UNIVERSITY OF KWAZULU-NATAL

The Implementation and Sustainability of Lean in Pfisterer (SA) Pty (Ltd)

By

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DECLARATION

This research has not been previously accepted for any degree and is not being currently considered for any other degree at any other university.

I declare that this Dissertation contains my own work except where specifically acknowledged.

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ABSTRACT

The manufacturing sector is competitive and economically challenging. To deal with the challenges, the Toyota motor vehicle manufacturer developed a ‘Lean’ process of manufacturing that emphasised the elimination of waste. From 2008 to 2014, Toyota was ranked the largest car manufacturer in the world, and Lean was largely credited for this success, prompting much research and effort into Lean as a practice in manufacturing companies, globally. Despite its proven benefits, Lean is still not a very well-established methodology in manufacturing firms, especially in South Africa, since it carries with it numerous logistical challenges. Changes from the status quo and becoming Lean require shifts in organisational attitude and mind-set, substantial initial investment, and training, which are often received with resistance from key stakeholders. Understanding and improving the limiting factors of Lean are therefore crucial for the successful implementation of Lean. This study observed the implementation and sustainability of Lean practices in the manufacturing environment of Pfisterer Pty (Ltd) in Pietermaritzburg, using a mixed qualitative-quantitative methodology that incorporated 134 general employees and the nine production managers and foremen from the production unit. This was performed to understand the benefits, shortcomings and factors that have been responsible for any failure and/or limited successes of Lean in the company.

The classification of which departments were operating well or poorly according to Lean appeared to conflict between the employees, managers and foremen, as did whether there were sufficient numbers of employees, raw materials, equipment or space. Lean efficacy in the company was affected by the motivations of the employees, the amount of time machines were functional or in use, the amount of time raw materials were late or unavailable, and the frequency that the factory was down. From the findings, it was postulated that this would have had an effect on client satisfaction and orders from the company. The study found that managers and foremen doubted whether Lean would be sustainable over the long-term in its current arrangement; however, there was a consensus that perfecting Lean would be in the best interest of the company, and indeed a non-negotiable requirement for the future.

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INTRODUCTION OF THE STUDY

1.1 INTRODUCTION AND BACKGROUND

Toyota grew from manufacturing “a few thousand vehicles a year” (Womack, Jones & Roos, 1990, p.52) to the largest car manufacturer in the world between 2008 and 2014 (Gibbs, 2014). Central to Toyota’s phenomenal growth and success was its approach to manufacturing, which emphasised the elimination of waste, promoting value for the final customer and developing a spirit of perpetual improvement (Womack *et al.*, 1990). In the 1990 publication, The Machine that Changed the World by Womack *et al.*, the result of a five-year research initiative on the future of the car provided the Anglophone world with a detailed examination of Toyota’s approach to production and manufacturing, and popularised a term to describe it: “Lean” (Jasti & Kodali, 2014, p.1082).

Making these concepts available to Western audiences has triggered both organisational attempts to implement Lean principles, and a great deal of academic writing on the subject, leading to an array of theoretical terms and business practices: total quality management, theory of constraints, world class management and so forth (Stone, 2012). Womack *et al.* (1990, p.278) concluded their pivotal work with the statement that “Lean production will supplant both mass production and the remaining outposts of craft production … to become the standard global production system of the twenty-first century”.

The manufacturing sector is a competitive and economically challenging one. There is overwhelming evidence that successful implementation of Lean techniques results in greater productivity and improved overall company performance (Bhasin, 2011). An evaluation of various performance markers, for example earnings per share, rate of return, market share and manufacturing efficiency, revealed a strong relationship between Lean and overall performance of companies (Bhasin, 2011). For this and other reasons, the Lean philosophy has been embraced by manufacturing organisations to reduce costs, improve productivity and gain a competitive edge in the market place (Ghosh, 2012).

Despite the proven benefits of employing Lean concepts and methods, as well as Toyota's phenomenal success, Lean implementation is far from global. According to Robbins, Judge, Odendaal and Roodt (2009), change from the status quo is often received with resistance, especially when key role players feel that they are not part of the change. The Lean journey is a paradigm shift of a long-term process to maximise business performance, and Lean style demands a serious change in organisational attitude and mind-set (van der Merwe, Pieterse & Lourens, 2014, p.134). Furthermore, the changes to manufacturing and production required by Lean often require a substantial initial investment, both in cost and training (Meade, Kumar & White, 2010; Bhasin, 2012a). Organisations that implement Lean have also observed short-term losses in profits, indicating that Lean is a long-term process; and organisations that view immediate profit as a key indicator of success look negatively upon the prospects of implementing Lean.

In order to understand further why Toyota's success has not been successfully adopted by many other organisations, especially in South Africa, it is necessary to consider not merely the operational benefits of a Lean approach, but the methods by which it is implemented, perceived, and best employed. An example of this, "less than 10 percent of UK organisations have accomplished a successful Lean implementation" (Bhasin, 2012a, p.439). It is important to observe and understand what effects the implementation of Lean has in manufacturing companies, such as in South Africa, along with the perceived opinions of key stakeholders towards its implementation and sustainability, and the key factors that are responsible for any failure and/or limited successes of Lean in these organisations.

The purpose of this study was, therefore, to observe and understand the implementation and sustainability of Lean practices within the manufacturing environment of Pfisterer Pty (Ltd) in Pietermaritzburg, South Africa.

1.2 RATIONALE OF THE STUDY

Miller, Pawlowski and Stanridge (2010) state that Lean is a way of thinking, or a mindset towards achieving a completely waste-free operation, and which is focused on customer success. Balle (2010) states that CEOs must radically change the way they manage a Lean organisation, since the golden rule of Lean is about “making” people “make” products for you. For Lean, the philosophy of management in an organisation must be changed (Womack, 2009). It entails a shift from a vertical flow of authority to a horizontal flow of value; even to the customer. Employee involvement and organisational culture are pivotal in the implementation and sustainability of Lean (Miller *et al.*, 2010). Balle indicates that questioning is a key component for overcoming resistance from within organisations.

For observing and understanding the effects that Lean implementation has in the context of a manufacturing company in South Africa, as well as its perceived sustainability, Pfisterer Pty (Ltd) was used as an example. Established in 1978, Pfisterer is a manufacturer and supplier of high-current conductors, and one of the leading manufacturers of cable and overhead line accessories for low, medium, high and extra high voltage (EHV) applications in the country (Pfisterer, 2015). The plant produces products such as insulator strings, composite insulators for railway applications, composite insulators for distribution and transmission applications, silicone cut outs, spacer dampers, and line hardware for distribution networks (SAEEC, 2015). The company is involved not only in the manufacturing of high-current conductors, but also the marketing, transportation and supply of these products (Snupit, 2014). The company currently has 134 general employees and nine Foremen and Managers operating in the production unit of the plant, and is a major supplier of products to the national electricity provider, Eskom (Philip, 2014). Lean has been introduced to a moderate-extent in recent years as a management practice at Pfisterer, and it therefore formed a suitable model to analyse for the purposes of this study.

1.3 STATEMENT OF THE PROBLEM

Schlichting (2009) cites the results from 32 websites and expands on seven specific reasons for the unsuccessful implementation and limited sustainability of Lean that is commonly experienced in manufacturing firms. Lean success is primarily dependent on the development of a Lean culture in the organisation; whereby, a lack of co-operation from employees could present a serious challenge to Lean implementation (van der Merwe *et al.*, 2014, p.133). Lean implementation is also a long-term philosophy that demands a great deal of effort — both to change the methods of production, and to adjust the prevailing attitudes of the staff (Schmidt, 2011).

Although Lean has been introduced as a manufacturing philosophy at Pfisterer, it is unclear what effects it has had on the company, such as what benefits or shortcomings have been observed at the company, what the perceived opinions of key Pfisterer stakeholders are about the implementation and sustainability of Lean at the company, what factors have been responsible for any failure and/or limited successes of Lean at the organisation, and whether there are any ways in which the Lean implementation of the company should be changed. While it is assumed that purely implementing Lean within an organisation would prompt a spectrum of benefits to be realised, this is not necessarily the case, and it is important to understand where the shortcomings of the Lean implementation are to allow measures to be taken to improve such shortcomings. Studies like this one are important for emphasising where changes can be made that would have significant effects on productivity and output. This generated the purpose of this study, as outlined in the next subsection.

1.4 AIM OF THE STUDY

The aim of this study was to observe and understand the implementation and sustainability of Lean practices within the manufacturing environment of Pfisterer Pty (Ltd) in Pietermaritzburg, South Africa. In that regard, the study asked the following research questions.

1.5 RESEARCH QUESTIONS

In line with the aim of this study, the following research questions were drafted to provide an inquisition framework that would allow the aim of this study to be achieved:

- What are the perceived opinions of key Pfisterer stakeholders about the implementation and sustainability of Lean at Pfisterer Pty (Ltd)?
- What are the key factors that have been responsible for any failures and/or limited successes of Lean at the organisation?
- What benefits or shortcomings have or will be observed at Pfisterer from improving the Lean philosophy of thinking?

- Can any guiding principles be established to aid better implementation and sustainability of Lean at Pfisterer?

1.6 RESEARCH OBJECTIVES

In line with the aim of this study, the following research objectives were drafted to provide the intentional framework for answering the above research questions:

- To determine the perceived opinions of key Pfisterer stakeholders about the implementation and sustainability of Lean at Pfisterer Pty (Ltd);
- To determine the key factors that has been responsible for any failures and/or limited successes of Lean at the organisation;
- To determine the benefits or shortcomings that have or would be observed at Pfisterer from improving the Lean philosophy of thinking; and
- To establish some guiding principles to aid better implementation and sustainability of Lean at Pfisterer.

1.7 SIGNIFICANCE OF THE STUDY

By performing this study, numerous companies in South Africa — not least of which being Pfisterer — would stand to benefit, as it would present answers to issues that would help these companies improve their manufacturing processes by overcoming difficulties and challenges that they may have experienced with implementing a Lean management philosophy. It also stands to improve the knowledge base on the topic of Lean manufacturing, specifically within the South African context.

1.8 METHODOLOGY

A research paradigm may be categorised into two classes of research, according to Rubin and Rubin (1995), namely: phenomenology and positivism. Researchers who perform qualitative methods of interrogation and description to draw conclusions are termed phenomenologists; while positivists perform studies using quantitative methods and tools that analyse circumstances in a scientific manner (Rubin & Rubin, 1995).

In order to overcome limitations of either methodology for this study, a mixed qualitative-quantitative method was chosen to provide complete and comprehensive answers to the research questions that were posed. Non-probability sampling was used in both the quantitative and qualitative phases of the research. The quantitative study (phase one) comprised 134 general employees from Pfisterer, where the majority were machine operators, with some handlers, hyster drivers, furnace operators and grinding operators. These employees were based in the Cut Outs, Silicone Moulding, Ali Foundry, Rod Plant, Sg Foundry, Silicone Blending, Speed Craft (and wireform), and Spacer Damper departments. The qualitative study (phase two) comprised nine production managers and foremen from the company.

In the quantitative phase of the study, a multi-choice survey questionnaire was prepared, printed and distributed to the employees for a paper-and-pen type of information input. In the qualitative phase of the study, a separate survey questionnaire was prepared in Microsoft Word with open-ended questions and the respondents were requested to enter their responses electronically into the word document.

Data that was collected from the employee sample (Sample One) was analysed with quantitative techniques of statistical analysis, such as descriptive statistics, contingency tables, bivariate correlations, and reliability analysis. Data from the qualitative study was analysed with the common qualitative technique of content analysis.

1.9 OUTLINE OF THE DISSERTATION

This first chapter of the dissertation has presented the introduction to the study, along with the background to the study, the statement of the problem, the aim of the study, and a brief overview of the methodology that was performed to conduct the research. Chapter Two presents the literature review of the study, outlining the literature on the implementation and sustainability of Lean practices within the manufacturing environment. Chapter Three highlights the methodology of the study. It describes the research philosophy of the study and the research paradigms that were chosen for each phase of the research. It also outlines the target population for the study, the sampling strategies, research instruments and data analysis techniques. In Chapter Four, the results of the study are presented, giving the outcomes of each of the quantitative and qualitative phases of the study, and the evidence upon which the research questions were answered and deliberated. Chapter Five gives a detailed discussion of the dissertation, where each of the findings of the results is discussed in turn, presenting arguments for the outcomes of the research, as well as explanations for any of the shortcomings in the results. It offers comparisons between the quantitative and qualitative phases of the study and considers where the results of the research have supported the findings of other research. Finally, Chapter Six presents the conclusions based on the study, and any final thoughts from the research. It also presents some recommendations that may be performed for future research to enhance the body of knowledge on the subject.

1.10 CONCLUSION

Despite its proven benefits, Lean is still not a very well-established methodology in manufacturing firms, especially in South Africa, since it carries with it numerous logistical challenges. For instance, although Lean has been introduced as a manufacturing philosophy at Pfisterer Pty (Ltd) in Pietermaritzburg, South Africa, it is unclear what effects it has had on the company. The aim of this study was, therefore, to observe and understand the implementation and sustainability of Lean practices within the manufacturing environment of Pfisterer, using a mixed qualitative-quantitative methodology that incorporated 134 general employees and nine production managers and foremen. The following chapter presents a literary basis for this study, by providing a review of the principles and philosophies that have been developed — and the core research that has already been conducted — on the implementation and sustainability of Lean practices within the manufacturing environment.

CHAPTER TWO:
LITERATURE REVIEW

2.1 INTRODUCTION

Since the implementation of Lean at the hugely successful Toyota motor vehicle manufacturing company, a great deal of academic writing has been published on the subject, leading to an array of theoretical terms and business practices (Stone, 2012). This chapter presents a review of some of that literature, outlining some core research that has been conducted on the implementation and sustainability of Lean practices within the manufacturing environment. The chapter begins with a definition of Lean, followed by an overview of Toyota's production system, its organisational principles, and the systems employed for reducing waste. Reviewing Toyota's production system is beneficial, since much of the foundation of Lean was developed on the Toyota production system, and replicating similar production efficiencies in companies such as Pfisterer is considered an important means of reaching absolute 'Leanness'. A brief overview of the 'Toyota Way' is also presented.

The chapter then presents details on the benefits that are observed in organisations from converting their productions to Lean, specifically focusing on the productivity, waste reduction, and inventory and staff benefits. Conversely, the failures of Lean and the reasons for its limited success are presented at the end of the chapter, considering aspects such as human factors, organisational culture issues, problems with its definitions, cost considerations and logistical problems. Before ending the chapter, some perceptions of Lean are presented, such as by workers and management who identify some guiding principles on Lean implementation for organisations.

2.1.1 Defining 'Lean'

Before discussing the concept of Lean manufacturing, it is crucial to note that the term is hardly specific. 'Lean' itself, as a term, was not applied by Toyota but

Western writers (Stone, 2012)[1]. As Stone (2012, p.113) points out, Lean, in the manufacturing and business sense, has become an "example of ill-defined jargon." Pettersen (2009, p.136) found that "There is no agreed upon definition of Lean that could be found in the reviewed literature, and the formulations of the overall purpose of the concept are divergent". Therefore, it is important to note that the term can refer to a variety of concepts, which Stone (2012, p.114) lists as follows: "Lean thinking", in the sense of an overall operation philosophy or outlook; "Lean principles", as a set of tools or methods by which to make an operation Lean; and "Leanness", or an organisation's state of "being" Lean.

In short, there is no precise, absolute definition of Lean, or a particular Lean approach. Rather, there are a series of shared characteristics and tools that can be used to broadly categorise a philosophy or operation as Lean (Pettersen, 2009). The term can be used interchangeably to refer to an organisational set of values or goals, the physical process of production, or the extent to which an organisation has, or has not, employed these techniques and values.

2.2 TOYOTA'S ORGANISATIONAL PRINCIPLES

As an organisation based on large-scale, high-efficiency manufacturing, Toyota has numerous organisational philosophies that can be applied within organisations such as Pfisterer. It is generally accepted that the techniques and philosophies that inform the concept of Lean production originated in the "Toyota Production System" (TPS) (Gao & Low, 2013, p.664). The system's origins can be traced to the 1950s, when Eiji Toyoda, an employee of Toyota, studied Ford's manufacturing facilities in the United States. Building both through innovation and necessity on what had been learned from Ford, Toyota was able to develop its own approach to manufacturing over a period of twenty years (Womack *et al.*, 1990). The unique methods and approaches that Toyota adopted are now referred to as the Toyota Production System (Toyota Motor Corporation, 2014a).

However, in order to fully understand Lean as practiced by Toyota, it is important to distinguish between the Toyota Production System (TPS) and the 'Toyota Way'.

[1] John Krafcik is credited as the first person to use the term, in a 1998 article (Stone, 2012).

The former refers to the system and philosophy of production within the company, whereas the latter is a set of principles that summarise Toyota's underlying "management philosophy and values" (Toyota Motor Corporation, 2012). However, both are key parts of Toyota's overall approach to manufacturing and development (Toyota Motor Corporation, 2014a).

2.2.1 Toyota Production System

With Pfisterer attempting to replicate the Lean principles that were credited to the success of Toyota, it is sensible to consider the philosophies that have been engrained in the Toyota Production system, since understanding this presents a prototypical 'blueprint' of how Lean should be implemented in the Pfisterer manufacturing environment, which has similar goals of just-in-time (JIT) high-throughput production. At the core of the Toyota Production System, for example, lies the goal of "the complete elimination of all waste" (Toyota Motor Corporation, 2014a). Broadly, this can be considered any activity that takes time or effort but does not add value for the final customer (Liker, 2004). More specifically, these undesirable elements are classified into three categories: *muda*, *muri* and *mura* — Japanese terms referring to the concepts of waste, overburdening and irregularity, respectively (Toyota Great Britain, 2013b).

2.2.1.1 Toyota's 'wastes'

Muda can be defined as a "wide range of non-value-adding activities" (Toyota Great Britain, 2013b). Liker (2004, p.37-41) reports Toyota's list of wastes as follows:

- Overproduction: The production of items for which there is no need or demand;
- Waiting: Worker time not being adequately utilised, or workers not having anything to do;
- Unnecessary transport: Wasting time and energy on unnecessary transportation of material, goods, or parts, between locations or between manufacturing processes;
- Over processing or errors in manufacture: Spending unnecessary energy through inefficient manufacturing processes or using more motion than necessary;

- Unnecessary movement: Wasting employee effort through needless walking, searching for tools, stacking and so forth;
- Excess inventory: Having excess amounts of raw material or manufactured goods on hand, or holding excess inventory; and
- Defects: Manufacturing errors or spending time to correct or repair flaws or errors in the manufacturing process.

The next waste, *muri*, refers to “overburdening people or equipment” (Liker, 2004), emphasising the need to evenly distribute the demands of manufacturing to allow maximum efficiency. Giving employees insufficient time per task will compromise the process, whereas giving excessive time for an activity generates waste (Toyota Great Britain, 2013b). Finally, *mura* refers to “unevenness or irregularities in the production system” (Toyota Great Britain, 2013b). Liker (2004) explains this concept as fluctuating demands upon the production system, due to factors such as downtime, defects, or a lack of necessary components or material, all of which lead to unnecessary use of resources or stress on the system.

2.2.1.2 Toyota Production System concepts

In order to minimise or eliminate the various wastes and irregularities discussed above, the Toyota Production System (TPS) applies a variety of techniques and concepts to the process of manufacturing. While the following paragraphs do not provide an exhaustive account of all of Toyota’s concepts, they do touch upon those that can be considered crucial to its operational approach.[2]

Foremost among these concepts are ‘*Jidoka’* and ‘Just-in-Time’ (Toyota Motor Corporation, 2014b). Just-in-Time (JIT), or the ‘pull’ system, is perhaps at the core of the Lean concept, as it refers to the process of providing only that which is necessary for each step in the manufacturing process, rather than maintaining large quantities of unused products or parts (Toyota Motor Corporation, 2014b). The intended goal is that “the right parts and materials are manufactured and provided in the exact amount needed — and when and where they are needed”

[2] For a glossary of Toyota’s concepts and translated Japanese terms, see Toyota Great Britain (2013c).

(Toyota Motor Corporation Australia, 2014).

Toyota facilitates the Just-in-Time process by use of a '*Kanban'* system — a system of requisitioning the components or items that are needed for each stage in a process, through electronic or printed tickets and direct communication. This allows exactly that which is needed to be supplied as necessary (Liker, 2004). The concept of *Heijunka*, translated as "smoothing" or "levelling," also promotes Just-in-Time: by establishing and maintaining average volumes of production and supply, production as a whole can be smoothed out (Toyota Great Britain, 2013a).

'*Jidoka'*, as introduced previously, refers to the process of identifying and correcting problems as they occur — an approach that demands that each operator can halt production to address an issue (Toyota Motor Corporation, 2014b). While this may cause temporary disruptions in the flow of production, it prevents magnification of problems or defects further down the manufacturing line, eliminates the problem at the source, and "is much more effective and less costly than inspecting and repairing quality problems after the fact" (Liker, 2004, p.38). Central to Toyota's implementation of *Jidoka* is the idea of "automation with a human touch" (Toyota Motor Corporation, 2014b): machines should be capable of detecting errors or problems and immediately halting operation, thus enabling workers to correct the issue. To provide this *Jidoka* facility, a distinguishing feature of the Toyota approach is the presence of an '*andon*' cord, which allows any worker on the line to halt the manufacturing process (Toyota Motor Corporation Australia, 2014).

2.2.2 The Toyota Way

The Toyota Way emerged from the TPS, but should be considered as a separate, underlying set of principles rather than a particular approach to manufacturing (Gao & Low, 2013). Toyota considers "the way" to be an evolving, formal statement of "the management philosophy and values that had been passed on as implicit knowledge" within the company (Toyota Motor Corporation, 2012). Thus, while 'the way' does not govern the actual process of manufacturing within Toyota, it provides the underlying values and priorities that inform the company's approach to its operation. The company divides these principles into two core pillars:

“continuous improvement” and “respect for people” (Toyota Motor Corporation, 2012), with sub-principles within these main categories.

2.2.2.1 Continuous improvement

The Toyota way separates the concept of ‘continuous improvement’ into three main principles: challenge, *Kaizen*, and *Genchi Genbutsu* (Toyota Motor Corporation, 2012). Challenge demands the formation of a long-term vision for the company, embracing struggle and a “long-range perspective” (Toyota Motor Corporation, 2012).

Kaizen refers to an on-going pursuit of improvement within the company, encouraging continuous evolution of techniques, Lean systems, and organisational learning (Toyota Motor Corporation, 2012). *Kaizen* also encourages teamwork, self-management, and the collection of data and information (Liker, 2004).

Finally, *Genchi Genbutsu* encourages the process of going to the source: employees and leaders should physically investigate operations in order to obtain facts, attempt to reach a consensus effectively and “commit to achievement” (Toyota Motor Corporation, 2012). This encourages management to take a more active role in the nature of production and develop an understanding of the processes involved (Liker, 2004).

2.2.2.2 Respect for people

Toyota divides ‘respect for people’ into two principles: respect and teamwork (Toyota Motor Corporation, 2012). Respect itself proposes respect for stakeholders, mutual trust and responsibility within the organisation, and forthright and “sincere” communication (Toyota Motor Corporation, 2012). Teamwork encourages “personal and professional growth”, with an emphasis on on-going education and development and respect for both the individual and the potential of teamwork (Toyota Motor Corporation, 2012).

2.3 BENEFITS OF LEAN PRINCIPLES

The literature of the last four decades provided a wealth of information on the benefits, issues, novel applications and principles that Lean offers (Stone, 2012). Unsurprisingly, many of the reported benefits correlate with the goals of the TPS, including enhanced productivity, less inventory and greater employee participation.

2.3.1 Productivity

A consistent theme in the literature is Lean's positive impact on productivity. "From a theoretical perspective, Lean practices are expected to improve operational performance by streamlining processes and increasing process consistency", and this seems to be the predominant reason for organisations adopting a Lean approach (Alsmadi, Almani & Jerisat, 2012, p.384). Of 68 surveyed British organisations in a particular study, improved performance was considered by far the most important reason for adopting Lean (Bhasin, 2012a).

There is overwhelming evidence that successful implementation of Lean techniques results in greater productivity and overall company performance. An evaluation of various performance markers, such as earnings per share, rate of return, market share, and manufacturing efficiency among 68 British organisations revealed a strong relationship between Lean adaptation and overall performance (Bhasin, 2011). It was found that "the best performing organisations had 72.5% of the departments and 74.5% of employees operating under Lean as opposed to 54.7% of the departments and 55.4% of the employees in the remaining organisations" (Bhasin, 2011, p.27).

In an investigation of Lean implementation among 79 Indian manufacturing plants, Ghosh (2012, p.113) reports that those that adopted Lean concepts — some 80 percent — "improved on all accounts: high productivity, reduced lead time, improved first-pass correct output, reduced inventory and space requirement." Similarly, a study of 11 textile manufacturers in the United States revealed that the benefits of adopting Lean manufacturing principles included increased production, lower production times and a reduction in product complexity (Hodge, Ross, Joines & Thoney, 2011).

Individual companies also report greater productivity as a result of utilising Lean principles: a major Sri Lankan clothing manufacturer indicated that "Lean implementation caused a reduction in the cost of production (10%), reduction of lead time (30%), and increase in plant efficiency (20%)" over a two and a half year period (Gamage, Vilasini, Perera & Wijenatha, 2012, p.423). An unnamed Norwegian manufacturer implemented Lean principles from the early 2000s, which led "to a doubling of factory up-time, tripling the number of good parts pr [sic] time unit and reducing change over time by 60%" (Ringen, Aschehoug, Holtskog & Ingvaldsen, 2014, p.246).

Furthermore, processing times are reduced, sometimes dramatically, by the switch to Lean manufacturing. Among a group of 40 manufacturers in a particular survey, an average of 50 percent increase in productivity was reported as a result of adopting Lean (Industrial and Financial Systems, 2010). Individual cases also support these findings: Singh, Garg, Sharma and Grewal (2010), for example, identified a 12.62% reduction in processing time for an Indian manufacturer as a result of adopting Lean principles. From Toyota's original success to contemporary evidence, it seems clear that successful Lean adaptation leads to increased productivity.

2.3.2 Reducing waste

While this is perhaps implicit in enhanced productivity, Lean manufacturing principles can also help reduce waste. Miller *et al.* (2010) explored the case of a furniture production company that integrated Lean tools and approaches. The authors noted that "Lean's systematic elimination of waste helped the company become more operationally stable", but also explore another aspect of waste avoidance (Miller *et al.*, 2010, p.19). By applying *Kaizen*, the company was able to divert the waste of some "1.75 dumpsters per day" to recycling, thus reclaiming "a significant amount of material previously disposed of as waste" (Miller *et al.*, 2010, p.28). By encouraging on-going improvement and critical evaluation of existing methods, Lean principles can therefore reduce waste.

2.3.3 Inventory

The literature suggests that a Lean approach allows organisations to maintain lower inventory levels and enjoy higher levels of inventory turnover. Meade, Kumar and White (2010, p.858) note that this is an important aspect of Lean implementation, as “Inventory reduction is frequently a primary objective and key success measure of a Lean manufacturing programme”.

Given Lean’s emphasis on Just-in-Time and the delivery of only that which is necessary for production, it is unsurprising that Lean companies “keep fewer inventories” (Demeter & Matyusz, 2011, p.161) when compared to other organisations. Individual examples provide some idea of the possible outcome of Lean principles. For example, applying Lean principles allowed a Trinidadian pharmaceutical company to reduce its storage space by “38 percent” (Chowdary & George, 2012, p.56) and an American textile manufacturer to cut inventory by half (Hodge *et al.*, 2011).

Inventory turnover is also higher for Lean companies. With smaller inventories and a more precise idea of what manufacturing and the customer demands, Lean companies “have significantly better inventory turnover for each type of inventory…than do traditional companies” (Demeter & Matyusz, 2011, p.160). In short, a Lean approach can allow companies to keep lower levels of inventory, reduce storage space, and move inventory more rapidly.

2.3.4 Staff involvement

The overarching Lean philosophy encourages employee participation and collaboration. In order to minimise waste, it is important to “empower the employees not to produce unnecessary costs” (Schmidt, 2011, p.862). Because of the collaborative nature that Lean principles encourage, employees can “stay informed about the status of the operation. This gradually fosters a sense of ownership” (van der Merwe *et al.*, 2014, p.140).

Similarly, greater employee participation in production and the overall activities of the company can result. Hodge *et al.* (2011) deal with the case of a single textile manufacturer that adapted Lean principles. At first, employees were “reluctant to offer ideas," (Hodge *et al.*, 2014, p.241) but soon warmed to the process and eventually some 32 employees' suggestions were adopted by the company.

Wong and Wong (2011, p.2169) observed that four years of Lean practice at a Malaysian electronics manufacturer left employees with a more proactive, "aggressive" and independent approach to their work, including a willingness to engage in tasks without having them set by managers. The authors also noted an increased presence of managers on the floor, presumably embracing the spirit of *Genchi Genbutsu.* The literature suggests that Lean can result in both enhanced staff participation and a greater sense of employee involvement within the organisation.

However, implementing Lean does not guarantee greater employee satisfaction and morale. A study by Distelhorst, Hainmueller and Locke (2014, p.3) of Nike Inc. indicated that the company's adoption of Lean manufacturing produced a "15 percentage point reduction in serious labour violations on average", but no obvious effect on workplace health or safety. This is discussed in more detail in the next section.

2.4 LEAN FAILURES AND LIMITED SUCCESSES

Bhasin (2012a, p.454) notes that "a Lean journey is both difficult and time consuming". Unfortunately, organisations cannot hope to replicate the success of Toyota overnight — as Bhasin (2012a) points out, Toyota's development took several decades. The literature identifies a number of factors that can lead to the failure of Lean initiatives or their limited success. Bhasin (2012a) reports that, of 100 surveyed organisations, the following barriers to Lean implementation were identified:

- Company culture: 48 percent;
- Investment or cost: 47 percent;
- Staff attitude: 38 percent;
- Issues relating to change: 33 percent;
- Lack of understanding of the Lean process: 29 percent;
- Lack of understanding of Lean's benefits: 29 percent; and
- Nature of manufacture facility: 27 percent.

Bhasin (2012a) further reports that, of over 900 surveyed executives, the following issues for Lean transformation were identified:

- Backsliding to previous work techniques: 36 percent;
- Lack of knowledge of Lean implementation: 25 percent;
- No obvious urgency: 24 percent;
- A traditional cost accounting system: 22 percent;
- Resistance by middle management: 21 percent;
- Lean being viewed as a fad: 19 percent;
- Internal resistance to change: 18 percent;
- Resistance by hourly employees: 11 percent;
- Resistance by supervisors: 10 percent; and
- Failure of previous Lean attempts: 6 percent.

Despite all these different barriers, there is an overwhelming academic consensus on the principle reasons for any failure of Lean: the human factor and corporate culture (Bhasin, 2012a). These are discussed below.

2.4.1 Human factor

As discussed previously, a Lean approach calls for a certain trust in the judgment and autonomy of all employees. However, this is not easy to quantify or measure. As Pettersen (2009, p.135) notes, "the Lean literature is generally weaker on the human behaviour side, focusing more on instrumental techniques for improving system performance".

However, it is possible to make a few inferences from the available literature, particularly with regard to the role that workers play in establishing the crucial Lean culture. "Lean success … is largely dependent on the attainment of a Lean culture" state van der Merwe *et al.* (2014, p.133), and since workers are responsible for the daily implementation of Lean procedures and methods, a lack of co-operation on their part will provide a serious challenge for Lean implementation.

A consistent theme in Wong and Wong's (2011) study of Malaysian manufacturing plants was 'backsliding', such as the initial resistance to change, reluctance to adopt Lean methods and 'backsliding' to previous working methods. It is only when workers are fully convinced of "the benefits that Lean can bring" that this reluctance fades (Wong & Wong, 2011, p.2173). Thus, as noted in the literature, if workers fail to adopt Lean thinking or are unable to see the advantages of Lean principles, it will be more difficult for their organisation to successfully implement a Lean approach.

An Executive Vice Chairman, Yasuhito Yamauuchi, of the Aisin Seki Toyota Group Company in Japan stated that a key factor that was linked to successful Lean management was motivation in the workplace (Process Improvement Japan, 2010). According to Yamauuchi, unless a company has "vitalised front line workers", it cannot be successful. Yamauuchi went on to suggest that workers "are the ones who actually produce the product and the profit" thus, the job of the management "is to make them energised". He also argued that the corporate culture should be "vitalised".

The topic of motivation in Lean practices is an important concept, which according to Beale (2007), is an often-ignored aspect of Lean management. Miller (2014) argues that most Lean implementations are too focused on problem-solving skills within the work place, but they fail to consider the system or culture of motivation within the staff. Indeed, according to Leading Edge Group (2014), a manager can be an expert on Lean management, having applied the principles of efficiency and adaptability through the organisation, but by failing to focus on motivation, the "Lean package" would still be "desperately incomplete". Miller (2014) summarises the perception of many managers by saying "Too many rely on the 'they ought to want to' assumption, which usually results in disappointment." Additionally, according to Distelhorst *et al.* (2014), steadfastly implementing Lean in companies does not guarantee greater employee satisfaction or morale; and in fact, the opposite is often true. For example, in the study by Distelhorst *et al.*, the adoption of Lean manufacturing in companies was often found to increase the occurrence of employee motivation problems, such as labour violations.

Miller (2014) explains the importance of motivation simply by stating that at the root of performance in organisations is human behaviour, which Miller argues is regulated by each of the aspects of *competence* and *motivation*. Miller goes so far as to illustrate the example in pseudo-mathematic form, stating that:

$$\boldsymbol{Competency \times Motivation = Performance} \qquad \textbf{[1]}$$

According to Miller (2014), despite advanced skill and ability (competence) by an employee, without motivation to use these skills, they are effectively “useless”. Yamauuchi (2010, cited in Process Improvement Japan, 2010) agrees that unless employees are motivated, companies cannot create a working Lean system. Comparing Proctor and Gamble’s corporate philosophy on motivation to that of the Toyota Group, Yamauuchi argued that “Proctor and Gamble share the same idea. They pay good attention to employees. We see things in common among excellent companies throughout the world”.

The concept of a team spirit and family unit is central to the Toyota culture, and Toyota promotes a practise where every member is awarded the highest level of ownership and accountability in what they are doing — they are taught to understand that their fate is integrally linked to that of the company’s (Miller, 2014). As a means of overcoming issues with motivation in the Lean environment, Miller (2014) asserts that managers should focus on developing a “systematic approach to motivating all members of the organisation”. According to Miller (2014), it is firstly important to understand that people are motivated differently by diverse stimuli, at different times and under differing circumstances. Some are motivated by financial stimuli (money), while others are motivated by “a higher calling” (Miller, 2014).

Within the concept of *multiple schedules of reinforcement*, for example, is the idea that people are often motivated by multiple stimuli simultaneously, each holding different ranks within the psyche (Craig, Cunningham & Shahan, 2015). Miller (2014) argues that motivating stimuli should be presented across a spectrum from the material to the spiritual — with none being given more importance than others. According to Miller, people are happier when they are focused on working in groups, when they are serving others and when they feel that their lives are achieving an honourable purpose.

Yamauuchi (2010, cited in Process Improvement Japan, 2010) presents examples of techniques that he used to vitalise employees and grow motivation during his executive vice chairmanship at Aisin Seki of the Toyota Group. Yamauuchi recommends reminding the workers that they are the ones who create profit in the organisation — through their wisdom and skills. Emphasising the point, Yamauuchi argues that as a leader, one should communicate the corporate vision to every member of the organisation, emphasising how important the vision is for the future direction of the organisation. In communicating this vision, Yamauuchi asserts that managers should approach the employees directly in their respective places of work — going to the employees, as opposed to summoning them to the managers' place of convenience.

In terms of gaining employee buy-in and enthusiasm for Lean, though, this is not always a smooth process and resistance can often occur — particularly from senior workers (Wong & Wong, 2011, p.2170). According to Wong and Wong, employees often perceive Lean as an attempt by management to force them to do more work. Misunderstanding, or a lack of appreciation for the possible benefits that Lean offers, can cause employees to engage the Lean principles less seriously and ultimately affect their motivation.

A technique that has been described in the literature for attempting to stimulate employee motivation and participation in Lean is rewards programmes, such as employee-of-the-month awards for small improvements in work performances (Peterson & Luthans, 2006). In the contrary, though, Bigelow (n.d.) argues that while small improvements should be recognised and rewarded, such rewards programmes are contrary to true Lean-ideology, since they derive "extrinsic-motivation". Likening such systems to "a drug", Bigelow asserts that "in order to maintain the 'high', doses must continue periodically … [and] the dosage must increase to get the same result". Instead, Bigelow proposes that companies should focus on the development of robust career paths for workers, where employees should comprehend how their actions can impact the company and therefore their lives. Gaining this mutual understanding, he argues, is key to gaining buy-in for

Lean and motivation to achieve the common goal.

2.4.2 Organisational culture

Beyond employee participation, the overall culture of an organisation can also prove to be a barrier to Lean adoption. As "Lean success… is largely dependent on the attainment of a Lean culture", an adoption of Lean principles requires a shift in the prevailing corporate culture (van der Merwe *et al.*, 2014, p.133). Furthermore, the change from a traditional "top-down" leadership approach to the more participatory Lean style demands a serious change in organisational attitude and mind-set (van der Merwe *et al.*, 2014, p.134). If existing organisational culture is incompatible with these approaches and values, "the transition [to Lean] is destined to flounder" (Bhasin, 2012a, p.440).

As discussed previously, Lean thinking emphasises the establishment of a long-term goal. Leadership is essential to implementing both Lean thinking and setting the overall goal of the organisation, but "any strategy, regardless of its strengths, will not be accepted if it is outside the bounds of an organisation's culture" (Bhasin, 2012a, p.439). If leaders "fail either to realise the importance of changing the organisational culture at the onset of Lean implementation, or to enact the required cultural change", Lean success will be severely undermined or rendered impossible (van der Merwe *et al.*, 2014, p.133).

2.4.3 Difficulty of adopting Lean

A major problem in adopting Lean is the difficulty of implementing and sustaining the shift to a new operational philosophy. "Lean, certainly in the early stages, requires considerable commitment" (Bhasin, 2012a, p.455). Lean implementation is not accomplished overnight and demands a great deal of effort, both to change the methods of production and adjust the prevailing attitudes (Schmidt, 2011).

Foremost, there is no single 'Lean approach'. Lean is not a pre-packaged set of actions or ideas, but rather a philosophy that offers a variety of tools and methods. "Organisations need to recognise that there is no standard implementation formula to implement Lean" (Bhasin, 2012b, p.422). Each organisation has its own challenges, problems, and distinguishing characteristics; and therefore, a unique application of Lean must be developed for its specific needs (Bhasin, 2012b). This makes initial application and implementation of Lean principles more challenging.

The changes to manufacturing and production approaches required by Lean may also require a substantial initial investment, both in cost and in training (Bhasin, 2012a). It is possible that companies may underestimate the difficulties of switching to a Lean approach, which may place strain on the staff tasked with implementing the new approach (Bhasin, 2012a).

Inadequate initial efforts can also prove detrimental to the implementation and success of Lean programs. Lean demands a shift in overall attitude and philosophy, not merely a few minor changes to production style. However, “early attempts to implement Lean are often characterised by short training programmes that are specifically aimed at making a few individuals proficient in the use of selected Lean tools. Limited application of these tools, however, does not bring about the expected results, and disillusionment naturally follows” (van der Merwe *et al.*, 2014, p.132-133).

Limited implementation of Lean methods and tools can also prove detrimental. By only implementing some tools or particular approaches, without a holistic understanding of a Toyota-style approach to manufacture and productivity, implementation of Lean may prove unsuccessful (Liker, 2004). The effectiveness of Lean operations and a Just-in-Time approach may vary depending on the nature of a company and its operations. Thus, “while Lean inventory strategies may be economically viable in some industries, other industries may not be amenable to such approaches due to their particular product, production technology, supply or demand characteristics,” note Eroglu and Hofer (2011, p.364).

Furthermore, a Lean transformation is not a once-off process. As the values implicit in *Kaizen* suggest, an entirely new culture of on-going evolution is required. “It takes a lot of time and effort to understand and implement the Toyota Production System as well as develop the employees as [a] benchmark for Lean production. It is also necessary to adopt sustainable process improvements with a new production philosophy" (Schmidt, 2011, p.863). Sustainability can prove difficult: "early Lean gains may prove unsustainable as employees slowly revert to previous work practices. Leaders in these organisations fail to understand that Lean is a management philosophy…" (van der Merwe *et al.*, 2014, p.132). Without constant efforts to entrench the Lean philosophy, the initial change may prove to be a failure in the long-term. Lean requires both an initial investment of effort, training, capital and an on-going process of implementation and consolidation. Therefore, a major cause for Lean failure is that organisations may not be fully prepared for the profound and long-term cultural transformation that Lean requires (Bhasin, 2012a).

2.4.4 Difficulty of defining and quantifying Lean

Lean is not a monolithic concept, and this may make it more difficult for organisations to implement and enjoy the benefits of Lean methodologies and philosophies. As Pettersen (2009, p.133) explores, there is no academic consensus on the exact definition of Lean. Rather, it is a general concept "comprising just in time practices, resource reduction, improvement strategies, defects control, standardisation and scientific management techniques" (Pettersen, 2009, p.133). This means that it is difficult for an organisation to quantify its Leanness, since by what criteria can 'Leanness' be evaluated?

Many benefits of Lean are non-tangible, non-quantifiable, or difficult to easily quantify, such as employee morale and organisational culture. This means that organisations may not fully perceive the benefits of being Lean, as they "lose sight of the intangible aspects of change and culture" in favour of tangible, quantifiable outcomes (Bhasin, 2012a, p.454). Thus, organisations may not fully appreciate the advantages that Lean brings, which could result in termination of new Lean initiatives. It is sometimes difficult for managers to "adopt new production paradigms if the expected benefits are unclear or if there is no prompt way to measure those benefits" (Alves, Carvalho, Sousa, Moreira & Lima, 2011, p.1). Therefore, given the nonspecific nature of Lean as a philosophy and the intangible nature of many of its benefits, organisations may be reluctant to engage in Lean practise.

2.4.5 Costs

As discussed, Lean is a process, rather than a single change, so this means that its long-term positive effects may not be immediately apparent. An ironic cause for Lean failure is misinterpreted success. Meade *et al.* (2010) explore how one of the main effects of Lean implementation — reduced inventory — can lead to a reported loss of short-term profits, due to less stock on hand. The long-term benefits of Lean operational savings, though, should outweigh the short-term profit losses; but this may take time: “The length of time it will take traditional financial reports to reflect the real improvements from Lean manufacturing is dependent on how poorly the operation was doing in terms of inventory management prior to the initiation of the Lean effort” (Meade *et al.*, 2010, p.858). However, as profit is a key indicator of success, lower reported profits can be seriously damning for the prospects of a Lean program, if management is not cognisant of the long-term advantages (Meade *et al.*, 2010). In short, a lack of understanding of Lean principles can cause successful implementation to be misinterpreted as a failure, which will consequently have negative effects on the long-term survival of a Lean program.

2.4.6 Organisational size

The size of an organisation can dramatically impact on the adoption of Lean principles. Factors such as the number of employees, cost of implementation, and the difficulty of changing workplace culture are perceived differently depending on the size of an organisation (Bhasin, 2012b). Understandably, for smaller organisations, cultural change is less of an issue, whereas large organisations report higher levels of resistance to change (Bhasin, 2012b). Costs are also perceived differently: in a recent study, smaller organisations were observed to report the expenses involved in switching to Lean methods as the most important consideration, while larger corporations were more concerned with insufficient management time (Bhasin, 2012b). In short, different-sized organisations perceive the challenges of Lean implementation differently; and therefore, the reasons for Lean failure may vary depending on the size of the organisation.

2.4.7 Lean as a philosophy

It is important to remember that Lean is not merely a set of operational tools or methods, but rather an entire change in operational values and thinking. This can easily be overlooked, as Bhasin (2012b, p.423) reiterates: “it should be treated as a long term commitment with the ultimate goal being the need for it to be viewed as a philosophy […]; this concept was not clarified to shareholders”. If organisations adapted Lean principles or techniques without considering the broad, cultural change — as exemplified by the TPS and the underlying Toyota Way — the final practices could become nothing more than “absurd austerity programs” that were ultimately counterproductive (Schmidt, 2011, p.863). Lean failure, in the end, is often attributed to a lack of cultural compatibility in the workplace, lack of human engagement, and a misunderstanding of its central philosophies.

2.5 PERCEPTIONS OF LEAN

Making the switch to a Lean approach places new expectations on workers, as they are expected to exercise their own initiatives: “employees under Lean manufacturing use a broader variety of skills through job rotation and cross-training” than their non-Lean counterparts (Cullinane, Bosak, Flood & Demerouti, 2012, p.9). Management, on the other hand, has new expectations placed upon it with concepts such as *Genchi Genbutsu*, encouraging a more hands-on commitment with the production floor.

2.5.1 Workers

Literature offers little information on the workers’ perspectives when it comes to Lean implementation, but it is possible to detect some trends (Losonci, Demeter & Jenei, 2011). Lean often expands the scope of work for an employee, as he or she may be expected to multi-task, or handle more than one task simultaneously (Losonci *et al.*, 2011). Thus, workers can see Lean as a mere nuisance, or another workplace burden. For example, Wong and Wong (2011, p.2168) noted that in the process of Lean adaptation in a Malaysian electronics manufacturer, there “was resistance from the employees because they believed Lean would increase their work load rather than helping them to work better”. Similarly, employees at another manufacturer felt that Lean was “another program that the company is focusing on,” rather than a sustained shift in attitude and culture (Wong & Wong, 2011, p.2169). The authors also stated that resistance, particularly from senior workers, is "always" an issue, as they may think that management is attempting to force them to do more work (Wong & Wong, 2011, p.2170). Misunderstanding, or a lack of appreciation for the possible benefits that Lean offers, can cause employees to engage with Lean principles less-seriously.

However, when management takes care to communicate the benefits of Lean, and ensure employee comprehension of its benefits, the literature indicates that there is a shift in perception, as workers "notice the benefits and are convinced that Lean manufacturing can help them"; and as a result, "they will start to develop enthusiasm to achieve it" (Wong & Wong, 2011, p.2173). When management takes care to communicate the principles of Lean, and workers' roles on the Lean production floor, employees are "more likely to understand and appreciate how the new system works" (Losonci *et al.*, 2011, p.38). As van der Merwe *et al.* (2014) note, workers who understand the status of production and operations are more likely to take an interest in the overall success of their organisation.

2.5.2 Management and leadership

From its leadership perspective, management may have different views on Lean implementation. In a survey of managers from 68 British manufacturers, Bhasin (2012b) rated participants' opinions on a scale from one to five, where one indicated total agreement and five indicated total disagreement. The survey found that managers mostly agreed with the idea that Lean implementation would result in more pressure, at an average rating of 1.9; whereas greater job security only received a rating of 2.3, and the possibility of Lean resulting in more pay received a low average of 3.5 (Bhasin, 2012b). According to Bhasin (2012b), Lean can often result in managers and team leaders being required to do additional work, or carry additional responsibilities without sufficient support, which may cause them additional stress. Given the different expectations and responsibilities between the workforce and leadership, it is unsurprising that these different perceptions emerge. While workers and management may initially share the opinion that Lean means increased work and pressure, it seems that employees are only likely to adopt a positive outlook when they are adequately informed and involved in the overall Lean process.

2.6 GUIDING PRINCIPLES OF LEAN IMPLEMENTATION

Having examined the major causes of the failure of Lean implementation — the human factor, difficulty of adoption, costs, and so forth — it seems appropriate to outline the principles that have been shown to promote successful and enduring Lean implementation.

2.6.1 Lean as a philosophy and a process

The core principle that organisations must be willing to accept is that Lean demands a long-term commitment, or an essentially unending-process. Organisations hoping to implement Lean successfully must avoid simply introducing a few techniques in favour of the institution, and rather develop a 'Lean culture'. "There is no final product and no end game; it is a journey that needs to start strong and never ends. It is imperative that Lean is ingrained in the organisation so that it can find its own answers" (Bhasin, 2012a, p.454). An organisation hoping to successfully adopt Lean principles must firstly appreciate that it is not an immediate transformation, but that it instead demands commitment to a company-wide, on-going pursuit of Leanness and improvement: it must be accepted that making the change to "Lean manufacturing requires huge investments in time and discipline" (Wong & Wong, 2011, p.2167).

2.6.2 Instituting a new culture

In order to make a long-term commitment to the Lean 'journey' possible, an organisation must commit to developing a culture that can support it. As the literature has indicated, the existing corporate culture can be a tremendous obstacle for the successful implementation of a Lean program. Therefore, "companies which want to implement Lean manufacturing should continuously train their people to 'think Lean' and 'act Lean', and support them by giving them the right tools" (Wong & Wong, 2011, p.2173). This includes persuading employees to adapt to a new culture, which leads to the next principle: communicating goals to employees.

2.6.3 Communicate goals to employees

An organisation must communicate the benefits and projected goals of a Lean transformation to its employees. Wong and Wong (2011, p.2170) argue that employees are the “key factor” in Lean success. It is imperative, then, that workers actively co-operate with the Lean process; and communication is the best method to achieve this. Communication has “the greatest total effect […] on feelings regarding the success of Lean production from the employee’s perspective (Losonci *et al.*, 2011, p.37).

Adequate communication of goals and the basic concepts behind Lean “give greater level of understanding about the system and encourage motivation and innovation in the work culture” (Nordin, Deros & Wahab, 2010, p.379). The workers must come to believe that “the new method can help them rather than burden them” (Wong & Wong, 2011, p.2170). Greater workplace transparency promotes an environment in which workers can see the results of Lean methods, encouraging involvement (Losonci *et al.*, 2011).

2.6.4 Providing adequate training and support

In order to ensure employee commitment to a program, and facilitate a Lean culture, it is important to provide training and support in the new concepts. Hodge *et al.* (2011, p.245) argue that “Implementation of Lean manufacturing should begin with policy deployment tools to initiate cultural changes [...] policy deployment methods get the workforce actively involved in the Lean process”. This facilitates the development of a Lean culture. Similarly, Wong and Wong (2011, p.2170) argue that Lean training and workshops are “necessary in order to spread Lean” throughout the organisation.

One approach that Bhasin (2012a) suggests is a contributing factor to Lean success is the use of a sensei or mentor, which is an external authority that can introduce and spread Lean principles within an organisation. Wong and Wong (2011, p.2167) are in agreement, stating that “a good mentor that could guide and coach the Lean team is desirable as he could share his experience and understanding of Lean.”

2.6.5 Instituting a system of evaluation

Given that Lean benefits are not always tangible, it “is imperative to both develop and implement Lean performance indices in order to gauge the progress of Lean”

(Bhasin, 2012a, p.455). As traditional metrics do not adequately map the advantages that Lean offers, such as waste reduction and improved workplace efficiency, it is important to develop mechanisms by which improvements can be tracked (Bhasin, 2012a, p.455). This will allow an organisation to appreciate the benefits of Lean, and understand how it impacts on performance and ultimate productivity.

2.6.6 Lean implementation framework

Given the principles covered above, it is important to consider the most effective means by which to fulfil the essentials of practical Lean implementation. Van der Merwe *et al.* (2014) offer a well-reasoned framework for effective implementation of Lean principles within an organisation (see Table 2.1).

Table 2.1: Lean implementation framework

Category	Activities
Justification	Identify the need for change Develop a valid justification for change Communicate the justification for change
Vision	Create the vision Develop the vision attainment plan Communicate the vision and the plan
Success	Identify areas where rapid success can be achieved Plan interventions in these areas Communicate the ensuing success Link the success to the overall change
Structure	Identify structures that support the ‘old way’ Develop alternatives Communicate proposed changes Replace inhibiting structures with enabling structures
Teamwork	Define team objectives based on vision Align objectives with skills required Identify optimal team configurations Communicate new team system
Training	Identify the skill gap, at all levels Procure/arrange for appropriate training Communicate the training plan
Performance	Develop objectives and goals aligned with the vision Identify critical processes Define appropriate measures Link incentives to objective-aligned performance Communicate the performance system

Adapted from van der Merwe, K.R., Pieterse, J.J., & Lourens, A.S. 2014. The

Development of a Theoretical Lean Culture Causal Framework to Support the Effective Implementation of Lean in Automotive Component Manufacturers. S*outh African Journal of Industrial Engineering*, vol. 25, no. 1, p.140.

This framework allows for gradual implementation of each step in the process of Lean implementation, hopefully allowing for a smooth and effective introduction of Lean concepts.

2.7 CONCLUSION

Toyota’s phenomenal success and the subsequent study of its production system and ‘way’ have given rise to a large body of academic literature, and a highly effective approach to production, manufacturing and organisational function. A successful adoption of Lean principles should result in reduced waste, greater workplace efficiency, and enhanced overall productivity.

However, the literature has shown that it is not at all straightforward to emulate Toyota’s protocols and philosophy; rather, adopting a Lean approach calls for a long-term commitment, rather than simply changing the methods or layout of a manufacturing facility. In order to exploit the benefits of Lean fully, and to ensure that Lean implementation remains successful, the academic consensus is that organisations must be willing to wholly overhaul their corporate culture, and accept that Lean is a state of operation, rather than just a set of manufacturing tools and concepts.

In order to successfully switch to a Lean approach, the literature identifies a number of important factors. Foremost among these is worker participation. As part of the development of a Lean culture, an organisation must ensure that the workforce — both employees and the leadership — understands the mechanisms and benefits of Lean. An organisation must also be willing to change its hierarchy. Employees must be encouraged to participate and take initiative, whereas the management must become more alert to the daily processes of the facility. Finally, it must be remembered that many of Lean’s benefits are not evident on traditional metrics, so implementing a new system of evaluation to monitor performance is essential.

Evidence suggests that Lean remains a highly effective approach to enhancing productivity, quality and workplace efficiency, if an organisation is willing to make the commitments to long-term evolution, reduction of waste and the restructuring of staff hierarchy and the workplace.

Chapter Three follows next, with a deliberation of the methodology performed to observe and understand the implementation and sustainability of Lean practices within the manufacturing environment of Pfisterer Pty (Ltd) in Pietermaritzburg, South Africa.

CHAPTER THREE:
RESEARCH METHODOLOGY

3.1 INTRODUCTION

This chapter presents the research methodology of this study. The purpose of this study was to understand the profile of the Lean characteristics at Pfisterer, and to gather both a quantitative and qualitative understanding of the underlying nature of the Lean operations at the company. This chapter presents the procedures and considerations that were made in order to answer the research questions of this study, and thereby achieve its goals. The chapter begins with a deliberation on the research philosophy of this study and the research paradigms that were chosen for each phase of the research; followed by an outline of the research design. Each aspect relating to the research strategies that were undertaken, as well as the target population for the study, the sampling strategies, research instruments and data analysis techniques are discussed in detail. Before ending the chapter, some peripheral considerations related to the study are presented. These include the limitations and delimitations of the research; any bias that may have occurred, and steps that were taken to overcome them; as well as the ethical issues that needed to be considered in relation to the application of the research.

3.2 THE RESEARCH PHILOSOPHY

According to Mariappan (2015, p.8), research is “an organised, structured, and purposeful investigation aimed at discovering, interpreting and revising human knowledge on different aspects of the world by someone first hand”. A research paradigm, or research philosophy, may be categorised into two classes of research, according to Rubin and Rubin (1995): phenomenology and positivism. However, authors such as Saunders, Lewis and Thornhill (2009) define research philosophy within a wider spectrum of classes, which they term interpretivism, realism, pragmatism and positivism; although the two classes of interpretivism and positivism largely resemble Rubin and Rubin’s (1995) categories of phenomenology and positivism, respectively.

Studies in which qualitative methods of describing and counting are employed to render a conclusion are termed phenomenological studies, while studies that use scientific methods of observing and counting are termed positivist studies. Researchers who perform qualitative methods of interrogation and description to draw conclusions are termed phenomenologists, while positivists perform their studies using quantitative methods and tools that analyse circumstances in a scientific manner (Rubin & Rubin, 1995). Positivists and phenomenologists differ in their opinions of what matters in a study. For example, positivists believe that there is one single external reality that exists, which is constant and precisely measurable; while phenomenologists believe that reality is continuously changing, and therefore that numerous different versions of reality exist, which can be observed and interpreted indirectly through interpretation by people. Rosnow and Rosenthal (2005) assert that qualitative research is often suitable for studying organisational management, while Adams, Khan, Raeside and White (2007) argue that qualitative data research is flawed, as it is numerically unmeasurable. Thus, they stress that research should, instead, include quantitative techniques with data that can be mathematically measured and calculated.

In order to overcome limitations of either methodology, a mixed qualitative-quantitative method (Q^2 methodology) was chosen to provide a complete and comprehensive answer to the research questions that were posed for this study. Also referred to as the mixed method, or 'Qual-Quant' methodology, the Q^2 methodology is well suited to capture positive elements of both the phenomenological and positivist philosophies (Kramer, 2011). In the mixed method approach, a multi-disciplinary methodology is used with both quantitative and qualitative techniques, in order to present both scientifically sound results, as well as interpretations of a phenomenon in a manner that is only possible by discussing the phenomenon with those who have interacted with it. Thus, there is a growing acceptance for Q^2 methodologies in research due to its ability to harnesses advantages from each of the primary research paradigms (Teddlie & Tashakkori, 2009).

Other advantages of mixed methods research include the ability to generate and test theories, confirm findings, and obtain depth and breadth on a topic of research (Teddlie & Tashakkori, 2009). Drawbacks do exist with this method, though, such as the prolonged time to gather and analyse its data, and the complexity of performing both methodologies (Cronholm & Hjalmarsson, 2011). To overcome these drawbacks, suitable funding must be sourced, and sufficient planning must be done for the study's research design, as described in the next section.

A mixed methods approach was undertaken here to offer both a scientific and statistically significant understanding of Pfisterer's Lean manufacturing operations, as well as a deeper understanding of the Lean phenomenon at the company. The rationale for choosing the mixed qualitative-quantitative research paradigm stemmed from the need to explore whether any statistically significant results could be found, firstly, to aid in understanding the profile of the Lean characteristics at Pfisterer; such as whether the profile of Lean characteristics between the employees and facilities differed, based on the departmental, title, or tenure demographics of the employees. Secondly, this methodology attempted to gather a qualitative understanding of the underlying nature of the Lean operations at Pfisterer, according to a selection of the managers and Foremen at Pfisterer, in order to present results that related to the existing strengths of the organisation and its employees, the management at Pfisterer and how it related to the company's Lean operations, the advantages of improving Lean at Pfisterer, and the logistical considerations of any adjustments that could be made to render the company more Lean.

3.3 RESEARCH DESIGN

The research design of a study is the framework that guides the implementation of its research methodology and analysis of its data (Bryman & Bell, 2007). It is the technique that is performed to transfer the research questions and objectives into an executable plan (Cheek, 2008). As described previously, this research was established on the principles of a mixed methodology. Therefore, the basis for gathering and analysing the study's data involved techniques that corresponded to the principles of both quantitative and qualitative data collection and analysis. The research strategy, upon which the research design was devised, is detailed and explained in the next section.

3.3.1 Research Strategy

In any research, the research strategy structures the general direction of the study, and any procedures that the researcher should follow (Remenyi, Williams, Money & Swartz, 1998). As described by Creswell (2009), and Zikmund, Babin, Carr and Griffin (2012), numerous research strategies exist:

- **Action research:** involves collaboration and co-operation between individuals or groups of researchers, and necessitates problems to be identified and solutions to be devised and implemented;
- **Grounded-theory research:** data collection starts before an initial theoretical framework is formed, and the theory for the research is devised from any data that is generated;
- **Experimentation:** involves studies with careful controls, where a hypothesised cause is manipulated, and any corresponding changes in outcomes are observed;
- **Ethnographic research:** involves studies on cultures, or between population groups, to explain or describe any underlying social interactions;
- **Survey research:** involves studies where a population sample is questioned in some manner in order to observe the opinions or behaviours of the individuals; and
- **Case study research:** involves "an empirical inquiry that investigates a contemporary phenomenon within its real life context" (Yin, 2003, p.13); or "an inquiry that focuses on describing, understanding, predicting, and/or controlling the individual, such as a process, animal, person, household, organisation, group, industry, culture, or nationality" (Woodside, 2010, p.16).

Upon consideration of the principles of the above research strategies, the research design of this study was chosen to correspond to both the 'case study' strategy, the quantitative phase and the 'survey' strategy, the qualitative phase. Although surveys were the method employed for the collection of data for both the qualitative and quantitative phases, as discussed later in the chapter, the ultimate purpose of the strategy of the quantitative phase was to investigate the Lean phenomenon in its current real-life context, and this therefore formed the strategy upon which the quantitative phase of the research was designed.

3.3.2 Target population

For a research, it is important to define the population that is to be studied (Tashakkori & Teddlie, 2003). According to Given (2008, p.519), a study's population, or "universe" comprises all the possible elements that exist in an environment upon which a study is to be performed. A population can include, for instance, entire communities, assortments of cultural rituals, classes of individuals, or sequences of events (Given, 2008).

The target population for the quantitative and qualitative phases of this study included all of the staff that was employed in the Production department at Pfisterer at the time of this study. The total potential population constituted of 191 employees and nine managers and foremen at the time of the study. Table 3.1 later in the chapter presents a tabulated overview of the staff compliment per department within the production unit. For the quantitative phase, a sub population of general employees was targeted, while for the qualitative phase, all nine of the Foremen and managers were targeted.

Table 3.1: Distributions of employees per department at Pfisterer, and the respondents gathered for Sample One

Department	Distribution of Sample One Respondents
Cut-outs	37
Ali foundry	31
Silicone moulding	35
Rod plant	2
Silicone blending	3
Sg foundry	13
Speedcraft	13
	134

3.3.3 Sample

The sample of a study consists of only the elements of a population that actually participate in the study. In research, a representative sample of participants is selected from the whole population or universe in order to infer conclusions that are characteristic of that population (Adams *et al.*, 2007). Sampling describes the technique of gathering a suitable sample from the study's population (Given, 2008). In order to be considered as representative of an entire population, especially in quantitative research, Saunders *et al.* (2009) assert that the size of the sample should be sufficient. Gathering the research sample is therefore a central aspect of research and the sampling techniques should be carefully considered.

3.3.3.1 Sampling techniques

Two fundamental sampling techniques are typically applied in research to gather samples: probability and non-probability sampling (Adams *et al.*, 2007; Saunders *et al.*, 2009). According to Adams *et al.* (2007), a probability sample is one that is generated from a population following a randomised selection process, and in which every element of the population has had an equal chance of inclusion in the study. Inversely, a non-probability sample is one that is generated through personal intention, or where an appropriate sample is purposefully selected. These are each outlined, next.

Probability Sampling: According to Saunders *et al.* (2009), probability sampling is often employed when inferences are to be made from a sample about its population. This is because in order to prevent issues of bias, each unit of the population must have been afforded an equal chance of participation in the study. Five types of probability samples can be formulated, as follows (Saunders *et al.*, 2009; Adams *et al.*, 2007):

- **A simple random sample**: involves a sample that is generated through randomised selection from the population, such as with random numbers or tables, to choose participants randomly;
- **A systematic or quasi-random sample:** involves choosing participants at regular intervals along a list of all possible participants;
- **A stratified random sample:** as a variation of simple random sampling, this involves categorising the population before performing random selection on it;
- **A cluster sample:** involves a process similar to stratified sampling, whereby participants are categorised before selection, and a cluster of

participants is chosen at random; and

- **A multi-stage sample:** as an extension of cluster sampling, this involves a process of selecting a series of cluster samples.

Non-probability Sampling: Lund (2012) highlights five techniques of non-probability sampling, which were considered for this study:

- **Self-selection sampling:** involves collecting volunteers to participate in the research through their own effort, instead of the researcher directly approaching potential candidates;
- **Snowball sampling**: involves techniques to approach a sample that is hard to reach or hidden, where the units for inclusion in the sample are introduced via other participants;
- **Convenience sampling**: involves a technique where the units that are included in the sample are the easiest to access, which is in direct contrast to random probability sampling;
- **Quota sampling**: involves a sample where the group that is included in the sample is a smaller select sample of the larger population; although this method of sampling is much faster and easier to perform than probability sampling, as it does not require random sampling techniques to be adhered to; and
- **Purposive sampling**: involves a technique of selecting a sample by judgement of the researcher. Unlike quota sampling, the purpose is not necessarily to select a representative group from a larger population, but one that will most precisely offer answers to the research questions of the study.

3.3.3.2 Sample One

For the first phase (quantitative phase) of this study, a 'self-selection' technique of non-probability sampling was performed; whereby, all possible staff who worked at Pfisterer at the time of the study were categorised between general employees and management. All of the general employees were then approached and asked to volunteer to participate in the study. Participants who responded to the study were consequently included in the study by their effective selection into the sample group. Although a stratified probability sample was originally sought, since this study was conducted as a private study (outside of the confines of Pfisterer operations) and not as an intra-organisational census, employees were not obliged to participate as part of their employee duties. Rather, employees were simply encouraged to volunteer to participate in this study of their own free-will. In order to overcome issues with self-selection bias, as discussed later in the chapter, a large overall proportion of the employee workforce was ultimately entered into the study; whereby, a total of 134 out of a possible 191 general employees (70% of the employees) participated in Sample One, as shown in Table 3.1.

3.3.3.3 Sample Two

Non-probability sampling was also performed in the second, qualitative phase of the research. This is because the purpose of the second phase of the study was to provide a deeper understanding of the underlying nature of the Lean operations at Pfisterer, and any problems therein; which required detailed (quality) data, as opposed to large amounts (quantity) of data. According to Leedy and Ormrod (2001), samples with fewer participants can often provide more comprehensive insights into problems, instead of attempting to make generalisations from larger samples.

‘Purposive sampling’ was performed to generate the second sample of this study, as the intention was to generate a sample with particular experiences of Lean to aid in answering the research questions, and none of the other techniques offered the advantages of purposive sampling. The respondents for this phase of the study were four production managers and five foremen, and all nine of the respondents had been employed for at least six years at Pfisterer (three had been employed for over ten years); thus indicating that they would have had significant experiences in the underlying nature of the Lean operations at Pfisterer, and any problems therein. A census approach was employed since all nine of the managers and Foremen belonging to the production unit were targeted for this study.

3.3.4 Research instruments

Numerous data collection techniques are available in research. According to Yin

(2003), six primary instruments exist for gathering data: direct observations, interviews, physical artefacts, archival records, documentation and participant-observations. Adams *et al.* (2007) assert that the most suitable methods for collecting information from people are questionnaires, surveys, or face-to-face interviews.

Saunders *et al.* (2009) state that surveys form a popular methodology for answering questions, such as who, what, where, why and how; and are particularly applicable in deductive studies. Thus, they are often applied during research on organisations. Two types of surveys exist: questionnaires and interviews (O'Leary & Miller, 2008). Questionnaires often involve "paper-and-pencil instruments", where data recording is performed by the respondent, in person (Adams *et al.*, 2007, p.180). Conversely, interviews typically involve a process of instruction by the researcher, and they are often performed using face-to-face conversation or telephonic communication; while the data recording is typically performed by the researcher on behalf of the respondent (Adams *et al.*, 2007). The research instruments for each phase of the study are discussed in the following section.

3.3.4.1 Phase One

In the first phase of the study, a survey questionnaire was developed to gather quantitative knowledge from the employees on the profile of the Lean characteristics at Pfisterer. Questions were devised that would be easily understood by all the employees, and which targeted the Lean properties of the organisation. Questions were devised with multiple-choice-type answers, and questionnaires were printed and issued to the employees to complete and return to the researcher at their earliest convenience. Completion of the questionnaire was therefore based on a pen-and-paper type of information input.

The questionnaire was structured with 18 questions over six sections pertaining to the Lean characteristics of the organisation, from the employees' perspective. The questionnaire explored the demographic information of the employees; their knowledge of Lean; the state of the workforce; the sufficiency of staff, stock, equipment and space on the factory floor; the amount of staff, stock, equipment and space wastage; and the frequency of staff, stock, equipment and space wastage. The questionnaire is attached in Appendix C.

According to Saunders *et al.* (2009), a survey-based data collection instrument is often suitable for collecting data that is to be analysed quantitatively, as the responses can be clearly collated and analysed to infer any relationships that may exist between the responses, and to present models for these relationships. Upon returning the completed questionnaires to the researcher, the answers for each question were captured in a Microsoft Excel spreadsheet, in preparation for statistical data analysis, as discussed in the data analysis subsection later in the chapter.

3.3.4.2 Phase Two

In the second phase of the study, a second survey questionnaire was prepared, but this questionnaire was structured differently to the Phase One questionnaire so as to gain a deeper, qualitative insight from the Pfisterer management into the underlying nature of the Lean operations at Pfisterer, and any problems therein. To do so, the questionnaire was prepared with open-ended questions in Microsoft Word and the respondents were requested to type their responses digitally into the word files. Sufficient space was available for them to enter their answers, but due to the electronic nature of the instrument, additional space was created automatically to cater for their answers. This was deemed a suitable data collection instrument, since all of the managers worked regularly on their office computers and each had access to a computer terminal and Microsoft Word in which to input their data.

The questionnaires for the managers and foremen were identically structured with 17 questions that explored aspects such as what aspects of the organisation were working well with Lean, and why; which aspects of the organisation were not working well with Lean, and why; what changes would be necessary for better implementing Lean at Pfisterer; and what was preventing these changes from being implemented. The same questionnaire was issued to each of the participants in Sample Two to provide a broad scope of opinions on the topic at hand. The questionnaire issued to the Sample Two respondents is attached in

Appendix C. Upon returning the completed questionnaires to the researcher, the answers for each question were analysed, as described next.

3.3.5 Data analysis

Suitable techniques were used to analyse the quantitative and qualitative data from the Phases One and Two of the study, respectively.

3.3.5.1 Phase One

For the first phase of the study, quantitative data that had been collected from the employee sample (Sample One) was converted to Comma Delimited (.csv) format, and imported into the statistical analysis software IBM SPSS. Numerical codes were allocated to the categorical data, as per the practices of statistical data analysis (Adams *et al.*, 2007). Upon creating an SPSS data file, four techniques of statistical analysis were applied: descriptive statistics, contingency tables, bivariate correlations and reliability analyses.

Descriptive statistics: data were combined graphically and compared to observe their frequency distribution, means, modes, standard deviations, variances, skewness, and kurtoses (Agresti, 2007). The frequencies show how many respondents noted each answer, while the means and modes indicate the respondents' average and most frequently described answers, respectively. The standard deviation and variance present indications of the variability between the respondents' answers, while the skewness and kurtosis indicate the degree of symmetry in the distributions of answers, relative to a normal curve; and how closely grouped the respondents' answers are, producing either sharp or blunt distributions due to few, or many outliers, respectively (Agresti, 2007).

Contingency tables: categorical variables were cross-tabulated to assess whether any associations existed (Adams *et al.,* 2007), by determining whether the values of each of the categories were different to their predicted values (Agresti, 2007). Described differently, it tested whether two categorical variables that were grouped into discrete categories or classes were associated (Saunders *et al.*, 2009). The Chi-Square Test of Independence of Categorical Variables determines if the outcomes of one variable depended on the values of another; where an association was determined by presenting statistically significant results to either reject, or fail to reject the following hypotheses (Elevers, 2014b):

Null Hypothesis, H_o: The two categorical variables are independent — there is no significant relationship between the variables; and
Alternative Hypothesis, H_1: The two categorical variables are not independent — there is a significant relationship between the variables.

These hypotheses may be depicted mathematically within the following equations:

$$\mathbf{H_0:} \quad \sum\sum(\boldsymbol{O}-\boldsymbol{E})^2 = \mathbf{0} \qquad \textbf{[1]}$$

$$\mathbf{H_1:} \quad \sum\sum(\boldsymbol{O}-\boldsymbol{E})^2 \neq \mathbf{0} \qquad \textbf{[2]}$$

Where:

O is the observed frequency; and
E is the expected frequency.

According to the principles of Chi-Squared cross tabulations, if a statistically significant association is observed (α < 5%), the null hypothesis H_0 may be rejected, and the alternative hypothesis H_1 may instead be regarded, implying that the two variables are not independent, and are therefore related. This was valuable in this study for observing what aspects of Lean at Pfisterer were associated, as determined by the staff, and what aspects were independent; thereby presenting patterns of flaws in Lean at Pfisterer, and their potential causes.

It should be noted that with Chi-Square, an assumption is made that the data should not have expected frequencies of less than five respondents (Agresti, 2007). If more than 20 percent of the expected frequencies of any one variable category have less than five respondents, an important minimum sample size assumption is violated and Cramer's V tests should be performed as a post-hoc test instead, since sample size is not a primary assumption in Cramer's V (Elevers, 2014b). Post-hoc Cramer's V tests were performed where any of the necessary assumptions failed.

Bivariate correlation: Ordinal or ranked variables were correlated to conclude whether any of these variables were linearly related (Elevers, 2014a). This provided a second means of observing patterns, and which provided aspects of validity, as discussed next. An assumption of bivariate correlation is that the variables must contain ranked data. Unlike The Pearson's Product Moment Correlation Coefficient (PMCC), r, which is performed on numerical data, if one or both of the variables in question contain ranked data, Spearman's Correlation Coefficient, Rho ($\boldsymbol{\rho}$) should be calculated, instead.

3.3.5.2 Phase Two

Analysing the data from Sample Two followed a different process to the first sample. This included analysing the qualitative data in the Microsoft Word files from the Pfisterer managers through a standard process called content analysis. According to Braun and Clarke (2006), content analysis is a useful technique for analysing and interpreting narrative data. In this method, written text and discussions are systematically analysed to discern whether any patterns exist amongst the responses of the respondents. It involves the following steps (Taylor-Powell & Renner, 2003):

- Read through and understand the data, by discerning how participants responded to each of the questions or topics;
- Categorise any emergent themes or patterns within the data;
- Assign codes or abbreviations to the various emergent themes; and
- Tabulate and quantify the frequencies that each of these codes recur and highlight any descriptive quotes that embody the themed abbreviations for use in the discussion chapter.

It should be noted that a debate exists regarding the use of graphs or illustrations for qualitative data since counting and graphical illustration are, inherently, quantitative (Vaismoradi, Turunen & Bondas, 2013). However, it should be noted that qualitative methodologies are not a single approach to research, and include various "epistemological perspectives" (Vaismoradi *et al.*, 2013, p.388). While two main approaches exist, namely thematic analysis and content analysis, which are fundamentally similar, a primary difference exists whereby content analysis open to leeway to include an element of quantifying and counting within the data analysis. Thus, in line with the conclusions of Vaismoradi *et al.* (2013, p.388), in order to allow visualisation of how different themes and categories were encrypted during the data analysis, and in which frequencies or proportions the themes were described by the managers, counting and graphical illustration of codes was include with the qualitative content analysis of this study, and used “with caution as a proxy for significance.”

Reliability analysis and validity: Cronbach’s alpha was used and it was 0.799 (explained in Chapter Four, section 4.3.3) to confer the reliability between any dichotomous, ordinal and interval variables’ data. In so doing, it presented a description of the consistency of internal variances between the data, and therefore, the degree of reliability of any results (Rhatitter, 2010).

Contrary to reliability, validity provides an indication of how closely a set of tests examines the parameters they were intended to analyse (Heale & Twycross, 2015). In order to demonstrate the degree of construct validity, or the degree to which the variables reflected the intended focus of the research, convergent validity was applied to discern whether there were high correlations between variables measuring similar parameters; whereby it was expected that close correlations would exist between instruments measuring similar variables. Conversely, through the process of divergent validity, dissimilar parameters were observed to determine whether poor correlations existed between instruments measuring dissimilar variables. This provided further validity through disassociation, as recommended by Heale and Twycross (2015).

Bias: Bias is an issue that must be considered in any research. One form of bias can occur by the refusal of individuals to participate in the study, or to refuse to present answers to specific questions in the survey (Saunders *et al.*, 2009). Such aspects were only partially observed in this study and high rates of participation by the employees and management was considered acceptable to confer statistical significance and depth of intuition, respectively. Those who did not participate may have done so due to other work commitments, though every effort was made by the researcher to afford the participants suitable time and reminders to complete the surveys.

Another type of bias in research exists in the form of bias from the researcher (Black & Ernest, 2009). In this case, the researcher may make inadvertent or subliminal inferences in the data analysis or its presentation. To overcome this, the researcher consulted with external statistical specialists to aid in interpreting the results correctly and accurately.

3.4 LIMITATIONS OF THE STUDY

This study focused on the opinions of the employees, foremen and managers from only the production unit regarding Lean at Pfisterer. It did not consider Lean operations at any other company in South Africa or abroad. It also only focused on the company's Lean operations, and did not consider any other company operations outside of the confines of Lean.

3.5 ETHICAL CONSIDERATIONS

This research was conducted with consideration for the ethical principles of social research. Ethical permission was obtained from UKZN ethics committee, all information pertaining to the data was kept secure and confidential. None of the respondents' names were published in this study. Participants were told of their rights not to participate, their rights not to answer any questions that they did not approve of, or to withdraw from the study at any time during the surveys, if they so desired.

While conducting the study, costs on the environment were also considered; hence, responsible practices were performed wherever possible. For example, transportation — such as air or overland travel — was only done when completely necessary; and research, wherever possible, was performed via the internet, computer, or through other electronic platforms. Printing of any documents, such as emails, faxes, and other material was also minimised, and only employee questionnaires were printed for the sake of efficiency of data collection. Manager surveys, for example, were conducted electronically.

3.6 CONCLUSION

As described in the chapter, a mixed methods approach was undertaken to offer both a statistically significant and scientific understanding of Pfisterer's Lean manufacturing operations, as well as a deeper understanding of the Lean phenomenon at the company. Two independent samples of respondents were included in this study, with 134 of the total 191 general employees belonging to the production unit being generated for Sample One by self-selection non-probability sampling, and all of the nine Foremen and Managers belonging to the production unit was included in Sample Two through purposive non-probability sampling. A survey questionnaire was prepared with multiple-choice-type of answers to gather data from Sample One, and a questionnaire with open-ended questions in Microsoft Word was prepared to gather data from Sample Two. Techniques of descriptive statistics, Chi-squared with Cramer's V, Spearman's Correlation Analysis, Cronbach's Alpha and Content Analysis with theme quantification were each performed on the data in order to generate results that could be used to answer the study's research questions. Chapter Four follows with the results that were produced upon execution of this research methodology.

CHAPTER FOUR:
PRESENTATION OF RESULTS

4.1 INTRODUCTION

This chapter provides the results of the study. This research was conducted in two phases, beginning with a quantitative phase and ending with a qualitative phase that employed questionnaire surveys of two different samples at Pfisterer. The first phase of the research sought to discern whether any statistically significant results could be found to aid in understanding the profile of the Lean characteristics at Pfisterer, and whether the profile of Lean characteristics between the employees and facilities differed, based on the departmental, title, or tenure demographics of the Sample One respondents. In the results of this first phase of the study, outcomes of Chi-Square tests with post-hoc Cramer's V, Spearman's correlations, and Cronbach's alpha are presented.

The second phase of the study attempted to gather a qualitative understanding of the underlying nature of the Lean operations at Pfisterer, according to the study's Sample Two. Following a thorough content analysis with quantification of theme frequencies, results are shown that relate to the existing strengths of the organisation and its employees, according to the management, and how these strengths have contributed to the company's Lean operations, the advantages of improving Lean at Pfisterer, and the logistical considerations of any adjustments that could be made to render the company more Lean. The chapter begins with a presentation of the descriptive statistics from the first phase of the study.

4.2 DESCRIPTIVE STATISTICS

4.2.1 Demographic statistics

The wide majority, or 92.5% of the participants were machine operators (n = 124), while 4.5% (n = 6), 1.5% (n = 2), 0.7% (n = 1) and 0.7% (n = 1) of participants were handlers, hyster drivers, furnace operators, or grinding operators, respectively, as shown in Figure 4.1.

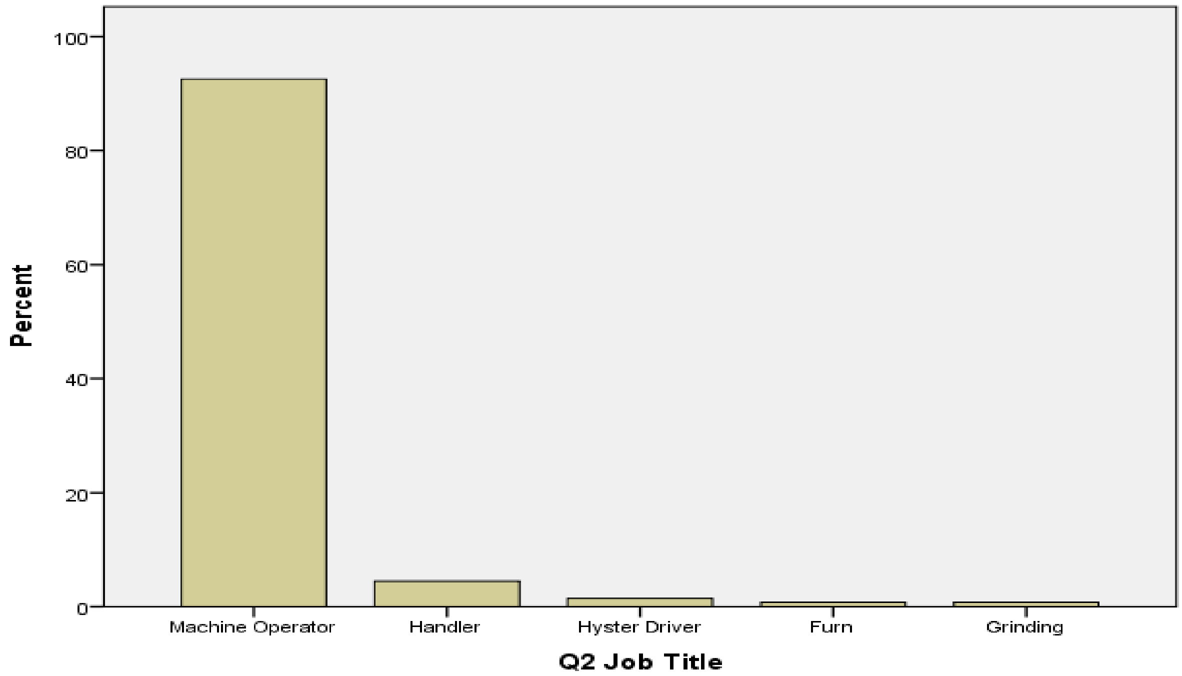


Figure 4.1: Profile of the job titles of the respondents in Sample One

The most common departments in which the respondents worked were Cut Outs (29.5%), Silicone Moulding (24.0%) and Ali Foundry (18.6%); although some respondents were observed from each of the other departments of Rod Plant, Sg Foundry, Silicone Blending, Speed Craft (and Wireform) and Spacer Damper, as shown in Figure 4.2, next.

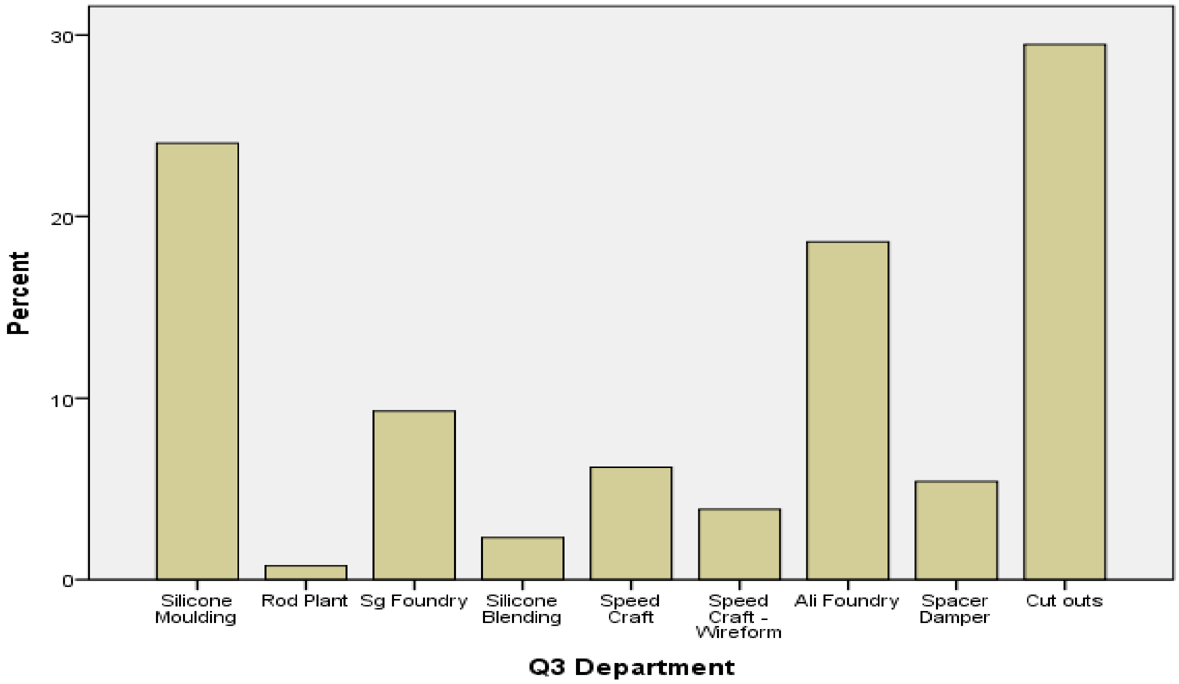


Figure 4.2: Profile of the departmental locations of the respondents in Sample One

Most respondents (56.7%, n = 76) had been employed at Pfisterer for between six and ten years, with 9.0% (n = 12), 19.4% (n = 26) and 14.9% (n = 20) having been employed for less than one year, one to five years, or over ten years, respectively. More than 73% of respondents appeared to know what Lean was, presenting a correct answer on the relevant multiple choice questions in the survey. Graphs of these results are presented in Appendix A.

4.2.2 Descriptive statistics on employee properties: motivation, employee numbers, and time wastage

The opinions of the Sample One employees about the efficacy of Lean at Pfisterer were interesting. As shown in Figure 4.3, nearly half of the respondents (47.8%) perceived the workforce to be unmotivated (questionnaire Q6), and the distribution was very heavily skewed towards the highly-motivated-end of the scale. This meant that very few respondents thought that the workforce was highly motivated, and the responses were clustered around unmotivated.

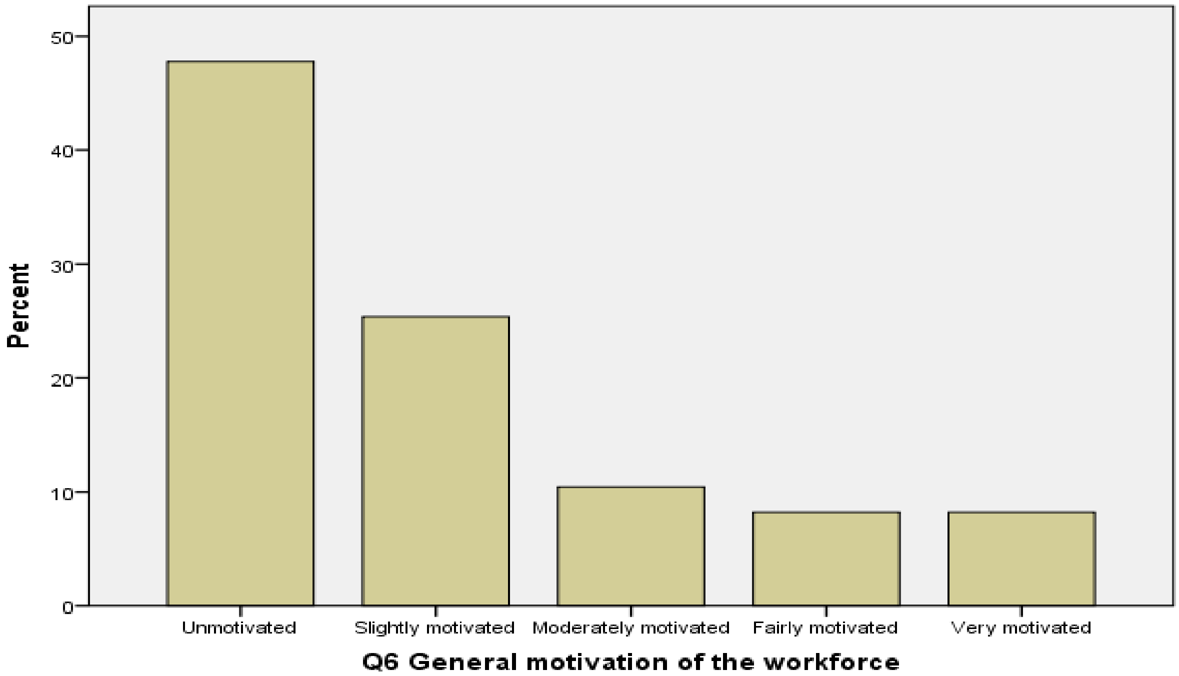


Figure 4.3: Frequency distribution of answers (in percentage of respondents) on the motivation of the workforce (Q6)

More than half of the respondents (56.3%, n = 64) also thought that there were not enough employees at Pfisterer (Q7), and only 10% of respondents were confident that there were enough employees; while one-third was undecided, as shown in Figure 4.4. A similar frequency distribution of answers was seen among respondents in relation to whether they believed that employees never wasted time (Q8). As shown in Figure 4.5, 47.4%, believed that employees never wasted time, while 14.1% *had* seen employees wasting time, and 38.5% were undecided.

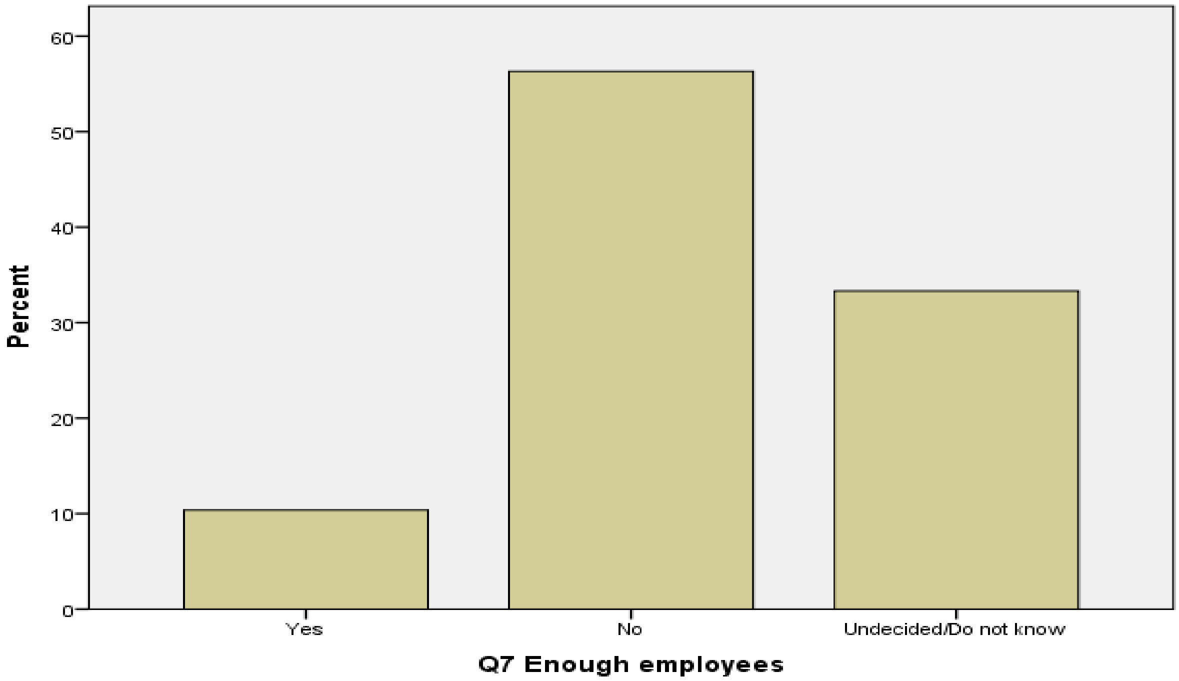


Figure 4.4: Frequency distribution of answers (in percentage of respondents) on the suitability of employee numbers (Q7)

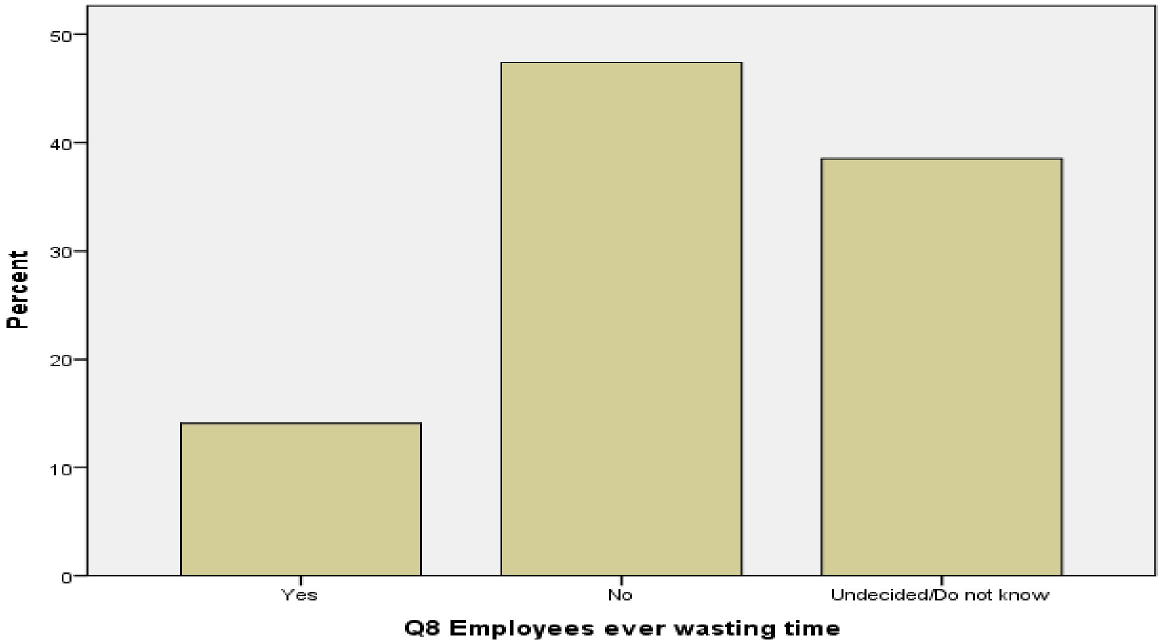


Figure 4.5: Frequency distribution of answers (in percentage of respondents) on whether employees ever wasted time (Q8)

Somewhat contrary to this result though, more than half of the respondents (54%), claimed that they observed employees wasting time for more than three hours per day (Q9), as counted by the total number of respondents who answered 3 – 4 hours (24%), 5 – 6 hours (22%), or more than 6 hours (8%) in Figure 4.6, below. Thus, upon analysing these results, some curious inconsistencies were apparent. For instance, while nearly half of the respondents thought that their fellow colleagues never wasted time (Q8), only 27% believed that their colleagues wasted less than one hour per day (Q9), outside of their lunch and tea-breaks.

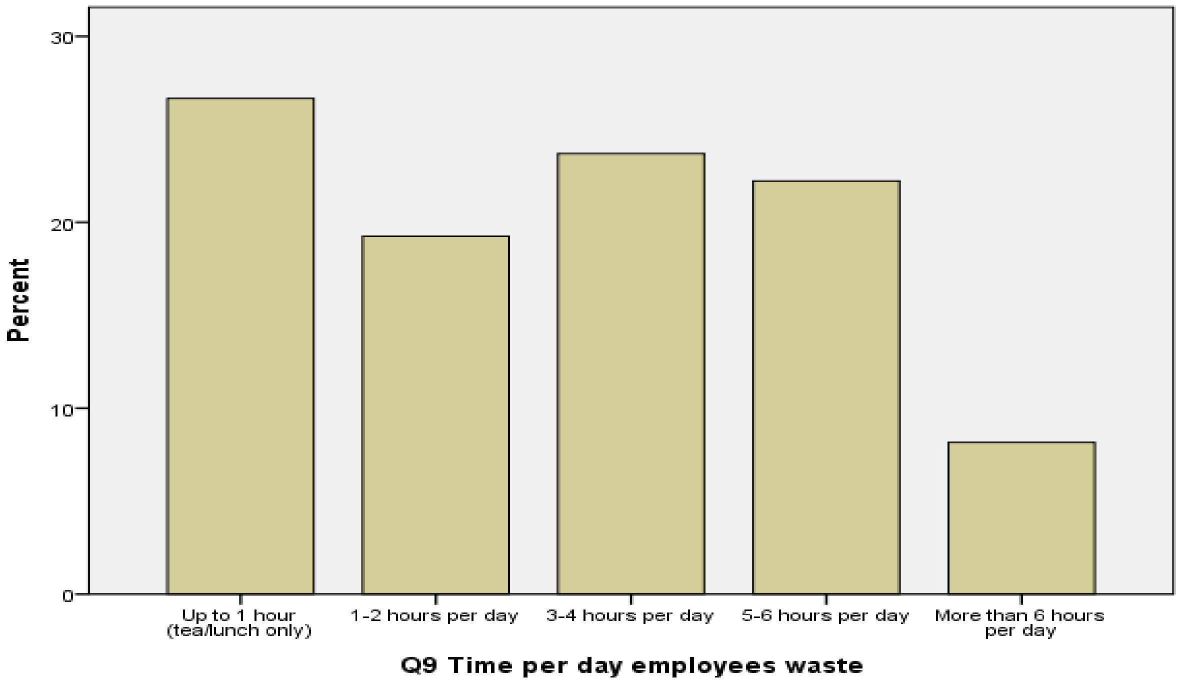


Figure 4.6: Frequency distribution of answers (in percentage of respondents) on the amount of time employees wasted, per day (Q9)

This indicates that there was a discrepancy between what the respondents classified as wasting time, and the degree of time an employee could spend not working. Clearly, for many of the employees, numerous hours could be spent not working, while still being perceived as not wasting time. In addition, upon selective scrutiny of the group of respondents from question 7 who thought that there were *not* enough employees at Pfisterer, only half (of these respondents) said that they never saw employees wasting time (Q8) — the other half said yes, or were not sure. More than half (55.3%) of the respondents who believed that there were not enough employees at Pfisterer (Q7) saw employees wasting time for more than three hours per day (Q9). By selectively scrutinising the answers of the respondents who thought there were not enough employees at Pfisterer, it allowed the notions of this group towards time wastage in questions 8 and 9 to be considered. The results indicated that while the respondents observed considerable rates of time-wastage among colleagues, they still perceived there to be a shortage of employees at the company, highlighting a disconnection between the perceived roles that employees played in overcoming employee shortages by minimising time wastage.

4.2.3 Descriptive statistics on company facilities: factory space, equipment functionality and use, raw materials, and factory down-time

The descriptive statistics relating to the Lean properties of the company's facilities were also interesting. Equal proportions of respondents thought that the factory space (Q10) was adequate versus inadequate (35.6% and 38.5%, respectively). Approximately one third each (31.9% and 34.1%, respectively) also thought that the storage space (Q12) was adequate versus inadequate, and approximately one-quarter each (27.4% and 25.2%, respectively) thought that the equipment (Q14) was adequate versus inadequate. The remaining respondents were undecided. Nearly half of the respondents (47.4%, n = 64; and 45.5%, n = 61) did not think that there was any wasted space, either in the factory (Q11) or in the company's stores (Q13), respectively. Frequency graphs of these results are shown in Appendix A.

The frequency distribution of the amount of time that machines at Pfisterer were broken (Q15) was alarming, with many suggesting a few times per week, and the distribution being skewed towards the longest time frames (few saw machines broken on less than one day per year), as shown in Figure 4.7.

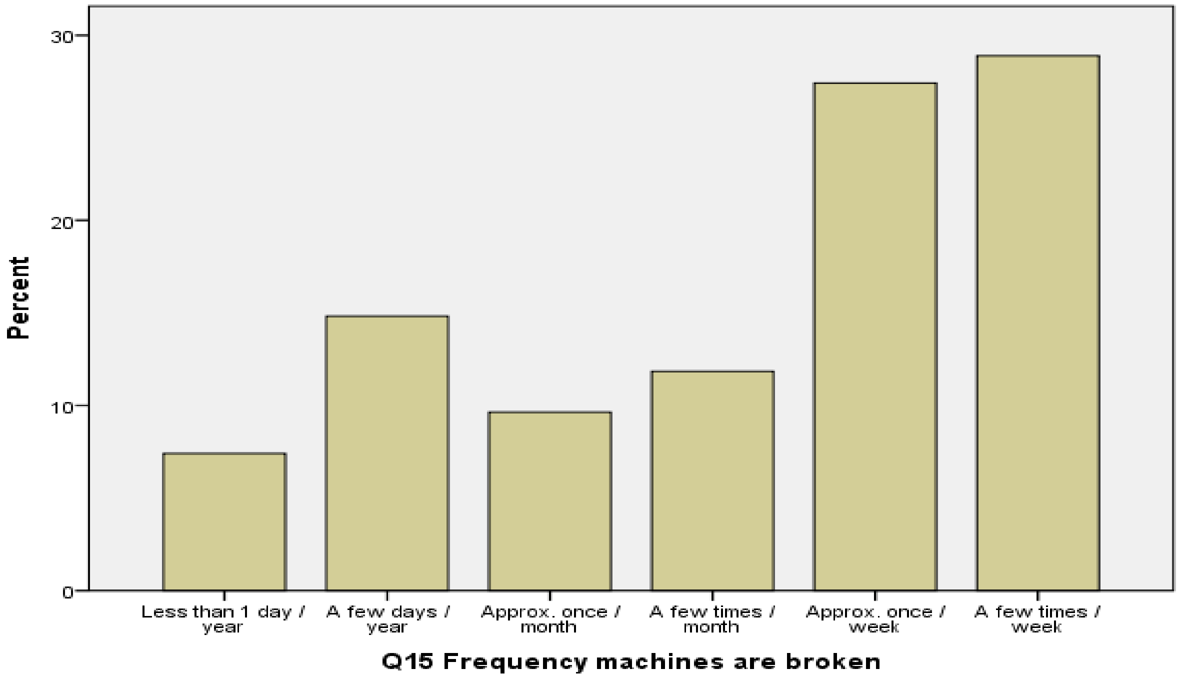


Figure 4.7: Frequency distribution of answers (in percentage of respondents) on the rate machines were broken (Q15)

The distribution of machine usage (Q16) was less worrying, with an even distribution between a few times a week, and a few times a year — as was to be expected with the variety of equipment used in a factory establishment of the size and scale of Pfisterer (see Figure 4.8). Once again, however, the frequency distribution that raw materials were late or unavailable (Q17) was alarming, with more than 40 percent (42.2%, n = 57) of respondents claiming that raw materials were late or unavailable a few times a week; and once again, the distribution was skewed towards the longest time frames (see Figure 4.9).

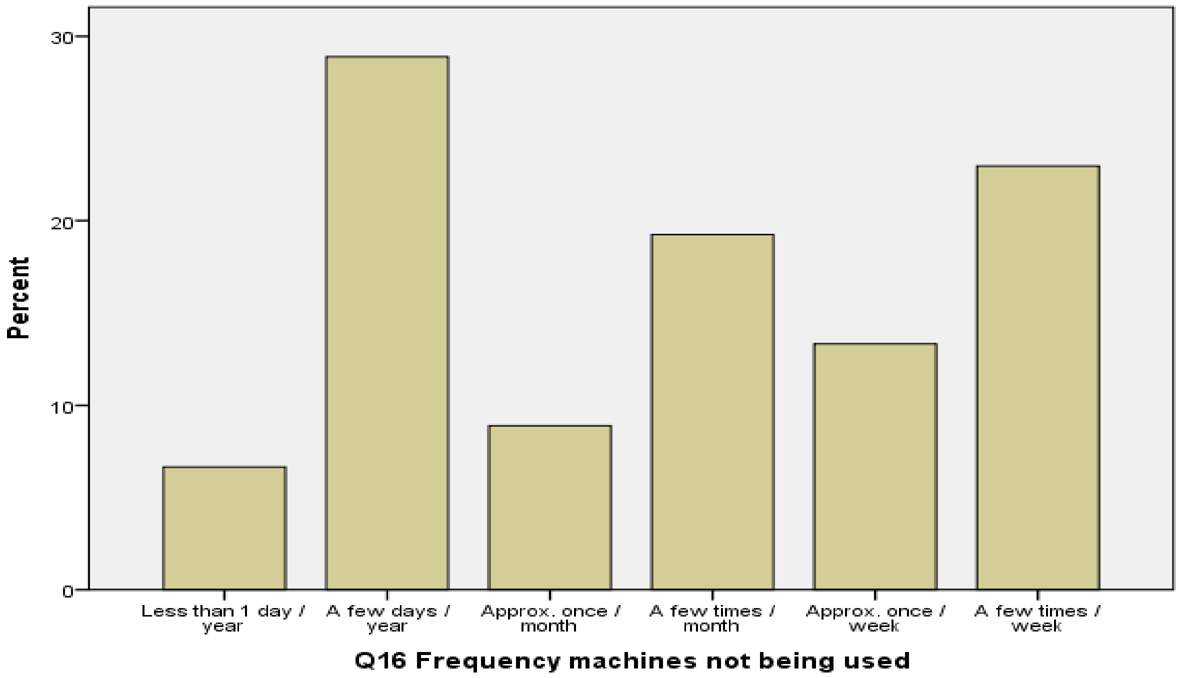


Figure 4.8: Frequency distribution of answers (in percentage of respondents) on the rate machines were unused (Q16)

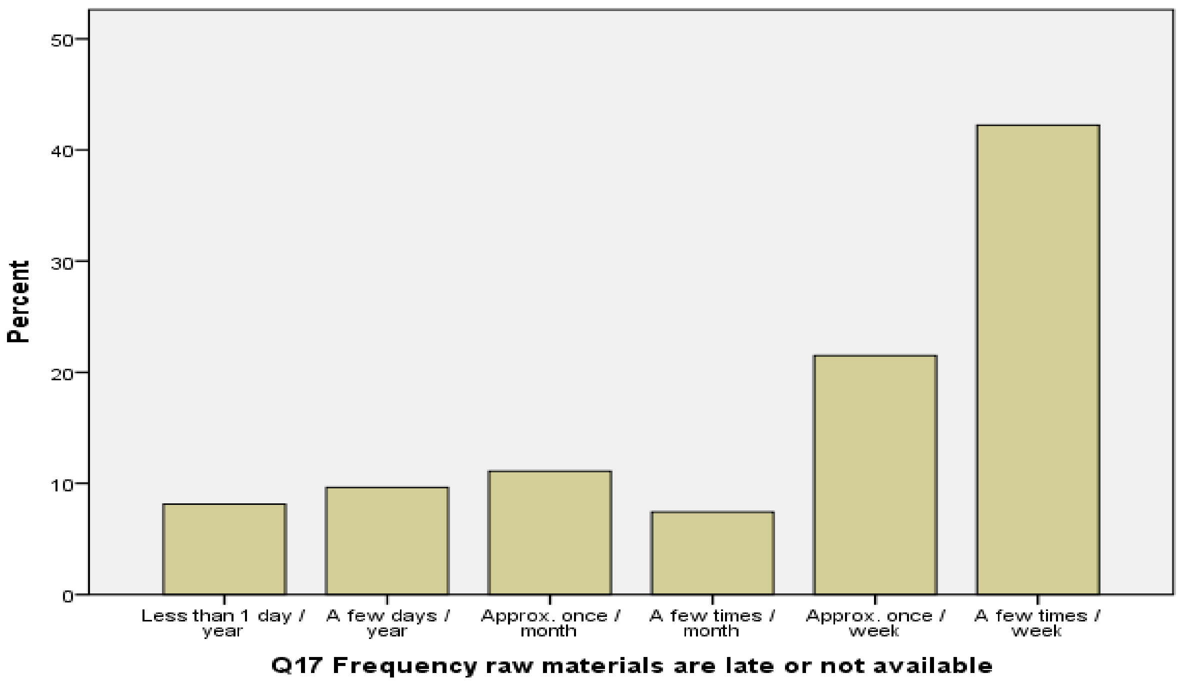


Figure 4.9: Frequency distribution of answers (in percentage of respondents) on the rate raw materials were late or unavailable (Q17)

These figures were also supported by results on the frequency per year that the factory was down (Q18), whereby most of the respondents (54.8%, n = 74) claimed that the factory was down a few times per week, while only a small number (4.4%, n = 6) suggested that the factory was down for less than one day per year, as shown in Figure 4.10, next.

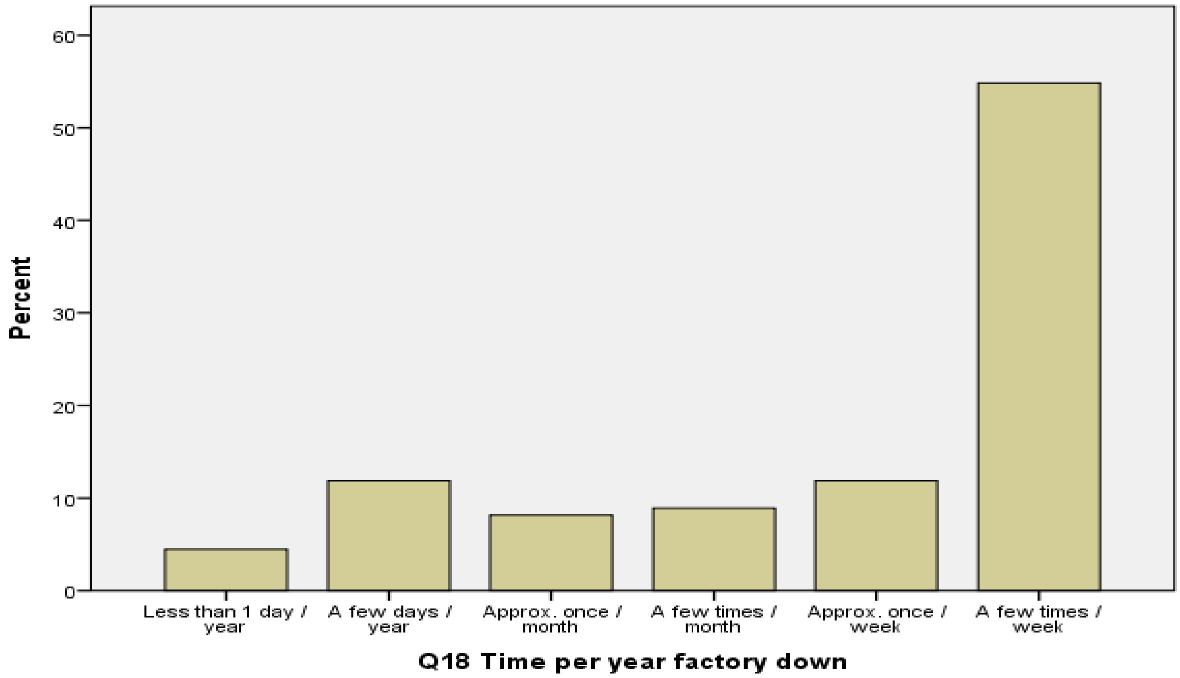


Figure 4.10: Frequency distribution of answers (in percentage of respondents) on the rate the factory was down (Q18)

4.2.4 Frequency distributions of Lean traits, split by department

In order to understand which departments were operating with more- or less-Lean practices than others, Lean traits were split according to department and converted into frequency-distributed bar graphs, with their associated mean and median statistics. This presented both visual and measured systems of observing what the average answers for respondents were, within each department. It should be noted that only the variables with statistically significant differences between departments, as observed in the Chi-Squared tests in Section 4.3.1, were reviewed according to inter-departmental differences, since variables without statistically significant inter-departmental differences were deemed to have occurred by chance alone, and therefore not be reliable variances. Statistically reliable variables were the motivation of the employees (Q6), whether employees wasted time (Q8), whether there was enough factory space (Q10) or factory space wasted (Q11), how often raw materials were late or unavailable (Q17), and the amount of time the factory was down (Q18).

Departments that appeared to show significantly more unmotivated individuals (Q6), on a scale between unmotivated and motivated, were Silicone Moulding, Speed Craft, Ali Foundry and Spacer Damper, as shown in Figure 4.11 and Table 4.1, next.

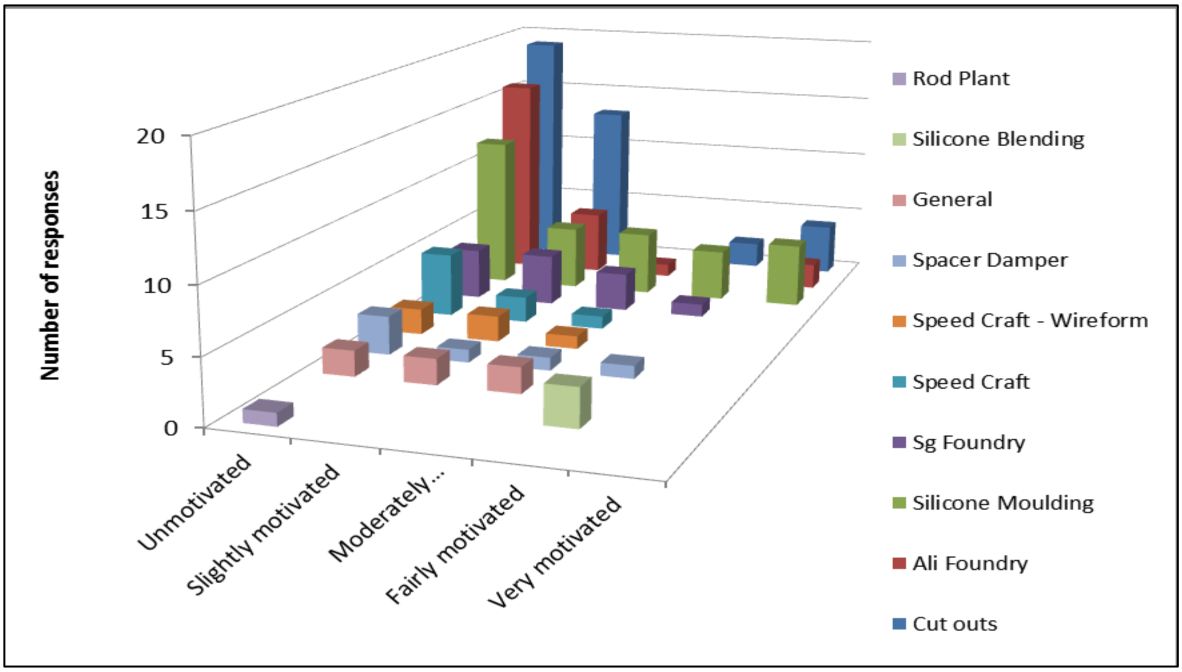


Figure 4.11: Graph of the motivations of employees (Q6), when grouped by department

Table 4.1: Descriptive statistics of the motivations of employees (Q6), when grouped by department

Department	N	Mean	Median	Mode	Std. Deviation	Skewness	Kurtosis
Rod Plant	1	1.00	1.00	1			
Speed Craft	8	1.50	1.00	1	0.755	1.323	0.875
Ali Foundry	24	1.63	1.00	1	1.173	2.231	4.498
Speed Craft – Wireform	5	1.80	2.00	1	0.837	0.512	-0.612
Cut outs	38	1.92	1.50	1	1.302	1.548	1.276
General	6	2.00	2.00	1	0.894	0.000	-1.875
Spacer Damper	6	2.00	1.50	1	1.265	0.889	-0.781
Sg Foundry	12	2.08	2.00	1	0.996	0.470	-0.654
Silicone Moulding	31	2.52	2.00	1	1.525	0.480	-1.262
Silicone Blending	3	4.00	4.00	4	0.000		

As shown in Table 4.1, the average motivation of the individuals (Q6) in Speed Craft — aside from the single individual in Rod Plant — was the lowest, with a mean of 1.50, and median of 1.00 (out of a minimum possible score of 1.00). Ali Foundry was next, with a mean of 1.63 and median of 1.00; followed by Cut Outs with a mean of 1.92 and median of 1.50. Although only three employees were from Silicone Blending, this department had the highest average motivation, with a mean motivation of 4.00 (out of a maximum possible score of 5.00).

The Speed Craft-Wireform department had the largest proportion of individuals who observed employees to be wasting time (Q8), compared to those who did not; while the Sg Foundry and Silicone Blending had an overwhelming number of employees who thought that there was not enough factory space (Q10), compared to those who thought it was sufficient. Conversely, those in Speed Craft primarily thought that there *was* enough factory space. Interestingly, more individuals from Sg Foundry thought that factory space was wasted (Q11) than those who did not; while those in Speed Craft primarily thought that factory space was not wasted (relative to those who thought that space *was* wasted). Ali Foundry, Silicone Moulding and Spacer Damper employees also generally thought that factory space was not wasted. Tables of these differences are presented in Appendix A.

As shown in Table 4.2 (next page), Ali Foundry, Spacer Damper and Cut Outs all observed machines to be broken (Q15) on a frequent basis (predominantly weekly), as opposed to on a monthly or yearly basis. Departments with the highest average frequencies (scaled between infrequently (1) and very frequently (6)) were Spacer Damper, which had a mean of 5.00 (once per week) and median of 6.00 (a few times per week), and Speed Craft–Wireform, which had an average of 5.00 and mean of 5.00 — although it only had 5 employees. Silicone Moulding, which had 31 participants, had a frequency average of 4.39 (between a few times per month, and once per week) and median of 5.00 (once per week). Sg Foundry (N = 12 participants) appeared to have problems with machines least frequently, with a mean of 3.92 (between once per month and a few times per month) and mode of 5.00 (once per week), while Ali Foundry (N = 24 participants) had a mean of 4.25 and median of 4.50 (between a few times per month and once per week); and Cut-outs had a mean of 4.34 (between a few times per month and once per week) and mean of 5.00 (once per week). Silicone blending, with three participants in the study, had a mean and mode of 3.00 (once per month).

Table 4.2: Descriptive statistics of frequency machines are not being used, when grouped by department (Q15)

Dept	N	Mean	Median	Mode	Std. Deviation	Skewness	Kurtosis
Rod Plant	1	2.00	2.00	2			
General	6	3.00	2.00	2	1.549	.968	-1.875
Silicone Blending	3	3.00	3.00	3	0.000	1.225	
Sg Foundry	12	3.92	5.00	5	1.929	-.772	-1.045
Speed Craft	8	4.13	4.50	2[a]	1.885	-.237	-2.216
Ali Foundry	24	4.25	4.50	6	1.675	-.311	-1.364
Cut outs	38	4.34	5.00	5	1.457	-1.025	-.048
Silicone Moulding	31	4.39	5.00	6	1.856	-.779	-.845
Speed Craft - Wireform	5	5.00	5.00	5	.707	0.000	2.000
Spacer Damper	7	5.00	6.00	6	1.528	-1.571	1.971

Speed Craft appeared to have an efficient use of machines compared to the other departments, where most individuals saw machines not being used (Q16) only a few days per year (N = 8, mean = 2.75, median = 2.00). Cut Outs and Sg Foundry each had the least efficient use of machines, or the highest frequencies of machines not being used (N = 38, mean = 4.21, median = 4.50; and N = 38, mean = 4.05, median = 5.00), respectively. Raw materials were frequently late or unavailable (Q17) in the Speed Craft-Wireform department (N = 5, mean = 5.60, median = 6.00), and in the Spacer Damper department (N = 7, mean = 5.43, median = 6.00). The Silicone Moulding department (N = 31, mean = 4.71, median = 5.00), Ali Foundry (N = 24, mean = 4.33, median = 5.00), and Cut Outs (N = 38, mean = 4.68, median = 5.00) also had poor overall frequencies of raw materials being late or unavailable. Only the Sg Foundry had lower frequencies of raw materials being late or unavailable, with 12 employees presenting mean and median scores of 3.75 (between once per month and a few times per month), and

4.00 (a few times per month), respectively. Tables of these descriptive statistics are provided in Appendix A.

Finally, when considering the time per year the factory was down (Q18), the five employees from Speed Craft-Wireform noted the highest mean frequency of 5.80 (between once per week and a few times per week), and median of 6.00. Spacer Damper and Cut Outs also suggested high frequencies, with mean = 5.14, median = 6.00; and mean = 5.08, median = 6.00, respectively. The 12 employees from Sg Foundry noted the factory to be down less frequently, with a mean of 4.25, although even this department was skewed towards the higher frequencies, with a median score of 6.00 (a few times per week). Once again, tables of these statistics are provided in Appendix A.

Further insight into which departments were operating on lower Lean principles than others, and why, is presented in the results of the second phase of the study, later in the chapter.

4.3 RESULTS OF PHASE ONE STUDY

Quantifying the frequency distributions into a more statistically reliable format was performed during the quantitative analysis phase of the study. The tests performed to achieve the objectives of this phase of the study were Chi-Square tests with post-hoc Cramer's V, Spearman's correlation analyses, and Cronbach's alpha to check for reliability. Results of these tests are each discussed in the following sections.

4.3.1 Chi-Square tests with Cramer's V

The Chi-Square null hypothesis (H_0) states that variables are independent, or that there is no significant relationship between the variables (Saunders *et al.*, 2009). However, if the null hypothesis is rejected with statistical significance, it can be concluded that the variables in question are not independent or otherwise that they are related. The Chi-Squared tests were employed in this study to offer a means of observing whether the answers noted by the respondents were related, such as whether the answers presented to certain questions may have 'influenced', or been associated to their responses to other questions. More specifically, it was useful to observe whether any of the demographic profiles of the respondents, such as their job titles, departments, length of time employed (tenures), or whether they understood what the principles of Lean were, related to their observations of the Lean properties within the organisation. Described simply, generating a Chi-Squared statistic was useful in observing whether different departments or job titles were following the different Lean principles consistently more or less closely than others.

Note, as per the principles of Chi-Squared analyses, an assumption was tested among the data to observe whether the expected frequencies of any single variable category had less than five respondents. In the event that more than 20% of the expected frequencies of any one variable category had less than five respondents (which occurred in virtually all data sets in this study), an important assumption on the minimum sample size for the Chi-Squared tests was violated, and Cramer's V tests were performed as post-hoc tests instead, since sample size was not a primary assumption for the Cramer's V statistic. It was more revealing to use Cramer's V for smaller category sizes, rather than collapsing the data into fewer categories, to allow richer findings between different departments or demographic profiles to be revealed.

4.3.1.1 Differences between job titles of employees

In the case of job title (Q2), which was cross-tabulated against the general motivation of the workforce (Q6), the Chi-square value was statistically significant [$\chi^2 = 38.719$; $p = 0.001$], as shown in Table 4.3, indicating that the job profiles of the respondents related, with statistical significance, to their opinions on the general motivation of the workforce (Q6).

Table 4.3: Lean profiles of the company in relation to job titles

Cross Tab	Pearson χ2	χ2 Sig.	Likelihood Ratio (LR)	LR Sig.	Cramer's V	Cramer's V Sig.	N of cases
Q6 General motivation of the workforce	38.719a	0.001	24.694	0.075	0.270	0.001	133
Q15 Frequency machines are broken	42.962a	0.002	28.042	0.108	0.283	0.002	134
Q16 Frequency machines not being used	35.724a	0.017	20.765	0.411	0.258	0.017	134
Q17 Frequency raw materials are late or unavailable	35.940a	0.016	22.859	0.296	0.259	0.016	134
Q18 Time per year factory down	59.627a	0.000	25.333	0.189	0.334	0.000	134

Thus, individuals with different job titles (Q2) appeared consistently to perceive differences in the general motivations (Q6) of the workforce. However, more than 20% of the cells in this Chi-Squared test had expected counts of less than 5 respondents, so the Likelihood Ratio (LR) statistic was therefore consulted instead, in conjunction with the Cramer’s V statistic. The statistical significance of the Likelihood Ratio for this association was above an alpha of 0.05, or less than 95% significance ($p = 0.075$; see Table 4.3), so this association was considered not to be reliable, even though the Cramer's V was also below 0.05. In the event that this Cramer’s V statistic was regarded, it would have been concluded that only a weak association existed between the job titles of the respondents, and their thoughts on the general motivation of the workforce [$V = 0.270$; $p<0.01$].

Whether there were enough employees (Q7) did not show any statistically significant associations to the job titles of the respondents, nor did whether the employees were ever seen wasting time (Q8), the time wasted per day by employees (Q9), whether there was *enough* or any *wasted* factory space (Q10 and Q11), whether there was enough or any wasted storage space (Q12 and Q13), or whether there was enough equipment (Q14), as shown in Appendix B. This means that the extent of these traits of Lean at Pfisterer did not appear to be related to the jobs that the employees performed; or that certain job titles were less Lean (according to these particular traits), compared to other job titles.

There did, however, appear to be statistically significant Chi-Squared associations between the job titles of the respondents (Q2) and the frequency that the machines were broken (Q15), the frequency the machines were not being used (Q16), the frequency that raw materials were late or unavailable (Q17), and the time the factory was down per year (Q18), as shown in Table 4.3. This seemed to suggest that certain types of equipment, which may be related to particular job titles, were more frequently broken or unused, than other job titles. Once again, though, it should be noted that more than 20% of the cells in these Chi-Squared associations had expected counts of less than five, requiring that the LR statistics (see Table 4.3) be consulted as well, in conjunction with the Cramer’s V statistic. Failure of the LR statistic above 95% significance meant that consideration should be made towards the possibility of a type-1 error among these associations, where a statistically significant result in the Chi-Square test may, in fact, have been due to chance or coincidence, rather than an actual relationship. Deliberation on these results, in relation to the literature, is presented in Chapter Five.

4.3.1.2 Differences between departments of employees

The Chi-Squared associations between the Lean characteristics at Pfisterer, in relation to the *department* demographic traits of the respondents (Q3) were far more revealing than the *job titles* (Q2) of the respondents. As shown in Table 4.4, next, high Pearson Chi-Squared values were observed between the general motivations of the workforce (Q6) in relation to the respondents’ departmental locations, as well as whether the employees were ever seen wasting time (Q8), whether there was *enough* or any *wasted* factory space (Q10 and Q11, respectively), the frequency the machines were broken (Q15), the frequency the machines were not being used (Q16), the frequency that raw materials were late or unavailable (Q17), and the time the factory was down per year (Q18). In the case of each of these variables, high Pearson Chi-Squared values were observed, which were each statistically significant below an alpha of 0.05, with LR values that were also statistically significant and with statistically significant Cramer’s V values.

Table 4.4: Lean profiles of the company in relation to the employee departments

Cross Tab	Pearson χ2	χ2 Sig.	LR	LR Sig.	Cramer's V	Cramer's V Sig.	N of cases
Q6 General motivation of the workforce	59.187[a]	0.002	49.806	0.023	0.340	0.002	128
Q8 Employees ever wasting time	39.955[a]	0.001	39.384	0.001	0.394	0.001	129
Q10 Enough factory space	31.527[a]	0.012	34.079	0.005	0.350	0.012	129
Q11 Factory space wasted	30.419[a]	0.016	34.461	0.005	0.343	0.016	129
Q15 Frequency machines are broken	84.595[a]	0.000	69.976	0.002	0.362	0.000	129
Q16 Frequency machines not being used	65.677[a]	0.006	57.195	0.038	0.319	0.006	129
Q17 Frequency raw materials are late or unavailable	86.199[a]	0.000	61.372	0.016	0.366	0.000	129
Q18 Time per year factory down	78.581[a]	0.000	59.554	0.024	0.349	0.000	129

This means that the extent of these traits of Lean at Pfisterer did appear to be related to the departments at Pfisterer; or that certain departments were less Lean (according to these particular traits) compared to other departments. This suggests that while some departments may have been operating smoothly at Pfisterer, in some departments the organisation was not operating smoothly according to the principles of Lean. Such issues would need to be addressed in order for improvements to be made in the organisation. This is discussed in Chapter Five.

Note that the Cramer's V values for each of these significant variables was between 0.319 and 0.394 (see Table 4.4), suggesting that weak-to-moderate associations existed between each of these variables and the departmental locations of the respondents. Described differently, it was observed that differences existed between these Lean traits across the different departments, with enough statistical significance to conclude that these differences could not have occurred by chance alone. The highest Chi-Squared, LR and Cramer's V values were observed in the case of the frequency that raw materials were late or unavailable (Q17) across the different departments [χ^2 = 86.199, p = 0.000; LR = 61.372, p = 0.016; V = 0.366, p = 0.000], with other high values being observed between the general motivation of the workforce (Q6) [χ^2 = 59.187, p = 0.002; LR = 49.806, p = 0.023; V = 0.340, p = 0.002], the frequency the machines were not being used (Q16) [χ^2 = 65.677, p = 0.006; LR = 57.195, p = 0.038; V = 0.319, p = 0.006], the frequency that machines were broken down (Q15) [χ^2 = 84.595, p = 0.001; LR = 69.976, p = 0.002; V = 0.362, p = 0.000], and the time the factory was down per year (Q18) [χ^2 = 78.581, p = 0.001; LR = 59.554, p = 0.024; V = 0.349, p = 0.000], between each of the departments.

It should be noted that while statistically significant Chi-Squared, LR and Cramer's V values were observed for these variables, there was no way of observing without individualised data examination, which specific departments were operating on lower Lean principles, and which specific departments were operating on higher Lean principles. The Chi-Squared statistic simply determined that there were statistically reliable differences between the departments and their Lean traits. In order observe which departments were operating more or less Lean, it was necessary to refer to the frequency distributions of the Lean traits, split by department, as discussed previously in Section 4.2.4.

Results of the other demographic profiles, such as the length of time the respondents had been employed (Q4) and their understanding of Lean principles (Q5) relative to their perceptions of the Lean characteristics at Pfisterer were less revealing than the departmental classification. These results are shown in Appendix B. In each of these cases, few cross tabulations were statistically significant between any of the Chi-Squared, LR and Cramer's V values that could have indicated significant associations between these demographic profiles. It thus indicated that the most noteworthy demographic for observing the successes and failures of Lean at Pfisterer was the inter-departmental differences of the company. Deliberation on these results, in relation to the literature, is presented in Chapter Five.

4.3.2 Spearman's Correlations

In support of the Chi-Squared tests, correlation analyses were undertaken using Spearman's correlation co-efficient (Rho, $\boldsymbol{\rho}$) to observe whether any correlations existed between the respondents' opinions of the Lean profiles at Pfisterer and their ordinally-ranked demographic profiles. Due to the assumptions of correlation analysis, only ranked data could be included in these tests; although it offered a means of observing whether the length of time the employees had been employed (Q4) correlated to the frequency that the machines were broken (Q15), the frequency that the machines were not being used (Q16), the frequency that raw materials were late or unavailable (Q17) and the time that the factory was down per year (Q18). Results of these correlations are shown in Table 4.5, next.

Table 4.5: Spearman correlations between ordinal variables

		Q9 Time/day employees waste	**Q15 Freq. machines broken**	**Q16 Freq. machines not used**	**Q17 Freq. raw materials late/ unavailable**	**Q18 Time/yr factory down**
Q4 Length of time employed	Correlation Coefficient	-0.019	0.188*	-0.071	0.111	0.139
	Sig. (2-tail)	0.826	0.029	0.413	0.202	0.110
	N	134	134	134	134	134
Q9 Time/day employees waste	Correlation Coefficient	1.000	0.315**	0.305**	0.420**	0.420**
	Sig. (2-tail)		0.000	0.000	0.000	0.000
	N	135	135	135	135	135
Q15 Freq. machines broken	Correlation Coefficient		1.000	0.157	0.745**	0.809**
	Sig. (2-tail)			0.068	0.000	0.000
	N		135	135	135	135
Q16 Freq. machines not used	Correlation Coefficient			1.000	0.290**	0.358**
	Sig. (2-tail)				0.001	0.000
	N			135	135	135
Q17 Freq. raw materials late / unavailable	Correlation Coefficient				1.000	0.718**
	Sig. (2-tail)					0.000
	N				135	135

As shown in Table 4.5, there was a very strong-positive correlation between the frequency that the machines were broken (Q15) and the time the factory was down per year (Q118), which indicated that respondents who listed higher frequencies of broken machines also listed that the factory was shut down more frequently per year. This correlation was also statistically very significant at more than 99% confidence [$\boldsymbol{\rho}$ = 0.809, p = 0.000]. Another attribute that was noted to be strongly-positively correlated, with high statistical significance, was the frequency that raw materials were late or unavailable (Q17), in relation to the time that the factory was down per year (Q18). This was also very statistically significant, at over 99% confidence [$\boldsymbol{\rho}$ = 0.718, p = 0.000]. Other factors that showed correlations to the time that the factory was down per year (Q18) were the time that the employees wasted per day (Q9) [$\boldsymbol{\rho}$ = 0.420, p = 0.000] and the frequency that the machines were not being used (Q16) [$\boldsymbol{\rho}$ = 0.358, p = 0.000].

One other strong-positive, statistically significant correlation observed between the respondents was the frequency that the machines were broken (Q15) and the frequency that raw materials were late or unavailable (Q17) [$\boldsymbol{\rho}$ = 0.745, p = 0.000]. This suggested that the respondents who observed high frequencies of machines being broken also observed high frequencies of raw materials being late or unavailable, and vice versa.

Thus, the results of the correlation analysis confirmed that the frequency that the factory was down per year most strongly correlated with the health of the machines, and to a lesser extent the availability of the raw materials, with the time wasted by employees per day being weak-to-moderate associative factors. Graphs showing the highest of these associations — the correlations between the time that the factory was down per year (Q18), and the frequency that machines were broken (Q15), or raw materials were late or unavailable (Q17) — are shown in Figure 4.12 and Figure 4.13, respectively, next.

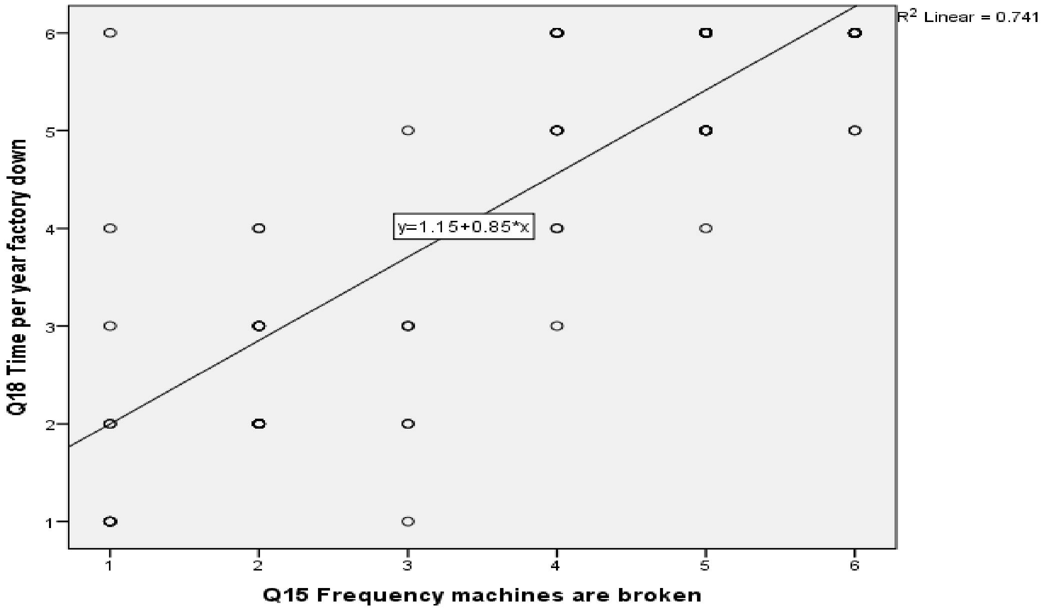


Figure 4.12: Correlations between the time that the factory was down per year (Q18), and the frequency that machines were broken (Q15)

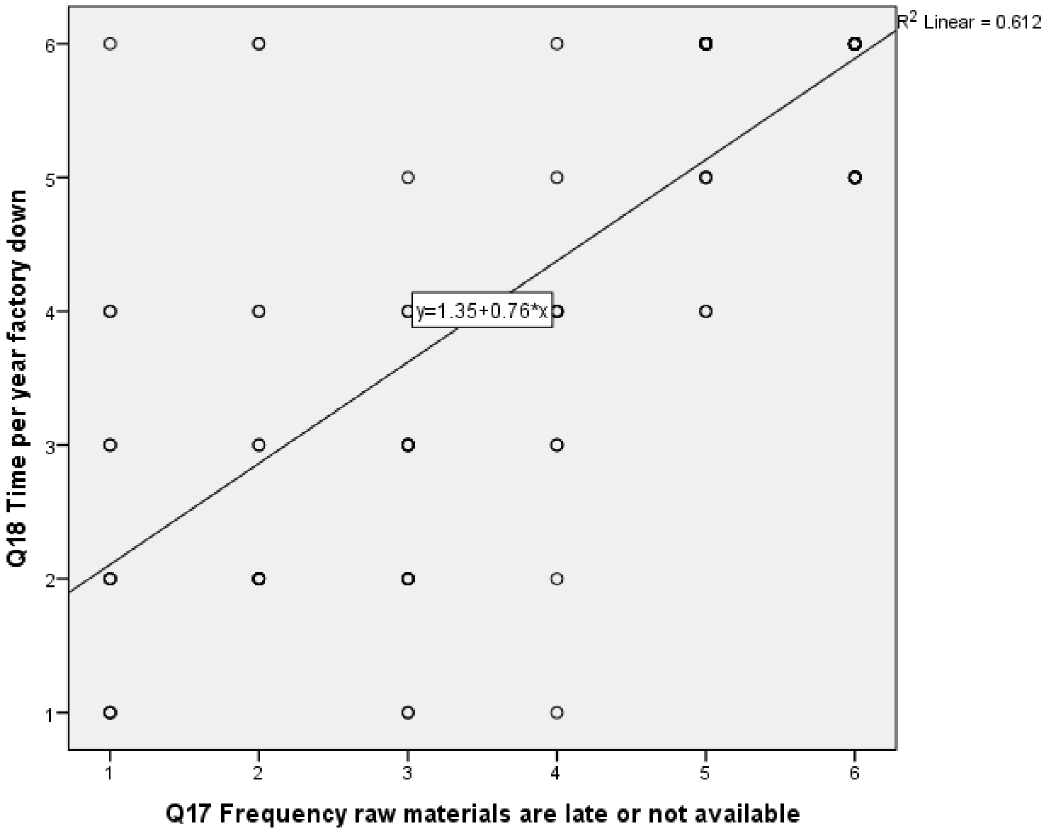


Figure 4.13: Correlations between the time that the factory was down per year (Q18), and frequency that raw materials were late or unavailable (Q17)

As shown in Table 4.5 previously, there were certain variables that were not correlated, which was to be expected especially among unrelated variables. For instance, the demographic profile of the length of time employed at Pfisterer, or tenure (Q4) showed a weak-positive correlation to the frequency that the machines were broken (Q15) [ρ = 0.188, p = 0.029], which although statistically significant, was too weak to indicate that any consistent differences occurred between the length of time individuals had been employed, and the frequency that machines were broken. The length of tenure also did not correlate to the frequency that machines were not being used (Q16) [ρ = -0.071, p = 0.413], whether raw materials were late or unavailable (Q17) [ρ = 0.111, p = 0.202], or the frequency the factory was down (Q18) [ρ = 0.139, p = 0.110]. This result added to the validity of the results, particularly due to the concept of divergent validity, discussed in Section 3.3.5.2.

The results of this correlation analysis therefore indicated that the successful and unsuccessful Lean practices at Pfisterer appeared to have been localised, whereby groups of individuals who observed machines often being broken, also observe raw materials being late or unavailable (and therefore higher frequencies that the factory was down per year). This indicates that certain 'hotspots' were failing in their Lean practices at Pfisterer. These issues should therefore be targeted for improvement, in order to improve the future efficacy of the factory. Understanding this in terms of where and how to do so, is covered in the qualitative phase of the study, later in the chapter. Deliberation on these results, in relation to the literature, is presented in Chapter Five.

4.3.3 Reliability

To observe the reliability between the data, the alpha coefficient (Cronbach's alpha) for all dichotomous, ordinal and interval variables from the quantitative questionnaire were calculated. The alpha coefficient for the six variables of employee tenures (Q4), the time wasted by employees per day (Q9), the frequency that machines were broken (Q15), the frequency that machines were not being used (Q16), the frequency that raw materials were late or unavailable (Q17) and the time when the factory was down per year (Q18), was 0.799, as shown in Table 4.6. This suggests that these six variables, when considered together, had a high internal consistency. Described differently, 79.9% of the variability in a composite score, when combining these six related characteristics, could be concluded as reliable and internally consistent variance (Tavakol & Dennick, 2011).

Table 4.6: Cronbach's Alpha testing reliability among matched ordinal and dichotomous variables

Matched Ordinal Frequencies: Q4, Q9, Q15, Q16, Q17, Q18	N of Items	Matched Dichotomous Variables: Q7, Q10, Q12, Q14	N of Items	Matched Dichotomous Variables: Q11, Q13	N of Items
0.799	6	0.620	4	0.674	2

When testing the related dichotomous variables of whether there were enough employees (Q7), enough factory space (Q10), enough storage space (Q12), and enough equipment (Q14), a Cronbach’s Alpha of 0.62 was observed, while when testing the related dichotomous variables of whether any factory space was wasted (Q11) or any storage space was wasted (Q13), a Cronbach’s Alpha of 0.674 was observed (see Table 4.6). This indicates that there was a moderate-to-high level of internal consistency between variables that measured similar Lean attributes, confirming the reliability of the data. Deliberation on these results, in relation to the literature, is presented in Chapter Five.

4.4 RESULTS OF PHASE TWO STUDY

The second phase of the study aimed to provide a deeper qualitative understanding of the underlying nature of the Lean operations at Pfisterer, and any problems therein. The respondents for this phase of the study were four production managers and five foremen. A sample of both production managers and foremen was gathered to provide a well-rounded view from the managers, rather than to compare the views of production managers and foremen. The results of the qualitative questionnaire, which was identically presented to both management types, are presented together throughout the remainder of the chapter. Six of the nine management respondents had been employed for between six and ten years, while the remaining three had been employed for over ten years. As explained in the methodology chapter, a detailed content analysis was performed to provide context to their questionnaire discourses, and results of this content analysis are presented here.

It should be noted that, as explained in the methodology chapter, while a debate exists regarding the use of graphs or illustrations for qualitative data analysis results, since counting and graphical illustration are inherently quantitative, graphical illustrations were generated following the content analysis of this study “with caution”, according to the conclusions of Vaismoradi *et al.* (2013, p.388), in order to allow visualisation of how different themes and categories were encrypted during the data analysis, and in which frequencies or proportions the codes were described by the Sample Two participants.

4.4.1 Strengths of the organisation and employees

The Sample Two of the foremen and managers from the production unit at Pfisterer noted a wide range of strengths of the company and its employees. As shown in Figure 4.14, the most frequently noted strength of the organisation (Q3) was the quality of its products (PRODCTS), followed by the technical capability of the organisation (TECH CAPAB): these were noted four and three times each, respectively. Other characteristics that were noted in recurrence were the customer focus of the organisation (CUST FOC) and its priority for customer satisfaction (CUST SAT), the fact that production was done “in-house” (IN-HOUS PRODN), that the company had products in a specialised niche of the market (NICHE), the quality of the company (QLTY), the timely presentation of its orders (TIMELY), and the company’s focus being on waste reduction (WASTE REDU). Other strengths observed were the drive of the individuals (DRIVE), the well-established reputation of the company (ESTAB BRAND), its global reach (GLOBL), its good job placement (JOB PLACMT) and job sustainability (JOB SUST), its mass-production capabilities (MASS), its growth in the market (MKT GRWTH), its safety levels (SAFETY), and its team-work among colleagues (TEAM WK).

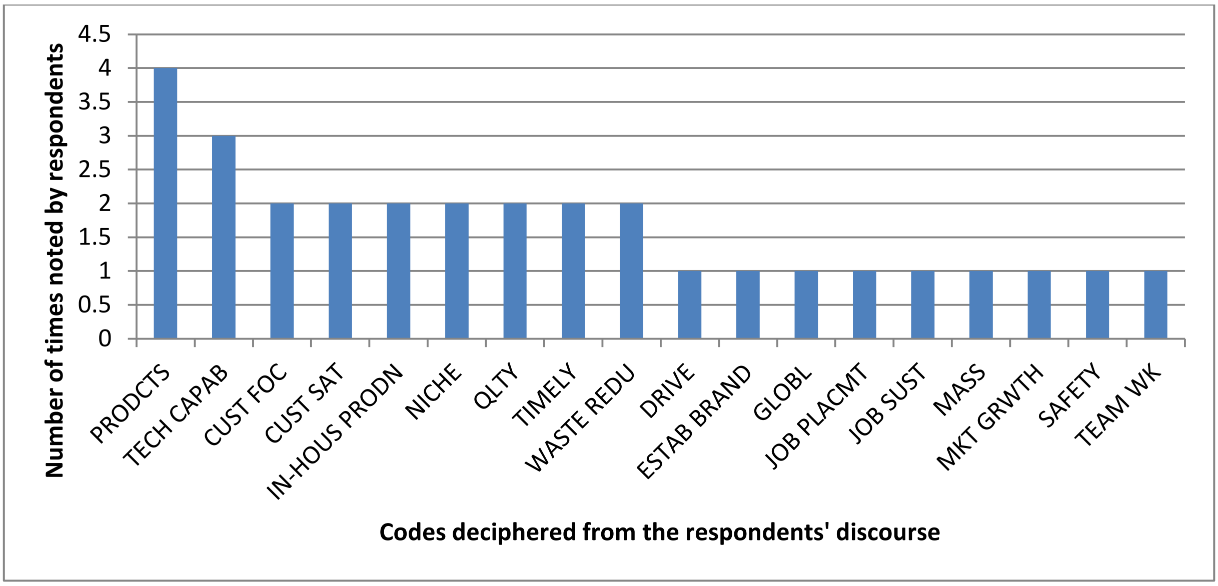


Figure 4.14: Strengths of the company (Q3) noted by Sample Two managers and foremen

As shown in Figure 4.15, in terms of the employees' strengths (Q4), respondents were forthcoming with numerous qualities. However, of the 16 different themes of strengths noted, only 2 were stated in recurrence: the teamwork of the employees was noted three times (TEAM WK) and the experience of the individuals (EXPRNC) was highlighted twice. Other strengths were the attitude of the employees (ATTITD), their commitment (COMMTD), sense of duty (DUTY), knowledge (KNOWL), being well-trained (TRAIND), quality of work (WK QLTY), motivation (MOTVN), proactivity (PROACT), timeliness (TIMELY), and length of tenure at the organisation (LONG TENR). It should be noted, however, that certain respondents did also take the opportunity to highlight a few criticisms of the employees, with one manager noting that the employees had "no strengths" (—NO STRNGTH), and that they lacked motivation (—NEED MOTVN). Deliberation on these results, in relation to the literature, is presented in Chapter Five.

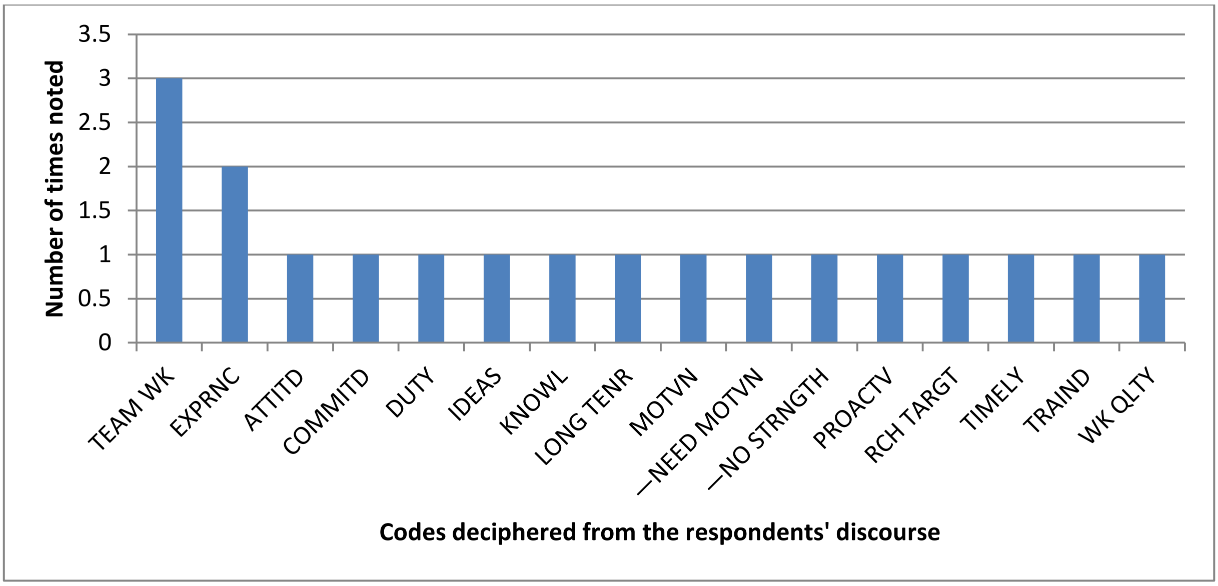


Figure 4.15: Strengths of the employees (Q4), noted by Sample Two managers and foremen

4.4.2 The management at Pfisterer

The respondents were asked to note two aspects relating to the production management at Pfisterer: what the current management leadership style at Pfisterer was like (Q5), and which areas employing the current Lean management style were working well (Q6). The respondents primarily stated that the management was autocratic (AUTOCRTC), motivating (MOTIVTG) and yet at times demotivating (—UNMOTIVTG), as shown in Figure 4.16. One respondent noted, for example, that the management "can be motivating at times and sometimes not so motivating". Indeed, the respondents noted a spectrum of characteristics of the production management style at Pfisterer: some of which were positive in nature, some negative, and some neutral. Ultimately, though, the negatively-natured comments outnumbered the positive and neutral comments in a ratio of 7:3:3 respectively.

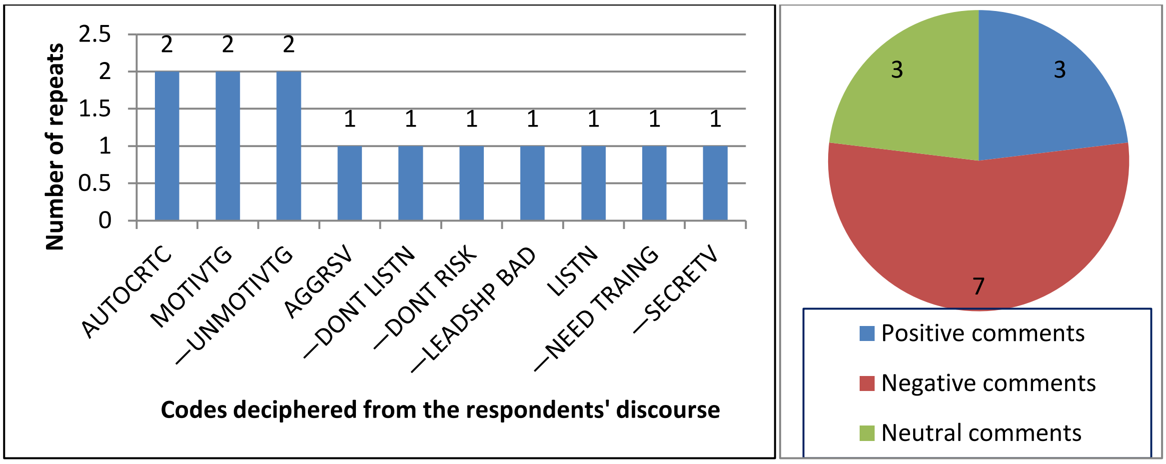


Figure 4.16: The current leadership style at Pfisterer (Q5), with codes of the respondents' discourse (left), and a pie chart of the proportions of positive, negative and neutral comments (right)

The generally-negative comments that were noted were, for example, that the management did not listen (—DONT LISTN), that they did not take risks (—DONT RISK), that they were secretive (—SECRETV) and needed training (—NEED TRAING), and one respondent even noted that the leadership situation was "bad" (—LEADSHP BAD). This respondent stated: "due to the decline in orders, I think the situation is bad (leadership is fin all celle [at the end])." Another respondent explained further that:

> *"We have some leaders who are willing to hear the views of others, some are do not take anything from others, what they says goes [sic]."*

Another respondent also noted: "They need to take chances and be more open, not so secretive."

In describing the areas within the current Lean management style that were working well, the range of responses was small, as shown in Figure 4.17, with the most commonly noted answer among the respondents being that certain departments (DEPTS) were working well, yet no company-wide style was described. Indeed, in support of the previous questions' results, two of the respondents reiterated that the current Lean management style was *not* working well (—NOT WRKG WELL). Departments that were noted by respondents to be working well were: "Uniflex crimping runner cell and Post cell"; "the Cut Out department"; "The crimping of high and low voltage insulators in the cell manufacturing" and the "Cut Out department fuse holder cell". Other areas within the current Lean management style that were described as working well were that some employees listened to the requests and opinions of others (SOME LISTN), that the company was solving problems (PROB SOL), and that the company was improving (CO IMPRVG). Deliberation on these results, in relation to the literature, is presented in Chapter Five.

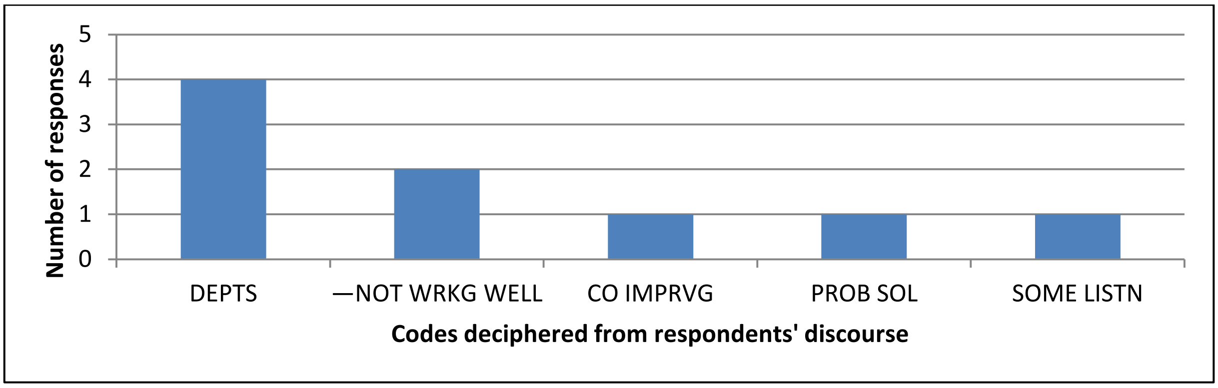


Figure 4.17: Areas within the current Lean management style that were working well (Q6), as noted by the Sample Two respondents

4.4.3 Linking the management to Lean

When asked to quantify how Lean was currently benefiting the organisation (Q7), the respondents asserted that numerous benefits were being enjoyed at the company due to Lean, which was primarily a reduction in inventory on the factory floor (INVNTRY REDU), followed by a reduction in the amount of waste (WASTE REDU), an increase in customer satisfaction (CUST SAT), a reduction in the amount of labour needed (LABR REDU), reduced lead times for satisfying orders (LEAD TIME REDU), and saving space (SAVE SPCE), as shown in Figure 4.18. Other themes that were observed were that Lean was balancing the work load (BALNC WK LOAD), reducing costs (COST REDU), improving housekeeping (HOUSKPG INC), increasing the use of the labour force (LABR USE INC), preventing over-production (NO OVER PRODN), controlling the flow of products (PRODCT FLOW), increasing productivity (PRODCTVY INC), increasing teamwork (TEAM INC), reducing production times (TIME REDU), and reducing time-wastage (TIME-WASTE REDU).

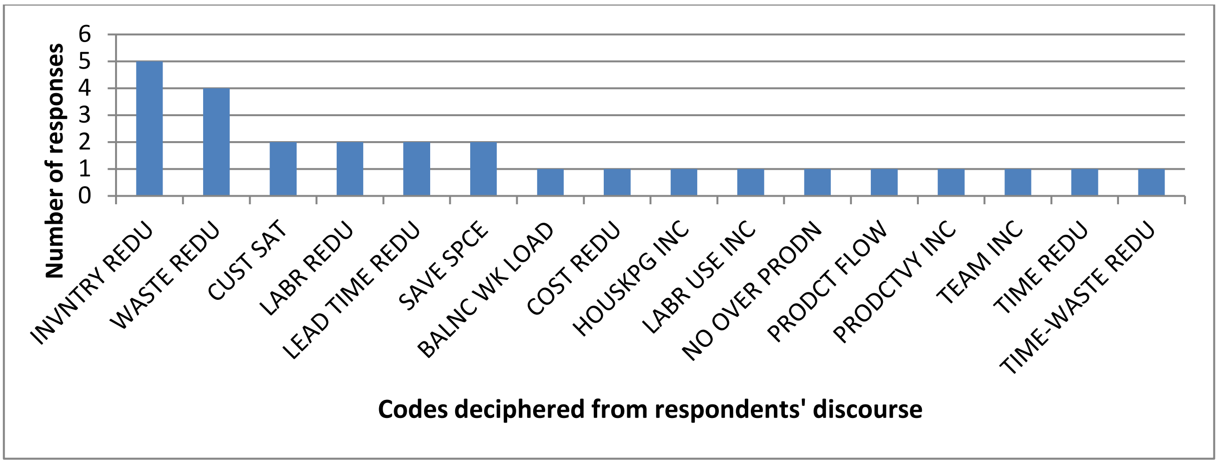


Figure 4.18: How Lean was benefiting the organisation (Q7)

Once again, when asked to identify their grievances in the form of areas in the current management style that were not Lean (Q8), the respondents were forthcoming with frank answers. Some departments were noted by respondents to have been operating outside of Lean practices and these were stated as follows, Inventory lag appeared to be a problem, "inventory left on the floor for more than a day or two before moving to the next stage". Furthermore, "ordering" was noted by another respondent, who stated: "ordering of components from stores". In support of the previous sentiments on the shortcomings of the company's Lean practices, 6 of the 9 respondents did not think that the company's Lean principles were working for the organisation (Q9), while only 3 stated that they were. Deliberation on these results, in relation to the literature, is presented in Chapter Five.

4.4.4 Improving Lean at Pfisterer

Upon identifying areas that needed to be improved within the current Lean management style (Q10), 16 factors were noted across 14 categories, as shown in Figure 4.19, next page. Extending the topic of results from the previous sections, two areas that needed to be improved were highlighted: "[the] Wireform-Gluing machine" and "in the Press department". Inventory management and planning were also highlighted, as was storage (STORG), supported by the argument: "Storage and preservation needs to be improved. The obstacle in this is the availability of cash". One respondent went so far as to sum up numerous issues as follows:

"Sometimes equipment and raw materials are duplicated to improve process flow. Also, the Lean style must be spread out through to all shifts etc. and not choose when to use Lean and when not to".

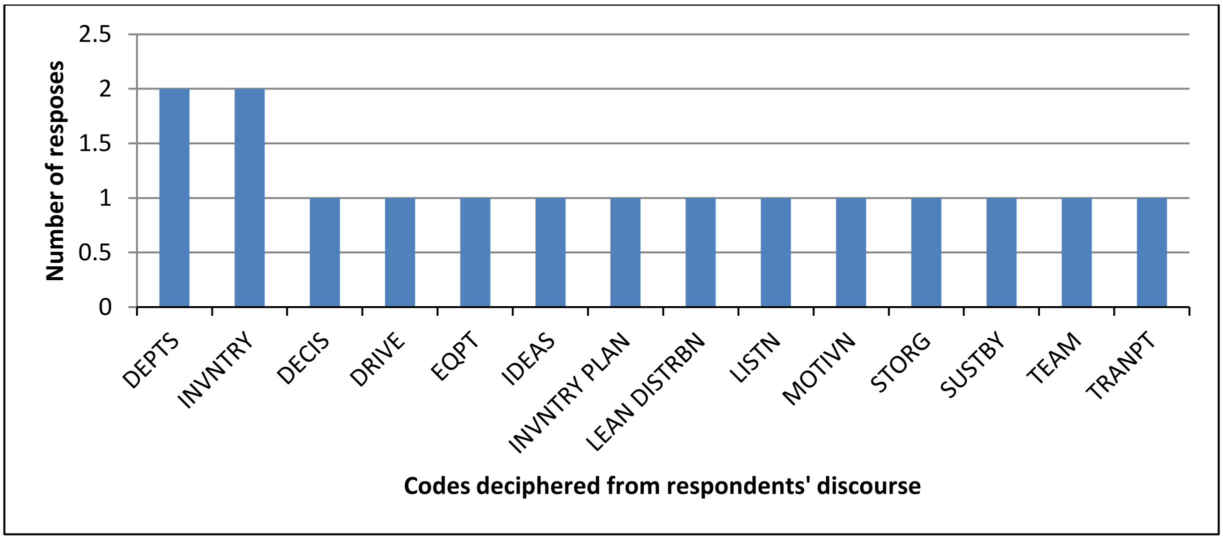


Figure 4.19: Areas that should be improved in the current Lean management style (Q10)

Other areas that should be improved in the current Lean management style (Q10), as shown previously in Figure 4.19, were decision making (DECIS), the drive of the employees (DRIVE), the state of the equipment (EQPT), the flow of ideas (IDEAS), the plan for the inventory (INVNTRY PLAN), the even distribution of Lean across all departments (LEAN DISTRIBN), improving staff listening (LISTN), increasing motivation of staff (MOTIVN), the amount of storage (STORG), the sustainability of the organisation (SUSTBY), the level of teamwork among the staff (TEAM), and the movement and transport of items and personnel (TRANPT).

Explaining how these improvements in Lean management would benefit the organisation (Q11), four respondents noted that it would increase output of the company (OUTPUT INC), while two others each claimed that it would reduce costs (COST REDU) and delivery time (DELV TIME REDU), respectively, as shown in Figure 4.20, next. Although stated in isolation, other factors that were anticipated to benefit the company by improving the Lean management were through increased customers' satisfaction (CUST SAT); faster production (FASTR); reduced inventory (INVNTRY REDU), labour (LABR REDU) and transportation requirements (TRANSPT REDU); increased safety (SAFETY INC) and quality

(QLTY INC); and increased employee satisfaction (SATFN INC), motivation (MOTVN INC), and use of equipment (EQPT INC). Deliberation on these results, in relation to the literature, is presented in Chapter Five.

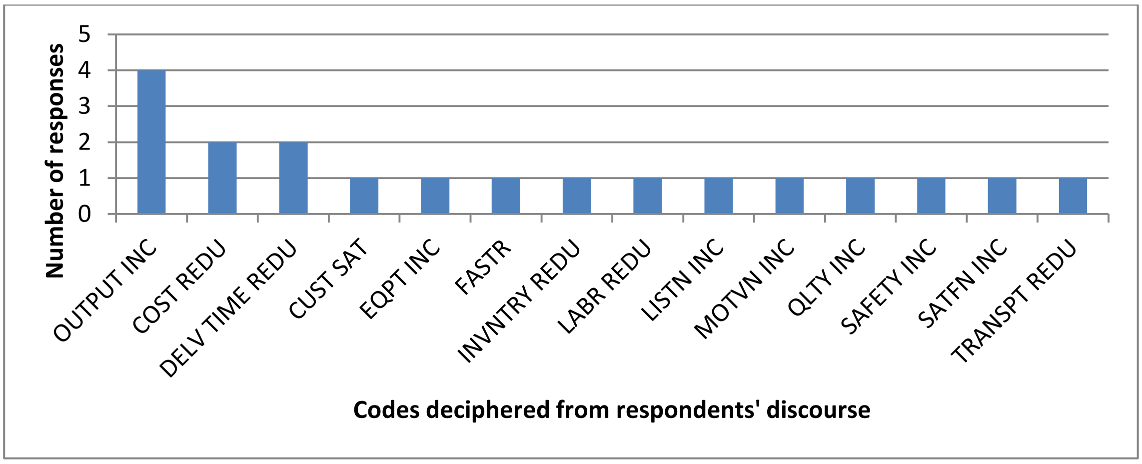
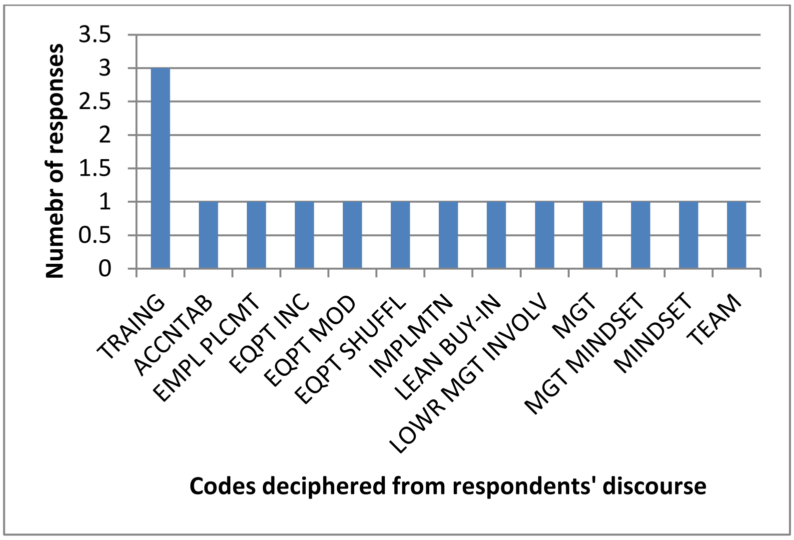


Figure 4.20: How the improvements in Lean management would benefit the organisation (Q11), as noted by Sample Two respondents

4.4.5 Logistical considerations of adjusting to Lean

The final section of the qualitative survey assessed the respondents' opinions on the logistical considerations of better adjusting to Lean, such as what structural changes would be required by the organisation to improve the existing shortfalls of Lean (Q12), whether the current Lean leadership style would require a significant change to improve these shortfalls (Q13), how they felt about changing the organisation's structure for improving the current Lean shortfalls (Q14), what challenges they foresaw with making such changes to the organisation (Q15), as well as whether they believed Lean would be sustainable in the organisation over the long-term (Q16).

Respondents most often thought that training (TRAING) would be required to improve the shortfalls of Lean (Q12), while other feelings were the shuffling of employees (EMPL PLCMT) and equipment (EQPT SHUFFL) and/or modifying or increasing the company's equipment (EQPT INC) (EQPT MOD), as shown in Figure 4.21. Other changes related to the logistical considerations of better adjusting to Lean included human changes that would be needed, such as increased accountability (ACCNTAB), changing the mind-sets of the management and general employees (MGT MINDSET) (MINDSET), gaining “buy-in” from the staff (LEAN BUY-IN), increased teamwork (TEAM), and implementation challenges faced (IMPLMTN) such as by encouraging the involvement of the lower and upper management (LOWR MGT INVOLV) (MGT).



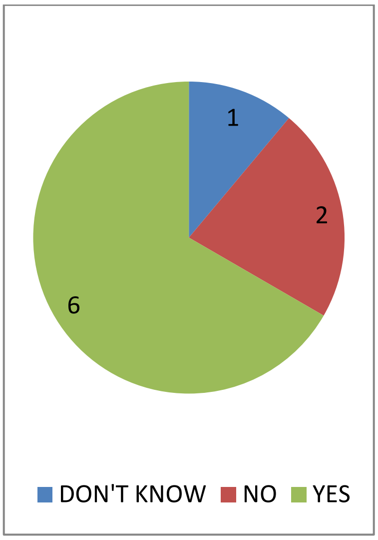


Figure 4.21 Structural changes required to improve the current Lean shortfalls (Q12); and answers to whether the current leadership style would require a significant change to improve these shortfalls (Q13)

The majority of the respondents (six out of nine) believed that the current Lean leadership style would require a significant change to improve the current shortfalls of Lean (Q13), as shown previously in Figure 4.21 (right). Most of the respondents were optimistic about changing the structure of the organisation to improve the shortfalls of Lean (Q14), though (see Figure 4.22), whereby four of the respondents noted positive comments (POSTV), and only one was negative, or pessimistic (ANTI). Some respondents were adamant that making such changes were even *necessary* or *non-negotiable* (NECSSRY), for example by stating that “Continuous improvement is one of the key factors in any business organisation”. Two respondents noted that it would be difficult (DIFFCLT), with one explaining: “[it is] difficult, but do what’s best for the company”. One respondent argued that a structural change would be required to improve the existing shortfalls of Lean, stating that “We need a support structure so that shortfalls can be eliminated and so that improvements can be made”. However, one of the production managers added that “I feel that the organisation`s structure should not be changed but rather be supported by higher management".

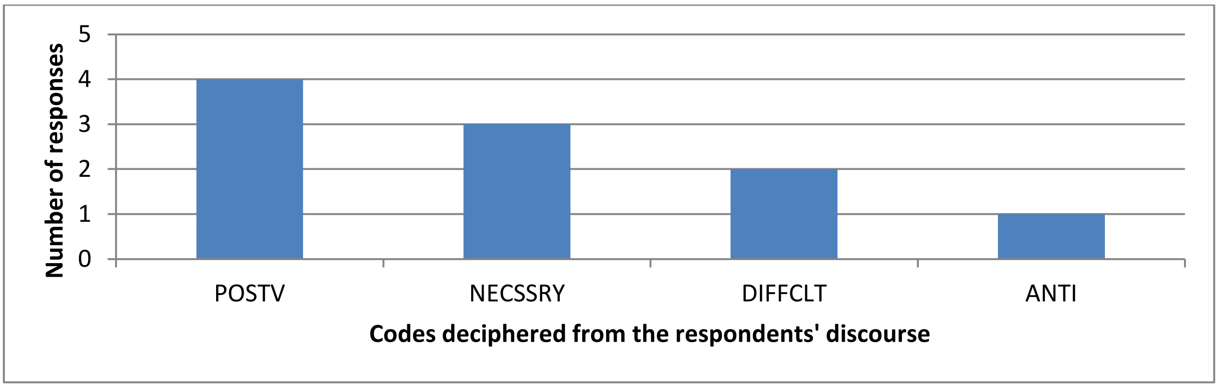
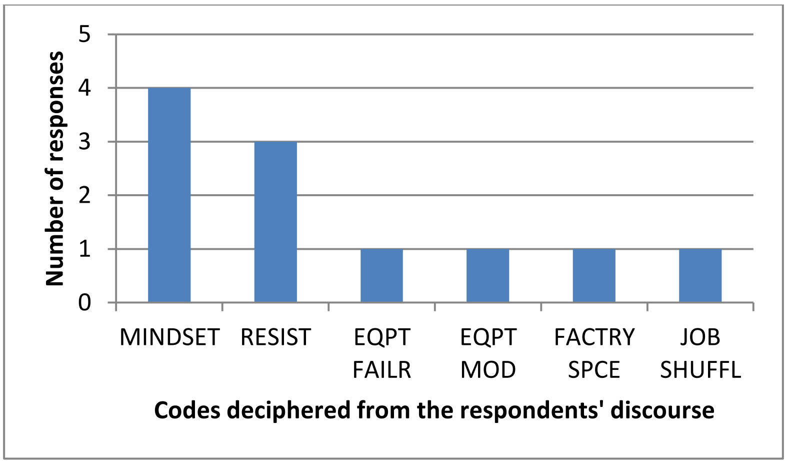


Figure 4.22: Feeling of the Sample Two respondents about changing the organisation's structure to improve the shortfalls of Lean (Q14)

One respondent summarised the challenges of the sustainability of Lean (Q15), arguing that it was not going to be sustainable at the company over the long-term, stating: "No because there are areas where we implemented lean but never did a follow up and it is falling down [sic]". The general themes that were observed relating to the challenges of better implementing Lean in the organisation, as shown in Figure 4.23 (left), were the mindset of the staff and managers (MINDSET), resistance from the staff and managers (RESIST), problems with equipment failure (EQPT FAILR), problems with modifying the equipment (EQPT MOD), limitations in factory space (FACTRY SPCE), and challenges with shuffling employees to different job roles (JOB SHUFFL).



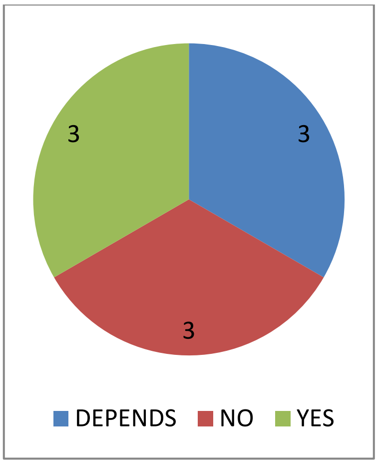


Figure 4.23: Challenges foreseen with better implementing Lean in the organisation (Q15), and the sustainability of Lean (Q16)

While only three of the respondents thought that Lean would be sustainable at the organisation over the long-term (Q16), as shown in Figure 4.23 previously, three did not think that, while the last three said it depended on other factors. For example, respondents noted that “[it is] possible in some parts of the organisation”, while conversely: “no, there must be a change in the leadership style”, or “Yes, if the team works together”.

In providing concluding remarks, some respondents stated: “I feel that [Lean] … will benefit the company for the future” and “Sustaining lean will not be difficult if you have the right people to drive it and to motivate the department heads”. Another point was highlighted by one of the production managers, who argued: “Production needs more support rather than being put under extreme pressure and strain”. Indeed, one respondent re-iterated the need for following up any changes to the organisation in order for Lean to be successful, stating that: “Whenever you implement something, you need to do a follow up in order [for it to be] sustainable”. Deliberation on these results, in relation to the literature, is presented in Chapter Five, next.

4.5 CONCLUSION

A large number of the employees, as determined by the Sample One participants of Study Phase One, perceived the workforce to be unmotivated, and more than half of these participants also thought that there were not enough employees at Pfisterer. More than 40 percent of Sample One respondents claimed that raw materials were late or unavailable up to a few times per week; while more than half of these respondents claimed that the factory was down a few times per week. It was observed that differences existed between the general motivations of the workforce across the different departments, with enough statistical significance to conclude that these differences could not have occurred by chance alone. High Chi-Squared, LR and Cramer’s V values were observed between the frequency that machines were broken down across the different departments, as well as for the general motivation of the workforce, the frequency that the machines were not being used, the frequency that raw materials were late or unavailable, and the time that the factory was down per year. Thus, while some departments may have been operating smoothly at Pfisterer, in some departments, the organisation was not operating smoothly according to the principles of Lean.

There was a very strong-positive association between the answers that Sample One respondents noted for the frequency in which the machines were broken, and the frequency the factory was down per year. One other strong-positive association was observed between the frequency that the machines were broken and the frequency that raw materials were late or unavailable, suggesting that the respondents who observed higher frequencies of machines being broken also observed higher frequencies of raw materials being late or unavailable.

The production managers and foremen surveyed in Sample Two noted a wide range of strengths among the company and employees. However, while this sample of respondents noted a spectrum of characteristics of the Lean management style at Pfisterer — some of which were positive in nature, some negative and some neutral — ultimately, the negatively-natured comments outnumbered the positive and neutral comments. Various departments were noted for not operating according to the principles of Lean. In that regard, improving Lean management was thought to benefit the organisation in many ways. The logistical considerations of adjusting to Lean management appeared to indicate scepticism; but ultimately, the respondents agreed that it was a good idea to do so, and many noted that making such changes was even necessary or non-negotiable.

Various challenges affecting the long-term sustainability of Lean at the organisation were described by the participants in Sample Two, which among others included the general mindset of the staff and management. There was also an even distribution of opinions between these participants as to whether or not Lean would be sustainable at the organisation over the long-term, or whether it depended on other factors. Given these results, Chapter Five deliberates on how these results provide a path for the organisation to advance more productive Lean practices for better implementation of Lean at Pfisterer, and improving the sustainability of Lean at the organisation over the long-term.

CHAPTER FIVE:
DISCUSSION OF RESULTS

5.1 INTRODUCTION

This chapter presents a discussion of the study. Each of the findings of the previous chapter is discussed in turn, presenting arguments for the outcomes of the research and explanations for any of the shortcomings in the results. It offers comparisons between the quantitative and qualitative phases of the study, and considers where the results of this research have supported the findings of others.

The chapter begins with the state of Lean at Pfisterer, indicating which areas of the company appeared to be more or less Lean, with a discussion on any contradictions that existed in the results. Then, the individual factors affecting Lean are discussed in relation to how they might have been responsible for the failure and/or limited success of Lean at Pfisterer. These factors include staff motivation, employee numbers, factory or storage space, equipment functionality and use, raw material availability, factory down-time, client satisfaction and management practices. Before concluding the chapter, the thoughts of the staff on the logistical implications of implementing Lean at Pfisterer are discussed.

5.2 THE STATE OF LEAN AT PFISTERER

The perceived opinions about the implementation and sustainability of Lean at Pfisterer were different for each of the two samples of stakeholders, with the employees from Sample One often perceiving the state of the company differently to the production managers and foremen from Sample two.

No departments appeared to be clearly benefiting from Lean above the other departments. In departments such as the Sg Foundry and Silicone Blending, for instance, some aspects were poor, while others were less problematic. For example, the Sg Foundry appeared to have problems with machines least frequently and the lowest frequencies of raw materials being unavailable, but also the least efficient use of machines. In addition, employees from the Silicone Blending department thought that there was not enough factory space, but the staff appeared to be more motivated than the general consensus of the other employees at Pfisterer. This suggests that Lean practices may be working in isolated instances, but they are not being applied across the board, or with uniform efficacy.

In the results, differences appeared between departments in relation to the general motivations of the workforce, as well as whether the employees were ever seen wasting time, whether the employees perceived factory space to be sufficient, the frequency that employees saw machines broken or not being used, how often raw materials were late or unavailable and the time that employees saw the factory down per year. For example, weak to moderate associations existed between these traits and the departments of the employees, meaning that while some departments were operating more smoothly at Pfisterer, others were operating poorly according to the principles of Lean.

Lean is a management philosophy of continuously improving and simplifying all of an organisation's processes, movements, actions and attitudes, with a focus on output and client satisfaction, in a bid to achieve a totally waste-free operation (Miller *et al.*, 2010; Stone, 2013). The philosophy of Lean was not being conveyed uniformly throughout the organisation, and it appeared that there were still many aspects of the organisation that need to be improved until it reached maximum efficiency.

Understanding this at an intimate level within the organisation was therefore important for deducing *why* it was not in a totally waste-free state of operation. Helping to comprehend this was determined through an analysis of how well the employees understood what Lean meant. This is because Lean is an integral organisational culture and philosophy, where the management of an organisation must constantly and continually communicate the goals of the Lean implementation to its employees, along with the goals and the basic concepts behind it (Bhasin, 2012b; Nordin *et al.*, 2010). Comprehending whether the employees understood the meaning of Lean was important because, as noted in the literature and discussed throughout this chapter, a fundamental aspect of successfully and sustainably implementing Lean in organisations requires communicating the goals of Lean to the employees, training on Lean and generating a culture of Lean (Wong & Wong, 2011).

Although Lean was not extensively interrogated with controls to ensure that respondents were not simply guessing, or that the answers to the multiple choice questions were not obviously deduced, it was possible to assume on face value that around three quarters of the employees could associate the correct meaning to the term Lean, suggesting that many of the respondents would have had some introduction to the concept. Whether or not the employees were being *encouraged* to follow such practices, though, was not clear from the question.

There appears to have been some failure on the part of the management at Pfisterer in this regard, though, such that the proportion of individuals who knew about Lean was not closer to 100 percent. If Lean were truly being implemented at the core of the company, and ingrained in its corporate culture and vision, only a few individuals (such as the fewer than 9 percent who had been employed at Pfisterer for less than one year) could have been excused for answering this question incorrectly. This result therefore highlighted an inherent failure in the execution of the company's Lean implementation, as it was clearly not being integrated into the culture of the organisation, with the goals of Lean being communicated and ingrained into the employees — and certainly not in a consistent manner throughout the organisation.

5.2.1 Contradictions in the results

Numerous contradictory results existed between the quantitative and qualitative phases of the study, suggesting that there was no unanimity concerning the state of Lean at Pfisterer. One contradiction, for example, included which departments were working well in the organisation. As noted throughout the quantitative phase of the study, the Cut Outs department was lagging behind in terms of high frequencies of factory down-time, poor availability of raw materials and inefficient use of machines, high frequencies of machines being broken, and poor overall employee motivation. According to the production managers and foremen in the qualitative study, though, Cut Outs was described on more than one occasion as one of the departments that was working *well*, with some even singling out the Cut Outs department in their comments about which departments were working well.

This presents a quandary in terms of the findings of this study. The quantitative phase was performed on a significant proportion of the total employees (134 of the 200 general employees) and the data were observed to have high reliability, high internal consistency and adequate validity following calculations of Cronbach’s alpha and correlation analyses in the results chapter. Thus, the results of the employees’ answers could be considered as accurate reflections of the state of the company on the factory floor — with statistical significance. Why some of the production managers and foremen would have said something so contradictory, therefore, remains curious.

One reason may be that even within larger departments such as the Cut Outs department, smaller units in such departments may still have been working slightly better than the overall average. However, judging by the similarity of answers and general consensuses of the employees in this particular department, this would have seemed unlikely. Admittedly, although very rarely, there were a few Sample One employees in the Cut Outs department who noted low frequencies of factory down-time, high availability of raw materials, efficient use of machines, low frequencies of machines being broken and high overall employee motivation. This, and the fact that more than one Sample Two respondent argued in favour of the Cut Outs department, would support this explanation.

Another similarly logical deduction on this discrepancy between the answers of some of the managers and the employees on the Cut Outs department is a disconnection, or lack of understanding between the perceptions of some managers and the actual Lean conditions or ‘goings-on’ of these departments. If this were indeed the case, it would indicate a clear failure of these managers to comprehend — at a foundational level — how bad the situations of these departments were, in terms of the Lean implementation. If, for example, some managers observed the Cut Outs department to be working well, then it would have been based on criteria that were not necessarily Lean-related. This again relates to the issue of how well Lean is being ingrained into the corporate culture and vision of the company — not only at an employee level, but also at the level of the production managers and foremen. As noted by Bhasin (2012b, p.423) Lean should be viewed as a cultural philosophy, and in many cases, this concept is not clarified to the organisation's shareholders, which may have been the case at Pfisterer.

It should be noted though, that numerous departments were described by Sample Two managers to be operating outside of conventional Lean practices, such as those described by Stone (2012) and Pettersen (2009), suggesting that the Leanness of many of the departments at Pfisterer was, to some extent, known by the production managers and foremen. In presenting what the problems with the current Lean system were, one Sample Two respondent suggested issues with amenities such as financial, sales and marketing works, although it was not clarified whether these were problems of waste or inefficiency (*Muda*) in these areas, or if they were simply not performing according to the vision of the company.

One problem that was noted by the production managers and foremen was that of inventory lag, where inventory appeared to be on the factory floor for more than a day before moving to the next stage. Incidentally, the efficient control of inventory continually appeared among the production managers and foremen as one of the ways in which Lean had been working *well* in the organisation, suggesting that clear discrepancies existed between the production managers and foremen of the different departments, and even on the attributes in which Lean had been succeeding and/or failing. Some of the specific factors that were found to be responsible for the failure and/or limited successes of Lean are discussed next.

5.3 FACTORS AFFECTING LEAN IMPLEMENTATION

Within the literature, numerous suggestions and recommendations are presented by authors and experts in the field for improving Lean practices in manufacturing organisations (van der Merwe *et al.*, 2014; Bhasin, 2012a; Cullinane *et al.,* 2012). However, it was useful to consider the opinions of those in the organisation who had experienced its problems, such as the managers and employees at Pfisterer. Indeed, according to Process Improvement Japan (2010), a central consideration of Lean or *Kaizen* implementation is the creation of a working environment where workers can propose logical improvements (*Gemba*) for the organisation; and listening to the experiences of the managers and employees is one such application of this philosophy.

The experiences of the production managers, foremen and employees in this study, and their observations of the different factors affecting the implementation of Lean at Pfisterer, are discussed next.

5.3.1 Staff motivation

One factor that was observed among the employees, and which would have been responsible for the failure and/or limited successes of Lean at Pfisterer, was the motivation of the employees. Most of the employee respondents thought that the workforce was unmotivated, with the Silicone Moulding, Speed Craft, Ali Foundry, and Spacer Damper departments showing significantly less motivated staff than the other departments.

The topic of motivation in Lean practices is an important concept, which according to Beale (2007), is an often-ignored aspect of Lean management. Yamauuchi (2010, cited in Process Improvement Japan, 2010) agrees that unless employees are motivated, companies cannot create a working Lean system. It is possible that the low general levels of motivation outlined by the Sample One employees may have been a factor affecting the implementation of Lean within the organisation. In addition, Miller (2014) argues that most Lean implementations are too focused on problem-solving skills within the work place, but they fail to consider the system or culture of motivation within their staff. This was noticeable in the second phase of the study, where only once, among the 16 themes observed, did a manager from Sample Two identify motivation as an area that needed to be improved to improve the current Lean management style at Pfisterer. Thus, the summary of Miller (2014, p.13) that “Too many [managers] rely on the ‘they ought to want to’ assumption, which usually results in disappointment” appears to have been apparent in Pfisterer, too.

In a somewhat feedback system, it is also possible that the poor current implementation of Lean at Pfisterer may have been at the root of the poor employee motivation levels. As noted by Distelhorst *et al.* (2014), steadfastly implementing Lean in companies does not guarantee greater employee satisfaction or morale; and in fact, the opposite is often true. For example, in the study by Distelhorst *et al.*, the adoption of Lean manufacturing in companies was often found to increase the occurrence of employee motivation problems, such as labour violations. It may therefore be postulated that some issues with the poor motivation of employees at Pfisterer, may indirectly have been caused through the company's implementation of Lean.

The concept of a team spirit and family unit is central to the Toyota culture, and Toyota promotes a practise where every member is awarded the highest level of ownership and accountability in what they are doing — they are taught to understand that their fate is integrally linked to that of the company (Miller, 2014). The development of team spirit is an aspect that may have received little attention at Pfisterer. The evidence for this is that the three individuals in the small family-sized group of the Silicone Blending department at Pfisterer were the only departmental group that appeared to be more motivated than the general unmotivated consensus of the other employees. Indeed, while reasons were not specifically garnered to explain why small numbers of individuals in the larger departments had higher levels of motivation, it could be postulated that these groups of individuals may have formed small-unit groups or family teams in the larger departments, with the result being an improved motivational state. In general, it could be concluded that the team and family spirit at Pfisterer must have been either weak or ineffective, and this would need to be focused on for improvement within the organisation's Lean practices.

5.3.2 Employee numbers and time wastage

An interesting result was observed in the Phase One quantitative study, relating to the availability of sufficient numbers of staff. The general consensus was that there were not enough employees at Pfisterer. While more than half of the employees thought that there was not enough staff, about the same proportion claimed that they observed staff wasting time for more than three hours per day. Another interesting dynamic was that around the same proportion of employees also thought that staff never wasted time, suggesting that there must have been a discrepancy between what they perceived as wasting time, and the number of hours spent not working. Clearly, spending a certain number of hours per day not-working was still not perceived as a form of wasting time. This highlights an important factor that should be targeted for Lean improvement in the company.

As described by Liker (2004), worker time not being adequately utilised, or workers not having anything to do is one of the principle non-value-adding activities referred to as *muda* within the *Kaizen* practices of Lean. Conversely, Toyota Great Britain (2013b) explains that giving employees insufficient time per task also compromises processes, while giving excessive time for activities generates waste.

As alluded to earlier in the chapter, there was also an interesting contradiction between the accounts of the Sample One employees and Sample Two production managers and foremen, in terms of the adequacy of the numbers of employees. Some of the managers and foremen appeared to see it as a benefit that Lean had reduced the amount of labour needed in the organisation. However, across the company on a non-department specific basis, nearly half of the employees thought that there were not enough employees, though many admitted that they saw large numbers of staff wasting time. This suggests that while the Lean implementation at Pfisterer may have acted to reduce the amount of labour needed, it should be considered whether the employees were adequately briefed about what was expected of them following the labour reductions, as well as the amount of work they should have been performing and the amount of time they could have spent not working (wasting) to overcome feelings of employee shortages. Lean often extends the scope of work of an employee, as he or she may be expected to multi-task or handle more than one task simultaneously (Losonci *et al.*, 2011).

5.3.3 Factory space

The principles of Lean suggest that factory and storage space should be adequate, but optimally used with minimum wasted space. A waste termed *muri*, for example, refers to the overburdening of equipment, facilities or people (Liker, 2004). Only around half of the employees thought that no space was being wasted, while only one third thought that factory space or storage space was adequate. The Sg Foundry and Silicone Blending departments had overwhelming numbers of employees who thought that there was not enough factory space.

Interestingly, while the majority of individuals from Sg Foundry also thought that factory space was wasted, those in Speed Craft primarily thought that factory space was not wasted and that the factory space was adequate.

Providing a different perspective to the employees, the Sample Two production managers and foremen suggested that one of the benefits of implementing Lean at Pfisterer was that it had helped them to save space. This suggests that the benefits of saving space with Lean may have been realised in some departments, but the organisation is still failing in this regard in numerous other departments. Furthermore, it appears that the implementation of Lean to save space has simply been perceived by many employees as creating inadequate space. It also confirms that Lean practices may be working in isolated instances, but are not being applied across-the-board, or with uniform efficacy. A positive finding of any unused space at Pfisterer could be that there is space for the company to grow and expand. However, there must be a balance between space being wasted in some areas and insufficient in others, as highlighted by Bhasin (2012b).

5.3.4 Equipment functionality and use

There was an even distribution of machine usage between a few times a week and a few times a year, according to the employees. This was perhaps to be expected with the variety of equipment used in a factory establishment of the size and scale of Pfisterer. However, it should be clarified that there was no indication of which types of machines were being used more or less frequently. For the above deduction to hold true, a requisite would have been for primary machines or equipment to be in constant use, and peripheral or specialist equipment to be used only on specific or isolated occasions.

Only around a quarter of the employees felt that the equipment at Pfisterer was adequate. The number of employees who thought that the amount of time that machines at Pfisterer were broken, though, was alarming, with many suggesting a few times per week and only a few employees stating less than one day per year. Ali Foundry, Spacer Damper and Cut Outs all observed machines to be broken on a frequent (predominantly weekly) basis, as opposed to on a monthly or yearly basis. Departments with the highest average frequencies of machine breakages were Spacer Damper and Speed Craft, which had machine breakages a few times per week. Indeed, the Wireform-Gluing machine was even outlined by one of the Sample Two respondents for being problematic in the organisation. Speed Craft appeared to have an efficient use of machines, though, compared to the other departments, where most individuals only saw machines not being used a few days per year.

In terms of the principles of *Kaizen*, Pfisterer was acting poorly to prevent defect-related *muda*, or the removal of manufacturing errors, or the amount of time spent to correct or repair flaws or errors in the manufacturing process (Liker, 2004). Thus, it appears Pfisterer was not succeeding in preventing the overburdening of equipment or people (Liker, 2004). Evidence of this was described in this and the previous section the high frequency of machines that were broken, as well as the high number of employees who thought that their staff compliment were insufficient.

5.3.5 Raw materials

The incidences that raw materials were late or unavailable were alarming; with a high number of employees stating that raw materials were late or unavailable a few times per week. Raw materials were frequently late or unavailable in the Speed Craft–Wireform and Spacer Damper departments, while the Silicone Moulding Ali Foundry and Cut Outs departments also had poor overall performances regarding raw materials. As mentioned previously in the chapter, Sample Two respondents could not agree on whether the Lean implementation at Pfisterer had increased or reduced raw materials on the factory floor, since both claims were made. Indeed, one of the Sample Two respondents illustrated the issue by suggesting that at times equipment and raw materials were duplicated in the organisation to improve process flow, while it was short in other areas of the organisation. According to many of the Sample Two respondents, the reduction of inventory on the factory floor was one of the key benefits that had been realised from the implementation of Lean at Pfisterer, further exemplifying the contradiction in observations between Sample Two respondents. This presents another area where Lean is not being uniformly implemented throughout the organisation and which should be focused on for future *Kaizen* in the organisation, as described by

Meade *et al.* (2010).

During the implementation of Lean, an important balance must be created between minimising excess inventory, such as excess raw materials at hand, and ensuring that raw materials are neither late nor unavailable (Liker, 2004). It appears that at Pfisterer, this balance was far from perfect. While to some managers there was a reduction of inventory on the factory floor, too many employees simply perceived raw materials as being frequently late or unavailable. It would be expected too, that in such departments where this was an issue (Speed Craft–Wireform, Spacer Damper, Silicone Moulding, Ali Foundry and Cut Outs), non-value adding activities such as unnecessary movement or the wasting of employee effort through needless walking, searching for raw materials and so forth (Liker, 2004), would have been another area where *muda* was not being alleviated.

In order to overcome this, Mathieu, Wray and Markham (2002) discuss the use of visual cues such as *Kanbans,* for improving the control of inventory in a Just-in-Time (JIT) manufacturing environment. This is a system of controlling inventory levels through the use of *Kanban* cards, which notify production managers and foremen when inventory levels are low. Pfisterer may need to invest in such a *Kanban* system to improve the efficacy of inventory flow on the factory floor.

The systems for ensuring that inventory was available in the quantities they were needed at Pfisterer was not specifically interrogated, but perhaps an understanding of the systems at Toyota would provide a model specimen towards which Pfisterer could grow. For example, Pfisterer could consider implementing a system of requisitioning the components or items that are needed for each stage in the manufacturing process through electronic or printed tickets and direct communication, which would allow exactly that which is needed to be supplied as necessary (Liker, 2004).

5.3.6 Factory down-time

More than half of the respondents claimed that the factory was down a few times per week and only a small number said less than one day per year. Looking at the larger picture of the amount of time that the factory was down per year, the small Speed Craft-Wireform department noted an average frequency of between once per week and a few times per week while Spacer Damper and Cut Outs also suggested similarly high frequencies. As noted by Alsmadi *et al.* (2012, p.384), “Lean practices are expected to improve operational performance by streamlining processes and increasing process consistency”, which is a predominant reason for organisations adopting a Lean approach. The fact that process consistency was a significant issue in various departments at Pfisterer indicates further overall failures in the current Lean system.

The results of the Spearman’s correlations were helpful in explaining the reasons for this down time. It was observed that the frequency that the factory was down per year correlated more to the health of the machines (whether the machines were broken), followed by the availability of raw materials and the time wasted by employees per day. One curious factor that appeared to correlate to the amount of time the factory was down per year was the frequency that machines were not used. This was curious because it was not immediately apparent why such a factor would correlate to the time the factory was down per year. Although it was only weak-to-moderately associated, it was still highly statistically significant. The correlation meant that respondents who noted machines seldom out of use also noted that the factory was seldom down. Employees, who noted inefficient use of machines, or machines often not being used, also often noted the factory to be down. Upon considering the Toyota Production System (TPS) in the literature, though, defects such as manufacturing errors or spending time to correct or repair flaws or errors in the manufacturing process are a known type of waste, or *muda*, which counters an organisation’s attempts to reach a state of Leanness (Liker, 2004).

Therefore, it appears that the health and usage of machines was an aspect of the manufacturing process that was closely related to any inefficiency of the factory. Contrary to the earlier postulation that the usage of machines between a few times per week and a few times per year was a plausible fluctuation among the variety of equipment used in a factory establishment of the size and scale of Pfisterer, it appears that in fact, it might have been an inherent corollary of inefficiency or poor

Leanness, since it was closely related to the amount of time the factory was down per year. This also appeared to concur with the finding of Bhasin (2012a), who found that among 27 percent of organisations in a study of 100 organisations, the nature of the manufacturing facility formed a significant barrier to Lean implementation. Thus, in the case of Pfisterer, it would appear that the nature of the manufacturing facility, in terms of its equipment's health and usage, was presenting a significant barrier to the efficiency of the organisation's Lean implementation.

It can also be assumed that factory down-time at Pfisterer may have been costing the company financially, because of the reduction in the overall factory output of the company. According to Mathieu *et al.* (2002), poor performance can cost companies that operate on a JIT manufacturing environment, in terms of client satisfaction and financial income. The topic of client satisfaction is discussed further, next.

5.3.7 Client satisfaction

One characteristic that was noted by the Sample Two respondents to be creating benefit for Pfisterer was the reduction in lead times thus ensuring that customer deliveries are achieved on time. As noted by the Toyota Motor Corporation (2014b), one of the foremost concepts of the Toyota Production System is *Jidoka* , or "Just-in-Time", where only that which is necessary for each step in the manufacturing process is provided, and that the correct products are manufactured for the client, at the exact time and amount that they are needed. It was a positive sign that such benefits were being realised by applying Lean at Pfisterer, despite the high frequencies of factory down-time described previously. It should however be questioned whether the reduction in lead times for satisfying client orders was in fact as high as it could have been with a more efficient, across-the-board system of Lean implementation. While Lean was described as reducing the lead times for satisfying orders and therefore attending to the concept of *Jidoka* (Toyota Motor Corporation, 2014b), it was a broadly contested argument in the results whether or not the inventory on the factory floor was in fact being provided to the employees Just-in-Time, or whether this *Jidoka* outcome was less-efficient than the Sample Two respondents thought. It would appear that there is still room to improve in this regard and providing exact quantities of raw materials at the precise time that they are needed is an area that the production managers and foremen would need to focus on more carefully to improve supply to the client more efficiently.

5.3.8 Managerial and logistical implications of Lean implementation

In the Phase Two qualitative questionnaires, a sample of both production managers and foremen was gathered to provide a well-rounded view from the management, rather than to compare the views of production managers and foremen. It was possible to deduce that numerous management shortcomings existed, which should be deliberated for their potential effects on the failure or limited successes of Lean at Pfisterer. Predominantly negative comments were described, including the fact that the management was demotivating, it did not listen, it did not take risks, it was secretive, and it needed training.

A final input from the production managers and foremen of the second phase of the study allowed for some logistical considerations of adjusting to Lean to be made. Respondents most often thought that training would be required to improve the shortfalls of Lean, while others felt it required the shuffling of employees and equipment, and/or modifying or increasing the company's equipment. Other factors included human changes that would be needed, such as changing the mind-sets of the management and general employees, gaining "buy-in" from the staff and encouraging the involvement of the lower management.

This appeared to concur with the views of Wong and Wong (2011, p.2170), who argued that gaining employee buy-in and enthusiasm for Lean is not always a smooth process and resistance can often occur — particularly from senior workers. According to Wong and Wong, employees often perceive Lean as an attempt by management to force them to do more work. Misunderstanding, or a lack of appreciation for the possible benefits that Lean offers, can cause employees to engage the Lean principles less seriously and ultimately affect their motivation.

This study also appeared to concur with the arguments of Bhasin (2012b) that not all higher level managers agree with the implementation of Lean. Reasons proposed were that managers normally expect that Lean implementation would result in more pressure, and few consider any possible benefits such as greater job security or receiving more pay. Managers, therefore, like employees, generally perceive that Lean implementation will require them to do additional work or carry additional responsibilities without sufficient support, which may cause additional stress (Bhasin, 2012b).

Bhasin (2012a, p.454) asserts that the pursuit of Lean is a difficult and time consuming “journey”, since company culture, financial costs, staff attitudes, lack of Lean understanding, and other inherent company characteristics can act to hinder the process. Bhasin also illustrates the point that organisations should not hope to replicate the success of Toyota overnight, since Toyota’s development took several decades to perfect.

Implementing Lean sustainably will be another factor that will need considerable effort. Only three of the respondents thought that Lean was sustainable at Pfisterer. As noted by van der Merwe *et al.* (2014), early gains in organisations from Lean may be lost as employees revert, over time, to their previous work practices. Van der Merwe *et al.* (2014, p.132) argue that it is important for the leaders in an organisation to understand that Lean is a “management philosophy”, rather than simply a manufacturing methodology, and that effort would be needed to ingrain this philosophy into the core of the staff beliefs and practices if long-term benefits are to be realised.

Thus, sustainably implementing Lean, according to literature, would require viewing Lean as a philosophy and as a process, where Lean would demand a long-term commitment and an essentially unending process (Bhasin, 2012a). For example, it would also require instituting a new culture, whereby Pfisterer would need to commit to developing a culture that can support Lean if it is to truly implement Lean successfully (Wong & Wong, 2011). The management at Pfisterer would need to communicate the goals of the Lean implementation to the employees, along with the goals and basic concepts intended by the Lean implementation. Pfisterer would need to provide adequate training and support to ensure employee commitment to the program, and to facilitate a Lean culture — perhaps in the form of mentors or "*sensei's*", as recommended by Wong and Wong (2011, p.2173). Policies would need to be implemented in the infrastructure of the company (Hodge *et al.*, 2011), and Pfisterer would need to institute a system of evaluation tools for measuring Lean performance (Mathieu *et al.*, 2002) so that improvements in performance, or reductions in waste could be accurately tracked. A more complete outline of recommendations for the organisation is presented in Chapter Six.

Ultimately, however, most of the respondents were optimistic about the effect that such changes would have at Pfisterer — if it were able to smoothly and universally be implemented throughout the organisation. How it would improve the company, final conclusions of the study in relation to the research questions of this research, and recommendations for both Pfisterer and future research, are concluded in the final chapter of the dissertation.

5.4 CONCLUSION

This concludes the discussion chapter of the dissertation. No departments appeared to be clearly benefiting from Lean above the other departments, and problems were observed in each department relating to either the staff motivation, employee numbers, factory or storage space, equipment functionality and use, raw material availability, factory down-time, client satisfaction, and management practices. While there was general pessimism on the implementation of Lean to date, various ideas were presented from the study, which indicated how to overcome the current problems at Pfisterer. The final chapter of the dissertation follows, next, with conclusions, final thoughts and recommendations based on the results of this study.

CHAPTER SIX:
CONCLUSION AND RECOMMENDATIONS

6.1 INTRODUCTION

The aim of this study was to observe and understand the implementation and sustainability of Lean practices within the manufacturing environment of Pfisterer Pty (Ltd) in Pietermaritzburg, South Africa. To achieve this aim, objectives were devised to determine the perceived opinions of key Pfisterer stakeholders about the current implementation and sustainability of Lean at the company, to determine the benefits or shortcomings of better adopting to the Lean philosophy of thinking; to determine the key factors that have been affecting Lean implementation; as well as to establish some guiding principles to aid better implementation and sustainability of Lean at the organisation. This final chapter presents the conclusions from the study and any final thoughts from the research. It also presents some recommendations to the company, and for future research, to enhance the body of knowledge on the subject. It begins, first with a presentation of the findings that emanated from the literature review.

6.2 PRESENTATION OF FINDINGS EMANATING FROM THE LITERATURE REVIEW

Toyota's phenomenal success and the subsequent study of its production system and 'way' have given rise to a large body of academic literature, and a highly effective approach to production, manufacturing and organisational function. A successful adoption of Lean principles should result in reduced waste, greater workplace efficiency, and enhanced overall productivity (Bhasin, 2012a ; Hodge *et al.*, 2011).

However, the literature has shown that it is not at all straightforward to emulate Toyota's protocols and philosophy; rather, adopting a Lean approach calls for a long-term commitment, rather than simply changing the methods or layout of a manufacturing facility (Wong & Wong, 2011). In order to exploit the benefits of Lean fully, and to ensure that Lean implementation remains successful, the academic consensus is that organisations must be willing to wholly overhaul their corporate culture, and accept that Lean is a state of operation, rather than just a set of manufacturing tools and concepts (van der Merwe *et al.*, 2014).

In order to successfully switch to a Lean approach, the literature identifies a number of important factors. Foremost among these is worker participation (Schmidt, 2011; Hodge *et al.*, 2014). As part of the development of a Lean culture, an organisation must ensure that the workforce — both employees and the leadership — understands the mechanisms and benefits of Lean. An organisation must also be willing to change its hierarchy (Bhasin, 2012b). Employees must be encouraged to participate and take initiative, whereas the management must become more alert to the daily processes of the facility (Wong & Wong, 2011). Finally, it must be remembered that many of Lean's benefits are not evident on traditional metrics, so implementing a new system of evaluation to monitor performance is essential (Pettersen, 2009).

Evidence suggests that Lean remains a highly effective approach to enhancing productivity, quality and workplace efficiency (Gamage *et al.*, 2012), if an organisation is willing to make the commitments to long-term evolution, reduction of waste, and the restructuring of staff hierarchy and the workplace. Next, the findings of the primary study are presented, with a summary of the pertinent literature that helps to account for these findings.

6.3 PRESENTATION OF FINDINGS EMANATING FROM THE PRIMARY STUDY

6.3.1 Perception of Lean implementation and sustainability at Pfisterer

The implementation and sustainability of Lean at Pfisterer was perceived differently by each of the two samples of stakeholders, with the employees from Sample One often perceiving the state of the company differently to the production managers and foremen from Sample Two. Most of the employees thought that the workforce was unmotivated, and that there were not enough employees, while many employees wasted more than three hours per day. The concept of a team spirit and family unit is central to the Toyota culture, and Toyota promotes a practise where every member is awarded the highest level of ownership and accountability in what they are doing (Miller, 2014). The development of team spirit is therefore an aspect that may have received little attention at Pfisterer.

Since Lean often extends the scope of work of an employee, as he or she may be expected to multi-task or handle more than one task simultaneously (Losonci *et al.*, 2011), it suggests that while the Lean implementation at Pfisterer may have acted to reduce the amount of labour needed, it should be considered whether the employees were adequately briefed about what was expected of them following the labour reductions, as well as the amount of work they should have been performing and the amount of time they could have spent not working (wasting) to overcome feelings of employee shortages.

Considerable numbers of employees argued that no space was being wasted and that the factory space, storage space or equipment was inadequate. Many employees suggested that machines were broken, and that raw materials were late or unavailable a few times per week, resulting in unacceptable frequencies that the factory was down. A waste termed *muri* refers to this overburdening of equipment, facilities or people (Liker, 2004). It appears that the implementation of Lean to save space at Pfisterer has ultimately been perceived by many employees as creating inadequate space and overburdening equipment. This emphasises that there must be a balance between space at Pfisterer being wasted in some areas and insufficient in others, as highlighted by Bhasin (2012b).

While the majority of the employees appeared to know what Lean was — suggesting that many would have had some introduction to the concept — there appeared to have been some failures on the part of the management at Pfisterer, such that the proportion of individuals who knew what Lean was, was not closer to 100%. This is because Lean is an integral organisational culture and philosophy, where the management must constantly and continually communicate the goals of the Lean implementation to the employees, along with the goals and the basic concepts behind it (Bhasin, 2012b; Nordin *et al.*, 2010).

It also appeared that Lean was only working in isolated instances, but they were not being applied across the company with uniform efficacy. Numerous contradictory results existed between the Sample One employees and Sample

Two managers and foremen; and even between the Sample Two respondents, suggesting that there was no standard consensus on the state of Lean at Pfisterer. Contradictions included which departments were working efficiently; whether employee numbers were improved or being made inadequate; whether space was being saved or limited; whether inventory management was being improved or leaving the factory floor with raw materials late or unavailable; whether client satisfaction was being improved or if the factory down-time would have been affecting business; as well as whether or not Lean was a sustainable management practice in its current form. Bhasin (2012a, p.454) asserts that the pursuit of Lean is a difficult and time consuming “journey”, since company culture, financial costs, staff attitudes, lack of Lean understanding, and other inherent company characteristics can act to hinder the process. Van der Merwe *et al.* (2014, p.132) also argue that it is important for the leaders in an organisation to understand that Lean is a “management philosophy”, rather than simply a manufacturing methodology, and that effort would be needed to ingrain this philosophy into the core of the staff beliefs and practices if long-term benefits are to be realised. Thus, sustainably implementing Lean at Pfisterer, according to the literature, would require viewing Lean as a philosophy and as a process, where Lean would demand a long-term commitment and an essentially unending process (Bhasin, 2012a).

In satisfying the research objectives, it is clear that much work needs to be done at Pfisterer in order to improve the Lean functionality and sustainability. The process of understanding the factors that have been responsible for the failure and/or limited success of Lean is helpful in providing the first step to this end. That is the subject of the next section.

6.3.2 Factors affecting Lean implementation at Pfisterer

The second research objective that was achieved in this study was to determine the key factors that were responsible for any failure and/or limited successes of Lean at Pfisterer. These factors could be categorised into each of the classes of staff motivation, employee numbers, factory or storage space, equipment functionality and use, raw material availability, factory down-time, management practices, and logistical issues.

Many respondents were unmotivated. As an often-ignored concept in Lean implementation, it is extremely important to remember motivation in JIT-manufacturing organisations, since without it the implementation of Lean will certainly be inhibited (Distelhorst *et al*., 2014). The general consensus was that there were not enough employees at Pfisterer, although staff members were seen not working for more than three hours per day. It was also argued by many employees that staff never wasted time. As one of the prime means of *mura*, or overburdening equipment, facilities or people (Liker, 2004), this would have formed a significant factor for any shortcomings in the Lean implementation.

While it was thought that Lean was reducing the amount of inventory on the factory floor, in many cases, the opposite was being observed; whereby raw materials were often being seen by the employees to be late or unavailable. This was also seen to correlate to the overall amount of factory down-time, productivity and the assumed satisfaction of clients. Thus, while “Inventory reduction is frequently a primary objective and key success measure of a Lean manufacturing programme” as noted by Meade *et al*. (2010), the management at Pfisterer should be careful that this reduction in inventory is being observed, instead, as inventory being late or unavailable. It is also likely that instead of working as an advantage to the company, it appears to be increasing the amount of factory down-time, reducing productivity, and potentially affecting client satisfaction.

Various negative comments about the management suggested that this was also a factor for the poor implementation of Lean. Problems were that the management was demotivating, they did not listen, they did not take risks, they were secretive, and they needed training. Specifically, it was also noted that the higher management in the organisation did not provide enough support for Lean, while the leadership style was not currently conducive to successful and sustained Lean implementation. This appeared to concur with the arguments of Bhasin (2012b) that not all higher level managers agree with the implementation of Lean. Managers, like employees, generally perceive that Lean implementation will require them to do additional work or carry additional responsibilities without sufficient support, which may cause additional stress (Bhasin, 2012b).

Logistical problems that were noted to have limited the uptake of Lean were poor buy-in from the staff, as well as the inability to change the mind-sets of the management and general employees. This concurred with the views of Wong and Wong (2011), who argue that gaining employee buy-in and enthusiasm for Lean is not always a smooth process, and resistance can often occur.

Quantifying the benefits or shortcomings of adapting to Lean was the third research objective of this study, as outlined next.

6.3.3 Benefits and shortcomings of better adapting to the Lean philosophy

Numerous benefits of Lean are described in the literature (Stone, 2012; Alsmadi *et al.*, 2012; Bhasin, 2012a; Ghosh, 2012; Hodge *et al.*, 2011). However, the challenge lies in understanding whether the stakeholders of the organisation in question are knowledgeable about, or appreciate these benefits. This was the third research objective of this study. Indeed, while there was a general pessimism as to whether Pfisterer would be able to successfully and sustainably implement Lean, there was still a consensus agreement that implementing Lean across the organisation would benefit the company for the future.

In identifying how improvements in Lean management would benefit the organisation, it was argued that the output of the company would increase, while costs and delivery times would be reduced. It was also anticipated that by improving the Lean management, the motivation of the staff would be increased, employees would become more satisfied, production would be accelerated, inventory would be reduced, safety and quality would be improved, and ultimately, customer satisfaction would be increased. This has been supported in the literature as well, where there is overwhelming evidence that successful implementation of Lean techniques results in greater productivity and overall company performance (Bhasin, 2011).

Furthermore, it was argued that converting the company to Lean was not a matter of benefit versus shortcomings, but rather a non-negotiable requirement for progressing in the best interest of the organisation. Provided the company applied the right people to drive its implementation and motivated the department heads, the implementation and sustainability of Lean in Pfisterer (SA) Pty (Ltd) was said to be enormously beneficial.

Upon deciphering each of these factors for the failed or limited success of Lean at Pfisterer, some overall recommendations for further implementation and sustainability of Lean at Pfisterer have become clear, as outlined next.

6.4 OVERALL RECOMMENDATIONS

6.4.1 Recommendations for better implementation and sustainability of Lean at Pfisterer

By understanding the factors that caused the failure or limited success of Lean at Pfisterer, some guiding principles have become clear for the better implementation and sustainability of Lean at the company. The implementation of Lean for the purposes of reducing the amount of labour, as well as the equipment's efficiency, should be re-evaluated on a department by department basis. Grounded on the results of this study, departments with the largest proportions of staff wasting time or equipment inefficiencies (such as the Cut Outs department) could have staff activities and equipment failures scrutinised more closely, while in departments where employees were complaining most about inadequate staff or equipment, a review could be conducted on why such complaints were being made. Then, staff perceptions of what constitutes work and time wastage should be altered to align more with the principles of Lean. Staff could also be reshuffled from departments where there were higher levels of staff-time wasted. To do so will require gathering buy-in from the current staff, a change in the mind-sets of the management and general employees, training, and a reshuffling of employee and equipment locations.

To overcome issues with space, there must be a review of the areas where insufficient factory and/or storage space was noted, and a balance should be created between some areas where space is wasted, and areas where space is insufficient. This will require inter-departmental communication, and a progression towards a more across-the-board implementation of Lean. To do so will require adjustments to the layout of the factory floor, and reshuffling of facilities to create more space in certain areas, with more efficient use of space in others.

Although guiding principles were not always clear from the respondents, an analysis of the literature was helpful in providing some guiding principles to overcome the shortfalls in the current Lean implementation at Pfisterer. For example, in order to improve staff motivation, a systematic approach should be implemented to motivate all the members of the organisation, through multiple schedules of reinforcement, such as with noble, financial and family-based stimuli. In order to overcome problems with the inventory levels on the factory floor, as well as to reduce the amount of late or unavailable raw materials, a *Kanban* card system could be introduced to notify production managers and foremen when inventory levels are low. In so doing, Pfisterer could implement a system of requisitioning the components or items that are needed for each stage in the manufacturing process through electronic or printed tickets, or through better direct communication. By implementing each of these guiding principles, it is expected that failings, such as in factory down-time, would be reduced, resulting in a further increase in product output and client satisfaction.

6.4.2 Recommendations for future research

This study performed a detailed analysis of the implementation and sustainability of Lean at Pfisterer. However, there are various avenues of research that could be followed to fulfil any unanswered questions from this study, as well as to further the knowledge base on Lean implementation and sustainability in other companies in South Africa and globally. Future research could, for example, be performed on the following:

- Gathering a better understanding of what, exactly, employees have been taught on Lean at Pfisterer, in order to refine the training system for teaching Lean as a philosophy at the organisation;
- Researching the reasons why the motivation of the employees at Pfisterer is so low, so that targeted measures can be implemented to improve in this regard;
- Analysing the current methods of inventory management and equipment maintenance to decipher specific flaws in the systems of inventory control and equipment upkeep;
- Studying the actual sales statistics from companies, following the implementation of different Lean techniques to observe where they have

improved the company; and

- Studying the implementation and sustainability of Lean at other organisations that are similar to Pfisterer, in order to observe any similarities in the results of this study, and those organisations.

6.5 SUMMARY

This concludes the study on the implementation and sustainability of Lean practices within the manufacturing environment of Pfisterer Pty (Ltd) in Pietermaritzburg, South Africa. Differences were perceived about the implementation and sustainability of Lean at Pfisterer by the two different samples of stakeholders, where many of the employees thought that the workforce was unmotivated, there were not enough employees, staff wasted much time, space was being wasted, the equipment was inadequate, machines were frequently broken, and that raw materials were often late or unavailable; thus, causing major downtime in the factory. Guiding principles were presented on how to overcome these issues, and for future research that can be done to satisfy any unanswered questions from this study, or to further the knowledge base on Lean implementation and sustainability in companies, globally.

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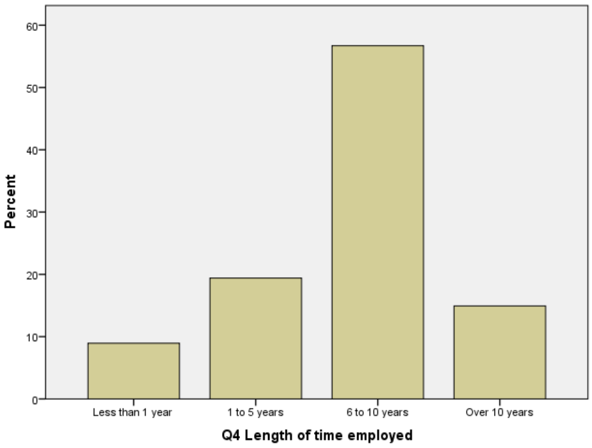
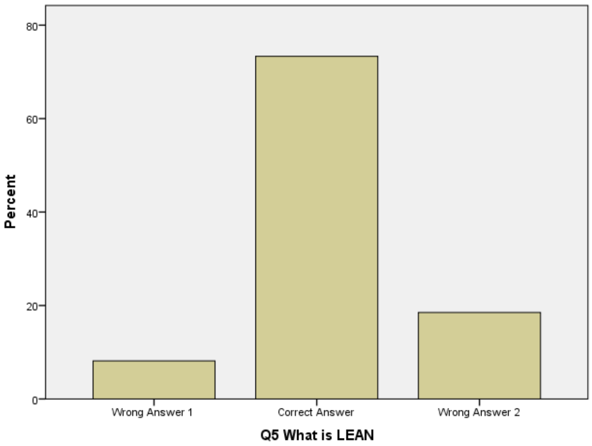
APPENDICES

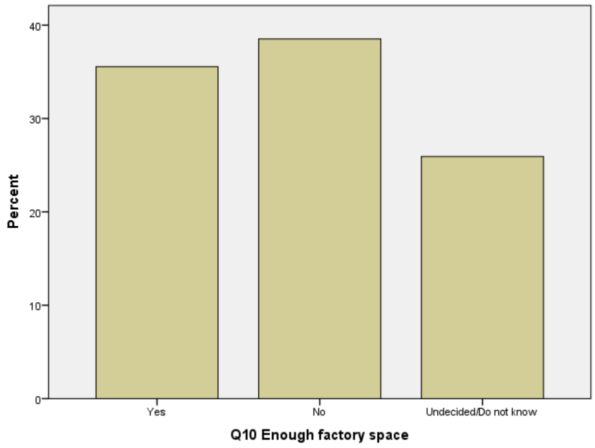
8.1 APPENDIX A: RESULTS NOT IN TEXT

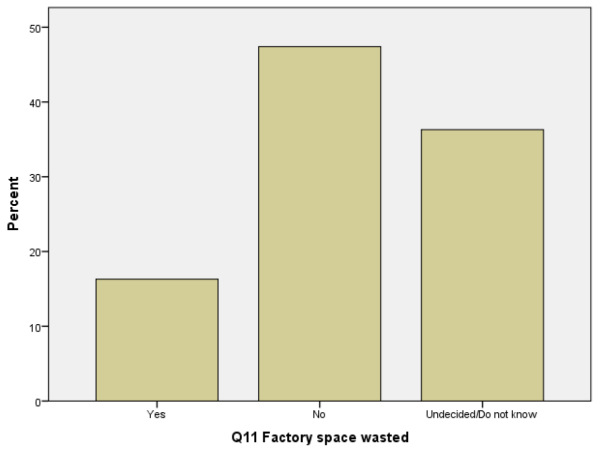
8.1.1 Demographic profiles of respondents in this study

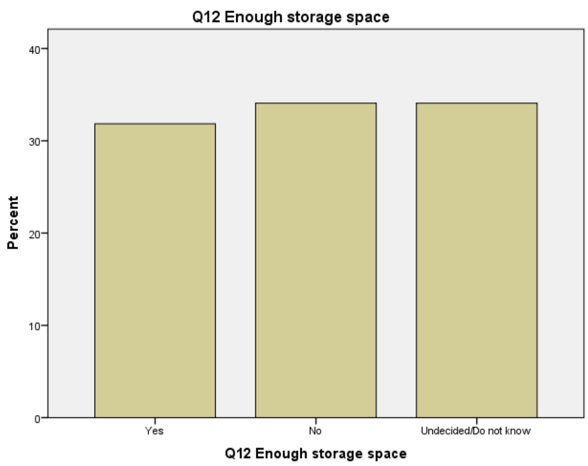


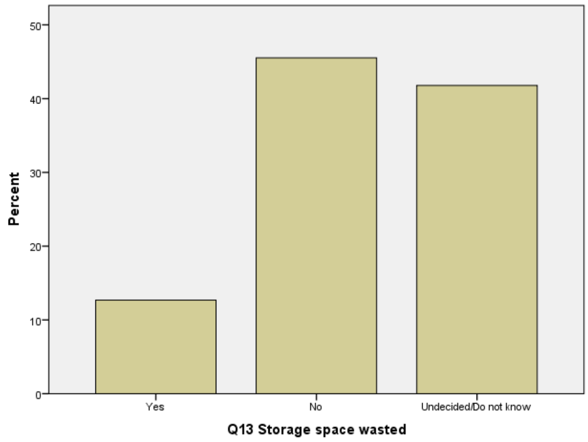


8.1.2 Frequencies of Lean characteristics at Pfisterer, according to the respondents

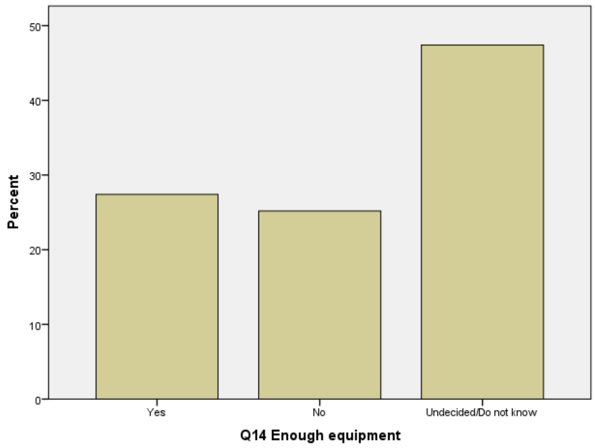








50
40
30
20
10
0
Percent
Yes
No
Undecided/Do not know
Q13 Storage space wasted



50
40
30
20
10
0
Percent
Yes
No
Undecided/Do not know
Q14 Enough equipment

8.1.3 Descriptive statistics of employees, when grouped by department

Table 8.1: Descriptive statistics of employees ever seen wasting time, when grouped by department (Q8)

Department	N	Mean	Median	Mode	Std. Deviation	Skewness	Kurtosis
Silicone Blending	3	0.00	0.00	0	0.000	1.225	
Speed Craft	8	0.25	0.00	0	0.463	1.440	0.000
Spacer Damper	7	0.29	0.00	0	0.488	1.230	-0.840
Ali Foundry	24	0.42	0.00	0	0.654	1.353	0.811
Cut outs	38	0.71	1.00	1	0.515	-0.324	-0.550
Sg Foundry	12	0.75	0.50	0	0.866	0.567	-1.446
General	6	0.83	0.50	0	0.983	0.456	-2.390
Silicone Moulding	31	0.87	1.00	0	0.806	0.246	-1.403
Speed Craft - Wireform	5	1.80	2.00	1	0.837	0.512	-0.612
Rod Plant	1	2.00	2.00	2			

Table 8.2: Descriptive statistics of enough factory space, when grouped by department (Q10)

Department	N	Mean	Median	Mode	Std. Deviation	Skewness	Kurtosis
Silicone Blending	3	0.00	0.00	0	0.000	1.225	
Sg Foundry	12	0.25	0.00	0	0.622	2.555	6.242
Speed Craft - Wireform	5	0.80	1.00	0	0.837	0.512	-0.612
Cut outs	38	0.97	1.00	0	0.854	0.052	-1.644
General	6	1.00	1.00	0	1.095	0.000	-3.333
Ali Foundry	24	1.00	1.00	0	0.978	0.000	-2.077
Spacer Damper	7	1.14	1.00	1	0.690	-0.174	0.336
Silicone Moulding	31	1.16	1.00	1	0.779	-0.297	-1.257
Speed Craft	8	1.38	1.50	2	0.744	-0.824	-0.152
Rod Plant	1	2.00	2.00	2			

Table 8.3: Descriptive statistics of factory space wasted, when grouped by department (Q11)

Department	N	Mean	Median	Mode	Std. Deviation	Skewness	Kurtosis
Cut outs	38	0.50	0.50	0	0.507	0.000	-2.114
Spacer Damper	7	0.57	0.00	0	0.787	1.115	0.273
Speed Craft - Wireform	5	0.60	1.00	1	0.548	-0.609	-3.333
Ali Foundry	24	0.63	0.00	0	0.824	0.834	-0.975
Silicone Moulding	31	0.71	1.00	0	0.783	0.577	-1.102
Speed Craft	8	0.75	0.50	0	0.886	0.615	-1.481
General	6	1.00	1.00	0	0.894	0.000	-1.875
Silicone Blending	3	1.00	1.00	1	0.000	1.225	
Sg Foundry	12	1.08	1.00	2	0.900	-0.185	-1.865
Rod Plant	1	2.00	2.00	2			

Table 8.4: Descriptive statistics of frequency machines were broken, when grouped by department (Q15)

Department	N	Mean	Median	Mode	Std. Deviation	Skewness	Kurtosis
Rod Plant	1	2.00	2.00	2			
General	6	3.00	2.00	2	1.549	0.968	-1.875
Silicone Blending	3	3.00	3.00	3	0.000	1.225	
Sg Foundry	12	3.92	5.00	5	1.929	-0.772	-1.045
Speed Craft	8	4.13	4.50	2	1.885	-0.237	-2.216
Ali Foundry	24	4.25	4.50	6	1.675	-0.311	-1.364
Cut outs	38	4.34	5.00	5	1.457	-1.025	-0.048
Silicone Moulding	31	4.39	5.00	6	1.856	-0.779	-0.845
Speed Craft - Wireform	5	5.00	5.00	5	0.707	0.000	2.000
Spacer Damper	7	5.00	6.00	6	1.528	-1.571	1.971

Table 8.5: Descriptive statistics of frequency machines were not being used, when grouped by department (Q16)

Department	N	Mean	Median	Mode	Std. Deviation	Skewness	Kurtosis
Speed Craft	8	2.75	2.00	2	1.165	1.355	0.620
Rod Plant	1	3.00	3.00	3			
Ali Foundry	24	3.42	3.00	2	1.472	0.446	-0.844
Silicone Moulding	31	3.48	4.00	2	1.610	0.313	-1.365
General	6	3.50	2.50	2	1.975	0.818	-1.953
Spacer Damper	7	3.71	4.00	2	2.059	-0.108	-2.051
Silicone Blending	3	4.00	4.00	4	0.000	1.225	
Speed Craft - Wireform	5	4.00	4.00	4	1.225	-1.361	2.000
Sg Foundry	12	4.08	5.00	6	2.193	-0.623	-1.590
Cut outs	38	4.21	4.50	6	1.773	-0.490	-1.215

Table 8.6: Descriptive statistics of frequency raw materials were late or unavailable, when grouped by department (Q17)

Department	N	Mean	Median	Mode	Std. Deviation	Skewness	Kurtosis
Rod Plant	1	3.00	3.00	3			
General	6	3.33	2.50	2	1.751	0.919	-1.205
Sg Foundry	12	3.75	4.50	1	2.221	-0.340	-1.853
Silicone Blending	3	4.00	4.00	4	0.000	1.225	
Ali Foundry	24	4.33	5.00	6	1.903	-0.648	-1.165
Speed Craft	8	4.38	5.50	6	1.996	-0.546	-2.230
Cut outs	38	4.68	5.00	5	1.526	-1.164	0.246
Silicone Moulding	31	4.71	5.00	6	1.553	-1.076	0.219
Spacer Damper	7	5.43	6.00	6	1.512	-2.646	7.000
Speed Craft - Wireform	5	5.60	6.00	6	0.548	-0.609	-3.333

Table 8.7: Descriptive statistics of the time per year the factory is down, when grouped by department (Q18)

Department	N	Mean	Median	Mode	Std. Deviation	Skewness	Kurtosis
Rod Plant	1	3.00	3.00	3			
General	6	3.33	2.50	2	1.751	.919	-1.205
Silicone Blending	3	4.00	4.00	4	0.000	1.225	
Sg Foundry	12	4.25	6.00	6	2.261	-.654	-1.591
Silicone Moulding	31	4.71	6.00	6	1.637	-.912	-.627
Speed Craft	8	4.75	6.00	6	1.832	-.999	-1.039
Ali Foundry	24	4.79	5.00	6	1.351	-.858	-.468
Cut outs	38	5.08	6.00	6	1.650	-1.542	.829
Spacer Damper	7	5.14	6.00	6	1.464	-2.122	4.735
Speed Craft - Wireform	5	5.80	6.00	6	.447	-2.236	5.000

8.2 APPENDIX B: CHI-SQUARED TESTS (COMPLETE LISTS)

Table 8.8: Job Title (Q2) * All variables

Cross Tab	**Pearson χ2**	**χ2 Sig.**	**Likelihood Ratio (LR)**	**LR Sig.**	**Cramer's V**	**Cramer's V Sig.**	**N of cases**
Q6 General motivation of the workforce	38.719[a]	.001	24.694	.075	.270	.001	133
Q7 Enough employees	6.752[a]	.564	7.225	.513	.159	.564	134
Q8 Employees ever wasting time	5.891[a]	.659	7.529	.481	.148	.659	134
Q9 Time per day employees waste	10.131[a]	.860	9.807	.877	.137	.860	134
Q10 Enough factory space	8.087[a]	.425	9.367	.312	.174	.425	134
Q11 Factory space wasted	6.184[a]	.627	8.655	.372	.152	.627	134
Q12 Enough storage space	6.420[a]	.600	7.367	.498	.155	.600	134
Q13 Storage space wasted	9.255[a]	.321	10.578	.227	.187	.321	133
Q14 Enough equipment	9.409[a]	.309	9.614	.293	.187	.309	134
Q15 Frequency machines are broken	42.962[a]	.002	28.042	.108	.283	.002	134
Q16 Frequency machines not being used	35.724[a]	.017	20.765	.411	.258	.017	134
Q17 Frequency raw materials are late or unavailable	35.940[a]	.016	22.859	.296	.259	.016	134
Q18 Time per year factory down	59.627[a]	.000	25.333	.189	.334	.000	134

Table 8.9: Department (Q3) * All variables

Cross Tab	Pearson χ2	χ2 Sig.	Likelihood Ratio (LR)	LR Sig.	Cramer's V	Cramer's V Sig.	N of cases
Q6 General motivation of the workforce	59.187[a]	.002	49.806	.023	.340	.002	128
Q7 Enough employees	20.900[a]	.182	17.860	.332	.285	.182	129
Q8 Employees ever wasting time	39.955[a]	.001	39.384	.001	.394	.001	129
Q9 Time per day employees waste	30.543[a]	.540	34.300	.358	.243	.540	129
Q10 Enough factory space	31.527[a]	.012	34.079	.005	.350	.012	129
Q11 Factory space wasted	30.419[a]	.016	34.461	.005	.343	.016	129
Q12 Enough storage space	22.736[a]	.121	26.775	.044	.297	.121	129
Q13 Storage space wasted	22.218[a]	.136	21.312	.167	.295	.136	128
Q14 Enough equipment	18.269[a]	.308	19.801	.229	.266	.308	129
Q15 Frequency machines are broken	84.595[a]	.000	69.976	.002	.362	.000	129
Q16 Frequency machines not being used	65.677[a]	.006	57.195	.038	.319	.006	129
Q17 Frequency raw materials are late or unavailable	86.199[a]	.000	61.372	.016	.366	.000	129
Q18 Time per year factory down	78.581[a]	.000	59.554	.024	.349	.000	129

Table 8.10: Length of time employed (Q4) * All variables

Cross Tab	Pearson χ2	χ2 Sig.	Likelihood Ratio (LR)	LR Sig.	Cramer's V	Cramer's V Sig.	N of cases
Q6 General motivation of the workforce	12.142[a]	.434	12.629	.397	.174	.434	133
Q7 Enough employees	5.775[a]	.449	6.045	.418	.147	.449	134
Q8 Employees ever wasting time	12.767[a]	.047	11.028	.088	.218	.047	134
Q9 Time per day employees waste	12.088[a]	.439	14.098	.294	.173	.439	134
Q10 Enough factory space	1.323[a]	.970	1.326	.970	.070	.970	134
Q11 Factory space wasted	18.103[a]	.006	19.168	.004	.260	.006	134
Q12 Enough storage space	7.928[a]	.243	7.764	.256	.172	.243	134
Q13 Storage space wasted	12.583[a]	.050	12.201	.058	.217	.050	133
Q14 Enough equipment	9.475[a]	.149	9.502	.147	.188	.149	134
Q15 Frequency machines are broken	20.346[a]	.159	20.734	.146	.225	.159	134
Q16 Frequency machines not being used	9.178[a]	.868	9.597	.844	.151	.868	134
Q17 Frequency raw materials are late or unavailable	14.540[a]	.485	14.690	.474	.190	.485	134
Q18 Time per year factory down	28.107[a]	.021	24.220	.061	.264	.021	134

Table 8.11: What is Lean (Q5) * All variables

Cross Tab	Pearson χ2	χ2 Sig.	Likelihood Ratio (LR)	LR Sig.	Cramer's V	Cramer's V Sig.	N of cases
Q6 General motivation of the workforce	8.630[a]	.374	8.926	.349	.179	.374	134
Q7 Enough employees	5.063[a]	.281	6.109	.191	.137	.281	135
Q8 Employees ever wasting time	14.478[a]	.006	12.031	.017	.232	.006	135
Q9 Time per day employees waste	10.255[a]	.248	11.338	.183	.195	.248	135
Q10 Enough factory space	8.967[a]	.062	9.972	.041	.182	.062	135
Q11 Factory space wasted	3.630[a]	.458	3.356	.500	.116	.458	135
Q12 Enough storage space	2.251[a]	.690	2.252	.690	.091	.690	135
Q13 Storage space wasted	13.710[a]	.008	12.850	.012	.226	.008	134
Q14 Enough equipment	10.399[a]	.034	12.448	.014	.196	.034	135
Q15 Frequency machines are broken	6.545[a]	.768	7.251	.702	.156	.768	135
Q16 Frequency machines not being used	10.147[a]	.428	10.625	.387	.194	.428	135
Q17 Frequency raw materials are late or unavailable	18.632[a]	.045	18.343	.049	.263	.045	135
Q18 Time per year factory down	9.331[a]	.501	9.835	.455	.186	.501	135

8.3 APPENDIX C: QUESTIONNAIRES

8.3.1 Phase One (quantitative) questionnaire

Employee survey of Lean Principles at Pfisterer

Opening remark:

Thank you for your participation in this study to analyse the perceptions, successes and failures of Lean at Company X.

Notes for completion

- Please complete in English in type or, if hand-written, in block capitals in black ink.
- Please complete the answers with an 'X' in the spaces provided.
- Please do not use abbreviations.
- All information you give will be treated as confidential.
- Please return one completed questionnaire by …………………….
  to:………………………..

	Please provide answer below.
1. What is your name?	
2. What is your job title at Company X?	
3. In which department do you work at Company X?	

4. How long have you been employed at Company X? Please mark 1 box with an 'X'			
Less than 1 year	1 to 5 years	5 to 10 years	Over 10 years

5. Do you know what Lean manufacturing means? Please mark only 1 box with an 'X'	
Lean means **L**oad, **E**xtensive, **A**ssembly-Line, **N**otation manufacturing.	
Lean means never ending efforts to eliminate or reduce 'muda' (Japanese for waste or any activity that consumes resources without adding value) in design, manufacturing, distribution, and customer service processes.	
No, I do not know what Lean manufacturing principles are.	

6. How is the general motivation of the workforce at Company X (South Africa)? Please mark 1 box with an 'X'				
Very motivated	Fairly motivated	Moderately Motivated	Slightly Motivated	Unmotivated

Please mark each question with only one 'X'	Yes	No	Undecided / Do not know
7. Are there enough employees at Company X?			
8. Do you ever see employees without a job to do, or wasting time			

9. How much time do you see employees not working each day? Please mark 1 box with an 'X'				
Up to 1 hour (lunch/tea only)	1-2 hours per day	2-3 hours per day	3-4 hours per day	More than 4 hours per day

Please mark each question with only one 'X'	Yes	No	Undecided / Do not know
10. Is there enough factory space at Company X?			
11. Are any factory spaces wasted?			
12. Is there enough storage space at Company X?			
13. Are any storage spaces wasted?			
14. Are there enough machines or equipment at Company X?			

Please mark only 1 box with an ‘X’	**Less than 1 day each year**	**A few days a year**	**At least once a month**	**A few times a month**	**At least once a week**	**A few times a week**
15. How often do you see machines or equipment not working (because they’re broken)**?**						
16. How often do you see machines or equipment not in use (they work, but are not being used)?						
17. How often are raw materials not available or late at the factory?						
18. How much down time do you see at the factory?						

Thank you for your help!

8.3.2 Phase Two (qualitative) questionnaire

Manager survey of Lean principles at Company X

Opening remark:

Thank you for your participation in this study to analyse the perceptions, successes and failures of Lean at Company X.

Notes for completion:

- Please complete in English in type or, if hand-written, in black ink.
- Please do not use abbreviations.
- All information you give will be treated as confidential.
- Please return one completed questionnaire by ……………………. to:………………………..
- You are requested to fill each of your responses within the spaces provided.
- If you require additional space, please continue on the reverse side of each page.

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1. What is your job title at Company X? Please mark with an 'X'	
Production manager	
Foreman	
2. How long have you been employed at Company X? Please mark with an 'X'	
Less than 1 year	
1 to 5 years	
5 to 10 years	
Over 10 years	

3. **What do you think are the strengths of the organisation?**
Comment:

4. **What do you think are the strengths of the employee teams (individuals)?**
Comment:

5. **What is your opinion on the current leadership style at Company X?**
Comment:

6. **Can you identify areas within the current Lean management style that are working well (the strengths of Lean)?**
Comment:

7. Can you quantify how Lean is currently benefiting the organisation (benefits to the organisation)?
Comment:

8. Can you identify areas in the current management style that are not Lean management (What aspects are not Lean)?
Comment:

9. Are these non-Lean principles working for the organisation?
Comment:

10. Can you identify areas within the current Lean management style that need to be improved (failures of Lean)?
Comment:

11. Can you quantify how these improvements in Lean management would benefit the organisation?
Comment:

12. What structural changes would be required at the organisation to improve these shortfalls of Lean?
Comment:

13. Do you believe the current leadership style will require a significant change to improve these shortfalls of Lean?
Comment:

14. How do you feel about changing the organisation's structure to improve the shortfalls of Lean?
Comment:

15. What challenges do you foresee with making such changes in the organisation (challenges of implementation)?
Comment:

16. Overall, do you believe that Lean is sustainable at the organisation?
Comment:

17. Do you have any other comments or suggestions?
Comment:

Thank you for your help!