**VAA (Volume Assembly Allowance):** 20-18% of local assembled vehicle's wholesale price is rebated against the duty payable on imported components that are used in the production of vehicles, irrespective of where the production is sold, as long as annual units per plant exceed 50,000
Industry incentives	**Export linked duty credits earned:** Benefits calculated on local material used	**Market neutral PI (Production Incentive) in place:** Benefits calculated on local production value Vulnerable Industries higher benefits
Investment assistance	**PAA (Productive Asset Allowance):** • Only benefits OEM and 1st tier suppliers whose investment is linked to a local OEM • 20% benefit, payable over 5 years (4% per year)	**AIS (Automotive Investment Scheme):** • Benefits OEM and auto component suppliers as long as investment is auto focused • 20-30% benefit, payable over 3 years (6.67% per year)

Figure 16: Comparison of benefits under MIDP and APDP schemes

It is expected that by 2020 the local vehicle production will be double the current production of around 600 000 vehicle per annum. The scheme will however only benefit factories that build 50 000 vehicles a year or more and there will be little benefit for smaller operators both in the OEM and automotive component sectors. The benefits for the automotive catalytic converter industry are expected to be minimal especially since most of the suppliers of converters are export orientated to gain economies of scale as they believe the local SA market to be too small to sustain their current operations. The intention of the APDP scheme is to build a sustainable automotive industry in South Africa. The benefits from the scheme however will not be enough to eliminate the underlying challenges faced by the South African automotive industry. These challenges include poor infrastructure and logistics such as railways, ports etc. as well as low productivity and wage/price inflation at double CPI rates (Parker, 2012).

The overseas automotive industries are improving their efficiencies and productivities according to the National Association of Automobile Manufacturers of South Africa (Naamsa) at 5% per annum, making the long term sustainability of the local automotive industry as a whole, not only the autocatalytic converter industry, difficult without

significant intervention and support, sustainable improvement in efficiencies and the expansion into sub-Saharan African markets (Parker, 2012).

Scenario 2: The industry considered competitive and the industry benefits from both the APDP and Beneficiation programmes

When this scenario was modelled the current market and industry conditions as per scenario 1 were considered together with the nodes for both “Benefits of APDP” and “Benefits of Beneficiation programme” activated. The output of the FCM for this scenario is depicted in appendix F.

The simulation stabilised after five cycles with the node “**Demand for SA converters” active.**

The simulation therefor seems to support the perception that benefits from the APDP scheme complemented by an additional and focussed beneficiation programme or combination of support programmes could be sufficient to sustain the autocatalytic converter industry on a long term basis.

Supplying catalytic converters from South Africa requires that the additional logistical costs associated with the location disconnect to the European markets be somehow off set. In an industry already associated with very narrow margins this will be difficult to achieve without some sort of external assistance. APDP aims to grow the local automotive industry through stimulating local production and assembly of vehicles. For the autocatalytic converter industry the benefits from APDP will be limited to the OEMs with a local assembly footprint and significant export potential of fully assembled motor vehicles. There will therefore be little benefit to the players within the autocatalytic converter industry with their major customers the OEMs that don’t have a significant local assembly footprint.

The local South African automotive market is considered to be too small to sustain the autocatalytic converter industry in its current format. The autocatalytic converter industry will therefore have to be sustained through other means until such time that the South African automotive industry under the auspices of APDP has grown successfully to sustainably support the local autocatalytic converter industry.

The autocatalytic converter industry may have to establish itself as a fully contributing member of South Africa's manufacturing sector instead of seeing itself as a subsector to the automotive industry only. The South African Department of Trade and Industry (DTI) have announced the Government's intention to increase industrial competiveness and broaden the participation of enterprises in the economy and are offering financial assistance through funding to various industry sectors such as manufacturing, export development as well as foreign direct investment. Among the incentives offered by the DTI that are relevant to the autocatalytic converter industry are the Manufacturing Investment Programme (MIP), Manufacturing Competitiveness Enhancement Programme (MCEP) and the Automotive Investment Scheme (AIS).

The MIP is a reimburse cash grant for local and foreign owned manufacturing entities to stimulate investment in the manufacturing sectors with the aim to create jobs.

The MECP provides enhanced manufacturing support to encourage manufacturers to upgrade their production facilities in a manner that sustains employment and maxim-

The AIS is designed to grow and develop the automotive sector through investment in new and/or replacement models and components that will increase plant production volumes, sustain employment and /or strengthen the automotive value chain.

The above mentioned incentive programmes could go a long way in supporting the autocatalytic converter industry, but according to the majority of the interview respondents the most benefit for the industry could come from a programme proposed by the Department of Mineral Resources (DMR) called the Minerals Beneficiation programme.

The aim of the beneficiation strategy is to provide a frame work to convert the country's comparative advantage it has inherited in the form of its mineral wealth, into a national competitive advantage. (Department: Mineral Resources Republic of South Africa, 2011). The beneficiation strategy, which is being honed by the DMR to mimic models used in Nordic countries, is central to Government's thinking on what's now being referred to as "resource nationalism" instead of a cry for the nationalisation of mines. The Minerals Beneficiation programme has not been finalised and extended to the autocatalytic converter industry but the industry is hopeful that the incentives provided under this programme will be a significant stimulus for the industry.

Scenario 3: The industry considered to be competitive and the industry benefits from both the APDP and Beneficiation programmes but in a global recessionary economic environment.

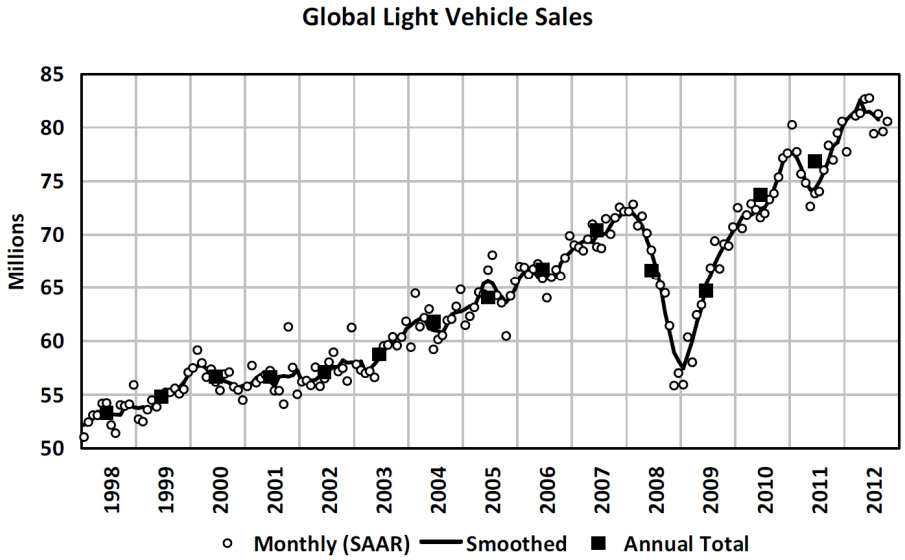
When this scenario was modelled the nodes were activated as per scenario two but in addition the node for "Global recession" was also activated. The simulation result for this scenario is presented in appendix F.

After seven cycles the FCM stabilised with the node **"Demand for SA converters" inactive.**

This scenario illustrates the sensitivity of the automotive industry to economic influences and cycles. It is not a reflection on the autocatalytic converter industry only but rather illustrates the buying habits of consumers with regards to luxury items such as automobiles in recessionary economic environments.

This simulation do however highlights the sensitivity of the South African autocatalytic converter industry to the economic health of the European markets. With an industry that is near 100% export orientated the impact of a global recession on the demand for automotive catalytic converters is more severe compared to the impact on certain automotive assemblers predominantly serving the local South African markets.

The Global Light vehicle Sales seems to be more stable during 2012 compared to the same time during 2011 and the seasonally adjusted annualised rate of sales for October 2012 as depicted in figure 17, were 80.6 million units per year. This reflects a year-on-year increase in sales of approximately 5% (LMC Automotive, 2012).



Source: LMC Automotive (November 2012). www.lmc-auto.com

Figure 17: Seasonally Adjusted Annualised Rate of Sales, Global Light Vehicle Sales, Oct 2012

As could be seen from table 8, the majority of the global light vehicle sales did come from the US and Asian markets; with sales in Western and Eastern Europe declining. The selling rate in Western Europe dipped under 13 million units per annum during October 2012 mainly as a result of lower consumer confidence; this negative trend is believed to continue into 2013 (LMC Automotive, 2012).

Global Light Vehicle Sales

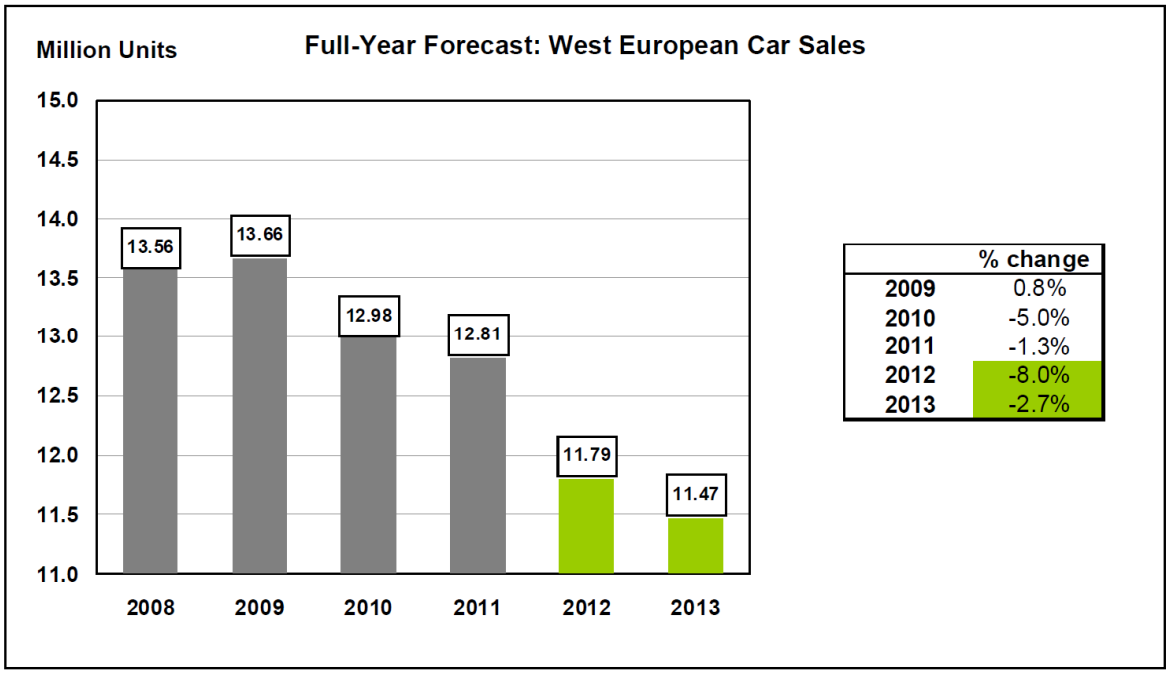
	Sales (units)						Selling rate (Units/year)			
	Oct 2012	Oct 2011	Percent change	Year to date 2012	Year to date 2011	Percent change	Oct 2012	Year to date 2012	Year 2011	Percent change
WORLD	**6,556,083**	**6,242,558**	***5.0%***	**67,593,976**	**63,636,228**	***6.2%***	**80,561,883**	**81,145,086**	**76,836,502**	***5.6%***
USA	1,090,016	1,018,694	*7.0%*	11,969,042	10,515,799	*13.8%*	14,200,814	14,259,247	12,748,374	*11.9%*
CANADA	134,976	125,816	*7.3%*	1,440,299	1,347,549	*6.9%*	1,719,387	1,690,943	1,582,660	*6.8%*
WESTERN EUROPE	1,047,281	1,108,338	*-5.5%*	11,215,245	12,172,532	*-7.9%*	12,952,636	13,443,054	14,370,428	*-6.5%*
EASTERN EUROPE	414,372	412,078	*0.6%*	4,028,006	3,808,804	*5.8%*	4,782,478	4,785,491	4,709,627	*1.6%*
JAPAN	353,939	374,199	*-5.4%*	4,539,876	3,405,443	*33.3%*	4,398,366	5,372,064	4,134,070	*29.9%*
KOREA	134,104	126,521	*6.0%*	1,224,070	1,284,443	*-4.7%*	1,570,990	1,492,781	1,541,403	*-3.2%*
CHINA	1,542,500	1,489,100	*3.6%*	15,504,557	14,704,604	*5.4%*	19,084,510	18,917,956	17,999,580	*5.1%*
BRAZIL / ARGENTINA	395,832	353,876	*11.9%*	3,571,950	3,585,126	*-0.4%*	4,688,234	4,266,212	4,376,553	*-2.5%*
OTHER	1,443,063	1,233,936	*16.9%*	14,100,931	12,811,928	*10.1%*	17,164,467	16,917,338	15,373,807	*10.0%*
Notes:	Eastern Europe includes Turkey. China data includes estimate of light vehicle imports, and excludes heavy vehicles. Late reporting countries and estimates are included in "Other". The percentage change in the final column compares the average selling rate in the year-to-date with the last full year.									

Source: LMC Automotive (November 2012). www.lmc-auto.com

Table 8: Global Light Vehicle Sales, Oct 2012

During the economic recession of 2008-2009 the South African economy seemed to have been shielded to a significant extent as a result of the relatively strong local banking and fiscal policies.

However since the majority of the South African produced autocatalytic converters are exported to Western Europe, any analysis on the future of the local industry can't exclude the future economic climate anticipated in Europe. The recent economic instability and debt crisis experienced in European countries such as Greece, Spain, Ireland, Portugal etc. and the bail-out initiatives undertaken and lead by Germany and the United Kingdom have impacted to a large extent on the demand for new motor vehicles in these countries and therefore the demand for South African autocatalytic converters (IHS, 2012).



Source: LMC Automotive (November 2012). www.lmc-auto.com

Figure 18: Full-year Forecast: West European Car Sales, Oct 2012

The 2012 Passenger Car or light vehicle sales for the Western European countries are reflected below and highlights the debt crisis and economic instability surrounding countries such as Greece, Spain, Ireland and Portugal and the impact thereof on the vehicle sales in Western Europe.

Western European Passenger Car Sales
(Thousands of units)

Country of Sale	October 2012	October 2011	Percent Change	Year-to-Date 2012	Year-to-Date 2011	Percent Change
Austria	*26.4*	28.9	-8.6	293.3	302.4	-3.0
Belux *	45.6	46.3	-1.4	469.6	525.1	-10.6
Denmark	15.2	12.4	22.7	143.7	139.6	2.9
Finland	8.2	10.1	-18.7	97.0	110.2	-11.9
France	162.4	176.1	-7.8	1592.8	1837.6	-13.3
Germany	259.5	258.3	0.5	2618.2	2660.0	-1.6
Greece	5.1	5.0	1.8	50.6	84.3	-39.9
Ireland	1.7	1.5	8.8	78.0	88.0	-11.4
Italy	116.9	134.5	-13.1	1213.3	1512.0	-19.8
Netherlands	26.9	43.6	-38.3	455.8	497.5	-8.4
Norway	12.4	11.5	7.5	116.6	114.4	1.9
Portugal	7.4	9.1	-19.2	81.9	132.7	-38.3
Spain	44.9	57.3	-21.7	600.2	681.2	-11.9
Sweden	24.0	25.1	-4.1	227.7	253.6	-10.2
Switzerland	26.6	27.0	-1.6	272.1	259.7	4.8
United Kingdom	151.3	134.9	12.1	1771.9	1688.0	5.0
Western Europe	**934.4**	**981.6**	**-4.8**	**10082.8**	**10886.3**	**-7.4**

Notes: Italics are best estimates as of November 2012.
Belux = Belgium and Luxembourg

Source: West European Sales Preview, October 2012 Advanced Automotive Sales Report, IHS 2012.

Table 9: West European Car Sales by country, Oct 2012

The supply chain for South African autocatalytic converters to European markets is approximately 12-14 weeks, resulting in a significant lag effect for any changes in demand cycles. This long production and supply lead times, combined with narrow profit margins, necessitates the requirement of strict economical monitoring and support policies to cushion the impact of global economic and demand cycles.

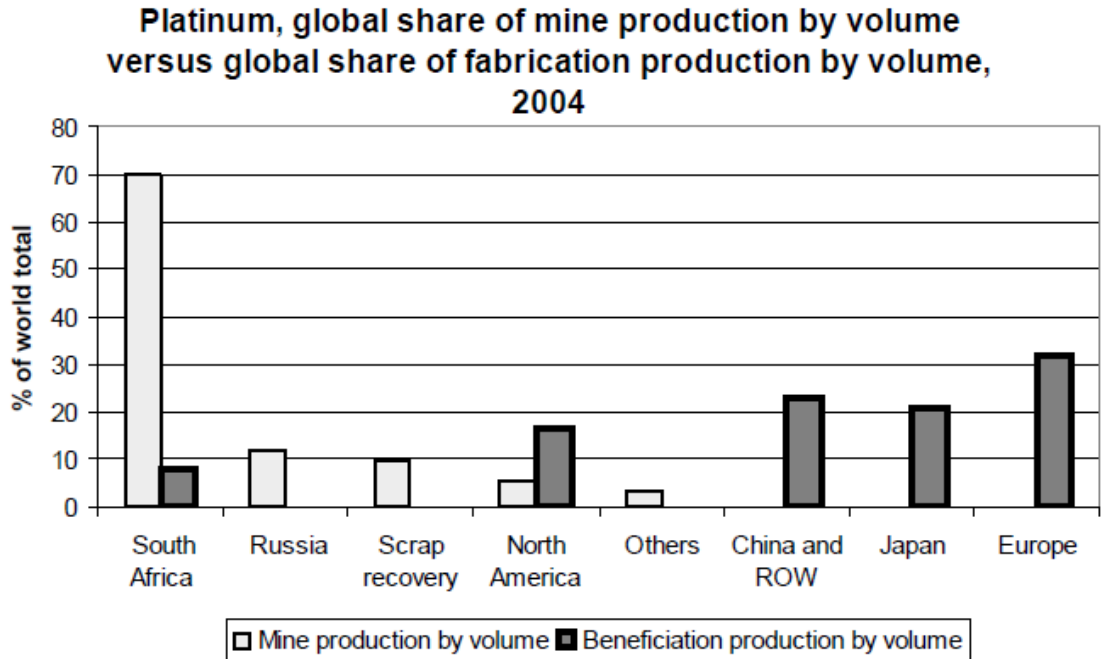
Scenario 4: The industry considered competitive, but industry only benefits from Beneficiation programmes no APDP program, no global recessionary environment

When this scenario was modelled the nodes were activated as per scenario two, the nodes for “Global recession” and “Benefits of APDP” were deactivated and the node “Benefits from Beneficiation programme” active. The simulation result for this scenario is presented in appendix F.

After five cycles the FCM stabilised with the node **"Demand for SA converters" active.**

This highlights the sentiment of the respondents that the benefits provided to OEMs under the Minerals Beneficiation programme will be substantial to ensure a strong demand for autocatalytic converters from South Africa.

South Africa is a major producer of many ores and metals; it is nevertheless a relatively small producer of processed mineral products (Robinson I.C. Von Below M.A., 1990).



Source: (Baxter, 2005)

Figure 19: Platinum, Global share of mine production by volume vs. Global share of fabrication production by volume

The primary reason for mineral beneficiation having occurred outside resource rich countries has been market access. End-user demand was spurred by many innovations over the years within developed countries; creating market demand for finished products in these industrialised countries. Traditionally beneficiation takes place where it is commercially feasible. South Africa has historically been strong in exacting minerals only and mining companies therefore find it very difficult to go into areas such as manufacturing or fabrication where they don't necessarily have the required competence and skills.

The beneficiation strategy provides a framework that seeks to translate the country's sheer comparative advantage inherited from mineral resources endowment to a national competitive advantage. The strategy is aligned to a national minerals industrialisation programme, which seeks to enhance the quantity and quality of exports, promote creation of decent employment and diversification of the economy (Department: Mineral Resources Republic of South Africa, 2011). The beneficiation strategy is prepared under the auspices of the Precious Metals Act 2005, Act No.37 of 2005 of which the objective is to provide for acquisition, possession, smelting, refining, beneficiation, use and disposal of precious metals. Precious metals include gold and the platinum group metals (PGMs). Silver has been excluded from the definition of precious metals.

The concept of beneficiation is not new in South Africa; it did however take major steps forward during the 1990s. Although during this period, the South African mining sector changed from being a predominantly primary commodity exporter to becoming a world exporter of processed minerals, the so-called first and second stage beneficiation (Baxter, 2005). The more significant value addition or beneficiation actually occurs during the second and third stages of the beneficiation process which falls more under the manufacturing sector with their specialised skills and craftsmanship. Countries such as India, China, Dubai, Turkey and Europe due to the lack of minerals have focused their skill sets onto the manufacturing side and are able to deliver a substantially higher relative output per unit labour than South Africa.

The challenges therefore faced by the South African Government to successfully reap the benefits from the Minerals Beneficiation programme are numerous and are not only limited to notoriously low productivity in the South African manufacturing sectors and low skills and experience base but also extends to lack of infrastructure, poor research and development capabilities and access to international markets for beneficiated products. From these challenges listed the low productivity arguably affects the South African autocatalytic converter industry the most.

Some of the criticisms against the beneficiation of minerals to finished consumer goods are that although it will provide increased revenue, it may not create as many jobs as hoped for and that the operations may be very power intensive. The National Planning Commission (NPC) has already raised concerns that the benefits of job creation may be outweighed by greater energy demands and increased carbon emissions. The majority

of job creation occurs in the first and second stages of the beneficiation process, where the production of concentrates, metals and alloys happens. While the third and fourth stages of beneficiation deal with making end products for consumers, these final stages aren't as labour intensive. Instead they rely on two things that SA is battling to grow and attract – technical skills and investment.

The ability of countries such as China to beneficiate minerals at much lower costs even when transport costs are included; necessitates that the benefits from the Minerals Beneficiation programme be significant to attract the required investments and skills base to allow the industry breathing space and a chance to become competitive in the longer term.

The Mineral Beneficiation programme extension to the PGM and autocatalytic converter industry is still under review and expected to be finalised and presented early in 2013. The following interventions for the autocatalytic converters and diesel particulate filters are thus far considered by the Department Mineral Resources (DMR) (Department: Mineral Resources Republic of South Africa, 2011):

- Invoke relevant provisions of the law to ensure security of PGM supply. The major mining companies have so far indicated their willingness to participate and advance the intended beneficiation strategy by participating in the Platinum Beneficiation Board (PBC).

- Aiming to unlock intrinsic value within the PGM sector through the sponsorship of research programmes. The proposed approach for these research programmes is through the formation of international partnerships and to support the technical upgrade of R&D centres of Competence in a proposed Advanced Metals Strategy.

- The alignment of existing initiatives on skills development as well as promotion of careers in related fields

- The promotion of investment in the automotive industry and the continuation of the sector incentive, such as the Automotive Production and Development Program (APDP).

The above mentioned interventions seems to be more focused on longer term skills development, although this is necessary, it also may leave a critical gap with regards to assistance in offsetting some of the operational cost.

Scenario 5: Industry considered competitive but no real leadership commitment to WCO

When this scenario was modelled the nodes were activated as per scenario two. When the node "Leadership commitment to WCO elements" was deactivated but the node "Benefits from Beneficiation programme" were left as active, the result after 4 cycles was that the node "Demand for SA converters" were inactive. The simulation result for this scenario is presented in appendix F.

This result seem to support the sentiment of the respondents that even with the benefits from a Beneficiation programme no industry can survive on a longer term without some attempt to continuously improve your operations. The level of competitiveness according to the WCO assessment model remains in many ways still a very subjective assessment and a company's competitiveness largely depends on their own progress relative to that of their competitors.

From this simulation what seems to be important is not how far a company has progressed on its journey to "world class operations" but rather an in-depth understanding of your customer's needs, commitment to continuously improve using the WCO assessment model as a framework but ultimately how you compare to your competitors on this journey to "world class operations" are critical for long term survival.

Scenario 6: Industry considered competitive and benefits from Beneficiation program but the industry is negatively influenced by instability with regards to South African labour relations, politics, and electrical supply.

When this scenario was modelled the nodes were activated as per scenario two but in addition the nodes for "Unstable SA labour relations" and "Unstable SA electricity supply" were also activated but the node "Stable SA politics" was deactivated. The simulation result for this scenario is presented in appendix F.

The simulation stabilised after 5 cycles with the node “Demand for SA converters” active.

This scenario simulation supports the predominant sentiment among the respondents that the demand for South African converters is sensitive to influences from the South African operational and economic environments but that the scarcity of PGM reserves throughout the world and the global demand for these PGMs will ensure that the demand for SA converters in the short term will remain relatively strong. Medium to long term sentiments are that the scarcity and inaccessibility of PGMs may accelerate the development of technologies that are not reliant on PGM. This however was believed not to be a significant short term threat to the industry but rather a longer term concern.

In a recent interim report by one of the respondents, Johnson Matthey, a global shortfall of approximately 400 000 ounces of platinum is expected during 2012. This shortfall is the direct result of the inability of South African mines to produce due to labour strikes, operational blackouts due to poor electricity supply as well as mine closures (De Lange, 2012). According to the report the annual production of platinum will be approximately 600 000 ounces less for platinum and 950 000 ounces less for palladium compared to last year, this is believed to be as a direct result of the violent strikes during the latter half of 2012. These reductions in PGM supply will according to the Johnson Matthey report result in an estimated loss of R8.3 billion (De Lange, 2012). This lower production will mean a 10% drop in PGM supply compared to last year.

From a demand perspective the demand for platinum is predicted to remain healthy despite the sharp reduction seen in the European automotive markets, mainly due to significant increases in global jewellery applications together with anticipated growth in the Indian and Japanese automotive industries (De Lange, 2012).

According to Bloomberg there is a significant risk that South Africa’s credit rating could be downgraded further to “high risk” based on increasing concerns among international investors about the country’s growing debt and increasing internal political uncertainty and labour unrest (Bloomberg, 2012). According to Bloomberg the reduction in European demand for South African products has contributed to a reduced growth rate of the South African economy of an estimated 2.5% only, compared to the 3.1% last year. It is further believed that purely based on economic reasons South Africa may be able to avert this possible downgrading but the uncertainty on political stability, regular calls for the

nationalisation of South African mines and resources together with the rising labour unrest are creating an uncertain investing environment for foreign investors.

It would therefore appear that despite the global scarcity of global PGM resources that could potentially sustain a healthy demand for South African PGMs, the uncertainty associated with political and labour issues could prevent new and further foreign investment within South African industries.

For the South African autocatalytic converter industry this could mean that although the demand for SA platinum is expected to remain strong, it doesn't necessarily mean that global OEMs would want their autocatalytic converters to be manufactured in South Africa. The SA autocatalytic converter industry must therefore find innovative ways to convince their foreign markets in their ability to deliver their products on time without any disruptions.

Medium to longer term the SA automotive industry will need support and incentives to promote and grow manufacturing and assembly within South Africa and not allowing OEMs merely to export the PGMs.

Scenario 7: Industry to be considered competitive, no global recession but influenced by global economic factors such as rising energy costs, international PGM reserves

When this scenario was modelled the nodes were activated as per scenario two but in addition the nodes for "Global energy costs", "Russian PGM reserves" and "Growth in Asian automotive markets" were also activated. The simulation result for this scenario is presented in appendix F.

The simulation stabilised after 6 cycles with the node "Demand for SA converters" active.

The simulation of this scenario highlights the impact of influences such as rising global energy costs will have on the demand for autocatalytic converters from South Africa.

The sentiment among some of the respondents were that the major strength of the South African autocatalytic converter industry is its proximity to one of the core raw materials of

the converter technology namely PGMs. A very big threat for the local industry therefore would be the discovery of natural PGM deposits in other parts of the world or the release of PGM reserves kept in stockpile of which Russia arguably has the greatest reserves. According to Yang (2009) recent geological studies have placed doubts on whether further deposits of PGMs will be discovered and according to De Lange (2012) the Russian reserves are close to be depleted and the quality of their PGM ore is inferior to that of South Africa. The respondents believed that this supports the increased demand for South African autocatalytic converters.

The rise in global energy costs such as electricity and fuel were perceived by the majority of the respondents as a longer term threat to the global automotive industry specifically the current internal combustion propulsion technologies; rather than a specific short term threat to the South African autocatalytic converter industry alone. Some of the respondents believed that rising fuel costs could present opportunities for the industry as the demand for more fuel efficient transportation could open the doors to new legal and technical demands placed on the industry. These respondents believe that whoever could respond first to these opportunities could reap significant financial benefits and possibly gain a sustainable competitive advantage.

The growth in Asian automotive markets was perceived by some of the respondents as a potentially bigger threat to the South African autocatalytic converter industry. They are of the opinion that the Asian autocatalytic industry is fast improving their expertise, technologies, process capability and quality; although the Asian emission legislation are not yet as strict compared to European and American legislation; their ability to supply to these stricter requirements are fast improving.

The risk therefore to the local industry; mainly supplying the European markets; is that the European OEMs could switch their supply chain over to the more cost competitive Asian manufacturers. These respondents further highlights that the current high growth rates seen in cars being sold in Asian markets may mitigate the risk of European OEMs switching in the short term since the capacity for Asian manufactures supplying customers beyond their own markets may still be limited for now.

The FCM simulation for this scenario therefore seems to be supportive of the majority of the opinion from the respondents that the global influences such as rising energy costs,

limited global PGM reserves and growth in Asian automotive markets are posing longer term threats but in the shorter term are not posing a significant threat to the demand for local autocatalytic converters.

Scenario 8: Industry considered NOT competitive, but leadership to have real commitment to WCO elements.

When this scenario was modelled the current market and industry conditions as per scenario 1 were considered together with the node “Benefits of Beneficiation programme” activated. All the nodes related WCO were deactivated to simulate the industry to not be competitive according to the WCO assessment model as presented in chapter 2 of this report. The node “Leadership commitment to WCO principles” was activated. The output of the FCM for this scenario is depicted in appendix F.

The simulation stabilised after five cycles with the node “Demand for SA converters” active.

The result of the simulation was quite interesting in that although the industry is perceived not to be competitive; as long as the leadership are perceived to be committed to sustainable improvement of their operations in an environment supported by a Beneficiation programme then the demand for South African autocatalytic converters remains healthy.

This result could also be indicative of the underlying sentiment among the majority of the respondents that the benefits from the Beneficiation programme will be significant for the sustainable future of the industry.

Although the sample of interviewees were specifically chosen across the broad spectrum of the autocatalytic converter value chain; to minimise any biased opinion; it seems that the expected benefits from a Beneficiation programme is a very strong theme within the industry in the advent of the change from MIDP to APDP after 2012.

CHAPTER 6: CONCLUSIONS AND RECOMMENDATIONS

6.1 Introduction

This chapter serves to emphasise the salient aspects of the research findings. In doing so, it will provide guidance to the role players and decision makers within the South African autocatalytic converters industry allowing them to better position themselves in the face of international competition and a changing operational environment.

6.2 Conclusions of the study

This study identified that the perception of most of the respondents are that the South African autocatalytic converter industry has not grown to be internationally competitive in most of the WCO elements that are considered to be critical or important for the industry. The respondents have rated their own performance on most of the WCO elements as either on the same level or slightly below their international competitors. It was therefore concluded by the author that the perceived competitiveness of the industry is quite low as there were only one WCO element in which the South African autocatalytic converter industry believed they were significantly better than their international counterparts.

This study further identified that the WCO elements that the respondents believed to be the most critical for their businesses, centres around employee involvement in quality and continuous improvement initiatives. Although these were perceived to be critical, hardly any of the respondents believed they are currently out performing their international competitors. Most of the respondents rated their level of performance as either the same or slightly below that of their international competitors. These WCO elements are indicative of the nature of the global automotive industry where a high emphasis is placed on quality of product and process as well as the ever on-going pursuit to reduce operational costs through continuous improvement (Mashilo, 2010). This will make it more difficult for South African autocatalytic converter suppliers to use quality and continuous improvement initiatives as a competitive advantage to attract new business and these will more likely only serve as hygiene factors or order qualifiers for the industry in the future. The only area that most of the respondents believe they are more

competitive than their international competitors are in the area of statistical process control (SPC). What is however very promising is the realisation among many of the respondents that quality programmes should evolve from the perception that quality is the sole responsibility of the quality department inspecting final product to the new understanding that quality is the responsibility of every worker at every stage of the process. This Quality-at-source approach could provide an advantage if implemented successfully across the industry. It is however notoriously difficult and historically very few companies were successful as it involves a total culture and mind set change for the all the workers in the organisation.

Interestingly most of the respondents rated WCO elements such as supplier/customer collaborative relationships and operational flexibility not as important as quality and continuous improvement. It seems that open collaborative relationships built on trust are not yet the norm within the industry. Current relationships have not yet evolved into completely open relationships where companies within the supply chain are working together to optimise the performance of the entire supply chain instead of driving their own performance agendas only. It is the opinion of the author that strong collaborative relationships will strengthen the supply chain and may be a valuable source of competitive advantage for the South African autocatalytic converter industry as a whole.

Government export stimulus programmes such as MIDP were not successful in developing the South African catalytic converter suppliers to a level where they could be self-sustainable serving only the local markets. Under MIDP suppliers of autocatalytic converters had no real incentive to improve their operations on a cost basis in order to remain internationally competitive.

The location disconnect of manufacturing in Africa for European/Asian markets increases the cost per unit to a point where the South African industry will find it increasingly difficult to remain attractive to international customers. The Global Automotive industry is already considered to be highly geared towards low margins and cost reduction; high quality demands as well as strict operational lead times. The local market for autocatalytic converters is considered too small to provide real economies of scale for the existing

players and some consolidation of the industry could be expected if these companies don't find other competitive advantages to remain attractive.

The WCO elements could considered to be hygiene factors with regards to winning new contracts from customers and the real attractiveness of the industry seems to be more dependent on external factors such global recession, local political and labour stability, PGM reserves.

A real commitment by industry leadership to World Class Operations (WCO) is critical for a sustainable future for the industry. However since the global automotive industry is already considered setting the trend with regards to WCO, the South African Autocatalytic converter industry will find it extremely difficult to reduce its cost base and operational lead times to the extent that the location disconnect is offset for the industry to remain attractive.

It therefore seems imperative that the industry will require additional support and stimulus in the form of incentive programmes to attract more autocatalytic converter sales to international customers and/or attract more automotive assemblers (OEM) to set up operations within South African borders.

With APDP the aim is to attract more automotive assemblers to South Africa. Whether the benefits under this programme will be sufficient to attract enough automotive assemblers with a local footprint to ensure adequate business for all role players within the autocatalytic converter industry is doubtful. The benefits under APDP to export suppliers are expected to significantly reduce after two years therefore some consolidation could be expected within the industry unless means could be found to stimulate export sales. The South African Government's Minerals Beneficiation programme could provide such benefits if rolled out to include the beneficiation of precious metals within the autocatalytic converter industry.

The automotive industry as a whole is also sensitive to global economics and global recessions. WCO could be considered a way for the industry to shield against recessionary troughs through highly efficient and flexible operations. The ability to adapt to changing economic environments will be the key for the long term survival of the catalytic converter industry of South Africa.

The external factors impacting on the future of the South African autocatalytic converter industry is numerous and although an attempt was made to

6.3 Recommendations

The South African autocatalytic converter industry is facing interesting years ahead. The replacement of MIDP with a new government incentive called APDP together with significantly reduced car sales in their primary European markets will force the local industry to critical assess their own operations and performance to ensure long term sustainability. The new Automotive Production Development Programme (APDP) programme aims to promote local assembly of vehicles for either the local South African market or for the export of fully assembled vehicles to overseas markets. The APDP aims to promote job creation by doubling the number of units assembled/produced to 1.2 million per annum by the year 2020. The incentives under APDP only significantly benefits OEMs with a local assembly footprint which have a plant capacity of 50 000 units /annum or more. Only a handful of OEMs currently assembles some of their models within South Africa. For APDP to really deliver on its intentions, the South African government will have to explore and implement complimentary structures and incentives to attract more foreign OEMs to set up their assembly plants within the borders of South Africa. Some of these complimentary structures could be in the form of tax breaks and or productivity based incentives. Some of the challenges faced by the South African Government in their attempt to grow the local automotive industry are the limiting size of the local market, the lack of critical skills, relatively high manufacturing costs and the notoriously low productivity levels associated with South African workers.

The limitation surrounding the size of the local automotive market is presenting itself as arguably one of the biggest challenges facing the South African autocatalytic converter industry. The current local automotive market is not big enough to sustain the autocatalytic converter industry in its current format. Therefore only two options exist for the autocatalytic converter industry; 1) to downsize and consolidate their operations to the smaller local market or 2) to actively grow their markets through exploring new geographical markets as well as complimentary product ranges.

With regards to complimentary product ranges the local autocatalytic converter industry could investigate to diversify some of their businesses into market segments where similar or related technologies are applicable. Possible market segments that could be considered are:

- Fuel cell technologies for vehicle propulsion or providing power for electronic devices,
- Catalytic converters for stationary power applications such as power plants.
- PGM refining to recover PGM from process waste streams
- Process catalysts for petrochemical applications.

With regards to the geographical expansion of the local automotive market there are two scenarios to be considered. The first scenario is for the suppliers of autocatalytic converter to start supplying directly to overseas markets without fitting the converter into the exhaust system first. There are concerns surrounding this scenario, of which the biggest is the possibility of job losses at the tail end of the supply chain. The fitment of the autocatalytic converter into the exhaust system by the canners is relatively labour intensive and further investigation to prevent these job losses will be required.

The second scenario of geographically expanding the local market is a scenario where the South African government will have a major role to play through trade agreements. The most likely geographical area for a possible market expansion would be into sub-Saharan Africa. The South African government is already entering into trade agreements with certain African countries and if these agreements could be expanded to actively promote sales of vehicles assembled in South Africa; then the local autocatalytic converter industry could serve as a springboard to supply the rest of Africa. The possibility of supplying other geographic regions is a bit more complex as most of these regions do have their own existing autocatalytic converter industries and stiff competition could be expected to enter these markets. The South African autocatalytic industry currently doesn't have any real competitive advantage to ensure the successful entering of these markets. The location disconnect to any of these markets will add to the manufacturing cost and make the South African products even less competitive.

The only source of a possible competitive advantage could come from exploring ways of reducing the associated manufacturing cost of making an autocatalytic converter in South Africa. This cost reduction could again come from two possible options: 1) Lowering the actual manufacturing cost through adopting “best practises” associated with “world class manufacturing principles” and the reduction of operational waste and 2) off-setting some of the manufacturing cost through some sort of production incentive.

The lowering of actual manufacturing cost will not be an easy task but is a necessary objective for the long term survival of the industry in a free and fair trade environment. Any attempt to lower the manufacturing costs and reduce process waste must be founded in a sincere commitment from the leadership of the organisation in exploring, developing and adopting “best practises” from what is considered “world class manufacturing principles”. The building blocks for “world class manufacturing principles” or “world class operations” (WCO) are found in programmes that provide quality-at-source and continuous improvement; both of which the aim are to improve process reliability, process repeatability, lead time reduction and ultimately greater customer satisfaction and cost reduction. The commitment of leadership to the successful integration of such programmes into the culture and fabric of their organisation is critical for the industry.

Reducing manufacturing cost in the long run is greatly dependant on the available skill levels in an organisation as well as the productivity levels associated with the manufacturing of the products. In both of these areas South Africa is not renowned for doing very well. Much work is still needed by both government and industry to promote the skills base available in South Africa. Sponsorship, bursaries, learnerships and the development of educational programmes related to the PGM and manufacturing fields that is aligned with the National Skills development programme of the Government are already underway. These initiatives will need to be increased and expedited as it may be the case of too little too late. The ultimate future differentiator in this industry will be the ability to innovate and developing newer and improved technology in the quickest time. Ensuring the correct skill levels to facilitate this will be critical for the South African autocatalytic converter industry.

The low levels of productivity associated with the South African labour force compared to other countries such as India and China is a very real threat to the South African

autocatalytic converter industry. First of all the threat of low cost imports from Asian suppliers will reduce the demand for South African produced autocatalytic converters. To protect the local market from these low cost imports will require some interference and protection from the South African government. The Asian markets are still growing at a phenomenal rate and Asian suppliers are currently still struggling supplying their own markets. This over demand situation may not always continue and the risk of these cheaper autocatalytic converters finding their way into Africa is a threat that requires close monitoring. The risk of Asian suppliers starting to supply into Western European markets is also a very big concern for the South African industry. Industry leaders will have to implement regular benchmarking exercises to stay abreast of all developments within the Asian region to ensure that they are not left behind.

To increase the productivity levels of the South African workforce is a difficult but necessary objective that South Africa as a country and not only the autocatalytic converter industry should prioritise. The reasons for the lower productivity rate are debateable and not easily determined. Improving the productivity levels will require a combined effort from the South African government, South African businesses and labour unions. A review of certain restrictive labour legislation and some sort of the productivity incentives may be possible solutions to be considered.

The benefits associated with collaborative working relationships between suppliers and vendors could also be explored by the autocatalytic converter industry. This would require greater openness and willingness to share information among organisations but could ultimately result in lower manufacturing costs across the entire value/supply chain and ultimately more demand for South African autocatalytic converters.

The South African autocatalytic converter industry may not be able to lower their manufacturing costs to the level where they will be able to off-set the transportation costs associated to get their product to their European markets. This will necessitates some sort of external support or stimulus in the form of trade or production incentive schemes. The South African government has developed the APDP scheme to stimulate assembly of vehicles within South African borders but these may not be sufficient and will have to be complemented with another programme where the benefits will be more direct to the autocatalytic converter industry. The Mineral Beneficiation as proposed by the Department of Mineral Resources may provide such benefits. It will be in the interest of

the industry that the South African government expedites the implementation of this programme as much as possible. This programme in its current format is focussing more on the long term sustainability and job creation. The government will however have to find ways of making it financially more favourable for foreign investment and the continued existence of the industry in the short term.

6.4 Suggestions for further research

The following research topics could complement the current research conducted:

6.3.1 Quantitative analysis of the competitiveness of the Autocatalytic converter industry of South Africa.

The current research was based on interviews of industry leaders and subject matter experts with the aim to establish their perception on the international competiveness of the South African Autocatalytic converter industry. This qualitative method of data gathering will inevitably remain to some degree subjective. A quantitative benchmarking comparison of the performance indicators of the players in the local industry to the performance of their international counterparts could provide a more objective insight to the competitive position of the South African industry.

6.3.2 The economic impact to the automotive industry if autocatalytic converters are directly supplied to overseas markets instead of canned within South African borders.

The possibility to supply coated converters directly to overseas markets exists and could provide a life line to South African coaters. This research however has revealed concerns among some of the respondents that this could be detrimental to the autocatalytic converter industry as a whole. Their concerns centres around the impact such a decision will have on the tail end of the value chain as the canners are playing a significant role with regards to job creation within the industry.

6.3.3 Exploring the economic impact of developments within the Asian automotive industries.

Although the respondents interviewed in this research report acknowledged the possible impact the Asian markets could have on the local industry, the majority of the respondents believed that trends or developments within the Asian markets will only impact the local industry in the long term. With the majority of the future world economic growth expected to come from Asian countries, it is the view of the author that an in-depth analysis of the current and anticipated future economic trends in these Asian countries is critical for the understanding of the possible future scenarios of the South African industry.

6.3.4 Follow-up study on the competiveness of the South African autocatalytic converter industry.

This research report is based on the perception of industry leaders during 2012 and is therefore limited to their understanding of proposed new Government incentive programmes such as the Beneficiation programme and the APDP scheme with regards to the potential benefits they will provide to the industry. A future economic analysis of the benefits provided under these programmes and how they will shape the South African autocatalytic converter industry will provide evidence to support or disprove the conclusions from this report.

6.3.5 In depth study on the benefits associated with Mineral Beneficiation programmes.

The Department of Mineral Resources are in the progress of implementing and rolling out a Mineral Beneficiation Strategy across the mining and manufacturing sectors. This programme is based on a similar programme adopted in the Nordic countries. A comparative study could reveal what benefits these countries have seen as a result of this programme and whether similar benefits have been seen or could be expected in South Africa.

6.3.6 Application and relevance of the World Class Operations assessment model, as developed in Chapter two of this report, to other South African industries/sectors

In Chapter two of this report the "World Class Operations " or WCO assessment model was developed to assist an organisation or industry to gauge their progress on the journey to become a World Class organisation. This model was developed from general literature on Business Operations Management and was applied in this report to the autocatalytic converter industry of South Africa. The relevance of this model to other sectors and industries such as mining or services could be the subject of further investigation.

6.3.7 The skills level and impact thereof on the productivity of a labourer within the South African manufacturing industry

This report aimed to understand the perceived competitiveness of the South African autocatalytic converter industry and has revealed that the industry is heavily impacted by low productivity and lack of skills. These challenges seem to be not unique to the autocatalytic converter industry alone but rather challenges impacting on the broader South African manufacturing sector as a whole. Understanding the current skills shortage and its link to improving the productivity of a labourer could provide key insight to improving the performance and perception of the manufacturing sector.

6.3.8 Refining the enhanced FCM with regards to the drivers that influence car sales in the European markets

This report has highlighted how closely the fate of the South African autocatalytic industry is intertwined with the economic environment in Europe. The focus of this report was mainly on the possible impact that recessionary economic forces could have on the demand for autocatalytic converters; an understanding of the non-recessionary economic forces influencing the industry's primary European markets will be greatly significant in predicting the future fate of the local industry.

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APPENDIX A – RESEARCH INSTRUMENTS

The structured interview questions are provided below. The interview questions focus on actual key performance areas of the organisation, the degree of which certain WCO best practises have been implemented and lastly the organisation's perception of importance of the particular best practise and how the organisation compares with their international competitors.

Cost Leadership

Key Performance	World class Best Practise	Perception on Importance/ Comparison
• Raw Material Stock Holding ☐ • Work in Progress Levels ☐ • Finished goods Stock levels ☐	• **Quality at source** *Degree to which a quality at source programme has been implemented and contributing to a measured cost saving.*	Rate the importance of an effective quality at source programme in your organisation

No sustainable and structured quality at source program	Initial and informal attempts to improve quality at source	Launched a formal and structured approach to improve quality at source	Structured approach to quality at source is fully implemented **Cost savings not measured**	Fully implemented and quantifiable cost saving

Not important		Important		Critical

Rate your perception on how your organisation compare against your international competitors on Quality at source

Far below their level	Slightly below their level	Same level	Slightly above their level	Outperforms competitors

• **Cellular production systems**

Degree to which your production systems follow a cellular arrangement

Cellular arrangement to production systems not applicable	No thought given to production layout	Initial attempts to improve organisation of production systems	Adopted some degree of cellular arrangement to production systems	Full cellular arrangement adopted to maximise variability in production systems

Rate the importance of a cellular approach to production in your organisation

Not important		Important		Critical

Rate your perception on how your organisation compare against your international competitors on Cellular production systems

Far below their level	Slightly below their level	Same level	Slightly above their level	Outperforms competitors

• **Production pulling systems (kanban)**

Degree to which your production scheduling follow a pull approach

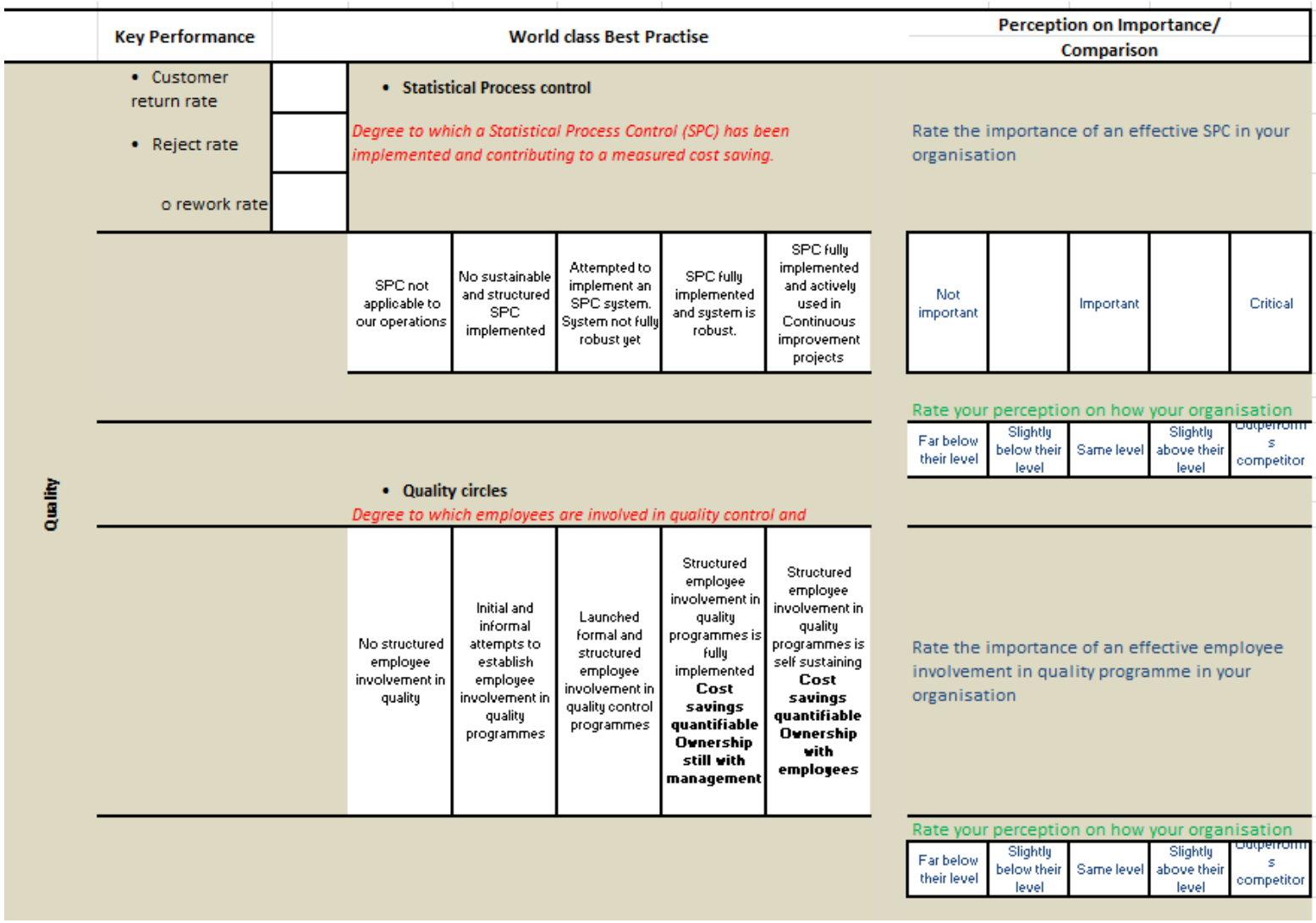
Cellular arrangement to production systems not applicable	No thought given to production layout	Initial attempts to improve organisation of production systems	Production scheduled according to hybrid of push and pull. Some control of material flow. System not fully robust	Production scheduled strictly according to a pull approach Material flow strictly controlled and systems are robust

Rate the importance of a *Pull approach* to production scheduling in your organisation

Not important		Important		Critical

Rate your perception on how your organisation compare against your international competitors on following a Pull approach to production scheduling

Far below their level	Slightly below their level	Same level	Slightly above their level	Outperforms competitors


Quality
Key Performance
World class Best Practise
Perception on Importance/ Comparison
• Customer return rate
• Reject rate
o rework rate
• Statistical Process control
Degree to which a Statistical Process Control (SPC) has been implemented and contributing to a measured cost saving.
SPC not applicable to our operations
No sustainable and structured SPC implemented
Attempted to implement an SPC system. System not fully robust yet
SPC fully implemented and system is robust.
SPC fully implemented and actively used in Continuous improvement projects
Rate the importance of an effective SPC in your organisation
Not important
Important
Critical
Rate your perception on how your organisation
Far below their level
Slightly below their level
Same level
Slightly above their level
competitor
• Quality circles
Degree to which employees are involved in quality control and
No structured employee involvement in quality
Initial and informal attempts to establish employee involvement in quality programmes
Launched formal and structured employee involvement in quality control programmes
Structured employee involvement in quality programmes is fully implemented Cost savings quantifiable Ownership still with management
Structured employee involvement in quality programmes is self sustaining Cost savings quantifiable Ownership with employees
Rate the importance of an effective employee involvement in quality programme in your organisation
Rate your perception on how your organisation
Far below their level
Slightly below their level
Same level
Slightly above their level
competitor

	Key Performance	World class Best Practise	Perception on Importance/ Comparison
(External Flexibility)	• Time from customer order to delivery • Delivery frequency of suppliers • Delivery reliability of suppliers	• **Supply chain flexibility: *Customers*** *Degree of focus on optimising the frequency of deliveries to customers and measuring the associated cost saving.*	Rate the importance of an effective delivery frequency management approach

No official or structured effort to measure customer delivery frequency	Delivery frequency measured but no structured optimisation initiative in place	Early attempts to optimise frequency of customer deliveries	Definite structured initiative to optimise delivery frequency	Effective, structured and fully implemented system to manage and optimise delivery frequencies and measure associated cost savings

Not important		Important		Critical

Rate your perception on how your organisation compare

Far below their level	Slightly below their level	Same level	Slightly above their level	Outperforms competitors

- **Supply chain flexibility: *Customers***

Degree of focus on optimising the reliability of deliveries to customers

No official or structured effort to measure customer delivery reliability	Delivery reliability measured but no structured optimisation initiative in place	Early attempts to optimise reliability of customer deliveries	Definite structured initiative to optimise delivery reliability	Effective, structured and fully implemented system to manage and optimise delivery reliability and measure associated cost savings

	Key Performance	World class Best Practise	Perception on Importance/ Comparison
Lead time (External Flexibility)	•	• **Supply chain flexibility:** ***Suppliers***	Rate the importance of an effective delivery reliability management approach

Degree of focus on optimising the reliability of deliveries from suppliers and measuring the associated cost saving.

No official or structured effort to measure supplier delivery frequency	Delivery frequency measured but no structured optimisation initiative in place	Early attempts to optimise frequency of supplier deliveries	Definite structured initiative to optimise delivery frequency	Effective, structured and fully implemented system to manage and optimise delivery frequencies and measure associated cost savings

Not important		Important		Critical

Rate your perception on how your organisation compare

Far below their level	Slightly below their level	Same level	Slightly above their level	Outperforms competitors

• **Lead time for new product/technology introduction**

Degree of focus on optimising the speed of new product/technology introduction and measuring the associated cost saving.

No official or structured effort to measure new product introduction	Lead time for new product introduction measured but no structured optimisation initiative in place	Early attempts to optimise lead time for new product introduction	Definite structured initiative to optimise lead time for new product introduction	Effective, structured and fully implemented system to manage and optimise new product introduction and measure associated cost savings

Rate the importance of the speed of new product

Not important		Important		Critical

Rate your perception on how your organisation compare

Far below their level	Slightly below their level	Same level	Slightly above their level	Outperforms competitors

	Key Performance	World class Best Practise	Perception on Importance/ Comparison
Internal Flexibility		• **Materials Handling: Just In Time** *Degree to which internal processes are capable to handle materials*	Rate the importance of a just in time materials flow

No structured approach to internal materials handling	Material flow monitored and recorded but no optimisation attempt	Attempted to implement material flow optimisation	Material flow are effectively managed but not yet just in time	Just in time effectively implemented and robust, cost saving measured

Not important		Important		Critical

Rate your perception on how your organisation compare

Far below their level	Slightly below their level	Same level	Slightly above their level	Outperforms competitors

• **Change over speed: SMED (single minute exchange of die)**

Degree to which there is conscious attempt to improve the

No structured initiative to measure or improve changeover times	Measuring changeover times but no structured attempt to improve the times	Early attempts to improve changeover times but no real significant reduction seen.	Formal and structured approach to improve changeover times, some isolated reductions seen	Self sustaining programme to continuously monitor and improve changeover times

Rate the importance of a definite focus on continuously

Not important		Important		Critical

Rate your perception on how your organisation compare

Far below their level	Slightly below their level	Same level	Slightly above their level	Outperforms competitors

	Key Performance	World class Best Practise	Perception on Importance/ Comparison
Internal Flexibility	•	• **Flexibility: Labour Skills** *Degree to which workforce on shop floor are multi skilled.*	Rate the importance of a work force that is multi skilled across various different functions.

Not multi skilled, task specifically trained	Can perform different tasks on own production line only	Can perform tasks across different production lines	Can perform tasks across different functions	Capable to do tasks across different functions as well as transfer of skills

Not important		Important		Critical

Rate your perception on how your organisation compare

Far below their level	Slightly below their level	Same level	Slightly above their level	Outperforms competitors

• **Flexibility: Capacity throughput – labour and equipment**

Degree to which workforce or equipment could be increased or reduced according to volatile demand cycles

Rate the importance of flexible operations in terms of

Only permanent workforce, Labour and equipment both slow response	Make use of some temporary labour, Labour responsive, equipment	Only permanent staff Labour unresponsive Equipment responsive	Some temporary staff Labour responsive Equipment responsive	Both labour and equipment are responsive and actively aligned with demand cycles

Not important		Important		Critical

Rate your perception on how your organisation compare

Far below their level	Slightly below their level	Same level	Slightly above their level	Outperforms competitors

	Key Performance	World class Best Practise	Perception on Importance/ Comparison
Innovation/Technology/Capacity to Change		• **Continuous improvement programmes** *Degree to which entire organisation is involved in continuous improvement and measuring the associated cost saving.*	Rate the importance of a formalised improvement culture in your organisation

No continuous improvement programme initiatives	First random attempts at improvement initiatives mostly driven by top management	Adopting formal improvement programme still driven by management	Formal improvement programme implemented good participation from employees	Formal improvement initiatives engrained in culture of whole organisation

Not important		Important		Critical

Rate your perception on how your organisation compare against your international competitors on self sustaining improvement culture

Far below their level	Slightly below their level	Same level	Slightly above their level	Outperforms competitors

• • **Self driven work improvement teams**

Degree to which employees are involved in quality control and improvement initiatives such as quality circles and contributing to a measured cost saving.

No structured employee involvement in improvement	Initial and informal attempts to establish employee involvement in improvement programmes	Launched formal and structured employee involvement in improvement programmes	Structured employee involvement in CI programmes is fully implemented **Cost savings quantifiable Ownership still with management**	Structured employee involvement in quality programmes is self sustaining **Cost savings quantifiable Ownership with employees**

Rate the importance of an effective employee involvement in improvement in your organisation

Not important		Important		Critical

Rate your perception on how your organisation compare against your international competitors on employee involvement in improvement

Far below their level	Slightly below their level	Same level	Slightly above their level	Outperforms competitors

APPENDIX B – RESULTS OF INTERVIEWS TO VALIDATE & RATE CAUSAL LINKS OF ENHANCED FCM

#	From	To	+	-	Strength	Comments	Respondent's strength ratings														
							Ave	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	Causal Links between Drivers of Demand and Sustainability Indicators																						
1	**Global Electricity costs**	**Steel availability (South Africa)**		X	-0.03	Steel production is deemed heavily dependent on electricity and therefore a negative relation is expected. However availability of steel within South Africa is more dependent on South African electricity costs and not as much on Global electricity costs.	-0.03	0	-0.04	-0.08	-0.05	-0.09	-0.1	-0.03	-0.04	0	-0.03	0	-0.02	0	0	0	0
2	**Steel availability (South Africa)**	**Steel price (South Africa)**		X	-0.60	Supply and demand influences	-0.60	-0.45	-0.85	-0.35	-0.5	-0.75	-0.4	-0.9	-0.3	-0.5	-0.6	-0.7	-0.7	-0.6	-0.6	-0.7	-0.65
3	**Steel price (South Africa)**	**Global demand for cars**		X	-0.03	Higher steel prices will place pressure on the margins within the automotive manufacturing value chain , but since the automotive manufacturers with a South African footprint are relatively small the impact on global demand for cars are expected to be almost insignificant	-0.03	-0.03	-0.05	-0.06	-0.02	-0.04	-0.01	-0.01	-0.05	-0.03	-0.02	-0.03	-0.01	-0.03	-0.02	-0.05	-0.03
4	**Global Electricity costs**	**Oil reserves**		X	-0.08	Although refining of oil consumes large quantities of electricity it is however thought that the demand and asking price for oil will not be significantly influenced by increases in electricity costs	-0.08	-0.04	-0.09	-0.15	-0.04	-0.08	-0.09	-0.06	-0.08	-0.1	-0.06	-0.07	-0.1	-0.09	-0.07	-0.08	-0.06
5	**Global Electricity costs**	**PGM Reserves**		X	-0.03	Although refining of PGMs consumes large quantities of electricity it is however thought that the demand and asking price for PGMs will not be significantly influenced by increases in electricity costs	-0.03	0	-0.03	0	-0.03	-0.06	-0.03	-0.03	0	-0.03	-0.06	-0.03	-0.08	0.1	-0.05	-0.05	-0.04
6	**PGM Reserves**	**PGM Price**		X	-0.80	Supply and demand influences	-0.80	-1	-0.5	-1	-0.75	-0.65	-0.8	-0.85	-0.9	-0.8	-0.75	-1	-0.9	-0.8	-0.85	-0.35	-0.85
7	**PGM Price**	**New propulsion method:Electric cars**	X		0.70	The more expensive PGMs become the greater the financial incentives to explore alternative propulsion methods such as electric cars. If electric cars however do become more popular than some of the demand for PGMs will be reduced since electric motors have no need for PGMs	0.70	0.5	0.9	0.7	0.6	0.7	0.8	0.7	0.7	0.9	0.4	0.75	0.7	0.7	0.5	0.7	0.9

#	From	To	+	-	Strength	Comments
	Causal Links between Drivers of Demand and Sustainability Indicators					
8	**PGM Price**	**New propulsion method: Fuel Cells**	**X**		**0.30**	Fuel cells require more PGMs than an ordinary catalyst and therefore the higher prices for PGMs may be a damper on the development of this technology in comparison to electric cars.
9	**Oil reserves**	**Global demand for cars**	**X**		**0.30**	The scarcer oil reserves become the more people will be dependent on alternative or public transportation and a decrease in the demand for cars could be expected
10	**Oil reserves**	**Oil price**		**X**	**-0.80**	Supply and demand influences
11	**Oil price**	**New propulsion method: Fuel Cells**	**X**		**0.50**	The more expensive oil reserves become the more people will be dependent on alternative or public transportation and a decrease in the demand for cars could be expected
12	**Oil price**	**Diesel Technology**	**X**		**0.20**	The more expensive oil reserves become the more people will be dependent on alternative or public transportation and a decrease in the demand for cars could be expected. Diesel technology is considered to be more economical
13	**Oil price**	**Global demand for cars**		**X**	**-0.40**	The more expensive oil reserves become the more people will be dependent on alternative or public transportation and a decrease in the demand for cars could be expected
14	**Oil reserves**	**New propulsion method: Fuel Cells**		**X**	**-0.60**	The scarcer oil reserves become the more people will be dependent on alternative or public transportation and a decrease in the demand for cars could be expected
15	**Oil reserves**	**New propulsion method:Electric cars**		**X**	**-0.60**	The scarcer oil reserves become the more people will be dependent on alternative or public transportation and a decrease in the demand for cars could be expected
16	**Global demand for cars**	**Overcapacity for production of converters**		**X**	**-0.80**	When the demand for cars increases the excess spare-capacity with regards to Asian countries' ability to manufacture catalytic converters are reduced

Respondent's strength ratings

Ave	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
0.30	0.08	0.3	0.15	0.3	0.3	0.2	0.5	0.3	0.7	0.3	0.3	0.1	0.25	0.3	0.45	0.3
0.30	0	0.3	0.25	0.55	0.3	0.35	0.4	0.3	0.2	0.7	0.25	0.15	0.3	0.12	0.1	0.5
-0.80	-0.8	-0.25	-0.75	-0.65	-0.95	-1	-0.8	-0.95	-0.8	-0.85	-0.8	-0.8	-0.85	-0.8	-0.75	-1
0.50	0.45	0.6	0.3	0.7	0.35	0.5	0.8	0.25	0.55	0.5	0.7	0.4	0.45	0.8	0.2	0.4
0.20	0.1	0.5	0.25	0.2	0.4	0.3	0	0	0.2	0.15	0.35	0.4	0	0	0.15	0.2
-0.40	-0.6	-0.4	-0.5	-0.4	-0.35	-0.55	-0.05	-0.45	-0.25	-0.3	-0.6	-0.45	-0.5	-0.3	-0.65	0
-0.60	0.1	-0.8	-0.7	0.15	0	-1	0	-1	-0.7	-0.75	-0.6	-0.8	-0.8	-0.9	-0.9	-0.85
-0.60	-0.05	0.4	-0.9	-1	-0.6	-0.8	-1	-0.95	-0.5	-0.65	-0.55	-0.4	-0.8	-0.75	-0.35	-0.65
-0.80	-1	-0.55	-0.45	-0.95	-0.85	-0.6	-1	-0.85	-0.6	-0.6	-0.9	-0.9	-0.85	-0.8	-1	-0.85

#	From	To	+	-	Strength	Comments
	Causal Links between Drivers of Demand and Sustainability Indicators					
17	**Overcapacity for production of converters**	**European demand for converters**		X	-0.00	Excess capacity to manufacture autocatalytic converters in Asian countries will not impact on the demand for converters in Europe as very few converters are currently imported into Europe from the Asian region.
18	**European demand for converters**	**Demand for SA converters**	X		0.90	Over 90% of current South African converters are exported to Europe, an increase in the demand for European converters therefore would mean an increase in the current manufacturing of autocatalytic converters within South Africa
19	**Global demand for cars**	**European demand for cars**	X		0.80	It is expected that if the global demand for cars increase the European demand for cars would also increase. Car sales in Europe remained flat during 2012 but car sales in North America and Asian markets increased. However cars manufactured in Europe for export to the USA and other export markets also increased therefore it could be assumed that there exists a significant positive link
20	**European demand for cars**	**European demand for converters**	X		0.99	Every car manufactured and sold in Europe need to comply to European environmental legislation and therefore require the fitment of an autocatalytic converter to the vehicle.
21	**Inflation**	**Economic recession**	X		0.51	Macro-economic principles related to the availability of funds and credit, spendable income of average citizen
22	**Economic recession**	**Global demand for cars**		X	-0.80	Economic recession under normal circumstances negatively impacts on the sales of luxury goods such as cars.
23	**Credit availability**	**Economic recession**		X	-0.50	Macro-economic principles related to the availability of funds and credit, spendable income of average citizen
24	**Economic recession**	**European demand for cars**		X	-0.80	Economic recession under normal circumstances negatively impacts on the sales of luxury goods such as cars.

Respondent's strength ratings

Ave	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
-0.00	-0.05	-0.05	-0.15	0.15	0	-0.2	0	0	0	0.15	-0.05	0	0.2	-0.15	0.05	0.05
0.90	1	0.9	1	0.7	0.95	0.65	0.9	0.9	0.85	1	1	1	0.95	1	0.85	0.8
0.80	0.5	1	0.85	0.9	0.75	0.65	0.8	1	0.8	0.95	0.5	0.95	0.8	0.8	0.75	0.8
0.99	1	1	1	1	0.9	1	1	1	1	1	1	0.95	1	1	1	1
0.51	0.5	0.65	0.45	0.3	0.5	0.5	0.75	0.4	0.5	0.5	0.9	0.5	0.45	0.4	0.5	0.35
-0.80	-0.95	-1	-0.8	-0.75	-0.65	-0.9	-0.85	-0.8	-0.8	-0.75	-0.8	-0.7	-0.8	-0.85	-0.65	-0.8
-0.50	-0.5	-0.2	-0.5	-0.5	-0.4	-0.5	-0.5	-0.5	-0.7	-0.5	-0.25	-0.8	-0.5	-0.5	-0.65	-0.5
-0.80	-1	-0.85	-1	-0.9	-0.4	-0.95	-0.9	-0.8	-0.9	-0.8	-0.95	-0.8	-0.8	-0.5	-0.4	-0.8

#	From	To	+	-	Strength	Comments	Respondent's strength ratings														
	Causal Links between Drivers of Demand and Sustainability Indicators						**Ave**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
25	**Global demand for cars**	**PGM Reserves**		X	**-0.40**	The world PGM reserves are limited and therefore the greater number of cars manufactured the more PGMs from this limited reserve will be used.	**-0.40**	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4
26	**Foreign Direct Investment in Africa**	**Economic growth in Africa**	X		**0.80**	Foreign direct investment is considered important for sustainable economic development and growth of Africa as a continent.	**0.80**	1	0.8	0.9	0.8	1	1	0.8	0.8	0.45	0.8	0.55	0.5	0.8	0.8	1	0.85
27	**Economic growth in Africa**	**Demand for SA converters**	X		**0.80**	It is expected that if Africa develops its economic capability, the living standards of its inhabitants will rise and so also the demands for cars. Africa is believed to be a massive untapped future growth market. South Africa with its established autocatalytic converter industry could therefore be a major supplier into African markets.	**0.80**	0.9	0.8	0.75	0.8	0.6	0.8	1	0.8	0.8	0.8	0.7	0.95	0.8	0.6	0.85	0.85
28	**Russian/Foreign PGM reserves**	**PGM Reserves**	X		**0.99**	The threat of Russia releasing their reserves of refined PGM could impact and disrupt the market forces surrounding the demand and supply of PGM	**0.99**	0.95	1	1	1	1	0.95	1	1	1	1	1	1	1	1	1	1
29	**Global demand for cars**	**Increase in pollution**			**0.80**	The increase of cars on the roads are expected to increase pollution levels emitted every year	**0.80**	0.8	0.8	0.8	0.8	1	0.8	0.8	0.8	1	0.45	0.9	0.55	0.8	0.85	0.8	0.8
30	**Increase in pollution**	**New propulsion method: Fuel Cells**	X		**0.50**	Higher pollution levels will strengthen the call for greener or more environmentally friendly propulsion technologies	**0.50**	0.35	-0.15	0.65	0.5	0.45	0.5	0.5	0.85	0.55	0.5	0.65	0.5	0.3	0.5	0.9	0.5
31	**Increase in pollution**	**Environmental legislation**	X		**0.90**	Higher pollution levels will strengthen the call for greener or more restrictive environmental legislation	**0.90**	1	1	1	0.9	0.9	1	1	0.9	0.5	0.8	0.9	0.9	0.95	0.7	1	0.9
32	**New propulsion method: Fuel Cells**	**PGM Reserves**		X	**-0.20**	Fuel cells require more PGMs than an ordinary catalyst and therefore higher production will reduce existing PGM reserves more.	**-0.20**	-0.2	0.3	0.4	-0.85	-0.2	-0.2	-0.2	-0.25	-0.2	-0.45	-0.2	-0.4	-0.2	-0.1	0.1	-0.55

#	From	To	+	-	Strength	Comments	Respondent's strength ratings														
	Causal Links between Drivers of Demand and Sustainability Indicators						**Ave**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
33	**Environmental legislation**	**Diesel Technology**		X	-0.20	Stricter environment legislation may reduce the demand for diesel technology as this technology maybe more economical it is also considered more detrimental to the environment	-0.20	-0.1	-0.4	-0.15	-0.2	-0.2	-0.35	-0.2	-0.05	-0.5	-0.2	0.05	-0.1	-0.2	-0.25	-0.2	-0.15
34	**Diesel Technology**	**PGM Reserves**		X	-0.50	Diesel technology in general requires more PGMs than an ordinary gasoline catalyst and therefore higher production will reduce existing PGM reserves more.	-0.50	-0.9	-0.5	-0.2	-0.55	-0.5	-0.45	-0.5	-0.5	-0.4	-0.5	-0.1	-0.5	-1	-0.5	-0.5	-0.35
35	**Increase in pollution**	**New propulsion method:Electric cars**	X		0.30	Greater pollution levels may strengthen the call for cleaner and more green technology such as electric cars	0.30	0.3	0.3	-0.1	0.3	0.3	0.65	0.3	0.3	0.55	0.3	0.25	0.15	0.45	0.3	0.25	0.2
36	**New propulsion method:Electric cars**	**PGM Reserves**		X	-0.00	Electric cars do not require PGMs and therefore will have limited impact on PGM reserves	-0.00	0	-0.4	0	0	0	0.05	0.05	0.35	0.35	0	0.2	0	-0.05	-0.55	0	0
37	**Environmental legislation**	**European demand for cars**		X	-0.00	Stricter environmental legislation may impose greater technology requirements on autocatalytic converters but will not necessarily reduce demand for cars in Europe	-0.00	0.2	0.1	0.15	-0.8	-0.6	-0.45	0.4	0.35	0.1	0	0	0	0.15	0	0.2	0.15
38	**Environmental legislation**	**New converter technology**	X		1.00	Stricter environmental legislation may impose greater technology requirements on autocatalytic converters and is considered one of the biggest drivers for improvements within the industry.	1.00	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
39	**New converter technology**	**PGM Reserves**		X	-0.20	New autocatalytic converter technologies generally require less PGMs per catalyst and would therefore reduce the demand for PGMs. Certain new autocatalytic converter technologies would however require greater combinations of different PGM metals and could influence the reserves of rhodium and palladium more significantly. The greater demand for PGMs associated with diesel technologies such as trucks could impact on available PGM reserves.	-0.20	-0.35	0.15	-0.2	0.35	-0.2	-0.05	-0.05	-0.2	-0.5	-0.3	-0.45	-0.25	-0.2	-0.35	-0.35	-0.2
40	**Other industrial uses for PGM**	**PGM Reserves**		X	-0.50	PGM reserves and deposits are finite and increase in the number of uses for PGMs will place these reserves under pressure	-0.50	-0.6	-0.5	-0.5	-0.55	-0.45	-0.7	-0.25	-0.5	-0.35	-0.7	-0.45	-0.5	-0.45	-0.5	-0.55	-0.5

#	From	To	+	-	Strength	Comments
	Causal Links between Drivers of Demand and Sustainability Indicators					
41	**Asian demand for cars**	**Global demand for cars**	X		0.50	The Asian automotive industry is believed to form a significant portion of the global demand for cars
42	**Asian demand for cars**	**Asian converter production capability**	X		0.70	Environmental legislation around automotive emissions are expected to increase in the near future and new vehicles will be expected to be fitted with a autocatalytic converter
43	**Asian converter production capability**	**European demand fof converters**	X		0.30	If the Asian autocatalytic converter production capability improves so will their capability to supply to European markets
44	**Asian Labour cost**	**Asian converter production capability**		X	-0.05	Relatively low labour costs in Asian countries is expected to in the medium term place a damper on the highly skilled labour force associated with manufacturing autocatalytic converters
45	**Exchange rate (Rand more favourable)**	**Demand for SA converters**		X	-0.90	Strengthening of the South African currency will make the converters supplied from South Africa more expensive as the majority of converters are supplied to European markets.
46	**Exchange rate (Rand more favourable)**	**Cost leader**	X		0.70	Strengthening of the South African currency will make the converters supplied from South Africa more expensive as the majority of converters are supplied to European markets. However majority of the raw materials used in the manufacturing of converters are imported and a strong ZAR will reduce operating expenses and improve profit margins.
47	**Steel price (South Africa)**	**Cost leader**		X	-0.40	Steel forms a major part of the final product (exhaust system) that is exported and a significant increase in the price of steel could make the exhaust system more expensive to the OEMs
48	**Oil price**	**Cost leader**		X	-0.50	Rising energy costs will increase manufacturing costs associated with the manufacturing of autocatalytic converters

Respondent's strength ratings

Ave	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
0.50	0.6	-0.05	0	0.05	0.75	0.5	0.65	0.35	0.5	0.5	0.85	0.5	0.45	0.7	0.85	0.75
0.70	0.3	0.55	0.7	0.95	0.75	0.95	0.7	0.7	0.85	0.9	0.7	0.7	0.7	0.65	0.45	0.7
0.30	0.3	0.25	0.5	0.3	0.3	0.35	0.4	0.25	0.3	0.3	0.35	0.25	0.25	0.25	0.25	0.25
-0.05	-0.05	0.05	-0.15	0.05	-0.015	-0.05	-0.05	-0.15	-0.1	-0.05	-0.05	-0.05	-0.05	-0.1	0.05	-0.05
-0.90	-1	-1	-0.9	-0.8	-0.75	-1	-1	-0.85	-0.85	-0.75	-0.9	-1	-0.9	-0.9	-1	-0.85
0.70	0.8	0.7	0.8	0.7	0.6	0.7	0.7	0.75	0.85	0.7	0.7	0.55	0.5	0.7	0.75	0.7
-0.40	-0.45	-0.35	-0.3	-0.4	-0.05	-0.4	-0.4	-0.4	-0.4	-0.45	-0.4	-0.45	-0.55	-0.4	-0.65	-0.4
-0.50	-0.5	-0.55	-0.5	-0.5	-0.5	-0.5	-0.65	-0.5	-0.35	-0.5	-0.5	-0.5	-0.5	-0.7	-0.25	-0.5

#	From	To	+	-	Strength	Comments	Respondent's strength ratings														
							Ave	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	Causal Links between Drivers of Demand and Sustainability Indicators																						
49	**PGM Price**	**Cost leader**		X	-0.60	Rising PGM prices will increase manufacturing costs associated with the manufacturing of autocatalytic converters	-0.60	-1	-0.95	-0.9	-0.6	-0.75	-0.6	-0.7	0	0	-0.85	-0.6	-0.6	0	-0.65	-0.6	-0.75
50	**Unstable SA Electricity supply**	**Cost leader**		X	-0.50	Inconsistent electricity supply will disrupt the manufacturing capacity and could lead to increased manufacturing costs associated with the manufacturing of autocatalytic converters	-0.50	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5
51	**Unstable SA Electricity supply**	**PGM Reserves**		X	-0.59	Inconsistent electricity supply will disrupt the mining capacity and could lead to increased mining costs associated with the mining and refining of PGM ore.	-0.59	-0.45	-0.6	-0.55	-0.75	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.65	-0.45	-0.4	-0.75	-0.65	-0.65
52	**Unstable SA Electricity supply**	**SA electrivity costs**	X		0.20	Inconsistent electricity supply will disrupt the manufacturing industry. The ability to meet demand for electricity will require capital expenditure to improve and increase the electrical grid infrastructure and could lead to higher electrical costs per unit.	0.20	0.15	0.2	0.15	0.15	0.2	0.15	0.2	0.2	0.35	0.2	0.25	0.2	0.3	0.15	0.1	0.3
53	**SA electricity costs**	**Cost leader**		X	-0.50	Rising energy costs will increase manufacturing costs associated with the manufacturing of autocatalytic converters	-0.50	-0.8	-0.7	-0.5	-0.5	-0.2	-0.5	-0.45	-0.45	-0.4	-0.55	-0.5	-0.5	-0.5	-0.7	-0.3	-0.5
54	**SA labour costs**	**Cost leader**		X	-0.50	Rising labour costs will increase manufacturing costs associated with the manufacturing of autocatalytic converters	-0.50	-0.85	-0.9	-0.3	-0.45	-0.6	-0.35	-0.25	-0.4	-0.55	-0.45	-0.5	-0.5	-0.45	-0.5	-0.45	-0.55
55	**Stable SA Politics**	**Foreign Direct Investment in Africa**	X		0.90	Stable politics regarded as significant to stimulate a positive sentiment for foreign investors.	0.90	0.7	0.65	0.9	0.9	1	0.9	0.9	0.9	0.8	0.9	1	1	0.95	1	1	0.9
56	**SA Globally competitive**	**Demand for SA converters**	X		0.80	The demand for autocatalytic converters are driven by quality, cost, legislation, technology.	0.80	0.75	0.8	0.6	0.8	0.8	0.8	0.75	0.8	0.8	0.7	0.8	0.8	0.9	0.95	0.8	1
57	**Unstable SA labour relations**	**PGM Reserves**		X	-0.70	Inconsistent and unstable labour supply to the mining industry will disrupt the capacity and output as the industry is heavily labour intensive.	-0.70	-0.7	-0.45	-0.7	-0.7	-0.55	-0.7	-0.6	-0.95	-0.7	-0.7	-0.7	-0.7	-0.7	-1	-0.7	-0.7

#	From	To	+	-	Strength	Comments
	Causal Links between Drivers of Demand and Sustainability Indicators					
58	**Unstable SA labour relations**	**SA labour costs**	X		0.40	Inconsistent and unstable labour supply to the mining and manufacturing industries together with continuous demands for higher wages will put pressure on already thin profit margins.
59	**External flexibility**	**Cost leader**		X	-0.20	External flexibility perceived to be associated with high stock levels, non-optimised production runs and batch sizes
60	**Clear two way internal communication**	**Cost leader**	X		0.30	Communication expected to promote process improvement and optimisation.
61	**Clear two way internal communication**	**Innovation capability**	X		0.50	Communication expected to enhance promote and enhance innovation
62	**Clear two way internal communication**	**Internal flexibility**	X		0.80	Communication expected to promote and enhance internal flexibility within the organisation
63	**Clear two way internal communication**	**Internal customer satisfaction orientated**	X		0.80	Communication expected to enhance clear understanding of customer expectations and requirements and also the cascading down of these requirements throughout the entire organisation
64	**Clear two way internal communication**	**External flexibility**	X		0.50	Communication expected to enhance clear understanding of customer expectations and requirements and also the cascading down of these requirements throughout the entire organisation
65	**Clear two way internal communication**	**Internal quality**	X		0.60	Communication expected to enhance clear understanding of customer expectations and requirements and also the cascading down of these requirements throughout the entire organisation
66	**Internal quality**	**Cost leader**	X		0.80	Internal quality lowers processing waste and therefore should lower manufacturing costs
67	**Internal quality**	**External flexibility**	X		0.60	Internal quality requires focus and commitment to optimise process and product and therefore should positively influence external flexibility

Respondent's strength ratings

Ave	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
0.40	0.55	0.4	0.65	0.4	0.4	0.3	0.4	0.4	0.45	0.4	0.4	0.1	0.4	0.4	0.35	0.4
-0.20	-0.2	-0.25	-0.2	-0.35	-0.2	-0.2	0.25	-0.6	-0.2	-0.2	-0.2	0.45	-0.2	-0.1	-0.8	-0.2
0.30	0.3	0.25	0.65	0.3	0.3	0	0.1	0	0.3	0.3	0.3	0.3	0.2	0.8	0.3	0.45
0.50	0.5	0.7	0.2	0.75	0.5	0.5	0.5	0.5	0.5	0	0.15	0.5	0.75	0.5	0.5	0.9
0.80	0.8	0.8	0.9	0.8	0.95	0.7	0.7	0.9	0.8	0.75	0.8	0.95	0.8	0.8	0.55	0.8
0.80	0.8	0.9	0.8	0.8	0.9	0.9	0.9	0.5	0.45	0.8	0.8	0.85	0.95	0.8	0.75	0.85
0.50	0.5	0.3	0.85	0.5	0.5	0.45	0.55	0.3	0.9	0.5	0.45	0.3	0.5	0.5	0.25	0.65
0.60	0.3	0.6	0.8	0.65	0.6	0.65	0.6	0.6	0.55	0.7	0.45	0.6	0.6	0.35	0.6	0.9
0.80	0.8	0.95	0.8	0.8	0.8	1	0.8	1	0.8	0.8	0.8	0.8	0.4	0.45	0.8	1
0.60	0.6	0.6	0.8	0.6	0.35	0.6	0.5	0.6	0.6	0.6	0.65	0.4	0.6	0.6	0.55	1

#	From	To	+	-	Strength	Comments
	Causal Links between Drivers of Demand and Sustainability Indicators					
68	**Internal quality**	**Internal flexibility**	X		**0.50**	Internal quality requires focus and commitment to optimise process and product and therefore should positively influence internal flexibility
69	**Internal quality**	**Innovation capability**	X		**0.40**	Internal quality requires strong focus on process and product quality and therefore should promote process optimisation, improvement and process innovation.
70	**Internal flexibility**	**Cost leader**		X	**-0.30**	Internal flexibility perceived to be associated with high stock levels, non-optimised production runs and batch sizes
71	**Internal flexibility**	**External flexibility**	X		**0.90**	Internal flexibility promotes capability to respond with sufficient speed to changing business environment and therefore will make the organisation more externally flexible
72	**Existance of effective waste elimination programme**	**External flexibility**	X		**0.80**	A programme that focus on the elimination of process waste is expected to promote an environment where an organisation will more successfully respond to changes in the external business environment
73	**Innovation capability**	**Cost leader**		X	**-0.19**	Innovation in the short term may increase operational costs due to the cost associated with implementation of the innovation. In the longer term innovation is expected to lower operational costs
74	**Production scheduling based on pull approach**	**Cost leader**	X		**0.40**	Production scheduling on a pull approach is expected to lower unnecessary inventory and therefore have positive impact on the cash conversion cycle and working capital
75	**Production scheduling based on pull approach**	**Internal flexibility**	X		**0.60**	Production scheduling on a pull approach is expected to lower unnecessary inventory and therefore have positive impact on the cash conversion cycle and working capital. This in turn may force an organisation to become more flexible with regards to its own internal operations
76	**Cost leader**	**SA Globally competitive**	X		**1.00**	With narrow profit margins considered to be a trademark of the industry, cost of a converter is one of the main drivers for demand.

Respondent's strength ratings

Ave	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
0.50	0.8	0.25	0.5	0.5	0.5	0.55	0.55	0.5	0.5	0.4	0.35	0.5	0.5	0.35	0.8	0.5
0.40	0.65	0.2	0.4	0.25	0.55	0.4	0.5	0.4	0.35	0.15	0.55	0.4	0.55	0.4	0.7	0
-0.30	-0.8	-0.85	-0.45	0	0	-0.35	-0.25	-0.3	-0.15	-0.05	-0.45	-0.5	-0.35	-0.3	-0.05	0.1
0.90	0.95	0.9	1	1	0.95	1	0.9	0.9	0.3	0.9	0.95	0.95	1	0.75	0.9	1
0.80	1	1	0.6	0.75	0.8	0.8	0.85	0.8	0.8	0.65	0.5	0.8	0.8	1	0.8	0.85
-0.19	-0.2	-0.5	-0.2	-0.2	0	0.15	0.3	-0.2	-0.5	-0.2	-0.3	-0.35	-0.2	-0.25	-0.2	-0.2
0.40	0.4	0.6	0.7	0.4	0.2	0.4	0.15	0.45	0.4	0.55	0.4	0.4	0.45	0.1	0.4	0.35
0.60	0.7	0.15	0.7	0.7	0.6	0.6	0.65	0.6	0.65	0.6	0.45	0.6	0.35	0.6	0.8	0.8
1.00	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

#	From	To	+	-	Strength	Comments
	Causal Links between Drivers of Demand and Sustainability Indicators					
77	**External flexibility**	**SA Globally competitive**	X		0.40	The ability to supply exactly what customers require with regards to quality, quantity and timing is a big driver in the industry
78	**Internal quality**	**SA Globally competitive**	X		1.00	The industry places high emphasis on quality of the components of a motor vehicle. Improve quality standards will provide a source of greater competiveness.
79	**Internal flexibility**	**SA Globally competitive**	X		0.40	The ability to restructure an organisations manufacturing capability to respond to new demands is considered to be advantageous and will improve competiveness
80	**Innovation capability**	**SA Globally competitive**	X		0.80	Customer demands and legislative obligations require the capability to regularly and speedily introduce new products
81	**Internal customer satisfaction orientated**	**SA Globally competitive**	X		0.70	Internal customer satisfaction orientated requires the breakdown of internal departments operating as silos and promotes adherence to quality standards
82	**Internal customer satisfaction orientated**	**Internal flexibility**	X		0.40	Internal customer satisfaction orientated requires the breakdown of internal departments operating as silos and promotes adherence to quality standards
83	**SA Globally competitive**	**Demand for SA converters**	X		0.90	The demand for South African convertors is driven by quality and cost.
84	**Exchange rate (Rand more favourable)**	**Foreign Direct Investment in Africa**		X	-0.60	The stronger the South African currency the more expensive it will be to invest in South Africa.
85	**Unstable SA Electricity supply**	**Foreign Direct Investment in Africa**		X	-0.80	The instability of electrical supply will make South Africa less attractive for most foreign investments into the manufacturing industries.
86	**Learning organisational culture**	**Existence of effective Quality at source program**	X		0.70	The ability for an organisation to learn from previous mistakes, correct behaviour will be beneficial to a Quality at source program.

Respondent's strength ratings

Ave	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
0.40	0.15	0.7	0.45	0.2	0.3	0.9	0.7	0.3	1	0.2	0.2	0.15	0.4	0.4	0.25	0.15
1.00	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
0.40	0.2	0.15	0.45	0.15	0.55	0.6	0.45	0.5	0.4	0.1	0.1	0.55	0.65	0.45	0.55	0.5
0.80	0.9	1	1	0.5	0.8	0.8	0.8	0.75	0.9	0.95	0.65	0.45	0.9	0.8	0.75	0.85
0.70	0.9	1	0.55	0.45	0.7	0.7	0.65	0.8	0.85	0.6	0.55	0.7	0.7	0.9	0.5	0.7
0.40	0.35	0.55	0.25	0.6	0.75	0.2	0.25	0.35	0.4	0.4	0.45	0.25	0.25	0.4	0.65	0.35
0.90	1	1	1	0.7	0.85	0.9	1	0.9	0.65	0.9	1	0.9	0.9	0.85	0.95	0.9
-0.60	-0.4	-0.8	-0.65	-0.6	-0.6	-0.4	-0.35	-0.8	-0.8	-0.6	-0.6	-0.55	-0.45	-0.6	-0.6	-0.8
-0.80	-0.75	-0.55	-0.9	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.65	-0.85	-0.8	-0.55	-1	-0.95	-1
0.70	0.9	0.85	0.7	0.55	0.7	0.85	1	1	0.4	0.45	0.6	0.7	0.9	0.5	0.6	0.55

#	From	To	+	-	Strength	Comments
	Causal Links between Drivers of Demand and Sustainability Indicators					
87	**Learning organisational culture**	**Ownership of quality among employees**	**X**		**0.70**	The ability for an organisation to learn from previous mistakes, correct behaviour will be beneficial to promote ownership and accountability among employees.
88	**Learning organisational culture**	**Optimum inventory levels**	**X**		**0.30**	The ability for an organisation to learn from previous mistakes, correct behaviour will be beneficial to manage their inventory levels at optimum levels
89	**Learning organisational culture**	**Strong focus on lead time reduction**	**X**		**0.60**	The ability for an organisation to learn from previous mistakes, correct behaviour will be beneficial to ensure sufficient focus on reducing lead times.
90	**Learning organisational culture**	**Integrated Materials Resource Planning (MRP) system**	**X**		**0.50**	The ability for an organisation to learn from previous mistakes, correct behaviour will be beneficial to manage their inventory levels at optimum levels
91	**Learning organisational culture**	**Innovation capability**	**X**		**0.90**	The ability for an organisation to learn from previous mistakes, correct behaviour will be beneficial to create an environment where innovation could blossom
92	**Learning organisational culture**	**Facility control**	**X**		**0.30**	The ability for an organisation to learn from previous mistakes, correct behaviour will be beneficial to ensure good and optimum use of a facility.
93	**Existence of effective Quality at source program**	**Existence of effective waste elimination programme**	**X**		**0.90**	Quality at source will ensure a mind-set among employees to do things right the first time and by doing that minimise waste throughout the process
94	**Well defined manufacturing strategy**	**Effective use of SPC**	**X**		**0.90**	A manufacturing strategy align all control , optimisation, improvement and quality aspects of the manufacturing process
95	**Well defined manufacturing strategy**	**Existence of effective Quality at source program**	**X**		**0.91**	A manufacturing strategy align all control , optimisation, improvement and quality aspects of the manufacturing process
96	**Well defined manufacturing strategy**	**Ownership of quality among employees**	**X**		**0.80**	A manufacturing strategy align all control , optimisation, improvement and quality aspects of the manufacturing process

Respondent's strength ratings

Ave	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
0.70	1	1	0.55	1	0.45	0.55	0.8	0.35	0.7	0.65	0.7	0.8	0.45	0.85	0.7	0.7
0.30	0.15	0.25	0.3	0.65	0.3	0.3	0.15	0.4	0.4	0.35	0.3	0.45	0.2	0.25	0.15	0.2
0.60	0.6	0.55	0.6	0.9	0.45	0.6	0.6	0.45	0.6	0.8	0.6	0.35	0.6	0.6	0.55	0.75
0.50	0.45	0.45	0.75	0.5	0.45	0.5	0.6	0.3	0.5	0.9	0.5	0.35	0.5	0.35	0.45	0.5
0.90	0.9	0.9	1	0.95	0.9	0.95	0.75	0.9	0.9	0.65	0.9	0.9	0.9	1	0.9	1
0.30	0.55	0.3	0.3	0.1	0.3	0.25	0.2	0.15	0.75	0.3	0.3	0.25	0.35	0.3	0.15	0.3
0.90	1	1	1	0.9	1	1	0.75	0.75	1	0.6	0.9	0.55	0.9	1	1	1
0.90	0.45	1	0.9	1	0.9	1	0.9	0.9	0.85	0.9	1	0.9	0.9	1	0.9	0.9
0.91	1	0.9	1	1	0.9	1	0.9	0.9	0.85	0.9	1	0.9	0.85	0.8	0.8	0.8
0.80	1	0.8	1	1	0.6	1	0.8	0.8	0.8	0.8	0.75	0.6	0.5	0.85	0.8	0.7

#	From	To	+	-	Strength	Comments
	Causal Links between Drivers of Demand and Sustainability Indicators					
97	**Leadership commitment to WCO**	**Well defined manufacturing strategy**	**X**		**1.00**	A commitment of the organisational leadership to the World class operational elements will enhance the manufacturing strategy
98	**Leadership commitment to WCO**	**Learning organisational culture**	**X**		**0.90**	A commitment of the organisational leadership to the World class operational elements will promote an organisational culture where an organisation continuously learn from and aim to improve their own performance
99	**Leadership commitment to WCO**	**Clear two way internal communication**	**X**		**0.80**	A commitment of the organisational leadership to the World class operational elements will enhance communication throughout the organisation top to bottom and bottom to top.
100	**Effective use of SPC**	**Existance of effective waste elimination programme**	**X**		**0.82**	SPC as a quality assurance tool aims to identify any trends in a process and if control limits are set correctly will prompt corrective action before waste is generated.
101	**Effective preventative maintenance programme**	**Facility control**	**X**		**0.80**	An effective maintenance programme will improve the optimum use of the facility e.g. equipment, machinery
102	**Cellular production layout**	**Facility control**	**X**		**0.80**	A cellular production layout could maximise the use of the facility e.g. buildings, floor space etc.
103	**Existance of effective waste elimination programme**	**Facility control**	**X**		**0.30**	A focus on the elimination of process waste could maximise the use of the facility e.g. buildings, floor space etc.
104	**Facility control**	**Strong focus on lead time reduction**	**X**		**0.70**	The optimum use of the facility e.g. buildings, floor space etc. could contribute to the improvement of materials handling and the reduction of lead times as well as the elimination of process waste.
105	**Effective vendor management programme**	**Internal quality**	**X**		**0.50**	Managing suppliers/vendors very closely will ensure that quality concerns with regards to inbound raw materials and equipment are identified and dealt with effectively before the internal quality of an organisation's processes are affected.
106	**Effective vendor management programme**	**Strong focus on lead time reduction**	**X**		**0.70**	Managing suppliers/vendors very closely will ensure that logistical concerns with regards to inbound raw materials and equipment are identified and dealt with effectively to ensure that raw materials arrive at the facility at the correct time to ensure that the processing lead times of the organisation are not compromised.

Respondent's strength ratings

Ave	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1.00	0.95	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
0.90	1	0.9	0.6	0.7	1	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	1	1	1
0.80	0.9	0.8	1	0.8	0.8	0.75	0.65	0.8	1	1	0.8	0.8	0.55	0.65	0.8	0.65
0.82	0.9	0.8	0.8	0.9	0.8	0.65	0.85	0.8	0.8	0.8	0.8	1	1	0.75	0.8	0.65
0.80	1	1	0.9	0.75	0.7	0.75	0.8	0.75	0.8	0.9	0.6	1	0.6	0.8	0.7	0.8
0.80	0.6	0.8	0.9	0.8	0.9	0.8	0.7	0.8	0.75	0.8	0.8	0.9	0.8	0.8	0.8	0.9
0.30	0.5	0.3	0.3	0.3	0.6	0.3	0.3	0.25	0.3	0.15	0.2	0.15	0.3	0.3	0.55	0.05
0.70	0.8	0.7	0.7	0.7	0.6	0.7	0.7	1	0.5	0.8	0.7	0.75	0.7	0.5	0.7	0.7
0.50	0.3	0.45	0.25	0.5	0.65	0.45	0.8	0.5	0.5	0.5	0.5	0.5	0.5	0.9	0.4	0.35
0.70	0.7	0.9	0.9	0.6	0.7	0.9	0.8	0.65	0.7	0.7	0.8	0.5	0.7	0.75	0.6	0.35

#	From	To	+	-	Strength	Comments	Respondent's strength ratings														
	Causal Links between Drivers of Demand and Sustainability Indicators						**Ave**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
107	**Effective vendor management programme**	**Optimum inventory levels**	**X**		**0.70**	Managing suppliers/vendors very closely will ensure that logistical concerns with regards to inbound raw materials and equipment are identified and dealt with effectively to ensure that raw materials arrive at the facility at the correct time consistently and reliably. This would then allow an organisation to reduce its inventory levels and not to carry excessive safety /buffer stocks.	**0.70**	1	0.7	0.7	0.5	0.7	0.7	0.6	0.7	0.8	0.7	0.9	0.7	0.4	0.7	0.7	0.7
108	**Strong focus on lead time reduction**	**Production scheduling based on pull approach**	**X**		**0.99**	Optimising processing lead time will cultivate a culture where the focus will be on the arrival of raw materials just-in-time for when it is needed and therefore stimulate production scheduling on a pull approach	**0.99**	0.95	1	1	1	1	1	1	1	1	1	0.95	1	1	1	1	1
109	**Materials Resource Planning (MRP) system**	**Production scheduling based on pull approach**	**X**		**0.99**	An integrated Materials Resource Planning system will cultivate a culture where the focus will be on the arrival of raw materials just-in-time for when it is needed and therefore stimulate production scheduling on a pull approach	**0.99**	0.95	1	1	1	1	1	1	1	1	1	0.95	1	1	1	1	1
110	**Optimum inventory levels**	**Production scheduling based on pull approach**	**X**		**0.90**	Ensuring that inventory levels are managed optimally will result in required raw materials arriving just in time when needed and therefore stimulating production scheduling based on a pull approach	**0.90**	0.9	0.9	1	0.9	0.7	0.9	0.9	0.9	1	0.9	0.9	0.9	0.85	1	0.9	0.9
111	**Ownership of quality among employees**	**Internal quality**	**X**		**0.99**	Ownership of quality among employees will minimise waste and promote an environment where quality at source improves the quality of every step of the manufacturing process	**0.99**	1	0.85	1	1	1	1	1	1	1	0.95	1	1	1	1	1	1

#	Causal Links between Strategies and Sustainability Indicators						AVE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	**Effective preventative maintenance programme**	**facility control**		**X**	**0.20**	An effective maintenance programme will improve the optimum use of the facility e.g. equipment, machinery	**0.20**	0.35	0.1	0.2	0.2	0.05	0.15	0.2	0.35	0.2	0.25	0.1	0.2	0.15	0.35	0.15	0.2

#	Causal Links between Strategies and Sustainability Indicators						AVE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
2	**Cellular production layout**	**facility control**	**X**		**0.20**	A cellular production layout could maximise the use of the facility e.g. buildings, floor space etc.	**0.20**	0.35	0.1	0.2	0.25	0.05	0.15	0.2	0.35	0.2	0.25	0.1	0.2	0.15	0.35	0.15	0.2
3	**Leadership commitment to WCO**	**manufacturing strategy**	**X**		**1.00**	A commitment of the organisational leadership to the World class operational elements will enhance the manufacturing strategy	**1.00**	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4	**Leadership commitment to WCO**	**Learning organisational culture**			**0.80**	A commitment of the organisational leadership to the World class operational elements will promote an organisational culture where an organisation continuously learn from and aim to improve their own performance	**0.80**	0.95	0.65	0.75	0.8	1	0.8	0.4	0.8	0.95	0.55	1	0.8	0.8	1	0.8	0.8
5	**Leadership commitment to WCO**	**Clear two way link to and understanding of custumer requirments**			**0.80**	A commitment of the organisational leadership to the World class operational elements will enhance communication throughout the organisation top to bottom and bottom to top.	**0.80**	0.85	0.75	0.65	0.75	0.8	0.8	0.8	0.7	0.7	0.8	0.9	1	0.8	0.8	0.8	0.9	0.8
6	**Unstable SA labour relations**	**SA Labour costs**	**X**		**0.50**	Inconsistent and unstable labour supply to the mining and manufacturing industries together with continuous demands for higher wages will put pressure on already thin profit margins.	**0.50**	0.4	0.5	0.65	0.35	0.5	0.45	0.5	0.9	0.35	0.35	0.5	0.5	0.8	0.5	0.4	0.4
7	**Unstable SA labour relations**	**PGM reserves**		**X**	**-0.80**	Inconsistent and unstable labour supply to the mining industry will disrupt the capacity and output as the industry is heavily labour intensive.	**-0.80**	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8
8	**Russian PGM reserves**	**PGM reserves**		**X**	**-0.80**	The release of stockpiled Russian PGM reserves into the open market will reduce the Russian stockpile but increase the PGMs available in the market	**-0.80**	-0.9	-0.8	-1	-0.8	-0.8	-0.9	-0.4	-0.5	-0.8	-0.8	-0.8	-0.95	-0.7	-0.8	-0.8	-1
9	**Global Electricity costs**	**PGM reserves**		**X**	**-0.39**	Mining and refining of PGMs consumes significant amount of electricity and increases in the global electricity costs will affect the PGMs mined and refined	**-0.39**	0	0	-0.4	-0.45	-0.8	-0.4	-0.6	-0.5	-0.4	0	-0.4	-0.4	-0.4	-0.5	-0.6	-0.45
10	**Global Electricity costs**	**Oil reserves**	**X**		**0.05**	Refining of oil consumes significant amount of electricity and increases in the global electricity costs could affect the available oil reserves.	**0.05**	0.05	0	0.05	0	0	0.05	0.05	0	0.05	0.25	0.05	0	0.15	0.05	0.05	0.05

#	Causal Links between Strategies and Sustainability Indicators						AVE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
11	Global Electricity costs	Steel Availability		X	-0.05	Steel production consumes significant amount of electricity and increases in the global electricity costs could affect the available steel.	-0.05	-0.05	0	-0.05	0	0	-0.05	-0.05	0	-0.05	-0.35	-0.05	0	-0.05	-0.05	-0.05	-0.05
12	Economic recession	Global demand for cars		X	-0.99	Motor vehicles are considered luxury goods and therefore heavily impact in economic constraint times where households would rather hold back on the purchase of a new motor vehicle for the family	-0.99	-0.95	-1	-1	-1	-1	-1	-1	-1	-1	-0.95	-1	-1	-1	-1	-1	-1
13	Economic recession	European demand for cars		X	-0.99	Motor vehicles are considered luxury goods and therefore heavily impact in economic constraint times where households would rather hold back on the purchase of a new motor vehicle for the family	-0.99	-0.95	-1	-1	-1	-1	-1	-1	-1	-1	-0.95	-1	-1	-1	-1	-1	-1
14	Asian Labour cost	Asian converter production		X	-0.39	Relatively low labour costs in Asian countries is expected to in the medium term place a damper on the highly skilled labour force associated with manufacturing autocatalytic converters	-0.39	-0.4	-0.25	-0.5	-0.4	-0.4	-0.6	-0.4	-0.5	-0.05	-0.4	-0.4	-0.4	-0.4	-0.55	-0.06	-0.6
15	Asian car demand	Asian converter production	X		0.81	Environmental legislation around automotive emissions are expected to increase in the near future and new vehicles will be expected to be fitted with a autocatalytic converter	0.81	1	0.8	0.65	0.8	0.65	0.8	0.9	0.8	0.8	0.8	1	0.8	0.7	0.8	0.8	0.8
16	Stable SA Politics	FDI in Africa	X		0.81	Stable politics regarded as significant to stimulate a positive sentiment for foreign investors.	0.81	1	1	0.8	0.9	1	0.9	0.8	1	1	1	0.65	0.65	0.5	0.8	0.5	0.4
17	Unstable SA Electricity supply	PGM reserves		X	-0.60	Inconsistent electricity supply will disrupt the mining capacity and could lead to increased mining costs associated with the mining and refining of PGM ore.	-0.60	-0.8	-0.9	-1	-0.4	-0.55	-0.6	-0.6	-0.8	-0.6	-0.4	-0.4	-0.4	-0.4	-0.5	-0.7	-0.6
18	Unstable SA Electricity supply	FDI in Africa		X	-0.80	The instability of electrical supply will make South Africa less attractive for most foreign investments into the manufacturing industries.	-0.80	-0.8	-0.9	-0.9	-0.65	-0.7	-0.7	-0.8	-1	-0.6	-0.8	-0.8	-0.8	-0.8	-1	-0.8	-0.8
19	Unstable SA Electricity supply	Cost leader		X	-1.00	Inconsistent electricity supply will disrupt the manufacturing capacity and could lead to increased manufacturing costs associated with the manufacturing of autocatalytic converters	-1.00	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1

#	Causal Links between Strategies and Sustainability Indicators						AVE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
20	**Unstable SA Electricity supply**	**SA electricity costs**		X	**-0.90**	Inconsistent electricity supply will disrupt the manufacturing industry. The ability to meet demand for electricity will require capital expenditure to improve and increase the electrical grid infrastructure and could lead to higher electrical costs per unit.	**-0.90**	-1	-0.9	-0.9	-1	-1	-0.9	-0.95	-0.8	-1	-0.9	-0.95	-0.9	-0.95	-0.45	-0.75	-1
21	**Effective vendor management programme**	**Internal quality**	X		**0.40**	Managing suppliers/vendors very closely will ensure that quality concerns with regards to inbound raw materials and equipment are identified and dealt with effectively before the internal quality of an organisation's processes are affected.	**0.40**	0.5	0.4	0.25	0.3	0.4	0.4	0.4	0.4	0.8	0.4	0.35	0.4	0.4	0.2	0.4	0.4
22	**Effective vendor management programme**	**Optimum inventory levels**	X		**0.81**	Managing suppliers/vendors very closely will ensure that logistical concerns with regards to inbound raw materials and equipment are identified and dealt with effectively to ensure that raw materials arrive at the facility at the correct time consistently and reliably. This would then allow an organisation to reduce its inventory levels and not to carry excessive safety /buffer stocks.	**0.81**	1	0.8	0.65	0.8	0,7	0.8	0.8	0.8	1	0.8	1	0.8	0.6	0.45	0.8	1
23	**Effective vendor management programme**	**Leadtime reduction**	X		**0.40**	Managing suppliers/vendors very closely will ensure that logistical concerns with regards to inbound raw materials and equipment are identified and dealt with effectively to ensure that raw materials arrive at the facility at the correct time to ensure that the processing lead times of the organisation are not compromised.	**0.40**	0.7	0.4	0.4	0.55	0.5	0.4	0.25	0.4	0.4	0.15	0.4	0.4	0.4	0.4	0.3	0.4
24	**Benefits of APDP programme**	**Demand for SA converters**	X		**0.41**	The import/export credits received under APDP is expected to provide some benefits to OEMs for the next two years, after which it is expected to benefit local production /assembly of motor vehicles more.	**0.41**	0.6	0.7	0.55	0.35	0.4	1	0.3	0.4	0.4	0.4	0.15	0.15	0,15	0.15	0.4	0.2	0.1
25	**Benefits of Beneficiation Programme**	**Demand for SA converters**	X		**0.57**	Benefits under this scheme is expected to e significant for the industry but the details on how this scheme will be applied to the Autocatalytic converter industry is still not clear	**0.57**	0.15	0.85	0.15	0.45	0.8	0.4	0.35	0.4	0.55	0.4	1	1	1	0.65	0.7	0.2

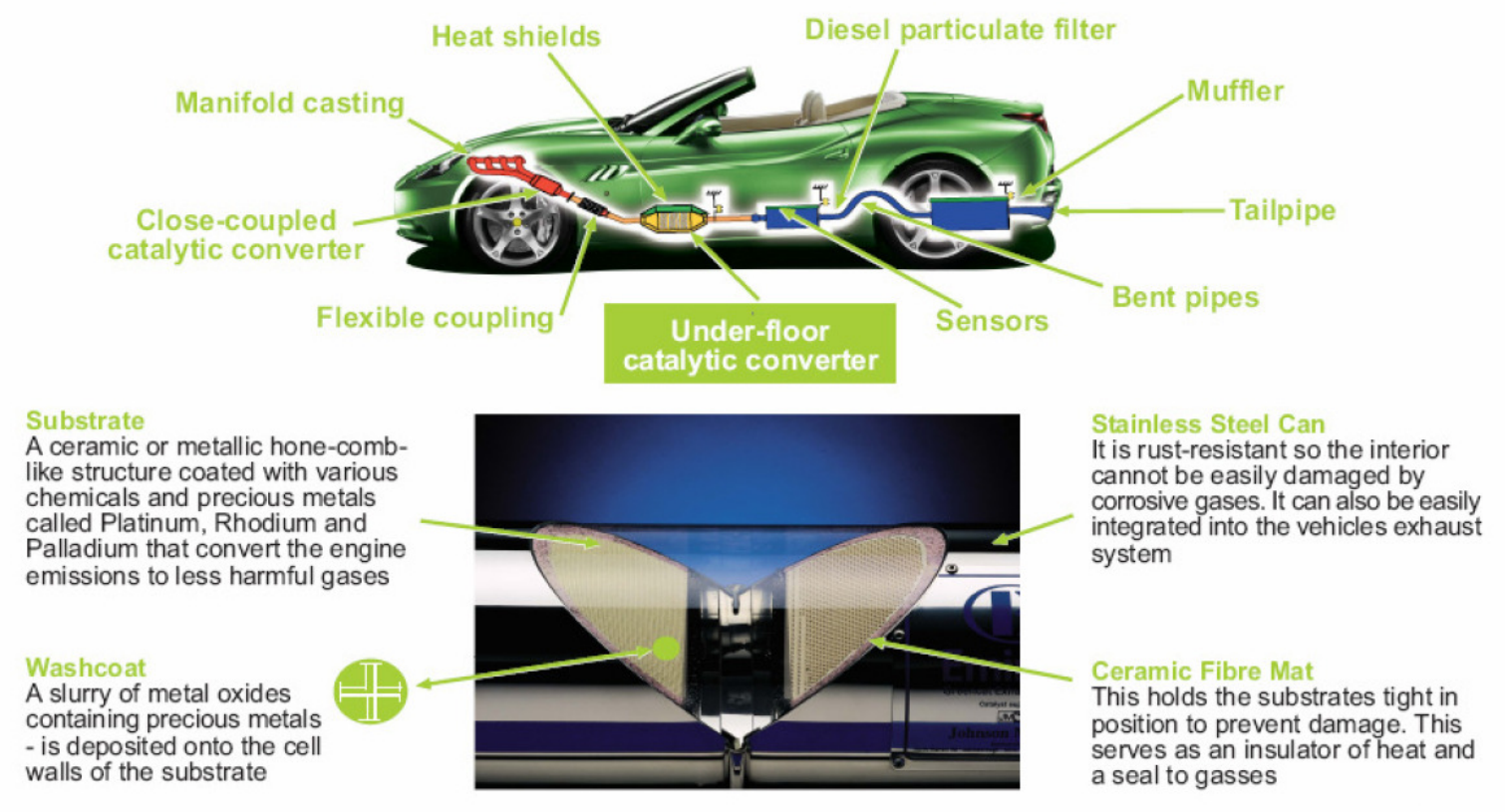
APPENDIX c

Consistency matrix

Consistency matrix ***To assess the Perceived Global Manufacturing Competiveness of the South African Autocatalytic Converter Industry without the Motor Industry Development Programme (MIDP)***				
Sub-problem	**Literature Review**	**Hypotheses or Propositions or Research questions**	**Source of data**	**Analysis**
Applicability of global manufacturing best practices to the South African catalytic converter industry	(Kasul and Motwani, 1995a) (Davies and Kochhar, 2002) (Barnes, 2000a) (Barnes et al., 2001) (Chan, 1993b) (Fick and Buys, 2005) (Maskell, 1989) (Roth and Miller, 1992) (Schonberger, 1996) (Slack et al., 1995) (Stalk and Hout, 2003) (Womack et al., 1990)	*The South African Autocatalytic converter industry has developed adequately in terms of "World Class Operations" in order for the industry to be considered globally competitive.*	*Structured interviews* *Actual questions in* ***Appendix A***	*Qualitative assessment of interviews, commonalities and trends*
Applicability of external factors on the perceived competiveness of the South African catalytic converter industry without MIDP	(Barnes, 2000b) (Barnes et al., 2004) (Black, 2001) (CCIG, 2011) (Emadi et al., 2008) (Yang, 2009) (Riley, 2002) (Mashilo, 2010) (Barnes and Morris, 2000) (Barnes and Morris, 2008) (Black, 2009) (Flatters, 2005) (Johnson Matthey, 2009b) (Wonnacott, 1996)	*There are causal relationships between events from the South African and global external business environments and the demand for South African autocatalytic converters that will impact on the sustainable future of this industry without the benefits from the MIDP incentive scheme*	Structured interview questions and simulations using an enhanced FCM	Simulations using the enhanced FCM

APPENDIX D

Description of an Autocatalytic Converter



Two Types of Reactions Occur in an Automotive Catalyst:

Oxidation Reactions that occur with Pt and Pd

$$2CO + O_2 \xrightarrow{Pt, Pd} 2CO_2$$

$$HC_2 + 2O_2 \xrightarrow{Pt, Pd} 2H_2O + CO_2$$

Reduction Reactions that occur with Rh

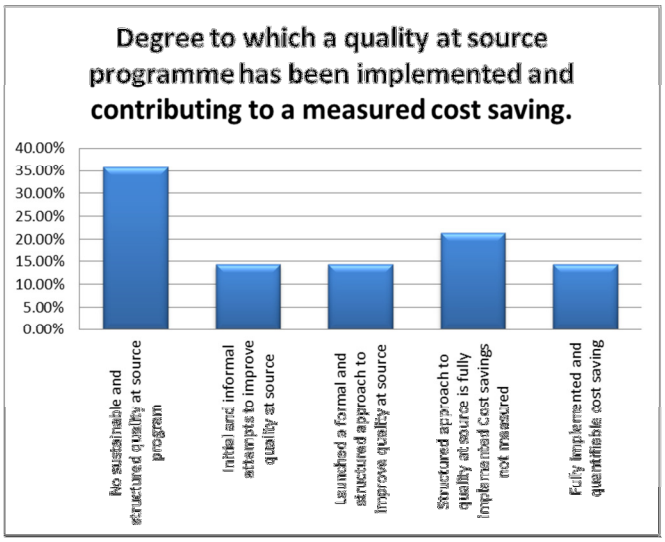
$$2NO_x + 2HC \xrightarrow{Rh} N_2 + H_2O + CO_2$$

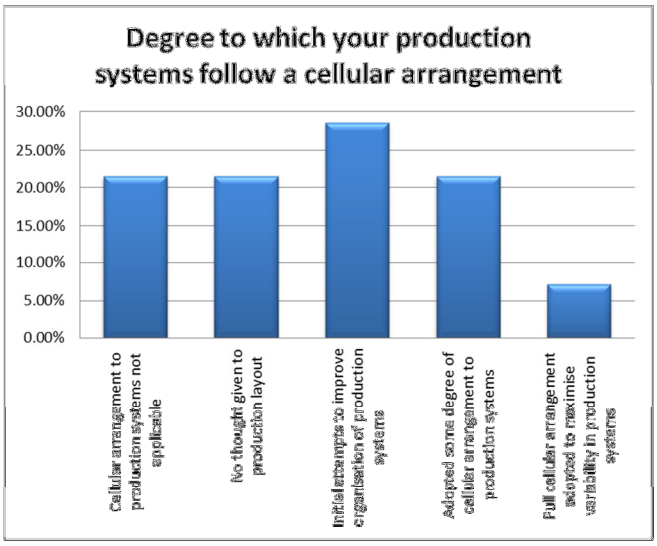


Components of a Gasoline Catalyst:

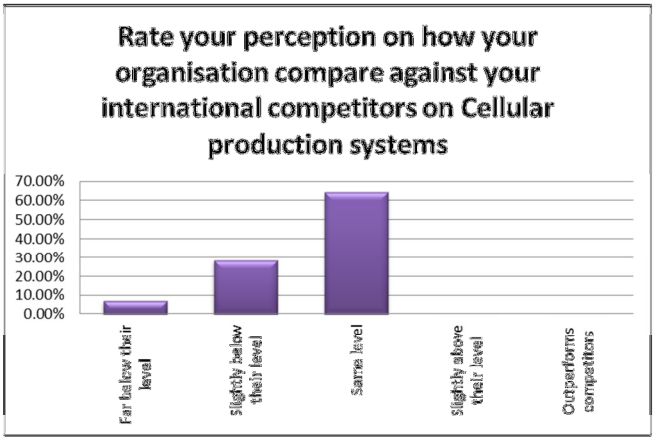
- **Precious Group Metals:** This is the active catalytic ingredient: Platinum (Pt), Palladium (Pd) and Rhodium (Rh)
- **High Surface Area Supports:** This is the surface upon which the catalytic ingredient is dispersed in order to maximise the number of available catalytic sites
- **Oxygen Storage Material:** This dampens rich-lean oscillations
- **Base Metal Promoters:** Multifunctional ingredients that improve performance particularly after ageing

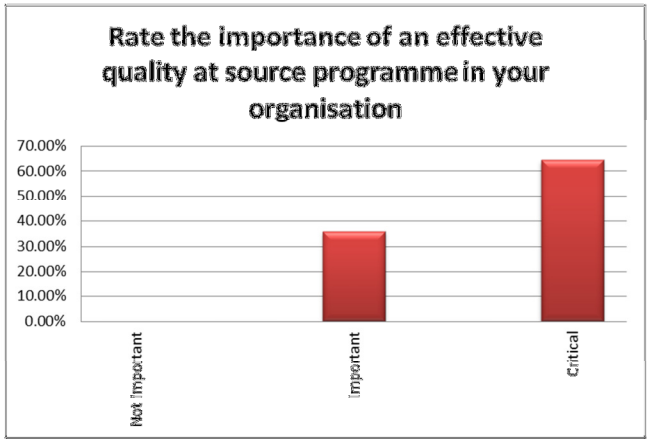
APPENDIX E - IMPLEMENTATION OF THE WCO ELEMENTS WITHIN THE SOUTH AFRICAN AUTOCATALYTIC CONVERTER INDUSTRY

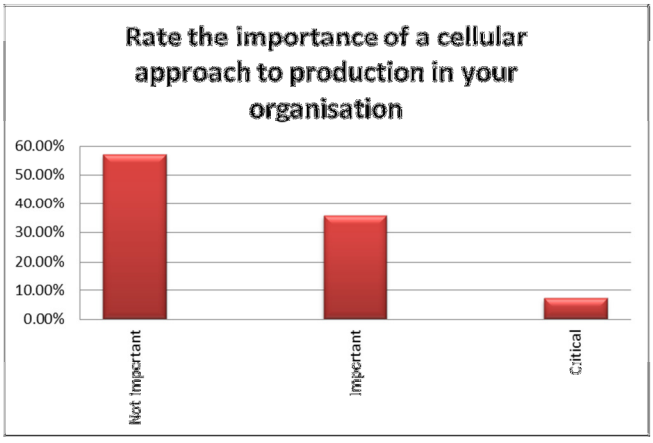


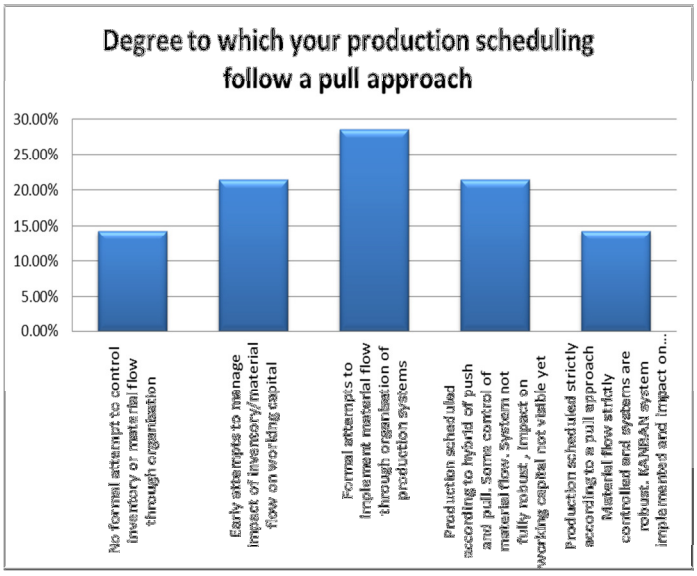


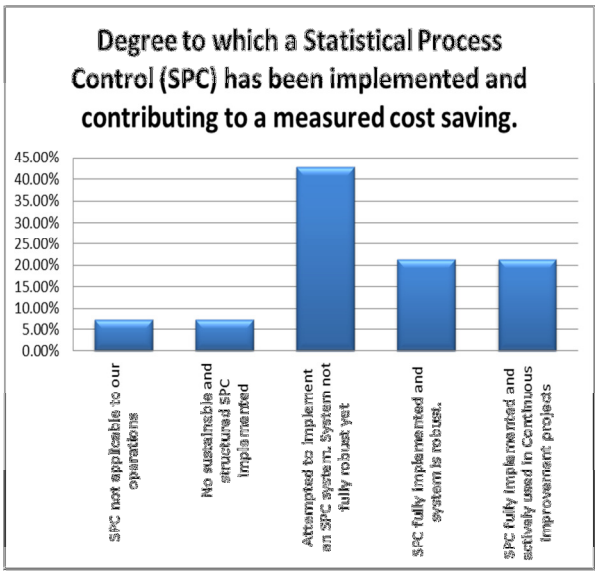




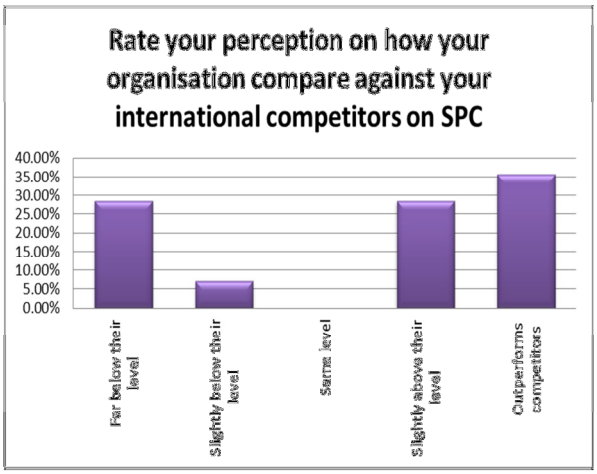


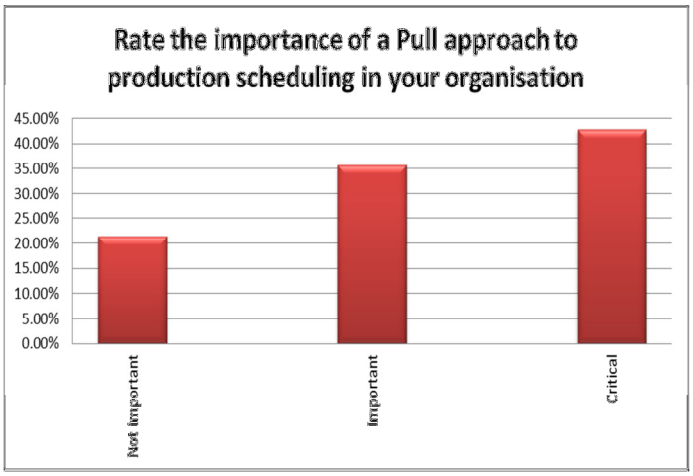


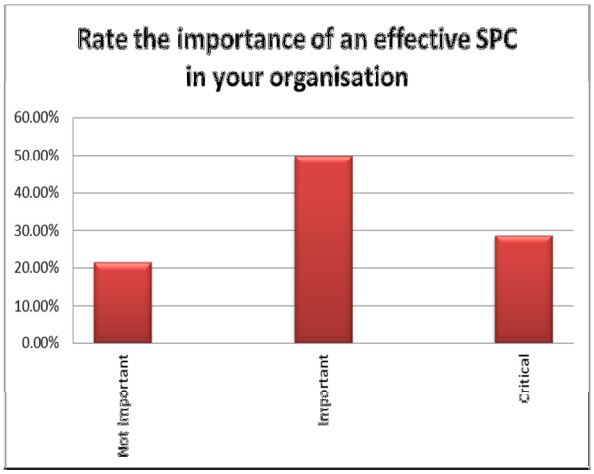

Degree to which your production scheduling follow a pull approach
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
No formal attempt to control inventory or material flow through organisation
Early attempts to manage impact of inventory/material flow on working capital
Formal attempts to implement material flow through organisation of production systems
Production scheduled according to hybrid of push and pull. Some control of material flow. System not fully robust. Impact on working capital not visible yet
Production scheduled strictly according to a pull approach Material flow strictly controlled and systems are robust. KANBAN system implemented and impact on...

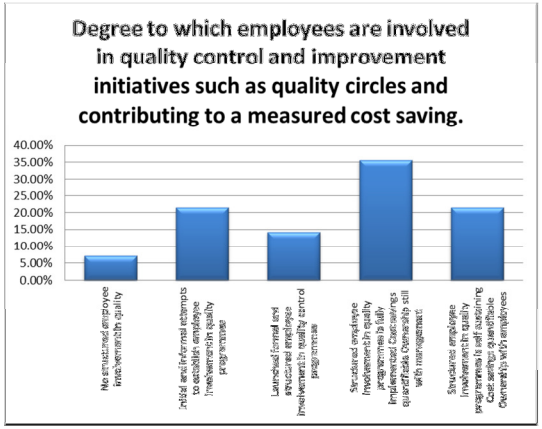

Degree to which a Statistical Process Control (SPC) has been implemented and contributing to a measured cost saving.
45.00%
40.00%
35.00%
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
SPC not applicable to our operations
No sucessfull and structured SPC implemented
Attempted to implement an SPC system. System not fully robust yet
SPC fully implemented and system is robust.
SPC fully implemented and actively used in Continuous Improvement projects

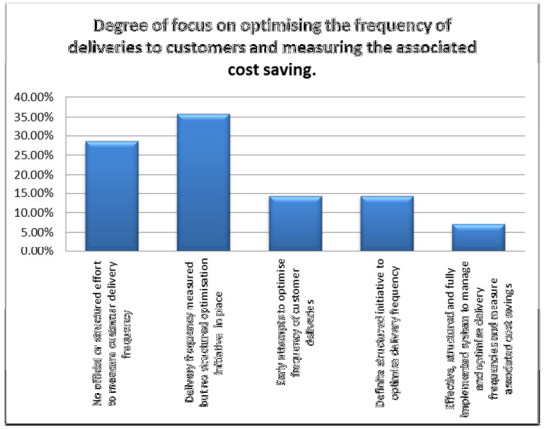

Rate your perception on how your organisation compare against your international competitors on following a Pull approach to production scheduling
40.00%
35.00%
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
Far below their level
Slightly below their level
Same level
Slightly above their level
Outperforms competitors

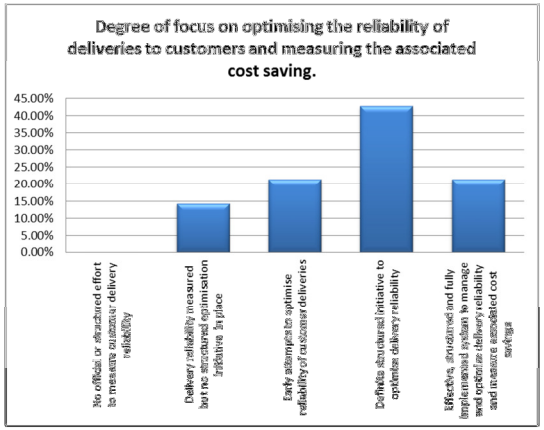

Rate your perception on how your organisation compare against your international competitors on SPC
40.00%
35.00%
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
Far below their level
Slightly below their level
Same level
Slightly above their level
Outperforms competitors


Rate the importance of a Pull approach to production scheduling in your organisation
45.00%
40.00%
35.00%
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
Not important
Important
Critical

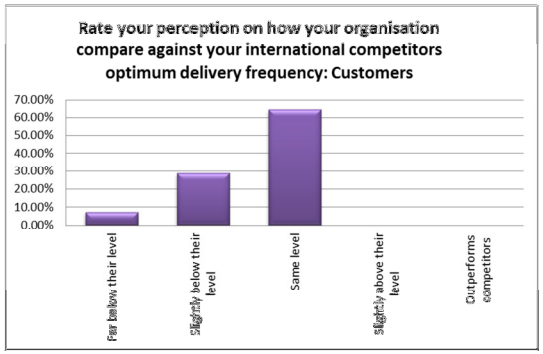

Rate the importance of an effective SPC in your organisation
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
Not important
Important
Critical


Degree to which employees are involved in quality control and improvement initiatives such as quality circles and contributing to a measured cost saving.
40.00%
35.00%
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
No structured employee involvement in quality
Initial and informal attempts to establish employee involvement in quality programmes
Launched formal and structured employee involvement in quality control programmes
Structured employee involvement in quality programmes is fully implemented Cost savings quantifiable Ownership still with management
Structured employee involvement in quality programmes is self sustaining Cost savings quantifiable Ownership with employees


Degree of focus on optimising the frequency of deliveries to customers and measuring the associated cost saving.
40.00%
35.00%
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
No official or structured effort to measure customer delivery frequency
Delivery frequency measured but no structured optimisation initiative in place
Early attempts to optimise frequency of customer deliveries
Definite structured initiative to optimise delivery frequency
Effective, structured and fully implemented system to manage and optimise delivery frequencies and measure associated cost savings

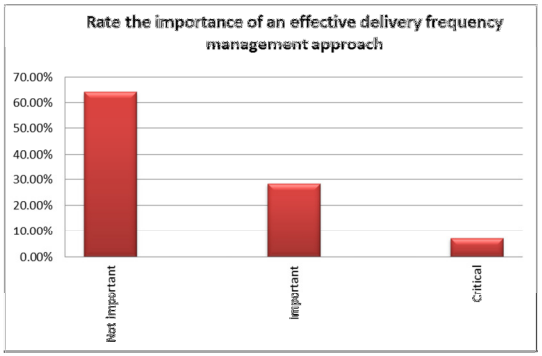

Degree of focus on optimising the reliability of deliveries to customers and measuring the associated cost saving.
45.00%
40.00%
35.00%
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
No official or structured effort to measure customer delivery reliability
Delivery reliability measured but no structured optimisation initiative in place
Early attempts to optimise reliability of customer deliveries
Definite structured initiative to optimise delivery reliability
Effective, structured and fully implemented system to manage and optimise delivery reliability and measure associated cost savings

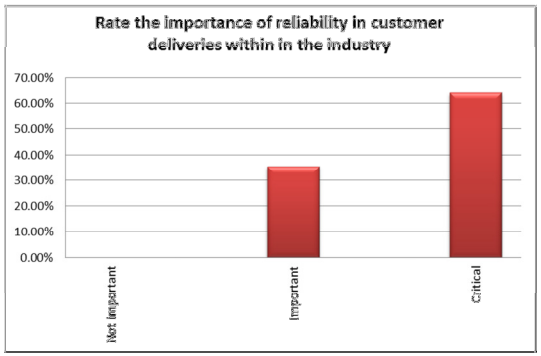

Rate your perception on how your organisation compare against your international competitors on employee involvement in quality control
45.00%
40.00%
35.00%
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
Far below their level
Slightly below their level
Same level
Slightly above their level
Outperforms competitors

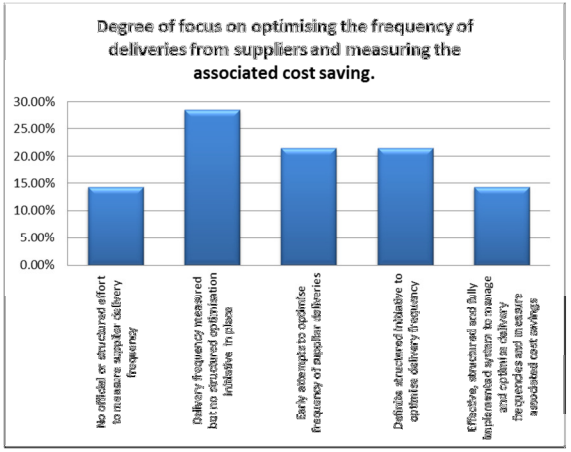

Rate your perception on how your organisation compare against your international competitors optimum delivery frequency: Customers
70.00%
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
Far below their level
Slightly below their level
Same level
Slightly above their level
Outperforms competitors

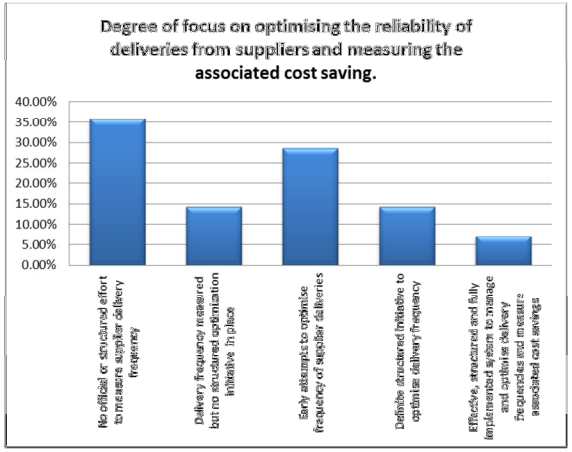

Rate your perception on how your organisation compare against your international competitors on reliability of customer deliveries: Customers
45.00%
40.00%
35.00%
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
Far below their level
Slightly below their level
Same level
Slightly above their level
Outperforms competitors

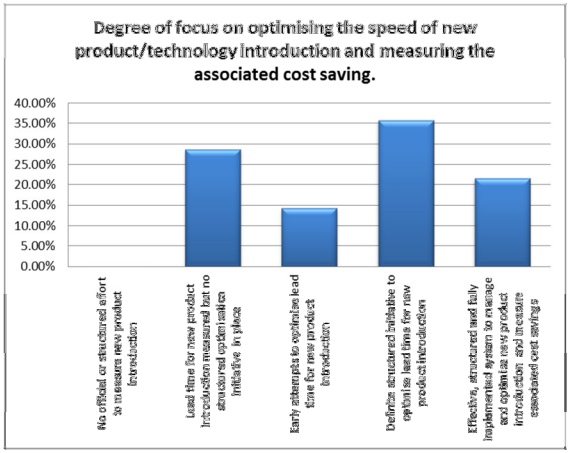

Rate the importance of an effective employee involvement in quality programme in your organisation
45.00%
40.00%
35.00%
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
Not Important
Important
Critical

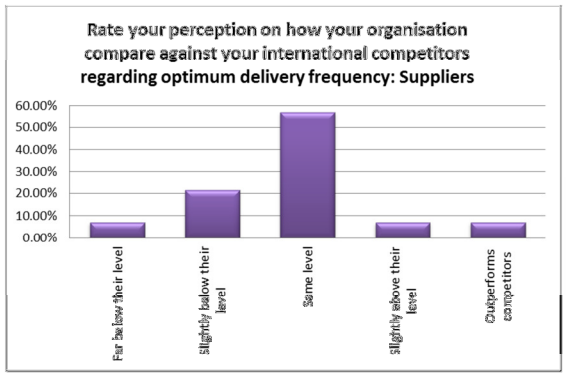

Rate the importance of an effective delivery frequency management approach
70.00%
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
Not Important
Important
Critical

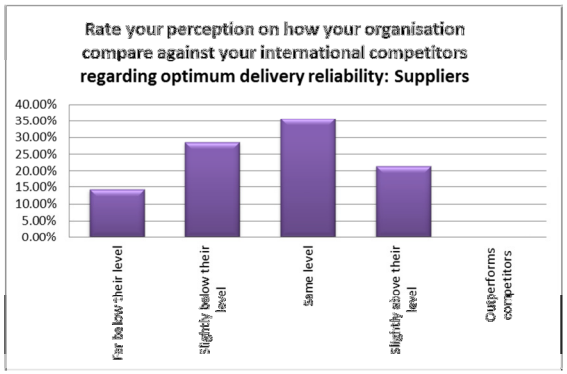

Rate the importance of reliability in customer deliveries within in the industry
70.00%
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
Not Important
Important
Critical


Degree of focus on optimising the frequency of deliveries from suppliers and measuring the associated cost saving.
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
No official or structured effort to measure supplier delivery frequency
Delivery frequency measured but no structured optimisation initiative in place
Early attempts to optimise frequency of supplier deliveries
Definite structured initiative to optimise delivery frequency
Effective, structured and fully implemented system to manage and optimise delivery frequencies and measure associated cost savings

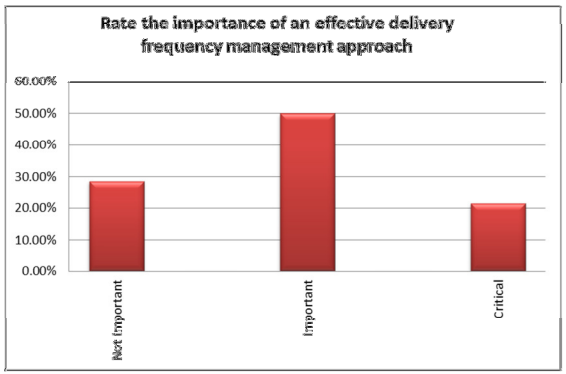

Degree of focus on optimising the reliability of deliveries from suppliers and measuring the associated cost saving.
40.00%
35.00%
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
No official or structured effort to measure supplier delivery frequency
Delivery frequency measured but no structured optimisation initiative in place
Early attempts to optimise frequency of supplier deliveries
Definite structured initiative to optimise delivery frequency
Effective, structured and fully implemented system to manage and optimise delivery frequencies and measure associated cost savings

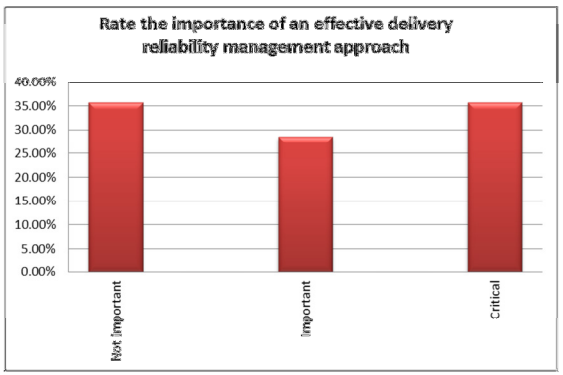

Degree of focus on optimising the speed of new product/technology introduction and measuring the associated cost saving.
40.00%
35.00%
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
No official or structured effort to measure new product introduction
Lead time for new product introduction measured but no structured optimisation initiative in place
Early attempts to optimise lead time for new product introduction
Definite structured initiative to optimise lead time for new product introduction
Effective, structured and fully implemented system to manage and optimise new product introduction and measure associated cost savings

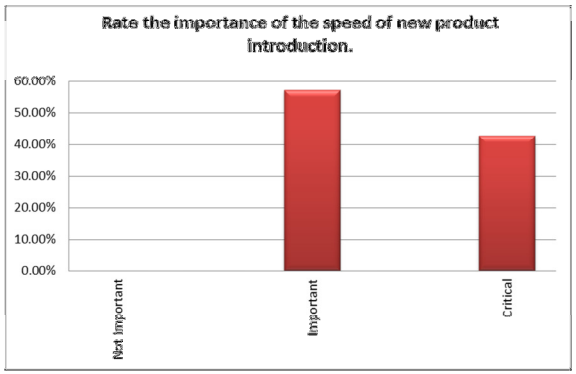

Rate your perception on how your organisation compare against your international competitors regarding optimum delivery frequency: Suppliers
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
Far below their level
Slightly below their level
Same level
Slightly above their level
Outperforms competitors

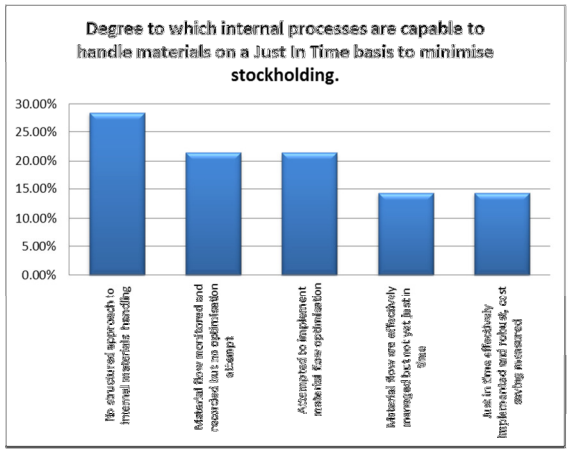

Rate your perception on how your organisation compare against your international competitors regarding optimum delivery reliability: Suppliers
40.00%
35.00%
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
Far below their level
Slightly below their level
Same level
Slightly above their level
Outperforms competitors

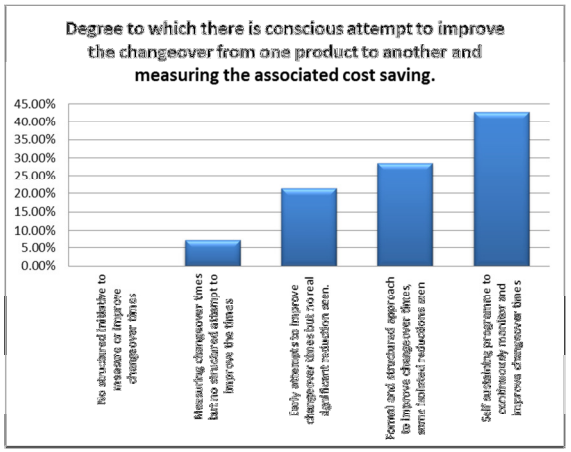

Rate your perception on how your organisation compare against your international competitors regarding the speed with which new products are introduced.
80.00%
70.00%
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
Far below their level
Slightly below their level
Same level
Slightly above their level
Outperforms competitors

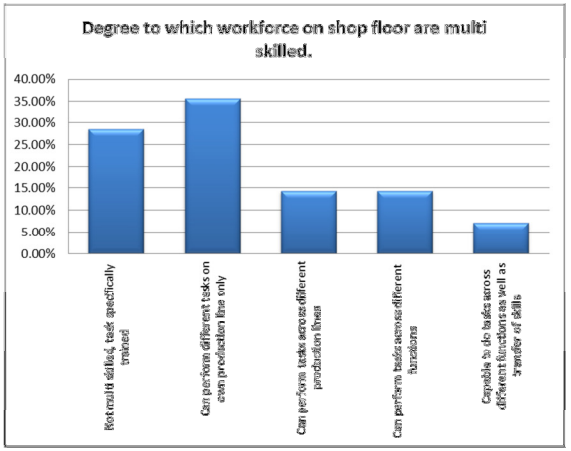

Rate the importance of an effective delivery frequency management approach
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
Not Important
Important
Critical


Rate the importance of an effective delivery reliability management approach
40.00%
35.00%
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
Not Important
Important
Critical

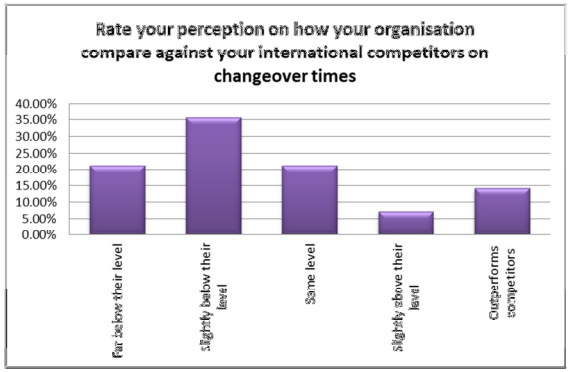

Rate the importance of the speed of new product introduction.
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
Not Important
Important
Critical


Degree to which internal processes are capable to handle materials on a Just In Time basis to minimise stockholding.
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
No structured approach to internal materials handling
Material flow monitored and recorded but no optimisation attempt
Attempted to implement material flow optimisation
Material flow are effectively managed but not yet just in time
Just in time effectively implemented and notably cost saving measured

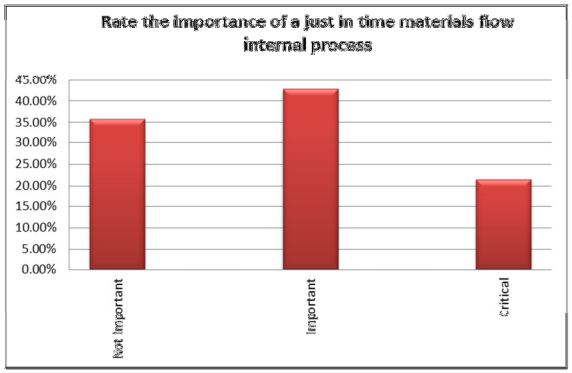

Degree to which there is conscious attempt to improve the changeover from one product to another and measuring the associated cost saving.
45.00%
40.00%
35.00%
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
No structured initiative to measure or improve changeover times
Measuring changeover times but no structured attempt to improve the times
Daily attempts to improve changeover times but no real significant reduction seen.
Formal and structured approach to improve changeover times, some isolated reductions seen
Self sustaining programme to continuously monitor and improve changeover times

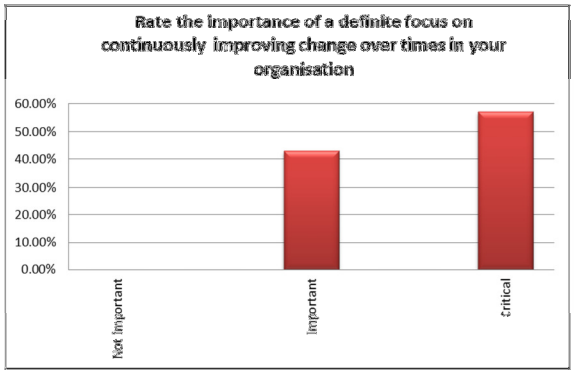

Degree to which workforce on shop floor are multi skilled.
40.00%
35.00%
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
Notmulti skilled, task specifically trained
Can perform different tasks on own production line only
Can perform tasks across different production lines
Can perform tasks across different functions
Capable to do tasks across different functions as well as transfer of skills

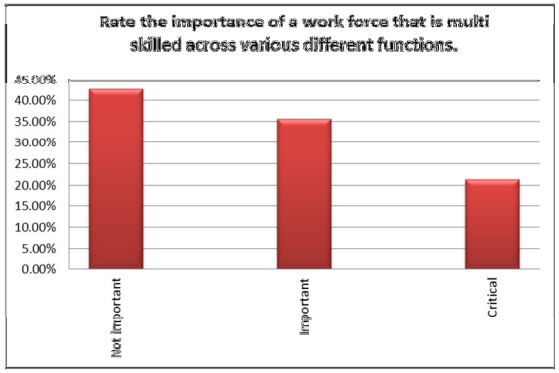

Rate your perception on how your organisation compare against your international competitors on just in time
45.00%
40.00%
35.00%
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
Far below their level
Slightly below their level
Same level
Slightly above their level
Outperforms competitors

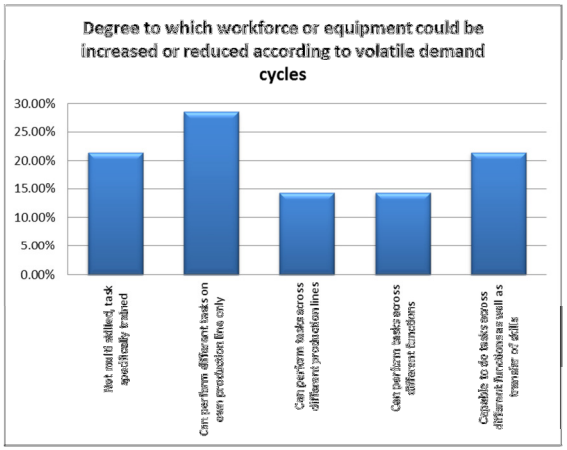

Rate your perception on how your organisation compare against your international competitors on changeover times
40.00%
35.00%
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
Far below their level
Slightly below their level
Same level
Slightly above their level
Outperforms competitors


Rate your perception on how your organisation compare against your international competitors on a work force that is multi skilled.
70.00%
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
Far below their level
Slightly below their level
Same level
Slightly above their level
Outperforms competitors

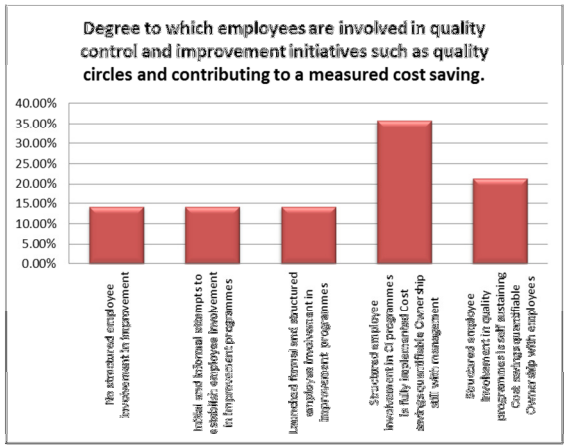

Rate the importance of a just in time materials flow internal process
45.00%
40.00%
35.00%
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
Not Important
Important
Critical

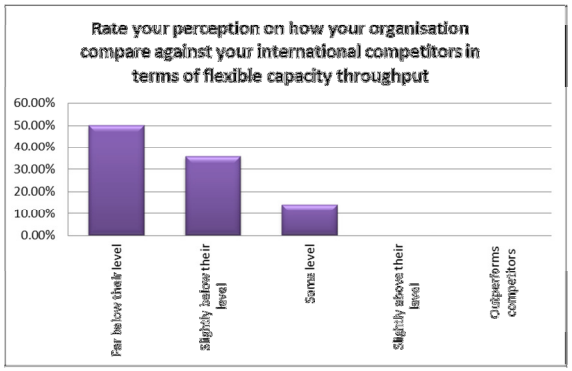

Rate the importance of a definite focus on continuously improving change over times in your organisation
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
Not Important
Important
Critical


Rate the importance of a work force that is multi skilled across various different functions.
45.00%
40.00%
35.00%
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
Not Important
Important
Critical


Degree to which workforce or equipment could be increased or reduced according to volatile demand cycles
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
Not multi skilled, task specifically trained
Can perform different tasks on own production line only
Can perform tasks across different production lines
Can perform tasks across different functions
Capable to do tasks across different functions as well as transfer of skills

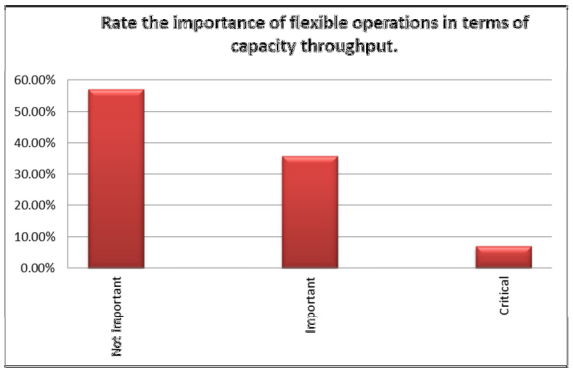

Degree to which entire organisation is involved in continuous improvement and measuring the associated cost saving.
40.00%
35.00%
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
No continuous improvement programme initiatives
First random attempts at improvement initiatives mostly driven by top management
Adopting formal improvement programme still driven by management
Formal improvement programme implemented good participation from employees
Formal improvement initiatives engrained in culture of whole organisation

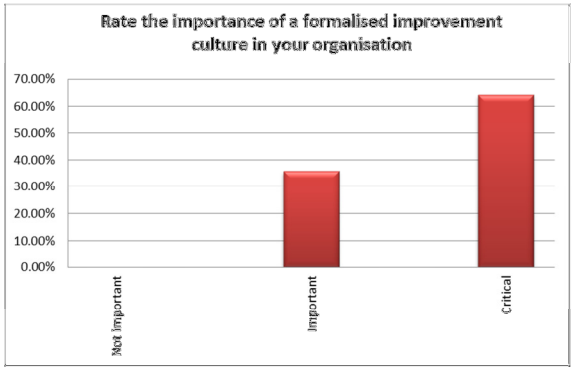

Degree to which employees are involved in quality control and improvement initiatives such as quality circles and contributing to a measured cost saving.
40.00%
35.00%
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
No structured employee involvement in improvement
Initial and informal attempts to establish employee involvement in improvement programmes
Launched formal and structured employee involvement in improvement programmes
Structured employee involvement in CI programmes is fully implemented cost savings quantifiable Ownership still with management
Structured employee involvement in quality programmes is self sustaining Cost savings quantifiable Ownership with employees

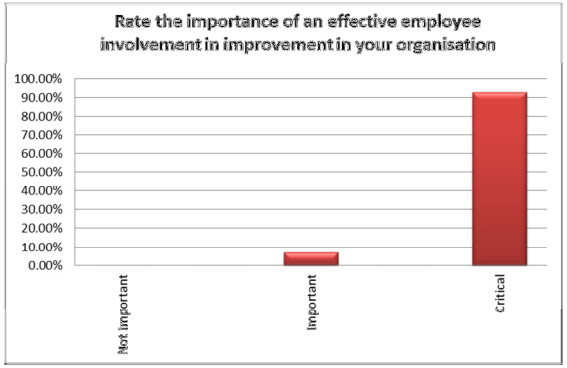

Rate your perception on how your organisation compare against your international competitors in terms of flexible capacity throughput
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
Far below their level
Slightly below their level
Same level
Slightly above their level
Outperforms competitors

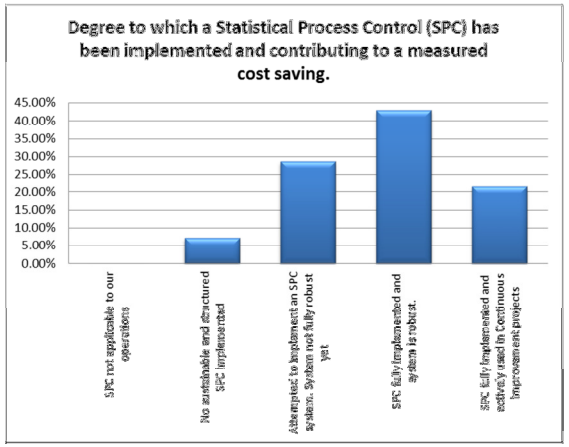

Rate your perception on how your organisation compare against your international competitors on self sustaining improvement culture
45.00%
40.00%
35.00%
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
Far below their level
Slightly below their level
Same level
Slightly above their level
Outperforms competitors

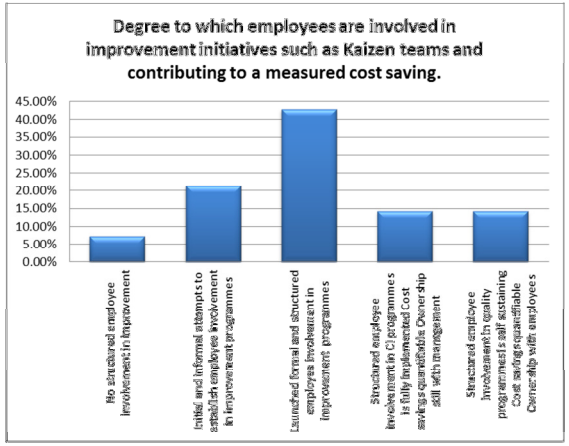

Rate your perception on how your organisation compare against your international competitors on employee involvement in improvement
45.00%
40.00%
35.00%
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
Far below their level
Slightly below their level
Same level
Slightly above their level
Outperforms competitors


Rate the importance of flexible operations in terms of capacity throughput.
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
Not Important
Important
Critical

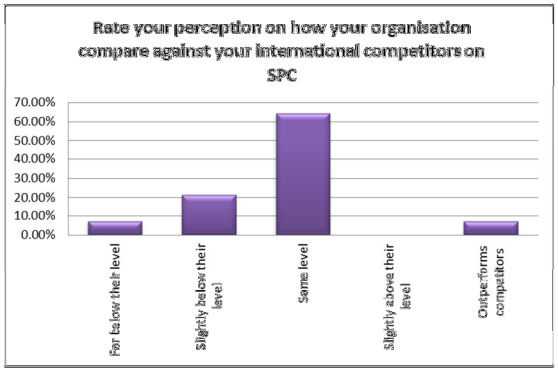

Rate the importance of a formalised improvement culture in your organisation
70.00%
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
Not Important
Important
Critical


Rate the importance of an effective employee involvement in improvement in your organisation
100.00%
90.00%
80.00%
70.00%
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
Not Important
Important
Critical


Degree to which a Statistical Process Control (SPC) has been implemented and contributing to a measured cost saving.
45.00%
40.00%
35.00%
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
SPC not applicable to our operations
No sustainable and structured SPC implemented
Attempted to implement an SPC system. System not fully robust yet
SPC fully implemented and system is robust.
SPC fully implemented and actively used in Continuous Improvement projects

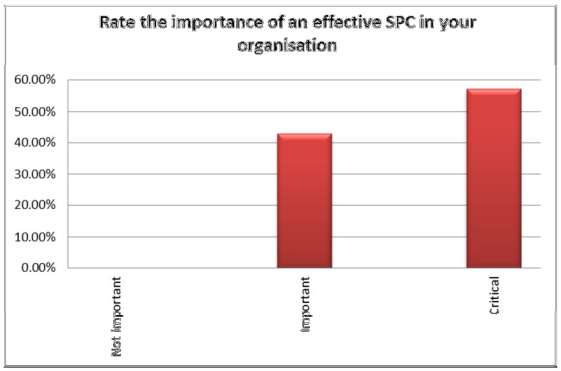

Degree to which employees are involved in improvement initiatives such as Kaizen teams and contributing to a measured cost saving.
45.00%
40.00%
35.00%
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
No structured employee involvement in improvement
Initial and informal attempts to establish employee involvement in improvement programmes
Launched formal and structured employee involvement in improvement programmes
Structured employee involvement in CI programmes is fully implemented cost savings quantifiable Ownership still with management
Structured employee involvement in quality programmes is self sustaining Cost savings quantifiable Ownership with employees

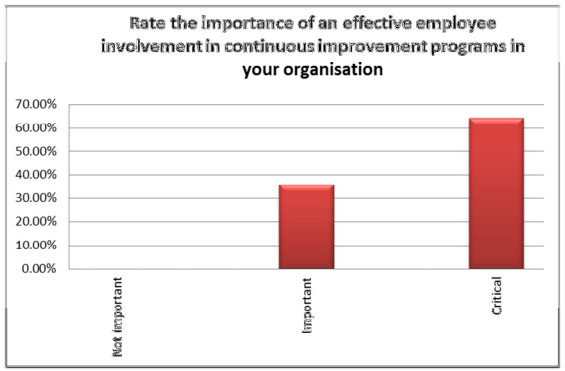

Degree to which the leadership have established and aligned clear and defined goals and objectives, that have been cascaded through all levels of the organisation and progress are closely monitored by the leadership.
45.00%
40.00%
35.00%
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
No clear business goals and objectives have been defined
Business goals and objectives have been established, but not necessary aligned with one another, and yet cascaded throughout entire business
Business goals and objectives have been defined, aligned and cascaded throughout busine ss but is still mostly driven by top...
Business goals and objectives have been defined, aligned and cascaded throughout busine ss but is still mostly driven by top...
Business goals and objectives defined, aligned and cascaded through all levels of business closely linked to market. Top management still heavily...

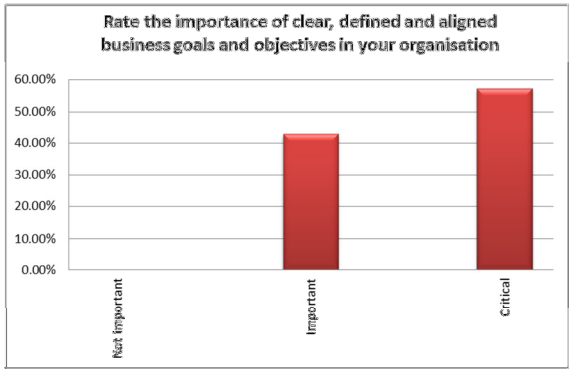

Rate your perception on how your organisation compare against your international competitors on SPC
70.00%
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
Far below their level
Slightly below their level
Same level
Slightly above their level
Outperforms competitors

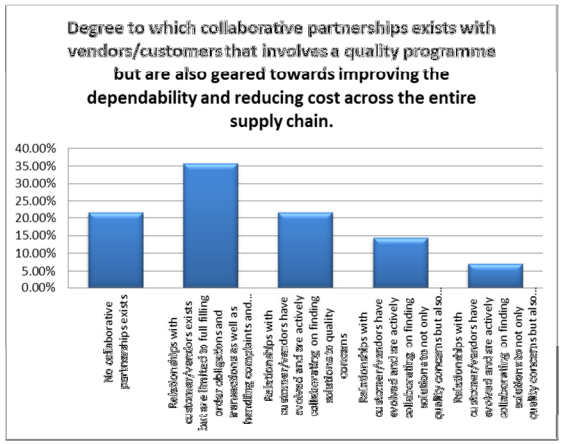

Rate your perception on how your organisation compare against your international competitors on employee involvement in Continuous Improvement
70.00%
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
Far below their level
Slightly below their level
Same level
Slightly above their level
Outperforms competitors

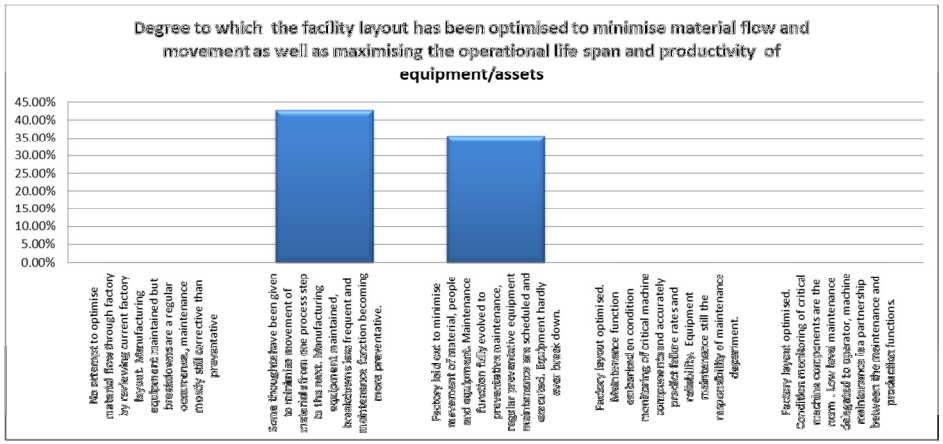

Rate your perception on how your organisation compare against your international competitors on clear, defined and cascaded business goals and objectives
40.00%
35.00%
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
Far below their level
Slightly below their level
Same level
Slightly above their level
Outperforms competitors


Rate the importance of an effective SPC in your organisation
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
Not important
Important
Critical


Rate the importance of an effective employee involvement in continuous improvement programs in your organisation
70.00%
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
Not important
Important
Critical

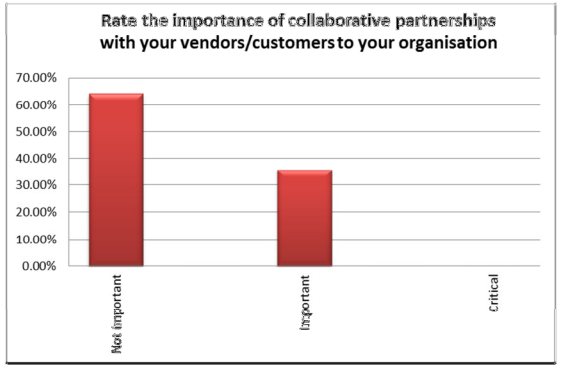

Rate the importance of clear, defined and aligned business goals and objectives in your organisation
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
Not important
Important
Critical

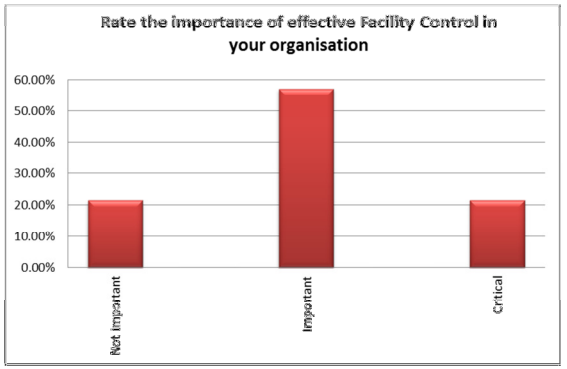

Degree to which collaborative partnerships exists with vendors/customers that involves a quality programme but are also geared towards improving the dependability and reducing cost across the entire supply chain.
40.00%
35.00%
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
No collaborative partnerships exists
Relationships with customer/vendors exists but are limited to full filling order obligations and transactional as well as handling complaints and...
Relationships with customer/vendors have evolved and are actively collaborating on finding solutions to quality concerns
Relationships with customer/vendors have evolved and are actively collaborating on finding solutions to not only quality concerns but also...
Relationships with customer/vendors have evolved and are actively collaborating on finding solutions to not only quality concerns but also...


Degree to which the facility layout has been optimised to minimise material flow and movement as well as maximising the operational life span and productivity of equipment/assets
45.00%
40.00%
35.00%
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
No attempt to optimise material flow through factory by reviewing current factory layout. Manufacturing equipment maintained but breakdowns are a regular occurrence., maintenance mostly still corrective than preventative
Some thought have been given to minimise movement of material from one process step to the next. Manufacturing equipment maintained, breakdowns less frequent and maintenance function becoming more preventative.
Factory laid out to minimise movement of material, people and equipment. Maintenance function fully evolved to preventative maintenance, regular preventative equipment maintenance are scheduled and executed. Equipment hardly ever break down.
Factory layout optimised. Maintenance function embarked on condition monitoring of critical machine components and accurately predict failure rates and reliability. Equipment maintenance still the responsibility of maintenance department.
Factory layout optimised. Conditions monitoring of critical machine components are the room . Low level maintenance delegated to operator, machine maintenance like a partnership between the maintenance and production functions.


Rate your perception on how your organisation compare against your international competitors on collaborative vendors/customer relationships
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
Far below their level
Slightly below their level
Same level
Slightly above their level
Outgerforms competitors


Rate your perception on how your organisation compare against your international competitors on Facility control
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
Far below their level
Slightly below their level
Same level
Slightly above their level
Outgerforms competitors


Rate the importance of collaborative partnerships with your vendors/customers to your organisation
70.00%
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
Not important
Important
Critical


Rate the importance of effective Facility Control in your organisation
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
Not important
Important
Critical

APPENDIX F: SCENARIO RESULTS FROM FUZZY COGNITIVE MAP

Scenario 1: Globally competitive but after 2012 only the benefits of APDP

	Output	Global Electricity costs	Steel availability (South Africa)	Steel price (South Africa)	PGM Reserves	PGM Price	Oil reserves	Oil price	Global demand for cars	Overcapacity for production of converters	European demand for converters	Inflation	Economic recession	Credit availability	Foreign Direct Investment in Africa	Economic growth in Africa	Russian/Foreign PGM reserves	Increase in pollution	New propulsion method: Fuel Cells	Environmental legislation	Diesel Technology	New propulsion method:Electric cars	New converter technology	Other industrial uses for PGM	Asian demand for cars	Asian converter production capability	Asian Labour cost	Exchange rate	Unstable SA Electricity supply
Startup		0	0	0	0	0	0	0	1	1	1	0	0	0	0	1	0	1	0	1	1	0	1	1	0	1	0	0	1
Cycle	1	0	1	1	0	1	1	1	1	0	1	0	0	0	1	0	0	1	1	1	0	1	1	0	0	0	0	0	0
	2	0	1	0	1	1	1	0	1	0	1	0	0	0	1	1	0	1	1	1	1	1	1	0	0	0	0	0	0
	3	0	1	0	1	0	1	0	1	0	1	0	0	0	1	1	0	1	0	1	0	1	1	0	0	0	0	0	0
	4	0	1	0	1	0	1	0	1	0	1	0	0	0	1	1	0	1	0	1	0	0	1	0	0	0	0	0	0
	5	0	1	0	1	0	1	0	1	0	1	0	0	0	1	1	0	1	0	1	0	0	1	0	0	0	0	0	0
	6																												
	7																												
	8																												
	9																												
	10																												

	Output	SA electricity costs	SA labour costs	Stable SA Politics	SA Globally competitive	Unstable SA labour relations	External flexibility	Clear two way internal communication	Internal quality	Internal flexibility	Existance of effective waste elimination p	Innovation capability	Production scheduling based on pull app	Cost leader	Internal customer satisfaction orientated	Learning organisational culture	Existence of effective Quality at source p	Well defined manufacturing strategy	Leadership commitment to WCO	Effective use of SPC	Effective preventative maintenance progr	Cellular production layout	Facility control	Effective vendor management programme	Strong focus on lead time reduction	Integrated Materials Resource Planning (I	Optimum inventory levels	Ownership of quality among employees	Demand for SA converters
Startup		1	0	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Cycle	1	1	0	0	1	0	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	0	1	0	1	1	1	1	1
	2	1	0	0	1	0	1	1	1	1	1	1	1	0	1	1	1	0	0	1	0	0	1	0	1	1	1	1	0
	3	1	0	0	1	0	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	1	0	1	1	1	0	0	0
	4	1	0	0	1	0	1	1	0	1	0	1	1	1	1	0	0	0	0	0	0	1	0	1	1	1	0	0	0
	5	1	0	0	1	0	1	1	0	1	0	1	1	0	1	1	0	0	0	0	0	0	1	0	1	1	1	0	0
	6																												
	7																												
	8																												
	9																												
	10																												

	Output	Effective preventative maintenance progr	Cellular production layout	Leadership commitment to WCO	Unstable SA labour relations	Russian PGM reserves	Global Electricity costs	Economic recession	Asian Labour cost	Asian car demand	Stable SA Politics	Unstable SA Electricity supply	Effective vendor management programme	Benefits of APDP	Benefits of Beneficiation Programme
Startup		1	1	1	0	0	0	0	0	0	1	0	1	1	0
Cycle	1	1	1	1	0	0	0	0	0	0	1	0	1	1	0
	2	1	1	1	0	0	0	0	0	0	1	0	1	1	0
	3	1	1	1	0	0	0	0	0	0	1	0	1	1	0
	4	1	1	1	0	0	0	0	0	0	1	0	1	1	0
	5	1	1	1	0	0	0	0	0	0	1	0	1	1	0
	6	1	1	1	0	0	0	0	0	0	1	0	1	1	0
	7	1	1	1	0	0	0	0	0	0	1	0	1	1	0
	8	1	1	1	0	0	0	0	0	0	1	0	1	1	0
	9	1	1	1	0	0	0	0	0	0	1	0	1	1	0
	10	1	1	1	0	0	0	0	0	0	1	0	1	1	0

Scenario 2: Globally competitive but after 2012 benefits from both APDP and Beneficiation Programme

	Output	Global Electricity costs	Steel availability (South Africa)	Steel price (South Africa)	PGM Reserves	PGM Price	Oil reserves	Oil price	Global demand for cars	Overcapacity for production of converters	European demand for converters	Inflation	Economic recession	Credit availability	Foreign Direct Investment in Africa	Economic growth in Africa	Russian/Foreign PGM reserves	Increase in pollution	New propulsion method: Fuel Cells	Environmental legislation	Diesel Technology	New propulsion method:Electric cars	New converter technology	Other industrial uses for PGM	Asian demand for cars	Asian converter production capability	Asian Labour cost	Exchange rate	Unstable SA Electricity supply
Startup		0	0	0	0	0	0	0	1	1	1	0	0	0	0	1	0	1	0	1	1	0	1	1	0	1	0	0	1
Cycle	1	0	1	1	0	1	1	1	1	0	1	0	0	0	1	0	0	1	1	1	0	1	1	0	0	0	0	0	0
	2	0	1	0	1	1	1	0	1	0	1	0	0	0	1	1	0	1	1	1	1	1	1	0	0	0	0	0	0
	3	0	1	0	1	0	1	0	1	0	1	0	0	0	1	1	0	1	0	1	0	1	1	0	0	0	0	0	0
	4	0	1	0	1	0	1	0	1	0	1	0	0	0	1	1	0	1	0	1	0	0	1	0	0	0	0	0	0
	5	0	1	0	1	0	1	0	1	0	1	0	0	0	1	1	0	1	0	1	0	0	1	0	0	0	0	0	0
	6																												
	7																												
	8																												
	9																												
	10																												

	Output	SA electricity costs	SA labour costs	Stable SA Politics	SA Globally competitive	Unstable SA labour relations	External flexibility	Clear two way internal communication	Internal quality	Internal flexibility	Existance of effective waste elimination p	Innovation capability	Production scheduling based on pull app	Cost leader	Internal customer satisfaction orientated	Learning organisational culture	Existence of effective Quality at source p	Well defined manufacturing strategy	Leadership commitment to WCO	Effective use of SPC	Effective preventative maintenance progr	Cellular production layout	Facility control	Effective vendor management programme	Strong focus on lead time reduction	Integrated Materials Resource Planning (I	Optimum inventory levels	Ownership of quality among employees	Demand for SA converters
Startup		1	0	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Cycle	1	1	0	0	1	0	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	0	1	0	1	1	1	1	1
	2	1	0	0	1	0	1	1	1	1	1	1	1	0	1	1	1	0	0	1	0	0	1	0	1	1	1	1	1
	3	1	0	0	1	0	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	1	0	1	1	1	0	1
	4	1	0	0	1	0	1	1	0	1	0	1	1	1	1	1	0	0	0	0	0	0	1	0	1	1	1	0	1
	5	1	0	0	1	0	1	1	0	1	0	1	1	0	1	1	0	0	0	0	0	0	1	0	1	1	1	0	1
	6																												
	7																												
	8																												
	9																												
	10																												

	Output	Effective preventative maintenance progr	Cellular production layout	Leadership commitment to WCO	Unstable SA labour relations	Russian PGM reserves	Global Electricity costs	Economic recession	Asian Labour cost	Asian car demand	Stable SA Politics	Unstable SA Electricity supply	Effective vendor management programme	Benefits of APDP	Benefits of Beneficiation Programme
Startup		1	1	1	0	0	0	0	0	0	1	0	1	1	1
Cycle	1	1	1	1	0	0	0	0	0	0	1	0	1	1	1
	2	1	1	1	0	0	0	0	0	0	1	0	1	1	1
	3	1	1	1	0	0	0	0	0	0	1	0	1	1	1
	4	1	1	1	0	0	0	0	0	0	1	0	1	1	1
	5	1	1	1	0	0	0	0	0	0	1	0	1	1	1
	6	1	1	1	0	0	0	0	0	0	1	0	1	1	1
	7	1	1	1	0	0	0	0	0	0	1	0	1	1	1
	8	1	1	1	0	0	0	0	0	0	1	0	1	1	1
	9	1	1	1	0	0	0	0	0	0	1	0	1	1	1
	10	1	1	1	0	0	0	0	0	0	1	0	1	1	1

Scenario 3: Globally competitive, both benefits of APDP and Beneficiation but in an Global Economic recession

	Output	Global Electricity costs	Steel availability (South Africa)	Steel price (South Africa)	PGM Reserves	PGM Price	Oil reserves	Oil price	Global demand for cars	Overcapacity for production of converters	European demand for converters	Inflation	Economic recession	Credit availability	Foreign Direct Investment in Africa	Economic growth in Africa	Russian/Foreign PGM reserves	Increase in pollution	New propulsion method: Fuel Cells	Environmental legislation	Diesel Technology	New propulsion method:Electric cars	New converter technology	Other industrial uses for PGM	Asian demand for cars	Asian converter production capability	Asian Labour cost	Exchange rate	Unstable SA Electricity supply	SA electricity costs	SA labour costs	Stable SA Politics	SA Globally competitive	Unstable SA labour relations	External flexibility	Clear two way internal communication	Internal quality	Internal flexibility	Existance of effective waste elimination p	Innovation capability	Production scheduling based on pull app	Cost leader	Internal customer satisfaction orientated	Learning organisational culture	Existence of effective Quality at source p	Well defined manufacturing strategy	Leadership commitment to WCO	Effective use of SPC	Effective preventative maintenance progr	Cellular production layout	Facility control	Effective vendor management programme	Strong focus on lead time reduction	Integrated Materials Resource Planning (I	Optimum inventory levels	Ownership of quality among employees	Demand for SA converters	Effective preventative maintenance progr	Cellular production layout	Leadership commitment to WCO	Unstable SA labour relations	Russian PGM reserves	Global Electricity costs	Economic recession	Asian Labour cost	Asian car demand	Stable SA Politics	Unstable SA Electricity supply	Effective vendor management programme	Benefits of APDP	Benefits of Beneficiation Programme
	Startup	0	0	0	0	0	0	0	1	1	1	0	0	0	0	1	0	1	0	1	1	0	1	1	0	1	0	0	1	1	0	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	1	0	0	1	0	1	1	1
Cycle	1	0	1	1	0	1	1	1	0	0	1	0	0	0	1	0	0	1	1	1	0	1	1	0	0	0	0	0	0	1	0	0	1	0	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	0	1	0	1	1	1	1	1	1	1	1	0	0	0	1	0	0	1	0	1	1	1
	2	0	1	0	1	1	1	0	0	1	0	0	0	0	1	1	0	0	1	1	1	1	1	0	0	0	0	0	0	1	0	0	1	0	1	1	1	1	1	1	1	0	1	1	1	0	0	1	0	0	1	0	1	1	1	1	1	1	1	1	0	0	0	1	0	0	1	0	1	1	1
	3	0	1	0	1	0	1	0	1	1	0	0	0	0	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	1	0	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	1	0	1	1	1	0	0	1	1	1	0	0	0	1	0	0	1	0	1	1	1
	4	0	1	0	1	0	1	0	1	0	1	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	1	1	0	1	0	1	1	1	1	1	0	0	0	0	0	0	1	0	1	1	1	0	0	1	1	1	0	0	0	1	0	0	1	0	1	1	1
	5	0	1	0	1	0	1	0	1	0	1	0	0	0	1	1	0	1	0	1	0	0	0	0	0	0	0	0	0	1	0	0	1	0	1	1	0	1	0	1	1	0	1	1	0	0	0	0	0	0	1	0	1	1	1	0	1	1	1	1	0	0	0	1	0	0	1	0	1	1	1
	6	0	1	0	1	0	1	0	1	0	0	0	0	0	1	1	0	1	0	1	0	0	1	0	0	0	0	0	0	1	0	0	1	0	1	1	0	1	0	1	1	0	1	1	0	0	0	0	0	0	1	0	1	1	1	0	1	1	1	1	0	0	0	1	0	0	1	0	1	1	1
	7	0	1	0	1	0	1	0	1	0	0	0	0	0	1	1	0	1	0	1	0	0	1	0	0	0	0	0	0	1	0	0	1	0	1	1	0	1	0	1	1	0	1	1	0	0	0	0	0	0	1	0	1	1	1	0	0	1	1	1	0	0	0	1	0	0	1	0	1	1	1
	8																																																									1	1	1	0	0	0	1	0	0	1	0	1	1	1
	9																																																									1	1	1	0	0	0	1	0	0	1	0	1	1	1
	10																																																									1	1	1	0	0	0	1	0	0	1	0	1	1	1

Scenario 4: Globally competitive, only benefits from Beneficiation Programme

	Output	Global Electricity costs	Steel availability (South Africa)	Steel price (South Africa)	PGM Reserves	PGM Price	Oil reserves	Oil price	Global demand for cars	Overcapacity for production of converters	European demand for converters	Inflation	Economic recession	Credit availability	Foreign Direct Investment in Africa	Economic growth in Africa	Russian/Foreign PGM reserves	Increase in pollution	New propulsion method: Fuel Cells	Environmental legislation	Diesel Technology	New propulsion method:Electric cars	New converter technology	Other industrial uses for PGM	Asian demand for cars	Asian converter production capability	Asian Labour cost	Exchange rate	Unstable SA Electricity supply	SA electricity costs	SA labour costs	Stable SA Politics	SA Globally competitive	Unstable SA labour relations	External flexibility	Clear two way internal communication	Internal quality	Internal flexibility	Existance of effective waste elimination p	Innovation capability	Production scheduling based on pull app	Cost leader	Internal customer satisfaction orientated	Learning organisational culture	Existence of effective Quality at source p	Well defined manufacturing strategy	Leadership commitment to WCO	Effective use of SPC	Effective preventative maintenance progr	Cellular production layout	Facility control	Effective vendor management programme	Strong focus on lead time reduction	Integrated Materials Resource Planning (I	Optimum inventory levels	Ownership of quality among employees	Demand for SA converters	Effective preventative maintenance progr	Cellular production layout	Leadership commitment to WCO	Unstable SA labour relations	Russian PGM reserves	Global Electricity costs	Economic recession	Asian Labour cost	Asian car demand	Stable SA Politics	Unstable SA Electricity supply	Effective vendor management programme	Benefits of APDP	Benefits of Beneficiation Programme
	Startup	0	0	0	0	0	0	0	1	1	1	0	0	0	0	1	0	1	0	1	1	0	1	1	0	1	0	0	1	1	0	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	1	0	1	0	1
Cycle	1	0	1	1	0	1	1	1	1	0	1	0	0	0	1	0	0	1	1	1	0	1	1	0	0	0	0	0	0	1	0	0	1	0	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	0	1	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	1	0	1	0	1
	2	0	1	0	1	1	1	0	1	0	1	0	0	0	1	1	0	1	1	1	1	1	1	0	0	0	0	0	0	1	0	0	1	0	1	1	1	1	1	1	1	0	1	1	1	0	0	1	0	0	1	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	1	0	1	0	1
	3	0	1	0	1	0	1	0	1	0	1	0	0	0	1	1	0	1	0	1	0	1	1	0	0	0	0	0	0	1	0	0	1	0	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	1	0	1	1	1	0	1	1	1	1	0	0	0	0	0	0	1	0	1	0	1
	4	0	1	0	1	0	1	0	1	0	1	0	0	0	1	1	0	1	0	1	0	0	1	0	0	0	0	0	0	1	0	0	1	0	1	1	0	1	0	1	1	1	1	1	0	0	0	0	0	0	1	0	1	1	1	0	1	1	1	1	0	0	0	0	0	0	1	0	1	0	1
	5	0	1	0	1	0	1	0	1	0	1	0	0	0	1	1	0	1	0	1	0	0	1	0	0	0	0	0	0	1	0	0	1	0	1	1	0	1	0	1	1	0	1	1	0	0	0	0	0	0	1	0	1	1	1	0	1	1	1	1	0	0	0	0	0	0	1	0	1	0	1
	6																																																									1	1	1	0	0	0	0	0	0	1	0	1	0	1
	7																																																									1	1	1	0	0	0	0	0	0	1	0	1	0	1
	8																																																									1	1	1	0	0	0	0	0	0	1	0	1	0	1
	9																																																									1	1	1	0	0	0	0	0	0	1	0	1	0	1
	10																																																									1	1	1	0	0	0	0	0	0	1	0	1	0	1

Scenario 5: Globally competitive, no leadership commitment to WCO elements

Output		Global Electricity costs	Steel availability (South Africa)	Steel price (South Africa)	PGM Reserves	PGM Price	Oil reserves	Oil price	Global demand for cars	Overcapacity for production of converters	European demand for converters	Inflation	Economic recession	Credit availability	Foreign Direct Investment in Africa	Economic growth in Africa	Russian/Foreign PGM reserves	Increase in pollution	New propulsion method: Fuel Cells	Environmental legislation	Diesel Technology	New propulsion method:Electric cars	New converter technology	Other industrial uses for PGM	Asian demand for cars	Asian converter production capability	Asian Labour cost	Exchange rate	Unstable SA Electricity supply	SA electricity costs	SA labour costs	Stable SA Politics	SA Globally competitive	Unstable SA labour relations	External flexibility	Clear two way internal communication
Startup		0	0	0	0	0	0	0	1	1	1	0	0	0	0	1	0	1	0	1	1	0	1	1	0	1	0	0	1	1	0	1	1	0	1	1
Cycle	1	0	1	1	0	1	1	1	1	0	1	0	0	0	1	0	0	1	1	1	0	1	1	0	0	0	0	0	0	1	0	0	1	0	1	0
	2	0	1	0	1	1	1	0	1	0	1	0	0	0	1	1	0	1	1	1	1	1	1	0	0	0	0	0	0	1	0	0	1	0	1	0
	3	0	1	0	1	0	1	0	1	0	1	0	0	0	1	1	0	1	0	1	0	1	1	0	0	0	0	0	0	1	0	0	0	0	1	0
	4	0	1	0	1	0	1	0	1	0	1	0	0	0	1	1	0	1	0	1	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0
	5																																			
	6																																			
	7																																			
	8																																			
	9																																			
	10																																			

Output		Internal quality	Internal flexibility	Existance of effective waste elimination p	Innovation capability	Production scheduling based on pull app	Cost leader	Internal customer satisfaction orientated	Learning organisational culture	Existence of effective Quality at source p	Well defined manufacturing strategy	Leadership commitment to WCO	Effective use of SPC	Effective preventative maintenance progr	Cellular production layout	Facility control	Effective vendor management programme	Strong focus on lead time reduction	Integrated Materials Resource Planning (I	Optimum inventory levels	Ownership of quality among employees	Demand for SA converters	Effective preventative maintenance progr	Cellular production layout	Leadership commitment to WCO	Unstable SA labour relations	Russian PGM reserves	Global Electricity costs	Economic recession	Asian Labour cost	Asian car demand	Stable SA Politics	Unstable SA Electricity supply	Effective vendor management programme	Benefits of APDP	Benefits of Beneficiation Programme
Startup		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	1	0	1	0	1
Cycle	1	1	1	1	1	1	1	1	0	1	0	0	1	0	0	1	0	1	1	1	1	1	1	1	0	0	0	0	0	0	0	1	0	1	0	1
	2	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1	0	0	0	0	0	0	0	1	0	1	0	1
	3	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	1	0	1	0	1
	4	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	1	0	1	0	1
	5																						1	1	0	0	0	0	0	0	0	1	0	1	0	1
	6																						1	1	0	0	0	0	0	0	0	1	0	1	0	1
	7																						1	1	0	0	0	0	0	0	0	1	0	1	0	1
	8																						1	1	0	0	0	0	0	0	0	1	0	1	0	1
	9																						1	1	0	0	0	0	0	0	0	1	0	1	0	1
	10																						1	1	0	0	0	0	0	0	0	1	0	1	0	1

Scenario 6: Globally competitive, with Beneficiation Programme and leadership commitment but with unstable South African politics, unstable electricity supply and unstable labour relations

Output		Global Electricity costs	Steel availability (South Africa)	Steel price (South Africa)	PGM Reserves	PGM Price	Oil reserves	Oil price	Global demand for cars	Overcapacity for production of converters	European demand for converters	Inflation	Economic recession	Credit availability	Foreign Direct Investment in Africa	Economic growth in Africa	Russian/Foreign PGM reserves	Increase in pollution	New propulsion method: Fuel Cells	Environmental legislation	Diesel Technology	New propulsion method:Electric cars	New converter technology	Other industrial uses for PGM	Asian demand for cars	Asian converter production capability	Asian Labour cost	Exchange rate	Unstable SA Electricity supply	SA electricity costs	SA labour costs	Stable SA Politics	SA Globally competitive	Unstable SA labour relations	External flexibility	Clear two way internal communication
Startup		0	0	0	0	0	0	0	1	1	1	0	0	0	0	1	0	1	0	1	1	0	1	1	0	1	0	0	1	1	0	1	1	0	1	1
Cycle	1	0	1	1	0	1	1	1	1	0	1	0	0	0	0	0	0	1	1	1	0	1	1	0	0	0	0	0	0	0	1	0	1	0	1	1
	2	0	1	0	0	1	1	0	1	0	1	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0	0	0	0	1	0	1	0	1	1
	3	0	1	0	0	1	1	0	1	0	1	0	0	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	0	0	1	0	1	0	1	1
	4	0	1	0	0	1	1	0	1	0	1	0	0	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	0	0	1	0	1	0	1	1
	5	0	1	0	0	1	1	0	1	0	1	0	0	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	0	0	1	0	1	0	1	1
	6																																			
	7																																			
	8																																			
	9																																			
	10																																			

Output		Internal quality	Internal flexibility	Existance of effective waste elimination p	Innovation capability	Production scheduling based on pull app	Cost leader	Internal customer satisfaction orientated	Learning organisational culture	Existence of effective Quality at source p	Well defined manufacturing strategy	Leadership commitment to WCO	Effective use of SPC	Effective preventative maintenance progr	Cellular production layout	Facility control	Effective vendor management programme	Strong focus on lead time reduction	Integrated Materials Resource Planning (I	Optimum inventory levels	Ownership of quality among employees	Demand for SA converters	Effective preventative maintenance progr	Cellular production layout	Leadership commitment to WCO	Unstable SA labour relations	Russian PGM reserves	Global Electricity costs	Economic recession	Asian Labour cost	Asian car demand	Stable SA Politics	Unstable SA Electricity supply	Effective vendor management programme	Benefits of APDP	Benefits of Beneficiation Programme
Startup		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	1	1	0	1
Cycle	1	1	1	1	1	1	1	1	1	1	1	0	1	0	0	1	0	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	1	1	0	1
	2	1	1	1	1	1	0	1	1	1	0	0	1	0	0	1	0	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	1	1	0	1
	3	1	1	1	1	1	1	1	1	0	0	0	0	0	0	1	0	1	1	1	0	1	1	1	1	1	0	0	0	0	0	0	1	1	0	1
	4	0	1	0	1	1	1	1	1	0	0	0	0	0	0	1	0	1	1	1	0	1	1	1	1	1	0	0	0	0	0	0	1	1	0	1
	5	0	1	0	1	1	0	1	1	0	0	0	0	0	0	1	0	1	1	1	0	1	1	1	1	1	0	0	0	0	0	0	1	1	0	1
	6																						1	1	1	1	0	0	0	0	0	0	1	1	0	1
	7																						1	1	1	1	0	0	0	0	0	0	1	1	0	1
	8																						1	1	1	1	0	0	0	0	0	0	1	1	0	1
	9																						1	1	1	1	0	0	0	0	0	0	1	1	0	1
	10																						1	1	1	1	0	0	0	0	0	0	1	1	0	1

Scenario 7: Globally competitive with Beneficiation Programme and leadership commitment. Both instability within South Africa and also affected by deteriorating global factors such as energy costs, global PGM reserves and growth in Asian markets

Output		Global Electricity costs	Steel availability (South Africa)	Steel price (South Africa)	PGM Reserves	PGM Price	Oil reserves	Oil price	Global demand for cars	Overcapacity for production of converters	European demand for converters	Inflation	Economic recession	Credit availability	Foreign Direct Investment in Africa	Economic growth in Africa	Russian/Foreign PGM reserves	Increase in pollution	New propulsion method: Fuel Cells	Environmental legislation	Diesel Technology	New propulsion method:Electric cars	New converter technology	Other industrial uses for PGM	Asian demand for cars	Asian converter production capability	Asian Labour cost	Exchange rate	Unstable SA Electricity supply	SA electricity costs	SA labour costs	Stable SA Politics	SA Globally competitive	Unstable SA labour relations	External flexibility	Clear two way internal communication	Internal quality	Internal flexibility	Existance of effective waste elimination p	Innovation capability	Production scheduling based on pull app	Cost leader	Internal customer satisfaction orientated	Learning organisational culture	Existence of effective Quality at source p	Well defined manufacturing strategy	Leadership commitment to WCO	Effective use of SPC	Effective preventative maintenance progr	Cellular production layout	Facility control	Effective vendor management programme	Strong focus on lead time reduction	Integrated Materials Resource Planning (I	Optimum inventory levels	Ownership of quality among employees	Demand for SA converters	Effective preventative maintenance progr	Cellular production layout	Leadership commitment to WCO	Unstable SA labour relations	Russian PGM reserves	Global Electricity costs	Economic recession	Asian Labour cost	Asian car demand	Stable SA Politics	Unstable SA Electricity supply	Effective vendor management programme	Benefits of APDP	Benefits of Beneficiation Programme
Startup		0	0	0	0	0	0	0	1	1	1	0	0	0	0	1	0	1	0	1	1	0	1	1	0	1	0	0	1	1	0	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	0	1	1	0	1
Cycle	1	0	0	1	0	1	0	1	1	0	1	0	0	0	0	0	0	1	1	1	0	1	1	0	0	0	0	0	0	0	1	0	1	0	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	0	1	0	1	1	1	1	1	1	1	1	1	1	1	0	1	1	0	1	1	0	1
	2	0	0	1	0	1	0	1	0	0	1	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0	0	0	0	1	0	1	0	1	1	1	1	1	1	1	0	1	1	1	0	0	1	0	0	1	0	1	1	1	1	1	1	1	1	1	1	1	0	1	1	0	1	1	0	1
	3	0	0	1	1	1	0	1	0	1	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	1	0	1	0	1	1	1	1	1	1	1	0	1	1	0	0	0	0	0	0	1	0	1	1	1	0	1	1	1	1	1	1	1	0	1	1	0	1	1	0	1
	4	0	0	1	1	0	0	1	0	1	0	0	0	0	0	0	0	0	1	0	1	1	1	0	0	0	0	0	0	0	1	0	1	0	1	1	0	1	0	1	1	0	1	1	0	0	0	0	0	0	1	0	1	1	1	0	0	1	1	1	1	1	1	0	1	1	0	1	1	0	1
	5	0	0	1	1	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	1	0	1	1	0	1	0	1	1	0	1	1	0	0	0	0	0	0	1	0	1	1	1	0	0	1	1	1	1	1	1	0	1	1	0	1	1	0	1
	6	0	0	1	1	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	1	0	1	1	0	1	0	1	1	0	1	1	0	0	0	0	0	0	1	0	1	1	1	0	1	1	1	1	1	1	1	0	1	1	0	1	1	0	1
	7																																																									1	1	1	1	1	1	0	1	1	0	1	1	0	1
	8																																																									1	1	1	1	1	1	0	1	1	0	1	1	0	1
	9																																																									1	1	1	1	1	1	0	1	1	0	1	1	0	1
	10																																																									1	1	1	1	1	1	0	1	1	0	1	1	0	1

Scenario 8: Not Globally competitive but with leadership commitment to WCO elements

Output		Global Electricity costs	Steel availability (South Africa)	Steel price (South Africa)	PGM Reserves	PGM Price	Oil reserves	Oil price	Global demand for cars	Overcapacity for production of converters	European demand for converters	Inflation	Economic recession	Credit availability	Foreign Direct Investment in Africa	Economic growth in Africa	Russian/Foreign PGM reserves	Increase in pollution	New propulsion method: Fuel Cells	Environmental legislation	Diesel Technology	New propulsion method:Electric cars	New converter technology	Other industrial uses for PGM	Asian demand for cars	Asian converter production capability	Asian Labour cost	Exchange rate	Unstable SA Electricity supply	SA electricity costs	SA labour costs	Stable SA Politics	SA Globally competitive	Unstable SA labour relations	External flexibility	Clear two way internal communication	Internal quality	Internal flexibility	Existance of effective waste elimination p	Innovation capability	Production scheduling based on pull app	Cost leader	Internal customer satisfaction orientated	Learning organisational culture	Existence of effective Quality at source p	Well defined manufacturing strategy	Leadership commitment to WCO	Effective use of SPC	Effective preventative maintenance progr	Cellular production layout	Facility control	Effective vendor management programme	Strong focus on lead time reduction	Integrated Materials Resource Planning (I	Optimum inventory levels	Ownership of quality among employees	Demand for SA converters	Effective preventative maintenance progr	Cellular production layout	Leadership commitment to WCO	Unstable SA labour relations	Russian PGM reserves	Global Electricity costs	Economic recession	Asian Labour cost	Asian car demand	Stable SA Politics	Unstable SA Electricity supply	Effective vendor management programme	Benefits of APDP	Benefits of Beneficiation Programme
Startup		0	0	0	0	0	0	0	1	1	1	0	0	0	0	1	0	1	0	1	1	0	1	1	0	1	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	1	0	1
Cycle	1	0	1	1	0	1	1	1	1	0	1	0	0	0	1	0	0	1	1	1	0	1	1	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	1	0	1
	2	0	1	0	1	1	1	0	1	0	1	0	0	0	0	1	0	1	1	1	1	1	1	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	1	0	0	1	1	1	0	0	1	0	0	0	0	1	1	1	1	0	0	0	1	0	0	0	0	0	0	0	0	1	0	1
	3	0	1	0	1	0	1	0	1	0	1	0	0	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	0	1	0	0	0	0	0	1	1	1	1	1	1	0	1	1	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	1
	4	0	1	0	1	0	1	0	1	0	1	0	0	0	0	0	0	1	0	1	0	0	1	0	0	0	0	0	0	1	0	0	1	0	1	1	0	1	0	1	1	1	1	1	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	1
	5	0	1	0	1	0	1	0	1	0	1	0	0	0	0	0	0	1	0	1	0	0	1	0	0	0	0	0	0	1	0	0	1	0	1	1	0	1	0	1	1	0	1	1	0	0	0	0	0	0	0	0	1	1	1	0	1	0	0	1	0	0	0	0	0	0	0	0	1	0	1
	6																																																									0	0	1	0	0	0	0	0	0	0	0	1	0	1
	7																																																									0	0	1	0	0	0	0	0	0	0	0	1	0	1
	8																																																									0	0	1	0	0	0	0	0	0	0	0	1	0	1
	9																																																									0	0	1	0	0	0	0	0	0	0	0	1	0	1
	10																																																									0	0	1	0	0	0	0	0	0	0	0	1	0	1