UNIVERSITY OF KWAZULU-NATAL

FACTORS AFFECTING THE AGILITY OF FIRMS IMPLEMENTING LEAN MANUFACTURING

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DECLARATION

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ABSTRACT

Production methods lie on a continuum from mass production to Lean and or Agile. Agile production represents an innovative supply chain strategy that shows promise in the manufacturing sector. Many South African companies are not yet aware of Agility. Currently, many manufacturers are implementing Lean and JIT principles. However, Lean and JIT may not respond adequately to modern market demands and shortened product lifecycles. The Agile paradigm focuses on speed, flexibility and response: critical factors that enable companies to achieve a higher level of differentiation.

The aim of this research was to determine the influence of different levels of Lean implementation on production Agility. This study was an innovative investigation into whether Lean and JIT contribute to, or detract from, Agility in manufacturing. There is little published research on this relationship. The study seeks to contribute to the body of knowledge and to benefit manufacturing companies: particularly those in South Africa. The research was exploratory in nature and consequently a case study approach was used. A non-probability, purposive sampling design was used to select three companies representing different categories on the spectrum of the Lean manufacturing continuum: Company A – beginner, Company B – intermediate and Company C – expert. The research was qualitative in nature.

A review of the literature tends to suggest that Lean and JIT restrict Agility by restricting speed, flexibility and response. Contrary to expectations, the findings of the study indicate that Agility tends to increase in companies that have undertaken the Lean journey. The results of the study confirm that Lean contributes to Agility within the manufacturing sector. As Lean levels increase from beginner to expert so too do the levels of speed, flexibility and response (SFR). The conclusion drawn from this study is that Lean is a pre-requisite for Agile and companies may need to implement Lean before considering Agile systems. The results of this study have been used to construct a conceptual framework and road map that may be used by firms wishing to undertake the Agile journey. The strategy has been termed ParaLeagile and it may assist manufacturing companies to make more informed and appropriate decisions, thus boosting the economy.

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CHAPTER 1 : INTRODUCTION

1.1. Introduction

A number of new strategies have been introduced into the supply chain environment over time. Lean manufacturing has been implemented, not only in production but also as a companywide culture. Theoretically Lean does not allow for waste of any kind or form and therefore it promotes a system that is extremely structured and rigid in nature. This creates 'concrete pillars' or inflexible practices which become necessary to ensure the smooth running of Lean in an organisation.

These 'concrete pillars' may restrict speed, flexibility and responsiveness (SFR) and hence act as constraints on a company's ability to respond to fluctuations in demand. Excess capacity renders the company inefficient and ineffective through underutilisation of assets. Through its inability to meet customer expectations, the company will lose out on sales and eventually customers themselves. Higher production costs will be incurred due to reduced efficiencies.

This suggests that there is a need to explore if Lean contributes to or detracts from Agility in the manufacturing sector. Agility requires SFR in production systems, allowing them to respond to customer demand. Thus an Agile system can be described as a customer centred or demand led strategy. Agility can help a company to convert itself from an order qualifier to an order winner.

1.2. Motivation for study

Globally, modern manufacturing companies are striving towards Leanness. South African manufacturing industries are following the same trend as they encounter an ever-changing environment. Cutting production costs is no longer always the primary concern. This study is an investigation into whether or not Lean and JIT contribute to, or restrict flexibility in manufacturing. The results of this study contribute to the framework of a conceptual model and a road map for an Agile Journey. This will assist manufacturing companies to make more informed and appropriate decisions with a better understanding of how the Lean, Agile or Leagile paradigms may enhance their competitiveness. Currently, decisions are made without an understanding of many of the longer-term

implications. South African firms risk continuing to be followers rather than co-leaders in the global manufacturing marketplace.

The Industrial Policy Action Plan for 2015 highlighted the need to create jobs and expand nine different sectors in manufacturing (Department of Trade and Industry, 2014: 36). KwaZulu-Natal's Provincial Growth and Development Plan, objective 1.2, referred to the inflexibility of labour which is a key theme of this study (Provincial Planning Commission, Province of KwaZulu-Natal, 2013: 31). This study makes a substantial contribution to addressing these concerns of government as well as improving manufacturing efficiency and effectiveness.

There is little published research in the area investigated. The study contributes to the body of knowledge and should benefit manufacturing companies, particularly in the South African context.

1.3. Problem statement

The main purpose of this study is to investigate if Lean contributes to or detracts from Agility in the manufacturing sector. However it is important to acknowledge that there may be other factors affecting the ability of firms to implement Agility. Secondary objectives are to investigate whether manufacturing companies require Agility and how companies deal with the concept of Agility in their service delivery. The need for Agility stems from the decreasing life spans of manufactured products. This requires rapid changes of manufacturing strategies and processes.

Theoretically, Lean and JIT systems may result in production systems that are unresponsive to changes in requirements. Therefore, there is a need to investigate the possible limitations associated with Lean manufacturing strategies. Furthermore, there is a possibility that Agile strategies may compensate and fill this gap. The Agile paradigm facilitates the management of uncertainty. Many companies may not be aware of this solution available to them.

1.4. Aim of the research

1.4.1. Research questions

- Does the company under investigation require Agility?
- What is the influence of Lean on speed, flexibility and response in manufacturing practices?
- What is the influence of Just-in-time on speed, flexibility and response in manufacturing practices?
- What is the influence of relationships with suppliers and customers on speed, flexibility and response in manufacturing practices?
- What is the influence of organisational culture on speed, flexibility and response in manufacturing practices?
- What other factors influence the degree of Leanness and Agility?

1.4.2. Research objectives

In order to tackle the research questions the following objectives where proposed:

- To assess if the company under investigation would benefit from increased Agility in terms of speed, flexibility and response.
- To determine if Lean is contributing to or detracting from a manufacturing company's Agility.
- To determine if Just-In-Time is contributing to or detracting from a manufacturing company's Agility.
- To identify how relationships maintained with suppliers and customers impact on speed, flexibility and response.
- To assess the internal environment or organisational culture of the company and the effect this has on speed, flexibility and response.
- To identify other factors that affect the degree of Leanness and Agility within a manufacturing company.

1.5. Background information

Production methods have evolved over time. Mass production, which strives to produce large volumes of standardised products with unskilled labour in assembly lines, has given way to Lean manufacturing (Stevenson, 2012: 22). This system strives to reduce waste

and produce higher quality goods. Relatively recently, Lean has been challenged to become more flexible and responsive by proponents of Agile systems. Agile manufacturing was developed by the Iacocca Institute of Lehigh in the USA in 1991 and was summarised in a report entitled "21st Century Manufacturing Enterprise Strategy" (Yusuf, Sarhadi and Gunasekaran, 1999: 33; Vazques-Bustelo and Avella, 2006: 1147).

Literature suggests that the different levels of Lean may reduce Agility but that certain practices such as JIT tend to improve Agility. The study investigated the impact that Lean and JIT practices have on SFR; critical elements required for Agility. A possible overall strategy of Leagile was investigated and the creation of a new ParaLeagile strategy was explored.

This study considered Lean systems and JIT systems which are currently in place in many firms. The existence of these systems can possibly hinder or facilitate the movement towards Agility. The challenge of moving from Lean to Agile was examined.

Devising clearly defined, generalisable solutions may not be realistic as each company's requirements differ. Therefore this study investigated three manufacturing companies and developed a conceptual framework and roadmap for the implementation of Agility if or when required. The literature review provided insight into the Lean, JIT and Agile paradigms. A secondary objective of the literature review was to identify key performance indicators and to categorise them into themes for further investigation. These themes encompass components of the conceptual model that was used.

This dissertation consists of six chapters. Chapter One provides an introduction and statement of the problem. Chapter Two reviews the literature on Lean, JIT and Agile. Thereafter Chapter Three describes the research methodology of the empirical study. Chapter Four presents the research findings and introduces the conceptual model. Chapter Five discusses the findings. Finally, Chapter Six presents the conclusions reached from this study, recommendations for the application of the study findings to industry and future areas for further research.

CHAPTER 2 : REVIEW OF THE LITERATURE

2.1. Lean and JIT

2.1.1. Introduction

The business world is an ever changing environment which requires operations to adapt and to seek efficient ways to reduce costs (Emuze, 2013: 6; Stevenson, 2012: 619). Heizer and Render (2011: 668) recognise that Lean principles seek to root out wastes and all non-value-adding activities, create a balanced level flow within the supply chain and then optimise the entire process from the customers' perspectives.

Various articles suggest that Lean principles can be traced back to the Japanese and the founders of the Toyota Production System (Agarwal, Shankar and Tiwari, 2006: 211; Christopher and Towill, 2000: 206; Huang and Li, 2010: 63). Authors such as Huang and Li (2010: 63) suggested that while Toyota principles have been adopted worldwide, the Americans were the first to discover that organisational cultural changes were required for proper implementation.

While Lean is becoming popular, Heizer and Render (2011: 668) cautioned that it is a difficult task to move an organisation towards a Lean system. They indicated that areas such as organisational culture, learning, empowerment and continuous improvement are challenging. Huang and Li (2010: 63) supported Heizer and Render in emphasising that Leanness has a strict and rigid nature; this being one of the main reasons that a Lean system is so hard to implement. Lamming (1996: 187) stated that it should also be possible to determine how Lean an organisation is and how far it can feasibly move towards Leanness.

In their study in the apparel industry, Stratton and Warburton (2003: 184) found that the implementation of JIT in a Lean environment has simultaneous benefits for customer service and efficiency by focusing on eliminating variation in the system and enabling a balanced flow. Heizer and Render (2011: 668) indicated that Lean organisations attempt to reach a state of zero inventories through JIT techniques and strive to put a system in place to produce a perfect part every time. However Lamming (1996: 187) noted that implementation of systems such as JIT can be seen as shifting costs up the supply chain.

These opposing views suggest that partners in the supply chain may not support tactical changes made within an organisation that are not mutually beneficial.

Naylor, Naim and Berry (1999: 108) reported that JIT was introduced in the 1980's to reduce lead times through the elimination of wastes. In contrast Stevenson (2012: 621) suggested that JIT can be traced back to Henry Ford's production line in the 1920's and emphasises the coordination and control of materials through the supply chain as and when they are needed. Ward and Zhou (2006: 178) suggested that improvements in lead-time can be achieved through the use of Information Technology (IT) and JIT principles. However, these authors show that there needs to be a balance between investments in both strategies, as both require significant resources for implementation.

In agreement with Stevenson (2012: 621), Kannan and Tan (2005: 154) describe JIT as a strategy that firms' supply chain management use to monitor and improve throughput and manufacturing cycle times. Heizer and Render (2011: 656) explained that the above requires the use of a pull inventory system to control the movement of material through the supply chain by focusing on customer demand. Kannan and Tan (2005: 158) identified long set-up times as a key area that tends to promote large inventory levels; therefore a reduction in set-up times by skilled employees can reduce inventory holding.

Ward and Zhou (2006: 178) describe JIT as a tool that is used to avoid over production and if implemented properly can lead to a manufacturing competitive advantage. This agrees with Heizer and Render's (2012: 656) description of JIT as a tool used to reduce variability within the production system.

Furthermore Stevenson (2012: 621) noted that JIT seeks to reduce Work-in-process (WIP) and material inventory by coordinating suppliers in the supply chain. This is in contrast to the views mentioned earlier by Lamming (1996: 187) regarding the shifting of costs within the supply chain. A requirement for a JIT strategy is that direct suppliers must be able to customise a schedule of frequent deliveries and supply the required parts in small batches (Sowards, 2013: 8). While the above authors had differing perspectives of JIT within a Lean strategy, they were mostly in agreement that JIT plays a major role within Lean and has tremendous potential to become a competitive advantage in Lean companies.

Helmond (2011: 48) was of the opinion that companies implementing Lean, JIT and flexible systems in their supply chains will be survivors in a modern economy. Leach (2013: 54) indicated that dealing with demand analysis and supply chain execution as a combination to meet market requirements, is key to survival. Adding to this complexity, Kannan and Tan (2005: 153) and Tinham (2005: 16) noted that a competitive market places pressure on the supply chain to deliver superior quality, increased responsiveness and shorter lead times at lower costs. The environment described by the authors above indicates the necessity for combining Lean and JIT within a manufacturing production line and demonstrates the efficiencies that they can provide.

2.1.2. Lean thinking

Naim and Gosling (2011: 343) described Leanness as creating a value stream to get rid of all wastes, including time, to ensure a stable production schedule. Studies conducted by Hallgren and Olhager (2009: 976) further specified that the value needs to be created from the customer's perspective. Harrison and Van Hoek (2011: 234) recognised that Lean thinking is the means by which many companies bring their processes under control by following a systematic approach to tackling waste. The next section describes the seven areas of waste as explained by authors Harrison and Van Hoek (2011: 229) and Stevenson (2012: 623).

2.1.3. Seven Areas of Waste in Lean and JIT

1. The waste of unnecessary inventory, described as hiding problems, results in increased lead times, the space required and results in tied up resources.

2. The waste of over production, which creates unevenness of material flow that results in bad quality and reduced productivity

3. The waste of waiting, which indicates that time has not been utilised effectively which in turn means that processes are idle or a bottleneck is present.

4. Unnecessary transporting, described as the movement of material and inventory within the production space which is not value-adding and can be improved by situating processes more closely and improving communication.

5. Processing wastes, resulting in an increase in the manufacturing workload.

6. Inefficient work methods/ unnecessary motion, leading to a reduction in overall productivity which is costly and decelerates the production system.

7. Product defects/ the waste of defects, resulting in increased cost in the form of time and money.

Harrison and Van Hoek (2011: 229) suggested implementing quality at the source with a mind-set dedicated towards prevention not detection. Stevenson (2012: 623) indicates that a Kaizen philosophy is crucial to tackling the seven wastes and where continuous improvement needs to be built into organisational culture.

2.1.4. Building blocks of Lean and characteristics of JIT

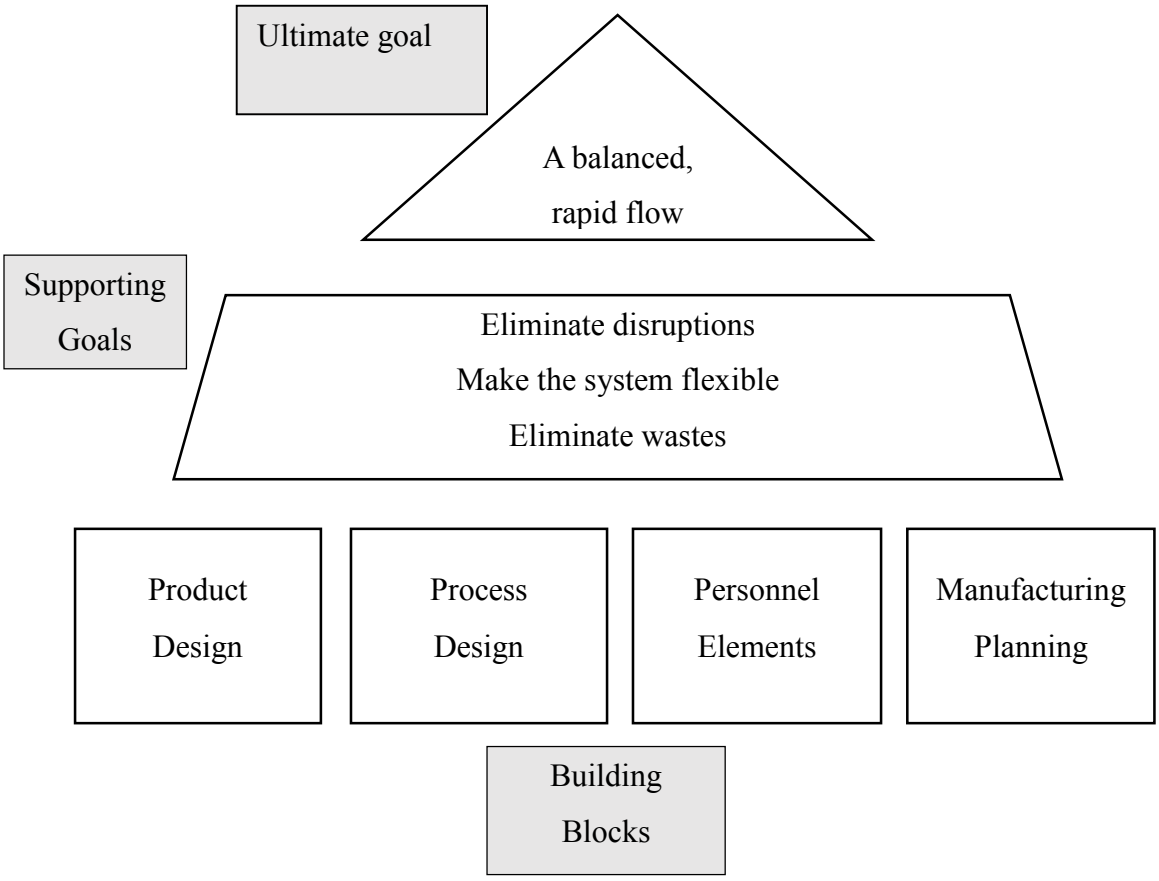

Figure 2.1: Stevenson's JIT goals and Building blocks
(Source: Stevenson, 2012: 620).

Stevenson (2012: 620) uses a pyramid to describe how Lean should be set up within manufacturing with the use of building blocks, containing three levels (see Figure 2.1).

Helmond (2011: 48) describes Lean as a house with a roof, mid-section and four pillars. Lean at the top with JIT just below and at the base and a flow principle, tack-principle, pull-principle and zero defect principle as the four supporting pillars (Helmond, 2011: 49).

Stevenson's (2012: 620) top of the pyramid "ultimate goal" is what all companies involved in Lean manufacturing should strive for. He explains that the second building block in the midsection is JIT supporting goals, made up of eliminating wastes, disruptions and making the system flexible. The author displays the building blocks as four core areas: (1) product design, (2) process design, (3) personal / organisational elements and (4) manufacturing, planning and control.

Contesting Stevenson's (2012: 620) view, Harrison and Van Hoek (2011: 224) describe JIT's involvement within Lean as a full pyramid structure.

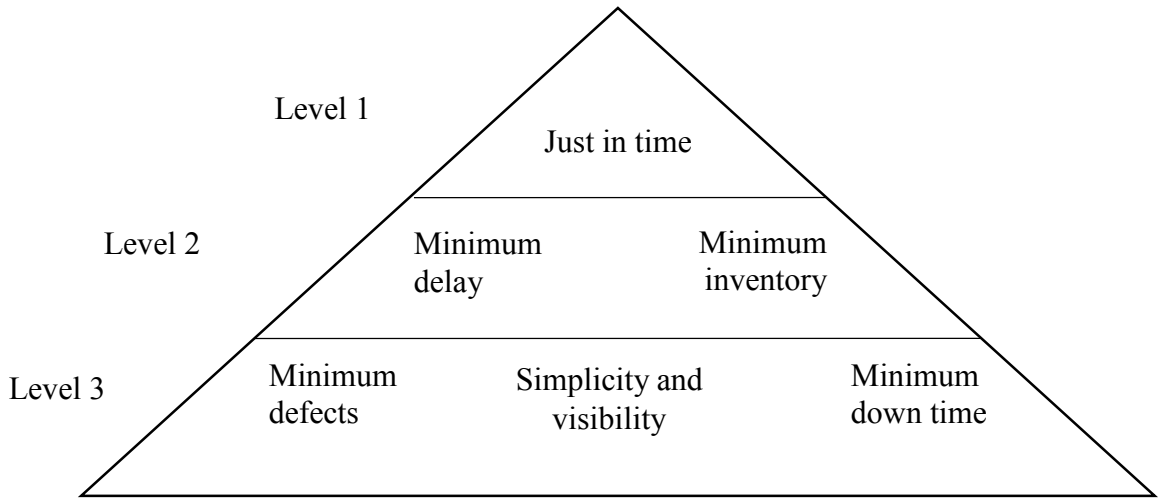

Figure 2.2: The pyramid of key factors that underpin JIT
(Source: Adapted from Harrison and Van Hoek, 2011: 224)

The authors described Level 1 as a highly capable, functional system, stating that all companies implementing JIT must strive to attain this level. They demonstrated two critical elements in Level 2, which supports Level 1; minimum delay and minimum inventory. They explain that a decrease in delays decreases inventory and has a further knock-on effect on cost reductions (Harrison and Van Hoek, 2011: 224). This point was defined by the authors as a "virtuous cycle" and the opposite as "vicious cycle."

The authors described Level 3 as support structures for the pyramid. They also indicated that there are three main pillars, firstly minimum defects, as defects increase delays and decrease production. This will further result in an increase in inventory required as a buffer against delays (Harrison and Van Hoek, 2011: 225). Secondly down time, including breakdowns, planned maintenance and change over time, leads to increased inventory. However total productive maintenance can decrease downtime and increase productivity (Harrison and Van Hoek, 2011: 225).

The third and final pillar complements the previous two factors; simplicity and visibility in the pyramid structure also supports the mid-level minimum inventory factor (Harrison and Van Hoek, 2011: 226).

In the comparison between these leading authors' frameworks it can be seen that despite differences between the two models they are both comprehensive frameworks that actually strive towards the same end product.

2.1.5. Role of Lean practices

Harrison and Van Hoek (2011: 235) described the principles of Lean as contrary to traditional manufacturing practices. Lean aims for small batch production with an ideal size of one and rapid change over as compared to the time-consuming setup for mass production. Similarly, Kisperska-Moron and de Haan (2011: 127) proposed that ideally Lean fully utilises capacity to produce what is needed, when it is needed, with a process that is 100 % reliable. In their study on improving supply chain performance to satisfy final customers, the authors acknowledged that Lean practices may decrease inventory surpluses and therefore expose hidden problems (Kisperska-Moron and de Haan, 2011: 128).

Harrison and Van Hoek (2011: 235) elaborated on the aims described by Kisperska-Moron and de Haan (2011: 128), describing a Lean system as one where economies of scope are favoured over economies of scale. This use of the same resources to make different products improves versatility without increasing inventory. Furthermore the authors indicated that a lack of flexibility is a major contributor to poor quality of service (Harrison and Van Hoek, 2011: 235; Kisperska-Moron and de Haan, 2011: 128). In order for companies to become Lean there needs to be constant communication with customers

and suppliers to deliver the perfect order (Kisperska-Moron and de Haan (2011: 132). These authors argue that Lean companies need to be able to predict a near-accurate demand forecast and assign capacity accordingly, in order to attain this level of JIT.

2.1.6. JIT partners: relationships and collaborations

In his article on what your supplier can do for you, Sowards (2013: 14) drew attention to the need for trust in supply chains. The author proposed that this is a key issue and that to develop trust one must be prepared to demonstrate trust in suppliers first. Helmond (2001: 48) supported the above and cites transparency as a requirement in supplier relationships to allow suppliers to see how JIT can be beneficial to their businesses as well. This contention was supported by Leach (2013: 56) who recommended combining transparency with accurate forecasts from both buyers and suppliers, thus allowing buyers to estimate how suppliers' businesses are operating and vice versa. This level of trust can lead to lasting and mutually beneficial business relationships. Kannan and Tan (2005: 154) supported this theory by affirming that supply chain management requires there to be a strong relationship between buyers, suppliers, vendors and customers for it to be successful.

According to Heizer and Render (2011: 657) there are four goals to be achieved through JIT partnerships. The authors listed these four steps as: firstly, the removal of unnecessary activities, secondly, removal of in-plant inventory, thirdly, the removal of in-transit inventory and lastly obtaining improved quality and reliability. They propose that these four essential areas can be negotiated with suppliers through collaboration, in which benefits for all parties involved can be attained (Heizer and Render, 2011: 657).

In agreement with Heizer and Render, Sowards (2013: 14) noted the importance of supplier relationships in JIT and identified some methods whereby suppliers can deliver better services: 'kitting' whereby the supplier's employees assemble materials on site and can deliver to a point further into the sequence of assembly; 'material staging' where materials are ordered when needed, managing lead times and hence allowing the buyer to avoid holding inventory (Sowards, 2013: 2). Supporting this view, SSA Business Solutions found within their case study of an Indian manufacturer, that proper implementation of kitting and material staging can improve productivity up to 209% (SSA Business Solutions, 2012: 3).

A third collaborative method identified by Sowards (2013: 4) was onsite services offered by suppliers which eliminate processes including administration procedures. Fourthly, the supplier can offer offsite storage thereby further customizing delivery options (Sowards, 2013: 9).

2.1.7. JIT layout

Heizer and Render (2011: 659) described JIT layout as encompassing movements externally and internally. The authors indicated that external layout includes the location of customers and suppliers and internal layout facilitates the control of inventory, such as delivering directly to where the items are required.

2.1.7.1. Distance reduction

According to Vazquez-Bustelo and Avella (2006: 1151), distance reduction internally is optimized by creating work cells. This is the grouping of man, machine and processes to create a family of employees; examples include U-shaped work cells. Similarly, Gunasekaran (1999a: 95) refers to work cells as manufacturing cells and indicates that these tend to be highly specialized and efficient production centres. The author highlights benefits such as: reduced change-over times, high equipment utilisation and support for cross-training of employees.

2.1.7.2. Increased flexibility

According to Stevenson (2012: 627) Lean and JIT seek to achieve the ability to service a smooth flow or process of a mix of products. The author highlighted a potential obstacle in the form of bottlenecks. However this can be overcome through process design (see Figure 2.1: Stevenson's JIT goals and Building blocks). Heizer and Render (2011: 659) agreed on the importance of design and suggested that the entire organisation from the administration side to the production side must be made flexible, and nothing must be set in one place or even bolted down. Everything should be movable and able to adapt to change including production lines, computer connections and telecommunication (Heizer and Render, 2011: 314).

2.1.8. Impact of JIT on employees

According to Yusuf *et al*., 2004: 382 JIT has a positive impact on employee empowerment. The authors indicated that it leads to crossed-trained employees which

allows for efficiency and flexibility within work cells. In their study authors Kannan and Tan (2005: 154) highlighted the relationship that JIT and TQM share and proposed that employee empowerment under JIT leads to improvements in quality. The focus on enhancing the skills of employees to support JIT has a positive effect on other areas such as continuous improvement.

2.1.9. JIT inventory

In contrast to traditional views Heizer and Render acknowledged that JIT has inventory which is just-in-case inventory, but referred to as JIT inventory that is present to keep a smooth flowing supply chain (Heizer and Render, 2011: 660). However Kannan and Tan (2005: 154) identified an alternative to JIT inventory. Pulling materials rather than pushing them through the supply chain has resulted in better inventory management, allowing for a better response to demand and therefore better service levels. Stratton and Warburton (2003: 184) agreed with these views and also highlighted the significance of unwanted inventory. The authors showed that when higher levels of inventory are combined with volatile demand, the trade-off is more significant, resulting in obsolescence and shortages (Stratton and Warburton, 2003: 185).

Sowards (2013: 12) provides a solution to the JIT inventory: using vendor managed inventory (VMI) to facilitate administration, reduce inventory and decrease variability. In studies conducted by Helmond (2011: 48) the author identified how JIT works to influence Lean by reducing inventories with the use of the 5R's which are: the right part, in the right quality, at the right time, in the right quantity, and at the right place. The above authors concur, that JIT and inventory management is heavily reliant on the capabilities of suppliers.

2.1.10. Reduced batch sizes

According to Heizer and Render (2011: 660) although it may not be practical for manufacturing, JIT seeks to bring production down to a batch size of one. Stevenson (2012: 624) agreed and indicated two advantages of reducing batch size to a minimum: Firstly, the this will reduce work-in-process inventory with resulting reductions in cost, space requirement, work place clutter and decreased inspection and rework costs . Secondly, an additional benefit of reduced lot sizes is increased flexibility in scheduling (Stevenson, 2012: 625).

2.1.11. Reduced set-up times

According to Qrunfleh and Tarafdar (2014: 344), by reducing set-up times a reduction in lot sizes and average inventory can be achieved. Stevenson (2012: 625) supported their views, and suggested that when introducing JIT techniques employees must be trained to handle their own setups. Sowards's (2013: 12) article identified how suppliers can deliver goods unwrapped and ready to install to avoid clutter and to reduce set-up times. Sowards's view was supported by Kannan and Tan (2005: 153) who suggested that a reduction in inventory can be achieved by controlling material flows, and utilizing preventative maintenance.

2.1.12. JIT scheduling

According to Heizer and Render (2011: 662) JIT scheduling involves better scheduling with suppliers; this requires good communication and enables the supply chain to meet customer needs more efficiently. Similarly Stevenson (2012: 633) highlighted the importance of manufacturing planning and control (MPC) to facilitate JIT scheduling and suggested the implementation of seven elements of MPC: level loading, pull systems, visual systems, limited work-in-process, close vendor relationships, reduced transacting processing and preventative maintenance.

2.1.12.1. Level scheduling

Kannan and Tan (2005: 154) maintained that level scheduling favours small batch sizes rather than large economic order quantities. The authors indicated that the key is to plan frequent orders that are as small as is feasible. In addition Leach (2013: 56) suggested that even global purchasing can be achieved with JIT scheduling. The author's contention was that knowing the suppliers' businesses well, including their cycle and delivery times, enables the purchaser to accurately estimate the time from the order being placed until delivery is received.

2.1.12.2. Kanban

Lamming (1996: 191) concurred with Heizer and Render (2011: 664) that Kanban is one of the most important controlling factors in a JIT system. The authors defined this as signals sent from one production point to the previous production point to initiate the production of materials that are further required (Heizer and Render, 2011: 664).

Stevenson (2012: 636) added two categories of Kanban (p-Kanban) and (c-Kanban) and described them as visual signals. The former signals the need to produce more parts and the latter signals the need to deliver to the next station.

The preceding literature has given an account of the framework of Lean and JIT in looking at how they function as a team, where JIT cannot exist without Lean having been implemented first. The following literature will introduce Agile into the complexity and investigate if the paradigm of Lean and JIT contribute to or detracts from paradigms of Agility within the manufacturing sector.

2.2. Agile

2.2.1. Introduction

It is necessary to make a clear distinction between Lean and Agile. Current literature and various authors make use of market environments to explain this distinction. They refer to the definition of Lean as a strategy that works best in market environments that have relatively stable, predictable demand and with low variety (Nel and Badenhorst-Weiss, 2012: 192). Agile in contrast, can be defined as a strategy that works best in market environments where demand is volatile and customer variety requirements are high (Bottani, 2010: 251; Christopher and Towill, 2000: 212; Elkins, Huang and Alden, 2003: 201; Faisal, Banwet and Shankar, 2006: 884; Hallgren and Olhager, 2009: 987; Yusuf *et al*., 1999: 36). Gunasekaran (1999b: 1) suggested that Agile manufacturing is driven by customer designed products and services, in a competitive market that experiences continuous and unpredictable change. Tseng and Lin (2011: 3693) agreed and indicated that the Agile concept deals with a twenty first century market environment, where increased numbers of products and services, shortened product life cycles and increased rates of product innovation are becoming a necessity.

Naylor *et al*. (1999: 108) further defined Agility as making use of market knowledge and virtual organisations to exploit volatile markets and the profitable opportunities that they may present. Naim and Gosling (2011: 343) concurred with this view. Yusuf *et al*. (1999: 33) contributed the recognition that Agile is facilitated by communication, technology and the previous paradigms of manufacturing which are embedded within Lean and JIT production systems. Agile production is sometimes simply defined as the ability to be

"first, fast and best" (Kisperska-Moron and de Haan, 2011: 128; Yusuf, Ganasekaran, Adeleye and Sivayoganathan, 2004: 379). As a result, companies are reviewing their traditional methods of operations and moving towards modern methods and models that target delivery times to deal with the fluctuating flow of high and low demands (Tseng and Lin, 2011: 3693).

Yusuf *et al*. (1999: 35) argued that equating Agile with one factor such as "just speed of response" or "flexibility" is a narrow understanding of what constitutes the Agile paradigm. For the purposes of this study, the focus will be on Gunasekaran's (1999a: 87) notion of Agility. The author suggested casting off of outdated ways of manufacturing goods which are no longer appropriate and changing the pattern from traditional operations to modern practices. Furthermore Gunasekaran's (1999a: 87) views were holistic, taking into account the entirety of an Agile manufacturing strategy in stating that it is not about small scale continuous improvement which constitutes a Lean strategy but a whole new way of doing business. Building on the above views Christopher and Towill (2000: 207) explained that it is no longer businesses competing but their supply chains, thereby emphasizing the need for Agile manufacturing to respond to the needs of the end customer.

2.2.2. Differences between Lean and Agile

Krishnamurthy and Yauch (2007: 588) found that Agile and Lean have distinct differences that are not entirely compatible. They used the example of inventory, which is required to maintain service levels in Agile but is unwanted in Lean strategies. Supporting this view Nel and Badenhorst-Weiss (2012: 196) suggested that firms need to make strategic decisions regarding the trade-off's involving responsiveness and efficiency within inventory management.

Bottani (2010: 254) conducted research into developing clusters to elucidate the differences between the characteristics of Agile and Lean. Cluster One was Agile and had the capability of responding flexibly to unexpected change. Cluster Two were those companies that measured performance against cost reduction, an important characteristics of Lean. Her analysis of the data obtained of 190 companies found that that Agile companies scored higher than Lean companies in speed, quality and flexibility.

In studies conducted by Agarwal *et al*. (2006: 213) and Christopher and Towill (2000: 206) the authors used four categories to distinguish market winners and qualifiers. They described Agility as dependent upon service levels and lead time as a market winner whereas Lean was dependent on cost and quality the market winner. These categories of market winners are in direct relation to Bottani's (2010: 254) clusters mentioned above and essentially work towards the same goals.

In their study Inman, Sale, Green and Whitten (2011: 343) indicated a difference in that Lean and TQM principles cut costs and increase efficiency but in doing some competitive advantages have been lost. The most important advantage that has been lost is the ability to respond to change, which is essential to Agility (Inman *et al*., 2011: 343). Huang and Li (2010: 63) attributed these losses to early stage development, where Lean focused on decreasing costs and resources while Agile focused on a reconfigurable production process without trading off on cost controls.

Naylor *et al*. (1999: 112) drew attention to the business environment as a difference. Agile manufacturing must be able to operate in conditions which contain demand variations and disturbances therefore requiring it to be robust. However Lean avoids robustness in calling for stability of demand by simplifying the supply chain. In agreement with this view Christopher and Towill (2001: 238) determined that the best strategy to follow under Lean is cost leadership and under Agile is differentiation with the highest level of service offered.

A key difference that sets an Agile strategy apart from a Lean strategy, is that under Agile the elimination of waste becomes a low priority and responsiveness becomes a high priority (Harrison and Van Hoek, 2011: 222). Harrison and Van Hoek (2011: 222) showed that the key is to find which target market suits a business's manufacturing capabilities (see Table 2.4 at the end of the chapter). Similarly, Hallgren and Olhager (2009: 980) concluded that an operation's characteristics influence the choice of competitive strategy.

In studies conducted by Inman *et al*. (2011: 349) the authors concluded that Agility improves operational performance and this can be a motivational factor to move from Lean to Agile manufacturing. However Agarwal *et al*. (2006: 212) found requirements that are vital when moving from Lean to Agility as a supply chain strategy which include:

dependency on information, knowledge, and appropriate positioning of the decoupling point.

2.2.3. Similarities between Lean and Agile

While there are many authors that point out differences between Lean and Agile there equally many that agree on similarities. Kisperska-Moron and de Haan (2011: 127) examined both Lean and Agile as strategies having common goals, with both aiming for competitiveness and flexibility, but achieving it in different ways. Christopher and Towill (2001: 241) evaluated both paradigms and pointed out that a factor such as reducing cycle time is a major goal in Lean, however it is merely a single pillar of Agile. They were in agreement with other authors that Agile is compatible with TQM, JIT, and Lean production (Christopher, 2000: 43: Mason-Jones, Naylor and Towill, 2000: 4068; Yusuf *et al*., 1999: 36). Christopher and Towill (2001: 239) supported the general consensus that both Agile and Lean demand high levels of product quality, in Lean as a foundational principle and in Agile as a facilitating factor.

Gunasekaran (1999a: 87) asserted that Agility originates from Lean, more specifically Lean flexible systems. In the studies conducted by Inman *et al*. (2011: 343) the focus was on describing relationships between Lean, JIT and Agile. The authors described JIT as one of four "bundles" comprising Lean production, along with TQM, TPM and Human Resources Management. From the four bundles, ten measurements arose: six out of the ten belong to JIT principles. Of these, three belong to JIT purchasing and three belong to JIT production (Inman *et al*., 2011: 343). JIT purchasing and JIT production are described as precursors to Agility (Krishnamurthy and Yauch, 2007: 594; Yusuf *et al*., 2004: 381). Therefore the above authors concurred that Lean is related to JIT and JIT is related to Agility.

Ward and Zhou (2006: 181) agree with the views of Inman *et al*. (2011: 343) by explaining the relationship of JIT and Lean. The authors highlighting how JIT production focusses on identification and elimination of all forms of waste which encompasses the seven wastes of Lean. Yusuf *et al*. (2004: 381) describes JIT purchasing as a set of techniques and concepts used to target and eliminate waste from the purchasing process. The authors identified the following as necessities in eliminating wastes: increasing frequency of delivery, small lot sizes, nearby suppliers, information sharing, VMI,

process design, ESI and supplier education. The authors add that using JIT production and JIT purchasing leads to a JIT strategy, with the potential to facilitate Agile manufacturing (Inman *et al*., 2011: 344). Therefore Agility can be developed on lessons learned from JIT, Lean and TQM. Agile is the modern trend in a continuum that started from mass production to Lean, to JIT and now Agile.

Qrunfleh and Tarafdar (2014: 343) were in agreement with Ward and Zhou (2006: 181) in finding that the integration of supply chains can be done via information sharing. They explain that this will lead to a reduction in lead time and suggest that Lean and JIT practices directly affect lead time in a positive manner which implies that Lean and JIT positively affects Agile. Hallgren and Olhager (2009: 978) highlighted five similarities of Lean and Agile manufacturing. These are elimination of waste, reduction of setup times, continuous improvement, the use of the 5S's (Sort, set in order, shine, standardize, sustain) and other quality improvement tools.

Hallgren and Olhager (2009: 978) proposed a practical method whereby Lean and Agile business can co-exist. They describe the use of a Pareto curve to segregate products to determine which ones are the most profitable. They then used a decoupling point approach, to determine where strategic inventory is needed and lastly the product is only completed when exact customer requirements are known. This strategy is examined further under Leagility.

Qrunfleh and Tarafdar's (2014: 341) contribution is that the same information systems that are used to achieve flexible capabilities in Lean can be implemented in Agile. The authors cautioned that this remains situation specific and the systems may need adjustments to suit an Agile environment. Hallgren and Olhager (2009: 980) concluded their study by confirming the assumption that Lean and Agile have more similarities than differences and that the differences have no significant impact on performance.

Naim and Gosling (2011: 343) described the Agile manufacturing as rapid reconfiguration with as much waste elimination as possible, similar to that present in Lean. However all waste elimination is not a pre-requisite of Agile. Lean manufacturing requires the elimination of all waste (non-value-adding activities) and tries to attain as much flexibility as possible. However, flexibility is not a pre-requisite to Lean but is essential to Agile (Naim and Gosling, 2011: 343; Krishnamurthy and Yauch, 2007: 590).

Naylor *et al*. (1999: 110) contributed to the above discussion by stating that both Lean and Agile seek to eliminate wastes (Muda) and strive for reconfiguration capabilities, but that Agile requires reconfiguration to maintain service levels but Lean requires it for changing products quickly to decrease time wastage.

Furthermore, Naylor *et al*. (1999: 110) stated that there are three characteristics that are present in both Agile and Lean foundations. These comprise: the use of market knowledge, lead time compression and integrating the supply chain to create value.

2.2.4. Theories of Lean and Agile

Studies conducted by Inman *et al*. (2011: 344) found that there are three mind-sets of the Lean-Agile relationship. The first mind-set conveys that they are mutually exclusive; the second mind-set conveys that they are mutually supportive and the last mind-set conveys that Leanness is a precursor to Agility (Inman *et al*., 2011: 344). Their study embeds the notion that implementing JIT production (to reduce wastes) and JIT purchasing (to increase flexibility), displays the reasoning of the three mind sets within the Lean-Agile relationship. The results of their study demonstrate the vital relationship that JIT plays in bridging the gap in the continuum of Lean-Agile.

When discussions arise around the Lean and Agile topic, divergence becomes a central topic. Concerns arise such as Lean seeking to reduce inventory-on-hand whereas Agile may require more inventory-on-hand to maintain service levels (Qrunfleh and Tarafdar, 2014: 344; Vazquez-Bustelo and Avella, 2006: 1154). However Naylor *et al*. (1999: 108) argued that it is a too simplistic a view to look at the development in Lean and Agile in isolation and that choosing one or the other would be a mistake. The authors indicate that Leanness and Agility is dependent on the total supply chain strategy with the key difference between the two strategies coming in to play at the decoupling point where the supply chain changes from one strategy to the other (Naylor *et al*., 1999: 108).

Gunasekaran (1999b: 3) and supporting authors create the view that Agile manufacturing aims to enrich the customer by co-operating with suppliers and competitors. The authors suggest that a competitive advantage can be obtained by organising the supply chain to manage change, uncertainty and complexity. In addition they call for simplification in delivering the final product and finally leveraging people and information to align the

competitive advantage (Gunasekaran, 1999b: 3; Kannan and Tan, 2005: 157; Krishnamurthy and Yauch, 2007: 589; Yusuf *et al*., 2004: 382).

2.2.5. Implementation and preconditions of Agility

Yusuf *et al*. (1999: 33) introduced the view that "an in-depth understanding of modern manufacturing is required to set a proper agenda for strategic implementation of Agile". Faisal *et al*. (2006: 879) indicated that the selection of a supply chain strategy cannot be made with a simplistic perception of what is right for the situation but is rather dependent on many factors. The main factors include product type and market conditions.

Yusuf *et al*. (1999: 33) added support to this view by highlighting various factors that modern manufacturing needs to consider such as adjustments in: automation, price/cost levels, aligning competitive priorities and integration of the supply chain to achieve manufacturing synergy. In relation to the three mind sets of Inman *et al*. (2011: 344) mentioned earlier, Mason-Jones *et al*. (2000: 4064) introduced the view that after a company achieves Leanness, the next logical step is Agility and suggests that Lean is a precursor to Agile. Yusuf *et al*. (1999: 35) suggested that this step wise improvement towards Agile concepts can prove successful in organisations that can show foresight, adaptability and response to change.

Tseng and Lin (2011: 3697) proposed that the requirement for the implementation of Agile production systems stems from change. They argue that there is nothing new about change, however the rate at which change is occurring is faster than before. An apt parallel of the above is Moore's law, where Moore identified that the computing power of a computer chip doubles every 18 months (Spinelli and Adams, 2012: 132). With the introduction of smart phones it is evident that even this law underestimates the rate of change and modern manufacturing faces an environment that follows this trend.

It is in this context that Tseng and Lin (2011: 3698) described a conceptual model that illustrates the development of an Agile house which provides a framework for the implementation of an agile strategy (see Figure 2.3).

Tseng and Lin (2011: 3694) stressed the importance of building or implementing an agile system from the ground up in a similar manner to building the foundations of a house. They indicated that for the proper implementation of Agility, there must be integrated

procedures within the business to ensure that the Agility providers meet Agility capabilities. In contrast to the conceptual model of Tseng and Lin (2011: 3694), Vazquez-Bustelo and Avella (2006: 1151) identified a project management strategy to deal with changing situations and offered flexibility in the implementation process. However they still cited the three key elements in the development and implementation of Agile, which are motivators (drivers), facilitators (enablers), and providers (pillars) which results in an Agile strategy. These coincide with elements of the model of Tseng and Lin (2011: 3694).

Leading authors agree that one of the most important factors in strategy selection of Lean, JIT or Agile is product classification, that is, determining if the product is, for example, a Fashion product or a Commodity (Christopher and Towill, 2001: 240; Kisperska-Moron and de Haan, 2011:133; Mason-Jones *et al*, 2000: 4063). Christopher and Towill (2001: 239) further proposed that supply chain lead times and volatility dictate the supply chain strategy to be implemented.

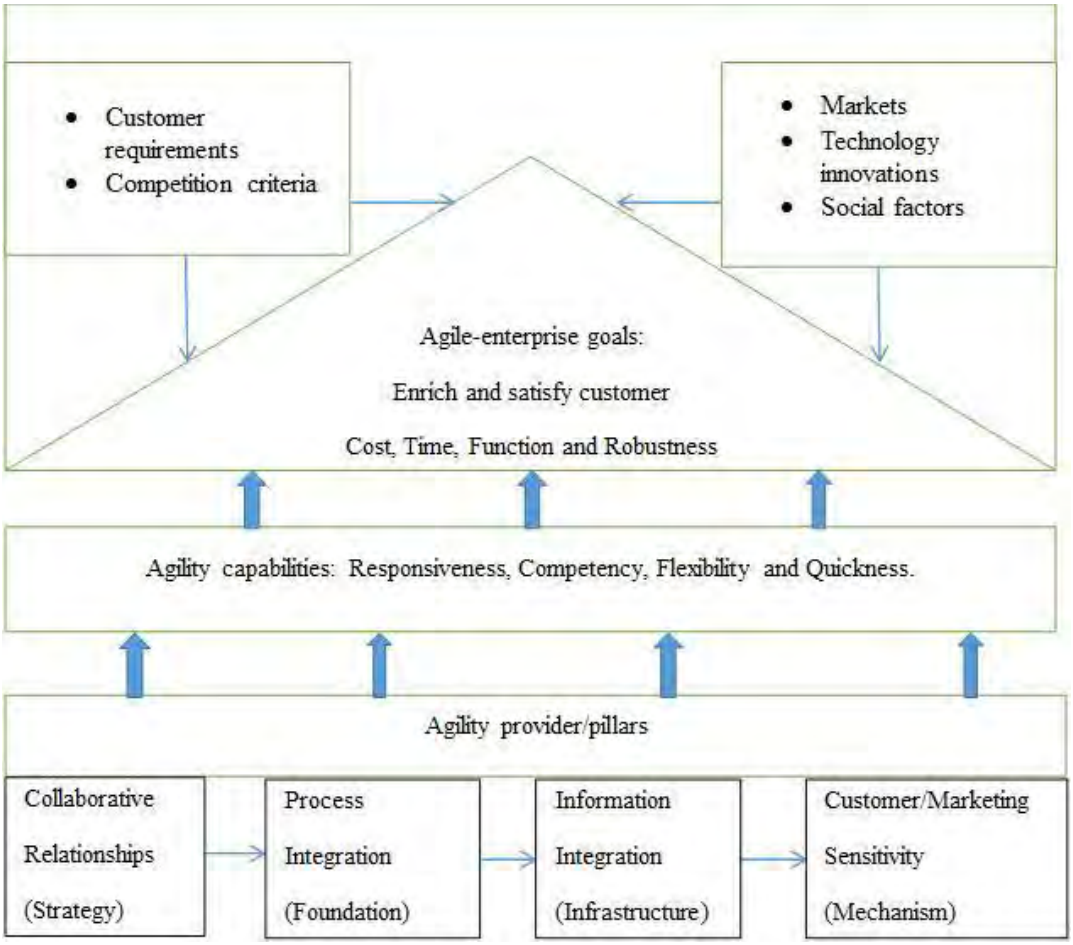

Figure 2.3: Tseng and Lin's conceptual model of an agile enterprise

(Source: Tseng and Lin, 2011: 3698)

Vazquez-Bustelo and Avella (2006: 1157) were of the view that the key to success in implementation of the correct strategy is the company's ability to change strategy according to what stage the product is on its life cycle. Kisperska-Moron and de Haan (2011: 134) suggested that the strategy of Agility can be used for new product development, subsequently Lean to level out the production in mature markets. Naylor *et al*. (1999: 112) also emphasised the importance of choosing the right strategy to implement. The authors use the example of Boeing, where the company implemented Lean systems in an Agile environment and failed to meet demand as the market environment was highly volatile.

2.3. Agility drivers

Within their study Tseng and Lin (2011: 3698) highlighted five drivers of Agility: customer requirements, competition criteria, markets, technology innovators, and social factors that influence the roof of Agile in Figure 2.3. This concept was supported by Vazquez-Bustelo and Avella (2006: 1157) as well as Agarwal *et al*. (2006: 214) who named four similar fundamental Agile manufacturing drivers: customer enrichment, co-operation between firms in the supply chain to increase competitiveness, mastering change and uncertainty and finally leveraging the impact of information and people.

2.3.1. Customer requirements

Tseng and Lin (2011: 3697) identified an increase in customer expectations. The authors attributed this to increases in product customization, quality and the requirement for quicker delivery times. This trend is supported by Bottani's study (2010: 255) which indicated that among Agility drivers "changes in customer needs" represented one of the main motivators or drivers of the need for manufacturing to become Agile. Therefore customer requirements can be seen as one of the main drivers and possibly the most important of drivers of Agility.

2.3.2. Classification and competition criteria

Harrison and Van Hoek (2011: 241) were of the view that there is a need to classify products according to areas which are appropriate for either Lean practices or Agile practices. They advised that classification leads to the correct strategy selection for production, whether Lean or Agile (Harrison and Van Hoek, 2011: 241). The authors

recommended that companies with multiple products on offer should conduct product classification to ensure that the right manufacturing process is selected for a particular product (Harrison and Van Hoek, 2011: 241).

Classification and competition criteria go hand in hand: once a product has been classified for production strategy, a company can leverage that competitive advantage. Yusuf *et al*. (1999: 38) and Krishnamurthy and Yauch (2007: 593) described the next step in moving classification into a competitive advantage within the four key concepts of Agile competition. Namely, competition based on core competency management, virtual enterprise formation, capability for reconfiguration and knowledge driven enterprises.

2.3.3. Market conditions

According to Mason-Jones *et al*. (2000: 4061) the market place environment will determine the success and failure of the business. In agreement with this view Bottani (2010: 251) identified that change can come from market place, competition, social factors, technology and most of all customer requirements. These factors indicate the level of Agility required. Bottani's (2010: 251) study highlights the main reason for companies to make a change to Agile strategies is "change" in itself.

With regard to changing markets, Tseng and Lin's (2011: 3697) study focused on the increasing demand for new products and shorter life cycles of products as factors that are continuously creating new niche markets which ultimately create demand volatility. Agarwal *et al*. (2006: 214) suggested ways of mitigating demand volatility by identifying six areas in which to measure and respond to market sensitivity: delivery speed, delivery reliability, new product introduction, new product development time, manufacturing lead time and customer responsiveness. Hallgren and Olhager (2009: 980) noted that companies need to continuously improve the operational capabilities to stay abreast of change.

Although the six areas provide a framework within which to tackle demand volatility, Faisal *et al*. (2006: 879) pointed out that it is becoming harder to generalise customer traits in the modern environment, therefore making it harder to manage variety and quantity in manufacturing. Bottani (2010: 251) agreed that "response to unpredictable change" was the most important variable in defining an Agile strategy.

Vazquez-Bustelo and Avella (2006: 1154) pointed out that opportunities and threats dictate the firm's need for resources and capabilities; successful organisations are the ones that are best adapted to their environments. Similarly, Huang and Li's (2010: 63) recognised that change is a major cause of losses for manufacturing companies. Various authors cited trends of modern manufacturing requirements, where companies are required to produce products at lower cost, higher quality and with decreasing lead times. Additionally they must remain proactive and innovative (Christopher and Towill, 2000: 208; Lin and Tseng, 2011: 3697; Yusuf *et al*., 1999: 35).

According to Naylor *et al*. (1999: 108) reductions in lead times lead to increases in risk where this year's order winners may become next year's mere order qualifiers. In agreement with the above view Christopher and Towill (2001: 242) and Tseng and Lin (2011: 3694) described a cyclical nature of order winners and order qualifiers where key characteristics change from cost leadership to differentiation of service levels and back over time.

2.3.4. Technological innovations

In his study Gunasekaran (1999b: 2) emphasised the need for information technology to facilitate Agile manufacturing systems. He indicated that technology plays a key role in Agility and its pillars. Yusuf *et al*. (2004: 381) identified a challenge in that technological requirements for a manufacturing facility are continuously evolving. These authors showed that newer and incrementally more efficient production processes are required to keep abreast of technological requirements in product design. Stratton and Warburton (2003: 187) added to the complexity in suggesting that there are strategic trade-offs associated with manufacturing investment. The customers and markets need to be evaluated to determine the technology levels required (Stratton and Warburton, 2003: 187).

Many authors have identified that technology plays a key role in a supply chain becoming Agile and that one of the most important technology facilitators is that of EDI (Vinodh and Aravindraj, 2012: 1186; Qrunfleh and Tarafdar, 2014: 340). These authors found that the implementation of information systems leads to better relationships with customers and suppliers, as well as increases flexibility which results in better supply chain performance. Similar to the views of Stratton and Warburton (2003: 187) mentioned

above, Qrunfleh and Tarafdar (2014: 340) highlighted a requirement in monitoring technology requirements, to ensure a smooth running process in the long run. Furthermore, fellow authors Faisal *et al*. (2006: 880) and Christopher (2000: 39) indicated that firms have little control over external disruptions but can control internal disruptions through the integration of suppliers using IT.

After assessing the requirements and speciation's of the four key Agility drivers the next step is to determine the Agile-enterprise goals.

2.4. Agile enterprise goals

In his study Gunasekaran (1999b: 3) defined Agile enterprise goals as using market knowledge and a virtual corporation to exploit profitable opportunities in a volatile market place. Tseng and Lin (2011: 3698) discussed how Agile enterprise goals assist firms to achieve this by enriching and satisfying customers with regards to cost, time and function, and enhancing the robustness of the company. This requires a reduction in lead time within the entire supply chain coupled with a reduction in information lead times, resulting in information enriched supply chains (Gunasekaran, 1999b: 3).

Huang and Li (2010: 66) described an eight step action plan used to attain Agile enterprise goals: 1) Synchronise operations, 2) Implement VMI, 3) Improve management, 4) Develop cross functional teams, 5) Ensure visibility of real demand, 6) Implement continuous replenishment of inventory levels, 7) Reduce waste and 8) Reduce the Pipeline. In using the eight steps, the results of their study showed significant improvements within a company's supply chain as a whole and alignment with Agile enterprise goals (Huang and Li, 2010; 66). This demonstrated how Agile enterprise goals lead guide the implementation of appropriate production systems.

According to Gunasekaran (1999b: 2) Lean and JIT manufacturing systems have the ability to bring production under improved control. However, t hese systems lack the ability to use equipment in different ways and thus are characterised by their lack of robustness and lack of flexibility. It is systems like these, which do not contribute to the move to Agile. Companies that cannot invest in flexible manufacturing systems will suffer in an environment demanding Agility (Gunasekaran, 1999b: 3).

In agreement with the views of Gunasekaran (1999b: 3) studies by Elkins *et al*. (2004: 204) identified business environments that dictate the use of Lean or Agile production systems. They indicate that dedicated Lean systems are favoured by demand of high volume production and low capital investment but render the production process inflexible. Agile is favoured by uncertain future demands and requires the re-use of equipment; this set a context to determine which production system firms fall into (Elkins *et al*., 2004: 208).

Once the goals have been set and the appropriate production system is selected then the parameters of the production system need to be identified within its Agile capabilities.

2.5. Agility capabilities

According to Tseng and Lin (2011: 3698) there are four key areas that comprise a company's Agile capabilities, which include: quickness, competency, flexibility and responsiveness within its supply chain. Building on this view Yusuf *et al*. (1999: 35) indicated that Agile manufacturing requires synergy, where focusing on just one area will not gain a competitive advantage. In agreement Christopher and Towill (2000: 207) have developed a mathematical model equation "TOTAL VALUE = (QUALITY * SERVICE LEVEL)/ (COST * LEAD-TIME)" to demonstration that improving one area at the expense of another is futile. However contrasting views by Yusuf *et al*. (1999: 35) single out speed as one of the most important factors supported by flexibility.

2.5.1. Quickness / Lead time

Speed is a supply chain's ability to deliver a product in the shortest possible time with consideration given to beating competitors to the market, according to Tseng and Lin (2011: 3698).

2.5.2. Competency / quality and cost

Tseng and Lin (2011: 3698) defined competency as how efficiently and effectively a supply chain can deliver on its promises. According to Naim and Gosling (2011: 343) the competencies of both Lean and Agile place emphasis on quality and lead time. They suggest that the difference is in cost, where Agility places less emphasis on efficiency and Lean places less emphasis on customization.

2.5.3. Flexibility

Tseng and Lin (2011: 3698) define flexibility as utilising the same facility to initiate different processes in changing market requirements to satisfy the customer. Krishnamurthy and Yauch (2007: 590) supported this theory and specify flexibility as using the same production line for different products. In their study Christopher and Towill (2000: 206) identified flexibility as a key characteristic of Agile systems. In studies conducted by Vazquez-Bustelo and Avella (2006: 1154) and Naim and Gosling (2011: 343) the authors cautioned that there needs to be a gradual incorporation of flexible manufacturing to increase speed and flexibility. Krishnamurthy and Yauch (2007: 591) recognised that flexibility requires heavy capital investment in equipment and therefore the correct levels of flexibility need to be determined first.

According to Elkins *et al*. (2004: 201) the level of equipment reusability is directly linked to flexible manufacturing systems; however Agile systems differ from flexible systems in that they adapt rapidly and cost effectively. Agarwal *et al*. (2006: 213) and his fellow authors noted variables that affect reusability are market sensitivity, process integration, and the information drivers. Elkins *et al*. (2004: 201) designed Agile and reconfigurable manufacturing systems that can support product flexibility, volume flexibility and general equipment reusability. Agarwal *et al*. (2006: 214) identified that automation increases flexibility by reducing set-up times. The challenge is how fast and how far a supply chain can change its speed, destination and volumes to increase supply chain Agility.

2.5.4. Responsiveness / Service

Responsiveness in the context of manufacturing is defined as the ability to identify changes and respond to those changes fast, efficiently and effectively to exploit the opportunity (Tseng and Lin, 2011: 3698). Krishnamurthy and Yauch (2007: 593) demonstrated how decentralizing production processes over different business units helps to improve responsiveness as smaller units are able to reconfigure more quickly. Therefore they reached the conclusion that smaller businesses are better at implementing Lean, Agile and Leagile systems.

In responding to the above requirements Krishnamurthy and Yauch (2007: 597) and Mason-Jones *et al*. (2000: 4064) showed how manufacturing companies offer their services strategically by categorizing customers into regular and premium customers.

They reserve a part of total capacity for premium customers in order to respond to their irregular demands.

2.5.5. Protective capacity and protective inventory

Stratton and Warburton (2003: 188) described protective capacity as central and shared capacity which can be reallocated to bottleneck points to relieve constraints. There is always variation in the system due to various factors such as machine failure, process adjustment, and quality problems. The authors put forward that it is these factors that reinforce the need for protective capacity (Stratton and Warburton, 2003: 188). It may be beneficial to conduct research which investigates the consequence that protective capacity has on Agility.

Krishnamurthy and Yauch (2007: 598) identified activity based costing (ABC) inventory as a tool to streamline forecasting in order to deal with variation as an alternative to protective capacity. Stratton and Warburton (2003: 190) disagreed with this view and advocated that inventory be used as a buffer to protect against variations. However, an alternative is investing in additional capacity. Thus the concept of protective capacity replaces protective inventory to enable stable flow (Stratton and Warburton, 2003: 191).

Naylor *et al*. (1999: 111) proposed that there should be a minimum reasonable inventory (MRI) level that will offer a safety-net which is essential in Agile operations to maintain capacity and robustness. Christopher and Towill (2000: 206) were in agreement with these views and they indicated that the use of MRI provides a practical approach in Agile manufacturing. Faisal *et al*. (2006: 881) supported the idea of MRI but also stressed the importance of information sharing and transparency which leads to a reduction in risk associated with inventory holding and supplier failure.

Stratton and Warburton (2003: 194) developed a sharing capacity strategy where Company A reserves capacity in Company B. They recognised a critical factor for success in that Company A needs to find something to utilise the reserved additional capacity in Company B when this capacity is not being used for its intended purpose and would stand idle. If this reserved capacity was not used for certain periods the relationship would not be cost effective for both parties and the partnership could not exist (Stratton and Warburton, 2003: 194). The authors encountered a solution in occasionally changing the

assigned capacity during periods of low demand to be used for alternative items carrying a low inventory risk and hence to keep the option of additional capacity on hand should demand for high risk items suddenly increase (Stratton and Warburton, 2003: 195). This strategy requires long-term relationships where there is a designated minimum level of work allocated to the supplier in return for maintaining the protective capacity (Stratton and Warburton, 2003: 195).

In their study Kim, Cox and Mabin (2010: 4155) also identified these two forms of protection against uncertainty in manufacturing; protective capacity and protective inventory. They indicate that protective capacity helps tackle cycle time and lowers the requirement for work-in-process (WIP) inventory, whereas protective inventory is used as a failsafe when capacity is not enough (Kim, *et al*., 2010: 4154).

The authors concluded their study by confirming that in both cases excessive inventory or capacity is undesirable and idle capacity or inventory must be justified according to customer need (Kim, *et al*., 2010: 4156). A clear lesson to be learnt from studies by Kim *et al*. (2010: 4157) is that there are trade-offs that develop when implementing one or the other and if they are used in a combination strategy then a better system will arise.

Stratton and Warburton (2003: 194) developed a sub-strategy in their study of using two different manufacturers, one local and one off-shore and leveraging their capacity to level output and stabilise production during unstable market conditions. Similarly, Christopher and Towill (2001: 241) expose a strategy of using “base” and “surge” demands to allocate production to offshore and local suppliers respectively. This creates the ability to react fast. However, it requires an accurate forecast and determination of which products are stable and which are volatile in order to allocate capacity accordingly (Stratton and Warburton, 2003: 194).

After monitoring the business environment and determining the required levels of speed, competency, flexibility and responsiveness that encompass Agile capabilities. It is vital to ensure that there are strong Agility providers set in place, as it these pillars that set the foundation for daily activities within an Agile manufacturing strategy. This top down approach ends with the overview of ten imperative areas to any manufacturing firm wishing to pursue the Agile paradigm. It is these foundational pillars that will make or break an Agile strategy.

2.6. Agility providers / pillars /enablers

According to Vazquez-Bustelo and Avella (2006: 1154), manufacturing firms need to implement appropriate Agility enablers, which are most suitable for their specific environment. The authors suggested that these firms need to review their own strategies, objectives, practices, methods and or tools. Pioneering authors of Agility such as Gunasekaran (1999b: 1) brought to light enabling technologies which are important to success in Agile strategies. These included standard for the exchange of products (STEP), concurrent engineering, virtual manufacturing and information and communication infrastructure. Another pioneer of the Agile paradigm Yusuf *et al*. (1999: 33) suggested that integration and productivity are key factors within Agility. Knowing customer needs aids a manufacturer to develop capabilities just ahead of need, in order to effectively and efficiently serve customers (Yusuf *et al*., 1999: 33).

Similarly, Vinodh and Aravindraj (2012: 1188) noted that there are five main enablers that that encompass the Agile paradigm. These are a virtual organisation, collaborative relationships, strategic management, knowledge and IT management and customer and market sensitiveness. In agreement with these views, Christopher and Towill (2001: 243) proposed that these five factors work together to achieve rapid replenishment and identified a further key factor, in stating that this will not be possible without good organisational culture. Organisational culture has been identified as one of the biggest barriers to change. Vazquez-Bustelo and Avella (2006: 1156) stated that there needs to be integration of human resources, information technology and systems, internal organisation, external relations, knowledge management and learning.

2.6.1. Collaborative relationships

According to Nel and Badenhorst-Weiss (2012: 190) it is important for companies to create and develop new business relationships in order to attain a competitive advantage. These relationships can be beneficial to any business strategy and not restricted to the Lean and Agile paradigms. In his study Gunasekaran (1999a: 89) develops Agile relationships within partnership selection criteria. He describes three distinct levels which are: pre-qualifying partners, evaluating products to assign them to the capabilities of their company's core competencies and then selecting the optimal set to begin manufacturing of the product. An alternative method described by Pan and Nagi (2010: 679) described

the selection of supply chain partners. The authors suggest using one company from each level in the supply chain, starting from manufacturing, warehousing, wholesalers, and distributors through to retailers. Thus Agile manufacturing combines the strengths of all its supply chain partners to meet uncertain market demand (Gunasekaran, 1999a: 89).

According to Yusuf *et al*. (1999: 36) Agility requires the ability to quickly satisfy orders with the combined capacity of partners and competitors, where a company needs to develop the ability to get in and out of strategic alliances speedily. Similarly, Vazquez-Bustelo and Avella (2006: 1151) recommended the use of strategic temporary alliances with competitors to share resources and to develop a competitive advantage. Gunasekaran (1999a: 89) indicated that temporary alliances or partnerships based on core competencies can help improve flexibility and responsiveness of an organisation.

Yusuf *et al*. (1999:36) suggested that a higher level of Agility can be obtained through collaborative relationships in combining resources within joint ventures to maximise the synergies of cooperation. However, the presence of collaborative relationships is not enough and performance measures need to be in place to monitor these relationships (Hallgren and Olhager, 2009: 988; Christopher, 2000: 42). Santiago (2012: 32) emphasized collaboration and cohesion with suppliers including early supplier involvement which leads to better information sharing and facilitates an Agile or hybrid system.

Yusuf *et al*. (2004: 390) viewed Agile manufacturing holistically, where Agile requires meeting changing market requirements by developing suitable alliances based on core competencies in leveraging people and information.

Bottani (2010: 255) found that an important variable within her study was “close supplier relationship” with the emphasis on a trust-based relationship with customers and suppliers. Faisal *et al*. (2006: 881) agreed with the fact that trust is important and points out that it increases supplier commitment. However a key contribution by Faisal *et al*. (2006: 881) was to emphasise that relationships need to be negotiated and rewards and burdens must be shared accordingly.

Benefits identified by Christopher and Towill (2001: 244) were that aiding suppliers in their process leads to them enhancing their service levels and results in better service

delivery from the manufacturing company to the end user. In an earlier study by Christopher and Towill (2000: 208) the authors recognised that network competition is becoming increasingly popular as rewards go to organisations that structure, coordinate and manage supply chain partner relationships by focusing on the end user.

2.6.2. Risks associated with networking

Risk and uncertainty is present in any supply chain decision involving movement from Lean to Agile or Leagile systems as it can prove costly to implement. However, it can be an opportunity which proves to be extremely profitable (Pearson, 2013: 10). According to Pearson (2013: 12) there are five main areas of risk, namely: physical, financial, informational, relational and innovation risks. Faisal *et al*. (2006: 880) added to the understanding of informational risk by identifying that risks arise in the process of sharing inventory levels and production schedules, as well as from seasonality and short product life cycles. The authors suggests this is an indication that risk factors are both predictable and unpredictable and the quest to become Agile increases the chance of risk (Faisal *et al*., 2006: 880).

In their study Faisal *et al*. (2006: 879) found that as partnering firms take advantage of leveraging each other's core competencies they need to also consider managing risks. Similarly, Pearson (2013: 12) indicated that Agility comes with a certain amount of risk and one of these risks is ensuring continuous supply; therefore supplier contingencies have to be in place. In agreement with the above views Faisal *et al*. (2006: 880) and Pearson (2013: 12) proposed that decreasing the number of suppliers dealt with can be risky in the form of dependence but can prove beneficial in the control of information and intellectual property. However, Faisal *et al*. (2006: 879) recommended that when it comes to information sharing supply chain risk management needs to be in place, where information, materials and money are closely monitored across the supply chain.

2.6.3. Process integration / selection and production process

The main focus of studies conducted by Tseng and Lin (2011: 3698) was on process integration in forming a business's foundation. The authors suggested that the aim of Agility is to integrate all business processes to deal with changes in the business environment and to capture market opportunities in order to create business value (Tseng and Lin, 2011: 3698). Yusuf *et al*. (1999: 38) and his fellow authors identified the benefits

of integration of internal processes, functions and technologies. The authors indicate that integration leads to superior competitive advantages such as responsiveness, increased customer service levels, faster new product introduction and quality improvement (Yusuf *et al*., 1999: 38).

Kisperska-Moron and De Haan (2011: 132) added that process integration can be achieved by integrating information systems throughout the supply chain. Tseng and Lin (2011: 3701) advised that process integration can be regulated by implementing appropriate policies, standard operating procedures (SOP) and a business structure which promotes an organisational culture of working together as a unit. Kisperska-Moron and de Haan (2011: 132) identified that processes must meet the demand of the final customer and have to be correctly sequenced and synchronized.

Vazquez-Bustelo and Avella (2006: 1148) provided insight to the three basics required for Agile manufacturing and the need for them to be integrated and co-ordinated. The three basics that the authors developed include, firstly becoming an innovative organisation, secondly motivating and empowering human resources, and thirdly attaining flexibility through technology (Vazquez-Bustel and Avella, 2006; 1148). Confirming this view Huang and Li (2010: 64) stated that Agility requires integrated, flexible technologies with highly skilled employees, with an organisation that promotes cooperation with both internal and external relationships of the company. Huang and Li (2010: 66) showed in their case study how process integration can be achieved with an example of Taiwanese manufacturers using build to order (BTO) or Configure to order (CTO) strategies coupled with Taiwanese direct shipment to achieve a formidable competitive advantage.

In agreement with the views of Huang and Li (2010: 66), Faisal *et al*. (2006: 882) and Emuze (2013: 14) indicated that BTO and CTO are correct strategies to follow in an Agile supply chain where inventory needs to be held as work in process awaiting final customer requirements. Pan and Nagi (2010: 669) identified that a make-to-order strategy suits Agile and advocated the use of parallel machines as opposed to single machines to reduce production time and to combat bottlenecks. Supporting views by Vazquez-Bustelo and Avella (2006: 1155) found that the use of concurrent operations and grouping of resources can reduce the time in new product development and introduction to the market.

The following authors describe how process integration can achieve competitive advantages. Vazques-Bustelo and Avella (2006: 1154) suggested work cells, which create flexible and cross-trained employees who control their own work, leading to higher productivity. Yusuf *et al*. (1999: 38) highlighted the advantages of delayed design or postponement in the production process, allowing for last minute changes where customers can dictate specifications shortly before the final product is completed. In agreement with the views of Yusuf *et al*. (1999: 38) Vazquez-Bustelo and Avella (2006: 1152) identified a disintegration strategy which means that the focal business no longer produces the entire unit but just a few main core parts which are sent off to partnering business units for completion. John Deere's current manufacturing process is an example of this strategy.

John Deere's' production system combines concurrent operations, reduced set-up times, the implementation of cellular factory manufacturing, utilisation of pull Kanbans and development of human resources as key factors in Agility (Vazques-Bustelo and Avella, 2006: 1152). In their investigation of John Deere, the authors noted the emphasis on integration of information systems and use of EDI, internet, computer-aided design (CAD) / computer-aided manufacturing (CAM), flexible manufacturing systems (FMS) and robotics to bring the manufacturing processes towards Agility (Vazques-Bustelo and Avella, 2006: 1153). These authors suggested that all of the above are coordinated by production systems such as MRP II with a movement towards ERP (Vazques-Bustelo and Avella, 2006: 1154).

2.6.4. Information integration

According to Gunasekaran (1999a: 89) coordination and integration are complicated in the supply chain environment with regard to information sharing and trade secrets. However, Tseng and Lin (2011: 3698) were of the opinion that information integration is essential as it forms the infrastructure of business operations. These authors indicated that the foundational elements of Agility must include an integration of personnel, information technology, the organising of business processes, innovation, and introducing facilities that add to a competitive advantage (Tseng and Lin, 2011: 3694). In her study Botanni (2010: 255) identified how to integrate information, a key factor being the use of advanced information and communication technology tools (ICT).

In this regard Agarwal *et al*. (2006: 213) noted that an information driver is using information technology to share data between customers and suppliers with facilitators such as EDI, internet, and data accuracy. Vazquez-Bustelo and Avella (2006: 1151) were of the opinion that an open door policy encourages communication to facilitate exchange of ideas and knowledge. They also suggested that Agile organisations need to develop a culture of innovation and market orientation to facilitate information transfer from external customers to internal processes.

2.6.5. Customer / market sensitivity

According to Tseng and Lin (2011: 3698) market sensitivity and customer knowledge is the most important mechanism of Agility. In their study Yusuf *et al*. (1999: 41) developed categories of thirty two Agility providers; their analysis found that knowledge-driven enterprises serve customers effectively. Studies conducted by Kisperska-Moron and de Haan (2011: 129) and Huang and Li (2010: 64) supported these views: they cited being market sensitive (being responsive to the customer) as an element that enables Agile supply chain success.

Christopher (2000: 40) posited that demand has to be recognised as one of the most influential determinants in supply chain strategy selection. Various authors have cited that this leads to the need for development of efficient consumer response (ECR) as a strategy, by using information technology to capture point-of-sale information as a way of responding to unpredictable market conditions (Kisperska-Moron and de Haan, 2011:129; Faisal *et al*., 2006: 882; Christopher and Towill, 2000: 208).

Studies conducted by Vinodh and Aravindraj (2012: 1190) demonstrated how important it is to use experts in the field to determine customer and market sensitivity and to make important decisions such as which supply chain strategy to follow under what market conditions. Mason-Jones *et al*. (2000: 4062) placed an emphasis on knowing the market place by concentrating on the product and customer. Mason-Jones *et al*. were of the opinion that product and customer knowledge leads to efficient service. Yusuf *et al*. (1999: 33) expanded these views by explaining that this can only be achieved by coordinating and integrating both customers and suppliers into the manufacturing process.

2.6.6. Employees as assets

According to Christopher and Towill (2001: 244) organisational culture stems from the people within the organisation. Managers play a key role in monitoring, managing relationships and introducing change. Santiago (2012: 32) suggested that all people involved in the supply chain need to play a part in institutional change as it is a company wide effort. He recognised that training and employee growth should be prioritised, as employees are seen as an asset to their companies.

In her study Bottani (2010: 252) found that employees play a key role in a company's Agility levels. Their competency in the company's processes and satisfaction, development / training, flexibility and job enhancement feeds into an employee culture that determines the organisation's relations with others in its environment. Additionally, Huang and Li (2010: 63) have found that Agility has been more easily adopted by employees, as it is a business wide practice and includes the key area of employee mind-set and culture.

According to Yusuf *et al*. (1999: 38) core competency management is dealing with the workforce on an individual level. The authors recognised that upgrades in skills can be made through training to take advantage of current market trends. They asserted that there is a need within most organisations for a well-trained and motivated workforce with the right sets of skills, expertise and knowledge. Empowered employees can solve problems instantaneously and reduce downtime (Santiago, 2012: 32; Yusuf *et al*., 1999:36). However Emuze (2013: 6) points out that as autonomy increases amongst employees the degree of overall coordination is challenged, therefore creating a need to change organisational structures to manage the operational performance of employees.

2.6.7. Strategic outsourcing

Vazquez-Bustelo and Avella (2006: 1154) introduced strategic outsourcing as way to focus on core competencies which allows a company's otherwise engaged resources to be freed-up. The authors indicate that this enables a company to increase its capacity and therefore its flexibility and responsiveness (Vazques-Bustelo and Avella, 2006: 1154). They suggested that these strategic agreements contribute physical resources and engineering knowledge but also share the risks of the production process.

Christopher and Towill (2000: 209) were in agreement that companies outsourcing non-core activities and focusing on the core processes create a greater reliance on suppliers and partners. The pivotal factor here is trust and transparency (Christopher and Towill, 2000: 209). Similarly Faisal *et al*. (2006: 879) indicated that customer sensitivity is improved by taking advantage of outsourcing and leveraging partners' capabilities.

2.6.8. Virtual organisations

In their studies, authors Pan and Nagi (2010: 668) and Christopher (2000: 39) identified that in virtual organisations, opportunities arise and different companies collaborate to use each other's core competencies to leverage a competitive advantage from a virtual supply chain known as an organisational web. Similarly, Kisperska-Moron and de Haan (2011: 129) and Christopher (2000: 38) proposed that the ideal situation for a virtual supply chain is where partners are linked with a common information system to accurately share data, thus reducing complexity by transparency. In support of the above views Ward and Zhou (2006: 184) stressed the use of information systems to integrate supply chains and to attain a virtual organisation within a virtual supply chain.

According to Yusuf *et al*. (1999: 38) manufacturing companies need to focus on core competencies and should develop capabilities that encourage multi-venturing. This will enable access to a greater portion of the market through virtual enterprising. Gunasekaran (1999a: 88) supported this by advocating the choice of organisations to partner with, that have similar supply chains focussing on speed to market, cost reduction and quality.

Yusuf *et al*. (1999: 38) advised that virtual enterprising involves alliances. The authors described two types of alliances: one which functions without operational involvement (Corporate level) and one that does so with it (Operational level). They suggested that big corporations can reorganise business units to protect expertise while small corporations can reorganise to share expertise (Yusuf *et al*., 1999: 38).

Mason-Jones *et al*. (2000: 4062) demonstrated a benefit of a virtual supply chain with the removal of the bull-whip effect through the use of efficient information sharing which leads to only dealing with market place uncertainty. The authors indicated that dealing with true market demand alleviates the need for exaggerated, costly Agile systems (Mason-Jones *et al*., 2000: 4063).

Christopher and Towill (2000: 208) and Damen (2001: 190) developed a different perspective, stating that virtual supply chains are information based rather than inventory based and make use of EDI to determine real demand and eliminate distortions like the Bull whip effect. However Christopher and Towill (2000: 209) agreed with the views of Mason-Jones (2000: 4062) in the example of Dell computers, which uses an Agile hybrid supply chain and shows the results that can be obtained through virtual organisations.

2.6.9. Technology as a provider

According to Bottani (2010: 258) technology leadership, computer-aided systems and technological awareness play a vital role in Agility. In her study Bottani (2010: 258) indicated that computer-aided systems can allow designing and changing a production processes almost instantaneously to achieve quick re-configurability, thereby enabling quick response. The author identified factors that support computer-aided systems such as time-value techniques, EDI, intranet / extranet and enterprise resource planning (ERP) (Bottani, 2010: 258).

Vazquez-Bustelo and Avella's (2006: 1154) assessments of this area were that new manufacturing practices and technologies are required ahead of competitors to enable the system to produce a product before the competitors can. Damen (2001: 185) argued that Agility is an organisation-wide philosophy with technology being at the forefront of the change. Opposing views by Gunasekaran (1999a: 87) note that technology on its own is not enough and that companies need to find the right combination of culture, business practices and technology to make themselves Agile.

Christopher and Towill (2000: 208) used an example to demonstrate the benefits of technology: where some companies still utilise traditional paper processing others use technology to move towards a paperless environment that streamlines processes. Santiago (2012: 32) identified advances in technology that allow customers to monitor the minute-to-minute shipment information, as higher levels of service are delivered and thus greater Agility attained.

Damen (2001: 186) suggested that logistics technologies are required to support manufacturing capabilities. Another area that the author provided insight into is the advancements in warehousing technologies, which will play a major role in Agile

logistics, such as radio frequency identification devices (RFIDs) which can streamline warehousing processes (Damen, 2001: 188).

2.6.10. Logistics as a catalyst for Agility

According to Christopher and Towill (2001: 235) Agile logistics is getting the right product, at the right time to the right place, with a good understanding of the market place constraints and thereby providing customer satisfaction. In support of this view Harrison and Van Hoek (2011: 236) indicated that the concept of Agility is a practical approach to organising logistic capabilities around end customer demand. In their study Pan and Nagi (2010: 669) specified capacity and transportation as key supporting structures to Agile manufacturing. Pearson (2013: 2) agreed that Agile logistics need to be present to support Agile execution and manufacturing.

Christopher and Towill (2000: 207) described another key area in a product delivery process (PDP). Here the product delivery costs are, Physical costs and Marketability cost where the former supports a Lean strategy to logistics and the latter supports an Agile strategy. Damen (2001: 190) pointed out that this in itself produces logistical concerns, such as getting the product to the market speedily and performing a service of higher quality simultaneously. Nakada's (2005: 15) asserted that Lean and Agile have placed an enormous amount of pressure on logistics to be efficient and dependable. Challenges that arise are support structures which need to facilitate complicated work flows (Nakada, 2005: 16).

2.7. Leagility

2.7.1. Introduction

According to Inman *et al*. (2011: 346) there are elements of Lean and Agile that can work together to deliver a faster service cost effectively and that combination has been termed "Leagile." However, Leagile can only exist as a whole system, which is the entire supply chain, not just one company on its own, unless that company has many business units from manufacturing through to retailers (Inman *et al*., 2011: 346; Krishnamurthy and Yauch, 2007:589). In support of the above views Christopher and Towill (2000: 208) recommended that the supply chains need to be seamless and all players need to think and act as one.

Harrison and Van Hoek (2011: 238) introduce Leagility as supply chains that can adopt Lean capabilities up to a given point, and then adopt Agile capabilities thereafter. The authors indicate that this enables high productivity, low cost processes to start with and followed by responsive processes to allow high levels of customization thereafter. Hence the concept of Leagility is born (Harrison and Van Hoek, 2011: 238).

Huang and Li (2010: 63) recognised that Leagile is a combination of Lean and Agile in the supply chain by introducing a decoupling point in the supply chain to allow downstream Agility and upstream Leanness. Huang and Li (2010: 63) suggest that Leagility can be achieved through re-engineering or re-designing the supply chain and can be used as a corporate strategy to achieve a competitive advantage for all within the supply chain over its competitors.

2.7.2. Market conditions

According to Naylor *et al*. (1999: 109) market knowledge is essential to understanding the end users in the market and states that the entire market will play a role in determining which strategy to follow; that is Lean, Agile or Leagile. Supporting this view, authors Inman *et al*. (2011: 347) and Tinham (2005: 16) recognised that just like choosing a strategy for Lean or Agile, market environments determine the need for Leagility and the extent to which it will operate. Additionally, Christopher and Towill (2000: 208) suggest that supply chains need to be market sensitive and develop the capability to respond to real demand.

2.7.3. Time-based competition

Various authors recognise that time based competition is supply chains competing on time as a factor to bring products to the market by lowering overall cycle time and providing a faster service to provide a competitive advantage (Harrison and Van Hoek, 2011:153; Christopher, 2000:37). Yusuf *et al*. (1999: 36) identified a strategy in that Agile organisations are able to compete on compression, using a critical path method to attain competitiveness. Studies conducted by Qrunfleh and Tarafdar (2014: 344) revealed another strategy, using information systems to reduce lead times and enhance time based competition.

According to Harrison and Van Hoek (2011: 153) and Ward and Zhou (2006: 179) time-based competition has two key areas namely; (P-time) which represents the gap between the time required to get the product to the customer and (D-time) that represents the time the customer is prepared to wait for delivery of the product. Additionally, time-based process mapping is used to create visibility of time across the network and monitor P-time and D-time (Harrison and Van Hoek, 2011: 153). The authors indicated that it is also a method to create visibility of materials in the pipeline by showing a time-to-completion perspective (Harrison and Van Hoek, 2011: 153).

2.7.4. The decoupling point

According to Christopher (2000: 40) the decoupling point was previously known as the order penetration point, describing it as how far back up the supply chain that customer orders become visible. Various authors recognise a Leagile system in supporting upstream Leanness and downstream Agility after the decoupling point (Nel and Badenhorst-Weiss, 2012: 192; Inman *et al*., 2011: 346; Krishnamurthy and Yauch, 2007: 591; Agarwal *et al*., 2006: 212). Huang and Li (2010: 64) advised that a decoupling point is a point that separates Leanness from Agile and that these points determine the structure of the supply chain.

According to Stratton and Warburton (2003: 194) the decoupling was created to reduce the impact of variation upstream and delay differentiation downstream. Christopher (2000: 41) revealed a key strategy with a decoupling point, is to carry a generic form of inventory before the decoupling point and assemble a finished product after the decoupling point. This strategy is supported by various authors who indicate that this results in a demand driven downstream approach which leads to a further reduction in inventory levels upstream (Christopher and Towill, 2001: 242; Stratton and Warburton, 2003: 194). Nonetheless, Yusuf *et al*. (2004: 388) suggested that both Lean systems upstream and Agile downstream need to make use of JIT principles to control inventory.

In studies conducted by Naylor *et al*. (1999: 108) the authors discovered that the positioning of the decoupling point is dependent on the longest lead time in the system and the point at which the most variability occurs. Other authors suggested that the position of the decoupling point is dependent on lead time levels acceptable to customers,

the extent of the influence of variability in end demand and the nature of the products being manufactured (Christopher and Towill, 2001: 242; Naylor *et al*., 1999: 109).

Christopher and Towill (2000: 210) drew attention to two types of decoupling points: "material" decoupling points and "information" decoupling points. Their research explains that the material decoupling occurs downstream and involves strategic inventory whereas information decoupling must occur as far upstream as possible where real demand can penetrate (Christopher and Towill, 2000: 210). Therefore managing these two decoupling points can lead to a competitive advantage in Agile (Christopher and Towill, 2000: 210).

Inman *et al*. (2011: 346) pointed out that the significance of the need for a decoupling point is that Lean and Agile cannot co-exist in a particular company unless it is vertically integrated but can in a supply chain as a whole. Mason-Jones *et al*. (2000: 4061) suggested that the decoupling point is the pivotal pillar of a Leagile strategy within companies.

2.7.5. Implementing leagility

Stratton and Warburton (2003: 194) described a strategy which entails the use of advance planning, scheduling and technology to enable expansion of the quick response capabilities and support for Leagile implementation. Naim and Gosling (2011: 343) identified postponement as a means of attaining leagility. However, one needs to determine the strength of Agile supporting structures after the decoupling point such as logistics performance levels to support Leagility. Harrison and Van Hoek (2011: 238) advised that postponement is an enabler of Leagile practices where postponement involves the assembly of final products as late as possible in the supply chain, moulded towards exact customer requirements.

Similarly, Christopher and Towill (2000: 210) suggested that postponement is the carrying of generic and semi-finished stock where final assembly is done on customer request. Harrison and Van Hoek (2011: 239) described a less ambitious form of postponement, which involves simple things such as, delaying packaging, labelling, adding documentation, or product peripherals until an order is received.

Leagile costs have two parts to them, namely, physical product delivery cost (Lean) and marketability (Agile) (Christopher and Towill, 2000: 207). The implementation of Leagile systems will be situation specific, where all players in the supply chain need to act as one (Christopher and Towill, 2000: 207).

Within their study Nel and Badenhorst-Weiss (2012: 194) created a framework for strategy selection and implementation of the most appropriate paradigm: Lean or Agile or a combination of both. This figure is reproduced below (Figure 2.4.).

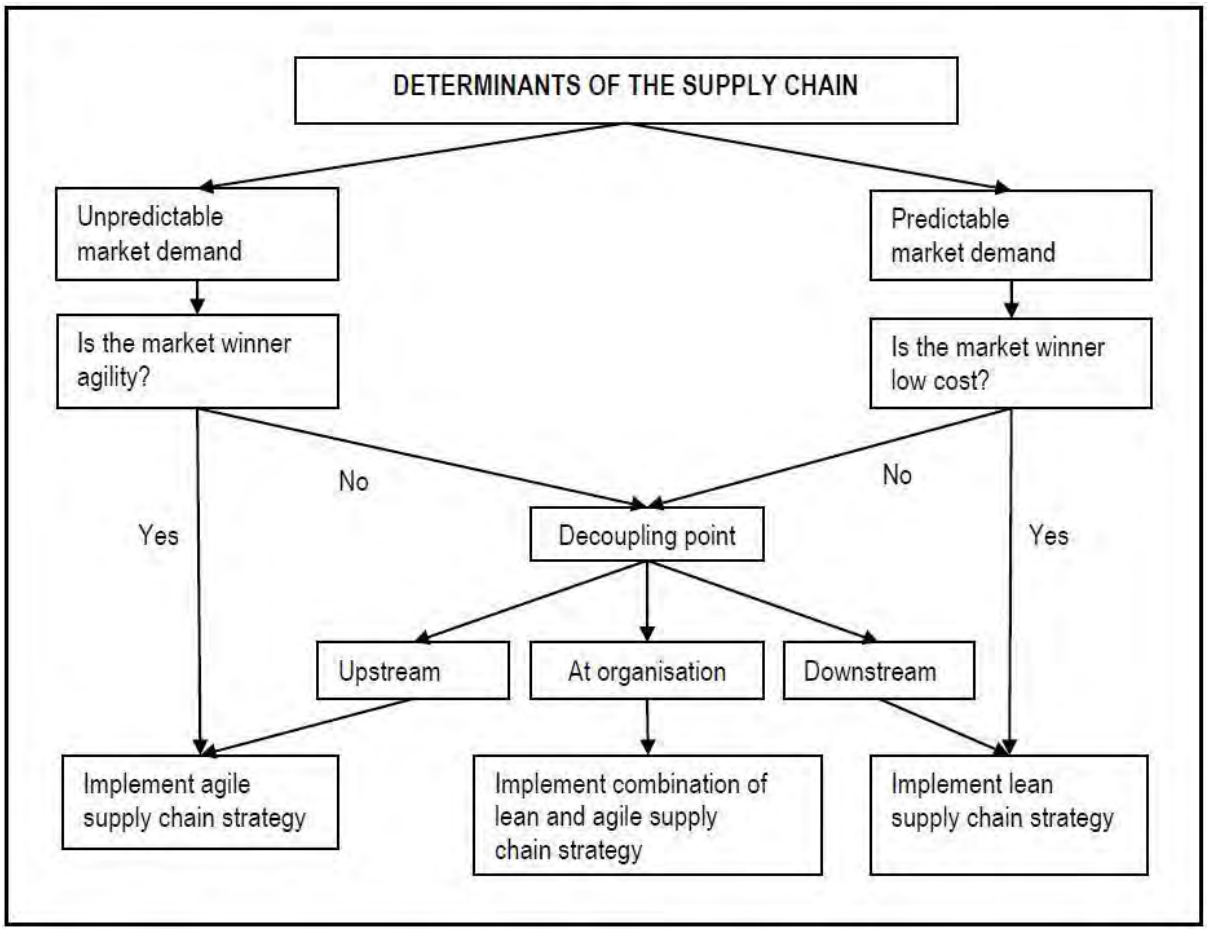

Figure 2.4.: Selection of supply chain strategy based on supply chain determinants.
(Source: Nel and Badenhorst-Weiss, 2012: 194)

Table 2.1: A comparison of lean supply with agile supply: the distinguishing attributes and characteristics.

(Source: Harrison and Van Hoek, 2011: 237)

Distinguishing attributes	**Lean supply**	**Agile supply**
Typical products	Commodities	Fashion goods
Marketplace demand	Predictable	Volatile
Product variety	Low	High
Product lifecycle	Long	Short
Customer drivers	Cost	Availability
Profit margin	Low	High
Dominant costs	Physical costs	Marketability costs
Stock out penalties	Long-term contractual	Immediate and volatile
Purchasing policy	Buy materials	Assign capacity
Information enrichment	Highly desirable	Obligatory
Forecasting mechanism	Algorithmic	Consultative
Characteristic	**Lean**	**Agile**
Logistic focus	Eliminate waste	Customer and markets
Partnership	Long term, stable	Fluid clusters
Key measures	Output measures like productivity and cost	Measure capabilities, and focus on customer satisfaction
Process focus	Work standardisation, conformance to standards	Focus on operator self-management to maximise autonomy
Logistics planning	Stable, fixed periods	Instantaneous response

2.8. Conclusion

To conclude this chapter, Table 2.1 provides a summary as well as a holistic view on all the key areas and points raised in the literature review discussion.

Harrison and Van Hoek's summary in the above table gives an overview of the two main dimensions that this study has investigated in the Lean and Agile paradigms. It brings to light how Lean Strategies and Agile strategies operate. The table indicates requirements to move from Lean to Agile, possible problems that may arise, as well as solutions to those problems.

Table 2.2 shows the five categories that were developed from the literature and data using deductive content analysis. The table shows main authors who have made significant contributions within those categories. These five categories formed the basis for investigation within focal firms. Where elements are duplicated, they are assigned to the most appropriate category. The following chapter contains the research methodology.

Table. 2.2: The 5 categories affecting flexibility, speed and responsiveness.
(Source: adapted from Emuze, 2013: 6)

Category	Description
Lean	Stevenson's – Elimination of the seven wastes of Lean Harrison and Van Hoek's - JIT pyramid(minimum delay and down-time, simplicity and visibility)
Just-in-Time	Stevenson's - JIT goals and Building blocks (excl. personnel) Harrison and Van Hoek's - JIT pyramid(excluding minimum delay and down-time, simplicity and visibility)
Supplier relationship management	Heizer and Render's - 4 goals of JIT partnerships (from a supplier perspective)
Customer relationship management	Yusuf *et al*., 1999 thirty two Agility providers
Organisational culture/Personnel	Yusuf *et al*., 1999 thirty two Agility providers Personnel/Organisational elements from Stevenson's JIT goals and Building blocks

CHAPTER 3 : RESEARCH METHODOLOGY

3.1. Introduction

Chapter One provided a background to this study and the movement from Lean to Agile. Chapter Two reviewed the literature concerning the five areas that this study encompasses. Chapter Three presents the methodology used to conduct the study. The main aim of this research was to assess the influence that Lean has on Agility levels of manufacturing firms.

Business research is a process that entails finding solutions to a problem by conducting an in-depth study and analysis of the situational factors of a business environment (Sekaran and Bougie, 2013: 2). The research reported in this dissertation adopts a case study method to investigate three manufacturing companies.

Case studies are appropriate in the initial stages of development of a new theory and in areas that are unknown with few examples to be studied (Vazques-Bustelo and Avella, 2006: 1149). This is appropriate in the context of the South African manufacturing sector. This method allows the researcher to develop recommendations and possible solutions tailored to specific problems within the context of the focal company's environment. Other companies that fall within similar environments can use and build on these recommendations and solutions.

Three manufacturing companies were selected for the study. They were selected based on their industrial variety and categorised according to the time they have spent progressing along the continuum from mass production to Lean. Company A is a plastic injection moulding manufacturing company. It makes products such as cable glands and light fittings and falls in the 0-2 years' category on the continuum. Company B is a staple food manufacturer producing products like oil, margarine, rice and soaps and falling in the 2-4 years' category. Company C is a light engineering company, manufacturing cutting tools such as drill bits, end mills, custom tools and surface coatings, falling in the 4 years plus category.

Key managers were interviewed within each of the three companies. Their roles included production, purchasing, sales and human resources managers. The study was subjected to certain constraints, in that some of the personnel occupying managerial roles were

recently appointed. This was a common occurrence within the Human Resources department of two firms. The second-in-charge person had to be interviewed along with the managers in such cases. Within Company B, only the sales manager was not available for interviews. The main information providers within each company were the production managers, who provided valuable insight into each company's production system. This information was then used to map out the companies production process for better understanding. The performance of the production systems were measured according to supporting areas namely production, purchasing, sales and human resources. Points were allocated to the performance of each company within the five categories. Points range from 0 to 2 according to the levels of SFR attributed to Lean.

3.2. Problem statement

The problem statement is that firms are implementing Lean Manufacturing but this may be a major factor that affects the Agility of manufacturing firms and hence their ability to respond to changes in the market.

3.3. Research design/strategy

This study was primarily qualitative in nature with the aim of reporting qualitative results. The study was exploratory, with the emphasis placed on gaining ideas and insights into the Lean-Agile paradigm. The aim was to break down this broad problem area into smaller more precise sub-problems (Churchill, Brown and Suter, 2010: 79). The study aimed to uncover the challenges of implementing Agile as a strategy in Lean organisations.

The research strategy follows a case study approach, ensuring that the appropriate data is collected for measurement and analysis (Sekaran and Bougie, 2013: 95). The sampling method was non-probabilistic and purposive.

3.4. Research objectives

- To assess if the company under investigation would benefit from increased Agility in terms of speed, flexibility and response.
- To determine if Lean is contributing to or detracting from a manufacturing company's Agility.

- To determine if Just-In-Time is contributing to or detracting from a manufacturing company's Agility.
- To identify how relationships maintained with suppliers and customers impact on speed, flexibility and response.
- To assess the internal environment or organisational culture of the company and the effect this has on speed, flexibility and response.
- To identify other factors that affects the degree Leanness and Agility within a manufacturing company.

3.5. Study site

The study setting was manufacturing firms in the Pietermaritzburg area. Three of the most suitable candidate companies were chosen according to industry and the Lean journey continuum position.

3.6. Target population

The target population was Lean firms that practice light manufacturing in Pietermaritzburg. It was delimited to those that are interested in implementing Agile systems.

3.7. Data collection

Secondary data was collected from text books and peer reviewed journal articles. Secondary data can prove useful in uncovering possible solutions to research problems (Churchill *et al*., 2010: 137). This was proven in discovering protective capacity and collaborative relationships as possible solutions to increase Agility.

Primary data was collected by mixed methods. Semi-structured personal interviews were conducted with the CEO and then senior management employees. Senior management included the production manager, purchasing manager, sales manager and human resources manager. Observation and physical documentation was viewed which allowed for triangulation and thus trustworthiness. (Churchill *et al*., 2010: 200). This method allowed for exploratory research to uncover challenges and provide potential solutions to them. Triangulation allows for trustworthiness and credibility (Shenton, 2004: 65).

The second method of data collection was observation. Observation entails a natural setting, where the observer was not a participant and the observation was not concealed (Sekaran and Bougie, 2013: 130). The third method of data collection was obtaining documented evidence to complete the process of triangulation, in order to test results of the previous methods. In all companies the observer was allowed to view the necessary documentation but not allowed to retain any documents or make copies.

3.8. Sample design

The sample was obtained from a list of manufacturing companies in the Pietermaritzburg area provided by the Pietermaritzburg Chamber of Business. A non-probability, judgement sampling method was used to select likely prospective medium sized manufacturing companies. The companies were contacted telephonically to determine potential interest and then a follow-up email was sent seeking confirmation. A non-probability convenience sample of three of the most promising and accessible companies was selected for this research (Sekaran and Bougie, 2013: 252). After obtaining ethical clearance, interviews commenced with the CEO and, subsequently, using a snowball sampling technique all relevant managers involved in decision making were then interviewed.

Snowball sampling was used to gather information within each company. Snowball sampling involves identifying the main person such as the CEO of a company, interviewing him/her and then asking the individual to suggest subsequent relevant people to interview (Crossman, 2014: 1). Time and cost constraints limited the sample frame size to three broadly representative companies and the snowball sampling was restricted to no more than seven respondents per company. All relevant top management personnel from the focal companies were approached.

3.9. Interview Guide

This study utilised semi-structured interviews to facilitate an in-depth interviewing process. In-depth interviews are a qualitative research technique that is used to explore perspectives on a particular idea, program or situation (Boyce and Neale, 2006: 3). Semi-structured in-depth interviews are useful in obtaining detailed information about a particular issue (Boyce and Neale, 2006: 3).

The interview guide is structured around the categories developed from the literature review. The interview guide contains five categories of questions to initiate probing into factors that affect the Agile paradigm. These categories probe the Lean and JIT production process, purchasing, sales and human resources. Thereafter the semi-structured nature allowed for respondents to highlight areas that had not been explored. This is known as projective methods (Churchill *et al*., 2010: 97).

3.10. Measurements

Within the semi-structured interview guide each question belongs to a category of which there are five main categories in this study. These themes were: Lean, Just-in-Time (JIT), Supplier Relationship Management (SRM), Customer Relationship Management (CRM) and Organisational Culture/Personnel. The questions were designed to elicit answers that would allow the researcher to assess each company's performance on specific aspects of the chosen categories. Questions also elicited information that could demonstrate the overall effect that a category can have on the variables speed, flexibility and response that affect the potential for Agility.

3.11. Data analysis

The individuals interviewed constituted the units of analysis (Sekaran and Bougie, 2013: 105). Data on these units was obtained by taking notes during the interviewing process and using audio recordings. These were converted into transcripts. The method of analysis was deductive content analysis (Emuze, 2013: 9). Content analysis enables the researcher to analyse large amounts of data by identifying concepts or themes present in the text (Sekaran and Bougie, 2013: 352). Data reduction helped in selecting, coding and categorising data for display. Data was categorised into the five main themes of the study. Particular words or phrases were identified as codes which expressed the ideas fundamental to the categories and which would allow the researcher to identify whether the company performed positively or negatively on these particular units of measure (Sekaran and Bougie, 2013: 339). The categories used and the theoretical frameworks from which codes were derived are summarised in Table 2.5. Tables 3.1 to 3.6 list the coded words or phrases under headings derived from the theoretical frameworks. These may be negative or positive indicators of the ideas within the category. Codes are

presented in bold in the findings (Chapter 4) and were identified in transcripts and through observation of processes and documentation.

Similar questions were grouped together for analysis. This allowed the researcher to conduct conceptual analysis and establish the frequency of concepts related to SFR. This then led the researcher to relational analysis by examining the relationships among concepts of SFR and Lean (Sekaran and Bougie, 2013: 352).

Based on the interviews, observations and documentation viewed, points were awarded to each company on performance within each theme. This was used to compare the effects that the different categories have on SFR within Lean. A maximum of two points were awarded per category (0 points being no or a bad effect on SFR/Agility and 2 being a good effect). The results are displayed in Chapter Four and discussed in Chapter Five.

Figure 3.1: Codes used to identify Lean ideas

Stevenson's – Elimination of the seven wastes of Lean **Harrison and Van Hoek's - JIT pyramid(minimum delay and down-time, simplicity and visibility)**					
IDEA(Wastes)	**CODES**				
inventory	bulk purchasing	finished stock levels	weekly shipping	WIP inventory	finished goods inventory
overproduction	continuous production				
waiting time	set-up	bottlenecks	sequencing	change over time	preventative maintenance
unnecessary transporting					
processing waste					
inefficient work methods	unbalanced production process	automated			
product defects	rework				

Figure 3.2: Codes used to identify JIT ideas

JIT: Building blocks of Lean/ JIT systems (Stevenson) (excluding Personnel/Organisational elements) Three levels of JIT pyramid (Harrison and van Hoek) (excluding minimum delay and down-time, simplicity and visibility)						
IDEA	**Product design**	**Process design**	**Manufacturing, Planning and Control**	**Capability for JIT supply**	**Minimum inventory**	**Minimum defects**
CODES	modular design	batch production	information to suppliers	delivery system/time	Delivery time	scrap cost
	quality	continuous process	push system	forecasts are shared	inventory levels	rework
	concurrent engineering	work cells	pull system	bulk buying	JIT inventory	scrap units
	variation	balance	Kanban	lead times		
	standardised parts	fail-safe	WIP levels	information (to) suppliers		
		change over time	process flow	delivery frequency		
		setup time				
		batch size of one				

Figure 3.3: Codes used to identify SRM ideas

Heizer and Render's - 4 goals of JIT Partnerships (from a supplier perspective)				
IDEA	**Removal of unnecessary activities**	**Removal of in-plant inventory**	**Removal of in-transit inventory**	**Improved quality and reliability**
CODES	inspection	deliver small lots	materials requirement planning	supplier evaluation
	paperwork/ documentation	order size	frequent small shipments	communication channels
	transaction processing time	bulk ordering	material flow	performance measures
	purchasing process	lead time	consignment inventory/VMI	monitor relationships
	order processing intervals	deliver on time	supplier location/ proximity to suppliers	co-operation
	consignment stock		deliver directly to where inventory is needed.	seven "rights" of supplier evaluation
	kitting			supplier relationship management
	material staging			transactional relationships
				collaborative
				strategic alliance

Figure 3.4 Codes used to identify CRM ideas

Yusuf *et al.*'s attributes of an agile organisation			
IDEA	**Quality**	**Partnership**	**Market**
CODES	service design.		returns procedures
	late delivery	transactional	communication
	3PL company	preference	customer product needs.
	delivery time		POS information
	stock out		product variety
	order fill rate	Safety stock	product availability
	order cycle time		sales promotions
	seven "rights		New product introduction
			customisations
			customer relationship management
			product modification

Figure 3.5: Codes used to identify ideas in organisational culture/employee

Yusuf *et al.*'s attributes of an agile organisation and Stevenson's Personnel/Organisational elements					
IDEA	**Employee Integration /Information**	**Team building**	**Education: Learning organisation**	**Employee Welfare / satisfaction**	**Workers as assets**
CODES	job descriptions	decentralised decision making	response to change	incentives	employee utilization
	impact on organisation	production boards	training	compensation	human errors
	feedback	employee empowerment	employee roles	health and safety	kaizen
	communication networks	leadership	problem solving	motivated	
	unions		cross functional team		
	work space plan		job rotation		responsibilities
	disciplinary hearings				
	absenteeism				
	production targets				

3.12. Reliability and Validly

Five themed categories were defined from previous studies and secondary data. This was to ensure category reliability (Sekaran and Bougie, 2013: 350). These categories consist of Lean factors, JIT capabilities, SRM, CRM and Organisational culture. Reliability was attained by identifying key performance ideas within each category from secondary data to utilize as probing areas. Validity was achieved by counting the number of events in each category and then representing them according to the most common occurrences (Sekaran and Bougie, 2013: 350). Each event was allocated a code and each code was applied across the three main levels on the Lean continuum (Beginner, intermediate and Expert). Deviant cases from the research process were included to provide a strong test of the study's conceptual framework. To further attain reliability and validity a process of triangulation was used, where replies from respondents was measured against hard evidence such as documentation and physically observing the process (Shenton, 2004: 65). Triangulation allows for trustworthiness as the researcher was able to confirm coded answers of respondents obtained during interviews. Observation tested coded answers against physical evidence in the form of recorded documentation of the event from each company. The researcher observed daily operations within each company that relate to each code to complete the triangulation process.

3.13. Ethical Considerations

- Ethical clearance was obtained from the University of KwaZulu-Natal ethics committee to approve this study prior to commencing primary data collection.
- Each interview guide was attached with two informed consent letters, one to be filled in by respondents and another by the researcher. Opposite parties retained a copy.
- All participation was optional, none of the participants were forced or persuaded unethically to participate or divulge any potentially harmful information concerning the company or themselves.
- Participants were informed of the confidentiality, given the option to withdraw at any time and information obtained from the focal company was not disclosed to any third parties. All information was used solely for the research purposes of this study.
- The researcher remained honest and did not manipulate data or distort it in anyway and gave a true reflection of the study.

- Ethics is a key area in academic study as well as social, economic and environmental considerations that have to be followed religiously. The object is to provide good, useful information that has not come at the expense of anyone or anything.

3.14. Limitations

- In-depth interviews were time consuming and participation by working individuals was difficult to obtain in Company B.
- Some of the personnel occupying managerial roles were recently appointed. This was a common occurrence within the Human resources department of two firms. The second in charge person had to be interviewed along with the managers in such cases.
- Within Company B, the sales manager was not available for interviews.
- The study being a case study approach destined solutions to be company specific, in relation to the three organisations selected. However, the data will be used for the creation of a conceptual framework and a roadmap that may benefit other companies implement strategies.
- In-depth data analysis had to be conducted on each of the three selected companies. The researcher carried out infield analysis while the information was fresh and used this as a time saving factor.
- The triangulation process of observation and collecting of documentation was time consuming. In all three companies documentation was available to view but not to retain.
- There is a lack of research in the South African context for any supporting secondary data; this is what the research seeks to remedy.

3.15. Conclusion

This chapter describes the research process utilized in the study. This study was qualitative and exploratory in nature. Therefore the semi-structured interview guide is proved useful in probing the Agile paradigm. Snowball sampling was used within focal companies to obtain the relevant information from the appropriate participants. Content analysis of each response was vital in extracting information in order to ensure reliability and validity. Transcripts proved useful in capturing the relevant data for each category

and then using the data to measure against the three main variables of this study SFR. The researcher was able to draw valuable conclusions from the measurements of these relationships. It led to the construction of a conceptual model and roadmap. The researcher was encouraged to follow ethical considerations at all times. No persons or entities were harmed in any form or manner during the conduct of this study.

CHAPTER 4 : RESEARCH FINDINGS

4.1. Introduction

Chapter Three defined the research methodology employed in this study. Chapter Four reports the findings obtained within the three focal Companies. The literature review of Chapter Two established that most research has been conducted on the Lean and Agile paradigms separately or as mutually exclusive strategies. There is little research on the movement from Lean to Agile, particularly within the South African context. It is this gap in the research that prompted this study. The researcher used a case study approach to investigate each company. Semi-structured in-depth interviews were conducted with relevant top level managers. The researcher observed daily work activities and obtained relevant documentation where appropriate. This resulted in a better understanding of the business activities.

Lean manufacturing is currently trending in the South African business context as well as throughout the world. South African business are consulting experts from more developed countries and directing their business processes to match companies in those countries. This may be beneficial if the business environments are similar. However, no two countries' business environments are identical. The three companies chosen within this study demonstrate how business environments actually differ even within the same country.

4.2. Overview of focal companies

The three companies studied are from different industries. All three are in different phases of the Lean journey. Company A is categorised as having Lean intentions (0-2 years into implementation) and is a light manufacturer. Their main competitors are similar products from China and a few local manufacturers with similar capabilities. Company A has been manufacturing electrical products for 42 years. It operates mainly within the plastic industry, producing plastic injection moulding products used predominantly as light fittings and cable glands. However they have a large product range in their catalogue. Most products are locally manufactured and some products are imported for resale.

Company B is categorised as in the intermediate phase of lean development (2-4 years into implementation) and practises mass production. Company B has a large number of

local and global competitors due to their products being commodities. Company B has 45 years of experience in manufacturing commodities.

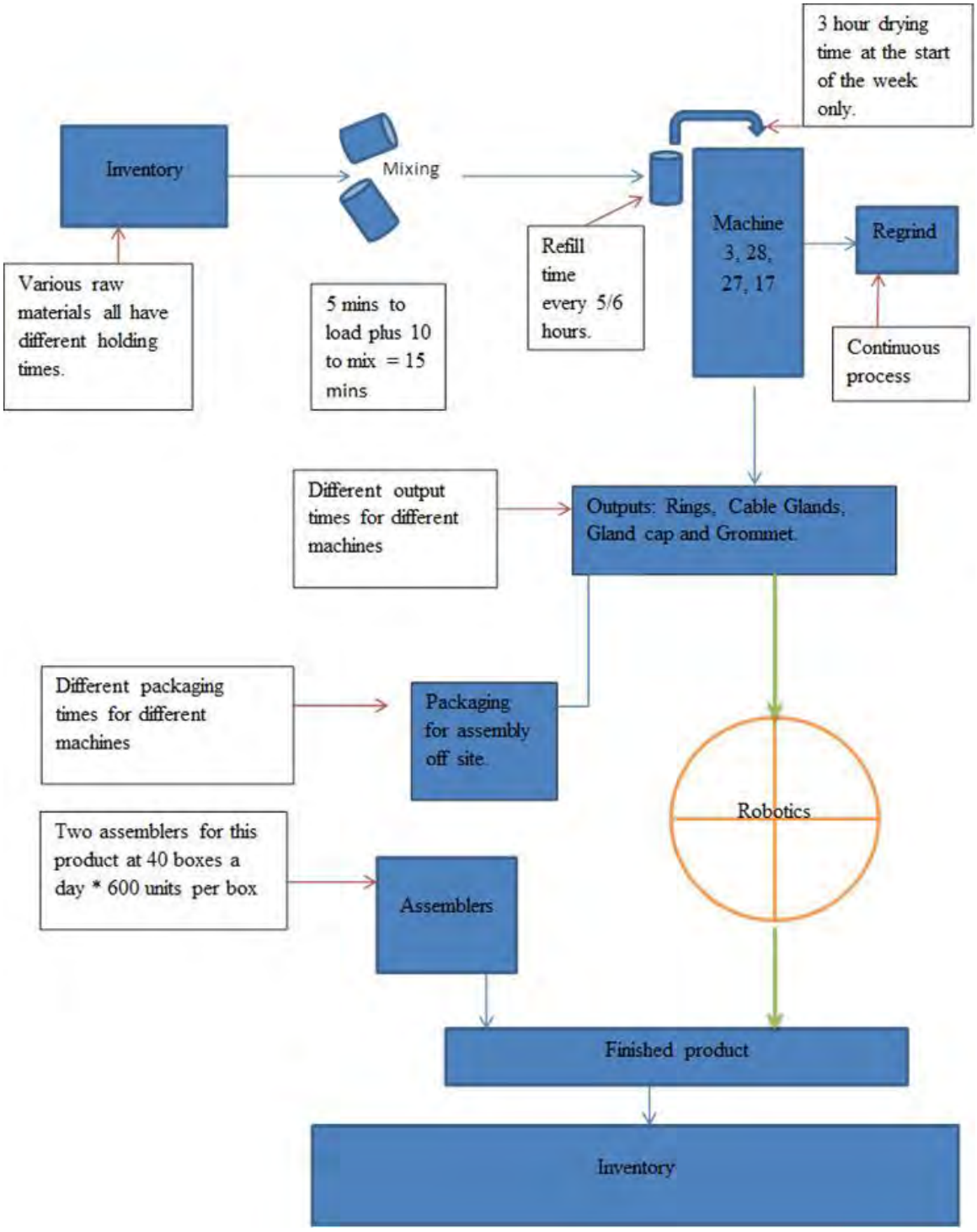

Figure 4.1: Process mapping of cable gland production in company A

(Source: Author's own construction)

Company B operates within the staple food industry, producing products such as rice, cooking oil and soap. Company B has a large product range but this research concentrated on the rice factory only. This factory is a new business unit that is less than 3 years old. Company C is categorised in the expert phase of Lean implementation (4 years plus) and is a light engineering company. Company C has few local competitors but a large number of international competitors. Company C has 60 years' experience in the cutting tool market and is a local market leader. Nonetheless, this company constitutes less than 1% of the global industry. Company C operates within the metal industry, producing High Speed Steel (HSS) cutting tools such as drill bits, reamers and carbide tooling. Company C has a large product range and this is continually increasing. Most products are completely manufactured in-house and a few are supplied in semi-finished form.

Senior management in each company indicated an interest in implementing Agile systems but none have yet taken specific steps to achieve this.

4.3. Production processes in focal companies

Company A's production begins with selecting raw materials for production. These consist of different plastic materials such as master batch, master batch blue, acrylonitrile butadiene styrene (ABS), thermoplastic rubber (TPR) and regrind plastics from recycling. After mixing the selected materials for a product run, the mixture is moved to input bins next to the plastic injection moulding machine. Machines require a three hour warm up on a Monday morning and then run continuously through the rest of the week. The machine processes product shots (volumes of material required to fill the moulds). Shot sizes are dependent on the product. Parts and off cuts are offloaded either at the bottom or sides of machines into cardboard collection boxes. When boxes reach capacity they are removed. Offcuts are sent to the regrind department for recycling and parts are packed and sent to third party assemblers. Some assembly does happen on site, if required. After assembly, finished products are retrieved and moved across the road to the inventory holding area, awaiting sale. Figure 4.1 shows the layout of a part of this factory which produces cable glands.

Company B's production run begins at an inventory holding area on site. Large unprocessed 1 ton bags of rice are moved by forklift, or many 50 kg bags are moved by employees and emptied in to the machine feeder. Thereafter the sorter separates the rice

into different grades and waste. After sorting, the rice is moved into silos awaiting packing. Each silo has a dedicated pack size allocated to it ranging from 2 to 20 kg bags. All processes up to this point are automated. After selected sizes have been packed, packs are moved onto wooden pallets and shrink wrapped. Each pallet is labelled with the packaging month and allocated a space in the finished goods holding area while awaiting sale. Figure 4.2 shows the production process in Company B.

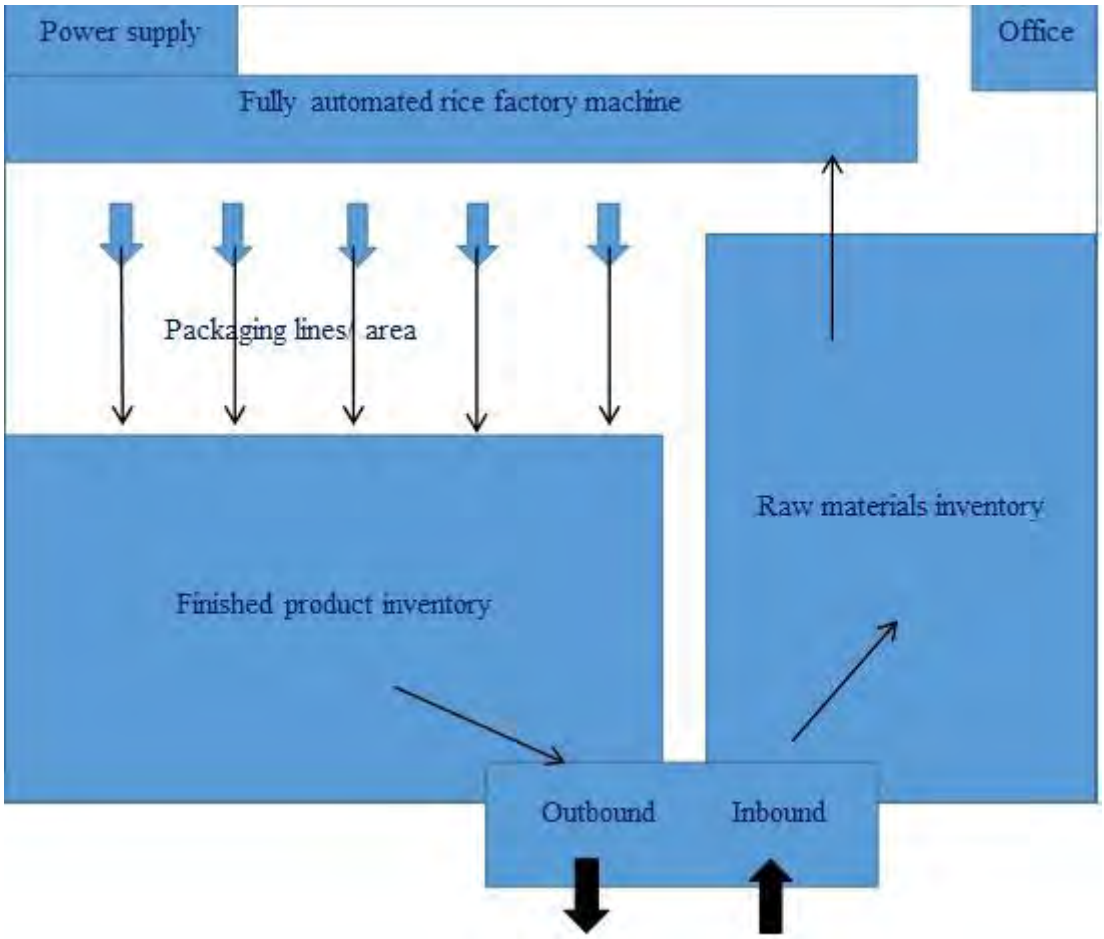

Figure 4.2: Company B layout

(Source: Author's own construction)

Company C's production run begins at an inventory holding area on site, moving to the blank preparation department where raw materials are cut into smaller pieces from large rods. These pieces are then moved to the heat treating department where they await batch preparation according to their heating requirements. Thereafter the blank moulds can follow two routes. Route One travels to the aging high speed steel (HSS) factory. The starting line machines prepare milling, then squaring and then moving to fluting. The next

step is one of five finishing lines which conduct sharpening or regrind. Route Two travels to the modern Carbide factory with state of the art machinery. Standard products move to one machine that does all the processes, where blanks are inserted and finished products are produced. Special line products move to the research and development (R&D) department and await approval to move onto a machine. After these processing routes have been travelled, products meet at the quoting factory. Finished local products are sent directly to customers within the province and to Company C's depot in Johannesburg. All other regions in South Africa receive within a 24 hour delivery time. Exported products are kept at inventory holding until orders are filled or economical batch quantity (EBQ) has been reached for shipping.

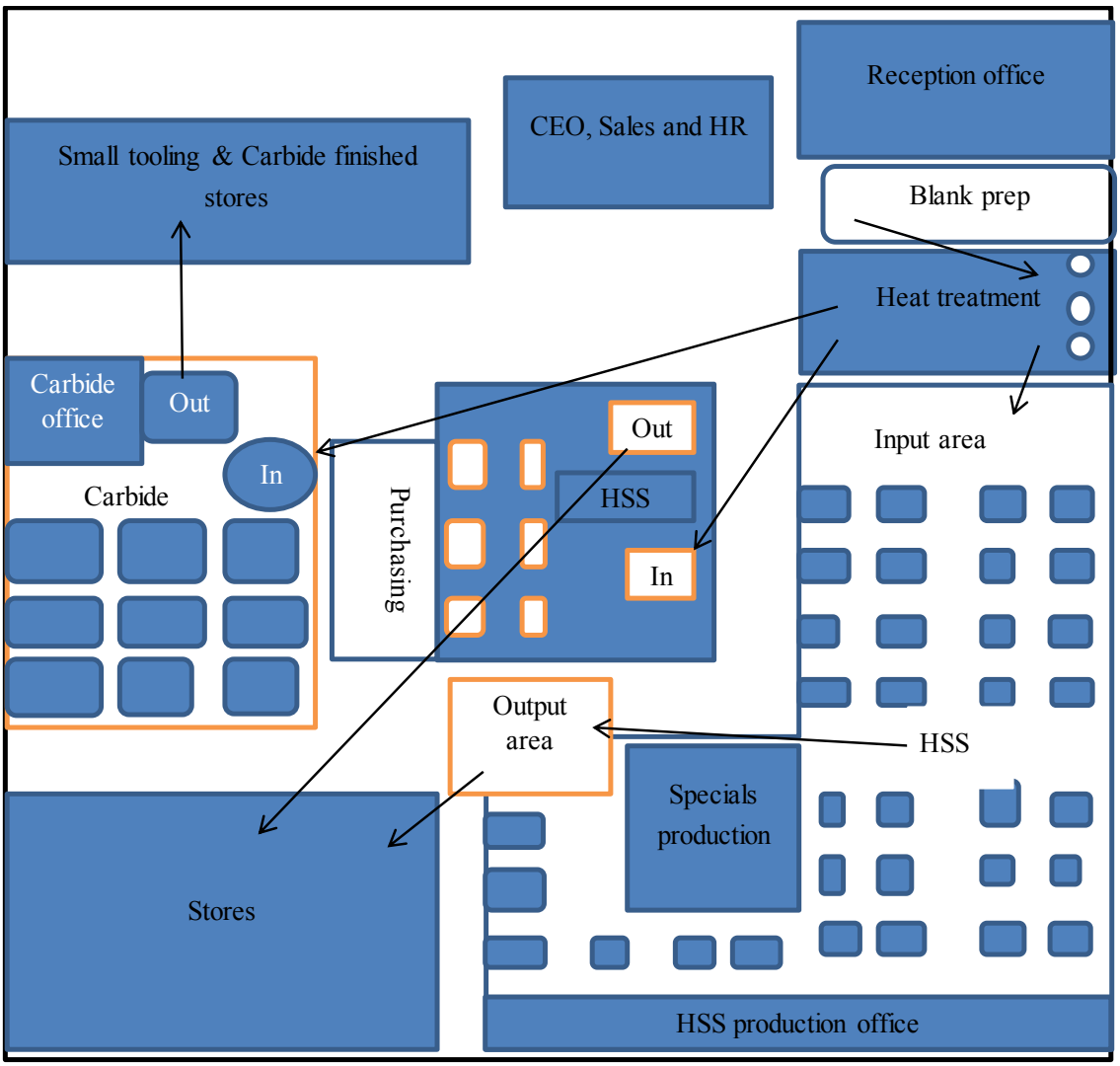

Figure 4.3: Company C layout

(Source: Author's own construction)

Layout figures (Figures 4.1–4.3) have been created in order to allow visualization of production processes and to improve understanding of the operations.

4.4. Strategies of focal companies

Company A produces to a traditional (mass production) manufacturing strategy, which experiences maintenance problems regularly. Machine breakdown and tooling problems affect production output during certain periods. Product types are highly differentiated and follow a fashioned life cycle. A production forecast is derived from a sales forecast. The sales manager averages sales people's ordering history, creating a demand forecast for manufacturing. The purchasing manager stated, "The production forecast is based on average sales from the sales peoples' perspective."

Company B, produces to a traditional manufacturing strategy that is semi-automated (machine controlled). The factory unit reaches 40 tons an hour on rice production. The factory is experiencing raw materials supply shortfalls. Product types are commodities which require high levels of efficiency to be profitable. The production manager commented, "Everybody needs commodity products and there are a lot of competitors, therefore production needs to be very efficient." Commodities follow a different product life cycle in terms of expiration dates opposed to fashioned products. This company offers a shelf life of twelve months on each bag of rice but its actual life span is much longer. A monthly sales forecast is used along with holding a two week buffer stock to create a demand forecast for manufacturing. The business unit is fairly new and requires daily planning due to lack of past history.

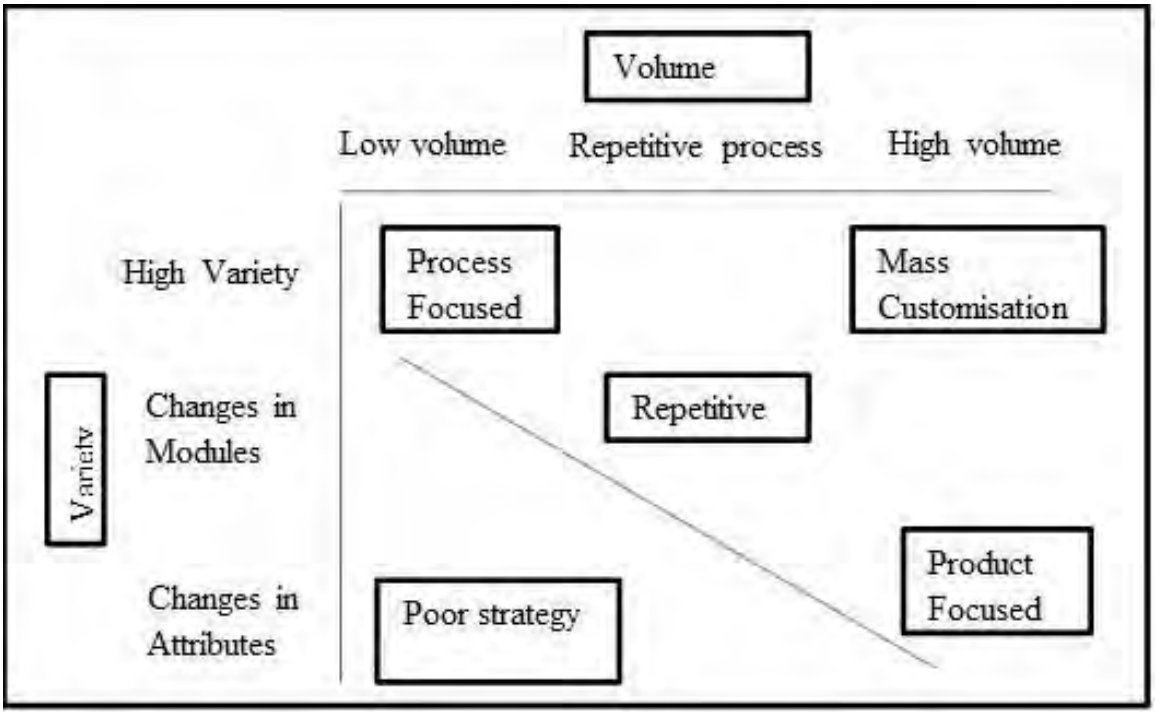

Figure 4.4: Product classifications for strategy selection

(Source: Adapted from Heizer and Render, 2011: 284).

Company C produces to a Lean manufacturing strategy (product focus) that is semi-automated (people controlled). The production line experiences problems due to the change over from traditional manufacturing to Lean production. Production systems need to be revised as they cannot accommodate the one piece flow requirement targeted by Lean principles. Product types are highly differentiated and follow a technological life cycle. Product life cycles can be shortened due to low quality and when competitors such as the Chinese slash price and enter the product market. The Carbide production manager said "Product life cycles are under new threats, currently price is playing a major role such as slashed prices on Chinese products." Previous sales are recorded on a software programme (Cispro) that predicts next month's demand. Cispro uses moving averages creating a demand forecast for manufacturing.

Figure 4.4 suggests strategy selection according to product classification. Currently Company A has a poor strategy and is producing according to outdated mass production methods. Company B is also producing according to mass production. However due to automation they able to follow a product focused strategy. This is the correct strategy for

the company as it is a growing business unit. Company C is also producing according to a product focused strategy guided by Lean principles.

4.5. Demand management in focal companies

Company A recognises the need to be responsive to variations in customer demand as they receive spike orders on a monthly basis. Information flows smoothly internally with office employees and factory employees across the road and communication is facilitated by the production manager. There is good information flow externally with suppliers and customers, facilitated telephonically and by electronic mails. Some information exchange does occur in advance ranging from 3 to 6 months with international suppliers. Company A's current production system satisfies customer requirements by targeting quality. The system meets demand with its locally manufactured products. However, imported products are sometimes on back order as they are more difficult to forecast. This is attributed to spike orders and irregular buying. The Sales manager commented that "Spike orders can throw off stock levels compounded by irregular buying makes it extremely difficult to forecast and predict." The current production system requires planning when new product introduction is considered. An estimated three months is required to create new machine moulds. This is compounded by SABS testing which can take up to a period of three months to attain approval. Furthermore the production system is always running at full capacity which requires forward planning for integrating new product manufacturing.

Company B recognises the variation in their ability to meet customer demand due to periodic shortfalls on the product range. This company follows a customer service driven manufacturing strategy. Internal information flow is good. Problems are experienced with temporary employees, where instructions have to be continuously explained. The Human resources manager said, "Most temporary worker come from rural areas waiting outside the gates for work, the language barrier creates a constant need to re-explain instructions." Information flows easily and regularly with suppliers, some weekly and some monthly.

Company C recognises the need to be responsive to variations in customer demand. They experience stock outs on catalogue items and standard items regularly. This is not in line with their customer service driven manufacturing strategy. Internal information flow is excellent and fast. There are notice boards in every department and where necessary

union members facilitate communication. The Human resources manager said, "Information flow is good, fast and made available to all staff at any time and union member assist where necessary." External information flow is good with both suppliers and customers, facilitated telephonically and by electronic mail. There are quick processing times by suppliers. Processing times to customers is 24 hours acknowledgement of orders both internationally and locally. Company C's production system falls short on capturing market share due to their stock out problems. This results in customers requirement satisfaction of 50 to 60% internationally and 70 to 80 % locally. The Sales manager said, "Stock outs create a major problem for this company, each percent lost in customer satisfaction is captured by our competitors." However the production system is effective when introducing new products to the market. The Research and Development department within the Carbide section is advanced. Designing of products is done in conjunction with experts from Israel. This allows Company C to be market leaders in the cutting tool industry worldwide. This includes customers from Germany who regard them as good as German suppliers.

4.6. Lean factors present in focal companies

4.6.1. Company A

Company A, has not eliminated the seven wastes of Lean:

- There are high levels of **inventory** to facilitate cycle time which increases inventory expense. The large amounts of raw material held are attributed to **bulk purchasing** from international suppliers of container sized, economical batch orders. High **finished stock levels** are attributed to erratic buying with occasional spike orders. Some product levels are built up well in advance to relieve system pressure and allow a degree of Agility.
- A certain degree of **over production** is occurring on slow moving items where **set-up** is costly and time-consuming, discouraging shorter production runs. The production manager commented that "Slow moving items are over produced to free up machines needed for fast moving items." All machines have a three hour set-up-time on Monday mornings. Machines run continuously through the week, shutting down on a Saturday morning. Interrupting a run causes a loss of three hours in

production. This puts pressure on faster moving products. **Continuous production** frees up machines after building up stock levels on slow moving items.

- Company A faces **bottlenecks** on mould sizes. Certain machines take 16 shots and others just 1 shot. Therefore products on 1 shot per mould production are natural/general bottlenecks. The main concern is matching demand with moulding capacity. This leads to assembly problems down the line and idle bottom end processes. Machines can be added to run concurrently with the same one shot mould however another production run must be interrupted. Sequencing occurs in the form of planned production creating **waiting times** for the next production run. Change over time as mention earlier is three hours and this is also the waiting time between sequencing.
- Smaller products run faster than a big product that is 16 shots per mould versus 1 shot per mould. This creates unnecessary **transporting** with employees walking from machine to machine looking for full production boxes to empty. Transporting to and from the assemblers who are physically challenged could also be considered as unnecessary transporting.
- Using disabled assemblers has positive ramifications on the company's corporate social responsibilities. Nonetheless, this slows down getting the product to the customer and creates work inefficiencies. Other system inefficiencies stem from aging machinery and an unbalanced, un-streamlined production process. There has been an estimated 10% to 20% loss in cycle time due to these inefficiencies.
- **Preventative maintenance** does occur. Shutdowns are planned and the onsite maintenance team are informed as to machine availability.
- The manufacturing system is directed towards **economies of scale.** Manufacturing is high volumes, continuous flow production according to specified demand forecast. Minimum and maximum stock levels are monitored and ultimately the production strategy is make-to-stock.

Certain factors present in the company could contribute to Agility:

- Machines have a high level of **versatility** attributed to the interchangeable moulds. Moulds can be manufactured to allow new small modifications.

- Company A's strategic alliance with a **third party logistics** (3PL) company has steered onsite logistics for delivery. This contractual agreement has led to increases in service levels and **flexibility in the delivery** process to the customers.
- **Warehousing** is positioned next to logistics however across the road from production. Space is sufficient to hold a month of finished goods. Component warehousing is done in the production factory.
- Company A's **capacity** is currently sufficient. Items can be produced to forecast within two weeks and this lead time is given to customers. This does exert small amounts of pressure on scheduled items which the system can handle. Capacity can deal with changes such as decrease in lead times, increase in volume depending on product cycle time and raw materials availability.

4.6.2. Company B

Company B, has not eliminated all the seven wastes of Lean:

- The factory maintains high levels of **inventory** to facilitate cycle time. The large amounts of raw materials are attributed to bulk purchasing at1000 tons per shipment. Six weeks of stock is purchased from international suppliers of rice. Two weeks of that stock is used as a buffer.
- Finished stock levels are attributed to the six weeks make-to-stock strategy. Over production is occurring of two weeks stock per month however once allocated spaces are filled then that product range is stopped. **Over production** speeds up cycle time in the form of availability. The previous month's stock is sold in the following month with 11 months expiry date to minimize returns.
- Compared to other production factories unnecessary **transporting** is in the form of factory location. Unprocessed rice is transported from the harbour to Pietermaritzburg then processed and sent back down again to Durban customers. The major effect is that 1000 tons of rice must be moved out of the harbour within a 48 hour time period resulting in day and night shift logistics which is extremely costly.
- The only inefficiency is the **time** and method used to open the 50 kg raw materials bags from India. Indian bags take 6 minutes versus rice from Thailand in 1 ton sacks that take 20 seconds to open. However Indian rice is slightly cheaper and readily

available compared to the seasonal Thai rice. This inefficiency does not have a significant effect on cycle time as employees are given a daily targets that must be adhered to.

In some respects the factory has made progress towards a Lean system:

- The rice factory is fully **automated** and programmable. Therefore exact output can be determined in advance. The level of automation in the factory creates control over the people therefore there are no visible **bottlenecks**. The only consideration within this factory is the limited space for stock. This is attributed to high volume sales increments of 400 % annually. **Sequencing** occurs as raw materials inputted to the fully automated machine, which outputs finished pack sizes for storage. Therefore there are no bottlenecks in the form of queuing or **waiting**.
- There are five products packed in the rice factory, due to the degree of automation **change over time** is estimated at five minutes. It then takes 6 minutes to reach specified production rate. **Wasted time** is therefore kept to a minimum.
- The production system does not produce any reject packs. Wastes are set aside and resold as unprocessed rice resulting in **no reworking** of any kind. Therefore there is no effect on cycle time from reworking
- All employees know their roles. There are no idle employees and always a substitute employee on hand for toilet relief.
- **Preventative maintenance** occurs in two forms. The factory runs three days a week and allows two days of cleaning. The factory can run up to five days but cleaning then has to occur on weekends. The factory shuts down completely for one month every four years for complete maintenance overhaul. If parts such as circuit breakers or air releaser bearings do break they are changed as soon as possible. A full investigation is then done as their general life span should exceed four years.

The factory is not versatile: it is designed to produce only rice and no other type of product can be packed. The manufacturing system is directed towards economies of scale, with a line flow process. A make-to-stock strategy is followed, which is sales driven and quality based to capture market share. The manufacturing system runs on continuous flow to a demand forecast.

The factory has some potential for Agility:

- Raw materials are kept at a certain **stock level** to service all finished pack sizes. Any order size can be met at any given time.
- Warehousing is supportive of **flexible manufacturing** and variation in stock levels.
- Capacity is planned to stock levels, if it is not sufficient then the factory is re-planned. If there are any changes such as decrease in lead times, increase in volumes or change in specifications then the **factory can be re-planned**. This is done by re-programming the system within 20 minutes.

- Company B has its own transportation service consisting of 280 super link trucks. If an order is to big then 3PL services are available to satisfy the **24 hour delivery time** quoted to all customers.
- Designing the factory with foresight has led to sufficient **capacity** for 15 years. Currently the factory is doing 40 tons an hour and capacity is capped at 8000 tons per month. Only the client can bring about change and there will never be a request that exceeds capacity.

4.6.3. Company C

Company C has focused on eliminating the seven wastes of Lean and has made progress in some areas while others are problematic:

- **Inventory levels** are continuously being reduced; currently this has no direct effect on cycle time. WIP inventory in the HSS factory is high at work stations. Projects are in place to reduce them. The Carbide factory has seen improvements of turning annual inventory from 4 to 5.8 times and strives for the goal of 10 times annually. This is gradually freeing up cash held within inventory.
- Company C is currently negotiating with suppliers from Europe to increase shipments from once a month to **weekly shipping**. This means that raw materials will decrease within the system. However the supplier side is still pushing in high levels due to economic batch orders of steel raw materials. **Finished stock** is sent out to local customers and Johannesburg depot within 24 hours. However stock holding occurs for international customers. A certain quantity or value must be reached before shipping becomes feasible.

- **Overproduction** does occur in both HSS and Carbide factories. Within HSS this is attributed to machines in the sequence not being balanced. Certain machines in the sequence cannot keep up with the speed of other machines. Step one may take 10 seconds but step two takes 3 minutes. Therefore over production in step one creates large amounts of WIP at step two. Within the Carbide factory stock is being built up to EBQ's seemingly a form of overproduction.
- Due to the age difference between the two factories, **bottlenecks** are less evident in the Carbide factory. The HSS factory is older and contains bottlenecks resulting from "monuments" or legacy machines such as the furnace capsule requiring large batch quantities and consequently over producing.
- There are bottlenecks in the form of **sequencing** within the HSS factory. They are attributed to the layout and process that has to be followed resulting in queuing and waiting.
- With the introduction of Lean, **change over time** has decreased from in excess of 2 hours down to 10 minutes. Overall all machines have improved by 40 % and a further goal of 5 minutes is being pursued. There is no specified production rate; production is measure on lead time to customer rather than demonstrated capacity.
- Unnecessary **transporting** occurs in both factories. Much of the movement is attributed to layout within the HSS factory. Movement of WIP trolleys is done physically in both factories. This has a minimal effect on cycle time in both factories. Each operation is unique within HSS and movement is done while machines are running in Carbide.
- Both factories **rework** defects if feasible. Implications are that they are done for free and during standard production time. This increases costs and causes a loss in production hours.
- **WIP inventory** levels are high within the HSS factory due to **over processing. Finished goods inventory** is high in Carbide due to economical batch shipments to foreign customers.
- The most visible **inefficiencies** are within the HSS factory. It is an aging factory that experiences regular breakdowns affecting cycle time and customer delivery.

Preventative maintenance occurs within the Carbide factory. However a more reactive approach is taken with HSS where it is done on breakdown.

Company C has some characteristics which favour Agile production:

- **Versatility levels** within HSS are low as machines do a single specific task and are up to 60 years old. Levels increase tremendously within Carbide as machines do all in one processes. The research and development department within the Carbide department increases versatility.

- Both factories direct their Lean manufacturing strategies to **economies of scope** and to compete on quality rather than price to gain market share. Continuous flow production occurs in HSS and **small batch** in Carbide with a make-to-stock and make-to-order mixed strategy. Lean production supports **make-to-order** manufacturing as complete products are made once off.

- HSS is moving from continuous flow to small batch quantities. This has been extremely difficult as they previously relied on EBQ's. Although **set-up-times** have been reduced, HSS is not fully adapted as the factory and is not set up for one piece flow. However Carbide is set up to do **one piece flow**.

Figures 4.5 to 4.9 are based on the results of interviews, observations and documents viewed by the researcher.

- Capacity is manually driven on scheduling and can be increased at any point by management in the HSS. Capacity has been reduced in Carbide by reducing machines and people. However there are more people than machines to allow for **flexibility** during spike orders.

- Both factories can deal with decreases in **lead times**; lead time has been reduced from 8 weeks to 2 weeks and aiming for a goal of 5 days.

- Currently warehousing is supportive of **flexible manufacturing** as the warehouse in Johannesburg is treated as Company C's customer. The **warehouse stocks** standard products on shelves; demand is triggered by a Kanban system for production in Pietermaritzburg.

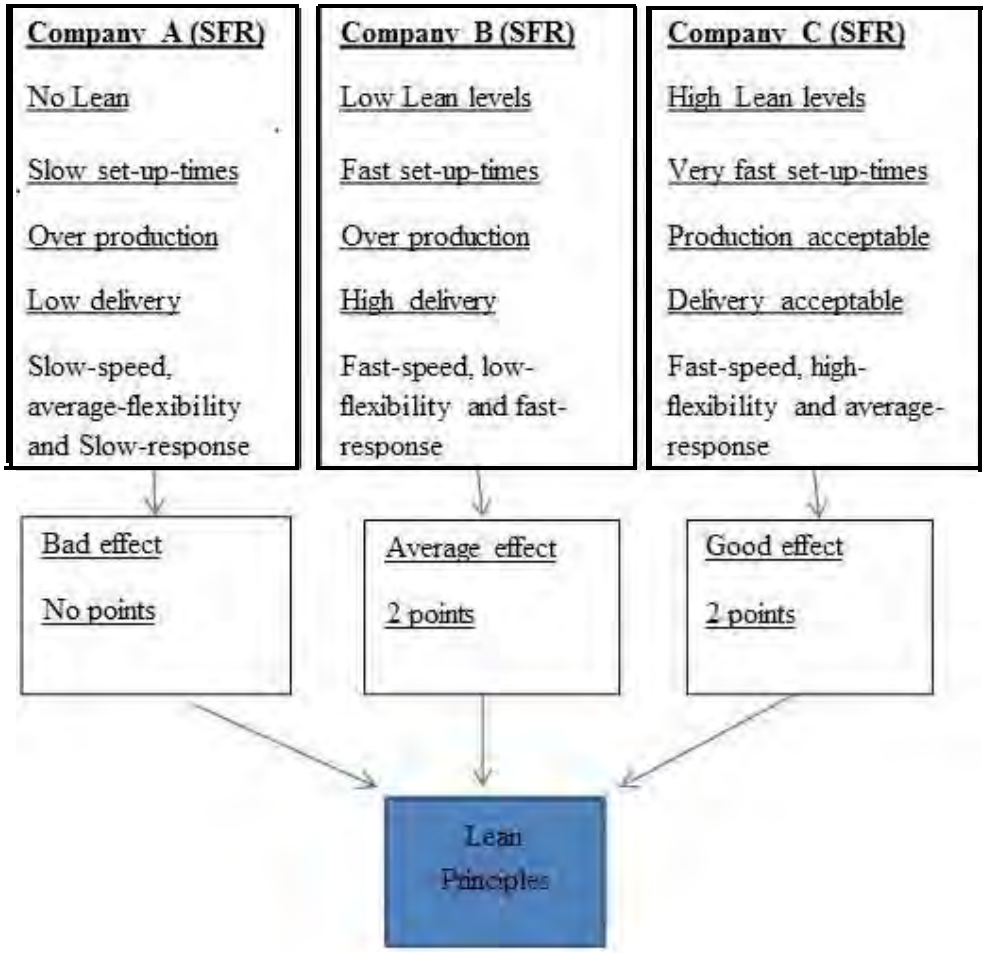

Figure 4.5: The Lean SFR relationship

(Source: Author's own construction).

- Both factories can deal with increases in volumes. Reductions in set-up-times resulted in a reduction in shifts. However a night shift is possible and employees are aware of this. This acts as **reserved capacity** that is not activated.
- Outbound transport to customers is set up to support flexible manufacturing. Competent **third party logistics** service providers are used. They provide road, air and sea freight to international customers and delivery within 24 hours to local customers.
- Inbound logistics of raw materials are about to change to follow more frequent flows.

Figure 4.5 summarises the relationship that each company has with Lean principles. These principles affect the company's Agility levels by influencing Speed, Flexibility and

Response. In the lower part of the table, a score has been allocated to each company based on the contribution to agility made by the application of Lean principles within the firm.

4.7. Just-in-time capabilities in focal companies

4.7.1. Company A

Company A does not practise Just-in-time (JIT) in daily operations. However, the local suppliers' **delivery system** is supportive of JIT purchasing. They can meet a delivery schedule set by JIT as all **forecasts are shared** with them. Furthermore all documentation and information is readily available to allow for JIT suppliers to function. **International suppliers** are not supportive due to the requirement for **bulk buying** and **long lead times**. The inbound logistics systems are not modified to support JIT receiving.

Raw material **inventory levels** average at two weeks on hand. Suppliers hold stock for the company and it is pulled on a **Kanban** system. Inventory levels on international raw materials are high, due to bulk buying and economical shipping orders. Production occurs as a continuous process and not according to **batch production** for JIT output. However there are forms of **JIT inventory** available to meet emergency orders.

Product design has a major impact on manufacturing and is the most important phase for Company A. If not done correctly, the manufactured products exhibit functionality problems and this hinders the downstream assembly process and the quality of the finished product. The technical team of designers work with salesmen to develop the best product for the customer.

Quality improvement is ongoing and is built in during design through the decision on what moulds will be used to make the product and what materials will be used. **Concurrent engineering** involves process planning during the design phase. The current production system affects product design. Company A takes a product life cycle management (PLM) approach in which they integrate engineering design and manufacture. This is part of their strategy to compete with other firms that are fast to market and regularly develop improved products. Products with improved quality tend to last longer on the market and have a positive effect on PLM.

Process analysis and design are regarded as very important and have huge cost implications. Improvements in **process design** lead to lower costs resulting in a cheaper product to the customer. The present design is for large **lot sizes** and continuous flow. **Work cells** are not used. Nonetheless a good **balance** is maintained. When a bottleneck arises then attempts are made to move it to create balance. Process design has created **fail safe** methods, such as altering and changing machine moulds.

Currently Company A is following a repetitive process design strategy which is directed at differentiation first then response second. The current process layout is repetitively oriented and is difficult to **reconfigure**. There are space constraints and contractors have to come in with heavy rigging to move machinery around. Manufacturing machines are movable but computer connections and telecommunications are not.

Cost accounting is used in the manufacturing process to push out high value items first. **Manufacturing planning and control** play a major role in production and are controlled by the production manager.

Certain products are allocated weekly capacity and remaining capacity is issued according to what products sales require. However communication with sales notifies them as to what is possible. The production system works on a **push system** and materials work on a **pull system.** The only visual systems that are in place are production boards; there are no Kanbans in the production facility. **WIP levels** are high due to inaccuracies in forecasting.

Standardised parts are manufactured and a **modular approach** is taken to assembly. Customers can request variations in product design only at the design stage. This increases pressure as new moulding or machinery may be necessary.

The third party assembly process used by the company increases costs in logistics, handling, time and third party payments. However these assemblers are from disadvantaged backgrounds. They play an important role in the social contributions of the company. Although this is in contradiction with customer perceived value when narrowly defined by reducing costs and increasing service delivery, the demonstration of corporate social responsibility may improve customer perceptions of the company as a whole.

4.7.2. Company B

Company B does not use **JIT principles** in daily operations within the rice factory. A demand forecast is created by monitoring past history and 50% buffer stock added for growth. All raw material purchasing is done in advance. All customer orders are confirmed and cannot be cancelled. Emergency purchasing will never occur on raw materials, therefore there are no forms of **JIT inventory.**

Production occurs as a **continuous process** and not according to batch production for JIT. Documentation and **information** is not readily available to allow for JIT **suppliers**. There are no local suppliers of raw materials in South Africa. However consumables such as packaging are sourced locally and can meet the above JIT requirements. Inbound and outbound logistics run according to a planned schedule and will not change to accommodate JIT. **Delivery time** of 24 hours is guaranteed anywhere in South Africa.

There are no **product design** requirements on commodities except the need for different pack sizes. There are five product lines dedicated to each pack size: 10kg, 5kg, 2kg, 1kg and 500g. There are other design considerations such as the clarity of the plastic and attractiveness of the bag, which is done by suppliers. Products are designed for product serviceability by means of various pack sizes within the range. Product design has minimal effects on process requirements as design is done once on a pack size. All pack sizes were designed when the factory was built. There is no machine **change over** but people may change to a different packing line.

Quality is built in right from the beginning when the production factory was designed. Each grain of rice is weighed, sorted and polished to obtain the best quality within each bag. **Concurrent engineering** does not occur.

A benefit of selling commodities is that there are no variations in **product design** requirements by customers. The same information is printed on all pack sizes. All bags are designed for pallet storage thereby facilitating logistics. Therefore product design has minimal effect on the current production system.

The company does practice **product life cycle management**; however this differs in relation to commodity products. PLM is in the form of expiry date rather than the product going out of fashion. Farmers guarantee a 2 year expiry date on the rice. Company B

requires 3 months from receiving till packing and sends out the product in the fourth month with a one year expiry date. This ensures no returns and a good product for the end user until the expiry date is reached.

The priority is to produce good quality rather than achieving speed. The production system runs slowly and efficiently to produce a high quality product to capture market share.

Process analysis and **design** was done once off for this factory. The process design strategy is aligned to low cost, with high volume and low variety. To be profitable in selling commodities costs must decrease and efficiencies must increase. There are no non-value adding steps due to automation and the production system avoids any **defects**.

The production process targets **customer perceived value** by reducing costs and providing a cheap high quality alternative. There are no lot sizes in this process design as it is **continuous** flow.

There are demarcated areas for each product on inventory indicating **stock levels**. If the space is full then production stops and concentrates on areas where spaces are empty. The same people work on all product lines. They develop expertise, decreasing production problems and increasing **flexibility**.

The system is **balanced** as the factory has the **capacity** to produce twenty thousand tons compared to the initial demand of two thousand tons.

There are no **failsafe** methods in the manufacturing process**. Maintenance** is done every 4 years. All changeable parts are renewed and only the best parts of the highest quality are sourced. The current **process layout** is fixed position and cannot be reconfigured.

Manufacturing planning and control is done through the fully automated and programmable factory. **Capacity** is allocated according to production target set during systems programming. Production runs on a **pull system** from stock spaces that act as visual systems. **WIP** is kept at low levels as only materials needed for production are processed and flow without restriction due to a **balanced** system.

Inventory levels are high but are in relation to sales. The aim is to create a situation where production never stops.

4.7.3. Company C

Company C practices **JIT principles** within the HHS factory and not within the Carbide factory. However the Carbide factory does make emergency orders. Carbide is aiming to have JIT principles up and running in 2016. **Logistics** systems from local **suppliers** are supportive of **JIT** principles for both factories. HSS has an agreement with local suppliers to hold a certain stock level for them that is available within 48 hours. Both factories are not yet set up for JIT suppliers internationally.

Inbound logistics can be modified to support **JIT delivery**. Sea freight cargo can be flown in. The Carbide factory is achieving Lean and JIT principles of a **batch size of one**. However this is not yet possible and very far from being realised within the HSS factory. There are forms of **JIT inventory** within Carbide. **Information** is readily available to all JIT **suppliers** within Carbide. HSS has only concentrated on local suppliers and not provided information to international suppliers. In 2016 Company C will approach all suppliers worldwide and encourage them to participate with JIT principles to qualify as first tier suppliers. **Forecasts** will be provided **to suppliers** and the **frequency of deliveries** will be increased from four times a year to twenty times from international suppliers.

WIP levels are high in the HSS department as there are **flow** problems due to the factory layout. Carbide has acceptable levels of WIP. **Inventory levels** are high within HSS, but with Lean implementation there have been reductions. The aim is to sell one and then make one. Carbide has low inventory levels and is manufacturing according to customer orders.

High-end products are designed in-house with the aid of an outside consultant from Israel. Catalogue items have standard design however customers do make specific requests. **Product design** is in relation to market conditions. For example, there are two products recently designed and awaiting patents that may be market leaders.

Process requirements are determined during product design. The HSS division does not allow for variations in product design and this has a negative effect on **flexibility** and

speed. Its machinery is set up to do one process at a time such as treading, tooling or fluting. Low **variation** products are sent to HSS and high variation, new products are sent to Carbide for production. In the HSS factory catalogue items are produced in large numbers or base products are prepared with variable finishes to provide variety to meet **customer demand**.

The Carbide division's production system permits variation in product design due to the new technology used with the latest **versatile** and **flexible** machines. A panel in the research and development department within Carbide determines feasibility and variations in production levels of products. This section meets customer demand for innovative and s**pecially designed products.** Product design requirements slow down production in the Carbide factory but customers are charged a premium for these products. Carbide produces high end premium tools that only selective customers want.

Company C looks to increase **quality** and attain ISO standards during process analysis and design. Process design must maximize the metal removal rate of the tool. Currently both factories' **process design** strategies are aligned to a product focus. Process design within HSS targets a low-cost strategy. HSS has many customers and a vast range of products. Process design within Carbide targets **differentiation**, where there is a limited number of customers with high variation in products.

Non-value adding steps are eliminated from the production systems in both factories. The company is continuously trying to increase the productivity levels of people. The 6 week **lead time** in the HSS section creates problems with customer value but it is being lowered by Lean. Carbide is targeting customer perceived value without problems.

The HSS section runs big **batches** through its process but Carbide runs 1 to 5 units within their process. **Manufacturing cells** are larger in HSS as different people do different operations on a product as it flows through the factory. Carbide has smaller manufacturing cells as complete products are made at one machine. HSS machines can be set up for different types of product but this is time consuming. Carbide has **versatility** built in, as any machine can do any process. Carbide has a good **balance** of processes due to small work cells.

Quality is built into the manufacturing system; it is more evident with the Carbide department. However, Lean is starting to improve quality in HSS. Continuous improvement to achieve quality is targeted in this company. Work cells have allowed quality to improve during production rather than at the end of a process. This has a positive effect towards future productions as it increases **flexibility.** Quality improvement in HSS has increased the **scrap cost.** Products are set aside when mistakes occur and new products are started. Carbide's process design has decreased scrap costs. Products are no longer set aside when mistakes occur as **rework** is immediate.

Carbide has **fail safes** in the form of Poka-Yoke machine systems. Machines are modified by the department to accept tools in one direction only. These inlet socket units reduce the production of **scrap units**.

HSS current **process layout** is fixed position mixed with work cells. Carbide is work cell orientated. Process layout is not easy to reconfigure within HSS, as heavy rigging is necessary. Carbide continuously **reconfigures** its **layout** until it finds the best fit. However, the computer connections and telecommunications are not movable. Lean initiatives have uncovered wastes in HSS which require layout reconfiguration. If the company wants to keep up with the market, certain departments need to be re-laid in cellular formation.

HSS is currently experiencing a **capacity** assignment problem which is currently under revision. Carbide allocates capacity according to allowed time over standard time example. 8 hours per shift over 10 minutes per product equals 6 products per hour. All machines have **balanced** workloads and are automated; consequently they should not be stopping.

Orders are treated on first in first out (FIFO) bases. **Manufacturing planning and control** has an impact on the production system. If it is done right then the **processes flow** smoothly if not then interruptions occur.

The HSS department is currently running on **push** production **system** however trying to change to pull systems, causing earlier capacity problems. Carbide is working on **pull production systems**. HSS is currently running all production manually with the aid of

production boards. Carbide has visual systems such as TV screens, production boards and notice boards.

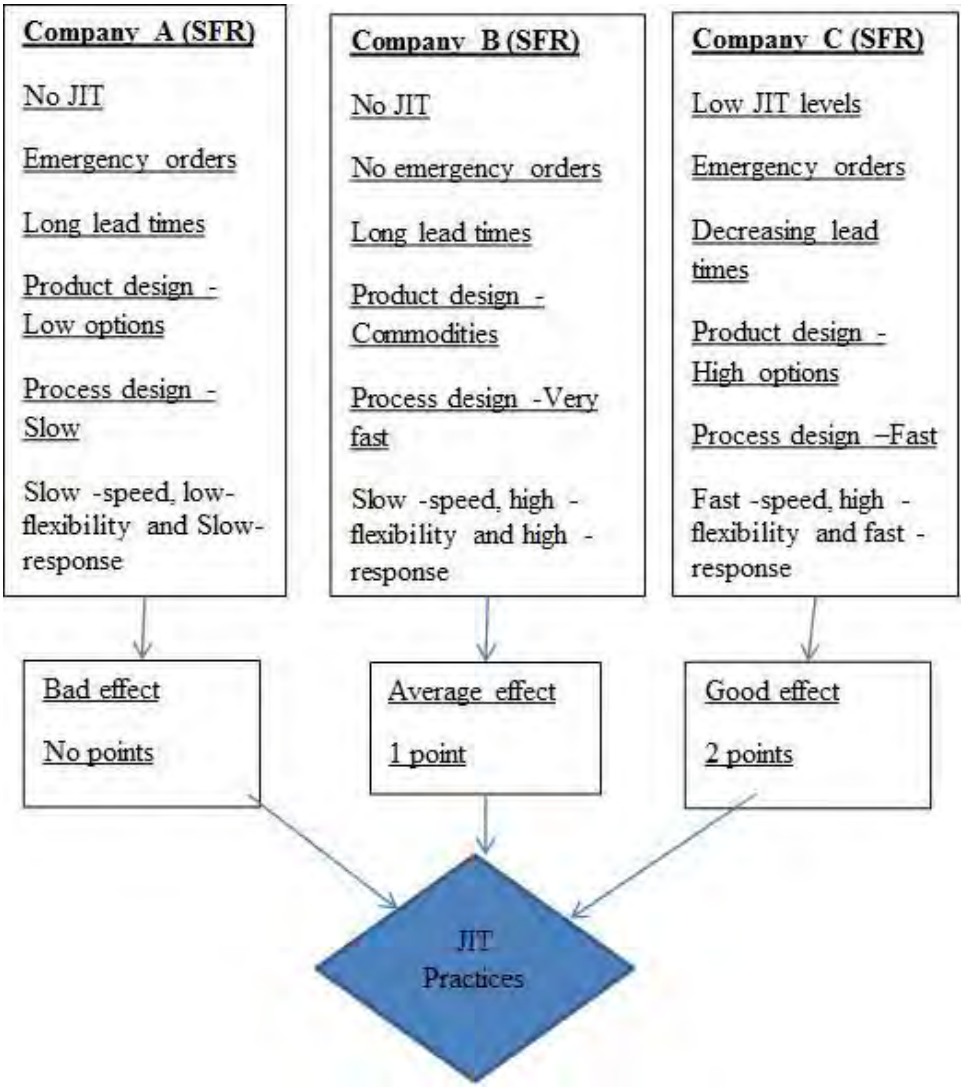

Figure 4.6: The JIT SFR relationship

(Source: Author's own construction)

After the first three months of Lean implementation, HSS reduced overall **set-up-times** by 42%. Machines that took two hours to set-up now take 7 minutes and 20 seconds. Carbide is currently running 10 minutes set-up times on 90% of machines; all others are down to 10.5 minutes. All manufacturing **parts** are **standardised** and tools are **made-to-order**. There is no form of **modularisation**, the complete tool is made from start to finish.

Figure 4.6 summarises the relationship that each company has with JIT principles. These principles affect the company's Agility levels by influencing Speed, Flexibility and Response.

4.8. Supplier relationship management

4.8.1. Company A

Company A has a purchasing department consisting of one person. The department delivers according to manufacturing needs. Large orders have to pass through the finance department for clearance and to insure sufficient funds for payment. The company only practices **supplier relationship management** (SRM) with assemblers. It does not practice supplier relationship with main line suppliers. The company has invested in structures similar to joint ventures with assemblers. Some assemblers have shares in the company. However relationships with main line suppliers are purely transactional.

Company A has an estimated 50 suppliers. Each supplier is important with some specialists providing only one product and some suppliers providing many products. There is no form of **supplier evaluation** carried out; it is done on gut feeling. When a supplier is not performing another is supplier is sourced. This leads to stock holding as a protective measure. International suppliers are a fixed group. If a local supplier performs poorly, the company then moves back to international sourcing on those products.

There are no **performance** measures in place to **monitor supplier relationships**. Raw materials are not inspected before manufacturing. Suppliers are currently working on a trust system. Agreements are made with suppliers based on the qualities of plastics in **test samples inspected** during the tender process. Some suppliers are included in New Product Design (NPD). This is product specific as some products have up to 6 different suppliers. Another factor for consideration is new materials for a new product therefore a new supplier may be required.

Materials requirement planning (MRP) is prepared on a spreadsheet created by the production manager. It is based on the sales forecast minus stock on hand, deriving a new bill of materials every month. Raw materials are standardised during the purchasing process. Plastics have a variety of three to four types from three to four suppliers respectively. Supply is dependent on price versus quality.

Suppliers do not share directly in company profits; however more profit means more business for suppliers. **Communication channels** are very good with suppliers. Suppliers do not have access to point of sale (POS) information: purchasing is done manually.

Transaction processing time is quick locally and internationally. However the fastest lead time internationally is three months.

The **purchasing process** is computer assisted but the final decisions are human, where broken units are made whole. **Order processing intervals** are quick to suppliers. Suppliers do not provide status reports however they do work well with the company. International supplier status reports come from the shipping company on request. Local suppliers work according to a delivery date on the purchase orders. In some cases emails are sent out to inquire on the progress of the order.

The seven "rights" of supplier evaluation are mostly met. Suppliers occasionally deliver the wrong product but most of the time it is correct. Suppliers deliver to the right place and in the right quantity. Most suppliers deliver the right quality and all deliver the right specifications. All suppliers local and international offer the right price. However international supply is highly affected by the exchange rate and raw materials are mostly imported. Fluctuations in the exchange rate lead to higher prices which are impossible to predict. Supplier delivery can prove difficult: certain suppliers can be a few months late and are the only source of supply.

Order size: Some suppliers are supportive of Lean systems but **bulk ordering** prevents this on certain products. Suppliers require economical shipment orders before dispatch. The company may require only one pallet of a product but find itself ordering three pallets to make the shipment economical. Internationally sourced items such as ABS can only be purchased by the container load which lasts two months.

International **supplier location** is not favourable and local suppliers are spread all over South Africa. Nonetheless, most local orders are **delivered within 24 hours**. Packaging is an exception as orders need to be placed three months in advance. Printed boxes are in high demand within South Africa. Local suppliers can **deliver directly to where inventory is needed.** However stock from assemblers must be retrieved by the company. Main line suppliers do not offer kitting: this is only done by the assembler. However, the assembler cannot deliver in sequence and cannot follow material staging.

Suppliers are **responsive to NPD** as they are in abundance. Currently there is list of twelve to choose from however only three to four are regular suppliers. Local suppliers

are responsive to process changes and international are not. This is due to lead times where raw materials are ordered up to three months in advance. Therefore it takes time to get up to speed on the international side.

4.8.2. Company B

Company B has a purchasing department headed by one person. Purchasing of packaging and raw materials are done on a weekly or monthly basis. There is a subsidiary department within purchasing commissioned to purchase engineering parts and spares. The company practices **supplier relationship management** (SRM). Nominated preferred suppliers are selected on past history based on price, servicing and quality. Suppliers demonstrating all three factors receive 50% of the company's business. The remaining 50% is apportioned according to supplier capabilities. The Purchasing manager said, "We always aim to have more than one supplier to ensure continuity."

There is always **more than one supplier per product**. The rice factory sources raw materials from Thailand and India. Occasionally prices are high; however there is price range for nominated suppliers. The company has an estimated 280 regular suppliers for raw materials, packaging and spares. However the data base has 1200 suppliers available.

Supplier **relationships** are purely **transactional** with local suppliers of packaging and shrink wrap to the rice factory. However there is collaboration with international suppliers of raw materials due to spot rates and exchange rates. **Communication channels** are straight forward with suppliers, mainly telephonic. Enquires and tenders are done via electronic mail. Suppliers do not have access to POS information.

Supplier evaluation is carried out according to a weighted plan. However there are no **performance measures** in place to monitor supplier relationships. Raw materials are inspected before the manufacturing process with new products. Prior inspections are done on supplier premises and raw materials are inspected by in-house laboratories. Upon approval suppliers become continuous suppliers and internal periodical **inspections** are done to ensure correct supply.

Materials requirement planning is done on the past years average and 10% to 20% is added to allow for growth. However growth within the rice factory has been exponential over the past few years. Raw materials for the company experience variation; however

the rice factory has a choice of two suppliers who provide a standard product. Specifications differ due to different countries however fall within the specification of the company.

Transaction processing times vary across suppliers; however they fall within company requirements. Packaging supply for the rice factory works on a three to four week **lead time.** Raw materials take between two to three months lead time. All raw materials and packaging runs on a three month forecast. The entire purchasing process is human initiated and no computer assistance is utilised. **Order processing intervals** are quick to suppliers. Suppliers are involved early in **NPD**; commodities such as rice are straight forward and only vary on the type such as long grain, short grain, white, brown and basmati.

The **seven "rights" of supplier evaluation** are usually met: suppliers do deliver at a 99% average across all rights that is, right product, place, quantity, price and time. **Quality** and specifications have to pass through the company's in house lab for approval before the purchasing process. Currently the quality of raw materials meets the requirements to support Lean systems.

Company B is **located in close proximity to suppliers** in KwaZulu-Natal. International supply is problematic. Durban port is the busiest port in Africa; ships can be parked for days due to queuing and wind factors. Waiting times are not necessarily attributed to the supplier rather how fast your local port can process imports.

Suppliers of raw materials for the rice factory cannot **deliver directly to where inventory is needed**. Materials have to pass through the port first and then Company B has to retrieve the rice with its own transportation system. However suppliers of packaging and spares can deliver directly to the factory. Suppliers follow bulk delivery to the rice factory. There is no form of kitting or material staging however suppliers can deliver in sequence.

Suppliers are **responsive to process changes**. All suppliers work well with the company. If the change is on their end the company is notified. If the change is on the company's end then suppliers are notified, therefore a good **relationship** with 280 suppliers. Suppliers provide order status reports on a weekly basis. Suppliers do not share in the profits of the company. More profits usually mean an increase purchasing from suppliers.

4.8.3. Company C

Company C has a purchasing department divided into raw materials department and consumables department. Both departments are under the control of the purchasing manager. Purchasing **delivers** exactly what is needed for the manufacturing process. Stocked items such as raw materials are done according to an established level of safety. However manufacturing does make extra ordinary demands on consumables such as spares.

Maintenance is reactive and not **planned,** which makes response to spares impossible to predict. Machine parts are always regarded as urgent and some parts need to be internationally sourced adding to the complexity. Other consumables utilized during the manufacturing process such as oils are stocked in stores. Safety levels of these items range between two to four weeks. The Consumables purchasing manager stated that "In most cases we order in parts as required, all other consumables are kept at a 2 weeks buffer level."

Company C practices **supplier relationship management** (SRM) on raw materials and not on consumable stores. Some suppliers are partnered with; the company promotes partnering as a method of aligning suppliers to the business strategy. Lean has caused greater emphasis on **partnerships.** Some suppliers are shareholders in Company C. An estimated 500 suppliers constitute the companies supplier list. They are categorised into regular and irregular, furthermore in to raw materials, semi-finished products and consumables.

A **combination of relationships** (**transactional, collaborative and strategic alliances**) is maintained with raw material suppliers. Consumables are dependent on the nature of goods however mostly transactional relationships are maintained. Suppliers are classified according to weighted plan, measured on performance and reclassified on the ABC list where necessary. The Raw materials purchasing manager said, "We have a last of proven suppliers, ABC classifications allows us to selected the most appropriate supply at the time."

Performance measures are in the form of a computer generated reports, on actual deliveries against purchase orders. This helps monitor supplier relationships by

measuring actual delivery against promised delivery. Additionally, performance schedules are sent out to customers on a quarterly basis to assess the supplier's products. Supplier sessions are held where suppliers present on order requirements, delivery dates and the history of Company C.

Raw materials are **inspected** before the manufacturing process which indirectly monitors suppliers. Suppliers are involved in **new product development** within both departments. In some cases the question of outsourcing is explored. The company attempts to stick to core competencies of 'finishing' of tools. **Materials requirement planning** is according to MRP1 generated by Cispro software system. This is streamlined by standardizing raw materials in the purchasing process.

Suppliers do not share in the profits of the company however profitability leads to larger purchasing orders and bigger volumes. **Communication channels with suppliers** are fast and positive, utilizing telephones, electronic mail and Skype software. Suppliers do not have access to POS information. **Transaction processing** times for raw materials ranges up to 6 months, causing difficulties in a fast changing environment. Local transaction processing time ranges between 24 to 48 hours, dependent on the nature of the goods and product mix.

The purchasing process is computer assisted and human initiated. Cispro develops an MRP for regular items and this is human initiated for new products and emergency items. **Order processing time to** suppliers is short and fast. Suppliers do not provide frequent order status reports internationally and locally. Purchasing has to check up on order status. The **quality** of raw materials from suppliers is good enough to support Lean as they go through prior supplier approval.

Raw material **supplier locations** are not favourable to the company; South Africa is too far from Europe. The location is problematic especially towards Lean and one piece flow. This increases shipping costs for the company. The company is now considering **consignment stock** to be kept on premises. The stock will still belong to the supplier however Company C can pull from it at any time. However one requirement is that the stock can never be returned and must be used within a specified time period.

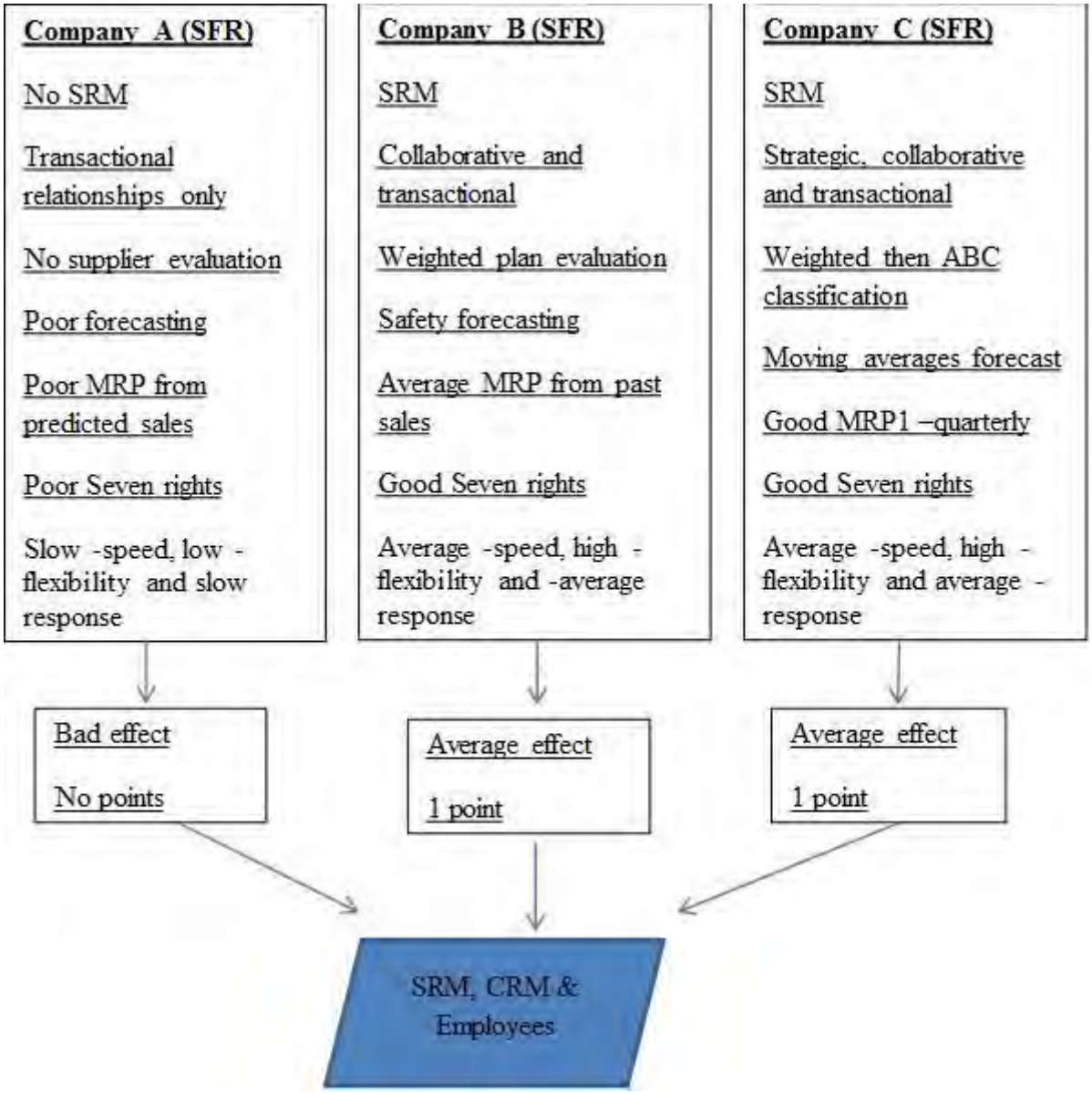

Figure 4.7: The SRM and SFR relationship

(Source: Author's own construction)

Company C utilizes a proven list of suppliers that categorizes suppliers in **ABC classification** for raw materials. Raw materials are internationally sourced. Suppliers deliver six out of the **seven "rights",** product, place, quantity, quality, specifications and price to an average of 90%. This is due to prior supplier evaluation. Samples are obtained for quality control, trial orders are issued and over time supplier will fall into ABC classification. The last right of suppliers, **delivering on time** tends to be problematic. Suppliers that show continuity suddenly experience changes and therefore create delays. This occurs on an average of 30% of orders and is unpredictable.

Suppliers cannot **deliver directly to where inventory is needed**; stock has to go through receiving first. Raw material suppliers deliver in bulk however some products are purchased in semi-finished form. Consumables suppliers can deliver following the **kitting method**. They do deliver in sequence and follow **material staging**.

Figure 4.7 summarises the relationship that each company has with SRM principles and the effect on the company's Agility levels

4.9. Customer relationship management

4.9.1. Company A

Company A does not practice **customer relationship management** (CRM) or have a CRM package. Relationships are **transactional** and reactive based. The sales manager follows up on queries and directs relationships towards CRM. Customer complaints are dealt with on a one to one basis. There are long standing relationships with 10 out of 390 customers which constitute 80% of sales. Good **relationships** are maintained with wholesale customers and who receive cheaper prices due to bulk buying. An industry standard is to extend credit to customers. The top 20 are regarded as premium customers. Production lines are reserved for premium customers. Sales can prioritise which customers get serviced. Generally production is on FIFO bases, however big customers take **preference**. The Sales manager commented that "Wholesalers are the main source of income and therefore given preference."

The company does not practice **service design**. Sales people develop long standing relationships over time. There is no service design in writing and the reaction to customers is based on the experience they have. The only form of service design is customers requesting information on the **returns procedures**. Returns occur three to four times a month, due to spike orders. Manufacturing has a week's delay to get stock out on spike orders. The factory then has to change from standard monthly production to keeping up with rush orders. This results in large stock holding of inventories.

There is a customer returns procedure on functionality or quality related problems. This is attributed to customers incorrectly installing products or moulding problems on machines respectively. Surprisingly the largest number returns are not attributed to these two problems. Largest returns are due to **late delivery** to a wholesaler resulting in

contractors cancelling orders and missed orders. However the company is better than most competitors in the industry relative to delivery. There is a long standing relationship with a **3PL company** based in-house, allowing speedy delivery.

Communication channels are excellent, utilizing telephones, email and sales people do monthly visits to customers. Some customers facilitate demand planning by indicating future order levels on certain lines. Not more than five customers order in advance on products they know they will use. However information from end users does filter back to Company A. Tiering from wholesaler to end user results in **no direct communication with end users**. Customers do not make unreasonable requests, occasionally last minutes orders from contractors to wholesalers. Customers occasionally make emergency orders; the main concern is getting stock by a certain time.

There is a good understanding of **customer product needs**. Sales representatives in the field speak to customers on a regular basis. Requests and suggestions are evaluated to test feasibility and profitability before production. This information is sent to the sales manager and decisions are made. New production methods are introduced to meet these needs by changing and adjusting machine moulds.

Products do not always meet constantly changing **customer requirements** and preferences. Product availability and appearances are lagging. New products are constantly entering the market from China. The current catalogue is old and needs to be updated. However, customer expectations are not transparent due to the tiering system of the supply chain.

The company does not have access to **POS information** of its customers. Only five customers provide a **demand forecast** based on past history. Cycle time on receiving, capturing and releasing an order, is same day shipping if there is stock on hand. If there are back orders, each customer on back order is contacted on a daily basis and updated on order status. Waiting times range from 24 hours to a week dependent on if the product needs to be manufactured. This ranges up to a month if the product is an imported item. Influencing variables such as demand availability and exchange rates can prove problematic.

Products are readily available in certain geographic locations. Company A has a warehouse in Cape Town. Products take a minimum of 48 hours to get there and this **delivery time** results in lost sales. However there must be an attractive sales market to justify a warehouse, therefore only one depot available.

Availability of products is affecting sales. However work has been done in correcting forecasting methods. Spike orders prove problematic as customers have to be place on back orders. This results in wholesalers not invoicing their customers and this leads to cash flow problems. Company A has decreased the range within the catalogue to increase **product availability** compared to competitors.

Customers do not have a choice in **lot sizes.** Breaking boxes and pack sizes causes breakages when they are not full. Items like flood lights tend to roll around if they are under packed. However with cash flow proving problematic, box sizes have been reduced to increase appeal.

Product variety is not sufficient to customers; however as variety increases so do stock levels and costs. Smaller pack sizes leads to smaller orders and hence to feasibility concerns with logistics. A minimum of R1000 per order is acceptable. Smaller and more frequent orders cause breakage problems and increases transport costs resulting in difficulties during stock counts. The current **stock out frequency** list is high due to variety, 15 to 20 products are regular stock out items. Imported products stay on the list for up to a month; local products are off within days.

The current **order fill rate** is 93%. Orders shipped complete against orders received are at an 80% average. This results in double delivery where the second delivery can be under R1000 resulting in loses. The **current speed of delivery** is 24 hours to Durban and Johannesburg and 48 hours to Cape Town.

The production system does not consistently meet customer orders. However the production system can accommodate modifications to basic service agreements. The production system supports unique sales promotion. Stocks have to build up before the promotion. **New product introduction** within the production system is problematic and slow due to moulding concerns. Moulds have to be modified or made new which can be

up to three months. Local and imported products need to pass SABS testing which ranges up to 120 days.

Product recalls can be **reworked**, dependent on product value. Cheap and faulty products are easier to replace and are rarely repaired. Production systems cannot deal with disruptions in supply. Striking in South Africa can last up to a month. It takes long to build up sufficient stock. Current months are not affected but there is a knock on effect for following months.

The production system can meet once-off **customisations** in basic service requirements for specific customers, which is cost dependent. **Product modification** or customization cannot be performed while in the logistics system. Price is the only change that can be made. Once on the road it is regarded as committed. Changes can only occur before hand over to the 3PL.

Customers are being serviced with the **seven "rights"**. The Price "right" is problematic due to imports from China. Right place and time is handled excellently by the 3PL. The right product is at 80% as the catalogue needs updating. The right amount and condition is accomplished by packaging according to full box quantities. This avoids breakages that occur when pack sizes are broken. Right information is fair, wholesalers are knowledgeable and customer training is done. However assuming perfect information from customers is not reality. Customers may order and then get it cheaper from elsewhere. There is never a firm commitment and creates the need for price to always be right.

4.9.2. Company B

Only Company A and C will feature in this section. There was no data available for Company B.

4.9.3. Company C

Company C uses **CRM** in practice. The company has an excellent understanding of customer needs and in addition wants to help customers grow their businesses. **Collaborative relationships** are maintained with customers. After-market services include **technical support** provided by the spindle department. Spindle is a subsidiary of the sales department which teaches and advises customers on how to use products.

Company C practices **service design** in tailoring services towards customers and accommodating them as far as possible. Customers are involved in the service design process. The company has in excess of 200 customers locally and similar numbers internationally. There are premium customers locally and internationally. However production lines are not reserved for them. Each customer is treated the same and encouragement is given to smaller customers to grow. Occasionally customers make and ask for emergency orders to be fast tracked and it is considered. The Sales manager said, "We aim to treat all customers equally, as we believe that today's small customer can be nurtured into a future big customer."

The company does not have access to **POS information** from customers. Sales requests monthly usage and is occasionally provided by customers. However **communication channels** are excellent with customers. There are language barriers with foreign customers. However google translate is utilized and effective. Occasionally international based agents are asked to step in and translate to Spanish. Only limited number larger customers facilitate demand planning. These customers order in advance. A small percentage of customers make unreasonable requests and some of them are turned down.

Cycle time of receiving, capturing and releasing an order is within 24 hours. This is acknowledgement of the order with delivery intent. Time to receiving the order locally is the same day if done before 2pm and if stock is available. Orders after 2pm are next day delivery. Internationally, **EBQ's** have to feasible before shipment as Company C bears theshipping costs. Orders must be greater than $5000 and meet customer order requirements. Requirements such as 100% complete order fulfilment which can prove time consuming.

Products are not readily available to customers geographically. However the **3PL** can service all of South Africa overnight. Pietermaritzburg and KwaZulu-Natal are serviced in-house and Johannesburg is serviced by the warehouse. **Product availability** is affecting sales especially locally. **Stock outs** reduce sales however the company is fortunate to be the only manufacturer of High Speed Steel in South Africa.

Understanding customer product needs is done from a company's perspective within innovative and market leading manufacturers. Company C utilizes marketing literature, digital video discs and technical support during end user visits to improve tool

understanding. The company has introduced new Lean production methods to improve their response to **customer product needs**. Set-up-times are reduced to get work out faster. Manufacturing products meet customer expectations however occasionally fall short on requirement specifications.

There are customer **returns**, attributed to poor quality. Quality problems can arise from inferior raw materials or mistakes during the manufacturing process. The quality department does a full analysis of the returned product. Customer return rates are very low. Lean allows rework on product recalls. This is dependent on the quality department's parameters to rework or scrap. Products are replaced free of charge or the customer is passed credit.

The current **order fill rate** on exports is 60% and on local is 70%. The average of orders shipped against orders received is 50% which is rather low for a market leader.

Speed of delivery is fast locally in most cases within 24 hours. International air freight can be done within a week. However hold up in production can prove time consuming. Furthermore the company incurs costs when production is late. International requirements standards are delivery within a week however production takes an average of four weeks from order placement. Customers do have options with lot size purchasing. Frequent, irregular purchasing causes production problems. **Safety stock** is needed affecting raw material levels.

The Lean system does consistently allow the company to meet customer orders. However it cannot accommodate modifications to basic service agreements. Lean does support quarterly **sales promotions** on specific products. Stocks have to build up to sufficiently promote, especially on new product introduction.

Lean cannot deal with disruptions in supply. South African strikes result in raw material shortages, production slowing down, delivery delays and overall negative impacts on service delivery. Lean can meet once-off **customisations** in basic service requirements for specific customers. A panel within research and development department signs off on these requests.

Lean cannot meet **product modification** while in the logistics system. However locally products can be retrieved and exchanged for correct products. A 10% handling fee is

charged on returns. Internationally this is difficult, costly to retrieve stock and exported items re-entering creates political concerns at customs. However international returns are rare. Customers are being serviced with the **seven "rights"** most of the time. That is the Right product, condition, price, information, time, place and amount. Time and place is serviced a 3PL and the right amount is problematic due to EBQ shipment on the international end.

Figure 4.8 summarises the relationship that each company has with CRM principles. These principles affect the company's Agility levels by influencing Speed, Flexibility and Response

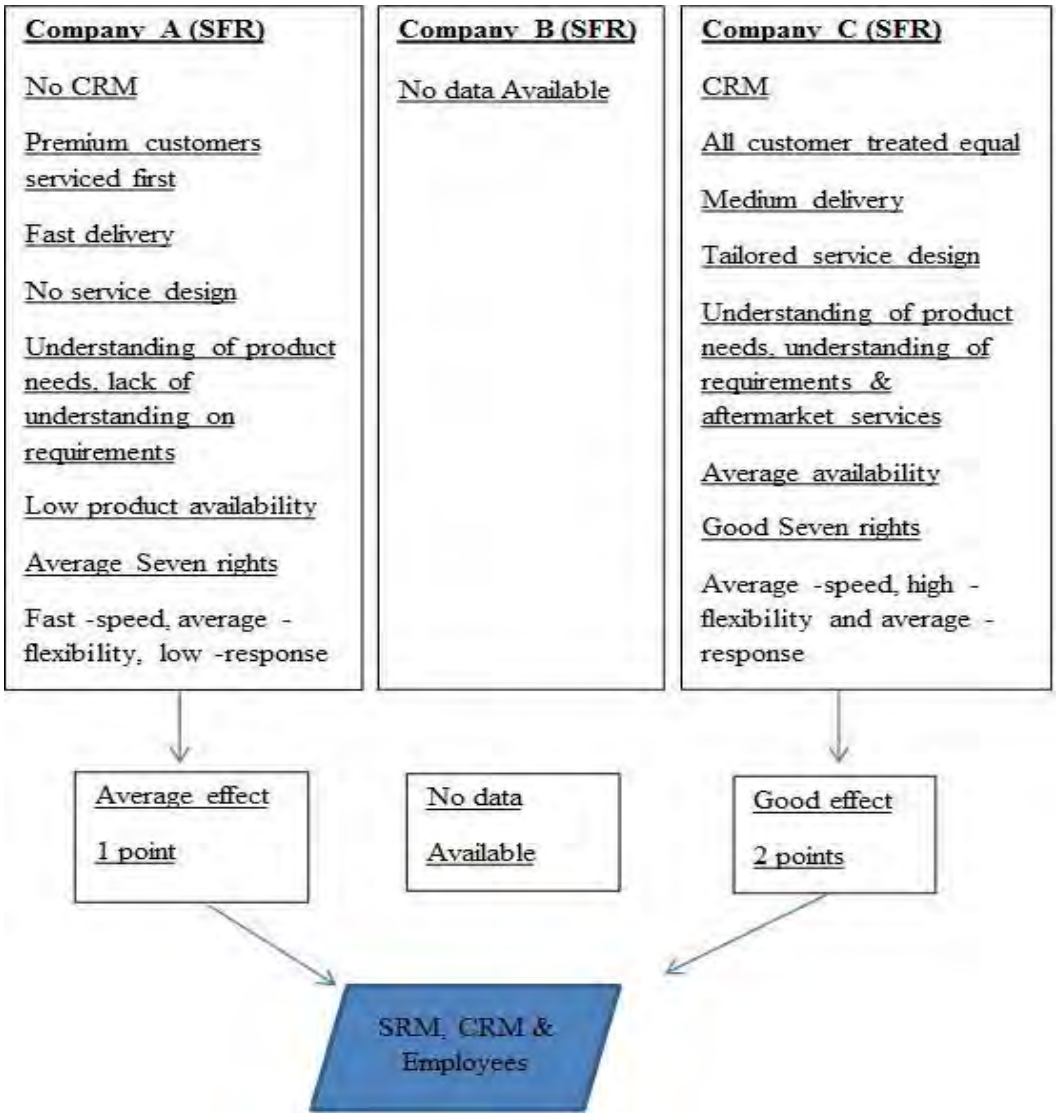

Figure 4.8: The CRM and SFR relationship

(Source: Author's own construction)

4.10. Organisational culture and personnel

4.10.1. Company A

Company A has two different types of **organisational cultures**. Management perceives a positive culture among office employees but enjoys a less amicable relationship with factory employees.

Office employees are aware and do understand their **impact on the organisation**. Factory employees are informed on their impact on the organisation. All employees are aware of their contributions externally. They are knowledgeable on the hiring policies of disadvantaged assemblers in different communities within Pietermaritzburg. If the company does not perform its functions then these disadvantaged assemblers do not receive work and therefore payment.

Employees are provided with **feedback** on their performance. Office employees receive **incentives** for targets. Factory employees are unionized and agreements are reached with unions. They receive production targets on production boards in the factory.

All relevant **information** is readily available to specific employees such as disciplinary codes and operational SOP's. Office employees receive electronic mails that keep them updated. The factory manager receives electronic mails and updates **production boards** to keep factory employees informed. This is the only **communication network** that is in operation. The company implemented skype unsuccessfully.

Managers and supervisors believe they are open and transparent with subordinates. The Human resources manager said, "Openness and transparency is at a relevant need to know basis, specific to that person's role." Information is passed on that is specific to the employee's role. There are organisational meetings when new business methods are implemented. Responsibilities are delegated from managers to office employees but the relationship with factory employees is less comfortable. Management attributes this to an uneasy **relationship** with the unions. The involvement of shop stewards is seen as reducing employees' willingness to participate in initiatives. Furthermore there are disciplinary hearings as a result of insubordination and high levels of absenteeism among the factory workers. An average of 15 days per year per factory is lost. Office employees seem to be happier with their levels of **compensation** than are unionised employees.

There are limited opportunities for advancement due to the size of the company and the low staff turnover.

Health and safety policies are in place and relevant **training** is conducted. Systems are regularly audited and evacuation drills are practiced. The company does not have many injuries on duty (IOD). Every employee is provided with protective equipment in their respective roles such as safety boots, overalls and goggles.

Human resource management believes that it encourages employees to work on their own without supervision as a form of **employee empowerment.** Office employees have responded well to changes in management strategy but factory employees have been slower to change. Management perceives cultural issues as problematic. While they believe that employees are encouraged and afforded opportunities, this has not always yielded positive results.

Leadership in the factory is provided by the production manager. He holds regular meetings with employees. Those who are required to handle equipment are trained. Retraining is provided as necessary and forklift and first aid training is done annually. The company and employees develop a **work space plan** annually.

The company does promote **cross functional team** work and this has been successful among office workers. However, it has been more difficult to implement in the factory in spite of this requirements being written into employees' job descriptions.

There have been changes that have led to **employee utilisation** levels decreasing. The logistics provider has changed their operation hours and these no longer match the factory. Some old machinery has been sold and new machines introduced requiring training of employees. Factory employee **incentives** are not linked to performance on production which effects employee performance.

Job rotation has been successfully implemented with office staff but less so in the factory. **Human errors** affect the production system, raw materials through incorrect regrind procedures and parts are not always correctly counted when they are sent to assemblers.

4.10.2. Company B

There is a positive organisational culture within the company. It is a multi-cultural organisation with good cooperation among employees. Most employees are unaware of their individual impact on the organisation. Employees are aware of their collective contributions as a department. Lower levels employees are unaware of how their jobs impact society. Senior level employees are aware. Employees are not provided with **feedback** on their performance but poor performance results in disciplinary procedures.

Senior level employees are empowered to achieve more. During team buildings competition is encouraged and performance recognised. **Information** is easily available at senior levels however not at lower factory levels. There are no **communication networks** regarding the manufacturing process. The rice factory employees receive information and instructions from the manager. Nonetheless managers and supervisors believe they are open and transparent with their subordinates and that they work as a team. The Production manager stated that "Only relevant information is passed to lower level employees, keeping it simple is the key to success and avoiding errors."

Responsibilities are moved from managers/supervisors to production employees within the rice factory. Specific **roles are predetermined** in the rice factory and employees adhere strictly to those positions. There are disciplinary hearings due to insubordination attributed to the large company size. Management believes that employees are compensated fairly across the company and are positioned appropriately in their jobs. There is a very low absenteeism rate. Employees receive an **incentive** for taking zero absent days of one week's pay annually. All **health and safety** measures are in place in each department. Employees receive safety boots, goggles and gloves and inspections are done often. There is an in-house doctor available at all times of the working day.

Employees play a major role in the production system within the rice factory. However when implementing new production systems all employees have to adapt. Employee input from lower level employees, is not considered the production process. Only senior level employees have an influence. Lower level employees are not included in **problem solving.**

Leadership has a large effect on the current production systems in the rice factory. The rice manger ensures that employees achieve production targets. All rice factory employees are well **trained** to handle equipment. Human errors and mistakes are at a minimal due to the level of automation. Employees are required to stay after work to rectify any mistakes. However this is unpaid work. **Retraining** is done on a daily basis and employees sign off on **job descriptions.** Training certificates are issued on inspection and qualification.

The company promotes **cross functional team** work. Employees from any department can be rotated and utilized in another department. Employees are cross trained to an extent. Cleaners can be trained to operate machines. Employees are promoted to increase their skill sets. Some supervisors such as the rice plant supervisor are totally illiterate and still supervise an entire department.

Employees are efficiently **utilized**, the rice plant has an exact and sufficient number of employees required on a daily bases. There are no extra idle employees with this factory.

4.10.3. Company C

Company C employees have good working **relationships** resulting in good organisational culture. Employees are afforded the opportunity to follow procedures when they have grievances. As members of a union, their representatives are free to talk to management at any time. Individual employees are aware of their impact on the organisation. This

Employee **awareness** of their **contribution** to the company has increased through Lean principles. The company has **Kaizen** meetings every morning within work cells. The HSS production manager said, “Employees are motivated and encouraged to discuss their ideas and problems, this creates an open environment building for change.” They are beginning to understand that delaying on their processes, results in delays to the process down the line. Employees are aware of their impact on contributions external to the company. The managing director occasionally visits customers in the field and returns with information for the staff. They are **informed** on the products’ performance, how products are utilized and who the customer is.

Employees are provided with **feedback** and information on their performance. Employees know their daily production targets. If production targets are not met, works

cells try to resolve them as a team. Employees are **empowered** to achieve more and encouraged to make suggestions and introduce innovations. They receive **cross training** through training on other operations and employees are **rotated** within their departments. There is always a training officer on hand to assist with training and quality. This helps employees to achieve more and produce more.

All departments are afforded the opportunity to develop innovations during daily Kaizen meetings teams or departments with worthy innovations receive monthly cash rewards to utilize as a team. These **incentives** range from R500 to R5000, motivating employees to excel at work functions.

Information is easily accessible to employees. An open door policy exists with the managing director and Human resources manager. Employees are included in **communication networks** regarding the manufacturing process. Most supervisors and managers are promoted from the floor.

Responsibilities are moved from managers and supervisors to production employees. Their daily functions are regarded as their own business. Employees only approach managers and supervisors if there is a problem. Employees are appropriately positioned in their jobs. However it is difficult to determine if people enjoy their work or are doing it just for a job. Some employees attended FET collages specific to their jobs. These employees tend to enjoy their work.

There are **disciplinary hearings** as a result of insubordination however this is minimal. Employees are compensated through agreements with unions. **Absenteeism** is regarded as fair within the company. Less than 20 people are absent daily from an estimated 300 employees.

There are **health and safety** measures in place. Employees are provided with safety equipment. An in-house nursing sister checks that the people have not been affected by the working environment (e.g. chemicals). Temporary employees receive the same treatment.

Most employees have adapted to the changes required in adjusting to Lean principles and implementing new production systems and are **motivated** by its benefits. Human errors do occur during production however Lean has managed to minimize them.

Implementing of Lean and Kaizen has exposed difficulties in measuring **production targets**. Lean's clarity has measure production at 35% to 40%; goals within Lean are gradually set. The current aim is a level of 50% of production targets.

Figure 4.9 summarises the relationship that each company has with organisational culture principles. These principles affect the company's Agility levels by influencing Speed, Flexibility and Response.

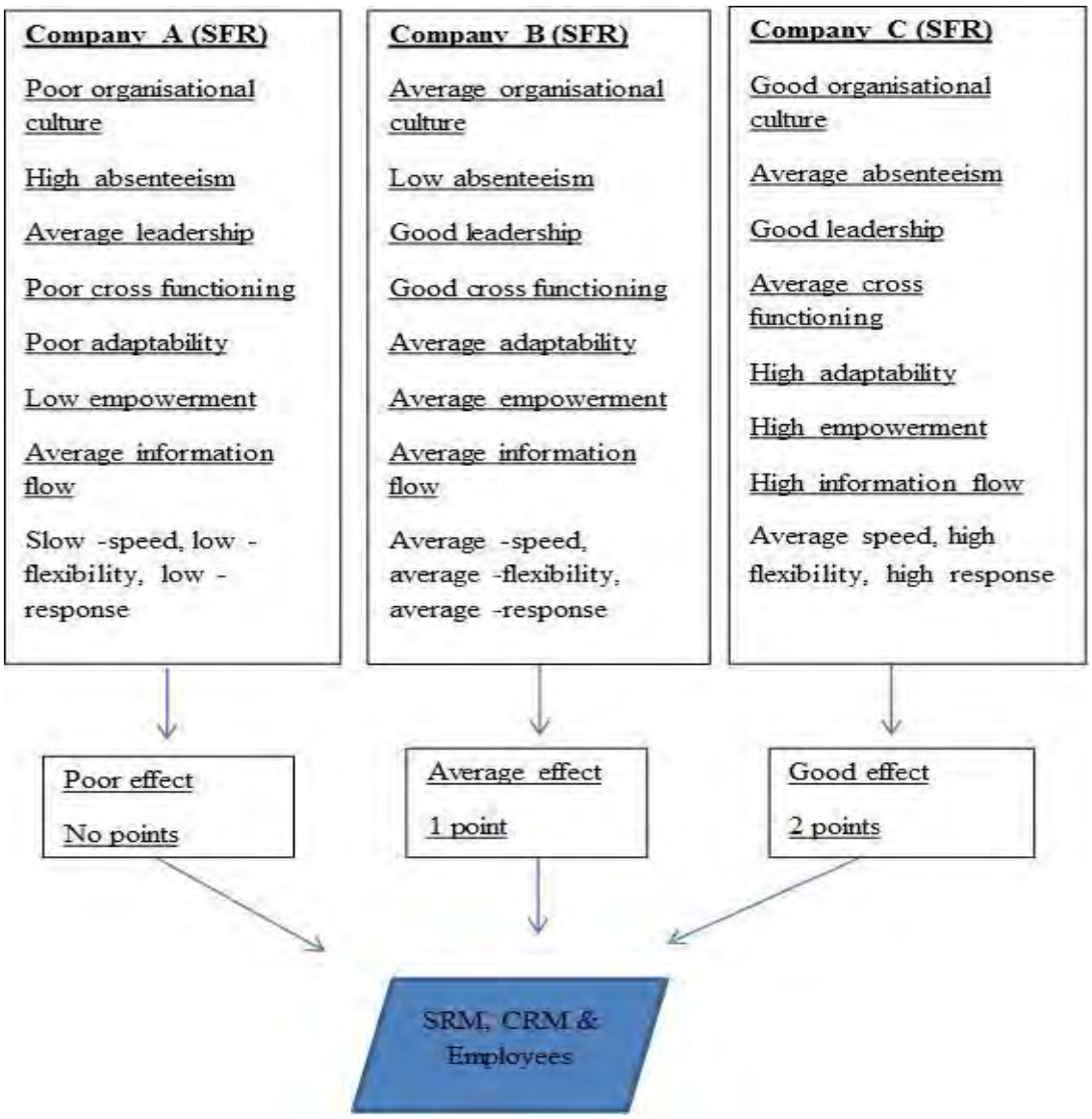

Figure 4.9: The Organisational culture/Personnel and SFR relationship
(Source: Author's own construction)

4.11. Conceptual model

The following conceptual model has been used to investigate the four major components of the conceptual model. Furthermore what effect does each component have on Speed, Flexibility and Response? These three main factors bond the four components. Each company is measured on their performance and given points to demonstrate how each Lean category affects Agility within the company.

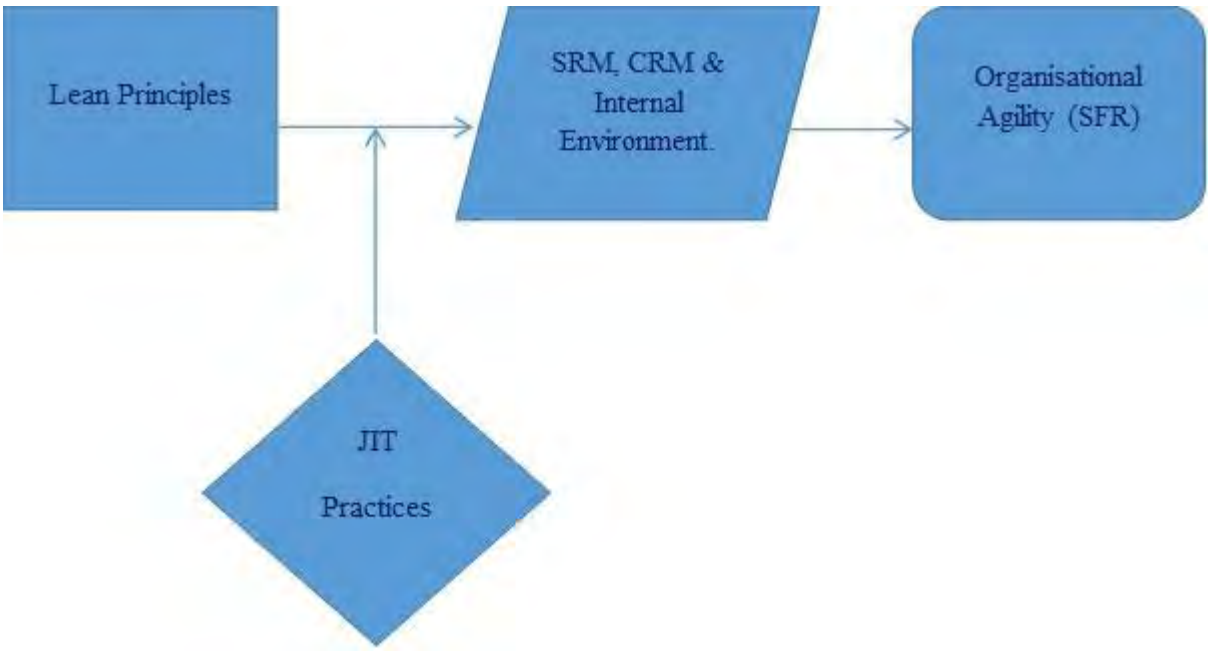

Figure 4.10: The conceptual model of Agility relationships
(Source: Adapted from Sekaran and Bougie, 2013: 76).

The conceptual model depicted in Figure 4.10 describes the relationship between Lean principles, Just-In-Time practices, speed, flexibility and response and their contribution to organisational Agility. This model suggests that elements of Lean are required to support the Agile paradigm. The elements in question include Lean factors that affect Agility, Just-in-time, Lean Supplier relationship management, Lean Customer relationship management and Lean organisational culture. Agility originates from Lean, or more specifically, Lean flexible systems and elements of JIT.

Eliminating the seven areas of waste is imperative to the implementation of Lean systems. If wastes aren't addressed through Lean in the first place, it is not advisable to move towards Agility. JIT and Lean have the same foundations and are mutually supportive of

one another in seeking to eliminate the seven areas of waste. Consequently, JIT purchasing and JIT production are considered as moderating factors on Agility.

4.12. Conclusion

There are definite relationships evident within the conceptual model. Relationships have both positive and negative effects on each component theme within the model. Each area of investigation was allocated a maximum of two points. The points demonstrate the effects that the different levels of Lean have on the companies Agility levels.

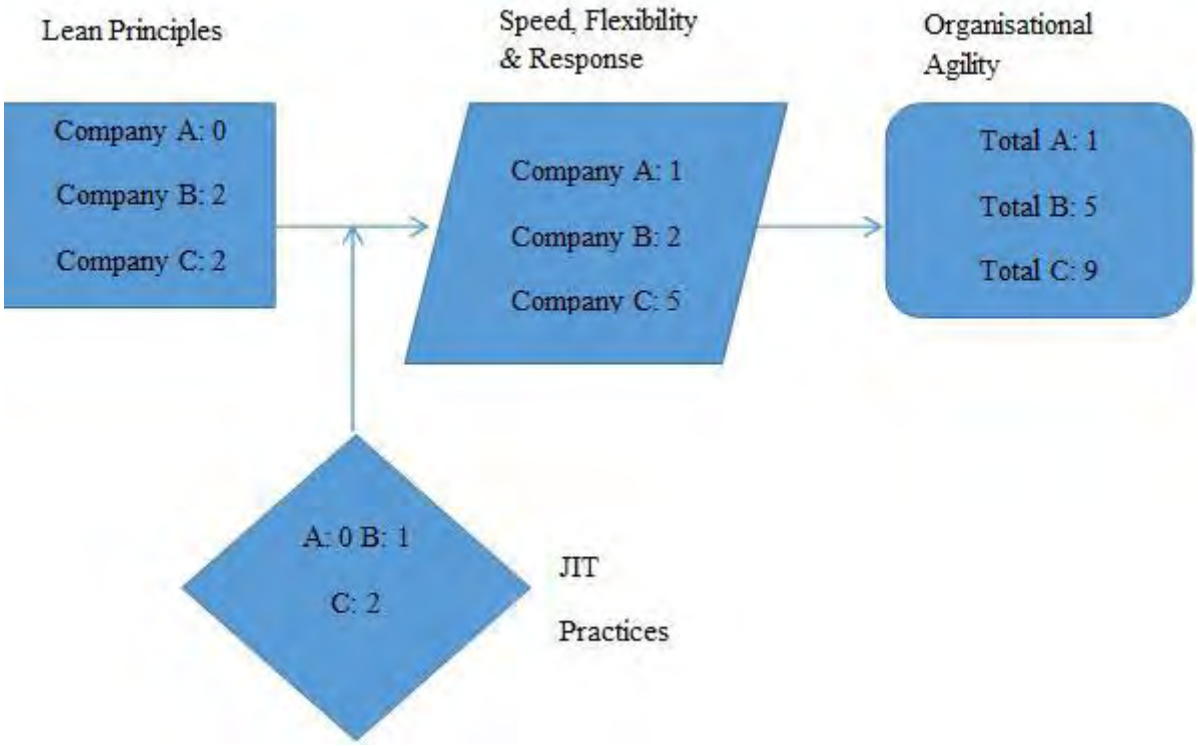

Figure 4.11: Organisational Lean category SFR scores
(Source: Adapted from Sekaran and Bougie, 2013: 76).

Company A was categorised as in the Lean intentions phase and scored just one point from a possibility of twelve points. The company also scores very low on Agility.

Company B was categorised as in Intermediate Lean phase and scored five points from a possibility of ten points. The researcher was not able to compare customer relationship data in Section 4.9.2. There was no sales manager available for this interview. Their Agility level was higher than that of Company A.

Company C was categorised as in the Expert Lean phase demonstrates nine points from a possibility of twelve points. This proves that high levels of Lean improve Agility.

A conclusion is that Lean is a pre-requisite of Agile and companies may need to implement Lean before thinking of Agile systems. The implementation of JIT in Company C has improved customer service and efficiency by eliminating variation and enabling flow. JIT is a key area in Lean operations and is helpful in contributing to both low cost and a rapid response strategy. JIT seeks to bring production down to its simplest form of a batch size of one, which is also an objective of Agile systems. This is a useful tool for Agility. Organisational Agility can only be attained by implementing JIT's responsiveness and Leans flexible manufacturing systems. Lean principles and JIT practices influence manufacturing Agility positively.

CHAPTER 5 DISCUSSION

5.1. Introduction

The aim of this chapter is to provide a review of the component themes within the conceptual model identified in Chapter Four. Reference will be made to the research questions and key areas explored within literature review of chapter two. The driving force of this research is to determine what influence the different levels of Lean have on Agility. This chapter will explore these influences to provide a basis for recommendations.

The literature review in Chapter Two suggests that Lean and JIT restrict Agility by restricting speed, flexibility and response. The Lean and JIT paradigms regard excess inventory and capacity as wastes and seek to eliminate them. South African companies changing to Lean generally carry over an inherent excess capacity from their traditional manufacturing practices. Yet the findings of Chapter Four indicate that, contrary to theory, Lean increases Agility in companies taking the Lean journey from mass production. This finding suggests that companies implementing Lean are better able to manage their capacity and this in turn will enable them to achieve Agility. Therefore, it may be concluded that a company may possess Agility while being well advanced on the Lean journey. Eliminating these Agility factors may compromise the company's ability to respond to market challenges.

Chapter Four has shown one main negative concern that works against the positive relationship between Lean and Agility. This is the concern of excess inventory, the main contributor to the dispute that Lean and Agile are mutually exclusive. However the overwhelming positive points outweigh this one solitary outlying factor.

The research questions, previously stated in Chapter One were:

- Does the company under investigation require Agility?
- What is the influence of Lean on speed, flexibility and response in manufacturing practices?

- What is the influence of Just-in-time on speed, flexibility and response in manufacturing practices?
- What is the influence of relationships with suppliers and customers on speed, flexibility and response in manufacturing practices?
- What is the influence of organisational culture on speed, flexibility and response in manufacturing practices?
- What other factors influence the degree of Leanness and Agility?

The factors that influence Agility will be discussed within each themed category.

5.2. Company strategies

The companies' overall strategies, production processes and demand strategies determine their ability to meet customer demand. Each company is discussed below and its need for agility is assessed.

5.2.1. Company A

Company A's mass production strategy renders their production system extremely inefficient and unprofitable. Production problems are attributed to wrong strategy selection, wrong product classification and poor forecasting. Mass production should no longer be regarded as an option for manufacturing companies. Company A's products are highly differentiated and follow a product life cycle. Differentiation and PLM continually require NPD and therefore new process design and therefore require an Agile strategy. The company correctly utilises a demand-type forecast however not in the correct form (predicted sales). Estimated sales forecasts tend to be exaggerated and therefore incorrect.

Company A's environment creates variation in demand so that their customer service driven strategy is appropriate. Company A's production system is directed towards economies of scale. However the company has a range of products in its catalogue. This means that production system is committed towards single product lines and not to the variety which should be available. Due to the mass production strategy, the current production system is not responsive to the market and customers. This detracts from

Agility by not capturing market share, not satisfying customer requirements and not facilitating new product introduction.

5.2.2. Company B

Company B claims to be a Lean manufacturer but the rice factory runs as a separate business unit. This unit does not practice high levels of Lean due the separation from other business units. Mass production is an appropriate strategy as the company is relatively new to the rice industry.

Company B's Lean and mass production combination strategy is appropriate as it is a growing business unit and demand is unknown. This strategy must change in the future to a product focused strategy as depicted in Figure 4.4. Economies of scale will be the eventual strategy for this business unit. Therefore producing according to continuous flow and not batch production is appropriate. Company B's Lean strategy will be more appropriate to selling commodity products with no fashion life cycle in the future.

Product design and process requirements will not have extreme changes in the future. The company is using the correct demand-type forecast and buffering to allow for growth. The operating environment of commodities does not create much variation in demand. The company is correctly following a customer service driven strategy, appropriate during initial entry stage to the industry. However this will have to change in the future. Competitive advantages within commodity products require a cost driven strategy.

Due to the current levels of automation this Lean system is responsive to the market and customers. It captures market share, satisfies customer requirements and does not require new product introduction. This indicates that current levels of Lean contribute to Agility.

5.2.3. Company C

Company C's Lean production strategy is appropriate, as it is starting to improve production. A product focused manufacturing strategy is currently appropriate however a repetitive focus will best suit the company's future. The next step for the company will be Agility. Production problems are a good sign in Company C's case. They are providing clarity for future improvements which will streamline the production process. This will help with implementing Agility.

Products are highly differentiated and follow a life cycle within Company C. This suggests continual future product design changes and process requirement changes. The company utilizes the correct type and methods of forecasting. The company is continually improving on forecasting methods aided by computer software. The customer service driven strategy is appropriate to service these customers and the variation in demand. Lean implementation has led to production slowing down. This is due to rectifying inefficient procedures. Lean demonstrates the potential to bring the company back up to speed and to increase performance. However, an end strategy of Agility is required to improve the response to changing customer demands.

5.3. Lean influences on agility

This section discusses the lean practices in each organisation through their success in eliminating the seven wastes of Lean and the influence of these factors on agility.

5.3.1. Inventory

Company A's capacity is currently sufficient to deal with unplanned changes such as decreases in cycle time and increases in volume. This is an expectation from mass production companies as they have not been influenced by the restrictive nature of Lean capacity. The negative aspect of this strategy is high levels of inventory, whether raw materials (through bulk purchasing), WIP or finished goods (due to unexpected customer demand).

Small item products run until stock levels are built up. This is an inefficient method of manufacturing and decreases SFR. The company must pay attention to forecasting and concentrate its efforts on customer knowledge.

Small batches are not produced as production is on continuous flow. This is rigid system and contrary to the principles of Agility. The above results in the lowest levels of flexibility required to service the variety on offer. Wrong strategy selection has created in an imbalanced system.

In Company B, inventory levels are high due to overproduction. This indicates that Lean cannot operate in markets with unknown demand. However, inventory is necessary to be responsive and to capture market share while competing as a new business unit.

Company B does not have capacity problems. Capacity was built in on designing the factory. The capacity that automation has created surpasses customer demand for an estimated 15 years into the future. Therefore the production system can deal with decreases in lead time and increases in volume. This may decrease the flexibility of the system but it is the right strategy to maintain balance in matching market requirements. This make-to-stock strategy is not truly Lean however results in SFR to capture growing market share.

Company C's Lean strategy has improved its production process in many ways. The use of the 5 S's and 7 wastes has provided clarity in manufacturing practices. These principles have decreased inventory levels and freed up cash as a result. Inventory levels do not affect the speed of cycle time. The company measures inventory according to the number of times inventory turns over annually. They are constantly trying to increase turnover rates. This is supported by JIT buying within HSS and emergency orders in Carbide. This indicates that decreasing inventory will not affect SFR required for Agility. Therefore JIT can bridge the gap in the main conflict over inventory between Lean and Agile strategies. JIT positively affects the relationship between Lean and Agile in the conceptual model (Section 4.11).

Company C's finished inventory levels are high in Carbide due to EBQs for international customers, which cannot be avoided. Finished inventory levels are high in HSS due to overproduction. These high inventory levels indicate that there is a need for Agility.

Company C's Carbide's production is repetitive with small lot sizes and HSS is changing from continuous flow to batch production. Batch production is a part of Lean that leads to Agility. Continuous flow is rigid and moves away from Agility.

5.3.2. Overproduction

Overproduction is occurring in Company A to service high inventory levels and these in turn increase cycle time. This is how the company responds to anticipated customer demand and spike orders. Lean is necessary to streamline the production process by reducing set-up-times. This will reduce the need for exaggerated inventory levels and

increase efficiency. This results in reduced cycle time to meet customer demand instead of overproduction.

Company B has a certain level of overproduction due to the policy of holding two weeks' stock of packed product. However, this is to allow some level of flexibility and is not excessive.

Overproduction is problematic within Company C due to the change over from mass production to Lean. Overproduction only occurs within the HSS factory as machines are not in balance. Overproduction is not an attribute of the Lean systems but rather due to inefficient machinery. HSS requires additional investments in machinery to support Lean and to decrease cycle time. Over production actually increases recovery and efficiency as production is not being broken up and set up regularly. This does increase inventory and affects customer service levels as the company is not making exactly what the customer requires.

Currently Company C's HSS section is producing according to a make-to-stock strategy that leads away from Lean. Carbide's production is in support of a make-to-order strategy. A truly Lean system will follow make-to-order strategies and any other strategy is not truly Lean.

5.3.3. Waiting time

The main bottlenecks within Company A's production system are a result of the shots produced by the machine moulds. These shots per mould vary according to the size of the products. Small items such as cable glands produce 16 shots per mould. Larger items such as centurion light fittings produce 1 at a time. This manufacturer faces bottlenecks in the form of sequencing which results in queuing and waiting. In this case a lack of Lean is decreasing the speed, flexibility and response (SFR) of the company. Changeover and time to demonstrated capacity are long in Company A's production systems. This is an indication that the company requires Agility to allow for customer response levels to increase.

There are unused old, broken and spare machines taking up valuable space. Newer machines should replace these machines and help with bottlenecks. Company A displays a need for a structured planned maintenance approach. Currently preventative

maintenance occurs when machines become available. This is not ideal as machines run continuously and may not be available for long periods. Therefore the reactive maintenance strategy slows down production when breakdowns occur.

Company B has a well-balanced production system. Technology and automation increase the levels of Lean in this business unit. Modern production systems decrease bottlenecks. This is an indication that companies need to invest should they wish to travel the Lean journey. However automation has a strict nature to it; therefore it is not possible to change the product. This means that only rice can be packed and no other product, decreasing flexibility. However there is no current need for this change. There is no form of sequencing in the production system therefore no queuing or waiting. Therefore automation assists Lean to have a positive effect on cycle time.

Changeover time is extremely fast. Company B is the fastest of all three companies. This indicates that automation is increasing SFR and consequently increasing Agility levels.

Company B practises a high degree of preventative maintenance. Production occurs only three days a week. On the remaining two days the factory implements the 5 S's: sorting, straighten, sweeping, standardising and ensuring that systems are sustained. Planned shutdown occurs for one month in every four years. This leads to very few stoppages attributed to breakdowns. This decreases cycle time and increases Agility levels. No value stream mapping is required.

Company C has revealed the importance of defining bottlenecks. There are two types of bottlenecks, those due to "monuments" and those due to poor balance. The theory of constraints must apply to any manufacturing company. 99% of engineering companies can never achieve true balance. Sequencing and capacity problems increase cycle time and not Lean. Lean is actually targeting these bottlenecks within Company C and can therefore be described as a facilitator to Agility within Company C by targeting obstacles to SFR in bottlenecks.

Lean has decreased changeover times in Company C, demonstrating that Lean systems are fast, flexible and moving towards Agility. Production is not measured on demonstrated capacity alone, but also on lead times. This indicates a need for agility however not from a capacity perspective rather a customer service driven perspective.

Preventative maintenance occurs in Carbide and positively affects cycle time. However HSS operates under reactive maintenance as parts that breakdown cannot be predicted. Company C's Lean maintenance influences SFR both positively and negatively. Lean maintenance therefore has no significant relationship with Agility within Company C.

5.3.4. Unnecessary transporting

Company A has high levels of unnecessary transporting within the production system as well as transportation to assemblers. This increases cycle time of the finished product.

Unnecessary transporting occurs in the form of double transporting to Durban customers. This cannot be avoided. The business unit is situated in Pietermaritzburg and this will not change. Decreasing cycle times to these customers will not be possible for Company B.

Company B's warehousing is currently flexible however as sales increase this may prove problematic. However warehousing cannot be looked at in isolation when demand increases. Constraints may include employees, handling equipments and environmental conditions since the rice cannot be moved in the rain.

Company B's inbound and outbound transportation is supportive of flexible manufacturing. These two aspects are by-products of Lean systems that will help implement Agility.

Lean has not yet targeted unnecessary transporting within Company C. The layout should be changed in the HSS factory and conveyor system be introduced in the Carbide section. This will reduce unnecessary transporting. Therefore Lean has the potential to decrease cycle time and streamline unnecessary transporting. Less handling will create a faster turnaround time adding SFR required for Agility.

Company C's transportation and warehousing is supportive of flexible manufacturing with higher levels of flexibility on outbound when compared with inbound. Transportation and warehousing has to be aligned to support flexibility of production to increase SFR levels within Lean. If not, then Lean is restrictive and moves away from Agility. These two factors are by-products of Lean systems that help with Agility.

5.3.5. Processing wastes

Value stream mapping has not been carried out in Company A and it is unclear to what extent processing wastes are affecting production. However, some waste of material was observed when moulds were in poor condition or fitted incorrectly. Trimming of products was required.

Process waste is minimal in Company B due to the automation of the system.

Lean has created five different value streams within Company C. Wastes and inefficiencies in these streams have been identified. Production must follow Takt-time, a key performance indicator within Lean principles. It measures the pulse of production. If one unit is required a day then one should be produced. This is a sales driven production strategy, requiring appropriate speed and therefore the need for Agility within Lean.

Machine flexibility cannot be measured within Company C as the same machines are being utilized from the changeover. It would be incorrect to state that machines under Lean in Company C increase Agility.

Both factories within Company C have Lean manufacturing strategies directed to economies of scope. Economies of scope demonstrate commitment to variety and a need for Agility. Company A and B are committed to economies of scale representing a movement away from Agility.

5.3.6. Inefficient work methods

Inefficient work methods in Company A are attributed to old machines and large item products. Production on these large items should run concurrently. Another positive aspect is that outbound logistics is supportive of flexible manufacturing. The in-house 3PL has improved the responsiveness of delivery to customers. Delivery and flexible warehousing worked together. Warehousing is situated next to the logistics Company, allowing for speed between processes.

Company B has only one form of inefficient work method, the opening of 50 kg bags. This is a supplier related problem. However the Indian supplier does not sell one tonne sacks and only Thailand's supplier has one tonne sacks. This is due to the creation of jobs

in India. The company prefers to do business with this supplier as they are the cheaper option. This has no significant impact on production.

Inefficient work methods are due to an aging HSS plant with frequent breakdowns that increase cycle time. However Lean is seeking to streamline HSS by targeting set-up-times and introducing new processes and machinery. Lean is increasing SFR within Company C and consequently Agility. This is an indication that Lean must be considered before Agility.

Capacity in Company C is adequate to meet unplanned changes. However this is not due to a Lean strategy. It is attributed to the change over from mass production to Lean. This company carried over capacity that is not compatible with Lean. This can be seen as a waste or as potential for Agility. Companies should not entirely eliminate these capacities as they may be required in terms of Agility. Protective capacity can help the production system deal with changes in specifications, increasing volume and decreasing lead times.

Company C has revealed two types of carry over capacity, machines and people. Spare machines no longer in use still remain to relieve workloads during high production periods. This is an expense that the company has already paid for but it is seen as a Lean waste. Spare people have been removed by removing shifts as Lean has streamlined efficiency. The number of people in Carbide has decreased but this resulted in an increase in the remaining employees' flexibility levels. These extra spare shifts can lead to protective capacity. Double and triple shifts can be reduced by set-up-time reductions and by exact production techniques. The capacity remains within Company C as employees are informed of possible second and third shifts during peak demand.

5.3.7. Product defects

Positive points include quality from design of Company A's products. Reworks are at a minimum and therefore have little impact on cycle time.

Company B's production system does not produce any rejects. This results in no reworking of any kind, indicating that quality is high. This decreases cycle time by not utilizing production hours on wastes and reworks. Therefore automation increases Lean levels in producing a quality product as well as increasing Agility.

Company C reworks products from customer returns. Returns due to raw materials require supplier interventions. Reworks due to the manufacturing process require system changes. Company C has introduced system changes by implementing Lean. Defects are no longer going out to customers. Inspections and reworks are now done immediately rather than at the end of the manufacturing process. This indicates that quality plays a major role in Lean and that Lean does decrease cycle time in calling for a better quality product.

Figure 4.5 summarised the effects that position on the Lean continuum has on SFR. At the Lean Intentions stage, Company A demonstrates that the lack of Lean decreases SFR since it leads to slow set-up-times, over production and poor delivery.

Company B is at the Intermediate stage of Lean implementation and demonstrates that Lean improves SFR by scoring two points. Set-up-times and delivery have improved but overproduction still occurs. Automation has improved Lean levels.

The Expert stage, as attained by Company C, demonstrates that Lean increases SFR by scoring two points. Set-up-times and changeover times are very fast and production and delivery are acceptable.

This suggests that companies seeking Agility must make the Lean journey first. Lean has been shown to be beneficial to Agility through decreased cycle time. None of the companies have reached the point of Lean's Six-sigma implementation yet. Six-Sigma can further decrease cycle time by calling for an extremely efficient manufacturing process.

5.4. JIT influences on agility

JIT requires reduced raw materials inventory through supplier support, modification of logistics systems, decreased batch sizes in production, JIT inventory, improved information exchange and delivery scheduling.

5.4.1. Product design

Product design plays a major role in any manufacturing system. Company A relies heavily on product design to streamline production, designing products for efficient manufacture. This decreases cycle time and increases flexibility; more importantly it shows

responsiveness to customers. Process requirements are taken into consideration while designing products. However Company A requires additional investments to increase capabilities or at the very least maintain machine moulds for exact production. Currently certain machine moulds do not produce exact expected shots per unit.

Company B's product design does not affect process design. Process design was done once off to accommodate one type of product. The company will never change the type of product (rice). The company has invested in capacity capabilities that increase SFR in the long run. This spare capacity may be seen as a Lean waste however it may be justified by growing demand. Product design in relation to commodities does not affect cycle time. There are no variations on requirements. Pack sizes may change however the production system is built for that.

Company C's product design of tools is done according to a market leading strategy with the help of an international consultant. The strategy is aligned with aftermarket services provide by the spindle department allowing responsiveness to customers. Products are designed for manufacturing this decreases cycle time and increases flexibility. Process requirements are considered during product design. The company increases speed by investing in capabilities beforehand. This indicates that Lean is not restrictive and moves towards Agility. Quality in Company C has improved with the introduction of Lean, indicating that Lean increases quality which decreases rework. Concurrent engineering increases speed and flexibility in both factories. This is an indication that Lean's quality and concurrent engineering is working towards Agility.

Company A manufactures standardised parts and modularised is practised in the assembly plant. Standardisation facilitates speed and modularisation increases flexibility, creating a decoupling point between the two. Company A must take advantage of this opportunity. It can introduce upstream Leanness and downstream Agility discussed under Leagility in Chapter two. Company A would then enjoy the benefit of both paradigms. Only Company A demonstrates the potential to create a Leagile strategy. Company B does not have a manufacturing decoupling point. Due to the commodity nature of its products, Company B's parts and process are standardised, a feature that increases speed. This is not a truly Lean system; however there are no significant set-up-times. There is no modularisation or concurrent engineering. There is no need for concurrent engineering as there are five

dedicated production lines for the five pack sizes. Company C's manufacturing parts are standardised and not modularised. Parts are made whole from the beginning to the end. The only decoupling point is at the beginning on the production system at the heating department. This department makes blanks in advance to service tooling. It creates a potential strategic decision of having blanks on hand and finishing the product on customer request. However this will increase WIP inventory but increase response levels.

Product life cycle management leads to more creative products and faster lead times. A difficult relationship with PLM arises in Company A. PLM affects new product cycle time to manufacture within Company A. Products take long to manufacture due to SABS approvals, which cannot be avoided. PLM does not decrease time to manufacture as there are mandatory waiting times created by the SABS. The company uses this time to plan the product introduction when it passes inspection. Therefore the mandatory waiting period acts as a buffer to planning and does not create an impact on current cycle time. Company B's product has no requirement for Product Lifecycle Management. Commodities such as rice do not experience product lifecycles in the way that products influenced by fashions do. The only consideration in this regard is expiry dates and the company purposely decrease the expiry date to move stock quickly. This results consistently good quality products and no returns. Company C's requirements for product design variation slows down cycle time but the company charges a premium for this feature. PLM affects only premium tools within Company C. Catalogue products have no significant considerations of PLM. PLM is managed in Lean to increase responsiveness to customers. PLM plays a vital role in product routing, materials, layout, assembly, maintenance and the production environment. PLM has the potential to streamline production by addressing these points before production occurs.

Company C's product design affects HSS and Carbides production systems in different ways. HSS has to adapt to new product introduction. Lean systems within HSS are not flexible however due to an aging plant. Investments must occur to improve production. Carbide introduces new products with ease. This indicates that investments and technology increases flexibility similar to the findings in Company B. Company C has the highest level of new product development from all three companies. Premium products are designed for specific customers. Products are also designed to keep up with

market conditions. This suggests that Lean should not be the end strategy for the company. Agility should be the next step.

5.4.2. Process design

Process analysis and design is important as it determines the layout of the production process. Process design can decrease cycle time within Company A. This can be acquired by grouping together machines with similar capabilities or machines that manufacture components of a product.

Company A is trying to align process strategy with differentiation first then response second. This indicates that there is a great need for Agility over Lean as costs are seemingly not the main concern. There are many non-value adding steps in Company A's production system. This is mainly attributed to large lot sizes and continuous flow. Large lot sizes indicate long set-up-times which decreases Agility and increases production requirements. However processes do maximise customer perceived value. This is how the company remains profitable. The current process design helps in winning orders. The company is following the right path in process design. It decreases processes and therefore costs. Early process design has created a competitive advantage for the company. However large lot sizes and continuous flow are not the appropriate strategy. Company A needs to decrease set-up-times and decrease lot sizes to increase Agility. This will improve on process design and maximise benefits. In Company B, reducing batch sizes will not be a concern to production in the immediate future. The only consideration in this regard is pack sizes and industry standards. Pack sizes are designed for product serviceability. This is a feature that should decrease cycle time however it does not. Packaging is done by a third party packaging company. The rice factory is therefore sticking to its core capabilities in production. The factory was designed to handle all five industry standard pack sizes. This feature actually increases flexibility and interaction with customer response levels.

Company A's set-up-times are far too long requiring 3 hours on a Monday morning. This can be avoided if production is planned and machines are set on timers to start 3 hours prior to Monday morning's shift. In Company B Set-up-times are extremely low when changing pack sizes. This proves that automation does increase SFR. In Company A, Process design does not create balance within the production system. Cycle time does not

match customer demand creating over and under production. These inefficiencies need to be rectified. Process design must change to create flexibility. Process design should be making use of manufacturing cells. Cells group parts, process and employees leading to improved performance and flexibility.

Failsafe production methods within Company A are insufficient. Failsafe is reactive and run as a backup plan; failsafe must be preventative to stabilise cycle time. Process layout is repetitive which is in line with the production strategy. However there is a need to reconfigure layout of production lines to be more productive. Reconfiguring similar process and products as mentioned earlier will bring about SFR. This creates the need to start the Lean journey soon.

Process analysis and design was done perfectly in Company B. A product focused strategy was selected from the creation of the factory. This is in line with the overall cost based strategy required on commodity products. By mastering process design through automation the company has eliminated most non-value adding steps.

Company B's lot sizes are large in process design however this is expected within commodity products. Process designed has incorporated work cells. These cells do not change, leading to people developing expertise adding greater levels SFR to the system.

Company B has a good balanced production system. The other two companies are far from realising these capabilities and do not come close to compare. This level of automation has created a balanced system that matches growing customer demand. Therefore this production system was built for Agility.

Company B's process design does not have an effect on the production process. Finished product inventory levels are high however justified by growing demand. This is the only type of failsafe method that is required in Company B's production system, automation takes care of itself. The current process layout is fixed position this is due to there being no requirement to change. There is no need to reconfigure process layout or move production lines. Therefore process design will not affect or limit future production systems of Company B.

Company C's process analysis has changed the manufacturing layout of Carbide regularly. HSS is facing process problems due to layout constraints. Process strategies in

both factories are directed towards product focus. This is correct to follow under Lean however it should change to a repetitive focus which is more in line with Agility. Layout is crucial in decreasing cycle time. A product focus requires a continuous process (Lean) however repetitive requires few modules (Agility). Process design strategy is mainly directed at differentiation with response and cost is a factor in HSS. The need for differentiation is a major indicator that Agility is a requirement and the company must consider future implementation.

Company C's process design eliminates non value adding activities, decreases cycle time and increases customer value which leads to order winning. Process design is continually decreasing batch sizes in HSS and has already decreased batch sizes within Carbide. This indicates lower set-up-times which is required for Agility. Single minute exchange of die (SMED) is the key to increasing Agility in Lean companies. Lean has decreased set-up-times in both factories. This increases SFR therefore Lean moves towards Agility.

Manufacturing cells have increased efficiency and balance in Company C's production. By reworking defects immediately process design has improved quality. Work cells enhanced how workloads are distributed which leads to improved balance. Process design has the ability to change to suit production in Carbide and is undergoing similar changes in HSS. This indicates that Lean does allow for flexibility to produce new products.

Layout is easy to reconfigure in Carbide and currently difficult in HSS. This indicates that Lean's flexibility is not controlled only by its principles but also by the business situation. An investment into modern machinery within Carbide allows easy reconfiguration and the ageing machinery of HSS does not.

Process design will affect future production systems of Company C in a positive manner. Lean has and will continue to increase SFR within Company C's production process. Chapter Two's theoretical review suggests that when building Lean manufacturing systems only what is required is implemented. This can lead to a lack of flexibility. However it has been established that when moving from mass production to Lean spare capacity is carried over. It is this capacity that must remain within Lean to allow Agility and a positive effect.

There are failsafe methods in the form of Poka-yoke systems. Adding preventative measures stabilises cycle time and is an advancement of Lean that works towards Agility. In turn this will enable increased responsiveness to changing demands.

5.4.3. Manufacturing Process Control

Company A's assignment of capacity indicates level loading however the production schedule does not allow stability and responsiveness. Sequencing is problematic due to long setup times and forecasting is not effective in creating a pull rather than a push system. There are high levels of raw materials. Suppliers keep emergency stock for the company indicating that emergency orders can lead to JIT purchasing and Kanban systems. This has the potential to decrease not only WIP but total inventory as well.

Cost accounting helps to service premium customers only however does not help with remaining customers. It has a major impact on Company A's production process. Managers can make informed decisions to allocate resources to relieve constraint during spike orders. This does increase Company A's Agility however to premium customers only. These spike orders need to be considered during manufacturing planning and control and is a key indicator that high levels of Agility is required.

Continuous improvement does not occur in Company B due to once off capacity design, Agility is built in. There is no need for cost accounting on commodities. All customers are treated the same and they all have an equal opportunity at ordering. Manufacturing planning and control has little effect on production. The entire rice factory is programmable in 20 minutes. This drastically decreases cycle time and therefore increases Agility. This proves that automation increases SFR within Company B.

Production works on a pull system from stock. Customers do not place emergency orders on commodity products. Therefore customer demand is easy to predict. This is a future call for higher Lean levels.

Company B's production process works on Kanban from empty floor spaces indicating production for that pack size. This may increase Company B's Agility however it does decrease the Lean levels.

In Company C, continuous improvement occurs, indicating that gradual incremental upgrades will improve manufacturing capabilities thus increasing Agility. Cost accounting does not influence the manufacturing process. However it remains an option to expedite orders and an option to increase Agility. Manufacturing planning and control has facilitated Agility by making the production system efficient and thus increasing responsiveness.

Production schedules have given a certain degree of stability to the production system in Company C. Level loading and sequencing has decreased set-up-times and costs. Production is heading towards pull systems in HSS and already in place within carbide. This creates problems on spike orders, indicating that Lean is moving away from Agility in this area. There are Kanbans in place with the Johannesburg warehouse. This indicates how lean can slow down the production process by restricting movement into the next step and production.

5.4.4. Capability for JIT supply

JIT supply does not exist in Company A as Lean has not yet been introduced. JIT requirements could bring improvements to the production process within Company A. Partnering with suppliers for support would create better relationships.

Company B currently has not introduced JIT supply due to growing demands. Growing demands has acted as a hindrance to JIT purchasing requiring two weeks of buffer inventory levels. Therefore the production manager will not consider introducing JIT until demand levels out.

Company C has introduced JIT supply practices within the HSS factory and similar emergency orders are evident in Carbide. Inbound logistics for Company C has the ability to support JIT. Direct optional emergency orders are provided by sea and air freight. The receiving department must be modified to include flexibility and speed on incoming orders. This department can be the key to producing blanks faster if amalgamated with the heating department.

5.4.5. Minimum inventory

Company A carries high levels of raw material, WIP and finished goods inventory. Modifying logistics could increase SFR. Decreasing batch size would improve handling

and reduce set-up-times. JIT inventory adds flexibility and decreases cash tied up in large inventory levels. Information exchanges can prove beneficial to suppliers and customers, if the company pays attention to its market. Delivery scheduling can facilitate speed by planning in advance and streamlining inbound logistics.

Company B has raw material inventory due to the international nature of its suppliers but does not have much WIP inventory, as daily production is programmed and is precise. This indicates that automation decreases WIP and therefore the need for high WIP inventory levels. Automation within Lean can decrease inventory and simultaneously increase speed. This is a welcoming benefit that both Lean and Agile paradigms, that potentially bridges the gap between the two strategies.

Company C's JIT inventory within HSS is increasing flexibility during the transition period from mass production to Lean. JIT inventory indicates that flexibility within carbide will increase similarly. Information flow to JIT suppliers is not a problem. Current JIT practices in HSS support information flow and measures are already in place within Carbide and its suppliers. HSS suppliers are meeting JIT scheduling requirements and Carbide will soon be aligned. This indicates preparation in supply requirements and an increase in SFR by supplier participation.

Company C's inventory levels are continually decreasing and so is cycle time this is perfect for JIT introduction. Similarly WIP levels are continuously decreasing. This decreases inventory and increases flexibility that would have been lost to tie up resources. This implies that low inventory levels should not increase cycle time and slow down Lean production. This is a literature review indication and a major concern of the mutually exclusive debate.

Company C's outbound logistics has Agility built in as the 3PL is responsible for most deliveries. Outbound logistics to international customers must remain at EBQ's. Trying to change this delivery system would be a mistake. HSS is currently seeking low batch sizes. Indicating that handling and set-up-times are not yet perfected, which is in contraindication of the JIT strategy. Carbide is meeting batch sizes of one, indicating that the introduction of JIT will be smooth.

5.4.6. Minimum defects

Company A's quality is built in from design another form of reliance. Quality has the ability to decrease cycle time by decreasing reworks. Continuous improvement must be introduced with Lean principles. However reworking does not affect cycle time in Company A. Preventative maintenance should be scheduled regularly instead of waiting for machine availability.

Company B's rice factory has increased customer perceived value by producing a high quality product at a competitive price. Quality was built into the system from process design. Company B has a state of the art production factory. Continuous improvement does not need to occur as a result. The rice factory is winning maximum orders and proving that the company is following the right production path.

Figure 4.6 reveals the effects that JIT and its building blocks have on all three categories of the Lean journey. Category One, Lean intentions as represented by Company A, demonstrates that the lack of JIT and building blocks decreases SFR. The lack of JIT and building blocks leads to long lead times, low levels of product design and slow process design.

Category Two, Intermediate Lean (Company B), demonstrates that automation and not JIT improves SFR. The lack of JIT in spite of some of its building blocks, leads to long lead times, limited product design options, however very fast process design.

Category Three, Lean Expert (Company C), demonstrates that JIT and its building blocks increase SFR. JIT and its building blocks have decreased lead times, increased product design options and increased speed within process design.

Two out of the three companies claim to that they are not set up for JIT however emergency ordering proves this wrong. This is what JIT is actually based on.

The aim of this section is to determine how JIT effects cycle time. Cycle time represents SFR. JIT is a compounding effect of Lean and seen as the next step within Lean. Therefore the building blocks of Lean's JIT play a major role in determining Agility levels of a company.

5.5. Supplier relationship management

Company A's purchasing department does not practice SRM but it does deliver what is required for manufacturing. SRM calls for integration which can lead to opportunities to decrease cycle time. SRM aims to ensure continuity of supply. Companies B and C's purchasing departments practice SRM. These departments deliver exactly what is required for manufacturing. This indicates that Lean purchasing does not deviate from the manufacturing plan.

5.5.1. Number of suppliers

Chapter Two's review suggests that the number of suppliers a company deals with is indicative of SRM levels. Few suppliers usually indicate long term relationship building as suppliers become more committed to business processes. However, this restricts flexibility of by limiting purchasing options. This study indicates that even with a large supplier list, relationships can be built with principal suppliers. Company A has 50 suppliers all of which are regarded as necessary. Company B has a large number of suppliers but the rice factory business unit has two main raw material suppliers. These could become long term relationships in the future as the business unit is fairly new. These relationships can lead to more commitment from suppliers, should the company increase Lean levels or introduce JIT. This may restrict flexibility but may increases speed and response.

Company C has in excess of 200 suppliers and uses an ABC classification.

5.5.2. Transactional vs collaborative relationships

Company A maintains transactional relationships with suppliers. Flexibility is need within Company A but transactional relationships are inflexible. Collaborative relationships are maintained with the raw material suppliers of Company B's rice factory. These suppliers could possibly increase flexibility through supply if Lean levels are raised within the business unit. Company C practices a mix of transactional, collaborative and strategic alliances with suppliers. Supplier involvement is high with all core suppliers. Collaborative suppliers help out during problematic times. Furthermore strategic suppliers increase throughput and facilitate high levels of SFR in supply. This mixture of relationships has increased supplier commitment to the business and this is

evident in suppliers' alignment for JIT introduction next year. In some cases production is outsourced to semi-finishers who are suppliers.

5.5.3. MRP

MRP facilitates the manufacturing process and increases responsiveness by planning with suppliers. MRP occurs within Company A however not in collaboration with its suppliers. The lack of planning with suppliers results in a negative effect on cycle time. Raw materials are standardised which leads to improvements in through-put. However suppliers are not coordinated, potentially leading to a customized service from the supplier. Customization increases SFR levels in the form of modularizing standard parts. This will allow Company A to introduce delayed differentiation at the decoupling point. This is a major advantage that Company A must take advantage of.

Company B works on the past years average for MRP. This facilitates the manufacturing process by ordering in advance from raw material suppliers. This will facilitate the introduction of JIT should it arise. Raw materials are standardised due to products being commodities. This has led to better production and as a result increased speed and flexibility within Company B. It is unfair to use this as a point of measurement against the other companies as commodities bring simplicity to manufacturing. However Company B should not be underestimated commodities as inefficiencies can still occur.

Company C utilizes an MRP1 system which is generated by Cispro software. The computer aided system aids the purchasing department make informed buying decision. MRP1 facilitates JIT introduction and manufacturing process. MRP1 in Lean increases responsiveness by planning with suppliers. Raw materials are standardised in the production process. This has created simplicity of raw materials waiting at the heating plant. Quality has increased due to standardisation leading to SFR to customers and thus low levels of returns.

5.5.4. New product development

Company A's suppliers are responsive to NPD but are not involved in the process due to the transactional nature of their relationship with the company and the location of some suppliers. International purchasing has a minimum lead time of three months. This decreases the speed to market of Company A's products. Supplier integration has the

ability to decrease cycle time in new product introduction. Company B has no need for early supplier involvement in NPD. Commodities rarely change in design. Therefore suppliers do not need to be responsive to process changes as they rarely occur. Company C suppliers are very responsive to NPD and process changes. Supplier responsiveness leads to a shorter cycle time of NPD introduction required for SFR. Most suppliers are motivated by the larger profits that new products bring in.

5.5.5. Profit sharing

Suppliers do not benefit from the business profits in all three companies. Suppliers only benefit from increasing demand, therefore increasing the need for supply. Sharing profits has the potential to increase long term commitment and make suppliers go the extra mile. This can increase the Agility levels of any company. Only Company C has a partnered supplier that benefits in the form of dividends on shares.

5.5.6. Communication channels

Communication channels are very good with suppliers in all three companies. All three companies use telephones and electronic mail to conduct business. Chapter Two's theoretical review suggests that dissemination of information facilitates speed in the supply chain. However there is no access to POS information made available to suppliers of all three companies. If suppliers are able to monitor stock levels of raw materials in a company it may lead to better response through transparency. POS has the ability to reduce cycle time of supply. However many companies do not share POS due to privacy concerns.

5.5.7. Transaction processing time

Transaction processing time is fast in all three companies but could be improve with automation and supplier integration. Vendor managed inventory (VMI) could increase responsiveness and flexibility of all three companies by decreasing order processing times. However this can prove problematic as all three companies source raw materials internationally. International sourcing could be streamlined with through SRM with the integration of information systems. Although only Company A does not have computer assisted ordering, all three companies utilize human initiated purchasing. Reduced order

processing times have the potential to decrease cycle time of supply in all three companies.

5.5.8. Supplier evaluation

There is no form of supplier evaluation carried within Company A. This leads to higher stock levels in anticipation of breaks in supply. Performance measures should be in place to determine if suppliers are good for Company A. This should also be the case for Company B. Within Company B and C supplier evaluation is on a weighted plan which is prominent in Agile strategies and not Lean. Lean strategies tend to utilise categorical plans. Weighted plans consider quality, service, price and technology.

International suppliers do not inform any of the three companies on order statuses. Local suppliers keep Company A and B up to date with orders. However this does not occur in Company C. Transparency enables production to plan flexibly when unexpected circumstances arise. Transparency can increase cycle time if continuity is hampered.

Raw materials are not inspected before manufacturing within Company A and B and this increases the speed of production. Company C inspects raw materials before production slowing down speed. However in Company A and B's case there are no performance measures. Company C has computer generated performance reports. Bad batches of raw materials can prove devastating to production in Company A and B. However Company B conducts periodical internal lab checks on raw materials. Managing the quality coming from suppliers can support a Lean system in all three companies. Prior supplier evaluation is done in Company A on tenders however monitoring is required. Company B evaluates and monitors raw materials, thereby ensuring high quality of supply.

5.5.9. Supplier location

Supplier location is a limiting factor for Company A. Plastic raw materials are available in South Africa and the company should consider partnering or supplier development. Suppliers could then deliver to where inventory is need which would decreases cycle time. Supplier locations for Company B cannot be improve as rice is predominantly produced in India and Thailand. Therefore cycle time cannot decrease on international suppliers. Company B's suppliers cannot deliver direct as the rice has to pass through the Durban port. This is the same for Company C but suppliers will be aligned to JIT in the

coming year, with suppliers developing local facilities. This will decrease the cycle time for the company and allow suppliers to deliver directly to Company C. This will decrease plant inventory and increase speed but levels of trust with suppliers are essential if they are to share the benefits of these changes.

5.5.10. JIT supplier collaboration

Kitting does not occur in Company A and B. However Company B demonstrates potential for the 50 kg Indian bags versus the Thailand supplier of one ton bags. The supplier could provide a change packaging to facilitate ease of manufacturing. Sequencing can occur in Company B however not material staging. Company C has implemented kitting with semi-finished product suppliers and consumable stores. Suppliers could deliver in sequence and follow material staging. Kitting has the ability to increase production by increasing speed. Suppliers can ready products for manufacturing to facilitate speed.

5.5.11. Seven rights of supplier performance

Company A has not achieved the seven rights of supplier evaluation. The seven rights is the best way to determine if the company has the right suppliers as well as their performance levels. Suppliers can drastically reduce cycle time, increase flexibility and responsiveness by ensuring continuity of supply. Company B has progressed further towards achieving these seven rights. Long standing relationships have led to nominated preferred suppliers. Business is allocated to suppliers is according to ratios which assess performance. This ensures continuity of supply and increase flexibility and response however speed remains problematic.

Company C enforces the seven rights of supplier evaluation. There is a list of proven suppliers according to ABC classification. This list allows the company to categorically select the right suppliers for business. Supplier performance levels are indicated by the category they are in. Due to prior approval flexibility and response levels have increased but speed remains a problem with a selected few suppliers. Some suppliers are shareholders and their supply facilitates SFR. Lean promotes supplier relationship management, as a greater emphasis is placed on business alignment.

Figure 4.7 reveals the effects that suppliers have on all three categories on the Lean journey. Category One with Lean intentions demonstrates that the lack of SRM decreases

leads to low speed, flexibility and response from suppliers. This results in low levels of service on the seven rights.

Category Two, Intermediate Lean implementation with average participation of SRM improves Agility through increases in speed and flexibility but response remains just acceptable. This results in mediocre levels of service on the seven rights.

Category Three or Expert as represented by Company C, demonstrates that high levels of SRM activity increases SFR. Lean strengthens SRM by promoting speed through alliances and collaboration. It increases flexibility by monitoring suppliers. Lean delivers improved service on the seven rights and therefore increases response.

Lean in SRM increases SFR. The aim of SRM is to measure the value added by the supplier to the company. SRM displays the role suppliers play in Lean and JIT cycle time and how this will effect Agility in the future application.

Table 5.1 illustrates the benefits of supplier relationship management. Benefits increase or decrease depending of the type of relationships manufacturing companies maintain with their suppliers. Strategic decisions and categorization of suppliers play a pivotal role in SFR levels of suppliers.

5.5.12. Service design

Company A does not practice service design however Company C does. Company C has tailored services for specific customers as well as aftermarket care. This increases the responsiveness to the customer. This is an indication that Lean's CRM can increase Agility. Tailoring services ensures that the company delivers exactly what the customer wants. Services can include delayed customization, modularisation and automation to reduce customer interactions. Currently tailoring in the South African context is centred on extensions of credit and aftermarket services.

Table 5.1: Characteristics of three types of relationships

Activity/Attribute	Transactional → Collaborative → Alliance	
Communication	High potential for problems	Systematic approach to communications
Competitive Advantage	Low	High
Connectedness	Independence	Interdependence
Continuous Improvement	Little	A focus
Contributions to New Products	Few	Many-early supplier involvement
Difficulty to Exit	Low	Difficult -high impact
Duration	Short	Long
Expediting	Reactive	Proactive
Focus	Price	Total cost
Level of Integration	Little or none	High or total
Level of Trust	Low	High
Number of Suppliers	Many	One or few
Open Books	No	Yes
Quality	Incoming inspection	Design quality into system
Relations	Inward looking	Concern with each other's well being
Resources	Few-low skill level	Professional
Service	Minimal	Greatly improved
Shared Forecasts	No	Yes
Supply Disruptions	Possible	Unlikely
Technology Inflows	No	Yes
Type of Interaction	Tactical	Strategic synergy

(Source: Burt, Petcavage & Pinkerton, 2009: 66)

5.5.13. Number of customers

Company A and C deal with an estimated 400 customers each. Company C has half local and half international customers. Too many customers can lead to orders not being met, which happens in both companies. It can result in the company following the wrong market niche and as a result targeting the wrong customers. Increases in response to the right customer can be achieved by removing the wrong ones.

Both companies have premium customers. Company A focuses on these premium customers. Company C treats all customers equally. Company A seems to have the better strategy for the short run and this increases speed. They reserve production lines and expedite orders for premium customers. However they put other customers on back order. Company C has the better strategy for the long run in growing all customers equally. This way small customers have the opportunity to grow into large customers.

5.5.14. Returns

Customers return goods in both production systems but this does not happen often. Company A's returns are attributed to functionality and Company C to quality. This is an indication that customer needs are not being met. Company A can introduce aftermarket services and Company C must relook how processes are run. These problems should be tackled under any strategy, not just Lean or Agile. It is important to note that these Agility problems cannot be attributed to Lean.

5.5.15. Communication with customers

Communication channels are good with customers in both companies. Telephones, electronic mails and customer visits are common. Efficient channels lead to faster receipt of orders creating better service delivery. More information exchange is required in both companies. However communication can be eliminated as a cause of low SFR levels in both companies. Both companies find transparency in only a limited number of customers, specifically larger customers. This helps them to determine customer behaviour and facilitates demand planning accordingly.

Both companies do not have POS information from customers. Companies should pursue POS to increase communication and transparency. This can improve service levels by anticipating and forecasting accurately.

5.5.16. Order fulfilment

Some of these customers order in advance. Encouraging more customers to do this will result in efficient planning and timely order fulfilment. This can help turn around both companies' strategies and increase Agility. Order turnaround times are excessive in both companies. Company A aims to have stock ready to ship. Company C aims for delivery date on orders. Company A requires high levels of Agility, as response is the selling point. Company C requires high levels of flexibility, as variety is the selling point. However both companies require speed in production to service these needs. Cycle time on customers receiving orders is much shorter in Company A. This is due to the large inventory holdings of finished stock. Company C has to wait for EBQ's on international orders. Therefore Lean does not restrict order cycle time to those customers.

Customers do not make unreasonable requests in Company A however they do in Company C. This indicates that Agility is required in Company C. Customers do make emergency orders in both companies. Company A tries to build stock to service these needs. Company C tries to accommodate large numbers of customer orders. This is the cause of the 50% order fill rate that the Company C is experiencing.

Orders shipped complete are at lower levels in Company C. Company A reaches 80% however Company C reaches only 50%. This indicates that Lean is not performing well in this regard. However Company C cannot be judged on this alone as Company A builds up stock to attain 80% levels. Delivery speeds are quite fast in both companies due to the presences of 3PL's. This is an indication that South African companies should stick to core activities to attain SFR.

5.5.17. Understanding of customer needs

Company A demonstrates understanding of customer product needs through salespeople's customer interactions. Company C demonstrates higher levels of responsiveness to customer product needs through a customer support package. Literature, videos and technical support indicate customer closeness within Company C. Company A defines customer product needs from a manufacturing perspective. This strategy is appropriate for Lean but not for Agility.

Both companies introduce new production methods to meet customer product needs. This indicates how dedicated a company is towards its customers. Company A has the ability to change machine moulds. Company C has a research and development department dedicated to the task. The implementation of new methods of production increases responsiveness to customers. This indicates that Lean companies are more responsive than traditional companies and Lean systems can be modified to respond to new product requirements. However, both companies' products are meeting customer expectations.

Product availability is not optimal both companies, and this failing therefore cannot be attributed to Lean. Both companies lack responsive to customers in this respect.

5.5.18. Location

Products are offered at spatial convenience in both companies. Company A supplies wholesalers and a depot in Cape Town. Company C has a warehouse in Johannesburg. Chapter Two's theoretical review suggests that reducing purchasing time to access products will increase responsiveness. Positioning close to the market increases product availability.

5.5.19. Product variety

Customers do not have choices of pack sizes in Company A however they do in Company C. This indicates that Lean actually adds to flexibility in service delivery. There are low levels of variety available in Company A, and high levels in Company C. However variety requires higher inventory levels on certain products. Company A therefore requires Lean as a strategy to decrease costs. Company C is not truly Lean indicating a need for agility as a solution. Company A is meeting the variety and assortment needs of customers by producing a wide product range. Company C is not, indicating that Lean is not responsive enough and its strategy must change to Agility. As variety and assortment increase, order sizes decrease, resulting in logistical costs and EBQ's. This leads to both companies experience stock outs on a daily basis. Current fill rates are low in both companies and therefore Lean is not improving this aspect of customer service.

5.5.20. Seven rights of customer relationship management

Company A does not fully service customers with the seven rights. They fall short on price, place and time. Price can be addressed by Lean, place and time are Agility

problems. Company C service customers seven rights most of the time. This indicates that a Lean system is more responsive than traditional systems.

Both companies can meet changes in basic service agreements. They can meet new product introduction. Both systems can rework product recalls. However they both struggle with disruptions in supply especially with employee strikes. Both systems can meet once off customizations. However both cannot implement modifications in the logistics systems to customers. Both production systems of the company's consistently deliver to customers. Some customers value consistency over speed. This is another measure that companies can use to determine if Agility is required.

Figure 4.8 reveals the effects that customer relationships have on two of the three categories of the Lean journey. Category One with Lean intentions within Company A, demonstrates that the lack of CRM does not affect SFR. The lack of CRM displays high speed, no flexibility and low levels of response to customers. This results in an average level of service on the seven rights.

Category Two cannot be assessed as no data was available for analysis.

Category Three, Expert Lean implementation, demonstrates that Lean CRM increases SFR. CRM promotes speed through relationship building and collaboration. It increases flexibility by tailoring services and understanding customers and products. CRM delivers better service on the seven rights.

5.6. Organisational culture and personnel

All three companies demonstrate a good sense of organisational culture. Only Company A experiences a separation between office and factory employees. There is a sense of unwillingness of Company A's factory employees to participate. All three companies find that employee participation plays a major role in production. Company A finds it difficult to balance employees and machines. Company B has the luxury of automation where employees and machines have an equal affect. Replacing employees in this environment is done with relative ease. Company C has highly trained employees who demonstrate balance, willingness to participate and need no replacement due to flexible work cells. Establishing that employees make a difference is a vital factor in fine tuning employee performance.

5.6.1. Response to change

Employees respond differently to change within all three companies. Company A's factory employees find it extremely hard to change due to cultural reasons. Company B finds medium response to change, some hard and some easy. Company C's employee respond well to change especially the younger employees. This demonstrates adaptability levels of employees that can decrease cycle time if process methods are changed. It can be deduced that Lean promotes change.

Change is good for Agility as change drives Agility. Companies that do not respond well to change under Lean will not respond well to Agility. These employees may need to be replaced while pursuing Lean. This will ensure that Lean's change is good for Agility. Chapter Two's theoretical review suggests that Lean employees are better skilled and support SFR, thereby increasing Agility.

5.6.2. Team building

Company A and B include certain employees in every step of the production process. However, factory level employees are not given full consideration. There is a top down approach and an autocratic management style. Company C includes all employees in every step of production. Special attention is awarded to factory level employees, creating an empowerment environment. They drive decision making and this company demonstrates more of a bottom up approach. How companies treat employees, value their responses and create employee empowerment affects SFR. Chapter Two's theoretical review suggests that employee empowerment leads to faster decision making and a reduction of cycle time.

Company A attempts to include lower level employees in problem solving but is hampered by a poor relationship with the union. Company B does not attempt to involve employees in decision making. Only Company C is successful in this area. The structure of an organisation's hierarchy can influence morale and daily performance and higher levels of general productivity are evident within Company C.

Company A attempts to shift responsibilities from managers to production employees. However resistance due to employee attitudes restricts this. Company B is able to do this due to automation. Company C promotes each employee to produce according to their

own mini business. This demonstrates the level of employee empowerment. It enables faster decision making decreasing cycle time and increasing flexibility. Efficiency can be increase when promoting team leaders of work cells from within. External manager can create resistance to production. Companies A and B are slow to react to changes and Company C is fast. Therefore Lean levels have a positive effect on employee empowerment.

5.6.3. Employee integration

Company A attempts to increase employee awareness of organisational impact. Company B does not. Company C does it regularly at Kaizen meetings. Employees must be made aware of their production levels and the effects of their performance on organisational performance. Employee awareness is increased under Lean principles. Employees understand that if they are not productive then the company is not. No productivity leads to no profits, resulting in no wages.

Company A and C increase awareness of how employee jobs impact society however Company B does not. This demonstrates the advanced levels of dissemination of information. Chapter Two's theoretical review suggests that this can motivate employees to perform and thus leading to better productivity.

All three companies provide employees with feedback of information on their performance. Feedback is vital in knowing if daily activities are meeting the company's expectations. If not then employees are not aware and cannot rectify the same problems in the future. This can potentially improve performance in cycle time by eliminating future erroneous activities. Company A allows company information to be accessible on a relevance level. Company B does not make information accessible to factory employees. Company C practices an open door policy with all employees. Easy information access potentially increases employee knowledge about daily activities. This can lead to efficiency which potentially decrease cycle time and increase Agility. Company C has complete transparency due to in-house promotions of factory level employees. Promoting from within results in improved organisational culture.

Companies A and B have limited communication networks in place to facilitate manufacturing. Employees receive information on a top down bases. Company C has

communication networks that are visible to all employees. These visual systems facilitate dissemination of manufacturing information. Informed employees decrease cycle time by creating what is needed, right the first time. Managers can attend to employee problems immediately due to visual systems. This aspect of organisational culture could be a limiting factor for Companies A and B for future process improvements due to poor communication channels.

5.6.4. Learning organisation

Company A trains relevant employees to handle machinery. Companies B and C train all employees who are willing to learn and operate machinery. Trained employees are efficient employees that increase flexibility. Companies A and B provide retraining as necessary. Company C trains employees annually. This ensures employees are up to date with training and remain efficient.

Company A attempts to promote cross functional team work however unionised employees tend to create resistance. Company B promotes cross functioning and Company C has the highest levels of cross functioning. Cross functioning leads to self-driven employees who better at problem solving. Chapter Two's theoretical review suggests that ground level employees tend to have the best solutions. Employees working in groups work faster and decrease cycle time. This is an indication of employee involvement in the production process. Cross training employees increase flexibility and assist in reducing bottlenecks.

5.6.5. Employee welfare

All three companies experience problems with employee positioning. Company A being the smallest has low opportunity on promoting employees. Company B has restricted roles for employees. Company C cannot determine if employees are there for a job or enjoyment of the position. Positioning people with the best skill set for a particular job can increase efficiency and decrease cycle time. This leads to employee enjoyment and a win-win situation for the company.

Absenteeism levels are high in Company A, low in Company B and acceptable in Company C. This is a direct relation to morale and employee commitment. Improvements in absenteeism can lead to productive employees that increase SFR levels. Human errors

are high in Company A, almost non-existent in Company B and low in Company C. Company A indicates that mass production has high failure rates. Company B indicates that automation decreases mistakes and losses in the production system. Company C's Lean increases the skills of employees to produce without error.

All three companies display a safe working environment and promote health and safety. This leads to confidence in the company and creates efficient employees. All three companies promote employees to increase their skill sets. All three companies compensate employees fairly and to industry standards. Compensation may affect motivation and increase productivity. Exploited workers tend to do the bare minimum.

5.6.6. Workers as assets

All three companies empower employees to achieve more. Driven employees are fast and efficient. Companies A and C motivates employees to excel by recognising this at work functions. Company B does not have work functions for lower level employees. This indicates the level of morale within an organisation. Higher morale may lead to higher productivity and reductions in cycle time.

Companies A and B have high numbers of disciplinary hearings due to insubordination while there is little need for these in Company C. This indicates that team work and respect among fellow employees is high within Company C. High disciplinary levels are related to low performance levels within companies A and B.

Employee utilisation levels are low in Company A, Company B has high utilisation and Company C is continually increasing utilisation. Job planning can decrease cycle time. Lean requires efficient use of employees. Company C demonstrates this through monitoring of people and machines. Prior to Lean people remained idle during machine operations now they finish off other processes. Therefore Lean decreases cycle time and increases speed required for Agility. All three companies demonstrate the right amount of employees available for daily operations. This is a major part of job planning that creates balance through even distribution of work.

Employee performance levels are low in relation to production targets in Company A. Company B has excellent levels and Company C is continually improving. This is a direct indication of how employees can influence cycle time. This is evident in the comparison

of Company A's slow production and Company B's high speed delivery. Company C demonstrates that Lean creates clarity and introduces measurement tools to monitor production. Only Company C monitors people and machine performance leading to informed decision on SFR.

Figure 4.9 reveals the effects that employees have on all three categories of the Lean journey. Category One, Lean intentions, demonstrates that employees under mass production decrease SFR. Mass production employees lack in speed (due to high absenteeism and low leadership), flexibility (due to poor cross functioning and adaptability) and response (due to low empowerment and information exchange). This results in low employee productivity levels.

Category Two, Intermediate Lean implementation, demonstrates that employees working under an automated system show improved productivity levels. A medium level of Lean leads to increases in speed (low absenteeism and very good leadership), flexibility (low absenteeism and excellent cross functioning) and response (average empowerment and information flow).

Category Three, Expert Lean implementation as practised by Company C, demonstrates that Lean improves employee performance. Lean strengthens employee performance as it promotes speed (average absenteeism and good leadership), flexibility (average cross functioning and high adaptability) and response (high empowerment and excellent information flow). As Lean levels increase, so does SFR within employee performance and hence Agility is increased.

5.7. Conclusion

It is evident from the findings and discussions that there are elements of Lean that are supportive of the Agile paradigm. For example the building blocks of Lean and JIT are essential to Agile. Agility originates in Lean, more specifically Lean flexible systems and elements of JIT.

The seven areas of waste are essential to the implementation of Agile strategies. If not eliminated through Lean then movement towards Agility will be restricted. JIT and Lean have the same foundations and are supportive of each other. JIT purchasing and JIT production are described as precursors to Agility. A conclusion is that Lean is related to

JIT, and JIT in turn is related to Agile, therefore it may be concluded that Lean is a pre-requisite of Agile.

South African companies must implement Lean before thinking of Agile systems. The implementation of JIT has identified simultaneous improvements in customer service and efficiency. JIT focuses on eliminating variation in the system and enabling flow, a useful tool for Agility. JIT is crucial in Lean operations and is helpful in contributing to both low cost strategy and a rapid response strategy. This is useful to the implementation of Agility. JIT seeks to bring production down to its simplest form of a batch size of one, a direct relation to Agile systems.

However some environments support Lean principles and some support Agile. Harrison and Van Hoek (2011: 327) highlighted key differences between Lean and Agile supply. Table 2.4 explains which market best suits the focal businesses manufacturing capabilities. Lean in a South African context is hard to achieve. Toyota is the sole company within South Africa with a truly Lean strategy. Most South African companies actually build on Agility without knowing. South African companies can only be as Lean as their suppliers and customers allow them to be. Some companies claim to be Lean however are built on Agility or have the necessities for Agility.

Businesses need to decide on a main approach, Lean or Agile. They can encompass the similarities. However they must know what category their products fall under, either “functional” or “innovative.” This distinction is the basis of choosing a Lean or Agile strategy.

Organisational culture can lead to a positive or negative influence on the adaptability of employees which is required in Agile strategies. Older employees tend to be negative towards change but are rich in experience. Younger employees tend to be more receptive to change. Employee empowerment will aid in attaining Agility.

From a South African perspective, cross training workers means increasing wages. Some workers are of the belief that if it is not their job then they are not obligated to do it. This is a major barrier to creating flexible workers. Culture and unions can act as inhibitors to Agility employee development. As a result certain environments are not conducive to Lean or Agile implementation.

Process design and set-up time reduction must be quick and cheap or it will not be practical. This is a key element of Agility. The use of Single Minute Exchange of Dies (SMED) can help monitor and reduce set-up times. Lack of control in process strategy can create problems such as increasing cycle time. This results in low levels of response time, which is highly undesirable in both Lean and Agile. Certain authors warn that improving one area at the expense of another is futile. Therefore this emphasizes the need for all round improvement with regards to Agility.

There has been great emphasis on the need for collaborative relationships by various authors. This will be a major focal area in the Agile paradigm. This increases the need for virtual organisation and highlights the importance of partnering in Agile supply chains. Collaborative relationships are extremely important. There are two types of relationships when it comes to manufacturing. Firstly the buyer takes initial action to direct the supplier and secondly when the buyer and supplier work parallel. The second can be disruptive if the buyer gets involved in the operations of the supplier.

An extremely promising area called protective capacity has been discovered within the theoretical review. A company can reserve capacity in another company. Protective capacity creates a challenge in that; the leveraging company needs to find something to fill the additional capacity while it stands idle. However this must be cost effective to both parties, or the partnership cannot exist. Findings and discussion reveal that South African companies pursuing the Lean journey retain inherent spare capacity. The two forms of capacity are people and machines. Companies should not entirely eliminate them but should rather determine and reserve a strategic protective capacity.

The Agile paradigm can be used to manage uncertainty. Forward integration of Agile throughout the supply chain is required from creation of the product through till delivery. This is of particular importance in businesses that produce new products on a regular basis. Agile supports processes in the introduction and growth phases. Thereafter lean supports processes in the mature and decline phases. Success depends on knowing each product's life cycle and identifying exactly where the focal product lies on that cycle. Backward integration of Lean can be used at the latter phases to save on costs. However, increasingly shorter product life cycles may prohibit Lean from entering the production process.

Certain companies segregate products into different production units or business units. Product classification allows for the separation. These units run separately from the company and have their own personnel managing daily activities. This allows the business unit control over Lean and Agility levels required. Each product has its own strategy. This can prove a useful solution to overall strategy selection within each company.

Chapter Five demonstrates that the companies under investigation require Agility. Lean has a positive influence on speed, flexibility and response in manufacturing practices. Just-in-time has a positive influence on speed, flexibility and response in manufacturing practices. If nurtured relationships with suppliers and customers can positively impact speed, flexibility and response. Organisational culture has a major impact on speed, flexibility and response.

CHAPTER 6 : CONCLUSIONS AND RECOMMENDATIONS

6.1. Introduction

Lean is not a new concept to the manufacturing world. However it is a fairly new concept to South African companies. Agile strategies are starting to be implemented in developed countries. Few South African companies have been introduced to Agility. The aim of this study was to investigate whether this could be beneficial to local companies and to establish whether those already practising Lean are in a better or worse position to introduce Agility.

Five main themes or categories were identified from the literature and applied to the results in Chapter 4. These were Lean, JIT, SRM, CRM and the Organisational culture /employees. These themes provide a basis or reference point for South African companies to follow.

In Chapter Five the researcher sought to discuss each of the themes and determine if they contribute to or detract from Agility. In Chapter Six, conclusions are drawn regarding the research questions and objectives. General recommendations for companies wishing to pursue Agility follow. The researcher has created a road map that graphically illustrates what companies should expect when pursuing Agility as a strategy.

This chapter will outline certain limitations of the study and describe areas for future research.

6.2. Requirement for Agility

The research objective relevant to this section was: **"To assess if the company under investigation would benefit from increased Agility in terms of speed, flexibility and response."**

Companies need to firstly categorise the types of product or services they offer as mentioned in Table 2.4. Commodities require a Lean strategy but a start-up company may display the need for early Agility while demand is still unstable. If fashion items are produced then Agility is required.

It is common for South African companies to produce a mix of products which have different levels of volatility of demand and which therefore ideally have different strategies.

Instead of striving for a completely Lean or Agile company or a Leagile supply chain, South African companies should try to divide manufacturing into business units. Certain production lines can follow Lean and certain can follow Agility within the same factory or business unit. This allows high levels of SFR in one factory and Leanness in another. Lean and Agile can work side by side in parallel systems: "ParaLeagile" for South African companies.

Company A could benefit from an Agile approach as the products which the company produces are a mixture of standard items for which the demand is fairly stable and items for which there is a more volatile demand, resulting in spike orders. An agile strategy would allow the company to meet the customer requirements for these latter items better. Collaboration with competitors is an Agile technique which could allow this company to address its volatile demand and introducing an Agile system would improve forecasting in that it would initiate transparency and collaboration with customers.

Company B is a relatively new business and demand is hard to predict so responsiveness is needed. The present stock levels which are maintained for this purpose are more aligned with an Agile approach than with a Lean approach. In terms of speed, this company already meets several Agile targets: product flow is efficient and the factory is well balanced due to its design and level of automation. Nonetheless, as a commodity processor, Company B will be best suited to maintaining a Lean approach as the ceiling on production is reached.

Company C has several characteristics that suggest that Agility would be an appropriate strategy. Their products are highly differentiated and can be classified as technological lifecycle products, meaning that there is a need for flexibility and response in this business. Volatile demand for Company C's products would be most adequately met by an Agile approach, particularly in the Carbide division

6.3. Contribution of Lean implementation to Agility

The research objective relevant to this section was: "**To determine if Lean is contributing to or detracting from a manufacturing company's Agility."**

The literature review has suggested that Lean and Agile approaches are mutually exclusive. This is when they are considered as options for a company at any particular point in time. However, viewed from a different perspective, the implementation of Lean at a particular time in a company's life may have an effect on its future potential for Agility. Since none of the companies studied have actively pursued an Agile strategy, this is the perspective which was taken: how much speed, flexibility and response do companies exhibit and hence what is their potential for Agility as it is affected by Lean implementation that has already occurred.

A deductive conclusion that could be drawn from this research was that the further advanced the implementation of Lean, the better placed companies were to become Agile. However, in contradiction to Lean principles, extra capacity retained as a legacy of mass production should not be eliminated as this would compromise the company's Agility. A strategic extra capacity, spare machinery and possible extra shifts can provide flexibility and response and thereby contribute to Agility.

In the specific companies studied, Company A is neither a Lean producer nor a speedy, flexible, responsive one. The presence of the seven wastes appears to give rise to inefficiencies which affect Agility as well as Leanness. A move towards Lean could be very beneficial for this company. Company B is not suited to an Agile strategy since it produces a commodity which does not experience volatile demand. It is better suited to using Lean principles and indeed reducing its Agile capabilities as it reaches capacity production. Nonetheless it exhibits more characteristics of an Agile system than Company A.

Company C is well advanced in the implementation of Lean. It also shows potential for Agility. The Lean capabilities of Company C seem to enhance SFR and hence the potential to move to an Agile strategy.

It is recommended that traditional companies must implement Lean first and then move towards Agility.

6.4. Contribution of Just-in Time to Agility

The research objective was: "**To determine if Just-In-Time is contributing to or detracting from a manufacturing company's Agility."**

JIT is very closely allied to Lean and hence the relationship between JIT and Agile would be expected to be similar to that between Lean and Agile. Particular areas addressed by JIT are product design, process design, MPC, the capability of the company for JIT supply and the quest for minimum defects.

Agility also requires efficiency in product and process design and encourages concurrent engineering where product and process are designed together. This also increases speed to market. JIT promotes rapid setup and changeover which also improves flexibility. Manufacturing planning and control which facilitates better flow through a pull system also improves response. JIT suppliers must exhibit some level of SFR to deliver material as it is needed. Reducing defects and hence improving quality is a requirement of JIT and Agile.

Companies A and B do not practise JIT. Company A is not well prepared for Agility. Although not actively implementing JIT, Company B has some JIT capabilities and hence could develop SFR. However, Agility is not appropriate for this company. Company C has implemented JIT and also has higher levels of SFR than the other two companies.

In implementing JIT, companies are more ready to implement Agility if it is appropriate.

6.5. Supplier and customer relationships and Agility

The research objective was: "**To identify how relationships maintained with suppliers and customers impact on speed, flexibility and response."**

Supplier relationship management strives to improve the supply chain through the removal of unnecessary activities, removal of inventory and improving the reliability and quality of products. Suppliers who deliver raw materials of a consistent quality with the shortest lead time increase the efficiency of the whole supply chain.

The companies studied in this research show different levels of supplier relationship management and this affects their speed, flexibility and response capabilities. Company

A has purely transactional relationships with suppliers and uses a wide supplier base. There are long lead times from international suppliers. SFR is compromised by this. Company B deals with only two main suppliers of raw materials and experiences reliable supply. Due to bulk deliveries and the holding of buffer stock their response is acceptable but speed and flexibility are poor. Company C improves its SFR through collaborative relationships with suppliers. Information is shared and some SRM techniques such as kitting are being implemented.

Customer relationship management is not highly developed in the companies studied. Company A is responsive to customer need in that it has the capability to introduce new products with the development of new moulds. However, this is a slow process. Problems with order fulfilment result the wide variety of products in the catalogue, but this does show responsiveness to customer demands. Company C does not perform well in terms of order fulfilment due to stock outs. It provides fast and efficient delivery to local customers.

This study provided a range of performance in SRM and improved SRM seems to be associated with better potential for the introduction of Agility. This relationship was less clear for CRM as there was only data for two companies and these did not differ drastically in terms of service to customers.

6.6. Organisational culture / employee relations and Agility

The research objective was: "**To assess the internal environment or organisational culture of the company and the effect this has on speed, flexibility and response."**

The organisational culture of the three companies studied differed greatly. Company A lacks team building and a sense of common purpose. There is an antagonistic relationship between management and the factory workers which hampers flexibility and response in particular. Attempts to introduce Lean techniques including work cells and Kaizen are not possible until a change of organisational culture is achieved.

Company B follows an autocratic, top-down approach which limits the potential for flexibility and response through the work force.

In contrast, Company C has used the Lean philosophy to introduce work cells, Kaizen meetings and cross-training. Relationships between management and workers are

healthy. This allows the company to initiate change rapidly in the internal environment and to be flexible and responsive to customer needs.

A positive organisational culture with good relationships is essential if a company is to enjoy high levels of SFR and hence be prepared for Agility.

The last research objective will be discussed in the form of recommendations for companies seeking to implement Lean and Agile manufacturing.

To identify other factors that affects the degree Leanness and Agility within a manufacturing company.

6.7. The Agile Journey

Research objective: "**To identify other factors that affects the degree of Leanness and Agility within a manufacturing company."**

Figure 6.1 describes what companies seeking Agility as a strategy should expect. It begins with mass production and notes the greatest downfalls of this outdated strategy. Companies must recognise the need for change. This leads to the next step of Lean implementation. Under Lean companies should master production techniques. Lean calls for improvements in SRM, CRM and Organisational culture. Once the company masters these three key areas and develops efficiencies the next step is JIT implementation. After a smooth process flow of manufacturing is attained. Companies must measure their readiness through Six-sigma or Taguchi concepts. This is an indicating stage that the company is ready for Agility as a strategy.

Other factors encountered in this study that affect Leanness and Agility in the South African context in particular are:

- International supply: This affected the ability of all three companies studied to implement Lean and hence to move towards Agility. Long lead times, delays at ports and the need for bulk supply all affect efforts to implement JIT and make companies

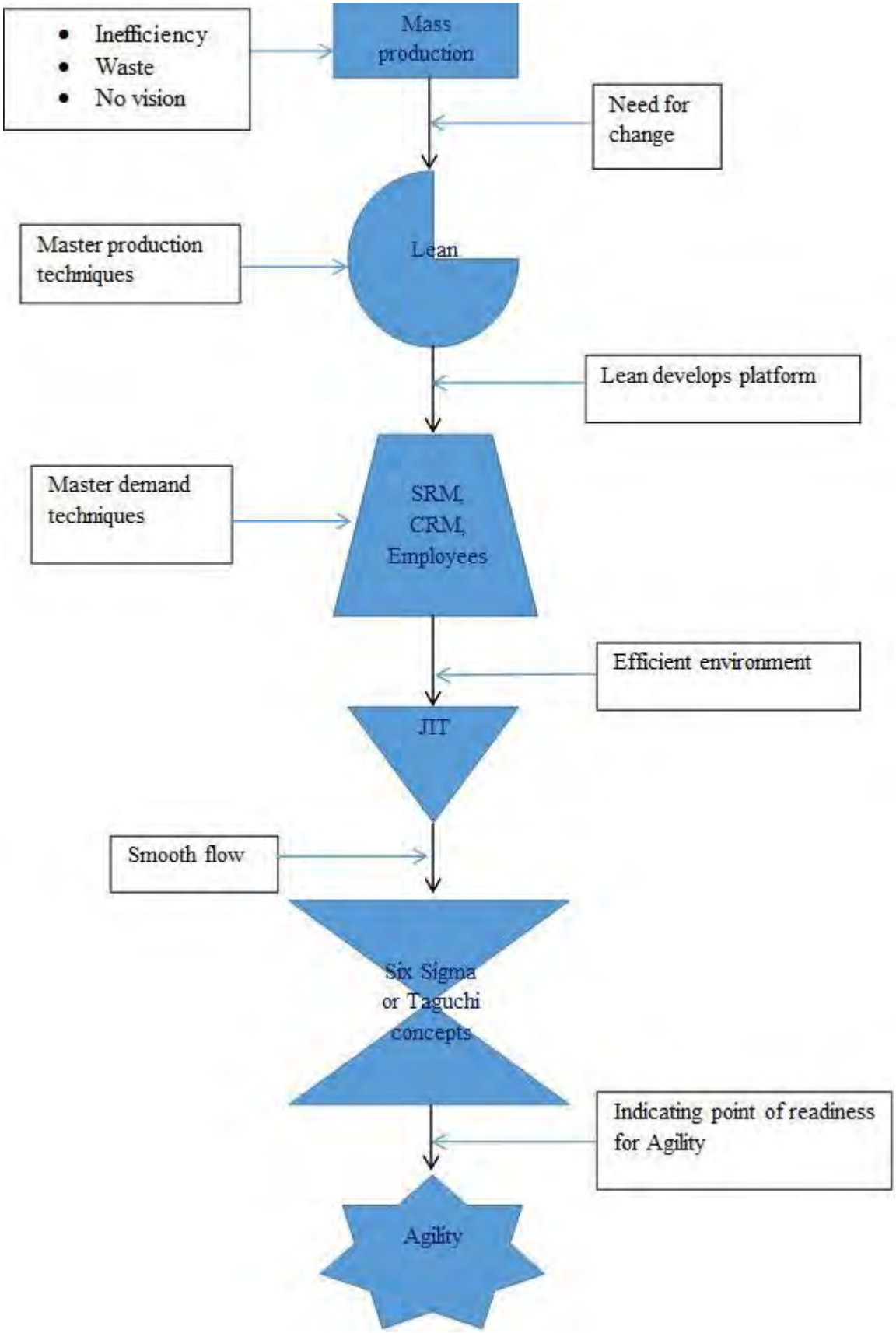

Figure 6.1: The Agile Journey

(Source: Author's own construction).

less speedy, flexible and responsive to customers. The allowance in Agility for some level of inventory means that it is less incompatible with international supply than JIT and Lean and this should be born in mind if the eventual goal is Agility: capacity to hold inventory should not be eliminated. Global purchasing can be achieved in JIT but the key is knowing the cycle time, delivery time and being able to estimate order delivery.

- Strikes: South African industry is prone to strike action. Strong unions and a poor relationship between management and employees may be a cause of industrial action, but certain industries, such as the metal industry, are vulnerable to industry-wide strikes that are out of their control.
- Automation: Technology and automation increase the levels of Lean in the business unit by decreasing bottlenecks. This is an indication that companies need to invest should they wish to travel the Lean journey. This has the potential to reduce the influence of organisational culture on speed and response but may also reduce flexibility and prove costly.

6.8. Limitations

- Due to time and cost constraints the researcher delimited case studies of only three manufacturing companies. A limitation of this research is that the findings may consequently introduce an element of bias.

- The implication of a case study approach is that solutions are company specific and so should be confined to the three organisations selected. Since the data was used to create a conceptual framework and a roadmap that may benefit other companies wishing to implement these strategies, further research should be conducted in order to establish the validity and reliability of the framework.

- Company B's sales and marketing managers were inaccessible. Therefore no data was collected for analysis. No comparison of medium levels of Lean on customers was possible.

- In-depth interviews were time consuming and consequently full participation by working individuals was difficult to obtain.

- Some of the personnel occupying managerial roles were recently appointed. This was a common occurrence within the Human resources department of two firms. The second in charge person had to be interviewed along with the managers in such cases.

- The triangulation process of observation and collecting of documentation was time consuming. In all three companies documentation was available to view but not to retain.

6.9. Future research

Possible areas recommended for further research in relation to this study are:

- What effect does Lean have on Green Supply Chains? Lean principles in essence works to do more with less. Hence Lean can be directed towards addressing sustainability within the green supply chain context.

- Can the balanced score card aid in the transition and mitigate challenges involved in implementing Agile systems in a Lean environment? The balanced score card is an excellent tool that can be used in to identify strategies and to select the Agility levels required within a company.

- What is the effect of South African employee strikes on Lean supply chains? Lean supply chains require streamlined flow. Strikes are a major cause of interruptions within the South African context. A topic worth investigating would be to develop strategies to anticipate these disruptions and solutions directed at ensuring continuity of production.

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APPENDIX A : INTERVIEW GUIDE

Good day, I would like to thank you for taking the time to meet with me today. My name is Neeshal Gurahoo and I am a master of commerce student in Supply Chain Management at the University of KwaZulu-Natal Pietermaritzburg campus. I would like to talk to you about your experiences with regards to Lean production. The interview should take less than an hour and contains eight sections in total, however only relevant sections to your job description will be explored. I will be recording the interview session, as I don't want to miss any of your vital comments. Due to the nature of the recording of this session, I would like to request that you speak up and clearly to enable us to record all your comments. All responses will be kept confidential. This means that your interview responses will only be used by the researcher and information included in the report does not identify you as the respondent or the company at any time or in any way. Remember, you do not have to respond to anything you do not want to and you may end the interview at any time.

Are there any questions about what I have just explained? (If not, proceed).

Are you willing to participate in this interview? (If yes proceed).

Section A

Focal company insight and the need for a solution or Agility

1. What is the current production strategy of the company: Traditional (mass production), Lean or Agile?

   _____

2. Are there any limiting factors with the current production system?

   _____

   _____

3. How would you categorise manufactured products at this company: commodities or highly differentiated products?

   _____

4. Do manufactured products follow a life cycle?

   _____

5. Is there any form of manufacturing forecast system in use?

   _____

6. If so, what type of forecast system does the company use? (Economic, technological or demand)

   _____

Environment of the focal company

1. Is there a need for the company to be responsive to variation in demand?

   _____

   _____

2. Where would you place the manufacturing strategy of the company, in the category of cost driven or customer service driven?

   _____

3. Can you describe how information flows internally?

   _____

   _____

4. Can you describe how information flows externally?

   _____

   _____

5. To what extent does the current production system allow you to increase market share?

   _____

6. To what extent does the current production system allow you to satisfy customer requirements?

   _____

7. Does the current production system allow you to facilitate rapid introduction of new products?

_____

_____

Section B

Lean factors that affect Agility.

1. Does the company use the 7 wastes of Lean in practice?

   _____

2. Does inventory under the Lean system effect cycle time? Or What can you tell me about the current inventory system with regards to cycle time?

   _____

   _____

3. Is there any form of over production occurring? Or what can you tell me about over production in this facility?

   _____

   _____

4. If so what effect does this have on cycle time?

   _____

   _____

   _____

5. What can you tell me about bottlenecks in the production system? Or Are there any bottlenecks in the current production system?

   _____

   _____

6. What would you attribute these bottlenecks to; a Lean system or general bottlenecks?

   _____

   _____

7. What can you tell me about the sequencing of manufacturing equipment/tasks in this Lean system? (Probe bottlenecks)

   _____

   _____

8. Are there any bottlenecks in the form of queuing or waiting?

   _____

9. Can you describe the period of change over time in this Lean system?

   _____

10. How long does it take to reach design/specified production rate?

    _____

11. Is there any form of unnecessary transport in the production system? Or what can you tell me about unnecessary transport in the production system?

    _____

12. If so what effect does it have on cycle time?

    _____

    _____

13. Does the production system process waste/rework products?

    _____

14. If so what effect does it have on cycle time?

    _____

15. Can you describe inventory levels of finished products?

    _____

16. Does the system have any inefficient work methods?

    _____

17. If so what effect does this have on cycle time?

    _____

    _____

18. Does the company use Six-sigma in practice?

    _____

19. What effect does Six-sigma have on cycle time?

    _____

    _____

    _____

20. What level of Lean belt is the company on at the moment? (Green to black)

    _____

    _____

21. Does the above Lean level have an effect on cycle time?

    _____

    _____

22. Does the manufacturing process incorporate preventative maintenance?

    _____

23. What can you tell me about value stream mapping within the production line? Or, does the production manager follow value stream mapping?

    _____

    _____

24. Can you describe the versatility levels of manufacturing machinery and equipment?

    _____

    _____

25. Can you describe the direction of the Lean manufacturing system? (Towards economies of scale or scope)

    _____

26. Does Lean support assemble-to-order manufacturing?

    _____

27. Does Lean support make-to-order manufacturing?

    _____

28. What can you tell me about small lot sizes or continuous flow within the production system? In the production process is there high repetition of small lot sizes or continuous flow?

    _____

29. What can you tell me about transport logistics in flexible manufacturing under current Lean strategies? Is transportation supportive of flexible manufacturing under current Lean strategies?

    _____
    _____
    _____

30. What can you tell me about warehousing in flexible manufacturing under current Lean strategies? Is the warehousing system supportive of flexible manufacturing?

    _____
    _____

31. What can you tell me about capacity under lean manufacturing with respect to unplanned changes? Is the capacity under Lean manufacturing adequate to meet unplanned changes?

    _____
    _____

32. Changes such as a decrease in lead time? _____
33. Increase in volume?

    _____

34. Change in specifications?

    _____

35. What is the current Lean manufacturing process being followed? (Probe continuous, line flow, batch or job shop)

    _____

36. What is the current Lean manufacturing strategy being followed? (Probe engineer-to-order, make-to-order, assemble-to-order or make-to-stock)

    _____
    _____

Section C

JIT and the measurement of its building blocks.

1) Does the company use JIT principles in daily operations?
   _____
2) What can you tell me about product design in the manufacturing process?
   _____
   _____
   _____
3) What can you tell me about product design? Or Are products designed for manufacture, assembly, product serviceability, six sigma, logistics or combination?
   _____
   _____
   _____
4) What can you tell me about process requirements during product design? Are process requirements taken into consideration when designing a product?
   _____
   _____
5) Are manufacturing parts standardised?
   _____
6) Are manufacturing parts modularised?
   _____
7) Is quality built into the manufacturing system?
   _____
8) Does concurrent engineering occur?
   _____
9) Does the current production system have an effect on product design? Or What can you tell me about product design in the current production system?
   _____
   _____
   _____
10) What can you tell me about product design variation requirements? Are there any product design variation requirements?_____
    _____
11) Do product design requirements have an effect on the current production systems requirements?
    _____

12) Does the company practise product life cycle management (PLM)?

_____

_____

13) What can you tell me about PLM in relation to cycle time? or Does PLM have an effect on cycle time?

_____

_____

14) Does the company practise process analysis and design?

_____

15) What process design strategy is currently in place (Probe process focus, repetitive, product focus or mass customisation?)

_____

_____

16) Is the process design strategy aligned to differentiation, response or cost?

_____

_____

17) Does the process eliminate non-value adding steps?

_____

18) Does the process attempt to maximise customer perceived value?

_____

_____

19) What can you tell me about current process design in winning orders?

_____

_____

20) Can you describe the lot sizes adopted in the process design?

_____

_____

21) Can you describe the internal set up time for a production run?

_____

_____

22) Does process design make use of manufacturing cells?

_____

_____

23) Can you describe quality improvement in process design?

_____

_____

24) What can you tell me about process design in relation to balance within the system? Or Does process design follow a balanced system?

_____

_____

25) Does process design have an effect on the current production system?

_____

_____

26) Can you describe the inventory levels of inputs/raw materials?

_____
_____

27) Are there any fail safe methods in the manufacturing process?

_____
_____

28) Can you describe the current process layout? (Probe fixed position, process-product or repetitive oriented, work cells)

_____
_____

29) Is the process layout easy to reconfigure?

_____
_____

30) Are the production lines moveable? (Computer connections, telecommunications, manufacturing equipment)

_____
_____

31) Does the existing process design have an effect on the future production systems?

_____
____.

32) Are there any limiting factors in process design with respect to future production? When building Lean manufacturing systems, they are usually exactly what is needed and not flexible in nature therefor any changes in future requirements will render the process or equipment unusable.

_____
_____
_____

33) Does continuous improvement occur in the manufacturing process?

_____
_____

34) Does cost accounting occur in the manufacturing process?

_____
_____

35) Does manufacturing planning and control have an effect on the current production system?

_____
_____
___

36) Can you describe how capacity is assigned to the different products within the manufacturing process?

_____
_____

37) Does the production system run on a pull system?

_____

38) Are there any visual systems in place? (kanban cards)

_____

_____

39) Can you describe how work-in-process is dealt with?

_____

_____

40) Is the logistics system for delivery from suppliers supportive of JIT?

_____

_____

41) Is the inbound logistic system modified to support JIT delivery from suppliers?

_____

_____

42) Lean and JIT seek a batch size of one. How close to this objective is the firm?

_____

_____

43) Is there any form of JIT inventory?

_____

_____

44) Is information readily available to JIT suppliers?

_____

_____

45) Can suppliers meet the delivery schedule set by JIT principles?

_____

_____

Section D

Supplier relationship management.

1) Is there a purchasing department to deal with suppliers?

   _____

2) Does the purchasing department deliver exactly what is needed for the manufacturing processes?

   _____

   _____

3) Do suppliers deliver the right product?

   _____

4) Do suppliers deliver to the right place?

   _____

5) Do suppliers deliver the right quantity?

   _____

6) Do suppliers deliver the right quality?

_____

7) Do suppliers deliver the right specifications?

_____

8) Do suppliers deliver the right price?

_____

9) Do suppliers deliver in the right time?

_____

10) Does this company practise supplier relationship management? (probe Many, few suppliers, vertical integration, backward integration, joint ventures, keiretsu)

_____

_____

11) How many suppliers does the company deal with?

_____

_____

12) What kind of relationships are maintained with suppliers? (Probe transactional, collaborative or strategic alliances)

_____

_____

13) Are suppliers involved early in new product design/development?

_____

_____

14) Is supplier evaluation carried out? (Probe Categorical plan or weighted plan?)

_____

_____

15) What type of materials requirement planning system is used? (MRP)

_____

_____

16) What can you tell me about raw materials in the purchasing process? (Probe standardisation) or Are the raw materials in the purchasing process standardised?

_____

_____

_____

17) How responsive are suppliers to new product design?

_____

_____

18) How responsive are suppliers to process changes?

_____

_____

19) Do suppliers share in or benefit from the business's profits?

_____

20) How would you describe the communication channels with suppliers?

_____

21) Do these suppliers have easy access to Point of sale information to ensure fast supply?

_____

22) Can you describe the speed of the transaction processing time? (Probe logistical, balancing, quality and change transaction cost)

_____

23) Is purchasing human initiated or computer-assisted ordering?

_____

24) What is the order processing interval with suppliers?

_____

25) Do suppliers provide frequent order status reports?

_____

26) Are there any performance measures in place to monitor supplier relationships?

_____

27) Are the raw materials inspected before use in the manufacturing processes?

_____

28) Is the quality of the raw materials coming in from suppliers good enough to support Lean systems?

_____

29) How favourable/convenient are your supplier's locations?

_____

30) Can suppliers deliver directly to where inventory is needed?

_____

31) Do suppliers follow kitting method or bulk delivery method?

_____

32) If kitting, Can they deliver in sequence?

_____

33) If kitting, Do suppliers follow material staging?
_____

Section E

Customer relationship management.

1. Does this company use customer relationship management?
_____
2. What are the types of relationships that the company has with its customers?
_____
_____
3. Does the company practise service design?
_____
4. If yes, Are customers involved in the service design process?
_____
5. How many customers does the focal company serve?
_____
_____
6. Does the focal company have premium customers?
_____
_____
7. Are production lines or schedules reserved for premium customers?
_____
_____
8. Do customers return goods for any reason?
_____
_____
9. What are the biggest come backs from customers?
_____
_____
10. How often does it occur?
_____
_____
11. How would you describe the communication channels with customers?
_____
_____
12. Do they facilitate demand planning?
_____
13. What is the cycle time when receiving, capturing and releasing an order?
_____
_____
_____

14. Do customers order in advance?

    _____
    _____

15. Do you consider that customers make unreasonable requests?

    _____
    _____

16. Do customers make emergency orders?

    _____

17. What can you tell me about understanding customer product needs? Or Does the company perform any form of improved understanding of product needs?

    _____
    _____
    ___

18. Does the company introduce new production methods to meet those needs?

    _____
    __

19. Are manufactured products meeting customer requirement specifications?

    _____
    ___

20. Are manufactured products meeting customers' expectations?

    _____
    _____

21. Does the manufacturing company have access to POS information of its customers?

    _____
    _____

22. Are customers being serviced with the seven rights? (Probe Amount, product, time, place, condition, price, information)?

    _____
    _____

23. What is the waiting time from the customer placing the order until the customer receives the order?

    _____

24. Are products readily available to customers in terms of geographic location?

    _____
    _____

25. Is availability of the product affecting sales?

    _____

26. Lean seeks to produce exactly what is needed; this means customers have a choice of the lot size they purchase in. Is this possible?

    _____
    _____

27. Is the level of product variety on offer to customers adequate?

    _____

28. Is the product assortment on offer to customers adequate (pack sizes, mixes)?

    _____

29. What is the current stock out frequency?

    _____

30. What is the current fill rate?

    _____

31. What is the number of orders shipped complete against the number of orders received?

    _____

32. What is the current speed of delivery?

    _____

    _____

33. Does the Lean system consistently allow you to meet customer orders?

    _____

    _____

34. Can the Lean manufacturing system accommodate modification to basic service agreements? (Probe changes in shipping location, frequency, time of delivery)

    _____

    _____

35. Can the Lean manufacturing system support unique sales promotion programs of customers?

    _____

    _____

36. Can the Lean manufacturing system meet new product introduction?

    _____

    _____

37. Can the Lean manufacturing system rework product recalls?

    _____

    _____

38. Can the Lean manufacturing system deal with disruptions in supply?

    _____

39. Can the Lean manufacturing system meet one-off customisation in basic service requirements for specific customers?
40. Can the lean manufacturing system meet product modification or customisation, performed while in the logistics system? (Probe such as price marking, mixing, or packaging?)

    _____

    _____

Section F

Internal environment with regards to employees

1) How would you describe organisational culture within the firm? _____
_____
2) To what extent do employees have an effect on the current production system? _____
_____
3) Can you describe how workers respond to change? _____
_____
4) Are employees able to adapt when implementing new production systems? _____
_____
_____
5) Is employee input involved in every step of the production process? _____
_____
_____
6) Are lower level employees included in problem solving? _____
_____
_____
7) Do employees know if their job has an impact on the organisation? Or Are employees aware of their contribution internally to the company? _____
_____
8) Do employees know if their job has an impact on society? Or Are employees aware of their contribution externally to the company? _____
_____
__
9) Are employees provided with feedback and information on their performance? _____
10) Are workers empowered to achieve more? _____
11) To what extent are employees motivated to excel at work functions? _____
_____

12) To what extent is information accessible to employees?

13) Are employees included in a communication network regarding the manufacturing process?

14) Are managers/supervisors open and transparent with, and supportive of, their subordinates?

15) Are responsibilities moved from managers/supervisors to production employees?

16) What can you tell me about leadership/project management within the current production system? Or: Does leadership/project management have an effect on the current production system?

17) Do you ever have disciplinary hearings as a result of insubordination?

18) Can you describe worker compensation? Do workers consider that they are compensated fairly?

19) Are employees well trained to handle equipment?

20) How often is retraining provided for employees?

21) Does the company promote cross functional team work?

22) Are workers cross trained?

23) Are employees promoted to increase their skill set?

24) Can you describe employee utilisation? Or Are employees being efficiently utilized?

_____
_____
____

25) Are there sufficient employees available for daily operations?

_____
_____

26) Can you describe how employees perform with regards to production targets?

_____
_____
_____

27) Can you describe the working environment with regard to health and safety?

_____
___

28) Are employees appropriately positioned in their jobs? (In terms of aspirations and skills)

_____
_____

29) Are employees rotated?

_____

30) What is the average number of days absent?

_____

31) Can you describe the number of human errors in production such as mistakes and breakages?

_____

Section G

Agility as a solution

1) What can you tell me about the investment process with regards production machinery, equipment, facilities and technology?)

_____
_____

2) Can you describe the type of technology utilised? (Probe machine technology, AISs and RFIDs, process control, vision systems, robots, AS/RSs, AGVs, FMSs, CIM)

_____
_____
____

3) How does the use of technology influence process strategy?

_____
_____

4) Is there a need for technology to facilitate communication?
_____
_____

5) Does new technology affect the current production processes?
_____
_____

6) Would this company consider co-operative alliances with competitors?
_____
_____

7) Is there a decoupling point?
_____

8) What can you tell me about the accuracy of the current forecasting system? Or: Can the company accurately forecast?
_____

9) Does the company understand the technology requirements of the industry?
_____
_____
____

10) What can you tell me about the capacity requirement of the industry? Or: Does the company understand the capacity requirements of the industry?
_____
_____
_____

11) What can you tell me about relative operating size in relation to the industry? Or: Is the company of an optimum operating size?
_____
_____
_____

12) Is the company built for change?
_____

13) Is the facility built for change?
_____

14) Are there any suggestions that you have that we may have overlooked?
_____
_____
_____
_____
_____

APPENDIX B: OBSERVATION SCHEDULE

	Observation of daily operations and corroboration with interview questions.	Corroborating Documents	Start Date (ongoing)
Company A	Participated as a voluntary worker and consultant.		
Tour/Induction	Induction- Observation freedom		08/09/2015
Lean elements	Operations viewed- High corroboration	Viewed	05/10/2015
JIT elements	Operations viewed- High corroboration	Viewed	06/10/2015
SRM elements	Operations viewed- High corroboration	Viewed	23/09/2015
CRM elements	Operations viewed- High corroboration	Viewed	28/09/2015
Organisational Culture	Operations viewed- Average corroboration	Viewed	30/09/2015
Company B	Day visitor		
Tour/Induction	Tour- Observation after interviews only		
Lean elements	Operations viewed- High corroboration	Viewed	07/10/2015
JIT elements	Operations viewed- High corroboration	Viewed	08/10/2015
SRM elements	Operations viewed- High corroboration	Viewed	03/11/2015
CRM elements	No interviews	No data	
Organisational Culture	Operations viewed- High corroboration	Viewed	04/11/2015
Company C	Participate as voluntary worker		
Tour/Induction	Induction – Observation freedom		01/10/2015
Lean elements	Operations viewed- High corroboration	Viewed	14/10/2015
JIT elements	Operations viewed- High corroboration	Viewed	15/10/2015
SRM elements	Operations viewed- High corroboration	Viewed	12/10/2015
CRM elements	Operations viewed- High corroboration	Viewed	13/10/2015
Organisational Culture	Operations viewed- Average corroboration	Viewed	09/10/2015

APPENDIX C: ETHICAL CLEARANCE

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

27 August 2015

Mr Neeshal Gurahoo (204517970)
School of Management, IT & Governance
Pietermaritzburg Campus

Dear Mr Gurahoo,

Protocol reference number: HSS/1139/015M
Project title: Factors affecting the Agility of firms implementing Lean Manufacturing

Full Approval – Expedited Application

In response to your application received on 07 August 2015, the Humanities & Social Sciences Research Ethics Committee has considered the abovementioned application and the protocol have been granted **FULL APPROVAL.**

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

.....
Professor Urmilla Bob (University Dean of Research)
On behalf of Dr Shenuka Singh (Chair)

/ms

Cc Supervisor: Dr RH Salisbury
Cc Academic Leader Research: Professor Brian McArthur
Cc School Administrator: Ms Debbie Cunynghame