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GORDON INSTITUTE OF BUSINESS SCIENCE

The role of modularity and module supply in the South African automotive industry

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A research project submitted to the Gordon Institute of Business Science, University of Pretoria, in partial fulfilment of the requirements for the degree of Master of Business Administration.

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Abstract:

This research focuses on the degree of implementation of modularity and module supply by the automobile manufacturers in South Africa and the benefits they experience. Special attention was paid to the effect the modularity has on the local supplier base and the ability of small South African companies to support this supply concept. Lastly the factors influencing the car manufacturers' outsourcing decision process was uncovered.

The semi-structured face to face interviews with representatives of all light vehicle manufacturing companies operating in South Africa provided rich data for setting the background for further quantitative researches.

Key words: Modularity, Modular supply chain, Automobile Manufacturers, Automotive Suppliers, South African Small and Medium Enterprises

Declaration:

I declare that this research project is my own work. It is submitted in partial fulfilment of the requirements for the degree of Master of Business Administration at the Gordon Institute of Business Science, University of Pretoria. It has not been submitted before for any degree or examination in any other University. I further declare that I have obtained the necessary authorization and consent to carry out this research.

Signed:

Emil Milenov

Signed at Pretoria on 13th day of November 2008

Dedication:

To my family for their great support during my academic endeavour.

Acknowledgements:

I acknowledge my mentor and my academic supervisor for the valuable input to this research.

Table of Contents:

List of Tables

List of Figures

List of Appendices

1. Introduction

1.1. Research problem:

Finding ways to improve the efficiencies of manufacturing systems has always been top priority for every company's operation managers and strategists. This is particularly valid in the automotive industry where the fierce competition between American, European and Japanese manufacturers has led to the development of many methods to reduce costs and improve the performance of manufacturing systems. One of these methods is the JIT – Just in time delivery. Initially it was aimed to improve intra-company and intra-plant processes. However, none of OEMs (Original Equipment Manufacturers) covered the entire supply chain and logically the next step was to include the first-tier suppliers and to incorporate them into the inter-company JIT system as so called "JIT suppliers".

As international economies opened to global markets so too, did the auto assemblers, followed by the component manufacturers. As a result, the JIT delivery system has become more complex, which hinders its efficiency. This was one of the major reasons for the adoption of modularity as a method to design and manufacture automobiles. Hence the formation of different types of JIT suppliers - the Integrated Module Suppliers (or simply 'module suppliers'), which focus entirely on

modules development, manufacturing and delivery to the OEM's assembly line on a "just in time" and "just in sequence" basis.

Modularity is widely used by European, American and to a lesser extent, Japanese auto manufacturers. Since the South African auto industry is part of the global manufacturing scene, with shared platforms, vehicle designs and supplier chains, the modular approach is evident in South Africa as well.

There are two distinct characteristics of the South African automotive industry – size and export orientation. According to a report, distributed by B&M Analysts (2007) to the members of the South African Automotive Benchmarking Club (SAABC) in 2004, the South African Automotive industry has been rated 19th globally, accounting for less than 1% of global manufacturing capacity.

According to the report "South Africa's automotive industry 2006", compiled by Shona Kohler (2006) along with the research unit at Creamer Media, seven global car manufacturers are present in South Africa - Volkswagen; Toyota; Mercedes; Ford; BMW; General Motors and Nissan/ Fiat.

Statistics released by the National Association of Automotive Manufacturers in South Africa (NAAMSA) shows that 36% of the total light vehicle production in 2006 was exported. This figure is expected to increase, stimulated by the Motor Industry Development Program (or MIDP).

Considering these facts, it will be interesting to establish whether the impact of modularity on the South African automotive industry is the same as in other parts of the world.

1.2. Research aim:

The aim of this research is to investigate the degree to which modularity is utilised, and its effect on efficiency improvement and cost reduction initiatives in the South African automotive industry.

By forging a better understanding of the processes related to modularity within auto manufacturing in South Africa, this research also aims to assist component suppliers to fit better within the module supply chain and automobile assemblers to explore the opportunities provided by the modularity to their fullest extent.

So far there is no indication of such a study being conducted in South Africa. This is hence part of the rationale behind this research.

2. Literature review:

2.1. Introduction:

Modularity is a complex operational and engineering approach to organising supply chain and designing products. It is adopted as a response to particular challenges faced by the automotive industry. It changes the supplier–assembler relationship and even affects the organisational structure of the companies. Modularity as a production and supply chain organisation method is closely related to the JIT supply model.

Therefore, the literature review will focus on:

- The state of the global automotive industry;
- The state of the South African automotive industry;
- JIT and supply chain issues in operations systems;
- The relationship of supplier – original equipment assembler;
- An overview of the modularity and module supply concept.

2.2. The state of the global automotive industry:

The global automotive industry is characterised by globalisation, saturated markets (with the emergence of new markets) and increased buying power in mature markets. These factors have led to dynamic changes in the business model of the automotive industry, including changes in its value chain.

2.2.1. *Challenges to the global automotive industry*:

Of the numerous challenges facing the automotive industry, Colin Whitbread (2003) highlights two: matching capacity to demand, and the ability to "efficiently produce a rapidly broadening range of new cars for the more mature markets in the world." Flexibility and streamlined processes throughout the complete supply chain is the key to resolving both issues. This, however, shifts the pressure from OEM to the suppliers who now have less time to deliver a greater variety of components.

Further, Whitbread (2003) highlights three main issues for the automotive industry:

- Rapid demand change - both in mix and volumes

- Major changes in manufacturing processes – associated with the intensified shift of traditional assembly operations down the supply chain;
- The manufacturing system's growth into a strategic tool to satisfy the end customer and charge a premium to that.

The increased buying power of the end customer means that auto manufacturers have to meet increased demand for variety through what is known as "mass customisation", and to combine this with the ability to accommodate a change in choice at a very late stage in the production process. According to Morris and Donnelly (2006), the latter is achieved through a manufacturing method called "late configuration".

Gary Murphy (2006) points out that saturated markets and increased competition in the auto industry combined with economic volatility puts downward pressure on prices. Another challenge he describes is attributed to the dynamics in the value chain – a decreasing number of vertical manufacturers, modularisation and consolidation of suppliers, which all aim at cost reduction. The third challenge Murphy (2006) describes relates to increased product complexity and the associated research and development costs, along with shortened platform lifecycles. In addition, the regulatory environment (environmental and

emissions control; passenger safety, etc.) also contributes to the challenges facing the auto industry and to the resulting complexity of auto products.

To illustrate this increased complexity we can follow the expansion of Volkswagen over the last two decades into different market segments in Figure 1. Over those two decades Volkswagen widened its presence to cover 40 segments in the automotive market.

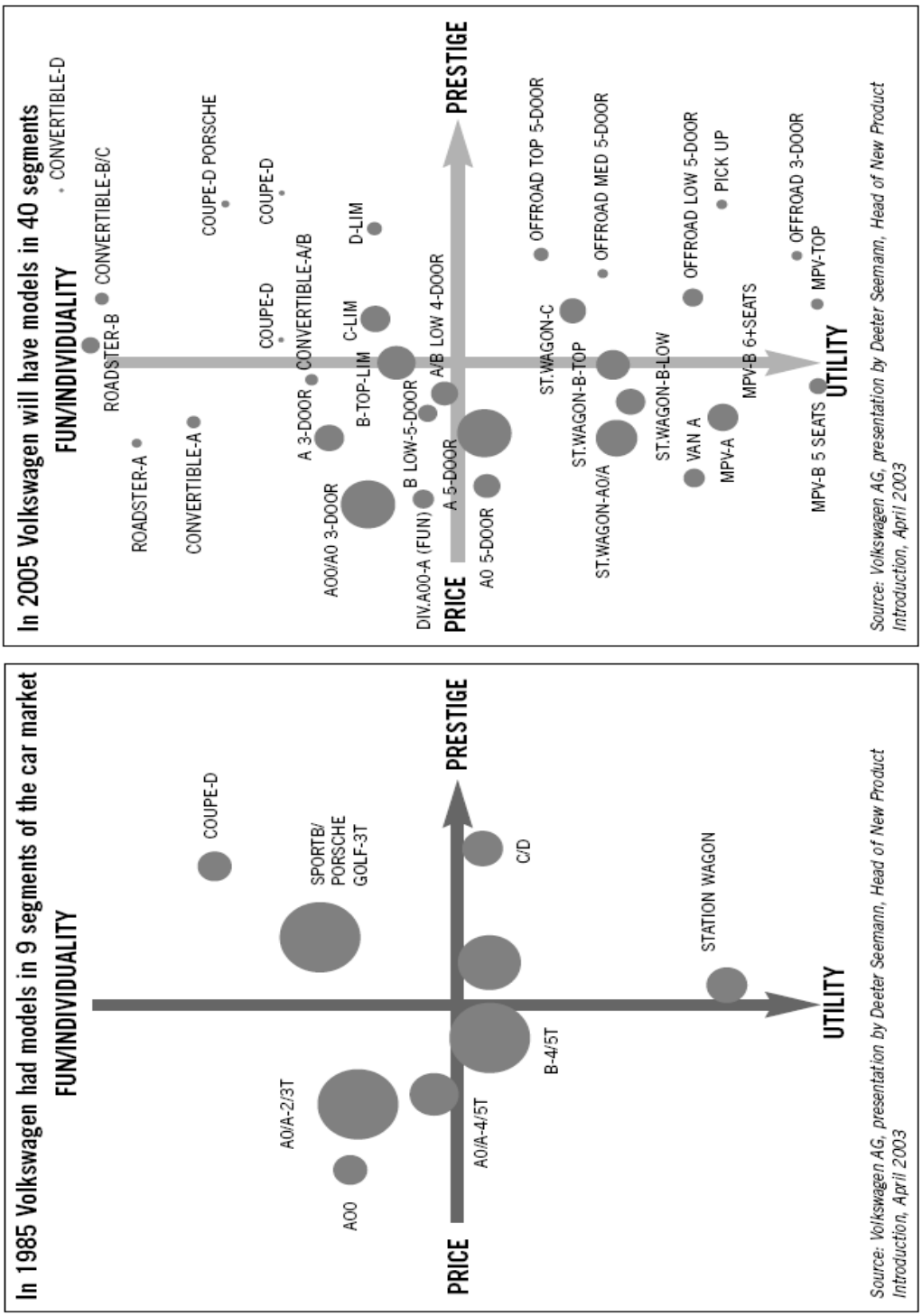
2.2.2. Response of automotive manufacturers to the challenges

In order to meet these challenges the automotive industry is undergoing major change. According Whitbread (2003), some of the dimensions to this change include:

- Flexible manufacturing – enhanced by modularity;
- Build to order – enabled by modularity and information technology;
- Risk sharing – suppliers share the risk of not recovering the capital investment;
- Outsourcing – not only logistics and manufacturing, but also research and development (R&D).

The above clearly illustrates the increased shift of responsibilities down the supply chain to the suppliers.

Figure 1: VW model segments 1985 - 2005



Source : Seeman (2003)

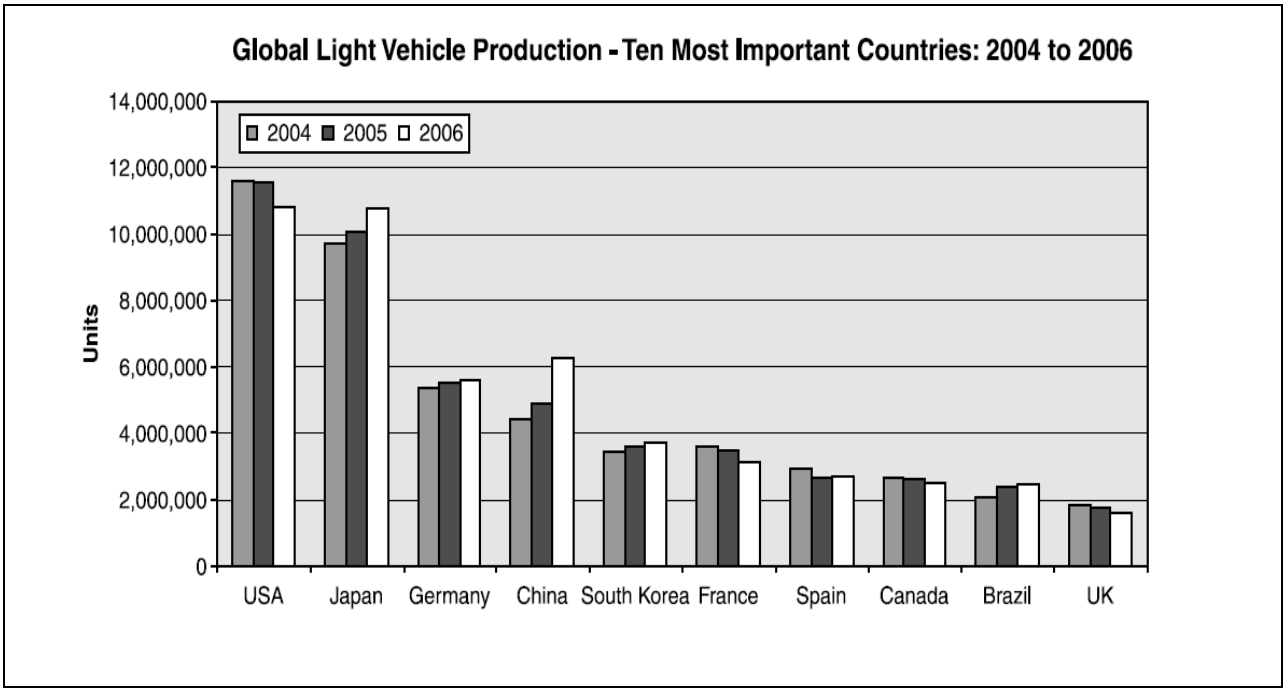
2.2.3 Trends in the automotive manufacturing

In their analysis of the trends in the automotive industry Donnelly, Morris and Donnelly (2006) detect a shift from a traditional mass production manufacturing set-up, focused on maximising economies of scale, towards a more disintegrated system. This move is characterised by globalisation and a new relationship between OEM and suppliers.

Starting in the late 1980s the globalisation of the automotive industry triggered a series of mergers and acquisitions and the formation of strategic alliances. Those dynamics filtered to the suppliers who then followed suit. Evidence of consolidation processes in the automotive supply sector is the fact that the number of suppliers fell from around 30000 to 8000 over a period of 20 years.

Another important trend according Barnes and Morris (2008), is the slow down in automobile manufacturing in developed countries (USA, France) and the increased number of vehicles manufactured in China and Brazil. Those trends are evident in the Figure 2 overleaf.

Figure 2



Source: www.oica.net

2.3. The state of the South African automotive industry:

2.3.1. Historical background of the South African automotive industry

The South African automotive industry was established during the 1920's with the opening of Ford and General Motors assembly plants. Barnes and Kaplinsky (2000) characterise the first three decades of the development of the local auto industry by low levels of value-adding (less than 20%), with only basic components like tyres and batteries sourced locally. Low value-adding levels prompted the government to initiate local content programs (6 in total between 1960 and 1995). These programs involved enforcing a series of tariffs and import

permits, but they wrongfully targeted weight as a measurement for local content instead of value. They also provided extremely high levels of protection to the local industry.

According to Barnes and Kaplinsky (2000), another feature of the SA automotive industry which shaped it significantly was the sanctions imposed on the country in the late 1970s. This led to the withdrawal of American manufacturers and signalled local ownership of the automotive industry.

The end of sanctions once again led to significant changes in the ownership of major manufacturing companies, a shift from predominantly local to multinational ownership. This is evident from Table 1 overleaf.

Table 1: SA based OEM ownership overview

SA-based OEM Ownership Overview: 1990 - 2005

South African assembler	Ownership: 1990	Ownership: 1998	Ownership: 2005	Ownership: 1990 to 2005
Toyota	100% local (listed on Johannesburg Stock Exchange)	Local: 72% (JSE), Toyota (Japan): 28%	Toyota (Japan): 75% Wesco (SA: 25%,	***SA to MNC-dominated Joint Venture***
Volkswagen	Volkswagen AG: 100%	Volkswagen AG: 100%	Volkswagen AG: 100%	***MNC – no change***
BMW	BMW AG: 100%	BMW AG: 100%	BMW AG: 100%	***MNC – no change***
DaimlerChrysler	DaimlerChrysler (Mercedes Benz): 50%, Local 50%	DaimlerChrysler (Mercedes Benz): 100%	DaimlerChrysler: 100%	***Joint Venture to MNC***
Ford	100% local (Anglo American)	Anglo American: 45%, Ford: 45%, Emp. trust: 10%	Ford: 100%	***SA to MNC***
Nissan	87% local, Nissan Diesel: 4%, Mitsui (Japan): 9%	Local: 37%, Nissan: 50%, Nissan Diesel: 4%, Mitsui: 9%	Nissan: 87%, Nissan Diesel: 4%, Mitsui:9%	***Primarily SA to MNC***
General Motors	100% local (management)	Local managers: 51%, GM: 49%	General Motors: 100%	***SA to MNC***

Source B&M Analysts

2.3.2. Globalisation and developing countries' automotive sector.

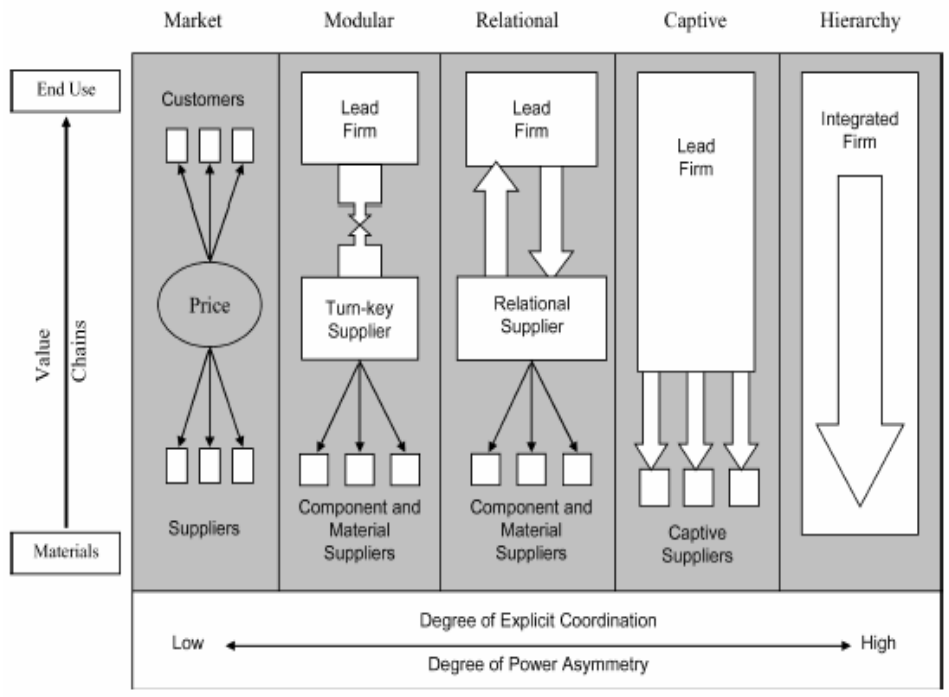
The effects of globalisation on the structure and governance of the value chain has been explored by Gereffi, Humphrey and Sturgeon (2005). Particular attention was paid to the effect of globalisation on the development of new capabilities in developing countries.

They distinguish five types of governance of global value chains, which is illustrated in Figure 3 overleaf.

- Market
- Modular value chains
- Relational value chains
- Captive value chains
- Hierarchy

They listed them from horizontal to a completely vertical and integrated value chain.

Figure 3: Governance of global value chains



Source: Gereffi, Humphrey and Sturgeon (2005)

The degree of power asymmetry is plotted on the horizontal axis in Figure 3 and represents the inequality in the relationship supplier–customer, whereas the vertical axis follows the transition of the material to the end-user product.

According Gereffi *et al*. (2005), modularity has to be supported by the product architecture and the application of technical standards, which help by reducing the number of variants. An important factor for achieving the modular state of the value chain is the competence of the supplier to provide complete packages to the customer and their ability to control large portions of the supply chain.

Gereffi *et al*. (2005) point out that the integration of suppliers originating from developing countries into global value chains poses a unique challenge. Very often they are required to exceed the requirements generally demanded by local markets. This creates a clear gap between domestic and global capabilities, which necessitates stringent controls over potential suppliers.

What options, then, are available to developing economies, which are positioned beside developed ones (traditional European, American and Japanese) and newly rising Asian stars (with huge domestic markets

and cheap labour)? This question is posed by Barnes and Morris (2008), who determine that the modern automotive value chain is one that is "producer driven". In it the automotive assembler holds key integration roles and simultaneously shifts larger operational responsibilities to the first-tier suppliers. The latter operate their own value and supply chains. The manufacturing value, added by component manufacturers, is estimated to about 70% of the total product value in the automotive industry.

The last couple of years have been marked by the poor financial performance of all OEMs. This, according to Barnes and Morris (2008) was triggered by overcapacity and limited market growth in mature economies. The automobile assemblers have responded to the challenge in three ways:

- Transfer of R&D responsibilities to first-tier component manufacturers;
- Move towards modular production, converting first-tier suppliers into module assemblers;
- Following from the first two - the integration of the component industry by large scale mergers and acquisitions.

The last two trends play a significant role in shaping South African automotive component manufacturing. Poor quality is no longer tolerable due to the high technical standards set by multinational OEMs. Over the past decade South African component suppliers have shifted their focus from product R&D to process engineering and the development of testing methods and equipment. The total spend on local, new product development has dropped from 2.08% to 1.48% of total sales during the period 2001 – 2006, as per Barnes and Morris (2008)

2.3.3. Challenges to the South African automotive industry

According to research conducted by Econometrix and referred to by NAAMSA in its 2008 yearbook, the automotive industry, as a whole, contributed to 7.53% of South African GDP. Vehicle and component manufacturing alone account for 3.83% of GDP. This makes it the largest manufacturing sector in SA, contributing 21% of total manufacturing output.

The seven global car manufacturers present in South Africa are Volkswagen; Toyota; Mercedes; Ford; BMW; General motors and Nissan/ Fiat. They assemble light, passenger cars, as well as medium and heavy commercial vehicles. They are located in three provinces:

Gauteng, which has 3 OEMs; Eastern Cape, also with 3 and Kwazulu-Natal which has 1 OEM. These provinces are also home to the component manufacturing industry, contributing 50%; 30% and 20% of national production respectively.

In the report "South Africa's automotive industry 2006", compiled by Shona Kohler (2006) along with the research unit at Creamer Media, special attention is paid to the conditions and trends in South African component manufacturing. Following the global drive for modularisation, eight out of the top ten global component manufacturers and three of the four tyre companies invested in South Africa. This shift in the industry means that small local companies are excluded from cutting edge design and development processes and assume the role of second-tier suppliers. Local suppliers, nevertheless still stand to benefit from extended business opportunities.

B&M Analysts (2007), in their report to the members of the South African Automotive Benchmarking Club (SAABC), highlight the fact that the South African automotive industry is a strong player in the global scene. This contention is supported by trends pointing to the reduction of the total number of platforms and the increase of the number of vehicle models, with yearly volumes rising above 40000 units, as

illustrated in Table 2. This is in line with the aim of the Motor Industry Development Program (MIDP) to stimulate domestic manufacturers to specialise in high volume models, destined for export, and to import much lower volumes.

In order to better understand the above, it is important to clarify the difference between 'platform' and 'model.' As Johannes van Biesebroek (2007) states, although car manufacturers define platform in different ways, it can be accepted as a set of common design and manufacturing practices over a number of distinct models. Outwardly different products are assembled by using common inner components and standard assembly methods.

Table 2: SA automotive industry key data

Indicator	1995	2005
Productivity (average number of vehicles produced per employee)	10.0	15.3
Auto industry contribution to GDP	6.5%	7.6%
No. of passenger car derivatives on sale in domestic market	228	1,071
Export destinations for vehicles & components above R1 million per annum	62	124
No. of model platforms	42	22
Models with production volumes >40,000 units	0	5

Source NAAMSA

However, South African production accounts for only 0.79% of global capacity, which signifies its marginal position. The vulnerable position of local auto manufacturing is aggravated by the limited growth in mature markets which leaves excess manufacturing capacity far greater than what South Africa produces.

Another threat to the SA automotive industry comes from China and India. Both countries are building significant manufacturing potential, capable of not only meeting the local demand, but supporting significant exports. Another alarming factor for the South African auto industry is the low price benchmark set by Indian and Chinese producers. These two factors are impacting negatively on local OEMs and component manufacturers.

The fundamental change in the South African automotive industry over the past decade has been attributed by Barnes and Morris (2004) to the principal changes in the global industry (vehicle platform rationalisation; global sourcing relationships OEM - supplier and the forming of follower supplier relationships), coupled with enabling domestic policies (MIDP in South African context). This change is demonstrated in the shift of ownership in auto assemblers and component manufacturers. The new demands on South African component manufacturers cover two areas:

the need for improved operational competitiveness and the demand for equity relationships between domestic and international component suppliers.

The South African automotive industry is fundamentally reliant on its exports. According to statistics released by the National Association of Automotive Manufacturers in South Africa (NAAMSA), the total domestic production of light vehicles for 2006 was 334 482 units, of which 119 171 (36%) were exported. A large portion of those exports are shipped to fairly distant markets – as far as the US and Australia.

The remoteness of South Africa from its markets results in complex logistics; long lead times and increased pressure on the price. The local market is also slowing down as a result of the cyclic nature of the auto industry, increasing interest rates and tighter credit regulations. As per NAAMSA, the sales (in terms of units) for 2007 shows a decline of nearly 5% compared to 2006. However, exports continue to rise on the back of ambitious export programs by all local automotive manufacturers.

As indicated by Barnes, Kaplinsky and Morris (2004), the aim of the MIDP, amongst others, is to improve the competitiveness of the firms

within the industry and to stimulate industry growth through exports. Further, they note the role of the program in shaping the industry in two distinct ways – to encourage the exporting of completely-built units and the sourcing of large quantities of components (catalytic converters being a typical example).

Over the past 12 years the industry has benefited from the Motor Industry Development Program (MIDP), which in broad terms stimulates the export of vehicles and components by awarding credits to offset the imports. The other aims of the program have been mentioned earlier. However, this program will run out in 2012, which means that the industry will have to face the effects thereafter without support.

2.3.4. Implications for South African component manufacturers.

Barnes and Kaplinsky (2000) investigate the alarming trend of the diminishing role of the typical local automotive components manufacturing firms, resulting from globalisation trends in the automotive industry.

According to their study the South African auto industry is characterised by the following features:

- Component sector is an important source of employment and a driver for other industries;
- Auto assembly plays a critical role in leveraging technological input into the component sector;
- The changes in the auto assembler's sector lead to the necessity for adjustment in the component sector as well.

According Barnes and Kaplinsky (2000) factors determining the use of domestically manufactured components include:

- Justification, based on comparison of transport cost to manufacturing cost
- Degree of product adaptation for local markets (e.g. technical adaptations due to geographical specificity)
- Resource intensity
- Availability of incentive schemes/ programs

Most car assemblers concentrate on their role as system integrators, partnering with a core pool of suppliers, and involving them already at the conceptual stage of vehicle design. This leaves very little opportunity for a domestic company with limited access to the latest technological developments to participate in a global supply chain. Another endangering factor for a developing country's component

manufacturing companies is the move towards modular design, which requires new sets of skills in outsourcing and supervising second tier suppliers.

Lorentzen *et al* (2004) concluded their study on innovation in the SA auto industry on a positive note. They state that local innovation still exists, and there is no evidence that re-structuring the innovation process will marginalise local capability to the point of extinction.

However, they also state that the latest pressures to car manufacturers force them to rely on trusted relationships with global partners, which leaves little room for the participation of local companies. This fact forces most of the local component manufacturers to lose their design capabilities and resort to other measures to secure supply contacts, which include seeking licence agreements, joint ventures and even selling to global companies. Supplying merely the local market, based on cost advantage alone, can position a particular company in a very vulnerable position. To reduce this effect, the component manufacturer must embed a technological advantage in their product, which will raise the barriers to substitution.

2.4. JIT and supply chain issues in operations management theory and publications

Melnyk and Denzler (1996) state that if someone wants to understand the JIT philosophy he "must approach it as a general philosophy of pursuing smooth, integrated production flows to eliminate waste and enhance value" (REFERENCE: pg number). They also give the following formula expression for the benefits of JIT:

$$\text{Value} = \frac{\text{Performance}}{\text{Cost}}$$

JIT-type operations increase value by both, decreasing the cost and increasing the performance of the system. Logically, one can increase value by strictly controlling cost, an approach taken by Ford in first quarter of the 20th century. Ford reduced the variety of products, (he is famous for the words: "The customers can have any colour vehicle they want, as long as it is black"), and applied complete control over his supply chain simply by owning every aspect of it. At the dawn of the 20th century, Ford Motor Company even owned mines and foundries, manufacturing the steel for their very own assembly lines.

Unfortunately, such an approach is totally inappropriate in modern times, which is marked by globalisation and increased demand for product complexity and customisation.

Melnyk and Denzler (1996) state that the reasons Japanese manufactured cars have a cost advantage over their American counterparts is higher labour productivity, lower inventory and better quality (or lower warranty cost). The explanation for these advantages is found in JIT organisation.

Hill (2005) finds the greatest advantage from JIT in inventory reduction. According to him there are two elements to it – reduction of the cost of inventory itself, as well as reducing the cost associated with its management.

2.5. The relationship between the supplier and the original equipment assemblers

As mentioned previously, the auto industry deals with a greater degree of complexity, which leads to specialisation and the build up of complex supplier chains. Within those chains, there is a dynamic interaction between suppliers and their customers. The relationship supplier – OEM,

according to Melnyk and Denzler (1996), can be classified into four types:

- Confrontation;
- Arms-length;
- Mutual goals acceptance, and
- Full partnership.

Confrontation involves a traditional purchasing relationship, but is characterised by strong distrust between both parties. Partnership, on the other hand, is the exact opposite – a relationship based on mutual respect and trust.

Pyke and Johnson (2002) stressed that the increased complexity of procured components inevitably directs companies to build long-term relationship with their suppliers.

Terry Hill (2005) follows the transition of operations management thinking from high asset utilisation to inventory-consciousness. The latter has proved more effective in enhancing the efficiency of the operations system. The underlying theory behind inventory thinking is the *theory of constraints*. According to this theory, a constraint is anything that limits the operation system's output. Effective

management of constraints reduces the need for inventories and improves the overall performance of organisations.

Hill (2005) focuses on supply chain management. Special attention is paid to the strategic considerations when taking "make or buy" decisions, by highlighting the benefits and disadvantages for the outsourcing company. Among the former are improved market flexibility, freed resources, reduced operating costs, improved cost control, flexibility, superior design, and opportunity to purchase from world class capability. The disadvantages are related to the loss of control, increased vulnerability, unprotected intellectual property, lack of reversibility, and the need for new management skills.

Hill (2005) also distinguishes four types of OEM – supplier relationship: market trawling, ongoing relationships, partnerships, and strategic alliances. This categorisation is similar to the one mentioned earlier, given by Melnyk and Denzler (1996).

Another insight into the OEM – supplier relationship is provided by Pyke and Johnson (2002), who establish that the increased complexity of

procured parts forces automotive manufacturers to reassess their procurement methods, and consider building strategic alliances with their suppliers.

Allnoch (1997) argues that companies can realise huge savings through effective supply chain management. Best practices include outsourced consolidation and packing and delivery to the customer's "point of use" – attributes which support the modularity and module supply chain.

2.6. Modularity and module supply concept

2.6.1. A Definition:

There is no commonly agreed definition of modularity (and related to it, modularisation and modules) as an operational phenomenon. For example, Donnelly, Morris and Donnelly (2006) state that modules are not easily defined. They nevertheless distinguish five types of modules: assembly, product, vertical, horizontal and integrating. For these experts, modularisation is a long term solution to the reality of low profitability levels in today's automobile manufacturing..

In their research, Kotabe, Parente and Murray (2007 p.100) concluded that "modularisation is a critical development in the global automotive industry". They support the definition of modularisation in the automotive context given by Sako (2003). According to Sako's definition, modules are components positioned in close proximity, which can be assembled as one unit into the car.

Doran (2004) supports this definition by giving the example of the design and manufacturing concept of Smart Car, which reduced the number of suppliers to 25, as opposed to the traditional involvement of about 100. Whitbread (2005 p. 4) in his study also refers to the module as "a set of components, physically co-located on a vehicle as a sub-assembly". This, in contrast to the definition of systems, where the components are grouped, based on commonality in function rather than physical location.

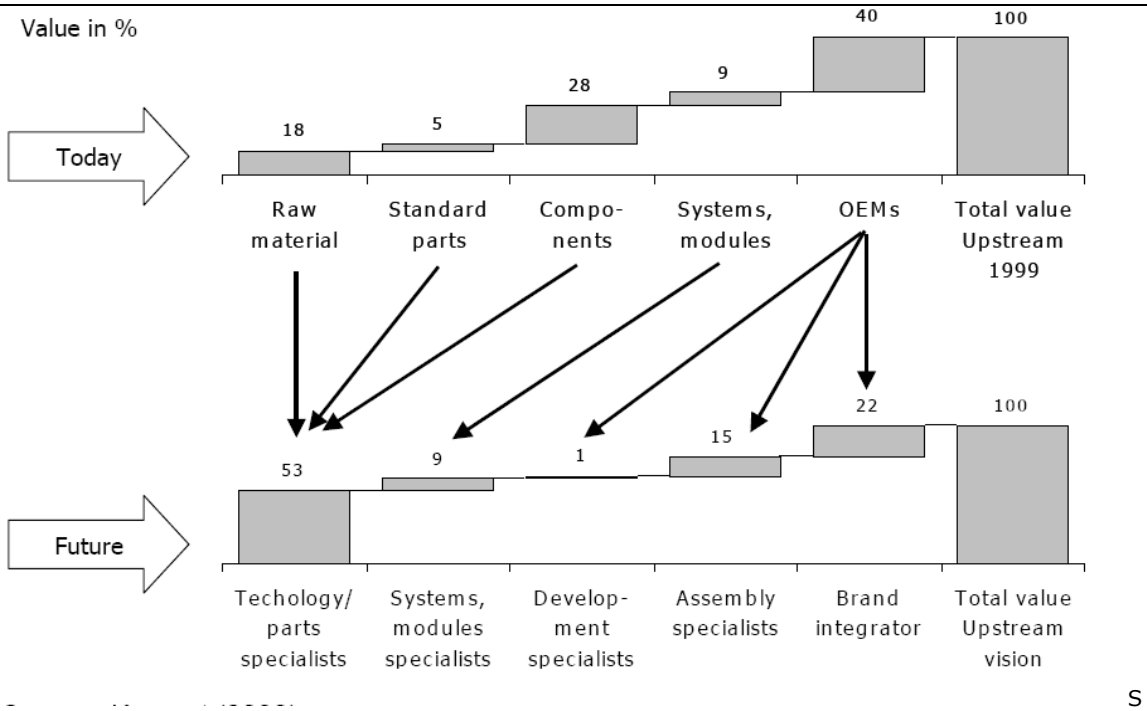
2.6.2. Literature review on modularity:

In his paper, Juergens (2003) also expresses the opinion that there is not a single definition for modules. Further, he cites Sako and Fixson (2001) who assert that "modularity really encompasses a bundle of product characteristics, and different constituencies place different weights on them". Irrespective of the fact that there is not a commonly and formally agreed definition of modularisation, the fact remains that

there is a trend towards shifting weights in the value chain from OEMs to specialised suppliers, illustrated by Figure 4.

The emergence of new forms of specialisation deeply affects the structures and strategies of all actors in the automotive sector.

Figure 4: Value transfer OEM - Suppliers



S

ource: Juergens (2003)

Fixson, Ro and Liker (2004) state that historically, modularity and outsourcing processes have been discussed in separate disciplines. Modularity was regarded as an engineering topic, and sourcing as a managerial issue. Those two concepts were linked together only after

the success of the IBM and Dell business models. Fixson *et al*. (2004) point out that IBM's modularisation of computer architecture led to the dramatic expansion of the personal computer industry. Further they state that Dell's business model would not be successful without combining modular architecture and innovative supply chain management.

An interesting and useful parallel between product design and firm structure is drawn by Fine (1998). According to Fine, the product design varies between modular and integral. The company structure, in its turn, contracts (with in-sourcing) and expands (with outsourcing).

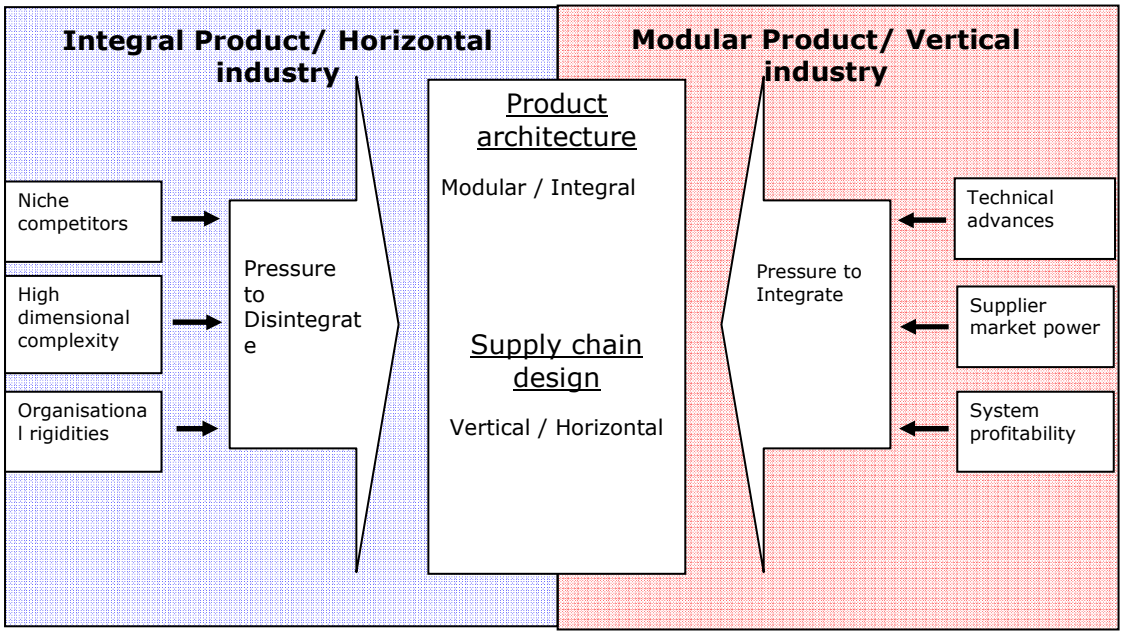
2.6.3. Forces determining the shift from integral to modular product architecture

According to Fixson, Ro and Liker (2004), scholars are divided into three camps regarding the relationship: product–organisation design, the first finding a causal link runs between product design and organisational architecture; the second finds the causal link running in reverse order; and the third asserts that the process is iterative.

Fine (1998), with his "Double Helix" business model, supports the last view. According to this model, market forces apply constant pressure

on product architecture to oscillate between modular and integral in the same way that the industry structure oscillates between horizontal and vertical (see Figure 5). This model is a good illustration of the dynamics in today's business world.

Figure 5: Double helix



Adapted from Fine (1998)

Schilling (2000) also defends the view that the movement to and from the modular product and supply system configuration is a dynamic process, influenced by:

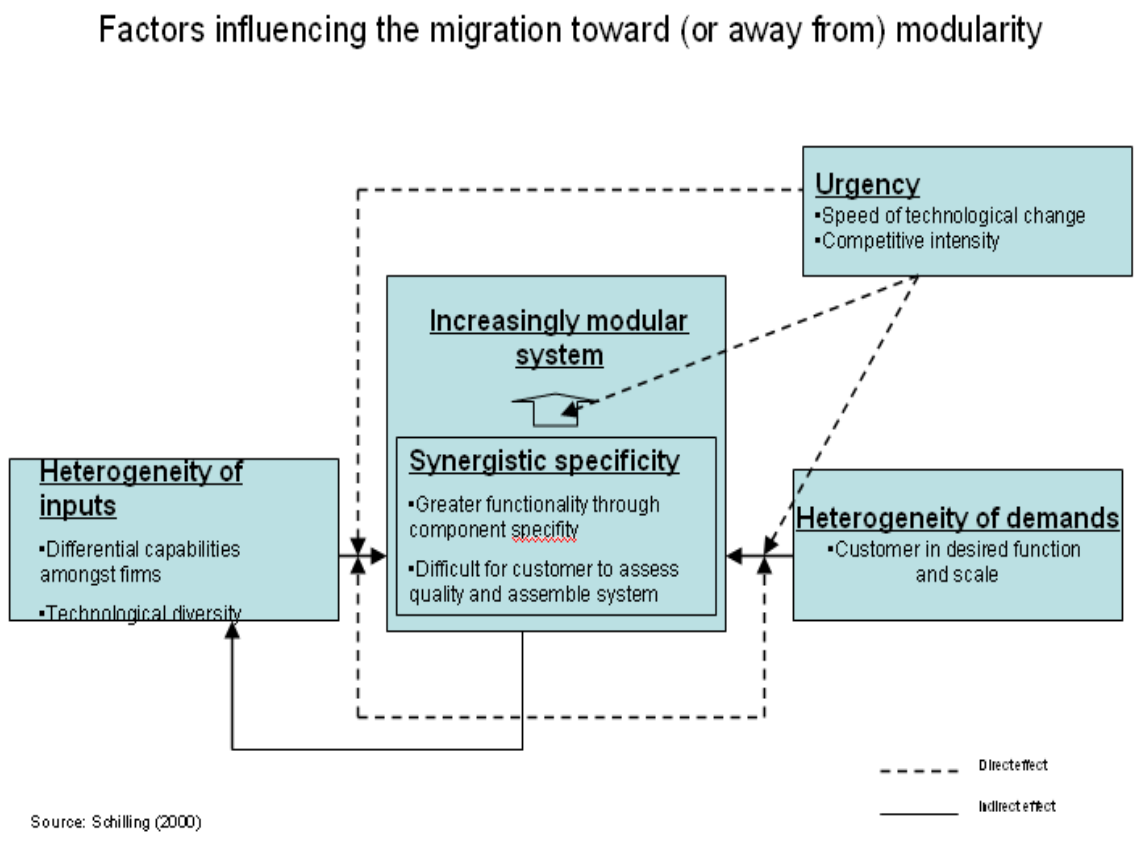
- Heterogeneity of inputs – both in terms of the technological options available and the production resources and capabilities of the firms involved in their production.

- Heterogeneity of demands – this is one of the most important factors, determined by the customer's pursuit for the differentiation.
- Synergistic specificity of integrated products, which can be achieved by using specialised components, and the customer's ability to choose and assemble components.
- Urgency – fuelled by the speed of technological change and competitive intensity, determined by the disparity between inputs and demand.

These driving forces, Schilling (2000), combines into a model illustrating the direct and indirect interactions between them.

This model is represented on Figure 6 – factors influencing the migration towards modularity on the following page.

Figure 6



Source: Schilling (2000)

Automotive manufacturers, according to Doran (2004), are either "modularisers" or "integrators", depending on their approach to modularisation. Further, he expands on order-winners and order-qualifiers from a modular perspective. The former includes global presence; project management skills and R&D capability. Order-winning requires flexible operation, a distinctive quality culture and the delivery of low cost modular solutions.

Whitbread (2005) shows the criteria applied by OEM when selecting suppliers includes cost, competitiveness, quality, technology and logistics capabilities. In order for a supplier to be a full-service provider they must have product research and development capabilities.

Tau, Vonderembse and Ragu-Natan (2004), established an instrument to measure module-based manufacturing practice and its interrelation with mass customisation capabilities in a particular organisation. According to them, modularity-based manufacturing practice is enabled by product and process modularity and dynamic teaming. The latter is related to achieving the necessary flexibility to re-organise the manufacturing resources quickly and efficiently.

2.6.4 Benefits of modularity:

Donnelly, Morris and Donnelly (2006) determined the benefits arising from modularity as:

- Increased flexibility - in meeting the wide variety of end-customer demands.
- Increased speed of delivery of products from the conceptual stage to the market. Firms using modularity free themselves

from the necessity to develop all the components and are able to concentrate on their core competencies.

- Expanded design capability – auto manufacturing firms can incorporate the knowledge of their suppliers, which can provide a wide range of solutions.
- Reduced direct labour cost – the assumption is that the supplier's labour costs are less than the costs of unionised labour at the assembly plants.
- Increased labour and capital productivity – attributed to specialisation and to economies of scale.

Kotabe, Parente and Murray (2007) see modularity as a major source of strategic flexibility for auto manufacturers in today's dynamic market conditions. Further benefits from modularity are efficient mass customisation and reduced product cycle times.

For Doran (2004), a typical example of modular application is the "Smart" Car. He states that, traditionally, the automaker had to deal with, and coordinate the activities of, around 100 first-tier suppliers. In the case of "Smart", the car has been engineered and manufactured using 25 module suppliers. The benefits for OEMs are clear: easier

control of the supply chain due to a reduced number of direct suppliers, lower costs, less risk and less investment in capital assets.

One of the positive outcomes from the modularity application, according to Gereffi *et al* (2005), is the creation of a fluid network structure which permits flexibility in meeting complex customer demands. Further benefits from modular value chains say Gereffi *et al*. lie in the fact that when suppliers provide "turn-key" services they take full responsibility for the process technologies and the capital outlay for materials on behalf of the auto manufacturer.

3. `Research questions

The purpose of this research is to establish the effect of modularity on South African automobile assemblers and their suppliers.

Based on the literature review the following research questions were formulated:

Question 1 – What factors determine the adoption or rejection of modularity by South African automobile assemblers?

Question 2 – To what extent is modularity used in the South African automotive industry?

Question 3 – How do South African auto manufacturers benefit from modularity, and how does this compare with international standards?

Question 4 – Is the modularity in the automotive industry supportive of South African small and medium enterprises?

4. Proposed Methodology

4.1 Research Design

Zikmund (2003 p.65) states "Research design is a master plan specifying the methods and procedures for collecting and analysing the needed information." There is an important link between the research problem and the research design.

The main determinants for the research design are the degrees of data availability and ambiguity. In areas with great ambiguity and data scarcity the use of explorative research design is appropriate. This type of research provides information for assessing particular phenomena, but is not enough to provide conclusive ground for action. Normally, more detailed surveys are subsequently conducted based on the discoveries from the explorative research. The techniques associated with explorative research are: secondary data analysis, pilot studies, case studies, in-depth interviews and experience surveys.

The above is supported by Leedy and Ormond (2001), who state that when little information on particular topics exist and the variables are

unknown, a qualitative study can help the researcher to establish the important issues in the phenomenon under study.

Further, Leedy and Ormond (2001) derive the following purposes for qualitative research:

- Description
- Interpretation
- Verification
- Evaluation

Description can reveal the nature of relationships whereas interpretation enables one to develop new concepts and to discover the problems within the phenomenon. Verification serves to test the validity of certain assumptions in a real world situation, and through evaluation, the researcher can establish the effects of particular practices and policies.

Different designs for qualitative research exist. Leedy and Ormond (2001) identify the following types: case, ethnography, phenomenological, grounded theory, and content analysis. These types of studies, their purpose and the data collection methods associated with them are summarised in the Table 3.

Table: 3 Study types

Design	Purpose	Focus	Data collection methods	Data analysis methods
Case study	To understand situation in great depth	One or few cases within natural setting	Observations Interviews	Categorisation and Synthesis
Ethnography	To understand how behaviour reflects the culture of the group	Field site in which a group share a common culture	Participant observation Interviews Document collection	Identification of significant phenomena Organisation of data into a logical whole
Phenomenological study	To understand an experience from a participant's point of view	A particular phenomenon as it typically lived by human beings	In-depth, unstructured interviews	Search for the meaning units Integration of the units into typical experience
Grounded theory study	To derive theory from a data collected in a natural setting	A process, actions and interactions and how they influence one another	Interviews	Data coding into categories Construction of theory from the categories
Content analysis	To identify specific characteristics of a body of material	Verbal, visual form of communication	Identification and coding in terms of defined characteristics	Frequency tabulation of each characteristic Descriptive analyses as needed to answer the res. question

Source: Leedy and Ormond (2001),

In recent years the term "qualitative management research" has gained popularity amongst theoreticians of research methods. Johnson, Buering, Cassel and Symon (2007) conducted an investigation to establish how the concept of a management qualitative study is defined and perceived by those directly involved in it. They concluded that the array of perceptions and definitions signify the diversity of management qualitative research methods. The question then, is whether this

diversity depicts the wide range of tools and methods used in qualitative research, or a lack of structure.

The former stance is supported by Leedy and Ormond (2001), who state that there is not a prescribed set of tools and methods to be used for any particular study, as very often the methodology continues to evolve as the study progresses.

Considering the above arguments and the fact that there is not specific data available for the proposed research, and that there is not much certainty about the implications of the implementation of the modularity model in South Africa, the use of qualitative research was deemed to be the most appropriate.

In terms of the definitions used by Leedy and Ormond (2001), (Table 3) the author defined this present research as a case study, aiming at verifying the effects of modularity within the South African context.
For this exploratory research, secondary data was analysed and in-depth personal interviews were conducted as a mean of uncovering the underlying factors determining the specifics of implementation and the impact of modularity on South African automotive industry.

According to Zikmund (2003) again, exploring secondary data in the form of specialised trade literature is a quick and economical way to source background information. Once the situational analysis of the context, based on the secondary data has been carried out, issues that need to be further explored will emerge.

Interviews, state Leedy and Ormond (2001), can yield useful information. Further, interviews in qualitative research are not as structured as the ones used in quantitative research.

In line with the above, semi-structured interviews were conducted based on questionnaires which were used as a platform to initiate discussion aimed at uncovering the South African specifics of modularity use and its effects on the automotive industry.

4.2 Population and Sampling

4.2.1 Population:

A population or universe, according Zikmund (2003 p. 369) is "any complete group of people, companies or the like that share some set of characteristics". Further, he refers to a census as an investigation of all

individual elements of the population – a total enumeration as opposed to a sample.

Based on the above definitions we can state that the population for this study consists of all passenger-vehicle manufacturers, operating in South Africa.

The automotive manufacturers in South Africa are represented by the National Association of Automotive Manufacturers in South Africa (NAAMSA). According to this organisation, the vehicle manufacturers in South Africa are (Appendix A) (in alphabetical order) :

- BMW (South Africa) (Pty) Ltd
- General Motors South Africa
- Ford Motor Company of Southern Africa (Pty) Ltd
- Mercedes-Benz South Africa
- Nissan S A (Pty) Ltd
- Toyota South Africa Limited
- Volkswagen of S A (Pty) Ltd

4.2.2 *Sampling*

4.2.2.1 Methodology

As the entire population of companies subject to the present research is small in terms of number of companies, the question is then, which criteria should be used in the selection of company representatives?

Leedy and Ormond (2001) state that, although ideally the sample must be chosen through a completely random process, most often researchers conducting a qualitative study resort to purposeful sampling. The underlying idea is that the selected interviewee must be an individual (or company representative in this case), who will yield the most information on the research topic. As an example, it would be pointless to discuss particular operational issues with the marketing personnel.

During the questionnaire-testing session, it emerged that the most appropriate sample of the targeted population must include one representative from each car manufacturer – a purchasing director or senior buyer, who operates in SA and who participates in supply chain management.

4.2.2.2 List of interviewees

The research design and questionnaire were pre-tested in sessions with automotive industry analysts and the researcher's mentor and supervisor. The subsequent semi-structured interviews were conducted with the representatives of the South African automotive manufacturers as per NAAMSA membership list- Appendix A. Due to confidentiality agreements with the participant interviews no real names are revealed.

4.2.2.3 Unit of analysis

Creswell (1998) suggested the use of the data analysis spiral when conducting qualitative research. According to this model, a four step process will help to transform the raw data into the final report. These steps are:

- Organisation – large data units are broken into smaller ones;
- Perusal of the data – the aim is to get a "sense" of the data and start preliminary interpretations;
- Classification – the data is grouped into categories;
- Synthesis – during this step the data is tabulated and new propositions can be offered.

Considering the details of the present research, the author took the following steps:

First, the content of the transcripts from the interviews was analysed (content analysis), organised and categorised based on key topics in order to establish any patterns. Grid format is deemed to be suitable for that. Second, the subsequent commonalities and differences were analysed (comparative analysis) in order to establish the key issues associated with the subject of research. Finally, the emergent issues, topics and trends were related back to the research questions described in chapter 3.

4.3 Questionnaire

As mentioned earlier, semi-structured face-to-face interviews were conducted. These were based on a questionnaire seen in Appendix B, which was designed predominantly to facilitate discussion on trends in the industry, and not at extracting data and statistics.

4.3.1 Interview schedule

The questionnaire design and pre-testing took over eight weeks. During this period the necessary adjustments to the questionnaire were made and the list of the participants was obtained.

The next step was to set-up the appointments. It took nearly eight weeks of persuasion and negotiation with personal assistants, which came as no surprise, considering the rank of the targeted participants. The main problem was coordinating the schedules of the different parties. It must be noted the high response (5 out of 7 contacts replied after the first mail). This serves as an indication that the interest within the automotive industry towards the topic of research is great.

The face-to-face interviews were conducted over a period of two months.

4.3.2 Interview pre-test

The questionnaire was pretested during discussions with the researcher's academic supervisor Mr. Aldryn Beyer, the researcher's mentor Dr. Albrecht Piro and Mr. Sean Ellis – chief facilitator of the South African Automotive Benchmarking Club (SAABC). Those discussions contributed not only in improving the questionnaire, but in shaping this research.

4.4. Data collection and analysis

A wide range of data collection tools were available to the researcher. As mentioned in preceding chapters, no "one size fits all" solution exists for researchers in general, and those embarking on qualitative research in particular.

Amongst the most common data collection methods, according to Leedy and Ormond (2001), are observations, interviews (structured and unstructured), secondary (literature) review, purposeful and sampling.

For the purposes of this research, as mentioned earlier, secondary data analysis and in-depth interviews were used.

The secondary data for the analysis will be sourced from publications specialising in, amongst others, management, operation management, supply chain management and engineering. In addition to that, publications specialising in automotive analysis, and data and reports from industry associations and organisations will also be used.

The interviews were conducted based on semi-structured questionnaires in order to, on one hand, provide flexibility in exploring

the views and individual experiences of the participants and, on the other hand, to provide some common basis of comparison of those experiences across the interviewees.

4.5 Potential Research Limitations

4.5.1 Assumptions

When designing this research the following assumptions were made:

- The company has a policy for modularity
- The company monitors the effect of modularity
- The interviewed participants are the most knowledgeable in the matter within the targeted organisations.

4.5.2 Limitations

The inherent disadvantage of open-ended or semi-structured interviews, according to Leedy and Ormond (2001), is the difficulty in making comparisons between interviewees.

Another sort of limitation would be of an organisational nature, firstly, the impossibility of reaching all the different geographical locations in South Africa, and secondly, scheduling appointments with the targeted executives.

5. Results

5.1 General

The interviews, with one exception were conducted on a face-to-face basis. Considering the geographical spread of the automotive industry in South Africa, the researcher was presented with a logistical challenge which necessitated a number of trips. Those trips were kindly sponsored by the researcher's employer.

The interviews took place over a period of six weeks (see timeline in Appendix D). This period of time was characterised by relatively stable micro and macro political and financial conditions.

5.2. Data presentation

In this chapter the content of the interview transcripts will be organised and classified according to the questionnaire. Further, the individual answers will be compared and consolidated in order to extract the common threads and trends.

The data will be consolidated and presented as per the discussion questions.

5.2.1 Definition of modularity

As mentioned earlier, there is not a commonly agreed definition of modularity. For the purpose of this research the following definition was adopted.

Definition of Modularity: According the definition given by M. Sako (2003): the modules are components, performing different functions and belonging to different systems, positioned in close physical proximity, which can be assembled as one self contained unit into the car.

The definition was agreed in general by all the interviewees, although most of the respondents had their own, based on different criteria. For example, in some instances they did not distinguish between modules and systems.

This ambiguity presented good ground for interesting discussion. The following are some of the highlights:

- Modularity started in Europe and it is important to note manufacturers from the Far East (Japan) have a different philosophy towards modules.
- For one of the respondents, who had just concluded a business case on modularity, its effect is not that pronounced in low cost

countries when compared to high cost ones. However, due to confidentiality conditions, no detailed evidence was provided for this finding.

- Another interesting view expressed was that export oriented OEMs would prefer the use of completely knocked down modules in their assembly process.
- The discussion brought some clarity on the module – system differences:
    - System is related to commonality in function whereas modules are related to commonality in space;
    - They differ at the fitment point. The system is fitted typically at preassembly stages while the module is fitted at final steps of the vehicle assembly;
    - A typical example for system is the brake system, while an example of a module is the front end of the vehicle.

- With the increasing complexity of new vehicles, some assemblies and systems could become modules – the axle can be a module in some platforms.
- Dealing with different types of components determines the use of different types of suppliers. This is illustrated in Table 4.,

Table 4: Type of supplier in relation to involvement in the supply chain

Activity / Type supplier	R&D	Manufacturing	Logistics	Complete delivery	Control subsuppliers
Manufacturer					
R& D supplier					
Component supplier					
Module supplier					
System supplier					

Source: Respondent 5

Some of the characteristics of modules and module suppliers, highlighted by the participants in the interviews, are:

- Reliance on supplier's "Know-How"
- Early integration of suppliers in R&D
- Stockholding at suppliers resulting in shortened assembly times
- Core competence concentrated at OEM
- Quality control by supplier
- Stock control by supplier.

5.2.2. Consolidated responses per interview question:

Interview question1: In terms of the definition discussed in 7.2.1. how many modules can we distinguish in the platforms manufactured in your plant? How many platforms are assembled in SA?

The first part of the question concerns the modules and the identification of their number. As it is already evident from the definition, there is no common understanding and interpretation of the modules. Hence there was a variety of answers:

Four of the respondents didn't provide specific numbers for the modules assembled into their respective vehicles; the remaining three indicated 21, 27 and 8 modules, respectively.

The second part of the question was aimed at establishing the number of vehicle platforms assembled in the country. Again, as discussed in 2.3.3 some of the auto manufacturers do not distinguish between platform and models, while the others define them differently. After the necessary clarification was established that the majority (5 out of 7) of the OEMs assemble one platform in the country, the remaining respondents stated 2, 3 and 4 platforms, respectively.

Interview question 2: How many modules are assembled off the main assembly line?

Out of the three respondents who provided a number for the modules assembled off the main assembly vehicle line, the first identified 8 modules, the second 21 and the third – 14.

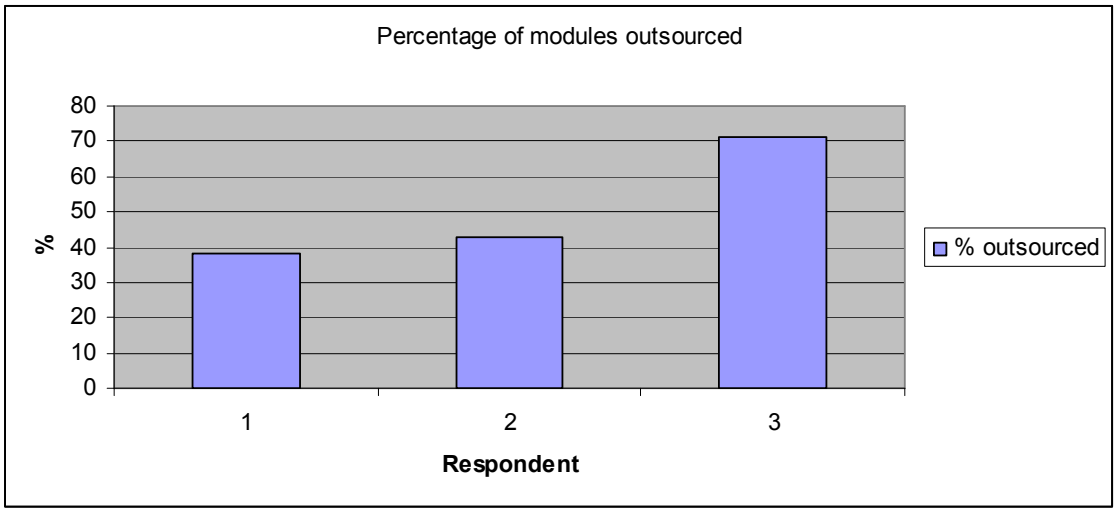
Further, the following trends were highlighted:

- A move towards outsourcing
- A move towards global platforms – and the adoption of global sourcing policy
- The number of modules used and assembled off the main assembly line varies with the age and rank of the platform - the newer and top platforms in SA have as many as 30 modules identified
- In South Africa, a limited number modules are assembled off the main assembly line,,for example, the instrument panel and corner unit.

Interview question 3: How many are outsourced to suppliers?

For the respondents, which provided information on interview question 1 the following number of modules were outsourced: 3 out of 8; 15 out of 21 and 6 out of 14, or expressed as a percentage – 38%; 71% and 43% of the total number of modules. This is represented in Figure 7:

Figure 7: Percentage of modules outsourced



The remaining four South African light vehicle manufacturers do not outsource module assembly and supply. One of the respondents explained this with the following reasons:

- Modularity does not mean only the assembly of components.
- The modular supplier must deal with new sets of tasks in controlling tier 2 and below of the supply chain.

- To achieve this status, new structure and expertise is needed, such as buying; quality assurance; expediting and technical expertise.

Interview question 4: List the benefits/ disadvantages of this concept.

The largest part of the interviews was spent on this discussion point. The **advantages** of modularity as seen by the interviewees are in optimised supply chain control, cost reduction, improved internal efficiency, improved supply chain efficiencies and improved product quality and faster new model launches. The supporting statements to those trends are summarised below:

Supply chain control:

- One interface to suppliers
- Supply chain consolidation done through T1 suppliers
- Number of suppliers to be controlled is reduced
- South African – supply chain is much shorter – easier and cheaper to control by module suppliers
- Shift in change management control towards the suppliers
- Increased number of options available (USB, Radio, GPS) , which results in thousands of permutations

- Managing variety requires special skill – which is not a core competence at the OEM
- Communication from the supplier to the OEM must follow the form established overseas between the mother companies.

Cost benefits:

- Long term cost benefit – after the capital expenditure is offset
- Reduction of capital expenditure
- Storage space is reduced
- Reduced inventory.

Increased OEM internal efficiency:

- Shifts logistical complexity outside the plant
- Improved production profitability
- Supports "Build To Order" by optimising the supply chain
- Labour efficiency improvement
- Modularity can bring more levelled work content
- Modularity sets new trends in main assembly line organisation towards reduced line length and new material supply organisation such as picking, fitting and sequencing.

Increased Launch speed

- Reduces launch time – work in parallel on many modules
- Quality improvement.

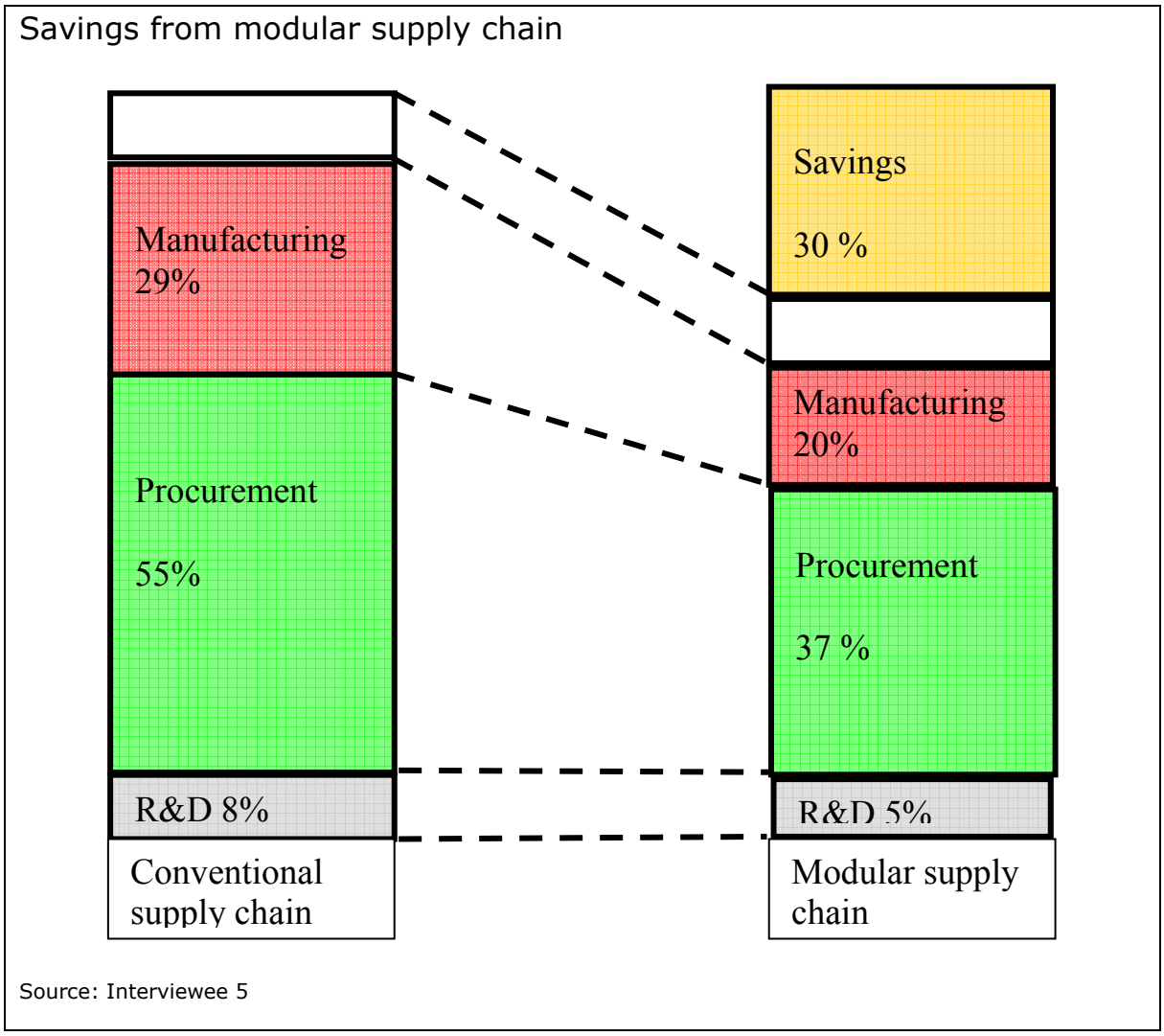
Increased efficiency of the supply chain

- Sub supplier management falls with the module supplier
- Reduction of the line side space required
- Provides quick reaction time to schedule changes
- Labour cost reduction – the assumption is that supplier has lower labour cost
- The outsourced engineering and Research and Development is creating a good opportunity for cost saving.

To summarise all the above statements one of the respondents kindly provided the following graphical representation of the benefits from the modularity, as seen in Figure 8.

This graphic is in line with the common threads extracted from the interviews. The savings in the manufacturing area stem from the improved internal efficiency; the procurement realises the savings from the improved supply chain control and improved efficiency of the supply chain.

Figure 8: Benefits from modularity



Although the concept of modularity appears to be very attractive it carries some **disadvantages.** The main areas of concern to the auto manufacturers are in the areas of intellectual property protection,

control over the cost and lower-tier suppliers and concern regarding the increased responsibility given to the module suppliers.

Intellectual property

- By creating mega suppliers OEMs are running the danger of creating and dealing with monopolistic structures
- OEM stands to loose capability if not used
- Strategic knowledge and development should stay in-house
- Mega suppliers are very closely matched in their ability to assemble cars. What stops them is unavailability of the brand and the fact that their sustainability is based on the component business, which comes from existing OEMs.

Cost increase

- In some cases, the tool investment leads to increased cost in the short term
- Under SA conditions the benefits of scale cannot be realised due to smaller volumes
- Encourages an increase in overhead structure – creates new O/H on the side.

Complicated supply chain control

- Long supply chain
- Control and managing inventories is difficult when the material for module assembly is provided by the OEM. .
- Supplier's organisation structure changes.
- Matching between modules assembled in-house and the ones assembled by the suppliers could create friction – "who's fault is it?" In the case of mismatch, the supplier is always wrong.
- Slows down the problem resolution – protracts the corrective action process – longer communication channel.

New requirements for the suppliers

- Supplier must have "Know-How" to deal with Tier X (or sub-suppliers).
- Module supply requires close proximity to supplier. Considering the geographical spread of the automotive industry in South Africa, this requirement would mean utilising a satellite operation. Hence the difficulties in controlling and maintaining them.

Interview question 5: If modularity is used can we compare conventional and modular supply chains in terms of: Flexibility, Time to the end customer, Platform complexity against the assembly time?

Answering those questions assumes direct comparison of the above criteria between the platforms which use modularity and the ones which do not. Unfortunately, none of the respondents had comparative statistics available.

Flexibility is the ability to customise – for example, a wider choice is available to the end customer and his ability to change his choice immediately before physical assembly starts counts too).

All respondents confirmed that modularity enhances their flexibility. One of the interviewees stated that the end customer's order is complete within 7 days from placement of the order, which has to be confirmed 4 days prior to assembly.

In another instance order fulfilment for a local customer is between 14 and 21 days, while the international standard is only 7 days.

Only one of the participants in this research provided a comparison between the old and the new platform in terms of product complexity and assembly time. According to the respondent's comparison, the old model had 200 options and was assembled in a time of 1.5 minutes,

while the new model, which has more than 420 options, has a reduced tact time of 1 minute.

Interview question 6: One of the prerequisites of modularity is that it has to be supported by the product design. The design of how many of the platforms, manufactured in your plant, supports modularity?

Six out of seven respondents provided information on this topic, while one indicated the existence of a modularity board, which deals with modularity specifics.

South African design capability

None of the OEMs subject to this research maintain design capability in South Africa. One of the manufacturers indicated that South Africa is regarded as a country most suitable to assemble completely knocked down units.

Although no design capability is maintained in the country, the South African subsidiaries can influence to a limited extent the design of the product. For example, testing is performed in South Africa to cater for specific climate conditions.

Product design

The ownership of the product design is important for the OEMs.

One of the auto manufacturers indicated that the key characteristic of the product design is its ability to be released in all markets.

Another highlighted that although South African companies do not perform design work, they have the freedom to influence decisions within their respective region.

Supply chain design

Besides the product design the indication is that the supply chain is also designed on a global platform.

Move towards global platforms

The general trend is towards the use of global platforms, which are designed abroad in specialised facilities with the involvement of main global suppliers.

In support of this statement, one of the respondents compared the previous production line-up, which consisted of 7 unique SA platforms, with the current line–up consisting of 2 global platforms.

Another thing unique to South African is that local subsidiaries are performing a support function only.

One of the interviewees pointed out the trend towards global platforms and the subsequent adoption of global sourcing policy.

Another respondent stated that his company manufactures global platform vehicles and that their design caters for different conditions and supports modularity.

Interview question 7: What percentage of your module suppliers can be classified as wholly South African-owned, small or medium enterprises?

Six of the seven participants provided comment.

The rest of the interviewees indicated that the supplier base in South Africa consists predominantly of global companies. The few local suppliers do not operate independently. They either operate under technical agreements with multinational global suppliers or form joint ventures with them. One interesting comment suggested that wholly-owned local companies contribute very low value. Another of the auto manufacturers stated that they expect by 2010 to have only 10 local suppliers out of the 38 which were in existence in 2003.

The change in the tendering pattern was also highlighted. In the past, OEMs released a tender on the drawings; today the suppliers tender on concept. One of the respondents summarised this part of the discussion as follows:

- There is a trend towards internationalisation whereby local suppliers find overseas partners.
- Overseas ownership is shifting from the minority to the majority.
- Joint ventures are also a common form of cooperation embraced by large companies while smaller companies are being acquired by large multinationals.
- Local companies do not have R&D capabilities, which makes it difficult for them to support global platforms.

Interview question 8: If the answer above is "none" – what could be the explanation?

The opinions of the participants in the interviews are summarised as follows:

- Suppliers tender at the concept stage of projects, which limits the opportunities for local companies.

- Design centres are concentrated overseas.
- Global vehicle platforms assume global offers from global suppliers.
- Modularity depends on specific knowledge and experience – which does not exist in South Africa.
- Skills shortages present a fundamental problem area.
- New car developments occur with suppliers' involvement.
- Tier 1 suppliers have "Know-How" in their specialised fields areas.
- SA is not a "development source", i.e. local suppliers do not have exposure to global platforms development.
- Special mention was made to the conservative attitude and mind-set of the local suppliers, which makes dealings with them complicated and tense.
- OEMs see the role of the local suppliers as a manufacturing source.
- No local parts are available
- There is low capability levels of the local suppliers and
- The manufactured volumes do not always justify localisation.

Interview question 9: According to Melnyk and Denzler, the relationship OEM – supplier can be classified into four categories ranging from confrontation through to partnership. Confrontation represents a traditional purchasing relationship, characterised by strong distrust between both parties. This is opposed to partnership, which is based on mutual respect and trust. How do you classify your relationship with your suppliers?

The general comment to this question was that every car manufacturer aims at establishing a partnership and long-term relationship with their suppliers. Some indicated the existence of special programs, aimed at achieving that, but did not produce evidence.

For one of the respondents, partnerships with local suppliers are based on four pillars:

Cost

Quality

Delivery and

Environment/ Safety/ Technology.

Another company finds the fulfilment of its social responsibility in the development of the local suppliers as an important criteria.

For one auto manufacturer modularity presents an answer to the BEE strategy. In this view, global companies can develop pure module assemblers, which are compliant with the empowerment policies. Skill shortages present a major challenge in this scenario.

The rest of the views are listed bellow:

- Partnership, build a win-win situation
- Challenges in dealing with the local suppliers are primarily cost and quality
- One of the companies facilitates transfer of information between the overseas supplier and the SA part manufacturer
- SA suppliers are described as conservative
- Without change South African suppliers will "miss the globalisation"
- If the supplier is structured properly it will eliminate the difference between overseas and SA supply chains.
- South African supplier mentality is very confrontational.
- South African suppliers do not demonstrate long-term vision.
- Two types of suppliers exist – assembler and T1, (which controls the supply chain).

Interview question 10: Is the outsourcing strategy defined locally or by the holding company?

For three of the respondents, outsourcing depends on viability and is reviewed on a case by case basis, while the other four follow global decisions. However, the case studies are also done by global teams.

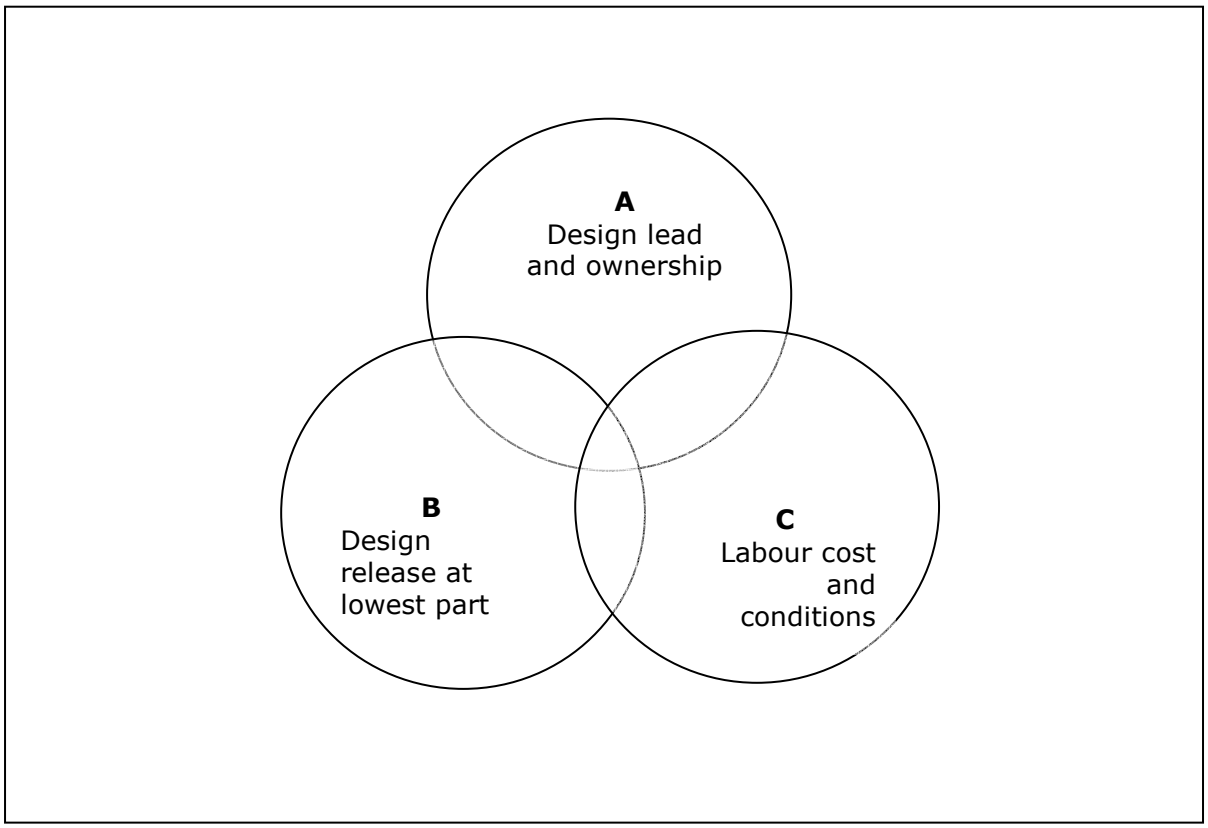
One OEM uses the opportunity to promote local companies through global outsourcing. However, no formal program exists and no measurement is provided.

One of the OEMs highlighted the criteria to be considered when making an outsourcing decision:

- Cost of labour
- Number of platforms
- Manufacturing complexity
- Labour efficiency
- Tool-making capability
- Maturity of the supplier base.

The ideal case would be when all of these criteria overlap, represented graphically by Figure 9:

Figure 9: Overlap of decision-making criteria.



Source: Interviewee 3

Other general comments on the outsourcing process include:

- Outsourcing is not a strategy on its own - it depends on the supplier's capability, and "Know-How".
- The major challenge in outsourcing is to define the process to benchmark the internal processes against the outsourced ones.

For one of the respondents outsourcing decision-making has the following specifics:

- Historically, global integration was applied with limited South African input.
- Planning will be done by regional/ global sourcing and will consider all activities – including the move to modularity.
- Outsourcing decisions depend on OEM's culture. For example, Eastern cultures prefer to deal only with trusted suppliers and tend to apply total control over the supply chain.
- A supplier to global markets must consider the financial implications.

Interview question 11: In your opinion are SME's capable of being involved in modularity?

The views, shared by the participants in the interviews, tended to be on the negative side. Only two saw the possibility for small companies to be able to participate in modular supply chain.

Responses ranged from:

- Yes
- No, due to the global tender on the concept
- No, due to a lack of local knowledge and skills
- No, because the R&D capability and high investment are preventing SME's from entering

- Yes, because there is a demand for a lot of them, especially if they are quick, innovative and customer-oriented.
- No, because SA suppliers have limited access to technology.
- No, limited access to finance creates barrier to entry for local companies.
- BEE can alleviate the problem with easier access to preferential finance.
- No, because there is low R&D capability in SA.
- Problematic areas for Small and Medium Enterprises are the lack of knowledge, limited source of information and "Know-How", and limited financial backing.

Interview question 12: According to Schilling (2000), the factors influencing the migration toward (or away from) modular supply chain is: heterogeneity of inputs (diversity of technological options available); heterogeneity of customer demands and urgency (speed of technological change). Which of those factors can you determine as the most important in your approach towards supply chain design?

This question received very limited attention as there was never enough time to discuss it. In addition to that, the question was to a large

extent, covered by the preceding answers. Because of this, no specific data will be discussed.

5.2.3. General trends and ideas

The interviews yielded various opinions on subjects not directly dealt with in the questions discussed so far. The opinions reveal interesting insights into trends in the automotive industry; the specifics of the South African automotive industry and issues relating to modularity.

The views are summarised in the following topics:

South African automotive industry:

- Labour in SA is not *that* cheap. It is equal to Australia and higher than India.
- It is difficult to explore the benefits of economies of scale under South African conditions, due to low production volumes.
- General and sustainable economic growth can create growth in the local auto market, which will help to develop the local supplier base.
- Some auto manufacturers in SA share a common supplier base.
- Historically, South African OEMs had little coordination in their sourcing activities. However, in the wake of the new millennium the anticipated Y2K problem opened the dialogue.

- South African OEMs can benefit from using common suppliers. For example, German suppliers successfully share a common supply base.

General comments and trends:

- More modules are being used across the platforms.
- More modules are outsourced.
- Quality of supplier base is of utmost importance for the successful use of modularity in car manufacturing.
- As the move to premium cars increases, the degree of customisation increases, which leads to increased inventory holding and increased cost.
- A better option for auto manufacturers is for the supply chain to be controlled by the module supplier.
- The development source is important in forming the supply chain.

Comparison between South African and EU/ US plants:

- Large components are not sourced locally;
- Content is coming from the East;
- Better structure set-up overseas;

- SA needs to consider low volumes scenario;
- US – modules are assembled offline;
- SA – modules assembled inline;
- SA – sub-assemblies are CKD;
- SA – local assembly is limited.

Modularity strategy faces three key issues

1. Underdeveloped Infrastructure – e.g. Supply park;
2. Insufficient skills development;
3. Inappropriate level of manufacturing;

Central services provided into automotive supply parks can address all these issues.

Broad Based Black Economic Empowerment (BBBEE) policy and the automotive industry.

Considering the ownership of the car manufacturing companies, the question is how they assure compliance with BBBEE policies? One of the respondents stated that they drive BEE compliance through the supplier chain as ownership points are impossible with multinational companies.

The German example of SME participation in automotive industry.

One of the interviewees drew parallels between the South African SME and German "Mittelstand" companies and was of the opinion that the automotive industry in South Africa needs a lot of them, especially if they are quick, innovative and customer-oriented.

What is Mittelstand? According to a publication in the Automotive News Europe from September 1st 2008, this category includes small to mid-sized companies with up to 1000 employees. The publication cites the German Auto Industry Association (VDA), which estimates that there are about 2000 of these companies in Germany.

According to industry specialists, despite the worldwide trend of a reduction of the number of suppliers due to globalisation processes, the number of German small and medium companies will stay constant, This is attributed to:

- They are committed to long term strategies
- They take fewer financial risks
- They work in networks and clusters to develop new technology

6. Discussion of the results

6.1 Introduction

This chapter represents the interpretation of the results from the interviews, which were reviewed in the preceding chapter. The consolidated data from the interview questions will be related to the research questions and to the literature overview.

The relationship between the questionnaire, relevant academic literature and the research questions is illustrated by the consistency matrix – Appendix B.

6.2 Discussion of the research questions

6.2.1 Research question 1 - What factors determine the adoption or rejection of modularity by South African automobile assemblers?

This question aims to ascertain the decision-making process followed by South African car manufacturers in product and supply chain design, in general, and in relation to modularity in particular.

The following areas have been investigated – design execution, outsourcing decision and the ability of South African suppliers to meet the specific demands emanating from modular supply.

As mentioned in 2.6.2 Fixson, Ro and Liker (2004) state that successful modular implementation requires a combination of product design and specific supply chain organisation. Hence, particular attention during the interviews was paid to product design processes.

One of the findings of this study is that none of the automotive manufacturers maintain design capability in the country. This fact is explained in terms of the global consolidation of research and development activities, which are carriers of significant costs. All of the currently assembled vehicle platforms in the country are global, designed in the centralised development centres with the view to be suitable for all the markets. That limits the possibility of a South African auto manufacturer to design unique products and subsequently, the supply chain. This forces them into the position of followers of the global trends and leaves them little room for adaptation to local specifics. This is supported by Barnes and Kaplinsky (2000), who outlined a trend indicating the replacement of local design capacities with global ones.

Only one of the respondents in the interviews mentioned that he is actively involved in the supply chain design, while three others mentioned limited ability to influence the product design. This limited influence relates to the adaptation of the product to suit local specifics, from a technical perspective. A typical example is given of this type of adaptation: the capability of the vehicles to perform at high temperatures and altitudes specific to a region.

The question which follows the above is what level of freedom do South African auto manufacturers have in designing their supply chains? As mentioned in the result presentation section – 5.2.2. the sourcing decision lies with global teams. However, with supply-chain decision-making, local OEMs have a greater degree of influence than the influence they have over product design. Three of them can influence the outsourcing decision based on a solid business case. That means that we can expect local sourcing patterns to be different to the ones globally applied. Amongst the main criteria in these cases are cost, quality, capabilities and "Know How", which can be offered by the local supply base. This is supported by Whitbread (2005), who identified identical criteria applied by the OEMs when making outsourcing decisions.

All of the respondents defined their relationship with their local suppliers as a "partnership", in accordance with classification given by Melnyk and Denzler (1996). However, only one respondent had a structured approach in the form of formal program. Another respondent sees the fulfilment of its social responsibility in the long-term relationship with the local supplier base, but did not provide evidence of a formal approach.

In conclusion we can state that South African automotive manufacturers have no ability to influence the design of the product to in order to support modularity in any other way other than globally defined. However, a greater degree of freedom exists in designing the supply chain around modularity.

All of the OEMs support the idea of building partnerships with the local suppliers, but not in a formal, structured way.

6.2.2 *Research question 2 – To what extent is modularity used in the South African automotive industry?*

In order to provide an answer to this question it was important to, firstly, agree on a common definition with all participants, and further

establish if the product design supports modularity, and lastly, establish whether the possibilities given by the design are fully utilised.

As already discussed in the literature review - 2.6.1 there is no commonly agreed definition of modularity as an operational and business phenomenon (Donnelly, Morris, Donnelly (2006)). Due to this, the disagreement within the automotive industry as to what constitutes a module came as no surprise. Some of the companies combine the modules and the systems in their monitoring processes while others do not pay particular attention in tracing the number of modules and their effect on the production processes.

In order to overcome this different view, and in an attempt to find common ground for comparison between different car assemblers, the definition given by Sako (2003) – 5.6.1, was adopted and submitted with the questionnaires prior to the interviews. However, this attempt to standardise the definition and obtain comparable data between the auto manufacturers was not successful.

However, the collected (and presented in 5.2.2) data regarding interview question 3 was sufficient to establish that modularity is not used to its full potential. Out of the seven companies subject to this

research, three presented the number of modules identified in their platforms along with the number of outsourced ones. Based on this data, the highest percentage of modularity utilisation (number of modules outsourced to number of modules identified, permitted by the vehicle design) was 78, the lowest, 38. (see Figure 7).

The practical implication of this finding is that there is still potential for expansion of the utilisation of modules and modularity in the South African automotive industry. This expansion creates subsequent growth opportunities for the automotive supplier base.

6.2.3 Research question 3 – How do South African auto manufacturers benefit from modularity, and how does this compare with international standards?

The benefits which OEMs experience are best summarised by Figure 8, page 60. From this it is evident that the biggest gain for the auto manufacturers resulting from modularity is in the procurement area and stems from the improved efficiency of the supply chain. This efficiency is enhanced by shifting the logistical complexity outside the OEM. The modular suppliers control the supply chain and serve as a one point interface with the car assembler. Optimal control of the supply chain also results in reduced inventories. This is in line with the findings on

modularity benefits from Doran (2004) and Gereffi, Humphrey and Sturgeon (2005).

Donnelly, Morris and Donnelly (2006) also see the benefits for the manufacturing side of car assembly, in increased labour and capital productivity, attributed to specialisation and economies of scale. The result from the interviews corresponds with this statement in attributing the improved labour efficiency to stabilised work content and reduced inventory levels. The latter has not only financial implications, but also reduces the space and storage requirements and improves the physical control of the components, a view which is supported by Hill (2005).

All interviewees agree that modularity enhances the flexibility and the speed of satisfying the end user's needs. The challenge of efficiently producing a broadening range of new cars has been recognised by Colin Whitbread (2003).

However, one of the interviewees, with limited use of modularity in his production, acknowledged the slow speed in fulfilling the customer orders compared to his overseas counterparts. The time to produce the customer order locally is 14 to 21 days, compared to an international standard of 7 days.

For comparison, in another case the company, which reported the highest utilisation of the modules, reported order fulfilment time of 7 days, which falls in line with international standards.

6.2.4 Research question 4: Is the modularity in the automotive industry supportive of South African small and medium enterprises?

The investigation of this topic showed that there are no South African SMEs in the automotive supply base. This has been explained by the interviewees by the globalisation processes, which triggered the consolidation of research and development activities and secondly, the formation of alliances with global suppliers. These alliances are formed already at the concept stage of the projects, making the entry into the supply chain impossible for small companies with a local presence and limited access to finance and technology. As one of the interviewees described this trend, in the past car manufacturers used to release tenders based on drawings, whereas currently the suppliers tender on the concept. These findings fall in line with Barnes and Kaplinsky (2000), who detected the trend of the diminished role of the component manufacturer with only a local presence.

The majority (5 out of 7) of the participants in this research expressed the opinion that SMEs are not capable to participate in the modular supply chain. They explained this inability as a result of the lack of research and development capabilities, and limited access to financial backing.

This finding strongly contradicts the conclusions Lorentzen and Barnes (2004) made regarding the innovation process still allegedly taking place in the South African component manufacturing environment.

The implication for South African component manufacturing companies is that in order to maintain and grow their position in the supply chain they have to develop research capabilities. Alternatively, if these capabilities already exist, they have to make them known to their customers.

Another interesting suggestion from one of the interviewees is to investigate and learn from the German model of operation of small and medium companies in automotive supply chain.

Another interesting view was that small BBBEE compliant companies have a better chance of accessing funding and, if developed in

cooperation with automobile manufacturers, could be suitable candidate for module suppliers.

7. Conclusions

The aim of this exploratory research was to investigate the utilisation of modularity in the South African automotive industry, to establish its effect on the performance of the supply chain, and to evaluate the ability of South African small and medium enterprises to support this concept.

It also aimed at understanding the processes affecting the decision to move towards or away from modularity in the South African automotive industry.

The literature gives evidence of a multitude of benefits that the automotive industry can experience from modularity. Kotabe, Parente and Murray (2007), and Doran (2004) show positive international experience not only in improved operational efficiencies, but in gains of speed and flexibility of the entire supply chain, which allows them to satisfy ever increasing customers' needs. Considering that South African auto assemblers use globally designed products and methods, we can expect the effects described so far to apply to the South African

automotive industry. However, this logic has not been tested for the entire industry.

Further many publications discuss the worrying trend of the diminishing role of local automotive components suppliers resulting from the effects of globalisation. Barnes and Kaplinsky (2000) for example, studied the changing ownership of South African component suppliers from local to wholly-owned multinational subsidiaries. Therefore, the question would be: Is modularity supportive for South African small and medium enterprises?

7.1. Key findings

The key driver in the implementation of modularity in the automotive manufacturing industry is improved cost efficiency and gained flexibility in satisfying ever-increasing customer needs in a shorter time. The suppliers and component manufacturers also benefit in this process, as a larger portion of value-adding activities are shifted from car assemblers down the supply chain.

This research attempted to answer the following questions:

Question 1 – What factors determine the adoption or rejection of modularity by South African automobile assemblers?

Question 2 **–** To what extent is modularity used in the South African automotive industry?

Question 3 – How do South African auto manufacturers benefit from modularity, and how does this compare with international standards?

Question 4 – Is the modularity in the automotive industry supportive of South African small and medium enterprises?

The key findings are summarised as follows:

Key finding 1: It was found that South African auto manufacturers have no ability to influence the design of the vehicles in order to enable the use of modularity or otherwise. However, they have the freedom to design the supply chain within the limitations posed by the design of the product and the support of the local component supply industry. Following that, the design of the supply chain outside the global norms is subject to thorough investigation and the business case established. However the major limitation to apply modularity in South Africa emanates from the absence of local research and development capability and access to new technologies.

Key finding 2: Modularity in South Africa is not explored and used to its full potential. This results from the limited capability of the local supply base. It also presents a good opportunity for the component manufacturers to engage in additional value-adding activities.

Key finding 3: Lastly, the modularity is not supportive for small or medium companies in South Africa. The modern technology, applied to motor vehicles demands extensive research and development resources, which can not be provided by a small company alone. Pooling and clustering of capabilities and sharing between the individual component manufacturers could uplift the competitiveness of the local supply base.

7.2. Recommendations

The implementation of modularity in the automotive industry changes the relationship between the car manufacturer and their suppliers. It results in a shift of the greater portion of value adding activities down the supplier chain. With that comes increased expectations of suppliers to develop new expertise in product development and supply chain control.

The implications for the stake holders in the automotive industry are that, in order to extract the most benefits of modularity, they have to be familiar with this concept and to relate it to the macro – and micro – political and economical developments such as globalisation.

Some specific recommendations following the findings of this research are:

- The data, collected during the interviews, shows that modularity is not equally applied amongst South Africa's automobile assemblers. The senior managers in automobile manufacturing companies must explore this opportunity for improvement in the supply chains' efficiencies.
- The process of implementation of modularity requires greater interaction and cooperation between assemblers and suppliers. That will require shift of the attitude of the managers of both OEMs and suppliers from confrontation towards building of partnerships.
- The ability to conduct research and development of automotive products is a qualifying factor for module suppliers. The managers of the companies willing to participate in the global automotive chain must consider this fact when building their business strategy.
- Building technical expertise in the automotive industry is a resource and capital intensive process, which cannot be supported by a single small or medium enterprise. The government and informal industry's organisations must coordinate their efforts and resources in creating pools of expertise, which will enhance the competitiveness of the local component suppliers.

7.3. Future research

As mentioned earlier this research was exploratory and as such, serves the purpose of identifying trends and areas which warrant future research. The interviews yielded a few interesting ideas which could be subjected to future, more detailed research. These are:

- More detailed studies on modular-based manufacturing practices, using the construct of Tu, Vonderembse, T.S. Ragu-Nathan and B. Ragu-Nathan, could help to quantify the degree of utilisation of the modularity in South Africa with greater precision.
- Building a model of the decision-making process, applied by the auto assemblers and specifically the methods of evaluation of the design and structure of the supply chain could simplify the decision-making processes.
- Investigation of the ability of BBBEE to enhance the competitiveness of South African small and medium component manufacturers in the context of globalisation.
- Research could focus on the role of small and medium enterprises in developed countries' automotive industries and the application of this model to South African conditions.

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11. Appendices:

Appendix A: NAAMSA Member Companies

	Manufacturing Director	SUPPLY DIRECTOR	Product Development Director	Customer Care Managers
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Appendix B

Questionnaire

Definition: Modularity, according to the definition given by M. Sako (2003) the modules are components, performing different functions and belonging to different systems, positioned in close physical proximity, which can be assembled as one self contained unit into the car.

1. In terms of the above definition how many modules can we distinguish in the platforms manufactured in your plant? How many platforms are assembled in SA?
2. How many of them are assembled off main assembly line?
3. How many are outsourced to suppliers?
4. List the benefits/ disadvantages of this concept.
5. If modularity used can we compare conventional and modular supply chains in terms of:
   - Flexibility (ability to customise – eg wider choice available to end customer and his ability to change his choice immediately before physical assembly start)

- Length of the assembly line/ time to end of line/ time to end customer
- Platform complexity v\s assembly time

6. One of the prerequisites of modularity is that it has to be supported by the design. The design of how many of the platforms, manufactured in your plant is supporting modularity?
7. What percentage of your module suppliers can be classified as wholly South African owned Small or Medium Enterprises?
8. If the answer above is "none" – what could be the explanation?
9. According Melnyk and Denzler the relationship OEM – supplier can be classified into four categories ranging from confrontation through to partnership. Confrontation represents traditional purchasing relationship, characterised with strong distrust between both parties as opposed to partnership, which is based on mutual respect and trust. How do you classify your relationship with your suppliers?
10. Is outsourcing strategy defined locally or by the holding company?

11. In your opinion is SME capable to be involved in modularity?

12. According Schilling (2000) the factors, influencing the migration toward (or away from) modular supply chain are:

- Heterogeneity of inputs (diversity of technological options available);
- Heterogeneity of customer demands and
- Urgency (Speed of technological change)

Which of those factors you can determine as the most important in your approach towards supply chain design?

Appendix C: Consistency Matrix

Question	Literature overview	Data collection tool	Analysis
1.1. **Question 1** – What are the factors, determining the adoption or rejection of modularity by South African automobile assemblers?	▪ NAAMSA year book 2008; ▪ Hill (2005); Denzler/ Melnyk (1996) ▪ Donnelly (2006) ▪ Jurgens (2003) ▪ Faxson (2004) ▪ Fine (1998) ▪ Doran (2004)	▪ Face to face semi structured interview ▪ Questions: 3,4,6,8,9,10,12	▪ Content analysis ▪ Comparative analysis
1.2. **Question 2** To what extent the modularity is used in SA?	▪ Donnelly (2006) ▪ NAAMSA year book 2008; ▪ B&M Analysts ▪ Sako (2003) ▪ Whitbread (2005)	▪ Face to face semi structured interview Definition; ▪ Questions: 1,2,3	▪ Content analysis ▪ Comparative analysis
1.3. **Question 3** – How do South African auto manufacturers benefit from it? Is it comparable to international standards?	▪ Whitbread (2003) ▪ Donnelly (2006) ▪ Tau (2004) ▪ Schilling (2000) ▪ Doran (2004) ▪	▪ Face to face semi structured interview Definition; Questions: 4, 5	▪ Content analysis ▪ Comparative analysis

1.4. **Question 4** – Is the modularity in automotive industry supportive of the South African small and medium enterprises?	NAACAM newletters B&MAnalysts – industry benchmark data Pyke (2002) Jurgens (2003) Kohler (2006) Whitbread (2005)	▪ Face to face semi structured interview ▪ Questions: 7,8,9,11	▪ Content analysis ▪ Comparative analysis

Appendix D: Time line