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The Effect of Engineering in Supply Chain management systems in the South African Automotive Services Industry

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ABSTRACT

This study examined the level of E-Supply Chain Management Systems application in the South African Automotive manufacturing industry. The objective is to have more transparency in the supply chain between the various segments, and methods being applied to integrate E-SCM systems and ERP platforms to discover a standard. In addition, the model required or available to encourage awareness of this systems and how they can assist in cost saving initiatives and improve quality and services rendered.

NAAMSA an organization for automobile manufacturers was contacted to understand which manufacturers classify component manufacturing and supply chain development as their core business. Three companies were contacted and they responded by granting permission for their members to participate. A total of 60 members partook in the survey.

The participants drawn consisted of (86.7%) from Toyota, 8.3% from Nissan and lastly, 5.0% from BMW manufacturing service firms, in order to determine the impact of E-supply chain management on their key supply chain operations. The data was analysed using Statistical Package for the Social Science to evaluate the degree to which the respondents knew about E-Supply Chain Management Systems and its application in the business.

The results of the research revealed that e-supply chain management systems have a positive effect on the automotive manufacturing industry, as there was an improvement in the level of focus employed towards sustaining customer needs through quality of data for internal communication and data relevance. The research further showed that e-supply chain management systems have many technical issues such as the remote access capability and Extranet for communication with external parties.

In order to overcome these challenges there are methods that can be applied to accomplish, firstly, world class performance by calculated partnerships between suppliers and the system to co-ordinate data and communicate effectively. Through the use of Internet of things as one form of system, companies have real time information

which enables the planning of resources more precise and accurate product development.

Several recommendations were made to overcome these challenges, such as areas of developments for the industry, specifically the requirement for employee training to utilise E-SCM to its full extend and the requirement to better synchronise E-SCM with Enterprise Resource Planning systems by re-engineering the business processes for better system integration.

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List of Abbreviations

CAN	Controller Area Network
EDI	Electronic Data Interchange
E-SCM	Engineering Supply Chain Management
E-SCMs	Engineering Supply Chain Management systems
EU	Europe
IoAT	Internet of Automotive Things
IoT	Internet of Things
IPAP	Industrial Policy Action Plan
IT	Information Technology
NAAMSA	National Association of Automobile Manufacturers of South Africa
NHTSA	National Highway Traffic Safety Administration
OEM	Original Equipment Manufacturers
PII	Personally Identifiable Information
SCM	Supply Chain Management
SPSS	Statistical Package for the Social Sciences
UK	United Kingdom
V2V	Vendor-to-Vendor
V2I	Vehicle-to Infrastructure

CHAPTER ONE

Introduction

1.1 Introduction

The main purpose of this study is to investigate the degree to which the automotive companies based in South Africa have implemented E-SCM philosophies. The chapter discusses the motivation of the research, followed by the problem statement, as well as the objectives of the study. Many companies have begun to utilise the enhancement of the Internet as a benefit to market their goods very well, as well as to maintain a real-time relationship with their consumers. The shifting environment of the manufacturing segment, with its emphasis on budgets, flexibility, good quality and modern technology to handle the economic challenges, is triggering massive inter-organisational trade relationship changes and various manufacturers are refining their relations with suppliers using the E-Supply Chain Management Systems approach to address these concepts. This type of business-to-business method not only offers the setting for information sharing, but also permits industries such as the automotive to improve their accuracy and productivity of industry transactions handling. The study continues to research whether or not the companies view these philosophies as a technique to advance their businesses and furthermore, if these philosophies are practical in different segments of the industry.

1.2 Motivation for the study

Supply chain is basically an arrangement of techniques used in the production and delivery of a product, which can be stock or services. Likewise, it includes the complete set-up of systems that are connected and co-dependent on each other in providing the customers with stock and services (Delbari et al., 2016). These systems may represent sole proprietorship, establishments, properties, events and expertise, all interested in the formation and trade of the goods (Rous, 2016).

The supply chain is a critical link amongst the manufacturing business and customer requirements; this sequence of events would typically begin with getting the suppliers that source and deliver the raw material as required and this results in a satisfied customer. The defining victory of a product is heavily influenced by the supply chain system which encompasses the production, quality control, packing and the supply of the product.

The introduction highlights the need to conduct research in the area of manufacturing practices in order to measure the degree on awareness and application of engineering to enhance the productivity of supply chain systems.

The targeted companies are located in South Africa and symbolise the backbone of the automotive industry. Deductions drawn from the research will underline the current position of the effect of engineering in supply chain principles in these companies and this will serve as a point of reference to other automotive companies.

1.3 Focus of the study

In this report, a complete list of five engineering qualities, with respect to supply chain management systems, will be studied for the degree of their application in three businesses in the automotive industry across South Africa. The research will attempt to evaluate the ideas that are recognised to be crucial for the finest quality and efficiency in a manufacturing industry. In addition, the study will concentrate on creating methods for evaluating the degree of engineering systems used, as well as awareness within businesses, in order to advance the framework for the South African context.

The improvement of a framework applicable in South Africa will help form a foundation for future academic survey. The implications deducted from the research will be beneficial in refining business performance of the studied companies and may furthermore be used to influence other sectors to embrace the principle of supply chain management systems, with the support of engineering.

1.4 Problem Statement

The development and effectiveness of manufacturing in South Africa has intensely declined over the past two decades, distressing the domestic import against export ratio (Fedderke, 2014). The result headed to job losses, fiscal deficit and declined economic growth. As a mitigation plan, the government has employed improved emphasis on localisation by the Industrial Policy Action Plan (IPAP). This plan acknowledged an aggregate of business sectors to be enlisted for governmental funding, in an effort to increase domestic production by innovation and process improvements.

The automotive industry however faces a larger industrialisation and supplier development challenge in a globally competitive and knowledge intensive market. In order to enable industry participants and new entrants to deliver globally consumed products and services that are eco-friendly, regulatory compliant and sustainable, industry participants need to invest in management systems supported by engineering which will not only advance productivity but also produce quality products.

Modernised manufacturing is complex, with globalisation requesting for more unique services and production lines. Even if the invention itself may be fairly modest, the process and supply chain might be complex. It has been revealed that even old-fashioned merchandises are quickly increasing in complexity, due to the requirement for personalisation, sustainability, customisation and the adding of engineered equipment.

This study aims to assess the status of engineering supply chain management system's application in South Africa's manufacturing services industry, with the purpose of underlining potential strategies for refining organisation practices and compete globally.

1.5 Research Sub-Questions

- Which methods will be used to accomplish world class performance in South Africa?
- Which model will be used to encourage awareness of supply chain engineering forces and effectiveness?
- What system can be used to decrease wide-ranging costs of a company?
- Which approach is best suited for improving services and quality?

1.6 Aims and objectives of the study

The South African automotive industry is the leading contributor to GDP in the manufacturing segment and therefore, the study of supply chain management procedures, which seeks to highlight the status of its development in this industry. This study is aimed at assessing the level of awareness of modern strategies practiced globally, as well as to recommend counter-measures to strengthen the competitive advantage of the businesses in South Africa. Therefore, the specific objectives of the study are as follows:

- To identify the methods which could be applied to accomplish world class performance in the South African automotive industry.
- To identify a model to encourage awareness of supply chain engineering dynamic forces and effectiveness in the South African automotive industry.
- To identify a system which can decrease wide-ranging costs of company to fulfil service level obligation
- To determine an approach which can be applied to improve services and quality rendered.
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1.7 Significance of the study

Based on the objectives indicated above, the study will benefit the manufacturing businesses, as well any business that practices supply chain principles or looking into evolving the way business has been done in the past. Improving the ability to be more efficient enough to manage the supply chain, which could ultimately result in business to remain competitive and sustaining a competitive advantage. This research will contribute to the growing body of supply chain management systems literature around the world, by using recognised engineering systems for logical assessment.

1.8 Chapter outline

Chapter one established the background of the study, described the problem which the study attempts to resolve and evidently identified the objectives to be achieved in the

study. The research questions were drawn together, with the determination and support to the study.

Chapter two explores the literature review of the study. This incorporates the background of supply chain management principles implemented, performance improvement as a result of engineering systems implemented and lastly, the summary of the automotive industry. The literature review and theoretical background address the research questions jointly, with the related hypothesis.

Chapter three investigates the study population and the approach applied in the investigation. The sample size is highlighted in detail, jointly with the technique of information gathering. The basis of the research instrument is also discussed, while the format of the questionnaire is jointly discussed with data analysis techniques.

Chapter four presents the findings of the survey. This consists of outcomes of engineering and supply chain management systems application through the use of numerous statistical techniques.

Chapter five discusses the results of the survey to highlight some of the discoveries linked to the current use of the supply chain systems and pin point exactly what fundamentals can be improved. Lastly, chapter six discusses the conclusion and implications of this study.

1.9 Chapter summary

This chapter discussed the background information to awareness of E-Supply Chain Management systems in automotive industry; the motivation and the problem statement, including the benefits and challenges identified that is aimed to be achieved by the researcher. Subsequently the researcher presented research questions and study objectives, justification of this study and the targeted population that the study aims to benefit and how it will benefit the target population. The next chapter will discuss the growth of manufacturing and how it has continued to advance, which includes the influence of engineering on supply chain and how this two supplement each other.

CHAPTER TWO

Review of Literature

2.1 Introduction

This chapter will begin with an outline of the manufacturing industry, followed by the effect of engineering in the supply chain management, as well as its influence as part of the whole business model.

Challenged by tough opposition, manufacturing companies in multiple industries are determined now more than before, to identify the diverse methods to decrease expenses, advance their processes and expand the productivity of their businesses. However, lately, the supply chain meaning in many companies had been mainly regarded as an operative function and later played a marginal role in framing the business approach or strategy (Bryans, 2017). The trend is shifting, as various companies, for instance, Ford Motor Company, DaimlerChrysler, Toyota, BMW and Nissan are starting to grant due acknowledgment to the supply chain function, thus using it as the basis for competitive advantage (Bryans, 2017). This improved emphasis on supply chain is mainly due to the recognition that supply chain costs make up a considerable percentage of manufacturing, as well as total expenditures.

Recently, attention has been on the application of the internet usage and the electronic markets it supplies has caused many organisations to calculate ways to advance their productivity, particularly when these expenses make up a considerable percentage of production, as well as total expenditure (Degraeve and Roodhooft, 2001). In other instances, a complex supply chain that links numerous suppliers with consumers in sequence, requires the market to abide by the processes setup which connects to the supply chain activity, for instance, supplier confirmation, supplier relationship management preparation, etc. if supply chain proficiencies are to be recognized (Aigbedo and Tanniru, 2004). For these explanations, supply chain is broadly defined to consist of all processes in the procurement, that have a direct influence on the

validation of suppliers and purchase of raw materials required in support of a company's production and supply of consumer goods or distribution of services.

A literature review associated with several models that make up and describe E-Supply Chain Management Systems was carried out. This review delivered valuable information about serious models that make E-Supply Chain Management Systems functional systems. This involved several meanings of supply chain management, the basis that the system is meant to accomplish, serious mechanisms that are significant in driving the systems and the effects projected from a positive application of the system. Using the evidence from both the literature review and the researcher's personal understanding, it was probable to develop the hypothesis for this study. The theory was established from the five values of E-Supply Chain Management Systems in enhancing productivity in the manufacturing industry which are:

1. E-SCM impact on SCM has placed on the manufacturing industry.
2. E-SCM effectiveness on SCM tasks as a strategy of enhancing the productivity.
3. Satisfaction of the E-SCMs users when dealing with customers, with respect to addressing the information and communication needs.
4. E-SCM Quality which attempts to measure the technical aspect of the E-SCM use in the firm.
5. E-SCM Performance in the different supply chain task areas which measures the efficiency of E-SCM in different workplaces in the firm, especially procurement, product distribution, and purchasing.

2.1.1 Importance of supply chain

In the past years, companies started to be conscious of the meaning of establishing collaborations with associates in the upstream and downstream sides of the value chain, commonly under product life cycle management. These types of collaborations influence the effectiveness and efficiency of the processes, which leads to reduction in costs and also improved profit margin. By inspecting the supply chain process tactically, three serious matters need to be considered in handling the supply chain: Preference, outsourcing and developing of suppliers. Although outsourcing approach is directly linked to a business' strategy about an amount of suppliers required to achieve its sub-assembly requests, supplier preference is about the unique selection of suppliers that would ensure these requests are met (Gunasekaran et al., 2017).

Supplier evolution is a distinct form of affiliation a business supports with a minimum choice of suppliers in order to achieve some premeditated desires. Supplier selection is a critical subject, particularly for businesses that handle intricate products. This is significant, not only to decrease the logistics expenses, but also to react to a business' attractiveness equally in the short and long-term. Lee et al. (2003) echo this idea by noting that supplier preference or selection is a deliberate subject to reflect in supply chain management. Some of the topics cover price flexibility, capacity to respond rapidly to varying consumer requests, in terms of capacity and combination, as well as the capability to successfully address quality concerns. Therefore, logistics needs to include synchronisation of data amongst the suppliers and the business in relation to its flexibility, alongside other simple price associated influences. Supplier development normally transpires amongst a business and its suppliers, through which it has planned relationships. Supplier development differs in scope of work and complexity, subject to the business strategy and the extent of strategic significance of the acquired products. This can vary from basic correspondence about product requirements and quality problems, to member training and mechanical funding in research and development. The methods differ from nation to nation as well. In a relative article about supplier relations in the automotive manufacturing like the US, Japan and Korea, Dyer et al. (1998) established substantial variances in the level of communication and mechanical

provision a business affords its suppliers. Some world class businesses have used such calculated partnership successfully for economic advantage. For instance, Dell Computers developed partnerships with computer monitor contractors (Magretta, 1998) and the automotive companies are known to use strategic partnerships with many of their crucial suppliers (Liker and Wu, 2006). Meaning, supply chain backing may differ according to how companies understand their connection with a supplier, as well as the type of support required may comprise shared product development, the distribution of crucial project documents and discussion on quality and program data.

2.2 Supply chain breakdown

When manufactured goods complexity continuously increase, the industry setting also turns to be more intricate. The fast globalisation not only deals with the prospect of a more varied set of possible suppliers and consumers, but also carries new rivalry (Stark, 2011). In addition, a globalised market also presents more difficulty in the method of variances in guidelines and cultural norms amongst countries and regions. Furthermore, a complex product also effects in a more complex supply chain.

As goods come to be more refined, engineering and manufacturing initiatives have to develop more specific modern products to go through numerous phases of incorporation and gathering, with the original equipment makers combining mechanisms, subsystems or even complete systems from countless suppliers (Gandhi, 2013). The manufactured goods of one enterprise are every so often any of numerous contributions into the fabrication process of a different enterprise. Otherwise, the invention of one company is recycled to assist the product of the next business. For instance, the elevating jacks intended and produced by company A is used to preserve the locomotives made by company B, which then is ran by company C. To retain product quality between corresponding traders, it turns out to be even more vital to assess each supplier and form valued associations.

2.3 Key areas of development

Engineers are involved in the planning processes or installing equipment to allow for simple process of the supply chain network. This can vary from raw material and production methods to supervision and delivery processes. The technology being considered should be developed effectively to permit for safe, capable, cost effective, high quality product manufacturing in a realistic time frame.

The five key areas for development are manufacturing, the internet of things, robotics, transportation and drones.

- Manufacturing is one of the significant areas of emphasis because it is the key driving force of the supply chain. If it did not exist, then raw materials would not be converted to a final product for sale to the customer. Commonly known manufacturing technology comprises software to control or operate processes and information capturing for reference, raw material ordering and dedicated equipment by process, material packaging tools, product quality regulation tools, equipment for material handling and an extensive variety of programmed systems (The Association of Manufacturing Technology, 2016).
- The internet of things represents any device that is capable of collecting and transmitting information through internet connection (Morgan, 2014). It is also classified as one of the three primary supply chain management styles by Robinson (2015). A supply chain can be controlled and enhanced by means of this concept in such a way that a supplier can react to the changing aspects of demands in the marketplace and then check readiness of raw materials automatically through information broadcast and examination in real time through the internet (Mello et al., 2017). This will include internal communication amongst machines using automatic decision-making tools and software technologies to remove any administrative problems which may possibly be time consuming. This can be predominantly valuable in manufacturing and distribution systems.
- Robotics is an alternative significant engineering technology which includes automated equipment to warrant that time is spent effectively and quality is sustained. This then links in with the internet of things to ensure an automated

reaction to information received from a different machine or even the internet (Karakostas and Bessis, 2016).

- Transportation is a crucial factor in the delivery of products, as well as the handover of raw materials to the production plant. At this point, engineering technology will play a vital role in planning efficient transportation routes, procedures to be followed and networks to minimise costs, shorten lead time and consistency (Karakostas and Bessis, 2016).

- Finally, drones are likewise a key player for the future of engineering technology for supply chain. Drones are skilled in recovering real time photo and video records, this can be very beneficial for monitoring of assets in transit and even company surveillance (Harbert, 2015). Drones are similarly beneficial for the distribution of small parcels for short distances, which does not require too much time to deliver. This can be used for transportation between retailer, supplier and customer, as well as inside enormous production plants or packing plants or warehouses (Hua and Cong, 2011).

The cases presented of engineering technology for supply chain development are just a small number of the numerous technologies present in the market and yet to be established. The existing problems in supply chain can be resolved by using these technologies to advance their processes. Engineers play an important role and have the expertise to challenge these obstacles.

2.4 Engineering of complicated products

Through the continuous growth in the difficulty of products, the systems methodology to product advancement, recognition, operation and funding increases in significance Erasmus et al. (2015). The method of systems engineering is fairly capable of addressing complex products with a great amount of parts and interfaces. The situation has succeeded in adapting from the traditional subject field of structural model into an applied approach of identifying and confirming complex systems.

2.5 The South African perspective in engineering and manufacturing industries

Despite the fact that fourteen of the sixteen businesses which are automotive, clothing, metal fabrication, agro-processing, forestry, plastics, pharmaceutical, primary minerals, green industries, business process services, water and sanitation, marine, aerospace and lastly electro-technical & white goods recognised by Industrial Policy Action Plan need contemporary engineering and manufacturing practices, the four businesses where South Africa participates most evidently in the global market are underlined here to classify the real problems faced in these industries (Erasmus et al., 2015).

2.5.1 Automotive

Fierce rivalry and high level of consumer beliefs in the current universal automotive market have enforced businesses to try for reduced product development phases by concentrating further on their supply chains models (Manzouri and Rahman, 2013). Supply chain management incorporates supply and demand controlling inside and across businesses as a collective methodology that comprises several role companies in the supply chain. These companies considerably add to enhanced product quality, reduced lead times, and a higher awareness, at minimal charge and better customer gratification levels (Bennett and O'Kane, 2006).

The South African automotive production has matured to grow into the primary manufacturing subdivision in the economy. Although the manufacturing is reasonably competitive and several world class organisation methods are currently in practice in the sector, the business setting has transformed over the previous years (Erasmus et al., 2015). There is influence on the South African automotive component manufacturers (ACMs) to contest with the finest in the world, starting with quality and cost visions in order to endure (Ambe and Badenhorst-Weiss, 2011). The automotive industry is under serious influence and faces several supply chain difficulties that are an outcome of quick improvements in supply chain organisation, technological developments, increased labour expenditures, globalisation, poor infrastructure and gradually challenging consumers who are squeezing their dealers on value and non-value

elements (Naudé et al., 2013). The task of ACMs in the effectiveness and the persistence of the automotive industry is important, as ACMs remain the key providers to occupation in the automotive industry and they can create a great influence on the cost attractiveness of the South African automotive manufacturing (Naudé et al., 2013).

2.5.2 Aerospace

A number of tasks for the South African aerospace sector consist of the following (Kraemer-Mbula, 2008):

- The shifting nature of aerospace engineering: main modifications in global assembly chains are gradually challenging higher technological abilities;
- The capability of local aerospace enterprises to adjust to the original terms of worldwide competition and to elevating the manufacturing abilities of sub-providers;
- The incorporation of aerospace manufacturing into local supply value chains: technological abilities in these areas continue to be inadequate, whereas most of the construction is exported instead of integrated into domestic advanced manufacturing.
- The intricate principle of aerospace and its old association to the state: forming a sufficient principal environment for aerospace. Close partnerships amongst industry, government, research institutions and academia institutes is a crucial part to advance the industry's attractiveness.

2.5.2 Coal mining

Supply chain management involves interactive and systems values of running the complete flow of a distribution network from suppliers to end user. A classic supply chain includes suppliers of resources, producers, vendors and customers (Erasmus et al., 2015). The critical points of a supply chain are ensuring customer fulfilment, refining quality, decreasing cost and refining services. Main role-players in the South African coal mining trade-off comprise mining businesses, municipal departments liable for

minerals and environmental dealings, local and export coal customs, rail transport amenities and the key coal export plant at Richards Bay Coal Terminal (Pooe and Mathu, 2011). The following ineffectiveness has been perceived in the mining business:

- The quality and supply of coal remains challenging and has impacted on power stations to function well beneath their volume, causing profit losses.
- Growing formalisation and combination among cooperating institutes
- Supply chains offer rational platforms for partnerships.
- The achievement of collaboration is mainly influenced by technology. The profits range from raw material dealers to consumers. It decreases inventory, increases forecast precision and escalates revenue to consumers.
- Operational collaboration is the basis of competitive improvement which targets to advance consumer service, asset utilisation, profit generation and cost reduction.

2.5.4 Agribusiness

Limited number of leaders of South African agribusiness namely Tiger brands, Pioneer Foods Group, Tongaat-Hulett, Astral Foods, AFGRI, Illovo sugar, Anglovaal Industries, Rainbow chicken, Clover Holdings and Oceana Group have highlighted the following three key responsibilities facing the industry segment past 2000 (Darroch, 2010):

- Poorer trade barriers and the skill of well-informed international businesses to handover technology, marketing and management expertise from state to state at moderately low price have commanded increased global competition (Darroch, 2010).

2.6 Empirical review

2.6.1 The future of supply chains

The short-term market research of four main businesses in South Africa indicates that supply chain management is causing major complications. South African businesses are experiencing difficulties in exploiting profits from their supply chains because of miscommunication and information distribution amongst members in the supply chain. Seeing that goods are becoming further difficult and supply chains greater with added specific suppliers, the difficulties experienced with supply chain management will continue to deteriorate. Innovative equipment manufacturers will come to be more reliant on suppliers to supply high quality machineries and facilities. When machineries become more sophisticated and refined, the manufacturing and engineering will occur more in the supply chain, before the consumer face to face initiative (Erasmus et al., 2015).

Before, businesses mass-produced goods expecting sales. Yet, in today's greatly challenging overall economy, the customer's higher anticipations are influencing demand for personal specifications. The thriving businesses are individuals that accurately recognise their markets and the distinct needs of each consumer. The world has moved slightly in a direction to create the increase of customer influence and power.

2.6.2 Engineering in supply chain

The method makes it challenging for domestic manufacturers to participate in the universal market and uphold accurate control of the goods as it evolves through the diverse life phases. It further makes it challenging for domestic engineering and manufacturing groups to contribute to specific high-technology businesses such as aerospace and the automotive (Mund et al., 2015).

Engineering in supply chain is a corporate solution which targets to modernise the movement of data about the invention and connected processes all over the product's

lifecycle, so that the precise material in the right setting at the right stage can be made accessible (Ameri and Dutta, 2005). Some contain software-enabled approach to advance processes to conceptualise, plan, improve and control products, motivating advanced stages of product productivity, engineering allows three types of combinations, along the following lines:

- Talks about the complete development of a product and the related information from the beginning through planning and growth, issue to manufacturing, after-sales service (operation, asset and maintenance supervision), removal and obsolescence.
- Permits for enhanced partnerships amongst practitioners from diverse disciplines and corporate purposes.
- Incorporates people, statistics, procedures and business systems to deliver a product information practice for the firm and its associates.

2.7 The role of coordination in ETO supply chains

Malone, Malone and Crowston (1994) state supply chain coordination as the act of handling dependencies between units and the joint effort of units working together headed for jointly clear objectives. In this sense, coordination is a significant feature of the decision-making process that sustains the order and steadiness of a system. To be completely coordinated, a supply chain entails that all the choices are united to achieve a universal system objective (Sahin and Robinson, 2002). A method assessment is vital to outline specific activities that may harm complete performance. Meaning that coordination is based on outcomes, communications and relations between supply chain associates and support businesses in handling information and material movements linked with crucial business practices (Romano, 2003).

In an ETO (engineer to order) framework, poor coordination among project members to deal with detailed customer requests and product variations creates delays which increase the lead time (Pandit and Zhu, 2007). Interruptions often result in complications in outlining precise lead times. As stated by Hicks et al. (2001), refining

delivery in an ETO framework is dependent on both decreasing lead times and growing the consistency of lead time estimations. The three main points that involve coordination are: marketing, engineering (research and development) and manufacture (product realisation) (Hicks et al., 2000). The coordination of these practices entails detailed coordination functions such as mutual alterations or groups, which can be used in a position of restricted standardisation and seldom any repeat orders.

2.8 Integrate engineering and production

Integration is required to accomplish engineering changes more efficiently and guarantee a unified material flow. Integration in shipbuilding depends on numerous features such as co-located groups joined IT, mutual goals, direct communication and comparable organisational values (Held, 2010). According to Held (2010), the correlation between tasks executed by the ship designer and shipyard is enormous, therefore, it is significant that the ship designer can work directly with the shipyard in order to monitor deviations rapidly and then avoid generation of interruptions in other downstream responsibilities. The significance of incorporating engineering and production is more obvious when production is sub-contracted (Mello et al., 2017). For example, de Treville and Trigeorgis (2010) discuss that the interaction between engineering and production is a serious aspect to supply tailored products on time and to openly manage complications. According to de Treville and Trigeorgis (2010), requiring engineering and production positioned at the same place allows businesses to better explore the innovation ability and to realise customisation and receptiveness. Outsourcing manufacture of unique products, when businesses do not uphold high levels of supremacy over the activities that are executed, makes coordination challenges that lead to mediocre project presentation (Mello et al., 2017).

2.9 Systems engineering effective supply chain innovation

The BRICS markets (Brazil, Russia, India, China and South Africa) are arranging considerable resources in the reality of a current worldwide financial disaster that has further deteriorated the manufacturing sectors of many nations (CAN 2013; Cassiolato

and Lastres 2009). In return, governments and trading alliances around the globe (e.g. Australian Government 2013; EU 2013) are advising their own businesses to develop more innovative ideas, and gradually recognise the ongoing cutting-edge studies, continuous improvement and innovation is required at the advancement of productivity (e.g. Coons, 2014).

Re-engineering groups tasked with accomplishing quick and drastic enhancements in organisational know-how will most likely favour greatest practice implementation over 'reinventing the wheel' (Goffin and Mitchell, 2005). This mostly includes an examination for better-performing organisations, and for recognised top practices that may be re-assigned. The application is made even further challenging when seemingly better-performing organisations are positioned in unrelated business/industry segments and economic backgrounds, later the organisation's outside setting may also influence its performance.

2.10 Supply chain innovation research

Prajogo and Sohal (2003) debate that alignment of innovation with operational and advanced management practices is necessary when considering the manufacturing and engineering segments. So far, innovation study linking SCs in Australia and New Zealand has concentrated on operations management philosophies; containing just-in-time (Clarke and Mia, 1993) and lean production (Singh, Smith, and Sohal 2005; Sohal and Egglestone 1994), and reflection of larger SC, processes and quality management practices (Childerhouse and Towill, 2011, Prajogo and Sohal, 2003).

Systems engineering and the SC development model, with its well-honed theory of uncertainty to frame SC development, is still to be extensively embraced in Australia and New Zealand (Basnet et al., 2006, Lee, 2002, Sun et al., 2009, Wong and Boon-itt, 2008).

Despite the well-recognised 'risks' of benchmarking (Denrell, 2005), the regular necessity for quick and thorough improvements forces countless re-engineering groups to pursue the identity of better-performing businesses, with an outlook to implementing

their greatest concepts (Goffin and Mitchell 2005). On the other hand, in a meta-study, Balachandra and Friar (1997) demonstrate that over half of the main causes contributing to innovative development are exclusive to the exact situation. This stresses the significance of exploiting a benchmarking practice that is capable of taking into consideration, the organisation's external setting; in that way allowing identification of openly better-performing businesses (Childerhouse and Towill 2011a; Foggin, Mentzer, and Monroe 2004; Frohlich and Westbrook 2001; Phillips et al. 2008; Salama et al. 2009; Van der Vorst and Beulens 2002; Van Donk and Van der Vaart 2005). The development of an independent, commonly similar and manageable measure of SC performance is complex by the sheer diversity of SCs and their irregularities, as well as the intricate and often complex multi-functional, multi-organisational methods they need.

2.11 Technology selection in the absence of standardised materials

The growth of innovative goods and applications built on new resources and technical innovations offers unlimited industry opportunities, like many challenges. One of the main tasks facing the young, energetic businesses is the variety of manufacturing technologies. Technology selection and reasoning include decision-making responsibilities that are critical to the success and growing of a business in the increasing competitive global setting (Chan et al., 2000). The decision-making practice of technology selection signifies a foremost task facing superiors as this will probably influence their company's business processes (Farooq and O'Brien, 2015).

The procedure of technology selection in the young, energetic businesses may be even tougher than in the old-fashioned, deep-rooted segments. In the young, energetic businesses, there may not be typical manufacturing methods, nor are there standardised resources with distinct or prohibited properties for businesses to select. Essentially, the selection of manufacturing technology has consequences that can influence the supply chain. The old-fashioned meaning of supply chain management narrates to the design of value by reaching further than the traditional limitations of a business including suppliers, consumers and other investors (Groen and Linton, 2010).

The existing academic literature highlighting the challenge of technology selection is considered for the usage of diverse methodologies. In their investigation involving the different devices used to incorporate new technology into the current products, Karlsson (Karlsson et al., 2010) measured the level of product progression as a significant element centered on whether a new technology provides a current product to have improved functionality outside its original space. Other illustrations include the practice of competitive strategy investigation built on performance indicators like value, quality, reliability and flexibility (Kleindorfer and Partovi 1990), the concept of fuzzy arrangements when applied to classified organisational study and economic assessments (Chan, Chan and Tang 2000).

Similarly concrete and immaterial influences used in joined fuzzy logic for decision-making practices (Wu and Barnes 2014) and assessment models consider practical ability (Sarkar and Mohapatra 2006).

Finally high-tech innovations (Choy, Lee, and Lo 2003) and classified techniques for formulating standards to use in partner selection decision-making in fast-paced supply chain methods is also part of the selection process (Wu and Barnes 2010). Additional methods existing include the systematic hierarchy practice using procedural level and supply capability (Xia and Wu 2007) and the usage of Quality Function Deployment for technology selection in manufacturing atmospheres, for example, metallurgy (Lowe, Ridgway, and Atkinson 2000).

The amount of literature that addresses technology selection from a supply chain viewpoint is still restricted. For instance, Farooq and O'Brien (2012) focus on the absence of studies that integrate the significance of the supply chain in the technology selection decision-making method. The academics highlight that this characteristic is predominantly important in the manufacturing businesses that are reliant on cutting-edge manufacturing technologies for their economic benefit and depend on external supply chains. Farooq and O'Brien (2015) make clear that technology selection has an important part in the alignment of the supply chain, as opportunities and threats are generally related to a technology substitute in the supply chain perspective.

Therefore, it is possible to see businesses being aggressively examining high-volume usage of carbon fibre in the automotive industry. The Ford Motor Company and DowAksa signed an agreement to investigate high-volume practices of carbon fibre mixtures, as its use has been hindered by the lack of high-volume manufacturing approaches and inexpensive material designs (Automotive News, 2015). The practice of PMCs can be found in various state-of-the-art products. For instance, in the 2016 BMW 7 series sedan, carbon fibre-reinforced plastic is used in the B- and C-pillars, alongside the centre tunnel, in the roof bows, in the sills, on the package tray, in a 9-foot arc that runs from the base of the A-pillar to the rear of the car and beside the roofline (Autoweek, 2015). The body assembly of the car is 90 lb lighter, in comparison to the former generation model.

2.12 The growth of the Internet

The growing of the internet in pursuit of business-to business (B2B) e-Commerce, which contains supply chain roles along with other kinds of material exchange, was predicted to raise from about $145 billion in 1999 to $7.29 trillion in 2004 (Noyce, 2002). Although the growing in the practice of the internet in business-to-customer (B2C) marketplaces is slightly mixed (Chopra and Van Mieghem, 2000) , its usage in maintenance of B2B dealings, mainly through expertise such as exchanges (i.e. computer-generated positions on the internet that bring commercial buyers and sellers together to trade with each other) was projected to raise considerably. The key drive for the practice of exchanges by businesses is the projected cost reduction and elevation in efficiencies that can be derived.

For instance, in 2000, more than 20 North American energy and utility corporations, including American Electric Power, Detroit Edison and Edison International, formed an association called the Pantellos Group to decrease their logistics costs (Senia, 2000). Owens and Minor, a healthcare firm in the United States, controls a private exchange to reduce logistics costs through the use of economic bidding for its parts and materials (Nelson-Rowe 2001).

The relative successes of some of these associations and remote interactions have created the desire for the improvement of an automotive exchange, called Covisint, by businesses such as General Motors, Ford, DaimlerChrysler and Nissan, while its original intent was to decrease supply chain costs and grow efficiencies alongside their supply chain. While online, devoted interface between automotive businesses and their suppliers is not new (technologies such as EDI have been in use for a fair amount of time), exchanges are invented to afford a wider set of prospects for customer/supplier communication (Aigbedo and Tanniru, 2004).

2.13 The Internet of automotive things: vulnerabilities, risks and policy implications

The international automotive manufacturing is experiencing an unmatched period of fast, complex change. This is being permitted by the same influences that are controlling the modern growth in the Internet of Things (IoT): computing solutions are growing in capability, while decreasing in size and cost, and universal connectivity is now being taken for granted (Bryans, 2017).

The intense transformations in computing power have enabled the improvement of features, for example, parking assistance, adaptive cruise control, and lane keeping assistance. Jointly, these Innovative Driver Assistance Systems are made to take much of the load of driving away from the motorist. New vehicles now come with Bluetooth as standard, and various new cars incorporate wi-fi and offer wi-fi-enabled features. By the year 2018, all new cars in the European Union will have to include e-Call (EU 2015), which in the occurrence of an accident, will make a 112 emergency call to report the whereabouts of the car, plus to permit an emergency worker to talk with the vehicle passengers. These concepts, headed for computing-intensive vehicles with various communication decisions, are driving two big modifications in the manufacturing industry, in the direction of autonomy and towards intellectual mobility.

Of the several benefits presented by autonomy, it may be debated that from a social point of view, the most important is the possibility to radically decrease the number of accidents caused by driver mistake. Although the UK is one of the world's best in terms of road safety and security, in 2015, there were 23,874 deaths or severe injuries reported on UK highways (Department for Transport 2016). In the U.S., motorists were considered to be the utmost serious factor in 94% of all accidents (Singh, 2015). Meaning that the motorists were accountable for the serious pre-crash result. The National Highway Traffic Safety Organisation in the UK is cautious to point out that this is not a shifting of blame, but nonetheless, by eliminating the driving duty from the motorist, autonomous vehicles have the likelihood to massively increase the safety of our highways. Powerful research and development in autonomous vehicles is in motion, and lately, reported assessment results in California show significant progress in the last year from the main U.S. companies in this space (Davis, 2017). All 11 companies that had state certificates to examine autonomous cars testified a rise in the percentage of test miles driven per number of human interferences required.

The UK is at the forefront of many of these modifications, and the declared goal of the UK government is to continue leading the way. The Department of Transport lately revised the present legislation and decided 'Real-world trials of automated technologies can be done in the UK nowadays, given that a test driver is present and takes accountability for the safe maneuver of the car; and that the car can be used together with road traffic law.' In the year 2015, they printed a code of training for assessing autonomous vehicles (Department for Transport, 2015). The Centre for Connected and Autonomous Vehicles, a common strategy unit of the Department for Transport and the Department for Business, Energy and Industrial Plan, has been arranged to support the study, advance, demonstration, and positioning of related and autonomous vehicles. They have been tasked with assigning an extensive programme of studies into connected and independent vehicles. The direction towards software in cars has also unlocked new opportunities in the nature of future driving.

The drive towards software-enabled features in transport (classified as intelligent mobility) opens up several new prospects for the way in which cars are driven, including the probability that the automotive market may move from the existing model of ownership towards one that includes Mobility-as-a-Service (MaaS). This idea, which emphasises the mobility necessities of motorists, appeal to more than just passenger cars. It comprises all kinds of transport and, expedited by intelligent mobility services, deals with multi-modal trips to meet the mobility desires of the consumer (MaaS Alliance, 2016).

By permitting a central method to trip planning, the MaaS model could theoretically improve jamming and contamination on roads. Technologically, this future is not far-off. There would be less demand for new vehicles, and an emerging industry offering mobility services, with manufacturers evolving towards service providers as a substitute of vehicle producers (Meyer and Shaheen, 2017). The economic outlook of the moves towards connectivity and autonomy is massive. Leech et al. (2015) state that by 2030, 'The complete economic and social value of connected and autonomous vehicles could equate to $51 billion per year.' This is a degree of the possible worldwide influence and only in the UK, they predict a further 320,000 UK job opportunities could be created, with 25,000 being in the automotive manufacturing. A statement by the Transport Systems Catapult studies policy opportunities to inspire the progression of the MaaS market in the United Kingdom (Datson, 2016). It highlights that such a prospect will require a considerable amount information sharing. An additional report by Hill (2016) discusses the degree of cybersecurity questions around smart mobility in further detail. A broader discussion about the attractiveness of the potential future atmosphere afforded by these variations is in order, but it is clear that whatever future choices are made, the Internet of Automotive Things (IoAT) will require a robust and calculated cybersecurity position.

2.14 The automotive industry

The universal automobile manufacturing relies on a unique international set-up of suppliers that offers parts and vehicle sub-assemblies to vehicle manufacturers (classified as OEMs, or Original Equipment Manufacturers) (Bryans, 2017). Innovative

vehicles are depending more severely on software and software is liable for recognising competitive distinction, meaning that software makes up an accumulative amount of the worth of a car. In 2003, Klaus Grimm wrote 'DaimlerChrysler specialists believe that 80 percent of all upcoming automotive improvements will be driven by electronic engineering, 90 percent by software' (Grimm, 2003). This is driving an intense revolution in the supply chain: Moazed and Johnson (2016) state that 'In the following 10 years, the distinguishing basis of supply and worth in the automotive industry will not be vehicle components or engines. In its place, it will be a system of software designers.' An important portion of the Intellectual Property within a car will then be in the manner of software. It is possible that the major part of this IP will be reserved by the designers, and not be given as an asset to the OEMs. The choice concerning software, and its resulting influence on the supply chain, has wide consequences for security. OEMs might not have complete access to the software in a vehicle and hence, face a challenging task in certifying it. In analysis terms, they should handle it as a 'black box'. Practical testing (testing for the existence or lack of practical, itemised performance) can be done, centered on the necessities the software has been designed to meet, but attacks on security regularly abuse the survival of unrecorded, unstipulated performance. Analysis for the lack of precise attacks is probable, but many attacks on software are often exposed after software has been launched, meaning that analysis or testing at production cannot read them. This means that software should normally collect repeated updates over the duration of its lifecycle, and a lot of these software updates will be security-critical. The normal lifespan of a car on the highway nowadays is around 15 years, longer than the supported lifespan of several functional systems. In automotive evolution, re-use is customary. The majority of the software and hardware systems, including a new vehicle, are not themselves original (Bryans, 2017).

The above mentioned features focus on the statement that a car is a combination of old and new structures. Software updates must be sensible of these legacy systems for the generation of the car. How will manufacturers afford software support for their cars? At present, car dealerships are at the forefront for vehicle support and this might include software maintenance, with manufacturers needing vehicles to be taken into the

dealerships to obtain software updates (Bryans, 2017). This result is insufficient, as it puts a huge and undesirable load on customers, and dealers are not fundamentally best positioned to meet technical matters that may be raised. An additional risk is that updates are distributed from the post office on a memory stick or downloaded, and the driver is expected to perform the update. This methodology was implemented by Chrysler, following the exposure of susceptibility. They circulated a patch on their webpage (Greenberg, 2015) and later updates were transported by post on a memory stick, with the customer expected to complete the update.

Yet again, this puts a huge obligation on customers. It similarly opens possible attack incidents: if memory sticks are interrupted, they could be loaded with malware encryption, and imitation memory sticks could be circulated by hackers. It seems improbable that this system will attest common with automotive businesses. In the long run, it appears that the only solution is to supply software patches ‘over the air’, the same way that we receive software updates onto our mobile phones and computer hardware. The over-the-air methodology, established by TESLA, is used frequently to advance the security and safety of their automobiles. These present regulatory difficulties: the type of proof for compliance to regulatory requests will vary, and if numerous updates are distributed, the licensed version of a vehicle could considerably differ from the one fitted and already on the road.

Lately, academics have established that vehicles are vulnerable to a wide range of cyberattacks (Checkoway et al., 2011), including a study where a cellular link was hacked and control of critical vehicle features (steering and braking) was taken over while the car was in motion (Miller and Valasek, 2015). This occurrence, which increased the level of attention in security within the automotive manufacturing, was very likely after numerous months of complete entry to the car, during the period this attack was constructed. However, this attack validates advancement headed for a troubling prospect for vehicles. If, as it appears possible, the security setting follows a similar configuration as for computer equipment, these forms of attacks will be seen as a way to generate revenue: they will be created and sold in the same manner that

systematic attacks are. The vulnerability of vehicles to these attacks is partially due to the type of interior vehicle systems (Bryans, 2017).

The most corporate system practice (Controller Area Network or CAN) is a multi-controlling transmission system, meaning that all mechanisms associated with it can connect on it, and all transmitted messages are received by all the equipment. CAN has no message verification, so when a component is under attack, it can convey random messages easily (Bryans, 2017). In the long term, it looks like CAN will be substituted by a practice more suitable for the purpose in the associated era, but in the interim, work focuses on protecting the CAN from outside attacks, indicating that OEMs are expected to form major corporations with software companies and telecoms businesses who by now have the type of expertise that is required here. In this situation, it is fascinating to highlight that less than 10% of the new contracts forecasted by Leech et al. (2015) are in automotive manufacturing and many are in other segments.

2.15 The relationship between IoT and IoAT

Universal connectivity and inexpensive computing influence have led to the quick development of the IoT. Internet related things are capable of collecting and exchanging information via rooted sensors, and the possibility of the IoT comes from this information gathering, along with the low-cost cloud storage and method that could be used to add substance to composed data. The IoT, along with proposing great future, is massive. In 2015, an estimation by technology examination company Gartner recommended that these ‘things’ would account for 6.4 billion worldwide by 2016 (Gartner Inc. 2015). Many of the presented descriptions of the IoT are broad as to accommodate ‘vehicles’ within the space of ‘things’. However, for the purpose of this report, a subsection of the IoT is discussed entitled here the IoAT (Bryans, 2017). This comprises the following:

- Vehicles connected together with the on-board systems of sensors and computer devices;

- Automotive appeal: Both the built-in ones as delivered by OEMs and the operator installed ones as delivered by third-parties, along with the backup systems to handle it;
- Gadgets connected to vehicles: whether tangibly, such as the ‘dongles’ that are plugged into the OBD-II port and permit drivers to display interior vehicle network communications, or wirelessly, for example, smartphones on Bluetooth networks;
- Systems and the permitting technology of Intelligent Transportation devices, as well as the roadside infrastructure;
- Backup systems: service agents will have accompanying backup systems to handle the necessary calculation and storage for the facilities they offer; and
- V2V and V2I networks: incorporated here are vehicle-to-vehicle (V2V) and vehicle-to infrastructure (V2I) connection, along with communications with in-cabin appliances.

Similar to the IoT, IoAT is a penetrable system. Penetrable, or accessible, networks are not different, and The Open Group has established overall design principles and strategies when dealing with security in such systems (Open Group 2007). These, although valuable, would need to be customised in order to be appropriate to the automotive manufacturing. The penetrable nature of the IoAT border turn out to be more important when we reflect that the IoAT contains the connected portion of the Transport Infrastructure. In the UK, transport is selected as Critical National Infrastructure, meaning that it comprises physical or electronic resources that are ‘important to the constant delivery and reliability of the critical services upon which the UK trusts, the harm or confrontation of which would lead to extreme economic or social concerns even loss of life’ (Böhme et al., 2014). Adapting this transportation infrastructure that is internet-enabled, evidently offers substantial rewards, for example the capability to centrally observe and regulate traffic on UK highways and investigation projects like the UK-CITE (RCUK, 2016) are increasing investigational infrastructure mainly to observe and regulate autonomous vehicles. On the other hand, IoT devices have particularly low points of security – for example, IoT policies used in October 2016 to promote a huge circulated rejection of service attack on servers that administered major internet Domain

Name System infrastructure (Woolf, 2016). This attack abused the point that devices were transported with default PINs provided in openly available online handbooks.

The IoAT as a result contains enormous, multifaceted vehicles and infrastructure basics shaped in a culture of rules and obligation and which are safety- and security serious, besides cheap, one-use electronic devices that are free and man-made to low standards, and that signify a penetrable network border offering many ways for somebody with hateful intent to have access to the IoAT (Bryans, 2017). Certain groups in the EU, U.S. and Japan are employed to explore standardisation procedures for V2V/V2I infrastructures, in several cases building upon basic options of 802.11 principles for wireless networking. Areas of conflict have been recognised, and determinations at management of these standards are also proceeding.

On the other hand, the IoAT is also experiencing continuous change, for example, third-party in-cabin systems can be connected to and disconnected from cars, and V2V and V2I connections are continuously opening and closing. But then, more significantly, it is also accurate that the IoAT is developing over longer periods, as new devices and applications aimed at vehicles are advanced, and as the transport network is established and improved to handle autonomous vehicles. The collection of probable attacks is then progressing over time, and vehicle manufacturers should take this into consideration when cars are designed. It is important to highlight that the IoAT is a technique with equally safety-critical and security-critical features. In addition, the IoAT, with its relations to customer equipment and the setup of the transportation linkage, is a difficult yet powerful system, together in a physical and a virtual logic. These very interdependent structures are a symbol of today's powerfully connected, universal networks and contain systems like information and communication networks, electrical power networks and financial or monetary markets (Bryans, 2017).

Helbing (2013) debates that their very intricacy, and the connections and strengthening effects to which they are vulnerable, can prompt network cascade properties and make the systems essentially insecure in a manner that is not yet entirely understood.

Helbing's emphasis is on the decrease of the danger built into these systems. It can also be argued that conceding the security of the IoAT may be an introduction to a calculated outbreak on safety, and that a minor outside blow to a system may effect an early worry that then alarms a composite chain of communications, leading to a disaster. The safety-critical environment of the IoAT makes it an appealing target and it is not sufficient to leave these calculated or pouring threats as the obligation of a specific automotive manufacturers and the insurance business.

Discovering the overview of these philosophies within the automotive industry would need close and long-term collaboration between all shareholders. IoAT weaknesses likewise exist around autonomy. These might be intense: the year 2014, the FBI cautioned that driverless vehicles can be used as deadly weapons (Harris, 2014) and lately, there have been stories of terrorists making autonomous vehicles for precisely that same purpose (Bigelow, 2016). More probable, however, when we study the reasons behind mismanagement of the IoAT, illegal activities will centre on making extra money. Evidently, the cars themselves are likely to be an appealing object for thieves. Innovative technology often delivers new prospects for offenders, in addition to providing a means for conflicting threats. Electrical 'key-cutting' equipment is accessible for buying freely on the internet (Bridge, 2016) and discussions with UK police officers have established that several high-value cars are being taken, without a trace of damage on those found. Though, the launch of the immobiliser technology, inhibiting cars from starting without the key, intensely decreased theft, mainly 'joy-riding' (Morgan et al., 2016). Lately, immobilisers themselves have been the theme of educational interest, and the four main transponder chips used in the business have been exposed to be uncertain (Garcia et al., 2016), signifying that the design needs to be re-visited.

The confidentiality of people is also a part of increasing worry for automotive manufacturers. Nowadays, vehicles collect extensive information about car drivers, and these data can be used as the basis for a whole variety of value-added services that companies and others could propose. This Personally Identifiable Information (PII) is the objective of the 2016 EU General Data Protection Regulation, which from 2018

onwards, will implement procedures about permission to use information and the right to be overlooked. Recording of data confidentiality breaches will become compulsory and data managers will be expected to inform a specialist of any breach of PII of EU citizens. Businesses which desire to store PII will require guidelines in place, concerning copy, handling, storing and erasing this information.

In some circumstances, information anonymisation can be seen as a 'get-out clause', permitting the company to source value from consumer information without exposing the loss of PII, but this method should be treated carefully, since systems to remove recognisable information from anonymised data have been verified (Narayanan and Shmatikov, 2008). However, the absolute weight of data that vehicles gather reduces users susceptible to breaches of confidentiality. Even data that is present for completely genuine purposes can be used to categorise people: Enev et al. (2016) explain how the information from the internal vehicle network can classify people according to their driving performance. Connection of these data with data from IoT devices only increases this danger.

As the intricacy of the IoAT increases, it is possible that the activities will become progressively tough to calculate (Helbing, 2013) and hence, to standardise. This volatility, and the relationship with other complicated systems, for example, energy and communication systems, raises the prospect for cascade effects and extensive undesirable concerns from single, fairly minor, interferences. This will verify an attractive target to some people. The IoAT should as a result be considered an important benefit by nationwide security policy.

2.16 Implications for policy

The automotive manufacturing is on the forefront of the fight to warrant the cybersecurity of cars and the IoAT. Usually, vehicle companies have been reluctant to team up and interchange statistics on cybersecurity, even though there is now an acknowledgment that this needs to change. This is recognised by the Automotive Information Sharing and Analysis Center (Wenzel, 2017), established at the request of

the U.S. National Highway Traffic Safety Administration (NHTSA) in July of 2015. Its direction is to improve the cybersecurity standpoint of the business, and it affords a setting for manufacturers to interact and share threat intelligence and finest practice and to describe cyber events. Some stages towards a comparable European body have now been explored.

The EU Command on security of web and information systems (EU, 2016a) seeks the lawful base for reporting violation of cybersecurity in transportation, in addition to other businesses and in 2018 reporting, violation of data confidentiality will become compulsory, according to the 2016 EU Global Data Protection Regulation (EU 2016b). Reporting cybersecurity violation is the chance to learn from them and here, there are morals to be learned from other transportation businesses. In aviation and rail, safety occurrences are seen as chances to advance the safety of the endangered systems. In the rail manufacturing, for instance, the Rail Accident Investigation Branch is set up to study rail misfortunes in a blame-free way, to pinpoint reasons for accidents and to make references to expand the forthcoming safety of the railway. The Air Accident Investigation Branch performs a comparable part for the aviation manufacturing. A related figure for road transportation, with relations to reference that contains the study of cybersecurity violation as well as safety disasters, and to make cybersecurity significant references, would be ideal. Likewise, the overview of new ideas around autonomous and connected cars justifies the public debate that such a body could inspire. Stilgoe (2017) examines the latest crash and the following research by the National Highways and Transport Safety Agency. In the event deliberated, an extremely advanced car with a feature defined by the manufacturers as an ‘autopilot’ collided while being driven by the autopilot. The analysis established that the (human) driver was liable, because the owner’s manual specified that the driver should continue to take note even when autopilot was activated. But, it measured only the technical mechanisms of the vehicle, and the connection between the motorist and the machine. Stilgoe (2017) claims that this statement meant that the occasion afforded by the crash for a public examination of a new technology was overlooked.

Undoubtedly, this was a safety matter instead of a cybersecurity one, but examinations of cybersecurity events should be administered in a public setting, as much as possible. A tough cybersecurity philosophy needs to be established within the automotive manufacturing. Security limitations and requirements include all parts of the vehicle design development, from planning through to ultimate testing (Bryans, 2017). It is commonly expected that security is most upgraded if it is measured at all phases of the project progression. This method (known as security-by design) lets the security inferences of results to be recognised and handled as early as possible, when the fullest variety of results is presented. This is roughly what the majority of companies are interested in doing, and OEMs already have demanding research and development practices set towards safety criteria, for instance, the automotive safety standard ISO26262 (ISO 2011), which regulates values and procedures for practical safety. It has not been verified what a corresponding security standard would be like, let alone how the two methods should be combined. SAE International offered some assistance in this regard by supplying standard J3061, a suggested preparation document providing direction on vehicle cybersecurity (SAE International 2016). However, there is much more effort that needs to be placed in this space.

This is a fast-changing area and any strategy reaction needs to use a flexible attitude. UK Auto-drive, an Innovate UK research project, lately issued policy references for autonomous cars (Gowling, 2016). Their article concentrated on the ethical matters highlighted by autonomous cars and specifically, how to reunite ethical standards with the individual self-interest of their customers. They suggested the design of a flexible and receptive lawful framework that permitted any ethical choices raised to be determined by an organisation similar to the Human Fertilisation and Embryology Authority. In the fast-changing automotive security environment, where new trials and dangers are continuously evolving and such a flexible approach will be mandatory. Regulation could also highlight roadside technology and assess its relevance to be part of the IoAT. Meeting at least a minimum security guideline could be a condition on businesses bidding for contracts, in addition to an obligation of the devices. Standardisation overall has to be treated with caution, but, since standardisation on

technologies can mean that cars have a shared set of errors, as well as strengths. This standardisation can automatically give rise to ‘single points of failure’ within systems, making them even more exposed than need be to unintended shocks, as well as harmful attacks. Best practices for security are continuously changing and standardising too early will only diminish innovation.

2.17 Chapter summary

In the direction to place South Africa on a higher, job-rich growing footpath and allow us to participate and prosper as an advanced destination in the universal economy, the manufacturing industry needs to be developed to sustain accurate regulation of products, as it evolves over the changing life phases. Engineering in supply chain restructures the movement of multi-disciplinary data around services, products and associated processes during a thorough lifecycle, to confirm that the accurate information is accessible in the right setting and at the right stage.

Through the product, the industry setting and the supply chain quickly growing in intricacy, decent systems engineering control is significantly vital to distribute products which fulfil consumer expectations. The study places engineering as an enabler, by authorising the discipline and spreading the practices to all product lifecycle stages and through the supply chain. Regardless of varied products in industries, by merely recognising the profits of engineering within a business that needs development, it can be understood that a need exists, aimed at engineering in South Africa. Following the literature review, a set of research questions and hypotheses were developed to be tested and analysed in the chapter that follows.

CHAPTER THREE

Research Methodology

3.1 Introduction

The research questions established in the previous chapter will be answered by relating a research methodology that is examined and put into perspective, in this chapter. This highlights the objectives of the research and its studied variables. The motivation behind selecting the location of the research, as well as the appropriate participants, is also reviewed. The research instrument and data collection approach are discussed in terms of the development and steps followed. In addition, this chapter explores the basic motivation for formulating the structure of the research instrument and will review the statistical methods used in studying the status of E-supply chain management systems variables.

3.2 Aim of the study

This study is aimed at assessing the level of awareness of modern strategies practiced globally, as well as to recommend counter-measures to strengthen the competitive advantage of the businesses in South Africa. Likewise to determine if the businesses view these philosophies as a way of refining their business models and determine if the application of these philosophies is consistent within the different manufacturing plants across South Africa.

3.3 Participants and location of the Study

The study was conducted in South Africa with special attention to automotive industry. The area was selected on the basis of understanding and awareness of industry technology enhancements being explored by other countries.

3.3.1 Survey Population

Welman, et al (2001:189) proclaim that when choosing a target group, first choice is given to significant informers who, on description of their experience and positions, have added material than regular participants and /or are capable to read the information. For that reason, the individuals who are specialists, engineers and managers are responsible for either ordering of material, planning of processes, vehicle distribution, logistics systems or transportation. They are entrusted with the responsibility of implementing the manufacturing industry's research and development ideas for the firms which form part of the original equipment manufacturers that will be studied: Toyota, BMW and Nissan.

The study employed the quantitative research method because the information can be sent to a sample population that is dispersed over a wide geographical and they can be answered by respondents at their own convenience.

The population size was made up of logistics departments from 3 major companies namely Toyota, BMW and Nissan. Toyota is made up of 45 members, Nissan has 5 members and BMW consists of 10 members.

3.3.2 Sample Size

The sample size required for the survey was estimated by using the Cochran's sample size formula which calculates an ideal sample size given a desired level of accuracy, desired confidence level, and the projected percentage of the quality present in the population.

The calculated sample size by using the Cochran's sample size formula for a survey of 5 points scale, alpha of 0.1, and population size of 60 and margin error of 5% is 52. The study thus included all 60 participants.

3.4 Research design and methods

3.4.1 Description and purpose

Leedy (1997) explains a research design as an idea for a study, providing the complete background for data collection. MacMillan and Schumacher (2001) describe it as a design for choosing topics, research places and data collection measures to answer the research question(s). They continue to specify that the aim of a complete research design is to deliver outcomes that are judged to be reliable. For Blanche et al. (2006), study design is a calculated structure for action that functions as a link between research questions and the implementation, or application of the research approach.

Schwandt (2014) describes research methodology as a concept of how an analysis should advance. It includes a study of the assumptions, ideologies and processes in a certain approach to analysis. According to Schwandt (2014), Creswell and Tashakkori (2007), as well asTeddlie and Tashakkori (2003) practices, clarify and outline the types of difficulties that are worth examining; what establishes a research worthy problem; provable hypothesis; how to structure an investigation in a way that it can be examined using specific strategies and actions; as well as how to choose and advance applicable ways of data collection.

Diverse research methods can be commonly classified into two options which are qualitative and quantitative research techniques or the grouping of the two.

Quantitative research method, stated by Van der Merwe (1996), is a research method intended at testing models, defining truths, validating relations between variables and calculating results. Quantitative research applies systems from the natural disciplines that are intended to verify fairness, simplification and consistency (Weinreich, 2009). The systems used in quantitative research contain non-specific selection of research applicants from the study population in a neutral way, the consistent questionnaire or

involvement they receive, and the numerical approaches used to examine pre-determined notions concerning the association between certain variables.

The researcher adopted a deductive reasoning method to draw results and also to determine the degree to which E-Supply Chain Management Systems have been adopted in the automotive manufacturing businesses in South Africa.

3.5 Data collection strategies

The process of gathering evidence or information can be done in two methods, namely primary and secondary data groups. Secondary information can be found through published sources such as books, academic literature, for example journals and virtual resources.

Primary information can be used in combination with secondary data or as an addition, if secondary data is lacking in contributing towards the study objectives. Sekaran and Bougie (2010:180) present that the most common study mechanism used to gather primary data is a survey or questionnaire, which is used by a researcher to gather variables crucial for the study. The type of study instrument used in this research was the self-administered questionnaire sent online. A total amount of 60 questionnaire was distributed and 60 replies were achieved. The distribution method was selected for the intent of explaining any reservations that the respondent could have and for the researcher to inspire faster replies per person.

The respondents were educated, based on the reasons behind their participation and the research objectives. This was done to ensure focus on the fundamental aim of the research, which highlighted accurate assessment of the existing E-Supply Chain Management Systems practices from individual standpoints.

3.5.1 Construction of the research instrument

A quantitative study method was used to plan the study instrument. Maharaj et al. (2009) claim that the benefit of a questionnaire-based research method is that it includes consistent questions, which gives the opportunity for constant analysis of questions by participants. A questionnaire similarly offers an effective way for information gathering and can be circulated to a bigger sample size, different from other approaches, for instance, interviews.

As stated by Maharaj et al. (2009) surveys could be used for exploratory or descriptive investigation. Maharaj et al. (2009) define an exploratory research as an analysis that qualifies an explanation and examination of interactions among variables, mainly cause-and-effect interactions. Sekaran and Bougie (2010) supplement this concept by stating that when little is known about the current status, or there is no obtainable material on how comparable matters were handled in the previous years, then exploratory investigations may be carried out. Descriptive investigations are undertaken to research the characteristics of companies that follow common practices or procedures (Sekaran and Bougie, 2010).

Based on this statements above a research instrument was established and managed in three companies in an automotive manufacturing industry to evaluate and quantify the degree of E-SCM system application, as well the assessment of the significance of these principles in accomplishing quality results. The research instrument was verified for reliability and validity, and was deemed appropriate in research to establish the level of E-SCM application in a manufacturing setting.

3.5.1.1 Structure of the questionnaires

The survey used in the research had one broad section to be answered, which began by assessing the participants' theoretical understanding of E-Supply Chain Management Systems and their view of its application in the business. The primary

concepts of E-Supply Chain Management Systems namely quality, information, communication, cost, sales, usability and access were established by presenting five options for participants to select the answer that conveyed their feelings most precisely, about the statement made. The research instrument had a 5-point Likert scale with closed-ended questions, the neutral choice being halfway the agreeing and disagreeing selections (Saade and Valverde, 2013). This was done to assist participants who chose not to comment on a specific question or participants who were merely not certain of their response. The questionnaire included two sections:

Section 1: This section dealt with the demographic information of the companies based in South Africa and the respondents. This was linked to the fraction of employees exposed to the systems on a daily basis, whether directly to produce reports or manage variations, or indirectly to see how the company is performing.

Section 2: This section began by an open-ended question to evaluate the respondents' theoretical understanding of E-Supply Chain Management Systems and then questioned the degree of E-Supply Chain Management Systems practices within the business.

Each one of the E-Supply Chain Management Systems principles had a set of questions to be responded to, which were adopted from several of E-Supply Chain Management Systems academics such Heinrich and Betts (2003), Hua and Cong (2011), and Valverde and Saadé (2015).

3.5.2 Recruitment of study respondents

The respondents were first nominated through inquiries with the companies and a judgement was made that the position held by the respondents was well within the requirements for participating in the survey; meaning that all respondents were, in one way or another, occupying positions associated to the supply chain business

applications of their respective firms for example vehicle distribution, ordering management, internal and external logistics planning, production planning and TLMS route planning are responsible for the controlling of parts and the logistics. The respondents were given a self-administered questionnaire sent online to complete and return to the surveyor.

3.5.3 Pretesting and validation

The research variables are imperative to ensure that they are operational and can be measured in a study which involves an instrument that can certainly measure them precisely. Hence, the reliability testing highlighting how accurately an evaluating instrument determines the variables that are to be assessed by the researcher. Steadiness in the result attained therefore demonstrates the consistency of the instrument employed in the research (Sekaran and Bougie, 2010). The current investigation can be considered as reliable if the collected data give the identical marks when the study is reiterated. The inner reliability of a questionnaire is determined by Cronbach's alpha, which is also significant for the removal of the distinct elements (Abusa, 2011). Abusa (2011) expresses that reliability coefficients of 0.70 or more are acceptable.

The Cronbach alpha coefficient was used to quantify the internal reliability and the measuring instrument. The Cronbach alpha coefficient for all the sections which were completed by all the respondents ($n = 60$), is 0.932.

Note: For the questionnaire to be valid and reliable, the Cronbach alpha coefficients should be above 0.70 (Gwet, 2012).

3.5.4 Administration of the questionnaire

This particular valuation was emailed to 60 employees working for South African companies and then followed up by email notices for completion. An association joined by this companies (NAAMSA) was contacted to gain access to the contact details so as to ask permission from the company management. General Managers were requested

to grant permission in order for the employees to participate in the research. Ultimately a total of 60 questionnaires were administered over a period of around 3 months. The 60 replies were examined using descriptive statistics.

3.6 Data Analysis method

The information was examined in line with the objectives of the research. Descriptive information involved the examination in relation to group mean scores, frequencies and group standard deviation score. Descriptive data were also visualised using bar graphs and pie charts, in addition to summary tables. Methods of significant tendency (mean), tables, dispersion quantities, graphs and charts are adequate to define, establish, review and visualise raw information (Curwin and Slater, 2008).

The primary objective of the study was to define the effect of engineering in supply chain management systems by identifying the methods which can be applied to accomplish world class performance, identify a model to encourage awareness and identify a system which can decrease wide-ranging costs of company. As a result, the survey was examined using descriptive figures. The Statistical Package for the Social Sciences (SSPS) version 17.0 was explored as a practice to study quantitative data collected.

The group mean scores, group standard deviation score and percentages were used to study the information and evaluate the level of technology that impacts positively on supply chain management. Once more, the complete assessment of engineering effects in supply chain management systems was studied and examined in terms of each group element or combined scores, to conclude which element had the highest level of impact positively, and which had the lowest.

The secondary objective was an approach which can be applied to improve quality and services. Descriptive statistics was also used to classify the subjects that had bottom scores. These were items and elements which respondents were displeased with and shown failure. ‘Strongly agree’ denoted high impact, with ‘strongly disagree’ indicating low impact points. The element with the lowest total would be considered as a

shortcoming and requires more awareness and development. Analysing respondent's comments logically was important in order for thorough conclusions and applicable references to be made.

3.7. Ethical considerations

Research ethics process was followed throughout the analysis process and the element that participants are allowed to withdraw from the study at any time without any negative or unwanted penalties to themselves was emphasised. An informed consent form was given to the participants to read and keep throughout the survey process. The form highlighted that this process is purely voluntary, members can refuse to participate or withdraw from the project at any time with no negative consequence and confidentiality and anonymity of records identifying any of members is prohibited.

3.8 Chapter summary

This chapter looked at the methods used to gather and analyse the data. As part of data investigation, a process of scaling questions was created by quantifying questions to ensure that participants score the factors such as electronic supply chain effectiveness and electronic supply chain impact to supply chain. This process ensured that the findings are measurable. Once the questionnaire was sent out and considerable response rate was achieved, data were collected and analysed using a statistical analysis tool Statistical Package for the Social Sciences (SPSS). Statistical practices to be used in the next chapter were studied and presented. The outcomes from the investigation is discussed in Chapter 4.

CHAPTER FOUR

Presentation of Results

4.1 Introduction

This chapter describes the results from the statistics acquired through the questionnaire circulated to respondents. The different statistical examination tools used to respond to the research questions will be deliberated on. The questionnaire was distributed to 60 people and all of them responded and returned, demonstrating a response rate of a 100%. The data collected through the survey comprised demographic evidence about the partaking respondents and the degree to which the respondents knew about E-Supply Chain Management Systems and its application in the business. The full breakdown of the results obtained from the survey is discussed in this chapter.

4.2 Analysis of data

The research was conducted to uncover the extent to which these leaders knew about E-Supply Chain Management System principles and its application in their respective companies. The survey also attempted to grasp the fundamental basics that were critical in the operational execution of the system.

1. The survey response rate was 100%, with a targeted number of 60 participants who all responded to the survey.

2. The demographics of respondents by company: (86.7%) of the respondents was from Toyota, 8.3% from Nissan and 5.0% from BMW, as shown by Figure 4.1.

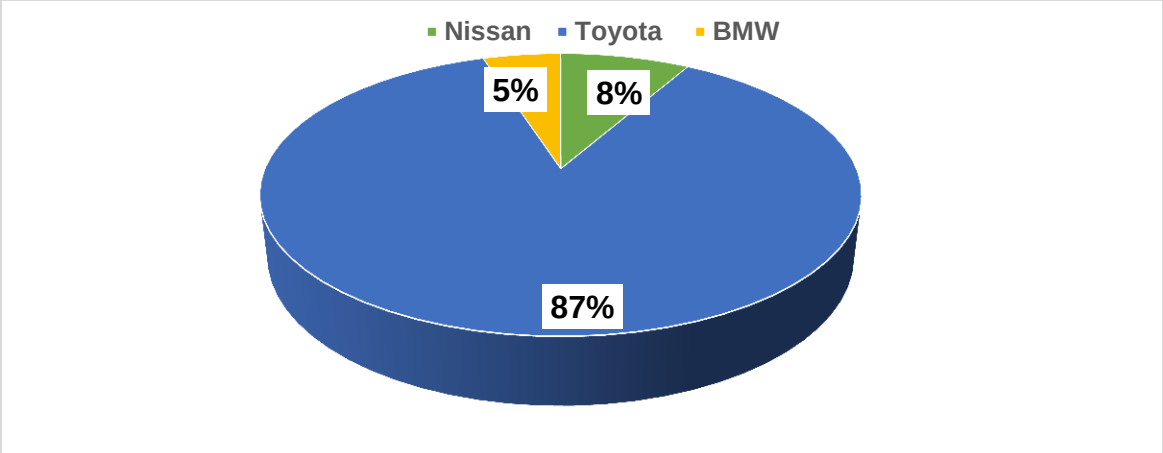

Figure 4.1: Distribution of respondents per company

4.2.1 Respondents by Department

A summary of the respondents' demographic elements, which include company and department, is indicated in Table 4.1.

Table 4.1: Profiles of the respondents

Demographic variable	Sub-category	Total	
		n	%
Company	Nissan	5	8.3
	Toyota	52	86.7
	BMW	3	5.0
Department	Logistic systems	5	8.3
	Internal logistic planning	11	18.3
	TLMS route planning	1	1.7
	Import parts ordering	12	20.0
	External logistic planning	4	6.7
	Production planning	9	15.0
	Vehicle distribution	9	15.0
	Order management	9	15.0

The group that dominated in terms of participation was the import parts ordering, with 20% answering the questionnaire. Internal logistics planning came second highest, with

18.3%. this was closely followed by production planning, vehicle distribution and order management, all at 15% participation rate.

4.3 E-Supply Chain Management System principles adoption

The following tables and graphs define how the respondents viewed the real application of the five E-SCM principles in the automotive manufacturing industry.

4.3.1 E-SCM impact on SCM

Table 4.2: Descriptive statistics for E-SCM impact on SCM

Questionnaire item	Respondent's responses (%)				
	Weak	Low	Medium	Considerable	Strong
Efficiency in flow of information and documents	1.7	6.7	18.3	45.0	28.3
Reduced costs in preparation of documents	1.7	10.0	23.3	36.7	28.3
Productivity increases in sales/total assets ratio	0.0	5.0	25.0	45.0	25.0
Increases in sale/employee ratio	0.0	10.0	30.0	40.0	20.0

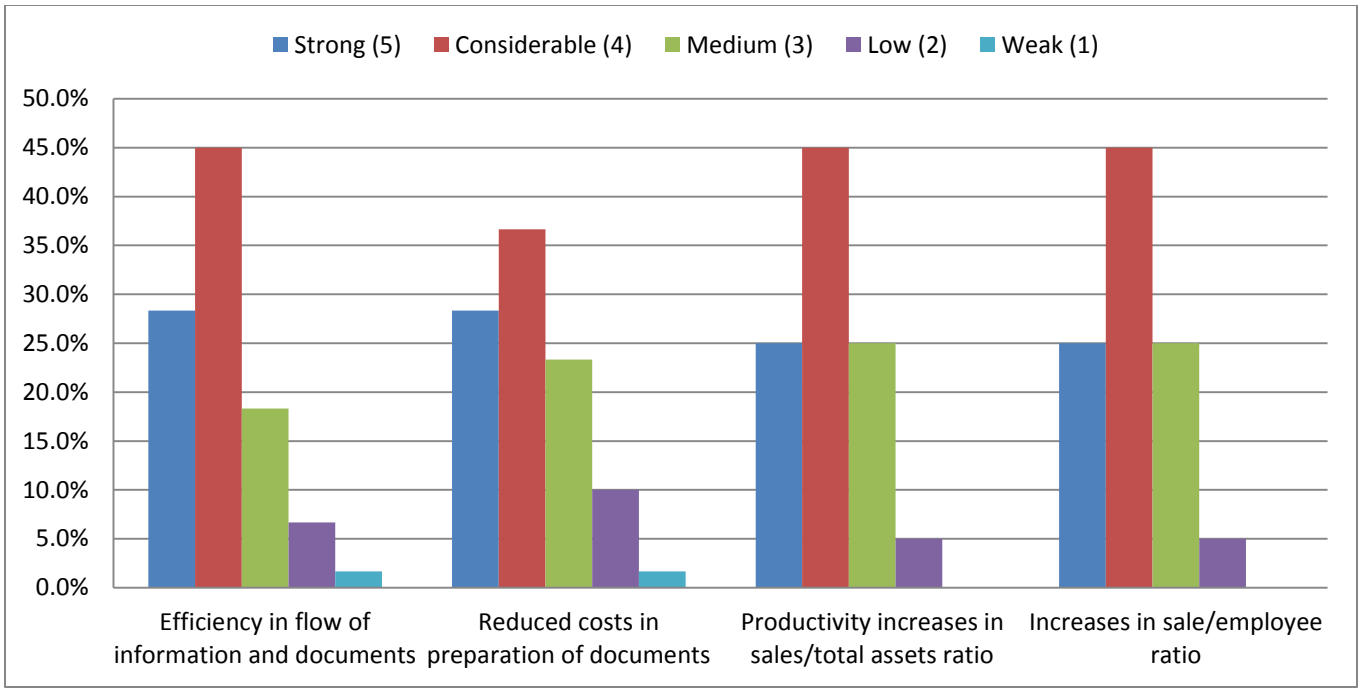

Figure 4.2: Descriptive statistics for E-SCM impact on SCM

In the first set of Table 4.2 and Figure 4.2, questions were organised in order to describe the level of influence of e-SCM on the productivity, efficiency and cost of method in the automotive manufacturing. The question asking about the efficiency of information flow proposed to measure the outcome of e-SCM in the circulation of the information in the SCM. The reduction in cost of document preparation question was used to measure the result of e-SCM in the cost saving due to paperless processes. Productivity question was aimed at measuring the effect of e-SCM on the industry. Lastly, the final question expected to measure the result of e-SCM in the efficiency of the industry, according to sales for workers used. The responses showed mixed reactions among the participants, with the highest percentage (45%) of the respondents considering e-SCM as being a technology that positively impacts on the management of supply chain. This was followed by 30% of the respondents who believed the system was neither strong nor weak in the properties it supplies to ensure good management. In addition, 28.3% of the people responded that the system's impact is very strong, allowing for improved productivity, reduced costs and efficient processes.

4.3.2 E-SCM effectiveness

Table 4.3 Descriptive statistics for E-SCM effectiveness

Questionnaire item	Respondent's responses (%)				
	Weak	Low	Medium	Considerable	Strong
Reduced lead time to customer	0.0	3.3	18.3	36.7	41.7
Reduced stock out of finished products	1.7	1.7	31.7	35.0	30.0
Reduced inventory carrying costs	1.7	6.7	25.0	33.3	33.3
Reduced stock outs of production materials	0.0	1.7	28.3	41.7	28.3
Reduced distribution costs to customers	0.0	1.7	26.7	46.7	25.0
Reduced distribution costs from suppliers	0.0	0.0	21.7	51.7	26.7
Performance increase in income/capital ratio	1.7	3.3	33.3	41.7	20.0
Increase in return on sales	0.0	5.0	30.0	45.0	20.0
Increase revenues	0.0	10.0	18.3	51.7	20.0

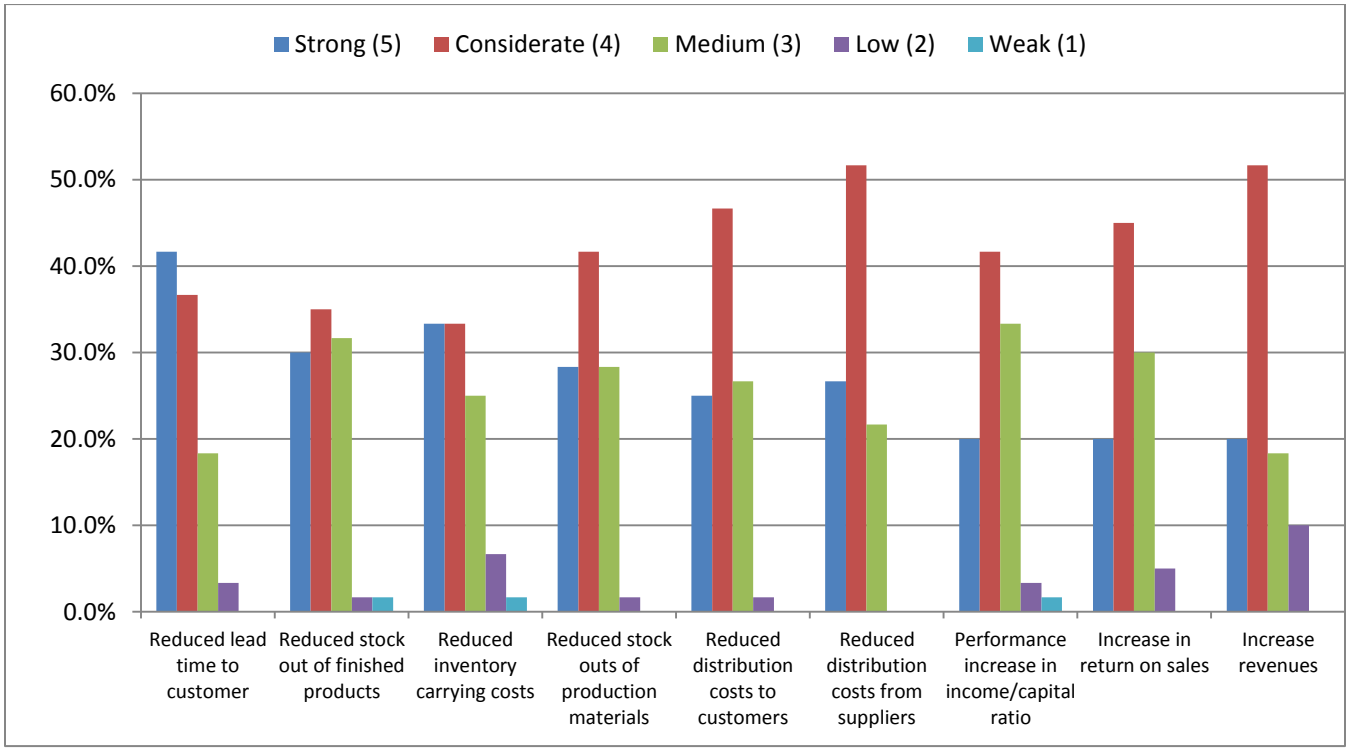

Figure 4.3: Descriptive statistics for E-SCM effectiveness

The second set of questions, Table 4.3 and Figure 4.3 were used to measure the result of e-SCM in productivity, cost and lastly, the profitability of the industry being studied in terms of the SCM responsibilities. The questions were planned to measure the decrease in lead time to consumer, stockouts, additional costs due to high inventory, stockouts of production material and reduction in distribution costs for consumers, distribution costs for suppliers and ultimately, increase in investment, sales and income. On that note, 51.7% of the respondents revealed that e-SCM contributes to the increase in revenue, while 41.7% noted that with the system in place, the reduction in lead time to customer is reduced. Others (33.3%) remained neutral in this regard.

In general terms, there is a considerable effect of the E-SCM in making SCM more efficient. Only reduced stockouts, inventory carrying costs and capital ratio of the respondents considered e-SCM as a weak contributor to the effectiveness of the SCM (1.7%). However most of them considered that it has a considerable positive effect on supply chain and it is effective.

4.3.3 Satisfaction of the E-SCM

Table 4.4: Descriptive statistics for satisfaction of the E-SCM

Questionnaire item	Respondent's responses (%)				
	Weak	Low	Medium	Considerable	Strong
Information needs internally	1.7	3.3	23.3	50.0	21.7
Information needs for transaction/interaction with suppliers	0.0	1.7	20.0	48.3	30.0
Information needs for transaction/interaction with customers	0.0	3.3	21.7	45.0	30.0
Communication needs internally	0.0	10.0	11.7	46.7	31.7
Communication needs for transacting/ interacting with suppliers	0.0	5.0	15.0	51.7	28.3
Communication needs for transacting/ interacting with customers	1.7	11.7	20.0	40.0	26.7
To what extent is e-SCM related to automotive industry	0.0	0.0	10.0	28.3	61.7

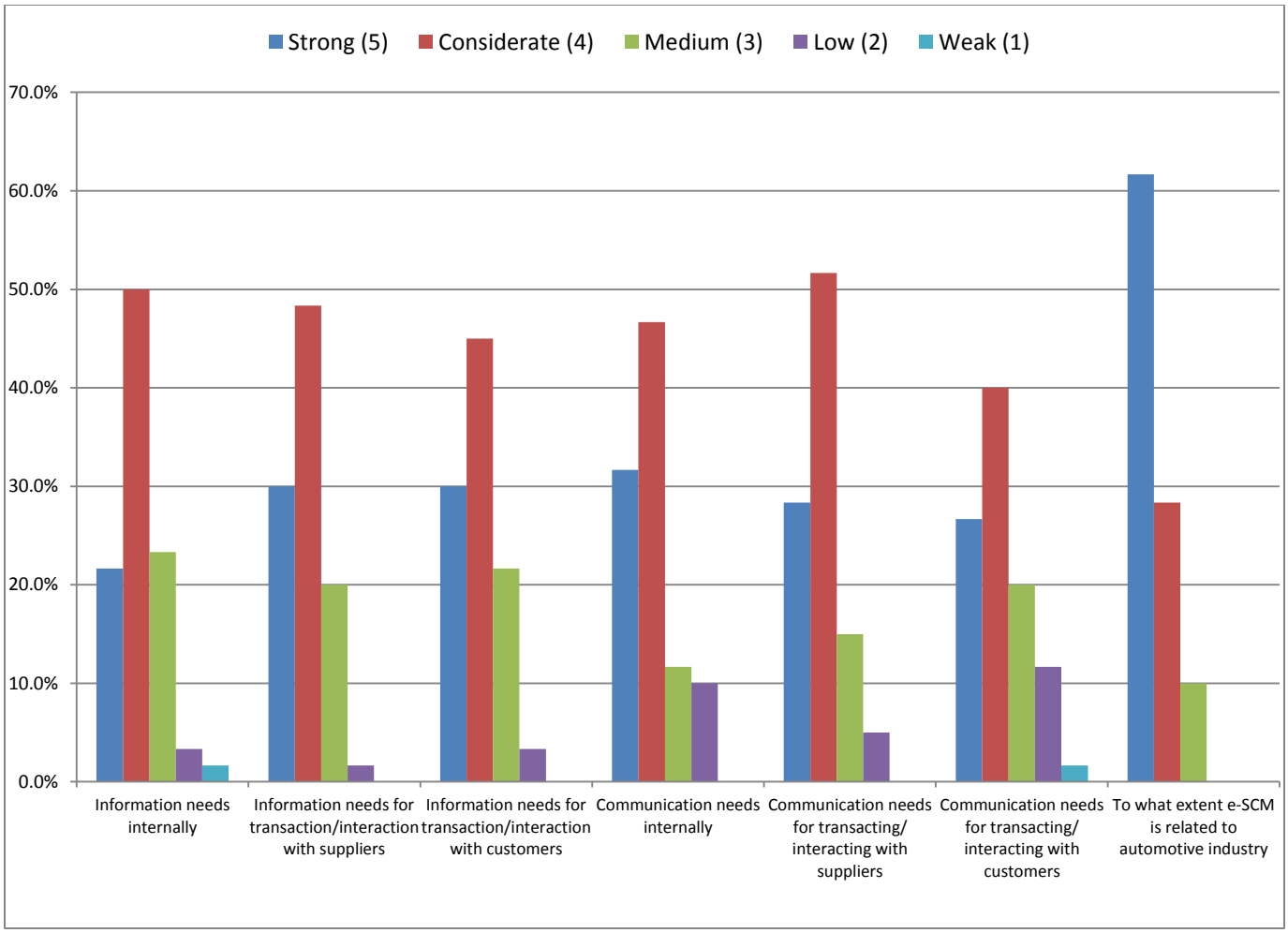

Figure 4.4: Descriptive statistics for satisfaction of the E-SCM

The third set of questions, Table 4.4 and Figure 4.4, were proposed to measure the level of approval that E-SCM effects to its operators of electronics SCM processes. The questions quantify how pleased were the operators in terms of data requests for communicating with suppliers and of a high of (51.7%) said that the communication is considerable between suppliers and operators exchanging data with them. Data needs for communicating with consumers, (45%) said the communication is considerable between operators and consumers for information sharing or updates, whether customer buying a car and checking the status on the network or internal customer who depends on the outputs of a process to begin his process.

In-house communication, (50%) of the participants believed the systems allow for the exchange of data within departments. Communications requirements for operation and collaboration with suppliers, (51.7%) believed the requirements are met. Communications wants for operation and collaboration with consumers, (40%) of the participants believed they were in close contact with the customers. Lastly, the relationship between e-SCM and the automotive manufacturing industry showed a high of (61.7%), highlighting that the members see the benefit of the E-SCM systems.

Based on the overall results, it is feasible to note that the majority of the respondents were considerably satisfied with E-SCM, even though there was a small number of respondents that had low satisfaction with the implementation of E-SCM.

4.3.4 E-SCM Quality

Table 4.5: Descriptive statistics for E-SCM quality

Questionnaire item	Respondent's responses (%)				
	Weak	Low	Medium	Considerable	Strong
Internal access convenience	0.0	5.0	21.7	45.0	28.3
Accuracy	0.0	1.7	13.7	48.3	36.7
Shorter response time	1.7	5.0	20.0	35.0	38.3
Useful function/features	1.7	6.7	16.7	41.7	33.3
Ease of learning to use	0.0	3.3	28.3	51.7	16.7
User friendliness of system	1.7	1.7	28.3	48.3	20.0
Remote access capability	1.7	20.0	28.3	36.7	13.3

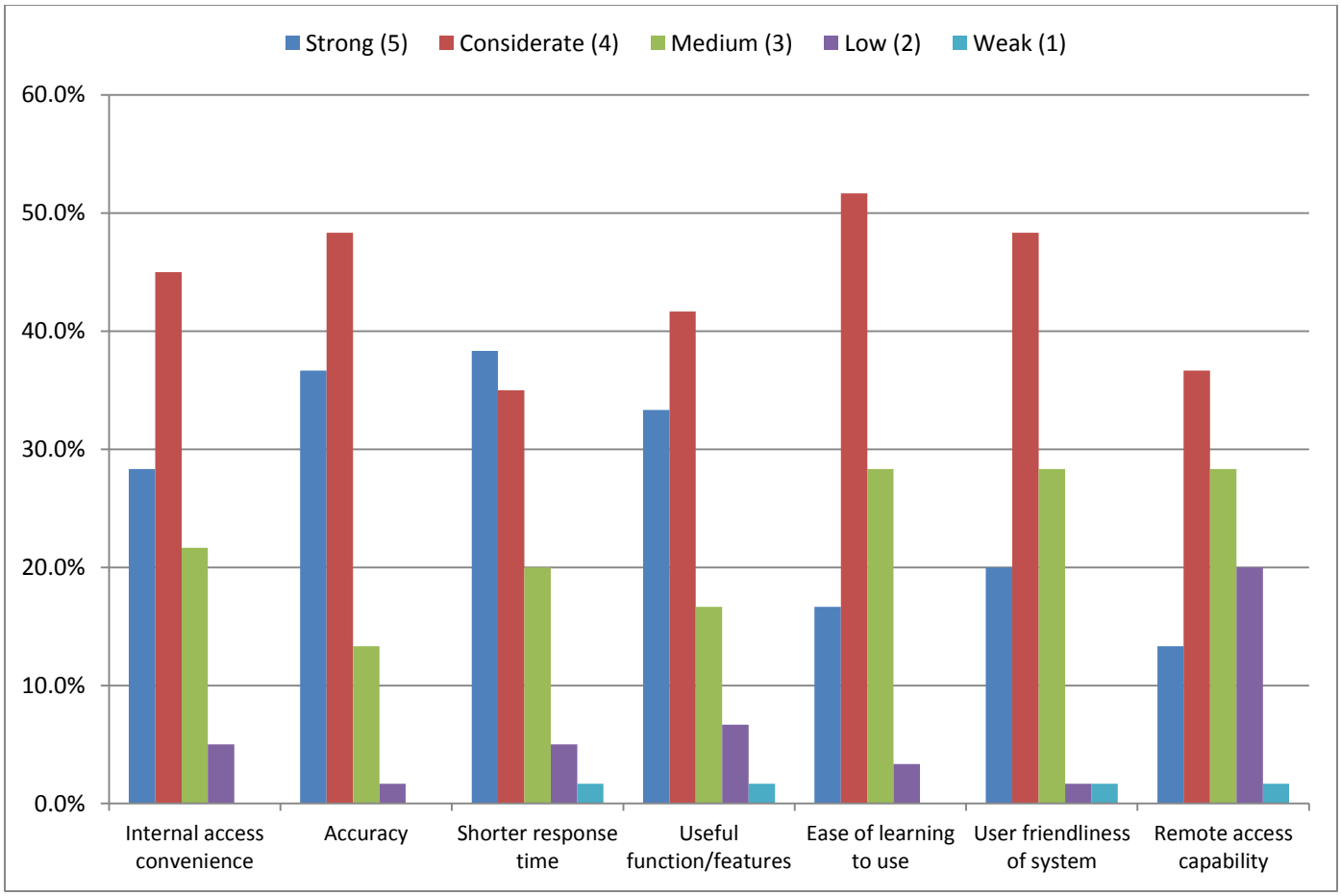

Figure 4.5: Descriptive statistics for E-SCM quality

Questions in the fourth group, Table 4.5 and Figure 4.5, were designed to quantity the quality or value of the E-SCM. The quality principles recognised in the survey were: internal access convenience with considerable high of (45 %), accuracy (48.3%), usability (41.7%), ease of learning (51.7%), user friendliness (48.3%) and response time with a strong result of (38.3%).

Most of the participants measured e-SCM as being of high quality; this validates that the existing technology for e-SCM is strong and steady enough to fulfil the quality expectation of operators.

4.3.5 E-SCM performance

Table 4.6: Descriptive statistics of E-SCM performance

Questionnaire item	Respondent's responses (%)				
	Weak	Low	Medium	Considerable	Strong
Effective intranet for internal communication	0.0	5.0	23.3	45.0	26.7
System monitors inventory and purchasing situation	1.7	3.3	25.0	55.0	15.0
Effective electronic system for product distribution	1.7	1.7	20.0	56.7	20.0
Effective electronic system for procurement	1.7	1.7	13.3	61.7	21.7
Automated transmitting and processing of data	0.0	5.0	21.7	46.7	26.7
Internet enabled system for information sharing	1.7	6.7	30.0	36.7	25.0
e-SCM system fully integrated with existing system	0.0	1.7	23.3	48.3	26.7
To what extent is e-SCM beneficial to the automotive industry	1.7	0.0	8.3	48.3	41.7
Adequate training provided for users	1.7	8.3	28.7	33.3	28.3
Extranet exists for communication to external parties	0.0	16.7	30.0	36.7	16.7

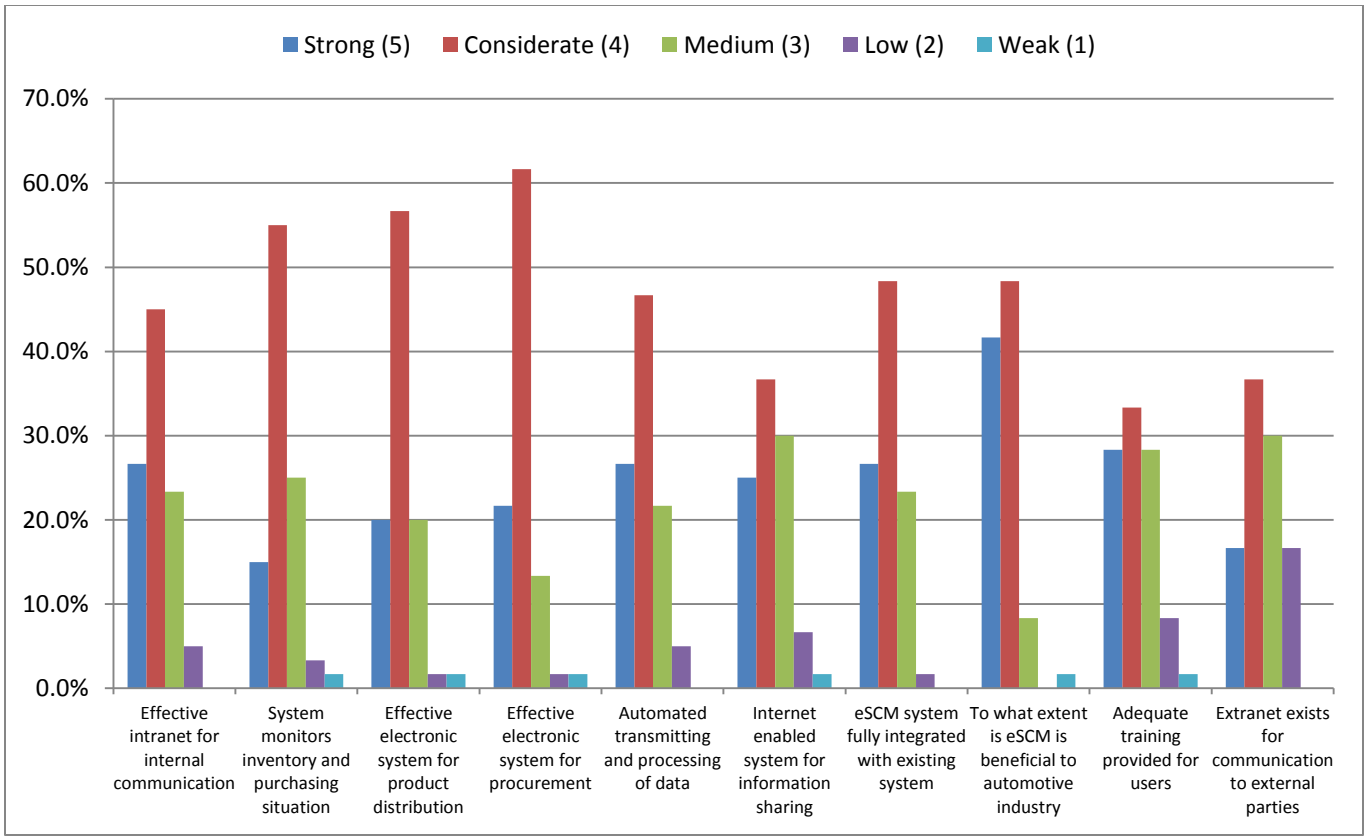

Figure 4.6: Descriptive statistics of E-SCM performance

Questions in the fifth group were designed to measure the result of the e-SCM in the effectiveness of tasks executed in processes in the automotive industry.

The variable identified to measure the efficiency of operations showed the following outcomes: internal communications (45%), inventory monitoring (55%), purchasing, procurement (61.7%), information sharing (36.7%), integration with existing systems (48.3%), training (33.3%) and communication to external parties (36.7%).

The above results disclose that most of the participants assess E-SCM as a tool that considerably simplifies the procedures of the SCM. Conversely, there were some participants who assessed e-SCM as a weak or low contributor to the simplification of processes in the SCM.

4.4 Evaluation of the highest and lowest ranked questions

Table 4.7: Five highest ranked questions

Question	Group	Mean
To what extent e-SCM is related to automotive industry	3	4.52
To what extent is e-SCM is beneficial to automotive industry	5	4.28
Reduced lead time to customer	2	4.17
Information needs for transaction/interaction with suppliers	3	4.07
Reduced distribution costs from suppliers	2	4.05

From Table 4.7, we can deduct that E-SCM has a positive impact on the automotive industry. The respondents also considered that e-SCM has a considerable impact and in the long run, the industry benefits due to the robustness of the system. This type of system allows for businesses to reduce the lead time to customers, ensuring that customers receive their orders as quickly as possible. This is achieved by constantly sharing information with suppliers to make sure they are aware of the orders which then allows them to plan how to distribute only the required quantities to prevent unnecessary travelling and incur preventable cost.

Table 4.8: Five lowest ranked questions

Question	Group	Mean
Remote access capability	4	3.40
Extranet exists for communication to external parties	5	3.53
Performance increase in income/capital ratio	2	3.75
Internet enabled system for information sharing	5	3.77
Communication needs for transacting/ interacting with customers	3	3.78
System monitors inventory and purchasing situation	5	
Adequate training provided for users	5	

In Table 4.8 are the five questions with the lowest means, meaning these five questions were found to have drawn the most undesirable reactions from the survey respondents.

Even though these 5 questions still have an average mean that reveals a positive view of E-SCM, they revealed areas of opportunities for development. The respondents measured that E-SCM can be improved, particularly in their integration with suppliers and customers by assessing E-SCM as an instrument that permits them to connect remotely to suppliers and that could significantly contribute to shorter response times and enhanced information flow.

Sufficient training for users highlight that even though E-SCM has been in the industry for a significant time, there are still some technical concerns that need to be fixed to make it totally accepted as an operational tool, as well as to streamline how inventory is managed or how the information is meant to be translated into inventory management reports.

4.5 Chapter summary

In this investigation, five management principles were used to understand the values of E-SCM systems as a management tool. These five principles comprised the E-SCM impact on SCM, E-SCM effectiveness, satisfaction of the E-SCM users when dealing with customers, E-SCM quality, E-SCM performance in the different task areas.

The results obtained were drawn and the degree of E-SCM application was calculated and presented. The results provided numerous suggestions of absolute improvement in the businesses, especially in the direction of performance merit, for example, the level of focus employed towards sustaining customer needs through quality of data for internal communication and data relevance. The study also highlighted several issues for the company to consider, such as the level of E-SCM awareness and its contribution towards a more streamlined process amongst the respondents. The findings also showed that there was a strong inter-correlation between E-SCM elements. The comments from some of the respondents in the analysis revealed that for employees to

be involved in their respective processes, one needs to understand what role they play as part of the complete supply chain, which means getting information to the customer on time, in order to avoid delays, which then shows commitment in leading this initiative. This type of empowerment and motivation must accompany the business strategy. The following chapter will be a presentation of the statistical data analyses and discussion of the findings.

CHAPTER FIVE

Discussion

5.1 Introduction

The purpose of this study was to provide statistical analysis of the information collected from the survey which involved identifying a research environment, population size and using a Cochran 5 point scale to measure the results. The results described in Chapter Four are discussed in this chapter, in response to the research questions drawn in Chapter One. This study focused mainly on E-SCM and its implementation in the automotive manufacturing companies which are located around South Africa. The automotive industry plays a key role in the social and economic development of South Africa, though to participate effectively on the world market, this industry, more importantly the manufacturing industry, needs to follow the example of successful businesses and their world-wide systems like the UK, in order to advance their service quality standards and achieve world class performance. As a result, the study attempted to expose the status of E-SCM implementation in these companies, with the aim of providing recommendations for improving systems to decrease costs and to meet proven methods that have accomplished world-class performance.

5.2 Discussion of the results

Did e-SCM impact positively on efficiency, satisfaction, quality and performance of South African automotive industry? This is the primary research question of this study. To examine this, a number of questions related to 5 impact categories were formulated, namely: E-SCM influence on SCM, E-SCM impact on effectiveness, E-SCM system quality, E-SCM satisfaction and E-SCM performance. The following is a summary of the objectives of the study, with respect to the study questions presented in Chapter 1.

5.2.1 Method to accomplish world class performance

A total of 48.3% of the respondents (Table 4.6) agreed that to achieve world class performance, one of the most imperative IT or electronic applications in this sector is the supply chain optimisation and planning tools that support visibility, finding improved results for intricate planning difficulties and integrating the entire value chain. The visibility and management of the data, for instance, order and inventory, businesses influence on time and production, effective purchasing, sales and distribution strategies.

Again, 46.7% of the respondents also highlighted the significance of computerised transmitting and handling of data, which some businesses use the secondary application called Electronic Data Interchange (EDI), which allows real time information interchangeability amongst all stakeholders in the supply chain. A supplier gateway or portal with the figures on price, volumes, logistics, quality and inventory level meter is a demonstration of how supply chain performance can be developed by influencing internet demand. With IT centered systems, companies can constantly check the stockpile and stock requests can be automatically conveyed to the supplier electronically. This type of application reduces safety stock for the stock procured and reduces rotation period. Further, with synchronisation between supply chain processes, on-time production requests or claims can be understood.

Similarly, internal communication was ranked considerably high by 45% of the respondents, highlighting that revolutionary data collection, processing and circulation, makes it effortless to merge independent supply chain elements, which contribute to the improvement of quality, cost, services and time, to form part of the supply chain performance.

The five lowest ranked (Table 4.8) shows that if the extranet does not exist for communication with external parties, or internet is limited, then how will the information be shared between the business and suppliers to ensure that the inventory is being monitored, as well as the user understand the information required. Although for some companies it is easier to manage what you have full control over, it can hinder the full potential of the E-SCM if these aspects of the study are not addressed.

According to Mello et al (2017), incorporating IT and production is vital, especially in companies whereby some aspects of the business are subcontracted. For example, de Treville and Trigeorgis (2010) noted that the communication between engineering and production is a serious element or method required to supply premium products on time and create an environment whereby the information is easily accessible. According to de Treville and Trigeorgis (2010), having engineering and production located at the same place permits businesses to better explore the innovation ability and to realise customisation and receptiveness, which then improves the company performance by implementing world class proven methods or practices.

5.2.2 A model to encourage awareness of supply chain engineering dynamic forces and effectiveness

It can be debated that E-SCM impacts on the competitive structure in a segment with the continuous development of advanced products and services, by encouraging accurate decision making, reinforcing ties between companies, reducing costs and with the combination of products and services. E-SCM is also very important in terms of the development of the effectiveness of supply chain management practices.

Table 4.3 and Figure 4.3 were used to measure the results of E-SCM forces and effectiveness in the current automotive setting. In that view, 51.7% of the respondents revealed that e-SCM contributes to an increase in revenue, while 41.7% said that with the system in place, the reduction in lead time to customer is improved. Others (33.3%) remained neutral in this regard.

Manzouri et al (2010) state that severe rivalry and high level of customer beliefs in the current worldwide automotive market have forced industries to try for reduced product development phases by concentrating further on their supply chains models. The model looks at supply chain management which combines supply and demand controlling inside and across businesses as a mutual methodology that includes several role companies in the supply chain. These companies considerably add to enhanced

product quality, reduced lead times and a higher awareness, at a minimal charge and better customer gratification levels (Bennett and O'Kane, 2006; Humphreys et al., 2007; Lockström et al., 2009).

5.2.3 Systems which can be used to decrease wide-ranging costs of company to fulfil service level obligation

By refining the model and method of the supply chain only, it is feasible to minimise various cost components like inventory carrying costs, shipping cost and warehousing. Furthermore, the firms that incorporate practices like product re-modelling and refinement with the supply chain, acquire value by decreasing product improvement times, price of goods sold and value of poor quality work. It has likewise positive influences on ordering to distribution lead times by enhancing the entire process and challenging some of the difficulties in the process, as a result it helps to expand businesses' cash conversion cycle.

The respondents recognised the difference between the manual and electronic systems and how significantly it has impacted on the method of processing data, especially the 28.3% that see the savings in cost by having paperless operations and more real-time information.

45% of the respondents agreed that by having a more paperless process, this allows workers to process information much quicker, which in turn shows improvement on productivity and this can be measured by the increase in sales, as proof that the more efficient the process is, the more orders can be processed to ensure the customers receive the product on time and because it is live, any changes can be seen or detected almost immediately.

Owens and Minor, a healthcare firm in the United States, designed a system to reduce costs by controlling exclusive relations using economical bidding of parts and materials based on requirement (Nelson-Rowe 2001). The relative successes of some of these associations and remote interactions have created the desire for the improvement of an automotive exchange, called Covisint, by businesses such as General Motors, Ford, DaimlerChrysler and Nissan, and its original intent was to decrease supply chain costs

and grow efficiencies alongside their supply chain. While online, devoted, interface between automotive businesses and their suppliers is not new (technologies such as EDI have been in use for a fair amount of time), exchanges are invented to afford a wider set of prospects for customer/supplier communication which supports the reasons why employees would rather have a more streamlined, paperless processes that not only improves efficiency, but also, the service level of goods manufactured and delivered is of highest quality.

5.2.4 Service quality and level improvement

In the universal markets today, competitive environment for the expansion of modern product development leads customers to low price, but good quality products. In this situation, resilient and sustainable key performances of the companies operating in global marketplaces depend on their capabilities to advance innovative products and practices (Chen and Kai-ling, 2004). The quality of the current systems used was measured to see how the process is setup to cater for the system user and how they perform their functions. The results showed that 45% of the respondents rated the system considerably high for internal access convenience, showing the system is setup to allow the user to gain access whenever a function needs to be completed without any hustles or unexpected logout, unless communicated by the I.T department due to maintenance.

User friendliness (48.3%) and ease of learning to use (51.7%) the system is not only made to ensure that the logistics and supply chain functions are maintained, but also the user and how efficiently can the job be done.

If the system was setup to only take care of the end results, then the member generating/updating the information would take longer due to the complexity and uniqueness of the system. Improvements to the system would not happen quick enough to compete with other businesses if the user is not comfortable enough or prepared

enough to recognise what features are required on a day to day basis and which ones are good to have, but not required.

However, with remote access, capability was one of the questions ranked low, with a mean of 3.40, for the reason that members felt certain individuals could access the system remotely and perhaps the criteria for who qualifies to have remote access was not clear in some companies as part of the system management policy.

An organisation needs precise skills in order to effectively form and accomplish supply chains, together with an emphasis on universal systems that incorporate the whole supply chain and an emphasis on product and service quality, as well as quality declaration (e.g. food safety) alongside the supply chain, (van Duren and Sparling, 1998; Boehlje et al., 1999; Tan, 2001). This has been proven by the high percentage numbers of system user friendliness and how employees view the system in terms of training or learning to use.

5.4 Chapter summary

The results of the study indicate that superior system quality portrays a crucial part in defining customer satisfaction. The results have assisted in identifying challenging parts of system quality that require expansion in order to boost user satisfaction and process efficiency. The views of the respondents on how system quality can be upgraded function as the foundation to construct beneficial strategies that would improve the quality of system presented applicable to satisfy consumers' needs. The results similarly expose the significance of continuously monitoring end-use's' requests and ideas about the system quality accessible both in-house and at the supplier. The next chapter focuses on the conclusion and recommendations of this research study.

CHAPTER SIX

Conclusion and Recommendations

6.1 Introduction

This chapter presents the conclusions based on the discussion made in the preceding chapter and incorporate these with understandings extracted from the literature review described in Chapter Two. Significant implications were recognised by the research, which may possibly be used for the expansion of a framework to promote E-SCM implementation in the South African automotive industry as a management tool. The study conclusions demonstrate an important contribution to the overall awareness of E-SCM management systems. There are some limitations to the study as well, which are also discussed in detail, in addition to the recommendations for future research, as emphasised by study participants.

6.2 Conclusions to the study

- ***To identify the methods which could be applied to accomplish world class performance***

The method of calculated partnership with suppliers has proven successful for economic advantage, for companies such as Dell and other automotive manufacturing in the US, Japan and Korea. This means that companies understand their connections with suppliers and the shared responsibility of quality product making, distribution and the use of information to communicate effectively. Other methods include the use of manufacturing technology, which consists of software to control or operate processes, as well as information capturing for reference. The internet of things collects and transmits the collected information through internet connection.

Robotics then link in with the internet of things to ensure an automatic reaction to data received is almost immediate and transferred where required. Lastly, transportation of goods, as well as efficient delivery routes, need to be followed to minimise the cost of long networks.

- ***To identify a model to encourage awareness of supply chain engineering dynamic forces and effectiveness***

Many businesses have started to be mindful of the meaning of forming collaborations with associates in the upstream and downstream sides of the value chain, commonly under product life cycle management. These types of collaborations influence the effectiveness and efficiency of the processes, which leads to reduction in costs and also improved profit margin.

With reference to the survey at the questions level, it was discovered that there are key models that were examined: communication, quality, data, cost, access, sales, and usability. These models are cutting-edge and can be seen in all 5 groups. The fascinating part is that there seems to be a strong consensus on the significance of data, access and communications and on a minor scale, the quality of the E-SCM systems.

- ***To identify a system which can decrease wide-ranging costs of company to fulfil service level obligation***

Supplier selection is a serious matter, especially for industries that handle intricate products. This is significant, not only to decrease the logistics expenses, but also to react to a business' attractiveness equally in the short and long-term. (Lee et al. (2003)) echo this idea by noting that supplier preference or selection is a deliberate subject to reflect in supply chain management. By using the internet of things, there is real-time information that can be shared between the supplier and the business in terms of the data detailing the type of product needed, quantity required and by when should the product be delivered to the customer. This type of communication allows the planning of resources required, e.g. manpower, machine, method and material to be more precise, eliminating all the unnecessary waste.

- ***To determine an approach which can be applied to improve services rendered and quality***

Most of the participants measured E-SCM as being of high quality; this certifies that the current technology for E-SCM is strong and steady enough to fulfil quality expectation of workers. An organisation needs precise skills in order to effectively form and accomplish supply chains, together with an emphasis on universal systems that incorporate the whole supply chain and an emphasis on the product and service quality and quality declaration (e.g. food safety), alongside the supply chain (van Duren and Sparling, 1998; Boehlje et al. 1999; Tan, 2001);

6.3 Implications and recommendations

In this research, a thorough list of E-SCM principles were highlighted to examine the degree of their application in the automotive industry for companies based in South Africa. The existing study's key motivation was to use E-SCM literature to demonstrate the ideas that result in optimal quality and efficiency performance in a manufacturing system. The extent of application of these ideas was then verified in the three manufacturing plants of automotive companies built in South Africa. The research supports the growing body of information on E-SCM application and it tries to outline E-SCM fundamentals that are applicable in the South African manufacturing industry setting.

The connection between existing E-SCM practices and its apparent significance on system performance was examined. The research had an impact on the literature by granting the respondents the opportunity to voice their views on principles that required immediate focus and emphasis. A framework for measuring E-SCM awareness within the logistics employees was also established in the research. This background provided the drive for E-SCM training to be robust to allow employees to have sufficient tools to tackle any tasks and advance complete productivity. The analysis also highlights critical implications and recommendations for the managers to develop their E-SCM application and therefore, improve their overall process and company performance. The

implications mean that this research may also be relevant to other manufacturing industries in South Africa, in an effort to encourage businesses to embrace E-SCM philosophies. The effects will be an expansion in the complete performance of the manufacturing industry and thereafter, the South African economy.

Detailed figures discovered that in the 5 groups of questions, the average was around 4 signifying that there was a reasonably solid agreement on E-SCM influencing in some way, the operations in a company. The outcomes of the research indicate that the majority of the participants have confidence that E-SCM has a significant dynamic influence on the SCM of the automotive industry, as it encourages improved communication amongst the company and its suppliers, simplifies document planning and preparation, as well as provide for enhanced remote access capability going forward. The survey indicated that the practice of E-SCM in the company for SCM will lead to less mistakes by workers and therefore, cost savings.

Better information flow and shorter response times have been realised as one of the utmost significant outcomes of E-SCM on the automotive industry. This is crucial for a low-cost strategy which entails the application of just-in-time and advance lean strategies that involve rapid response times and solid merger with suppliers for inventory control structures.

On the other hand, the research highlighted some areas that can be improved. The training of employees is essential to ensure that the E-SCM puts in place in the business functions efficiently. Employees recognise this venture as a continuing investment, which will eventually profit both the business and the employees.

The study similarly discovered that E-SCM has various technical challenges such as remote access capability, extranet for communication with external parties, communication needs for interacting with customers and monitoring of inventory systems and purchasing process. These challenges are linked to the intricacy of incorporating E-SCM with the current enterprise resource planning methods that may be

from numerous suppliers or use dissimilar standards. E-SCMs are typically used to incorporate business objectives and business procedures inside and across businesses, into a unified and high-level performance model. The present enterprise resource planning systems may require re-engineering to successfully support contemporary E-SCMs.

Various companies have financed a huge quantity of resources and determination in the improvement of E-SCMs. Overall, some state that this saves the company a substantial sum of money and time and mainly afford them a chance to be more economic and cost-effective. A great deal of subjective data in the literature validates their statement, but there is no firm first-hand indication to back the statement in the automotive industry. This study seals this gap by drawing empirical evidence for the much-awaited connections between E-SCMs and industry value.

The majority of the information gathered was from literature and restricted responses from participants surveyed. Future studies associated with this subject should be continuous. A proposal would be to initiate a similar survey, but exploring the technical side in detail and include technical teams, as some of the concerns appear to come from the technical standpoint. The majority of these concerns could be avoided only if the reasons behind it are exposed and supported in the selection and implementation of E-SCMs.

In conclusion, the research has been able to explore the influence of E-SCM on the automotive industry. Specifically, it was able to determine the exact parts where E-SCM has the highest control. The investigation also recognised areas of developments for the industry, specifically the requirement for employee training to utilise E-SCM to its full extend and the requirement to better synchronise E-SCM with enterprise resource planning systems of suppliers.

6.4 Limitations and areas for future research

The outcomes of this research should be measured in view of the limitations to the methodology used. Firstly, the survey presentation as a technique of research is not

restricted from the subjectivity of the respondents. The survey used in the research was an investigation of awareness of employees in the logistics departments, who could relate mutually at operative and strategic levels, the ideas behind E-SCM. Furthermore, while the respondents were predicted to be logistics system based employees (and attempts were made to confirm that they indeed were), and that the research topic is applicable to the respondents' framework; one needs to be careful not to generalise the results. For that reason, generalising the respondents' views to a larger labour force may be limited.

There were only 3 out of 8 participating companies that have manufacturing plants in South Africa. Even though these businesses play a primary role in the automotive manufacturing, with regards to sales and contribute to the economy as a whole, a broader research is necessary on E-SCM implementation, to include service corporations along with other manufacturing sectors, for example, Agribusiness, mining, textiles, pharmaceutical and clothing.

Not all senior managers participated in the research, especially from the large percentage company. Their judgement would have outlined their understanding of E-SCM and its significance as a measure of refining industry performance.

This research did not review the effects of E-SCM on complete performance of the 3 companies. In-depth literature review discovered that businesses that implemented E-SCM values accomplished better results than those that did not. The analysis concentrated on testing the degree of E-SCM application.

The survey carried out a brief investigation, as the information was gathered at one point in time, a duration in September 2017. A comprehensive study may be necessary to dissect this subject due to the findings, it must be addressed carefully when drawing any clear-cut conclusions about improvements over time.

The present research was administered in three companies and single manufacturing industry, namely the automotive. However, it is recommended that the research should incorporate dissimilar businesses of other industry brands. This would disclose the

phases of improvement and application of E-SCM values in the exclusive setting of South African businesses.

Furthermore, it is equally recommended that the operational performance should be included as part of evaluating the effectiveness of E-SCM for all companies. This will supplement to literature, the existing opinion of E-SCM as a method that improves business procedures, as well as underline distinctive areas of improvement in the South African business perspective, as observed in this investigation.

6.5 Chapter summary

The foundation of the study was based on the need for the South African automotive businesses to adjust to universal standards of management practices to advance their system of quality standards and ultimately, the business' operational performance. The reality is that South Africa's automobile export growth market and the competitiveness within the value chain globally, has proven to be a challenge for local businesses to follow precise performance standards, especially doing business with countries like the EU.

According to the problem statement, the level to which the three automotive manufacturing companies based in South Africa have implemented E-SCM philosophies was examined completely and the findings evidently drew the degree of the application. The survey defined the overall awareness of E-SCM and its application level within the three companies and recommendations were highlighted on how the companies can progress the present situation and then eventually, operational performance. The main limitation is the investigation which was conducted on only three out of eight companies, indicating that the outcomes of the study cannot be concluded to apply to the rest of the automotive industry.

It has been recommended that the investigation be carried out in the remaining five automotive firms and to the rest of the manufacturing segment, to develop a concise and uniform methodology to the examination of E-SCM application in South Africa.

This investigation focused on E-SCM and its application in automotive manufacturing businesses which are based in South Africa. The automotive segment plays a significant part in the financial and social growth of South Africa, yet to participate successfully on the world market, this segment, more highly the manufacturing segment, needs to follow the model of popular businesses and their global systems, in order to improve their quality standards and operating performance. Therefore, the study was tailored to disclose the position of E-SCM application in the industry, with the goal of providing recommendations for refining management practices to meet confirmed effective universal standards.

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Appendix I: Informed consent letter

Informed Consent Letter 3C

UNIVERSITY OF KWAZULU-NATAL
GRADUATE SCHOOL OF BUSINESS AND LEADERSHIP

Dear Respondent,

MBA Research Project
Researcher: Dineo Litabe (0319104639/0784074627)
Supervisor: Christoper Chikandiwa (031 260 8882)
Research Office: Mariette Snyman (031-260 8350)

I, **Dineo Litabe** an MBA student, at the Graduate School of Business and Leadership, of the University of KwaZulu Natal. You are invited to participate in a research project entitled: The Effect of Engineering in Supply Chain management systems in the South African Manufacturing Services Industry.

The aim of this study is to understand the movement of multi-disciplinary data about goods, services and associated processes through a thorough supply chain with the support of engineering, to certify that accurate information is available in the right framework and at the required time.

Through your participation I hope to understand the requirement for improved implementation of engineering systems to sustain supply chain operations in South Africa, by displaying probable benefit to selected South African engineering and manufacturing businesses. The results of the survey are intended to contribute to understand the current situation in the manufacturing industry which will then be analyzed using the data filtering technique in order to analyze the gap between South Africa and global market by achieving world class performance.

Your participation in this project is voluntary. You may refuse to participate or withdraw from the project at any time with no negative consequence. There will be no monetary gain from participating in this survey/focus group. Confidentiality and anonymity of records identifying you as a participant will be maintained by the Graduate School of Business and Leadership, UKZN.

If you have any questions or concerns about completing the questionnaire or about participating in this study, you may contact me or my supervisor at the numbers listed above.

The survey should take you about **30** minutes to complete. I hope you will take the time to complete this survey.

Sincerely

Investigator's signature_____ Date_____

Appendix II: Questionnaire

Survey: The Effect of Engineering in Supply Chain management systems in the South African Manufacturing Services Industry

Thank you for participating in the survey
Please fill this quick survey and let us know your thoughts (your answers will be anonymous

*Required

1. **Email address** *

Group 1: E-SCM impact to SCM

To what extent does eSCM impact in the key indicative areas below

2. **Q1: Efficiency in flow of information and documents** *
Mark only one oval.
- ◯ 5 - Strong
- ◯ 4 - Considerable
- ◯ 3 - Medium
- ◯ 2 - Low
- ◯ 1 - Weak

3. **Q2: Reduced costs in preparation of documents** *
Mark only one oval.
- ◯ 5 - Strong
- ◯ 4 - Considerable
- ◯ 3 - Medium
- ◯ 2 - Low
- ◯ 1 - Weak

4. **Q3: Productivity increases in sales/total assets ratio** *
Mark only one oval.
- ◯ 5 - Strong
- ◯ 4 - Considerable
- ◯ 3 - Medium
- ◯ 2 - Low
- ◯ 1 - Weak

5. **Q4: Increases in sales/employee ratio** *
Mark only one oval.

- ◯ 5 - Strong
- ◯ 4 - Considerable
- ◯ 3 - Medium
- ◯ 2 - Low
- ◯ 1 - Weak

Group 2: E-SCM effectiveness

To what extent does eSCM impact the effectiveness of SCM tasks

6. **Q1: Reduced leadtime to customer** *
Mark only one oval.

- ◯ 5 - Strong
- ◯ 4 - Considerable
- ◯ 3 - Medium
- ◯ 2 - Low
- ◯ 1 - Weak

7. **Q2: Reduced stock outs of finished products** *
Mark only one oval.

- ◯ 5 - Strong
- ◯ 4 - Considerable
- ◯ 3 - Medium
- ◯ 2 - Low
- ◯ 1 - Weak

8. **Q3: Reduced inventory carrying costs** *
Mark only one oval.

- ◯ 5 - Strong
- ◯ 4 - Considerable
- ◯ 3 - Medium
- ◯ 2 - Low
- ◯ 1 - Weak

9. **Q4: Reduced stock outs of production materials** *
Mark only one oval.

- ◯ 5 - Strong
- ◯ 4 - Considerable
- ◯ 3 - Medium
- ◯ 2 - Low
- ◯ 1 - Weak

10. **Q5: Reduced distribution costs to customers** *
Mark only one oval.

- ◯ 5 - Strong
- ◯ 4 - Considerable
- ◯ 3 - Medium
- ◯ 2 - Low
- ◯ 1 - Weak

11. **Q6: Reduced distribution costs from suppliers** *
Mark only one oval.

- ◯ 5 - Strong
- ◯ 4 - Considerable
- ◯ 3 - Medium
- ◯ 2 - Low
- ◯ 1 - Weak

12. **Q7: Performance increase in income/capital ratio** *
Mark only one oval.

- ◯ 5 - Strong
- ◯ 4 - Considerable
- ◯ 3 - Medium
- ◯ 2 - Low
- ◯ 1 - Weak

13. **Q8: Increase in return on sales** *
Mark only one oval.

- ◯ 5 - Strong
- ◯ 4 - Considerable
- ◯ 3 - Medium
- ◯ 2 - Low
- ◯ 1 - Weak

14. **Q9: Increase revenues** *
Mark only one oval.

- 5 - Strong
- 4 - Considerable
- 3 - Medium
- 2 - Low
- 1 - Weak

Group 3: Satisfaction of the E-SCM

To what extent, users of eSCM are satisfied

15. **Q1: Information needs internally** *
Mark only one oval.

- 5 - Strong
- 4 - Considerable
- 3 - Medium
- 2 - Low
- 1 - Weak

16. **Q2: Information needs for transacting/interaction with suppliers** *
Mark only one oval.

- 5 - Strong
- 4 - Considerable
- 3 - Medium
- 2 - Low
- 1 - Weak

17. **Q3: Information needs for transacting/interaction with customers** *
Mark only one oval.

- 5 - Strong
- 4 - Considerable
- 3 - Medium
- 2 - Low
- 1 - Weak

18. **Q4: Communication needs internally** *
Mark only one oval.

- ◯ 5 - Strong
- ◯ 4 - Considerable
- ◯ 3 - Medium
- ◯ 2 - Low
- ◯ 1 - Weak

19. **Q5: Communication needs for transacting/interacting with suppliers** *
Mark only one oval.

- ◯ 5 - Strong
- ◯ 4 - Considerable
- ◯ 3 - Medium
- ◯ 2 - Low
- ◯ 1 - Weak

20. **Q6: Communication needs for transacting/interacting with customers** *
Mark only one oval.

- ◯ 5 - Strong
- ◯ 4 - Considerable
- ◯ 3 - Medium
- ◯ 2 - Low
- ◯ 1 - Weak

21. **Q7: To what extent e-SCM is related to Automotive industry** *
Mark only one oval.

- ◯ 5 - Strong
- ◯ 4 - Considerable
- ◯ 3 - Medium
- ◯ 2 - Low
- ◯ 1 - Weak

Group 4: E-SCM Quality

With respect to e-SCM, how will you rate system quality

22. **Q1: Internal access convenience** *
Mark only one oval.

- 5 - Strong
- 4 - Considerable
- 3 - Medium
- 2 - Low
- 1 - Weak

23. **Q2: Accuracy** *
Mark only one oval.

- 5 - Strong
- 4 - Considerable
- 3 - Medium
- 2 - Low
- 1 - Weak

24. **Q3: Shorter response time** *
Mark only one oval.

- 5 - Strong
- 4 - Considerable
- 3 - Medium
- 2 - Low
- 1 - Weak

25. **Q4: Useful functions/features** *
Mark only one oval.

- 5 - Strong
- 4 - Considerable
- 3 - Medium
- 2 - Low
- 1 - Weak

26. **Q5: Ease of learning to use** *
Mark only one oval.

- 5 - Strong
- 4 - Considerable
- 3 - Medium
- 2 - Low
- 1 - Weak

27. **Q6: User friendliness of system** *
Mark only one oval.

- ◯ 5 - Strong
- ◯ 4 - Considerable
- ◯ 3 - Medium
- ◯ 2 - Low
- ◯ 1 - Weak

28. **Q7: Remote access capability** *
Mark only one oval.

- ◯ 5 - Strong
- ◯ 4 - Considerable
- ◯ 3 - Medium
- ◯ 2 - Low
- ◯ 1 - Weak

Group 5: E-SCM Performance

On system usage, how will you rate your current eSCM in the following areas

29. **Q1: Effective intranet for internal communication** *
Mark only one oval.

- ◯ 5 - Strong
- ◯ 4 - Considerable
- ◯ 3 - Medium
- ◯ 2 - Low
- ◯ 1 - Weak

30. **Q2: System monitors inventory and purchasing situation** *
Mark only one oval.

- ◯ 5 - Strong
- ◯ 4 - Considerable
- ◯ 3 - Medium
- ◯ 2 - Low
- ◯ 1 - Weak

31. **Q3: Effective electronic system for product distribution** *
Mark only one oval.

- 5 - Strong
- 4 - Considerable
- 3 - Medium
- 2 - Low
- 1 - Weak

32. **Q4: Effective electronic system for procurement** *
Mark only one oval.

- 5 - Strong
- 4 - Considerable
- 3 - Medium
- 2 - Low
- 1 - Weak

33. **Q5: Automated transmitting and processing of data** *
Mark only one oval.

- 5 - Strong
- 4 - Considerable
- 3 - Medium
- 2 - Low
- 1 - Weak

34. **Q6: Internet enabled system for information sharing** *
Mark only one oval.

- 5 - Strong
- 4 - Considerable
- 3 - Medium
- 2 - Low
- 1 - Weak

35. **Q7: eSCM system fully integrated with existing systems** *
Mark only one oval.

- 5 - Strong
- 4 - Considerable
- 3 - Medium
- 2 - Low
- 1 - Weak

36. Q8: To what extent eSCM is beneficial to Automotive industry? *
Mark only one oval.

- ◯ 5 - Strong
- ◯ 4 - Considerable
- ◯ 3 - Medium
- ◯ 2 - Low
- ◯ 1 - Weak

37. **Q9: Adequate training provided for users** *
Mark only one oval.

- ◯ 5 - Strong
- ◯ 4 - Considerable
- ◯ 3 - Medium
- ◯ 2 - Low
- ◯ 1 - Weak

38. **Q10: Extranet exists for communication to external parties** *
Mark only one oval.

- ◯ 5 - Strong
- ◯ 4 - Considerable
- ◯ 3 - Medium
- ◯ 2 - Low
- ◯ 1 - Weak

39. **Any overall feedback/comments?**

_____

40. **Name (optional)**

_____

☐ Send me a copy of my responses.

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Appendix III: Ethical clearance certificate

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

21 August 2017

Ms Dineo Litabe (215078706)
Graduate School of Business & Leadership
Westville Campus

Dear Ms Litabe,

Protocol reference number: HSS/1339/017M
Project title: The effect of Engineering in Supply Chain Management systems in the South African Manufacturing Services Industry

Full Approval – Expedited Application

In response to your application received on 04 August 2017, the Humanities & Social Sciences Research Ethics Committee has considered the abovementioned application and FULL APPROVAL for the protocol has been granted.

Any alteration/s to the approved research protocol i.e. Questionnaire/Interview Schedule, Informed Consent Form, Title of the Project, Location of the Study, Research Approach and Methods must be reviewed and approved through the amendment/modification prior to its implementation. In case you have further queries, please quote the above reference number.

PLEASE NOTE: Research data should be securely stored in the discipline/department for a period of 5 years.

The ethical clearance certificate is only valid for a period of 3 years from the date of issue. Thereafter Recertification must be applied for on an annual basis.

I take this opportunity of wishing you everything of the best with your study.

Yours faithfully

.....
Dr Shamila Naidoo (Deputy Chair)

/ms

Cc Supervisor: Mr Christopher Chikandiwa
Cc Academic Leader Research: Dr Muhammad Hoque
Cc School Administrator: Ms Zarina Bullyraj

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