Evaluation of the impact of Lean Manufacturing implementation on operational performance in Zimbabwean industries.

By

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Abstract

The rapid rate of increase in competition among the manufacturing industries has caused many organizations to continuously seek improvement in the quality of the products they manufacture to meet and exceed customer expectations. Organizations are under pressure to minimize the production costs to offer competitive prices for their products. The success story of Toyota Motor Company in implementing Lean Manufacturing (LM) has inspired many organizations around the world to adopt LM in order to improve their operational performance. There are, however, mixed results on the impact of LM on operational performance. Some studies have shown that its implementation increases operational performance while others have shown little to no improvement or even negative results.

Institutional and contingency theories may provide insight into some of these contradictions and give a perception of why the implementation of LM has yielded different results on operational performance. The institutional theory states that organizations mimic the actions and practices of other organizations because of the pressure to remain competitive. Organizations in the developing countries also seem to have been imitating the Toyota Motor company that has been successful in implementing LM. On the other hand, the contingency theory states that corporations are organized according to external situations. Related to the contingency theory is the effect of Industry Clockspeed (IC). Some industries are transforming at a high speed while others are transforming at a low speed. The high IC industries are characterized by the quick development and release of new products, shorter development time and frequent changes in organizational structures. Low IC industries, however, manufacture products with a long life cycle, thus the products, processes and organizational structures for these industries change only after a long period. This study opines that the environment under which an organisation operates may affect the results of LM implementation process.

The research was conducted in three parts and each of these parts is presented as chapters in this thesis. The first part (Chapter 4) gives a review and classifies the impact measurement models that have been used by various researchers to measure the success of implementing LM. These models can be classified as quantitative, qualitative, simulation-based and graphical measurement models. Pareto analysis is used to select the type of measurement model and Lean practices that are frequently used by researchers to develop Lean measurement models. The qualitative measurement model was preferred for evaluating the effect of implementing LM on

operational performance because of its ability to use question structures that allow qualitative data collection for a rich analysis of opinion. With a proper structure, the questionnaire items can also be parsed and analyzed quantitatively with modern statistical techniques like Structural Equation Modelling. The Lean practices selected were Just In Time (JIT), Jidoka, People integration and Stability and standardization for building the model. This part concludes by developing a structural model that can be used to measure the impact of Lean implementation in industry, using Zimbabwean industry data.

The second part (Chapter 5) evaluates the effect of implementing LM tools on operational performance across various industries in Zimbabwe. The major goal of this chapter was to develop an operational model (based on the lead from chapter 4) and test it in manufacturing organizations across various industries. A structured survey questionnaire was used for the collection of data in identified companies and 214 useful responses were obtained. The results of the study indicated that operational performance was improved by implementing the selected LM tools. The performance improvement variables that were significantly influenced were speed, flexibility and dependability.

The third part (Chapter 6) analyzed the moderation effect of IC on the relationship between LM tools and operational performance. The industries grouped under low IC were pharmaceutical, agrochemicals, steel, automobile, timber production, battery, chemical and plastics. The high IC industries were food, beverage, electronics and garment. A structural equation model was proposed and investigated across the two groups. A structured survey questionnaire was used to collect empirical data from manufacturing companies. The data obtained from the responses was analysed using Smart PLS 3 and SPSS version 25. The results of the study showed that IC had a moderating effect on the relationship between LM practices and operational performance for both low and high IC industries.

The last chapter summarises the findings, made recommendations and proposes directions for further research.

Publications

1. Maware, C. and Adetunji, O. (2019), Lean manufacturing implementation in Zimbabwean industries: Impact on operational performance, International Journal of Engineering Business Management Volume 11, page 1–12, DOI: 10.1177/1847979019859790

2. Maware, C and Adetunji, O. (2018), 'Lean Impact Analysis Assessment Models: Development of a Lean Measurement Structural Model', World Academy of Science, Engineering and Technology, International Science Index 137, International Journal of Mechanical, Aerospace, Industrial, Mechatronic and Manufacturing Engineering, 12(5), 554 - 561.

3. Maware, C. and Adetunji, O. (2019), The moderating effect of Industry clockspeed on Lean Manufacturing implementation in Zimbabwe, The TQM journal, Accepted for publication.

Dedication

I dedicate this thesis to my family; my two daughters Serenity Anenyasha and Salome Anotida Chimoto and my husband, Trust Chimoto.

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Lastly, I give glory to the Lord Jesus Christ. I can do all things through Christ who strengthens me.

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Abbreviations

LM: Lean Manufacturing

IC: Industry Clock speed

JIT: Just In Time

TQM: Total Quality Management

SEM: Structural Equation Modeling

TPM: Total Productive Maintenance

CM: Cellular Manufacturing

HRM: Human Resources Management

LE: Large Enterprise

SME: Small to Medium Enterprise

VSM: Value Stream Mapping

CSM: Current State Map

FSM: Future State Map

DMAIC: Define, Measure, Analyse, Improve and Control

LCO: Liquids, Creams and Ointments

QPI: Quality and Productivity Improvement

ANOVA: Analysis of Variance

SI: Statutory Instrument

CZI: Confederation of Zimbabwean Industries

Partial Least Squares- Structural Equation Modelling: (PLS-SEM)

SPSS: Statistical Package for Social Sciences

KPI: Key Performance Indicators

DTD: Dock-To-Dock

RCA: Root Cause Analysis

LPI: Lean Production Index

HPM: High Performance Manufacturing

Chapter 1: Introduction

1.1 Introduction

Globalization is having an impact in every country because it allows organizations to have access to customers and suppliers all over the world. The customers benefit a lot from it because they can buy goods from any location on the globe through digital networks. This has exposed them to greater variety, better quality and competitively priced goods. On the other hand, firms are under pressure to reduce production costs and lower prices for consumers. To achieve this, many firms are seeking ways to increase productivity, utilize resources efficiently and enhance operational performance so that they will be able to withstand competitive pressures.

This has led many organizations to develop an interest in measuring and comparing operational performance against set strategic aims, objectives and goals. Performance measurement acts as a compass that provides information about the past, current and anticipated position of a firm. It also quantifies the effectiveness and efficiency of operations so that an organization can improve its processes and capabilities. Performance measurement is crucial because it helps to monitor and maintain the activities of an organization so that the overall goals and objectives are achieved.

Many organizations are implementing diverse performance improvement techniques to make them competitive. Since the early 1990s, techniques such as Total Quality Management (TQM), Six Sigma, Business Process Re-engineering (BPR), Total Productive Maintenance and Lean Manufacturing (LM) have been used to improve business operations Griesberger et al. (2011). This research will focus on the implementation of LM in manufacturing companies. This philosophy has been applied by manufacturing organizations to eliminate waste in the production systems as well as to aid in meeting customer expectations.

1.2 Background of the problem

LM is arguably one of the most influential philosophies of the twentieth century which continues to hold sway. Since the birth of LM, its adoption has been pervasive, and even more recently, has made an inroad into the services system (Khan et al., 2019, Allway and Corbett, 2002), whereas it was initially embraced in the manufacturing sector (Ghosh, 2012). Several studies have shown that its implementation results in enhanced productivity, product quality, reduced defects and delivery lead times, increase in capacity and machine availability (Jasti and Kodali, 2019, Chauhan and Chauhan, 2019, Shrafat and Ismail, 2019, Maskell et al., 2016, Cirjaliu and Draghici, 2016, Abolhassani et al., 2016). This has led many organizations around the world to implement the philosophy when faced with challenges to remove waste and remain sustainable. However, Braglia et al. (2019) state that universally, not all Lean initiatives have been successful. This occurs because some companies implement LM gradually to get quick fixes, increase quality and reduce costs (Liker and Morgan, 2006). Hence, not all manufacturing organizations have had positive results and only 10percent or less of the companies succeed in Lean implementation (Baker, 2002; Browning and Heath, 2009 and Vienazindiene and Ciarniene, 2013).

The economy of Zimbabwe has faced many economic hindrances over the past ten years which has made the manufacturing sector difficult to grow (Mlambo, 2017). Its economy continues to decline even though the country has ample land and natural resources. Although natural resource exploitation is increasing (Spiegel, 2015), its manufacturing sector has been declining. This has been caused by escalating inflation, high costs of inputs, foreign currency shortages, poor infrastructure, old machinery and non-conducive investment policies. This has led the capacity utilization to decline from 47.4% in 2016 to 45.1% in 2017 (AfricanDevelopmentBank, 2018) and by November 2018, it further declined to 42% (OldMutualInvestimentGroup, 2019). Despite the decrease in capacity utilization, many companies are improving their operations to get benefits of the export incentive scheme that was introduced by the government to encourage and increase the production of local goods. The government also introduced the Statutory Instrument (SI) 64 of 2016 that eliminated 43 goods from the open general import license to foster local manufacturing, thus decreasing the import bill (Murangwa and Njaya, 2016, Moyo, 2017).

The economic instability over the past few years has caused some manufacturing firms to embrace the philosophy of LM to improve operational efficiency, quality, capacity utilization, delivery time and reduce the prices of goods. The Lean Institute of Africa in conjunction with the Confederation of Zimbabwean Industries (CZI) have been aiding companies to implement LM in Zimbabwe (Gapa, 2015). This has helped many organizations to lower the production costs so that their prices become cheaper compared to international competitors leading to value creation for the customers and investors.

Although LM has been adopted by many companies in Zimbabwe, no research that has been conducted to evaluate how the philosophy has affected operational performance for the manufacturing industries. Studies conducted by (Goriwondo and Maunga, 2012, Goriwondo et al., 2011, Goriwondo et al., 2013, Chisosa and Chipambwa, 2018, Dzanya and Mukada, 2015, Gudukeya and Mbohwa, 2013, Madanhire et al., 2013, Muvunzi et al., 2013) reported the impact of implementing LM for individual companies. This has led managers to be hesitant to implement the practice, though they do not question its ability to bring positive results to their organizations. It becomes important to study the achievements of the different Lean adopters and to understand the factors that are probably responsible for the success or failure of Lean implementation processes. Understanding such factors should make it possible to guide Lean implementation to always achieve good results.

The failure to successfully implement Lean manufacturing may result from a rush to become Lean (Ben Fredj-Ben Alaya, 2016), implementation of the philosophy in a fragmented manner (Negrão et al., 2016), lack of deeper understanding of Lean manufacturing and its practices (Pavnaska 2003, Mostafa 2009), piecemeal adoption of the practice and use of different methods to measure Lean performance (Fullerton and Wempe, 2009). As a result, any attempt to compare these implementation processes and their achievements throw up a lot of problems immediately. There is no common understanding of what constitutes Lean implementation in Zimbabwean industries, or what parameters are to be measured as achievements of Lean deployment. This makes it nearly impossible to compare most reports of Lean implementations in most companies because researchers have proposed different performance models to measure the impact of Lean practices on operational performances (Belekoukias et al., 2014). Also, considering what most companies that claim to be professional Lean implementers offer differs significantly from what most academics have reported being the published structure of the underlying Lean system. This shows that there may be a mismatch between theory and practice. This study aims to evaluate the impact of implementing LM practices in the Zimbabwean industries.

Manufacturing companies are now operating in a highly complex and competitive environment and should engage in Lean thinking initiatives to improve their manufacturing processes. The rate at which new products are being released into the market is increasing. This has led the manufacturing processes and the organizational structures to change as well. The phenomenon is referred to as the impact of Industry Clockspeed (IC). IC is defined as the rate of change products, process technologies and organizational structures of an industry (Peng et al., 2013, Fine, 1996, Meijboom et al., 2007). It can affect the impact of LM on operational performance in manufacturing organizations. A study by Chavez et al. (2013) revealed that IC acted as a moderating variable on the relationship between internal LM practices and operational performance. A moderator is a third variable that influences the strength or direction of the relationship between the independent and dependent variable. The study will evaluate the moderating effect of IC on operational performance.

1.3 Problem Statement

The evidence of improvement on operational performance for Zimbabwean industries that have implemented LM is still a major question in the manufacturing sector. This is because studies conducted by researchers are so diverse making it difficult to understand the impact of LM on these industries. There is also a gap between the model used by industry practitioners and models used in academia to measure the impact of LM implementation.

The foregoing is compounded by the fact that the Lean toolbox is made up of so many techniques such that it is difficult to state clearly the order of implementation of these practices. Lean implementation has been noted to require a cohesive set of techniques (Cua et al., 2001). Theoretically, more than one hundred Lean improvement techniques have been documented in the literature. A pertinent question concerns the minimum number of Lean techniques to be implemented together before such an implementation process is considered acceptable. For instance, if a firm does only VSM and then implement a number of cause and effect analysis techniques like the 5-whys, affinity diagram and/or Ishikawa diagram, (which is common in some observed and documented Lean implementation processes), can it therefore, be argued that it has implemented Lean manufacturing or not? To this end, there is a need to evaluate the effectiveness of LM implementation so that the benefits obtained from the implementation may be sustained.

The degree of change in an industry is of paramount importance to industry practitioners. This is referred to as the concept of Industry Clockspeed (IC). Organizations that operate in a fast clockspeeds environment evolve quickly and are characterized by abrupt changes in manufacturing processes, product design and organizational strategies. The slow clockspeeds industries have a fairly stable organizational structure, low product obsolescence and process technology replacements rates. The available literature lacks evaluation of how IC acts as a moderating variable on the relationship between internal and external LM practices and operational performance. Internal Lean practices are tools and methods that address problems of waste inside an organisation. External practices are techniques that are applied by organizations to reduce non-value added activities between an organization and customers and suppliers. This thesis therefore, addresses the problem of the absence of a measurement model to evaluate the effect of LM practices on operational performance in slow clockspeed and fast clockspeed industries.

1.4 Research questions

The study answers the following research questions:

Q1: What is the impact of internal and external LM practices on operational performance?

Many organizations in Zimbabwe have implemented LM practices, but no study has been conducted to analyze how LM has affected operational performance in Zimbabwean industries. The study of the literature revealed that there are few documented research papers on LM in Zimbabwe. A diverse number of LM practices have been implemented by companies and the frequently used practices were Visual Control (VC), JIT, Cellular Manufacturing (CM), Jidoka, Total Productive Maintenance (TPM), Stability and standardization, Kaizen, People integration. Diverse methodologies for Lean deployment and different measurement models for impact assessment of Lean implementation on organizational performance have also been proposed in the literature. The research aims to review the different measurement models of Lean manufacturing that are available in the literature and propose a new measurement model based on a construct that seems pervasive from the Zimbabwean industry perspective

Q2: To what extent does IC moderate the correlation between LM practices and operational performance?

The degree of change of product design, process technologies and organizational structure should be considered for a successful implementation of LM practices. This research suggests that an environment under which an organization exists will affect the LM practices adopted by managers. The study will therefore, analyze the moderation effect of IC on the relationship between LM and operational performance.

1.5 Research objectives

The objectives of the study were to:

- To evaluate the different types of impact performance models used for measuring Lean implementation success (Chapter 4). The objective would be achieved through:

- Identifying the Lean measurement models used by different authors in literature.
- Grouping the Lean measurement models into four categories which are qualitative, quantitative and graphical and simulation.
- Analyzing and identifying the frequently used method of evaluation using Pareto analysis.
- Selecting the evaluation method to be used.

- To analyze the impact of LM on operational performance across Zimbabwean companies (Chapter 5). The objective would be achieved through:
    - Developing a model using Structural Equation Modelling (SEM) technique that assesses the impact of LM practices on operational performance.
    - Analysing the effect of the LM practices on operational performance using SmartPLS 3.

- To analyze the impact of IC on the relationship between internal and external LM practices and operational performance (Chapter 6). This objective would be achieved through:
    - Developing a model and validating the impact of IC in the fast and slow IC industries in Zimbabwe.

1.6 Contribution to Knowledge

The research will contribute to the literature in the following ways:

- An evaluation of the LM measurement models found in the literature. The benefits and demerits of using each method will be explained. The commonly used method will be selected for evaluating the impact of implementing LM on operational performance in Zimbabwean industries.
- Development of a Lean measurement model based on Structural Equation Modelling that assesses the impact of LM implementation. This evaluation is not only crucial for the current implementations but also future implementation

endeavors. The evaluations can also provide evidence for the ability of LM to maintain long term benefits for organizations.

- An empirical assessment of the moderating effect of IC on the relationship between LM practices and operational performance.

1.7 Thesis framework

The framework shown in Figure 1.1 shows the sequence of activities done by the researcher in conducting the research.

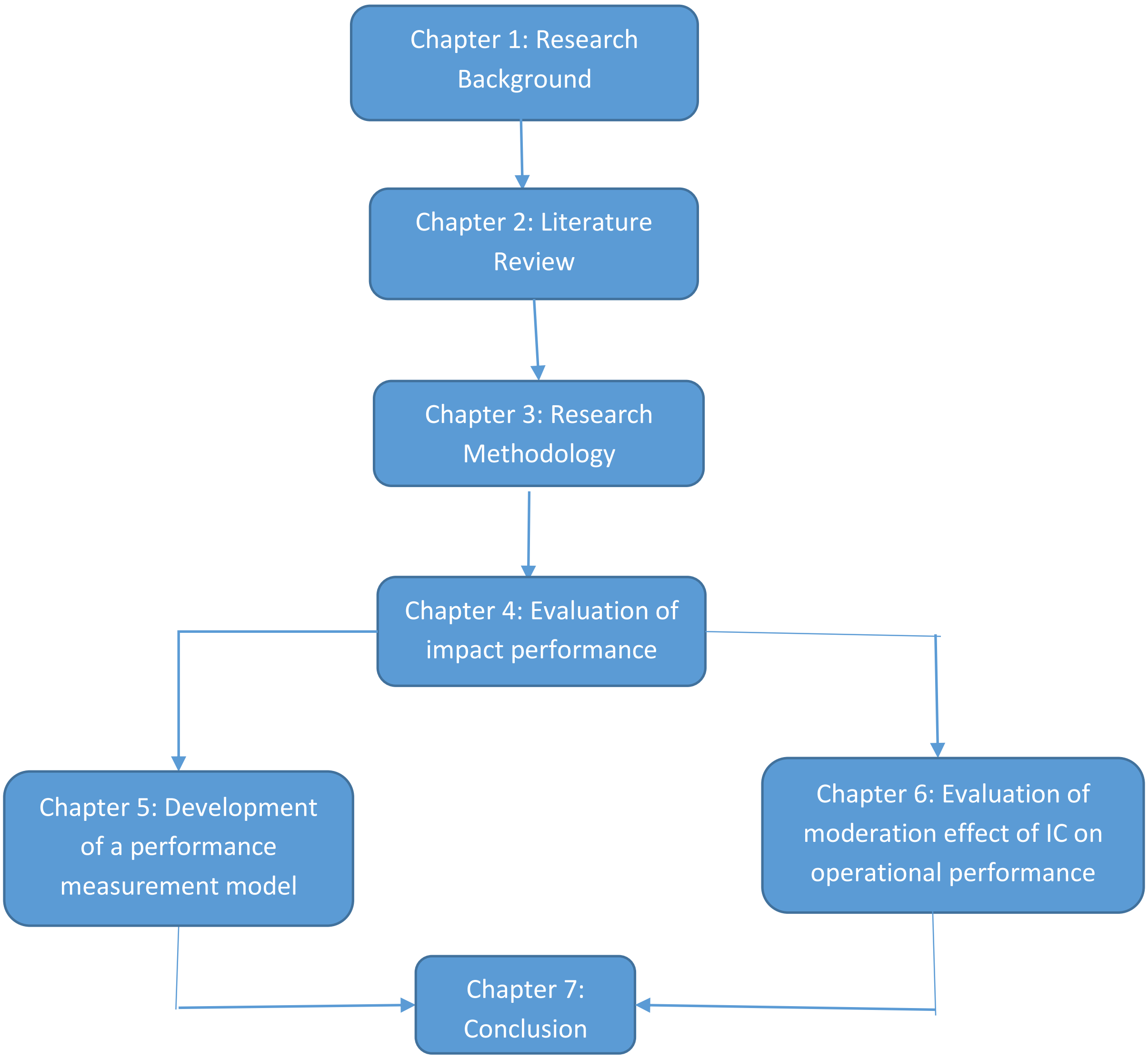

Figure 1. 1: Thesis Framework

The thesis has seven chapters. Chapter 1 outlines the background of the problem, statement of the problem, objectives, as well as research questions. The chapter also explains the major contributions of the study to the existing literature. Finally, the chapter ends by giving an overview of the subsequent chapters presented next.

Chapter 2: Literature review

The chapter describes the available literature on LM. It gives the terminologies found in literature and the measurement models that have been used by researchers to evaluate the effect of LM on operational performance. Then, it describes the Toyota Production System (TPS) house that has been used by other organizations to implement LM. The chapter also explains the studies of organizations that have implemented LM in Zimbabwe. The chapter ends by highlighting the research gap.

Chapter 3: Methodology

The chapter outlines the method that was used in assessing the results of the study. It also gives a detailed description of the Partial Least Squares- Structural Equation Modelling (PLS-SEM) technique. It explains the major advantage of selecting this method among other multivariate techniques. The development of a survey questionnaire and how data was collected in Zimbabwean industries is also explained. A detailed discussion of how to conduct this analysis and interpreting the results is also given.

Chapter 4: Development of the Lean assessment model

The chapter presents the development of the model that is used for assessing the impact of LM on operational performance A description of the four types of impact measurement models used for measuring the success of LM implementation which are quantitative, qualitative, simulation-based and graphical models is given. The chapter also gives the drawbacks of having diverse lean measurement models. It then uses Pareto analysis to select the frequently used Lean bundles for evaluating operational performance. It also links these bundles to the Toyota Production System house that is used by Toyota in its operations. SEM is selected in building the model because it allowed the researchers to validate the relationships between the bundles. It ends by developing a lean measurement model.

Chapter 5: Evaluation of the impact of internal and external Lean practices on operational performance

The chapter explains the evaluation of the effect of internal and external LM practices on operational performance. It starts by developing a model using LM practices used by organizations in Zimbabwe. A questionnaire is designed that is used for data collection in organizations that have implemented LM from the plastics, agrochemicals, pharmaceutical, automobile, food, steel, beverage, timber, garment, battery, electrical and electronics manufacturing companies. SmartPLS 3 and Statistical Package for Social Sciences (SPSS) version 25 are used for data collection. The chapter finds that the deployment of LM practices increases operational performance.

Chapter 6: Development of Lean assessment model to measure the moderating effect of industry clockspeed on the relationship between LM practices and operational performance

The chapter describes the development of a Lean assessment model that evaluates the moderating effect of IC on LM practices. Data is collected from 214 companies registered with the Confederation of Zimbabwean Industries (CZI). The statistical analysis software, SPSS version 25 and SmartPLS 3 are used for data analysis. The results revealed that the IC has a moderating effect on the relationship between LM and operational performance for both high and low IC industries in Zimbabwe.

Chapter 7: Conclusion and areas of further study

The chapter summarizes the significance of the study and the contribution of the research to the existing literature. It ends by giving limitations and areas of further study for the research.

Chapter 2: Literature review

2.1 Introduction

The following chapter investigates the available literature on LM and describes the studies that have been conducted by researchers on this philosophy. The chapter also discusses the LM practices and evaluation methods given in the literature. Its major aim is to highlight the gap in the literature on the impact of implementing LM on operational performance.

2.2 Brief history of Lean Manufacturing (LM)

The Toyota Production System (TPS) was first introduced by Taiichi Ohno in a bid to lower the raw material usage and increase productivity and efficiency of Toyota. The process was aimed at examining and removing non-value adding activities from the conception of the production processes to the final release of the product. Ohno got inspired by Henry Ford's theory on Mass Production strategy. However, he found it difficult to adhere to Mass Production due to the economic situation that was in Japan after World war II, which had a low demand for mass-produced vehicles. TPS helped in the production of small volumes of numerous car models at a low cost. This led to a reduction in inventory, production costs and lead time. As a result, Toyota managed to improve on the quality of their products and to meet customer specifications.

This concept was then termed Lean Manufacturing (LM) by Krafcik in 1988 which meant using less of raw materials, space and human labour. Its major aim was to reduce waste from the receiving of the raw materials to the final release of the product to the customer. Several Lean practices were developed to sustain this philosophy. Many definitions of LM have been presented in literature and no standard term has been proposed for this philosophy Tiamaz and Souissi (2019), (Stentoft Arlbjørn et al., 2011). These definitions are evasive and incomplete which may make it difficult for Lean practitioners to implement it successfully (Mostafa et al., 2013). Jørgensen and Emmitt (2008) state that there is no common definition that has been established for LM and as a result, numerous definitions for this philosophy have been formed. Yang et al (2011) define it as a group of tools aimed at minimizing wastes and non-value added activities in a production setup. It has also been defined as a multidimensional approach that includes Just In Time (JIT), quality system, different management practices, work teams, cellular manufacturing and supplier management in an integrated system to reduce waste (Shah and Ward, 2007).

2.2.1 Types of waste

The Japanese name that is used for the word waste is Muda, Muda/ waste is defined as any task or action that the customer is not eager to pay for (Xiong et al., 2019). It can also be referred to as any non-value added activity. Womack and Jones (2013) describe waste as any worker action that does not produce value for the customer after consuming resources, the errors that need to be fixed, the creation of more products than required and storing them in warehouses, any unnecessary activity, the movement of material and workers that are not necessary. Waste can be categorized into seven types which are: transportation, inventory, motion, waiting, over-processing, overproduction and defects

Transport waste refers to the conveyance of material or products from one place to the other (Allen et al., 2019, Sundar et al., 2014, Taylor et al., 2006). This type of waste does not add any value or transform product hence consumers are not willing to pay for such an action. This type of waste is caused by poorly designed process layouts, overproduction, material handling systems that are complex, large batches and having several storage points (Alves et al., 2015, Kilpatrick, 2003, Detty and Yingling, 2000).

The inventory waste is defined as any materials, parts or products that are in surplus and are not required by the customer (Hicks, 2007, Elnamrouty and Abushaaban, 2013, Belvedere et al., 2019). Any inventory that is stored before or after any manufacturing process indicates that there is no continuous flow of parts within the production system. The high level of inventory in the production system is caused by overproduction and poor workflow such that there is a buildup of materials at certain processes within the production system. This results in organizations tying up capital that could be used in other business processes (Kilpatrick, 2003). Costs can also be incurred to transport products to warehouses where they are stored, preserve products in a good state, buying an insurance and in administrative expenses of tracking products (Wild, 2017, Koumanakos, 2008). Inventory waste can be eliminated through pull production where the production process is initiated by customer demand and minimizing lot sizes (Karlsson and Åhlström, 1996).

The unessential movement of workers or material within the production system is called a waste of motion (Vamsi et al., 2019). This includes bending, searching for materials, lifting objects and moving (Radnor et al., 2012, Yusuff and Abdullah, 2016, Womack et al., 2009). This waste is normally caused by poorly designed workspaces. Organizations need to redesign jobs that have exorbitant movement of workers since health and safety issues is now a major concern for employees (Schonberger, 2019).

The waiting waste occurs when workers are waiting for materials to be delivered to them or when a machine is not performing any operation. This waste normally occurs as a result of unevenness in the production facility as materials may be ready to move to the next step but the process will not be able to accommodate these materials (Vamsi et al., 2019). Bottlenecks and lack of movement of materials within the production system may also cause the waiting time to increase (Elnamrouty and Abushaaban, 2013). This waste can be eliminated by redesigning the production flow to enable a continuous flow of materials, training of workers to be multi-skilled so that they can handle multiple operations and initiating standardized work (Parks, 2003, Curado, 2019).

Overproduction occurs when organizations manufacture more products than what is needed by the customers (Elnamrouty and Abushaaban, 2013). It occurs when organizations produce more goods in anticipation of demand (Just in case), leading to stockpiles in warehouses or at different work stations. This makes defects difficult to detect and increases inventory holding costs (Demirel et al., 2019, Nimeh et al., 2018). Overproduction is also the major driver of the following types of wastes; inventory, waiting, transportation, defects and motion. It can be eliminated by using pull production.

Over-processing occurs when more operations are performed on a product than what the consumer needs (Malek et al., 2018, Gupta et al., 2018, Coetzee et al., 2019). The kind of work done does not add value to the end-users and as a result, increases the amount of raw materials and labor required. In addition to that, there is wastage of time and energy. Over-processing can be avoided by understanding the customer requirements before any product is produced.

A defective product is a product that has a poor quality which might need to be scrapped or reworked (Sunder M and Antony, 2018, Goshime et al., 2019). This product would have drifted from the set standard that is required by the end-user and hence is not fit for use. The costs associated in handling defective products are the cost of re-inspection, isolating defective products and rescheduling. Countermeasures for eliminating defects include the design of a system that captures defects before they proceed to the next stage, redesigning the production process and applying standardized work (De la Vega-Rodríguez et al., 2018).

2.3 Merits of LM

The Implementation of LM has been reported by Bhasin and Burcher (2006) as a major drive that enhances competitiveness. The philosophy is aimed at increasing customer value whilst reducing waste. This enhances customer satisfaction which in turn boosts sales.

Lean also promotes the production of high quality products at a reduced lead time, thus products are produced at the pace of customer demand. Another benefit of Lean is that it improves sustainable performance in organizations. This is because the management practice enhances continual improvement, value creation, worker involvement and waste reduction.

While there is an extensive publication on the benefits of LM, the concept of LM is still underdeveloped for two reasons; lack of clear and agreed definitions of LM terms (Vujica Herzog and Tonchia, 2014); and a gap between the model used by industry practitioners and models used in academia to measure the impact of LM implementation.

2.4 Proliferation of terminologies

LM utilises many terms and concepts, and all these need to be clearly perceived in an integrated structure. Lean terminologies found in selected literature can be grouped into eleven broad categories. These broad terms are Lean tools, Lean practices, Lean strategies, Lean methods, Lean constructs, Lean bundles, Lean techniques, Lean dimensions, Lean factors and Lean elements. Table 2.1 shows a summary of Lean terms and number of authors who used these terms in a review of 170 academic papers that were selected by filtering publications that contained LM terms and performance measurement models in their abstracts.

Table 2. 1: Lean manufacturing terms and the number of authors that used these terms.

Lean broad terminology	Number of associated terms	Number of authors
1. Tools	196	50
2. Practices	261	43
3. Techniques	59	14
4. Methods	98	13
5. Strategies	18	4
6. Factors	61	4
7. Constructs	108	18
8. Bundle	27	10
9. Latent structures	20	3
10. Elements	42	7
11. Dimensions	20	4

The table shows that there are different terminologies found in the selected literature and authors use any term they are familiar with. These Lean terms can be classified into two categories which are the lower level and higher level terms. The lower level encompasses tools, practices, techniques, strategies, methods and elements. The higher level encompasses the bundles, factors, latent structures, dimensions and constructs.

2.5 Text analysis and visualisation

In identifying Lean terms and for subsequent text analysis, two techniques were utilised: a thematic analysis of the textual records was done using Atlas Ti; network visualisation and descriptive network analysis were done using R programming package. Atlas Ti was used for identifying the Lean terms used in literature and drawing network diagrams to show the inconsistency of use of the terms by authors. A spreadsheet was generated from the Atlas Ti co-occurrence and related analytical tools, which serve as an input into the R package to create network diagrams for better visualisation and to extract the Lean higher level terms (the constructs). These constructs were later used in building the Lean measurement model.

For coding the categories of Lean, the first three letters for the code in each category were used, therefore the following codes were developed: Lean tools (LTO), Lean techniques (LTE), Lean practices (Mackelprang and Nair), Lean strategies (LST), Lean methods (LME), Lean Elements (LEL), Lean bundles (LBU), Lean constructs (LCO), Lean dimensions (LDI) and Lean latent structures (LLS). Each category had objects that fell under it, and these were referred to as terms. For coding terms, the first three letters in the term or the first letter in each word in the term was used. For example, if JIT was used as a Lean tool, the code would be given as LTO_JIT or if kaizen was used as a Lean practice, the coding would be LPR_KAI. The same method was used for the authors whereby the first three letters in the first author would be used. For example, the coding for Bevilacqua et al. (2017) would be BEV_01. The number 01 was used because some authors had more than one paper. This taxonomy was referred to as codes in Atlas Ti.

Network diagrams drawn using Atlas Ti showed that Lean terms were being used interchangeably by authors. An example of an analysis of a network of Lean categories in Atlas Ti is presented in Figure 2.1. This figure indicates that based on the documentation of the authors, JIT has been presented as a lower level term and a higher level term at the same time, showing that there is confusion about the level it belongs to. It has been presented as a Lean technique, Lean construct, Lean practice, Lean method, Lean dimension, Lean strategy, Lean tool, Lean element and Lean bundle. A similar diagram can be shown for other terms as well. This suggested that these terms were not appropriately defined or classified by the authors.

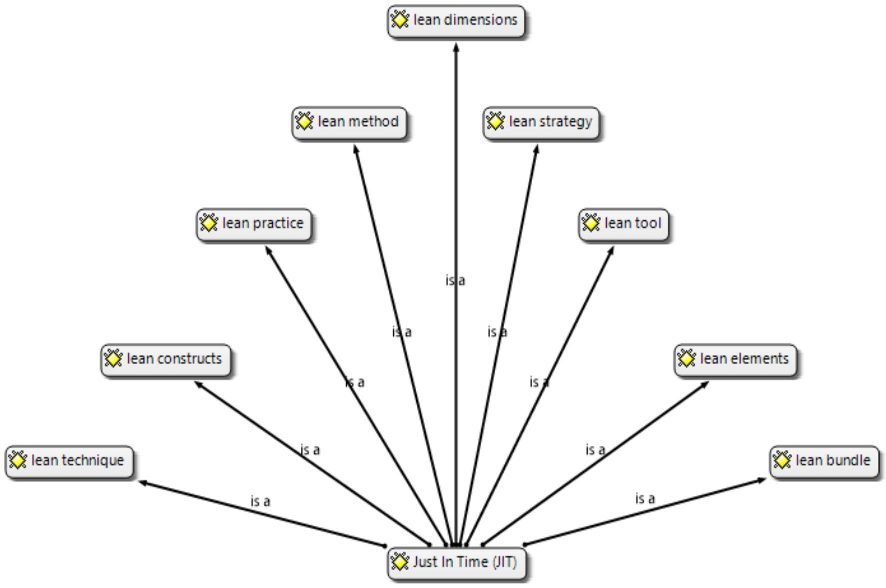

Figure 2. 1: The broad classification of JIT

Thirty-three network diagrams were generated. The diagrams for lower level terms, i.e. tools, practices, techniques, methods, strategies and elements could not be used because of the denseness of the diagrams. Graphs for high level terms like constructs, bundles, latent structures, dimensions and factors were also generated. However, the graphs for latent structures, dimensions, constructs and factors were not chosen because they showed that the authors used the terms independently. Therefore, the diagrams for Lean bundles were chosen because they showed a reasonable level of agreement between the Lean terms. Figure 2.2 shows a one-node network diagram for Lean bundles. A one node network diagram shows how the authors have used LM bundles in literature. The circles represent the lean bundle terms whilst the lines show how they are connected. The graph shows that there were three clusters formed between the bundles. The thickness of the edges indicates the level of agreement between the authors. The edges linking JIT, HRM and TQM were thick meaning that the authors used these terms together with other terms.

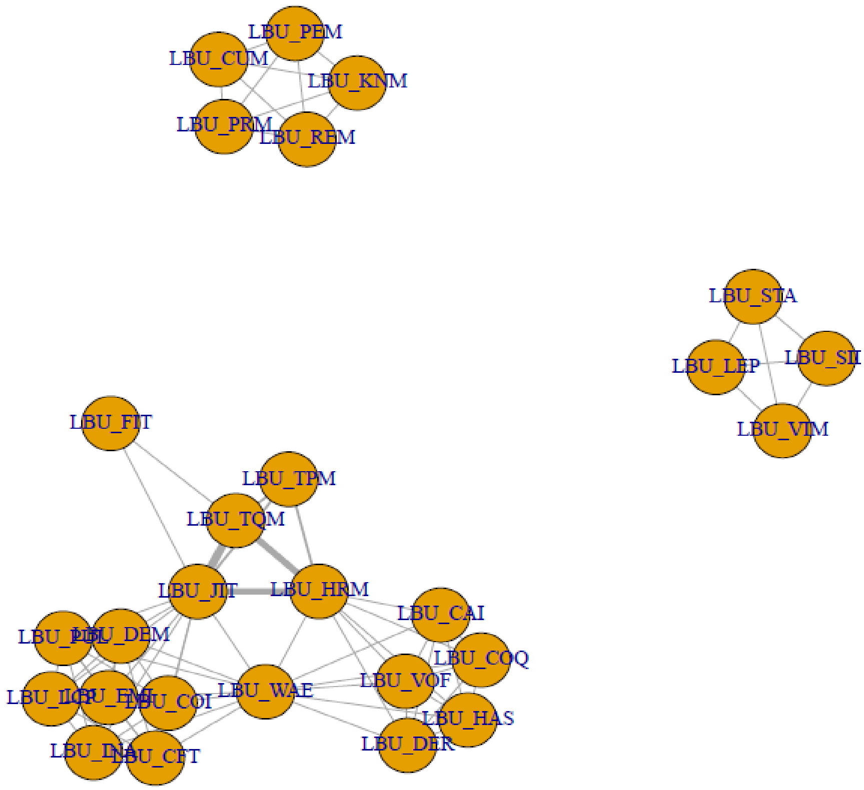

Figure 2. 2: Lean bundles network terms

A one-mode network diagram generated for the authors who used the term bundles showed that there were three communities. Two communities with the authors such as Birkie and Trucco (2016) and Tekez and Taşdeviren (2016) did not share any term with the other authors. The authors such as Papadopoulou and Özbayrak (2005), Shah and Ward (2007), Furlan et al. (2011), Dal Pont et al. (2008), Bortolotti et al. (2015), Jadhav et al. (2014), Al-Hyari et al. (2016) and Wickramasinghe and Wickramasinghe (2017) shared terms. These are shown in Figure 2.3.

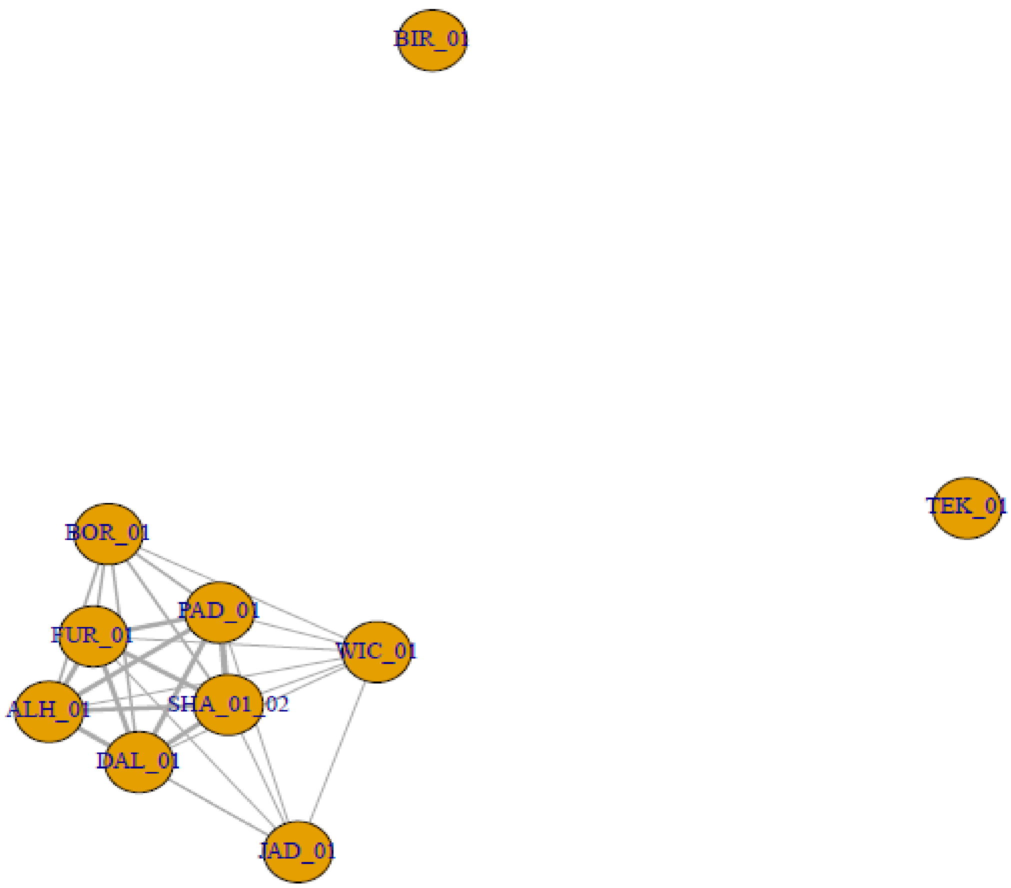

Figure 2. 3: one- mode network for the bundle authors only.

The literature revealed that there is a lack of systematic, clear and agreed-upon definition of these terms as some are used interchangeably to refer to the same concept. Vujica Herzog and Tonchia (2014) state that the concept of LM has been widely studied but no agreement has been reached on the definition of Lean terms, leading to confusion in the terminology being used. This has also created problems about the use of Lean terminologies such that one cannot be certain if another discussant means the same thing as what the one believes is being said.

While this task could be daunting in itself, the massive proliferation of terms in Lean such that different terms are used for the same concept and different concepts are referred to using the same terms have made the navigation of this domain quite difficult. For example, Wahab et al. (2013) named TQM, TPM and JIT as Lean factors, while Shah and Ward (2003) named them as bundles. Eswaramoorthi et al. (2010) named them as tools, Marodin et al. (2017) referred to them as constructs, Bevilacqua et al. (2016) called them practices and Rauch et al. (2017) called them methods. Another example that illustrates the inconsistent use of terms is given by McLeod et al. (2016) and Hofer et al. (2012). McLeod et al. (2016) referred to supplier feedback, TPM, supplier JIT, employee involvement, Statistical Process Control (SPC), customer involvement, supplier development, setup time reduction, flow production and pull manufacturing, as Lean constructs while Hofer et al. (2012) refer to these same elements as Lean practices. This shows that there is a lack of a coherent use of terms in Lean production. Pettersen (2009) points out that on a practical and theoretical level, this divergence can cause confusion when companies want to implement Lean.

2.5.1 Two level term structure

The definitions of terms from authors show that some terms belong to the same set of objects. For instance, Khanchanapong et al. (2014) stated that Lean practice refers to techniques and know-how of manufacturing used in JIT and TQM. Tortorella et al. (2016) also define Lean practices as elements that put into action the principles of Lean Manufacturing. Papadopoulou and Özbayrak (2005) define elements as techniques, tools, practices and methodologies used in Lean or JIT implementations. These definitions suggest that Lean techniques, Lean tools, Lean methods, Lean strategies, Lean practices and Lean elements probably refer to the same set of objects, and these we have referred to as lower level terms of Lean.

Similarly, Lean bundles have been said to refer to a combination of individual Lean practices to form a multidimensional nature of Lean Production (Shah and Ward, 2003). Similar definitions suggest that Lean structure, Lean constructs, Lean factors, Lean bundles, Lean latent factors and Lean dimensions all seem to refer to the same object based on their presentation in literature, and hence are referred to as the higher level Lean terms. As a result of the confusion in the use of terms by different authors, different measurement models have been developed for measuring the impact of LM on operational performance.

2.6 Measurement models found in literature and practice

Many authors have attempted to create models out of this massive pandemonium, but their structures are principally different from one another. It becomes difficult to simply adopt a model from literature as the acceptable Lean structural model since many diverse models have been built by authors. It is apparent from the review that to address what constitutes the structural model of Lean, there is a need to differentiate between what constitutes the logical structure of Lean and what lower level Lean techniques are, given the myriad terms of Lean defined in literature because most authors have intermeshed these terms. Atlas Ti and R programming packages were used to show the most commonly used terms by researchers. Shah and Ward (2007), for example, have created a rallying cluster to standardise the use of some key terminologies, but there are still both terminological and structural issues that still deserve attention. For instance, there is still a gap between what seems to be the industry standard of Lean's structural nature and the current publications in academia. This is in addition to the existence of different clusters that still have divergent definitions for common terms and ideas.

While it is generally difficult to select a popular structural model for Lean as a consensus from academic publications, three Lean bundles (JIT, TQM and HRM) identified by the authors also correlates to the practices in the TPS house which are JIT, People integration and Jidoka. Bicheno and Holweg (2000) state that most companies that embark on a Lean transformation start by implementing a few Lean practices not even a group of practices. The authors stated that no golden procedure can be followed. As a result, different frameworks have been proposed in the literature.

There are two types of structural models proposed by researchers; some seeking a relationship between operational performance and the lower level Lean terms and others seeking a relationship with operational performance and higher level Lean terms. The higher level measurement models, thus, evaluate the impact of Lean constructs/bundles on organizational performance, while the lower level structural measurement models analyse the impact of Lean practices on organizational performance.

2.6.1 Lower level measurement models

Models developed by Agus et al. (2012), Al-Tahat and Jalham (2013) and Fullerton et al. (2003) focussed on the synergistic results obtained from implementing Lean tools on operational performance. These different tools can be used for enhancing performance dimensions (Cua et al., 2001) and their simultaneous application will yield greater operational performance since they will be interrelated and complementary to each other (Shah and Ward, 2003).

Fullerton et al. (2003) studied the correlation between financial performance and the degree of JIT practices adoption in 253 manufacturing firms in the USA. The impact of profitability over the period that companies adopted JIT practices were also examined. The results suggested that companies that implemented JIT practices to a larger degree yielded more profits than companies that adopted a lower degree of JIT practices.

Agus et al. (2012) proposed a structural model to show the effect of implementing LM tools such as short lead time, reduced setup time, kaizen, pull production and small lot size on business performance and product quality performance in Malaysian firms. Structural Equation Modelling (SEM) was used for testing the model and the results showed that there was a positive correlation between business performance and implementing LM practices. There was also a strong indirect effect of LM on business performance via product quality performance.

Al-Tahat and Jalham (2013) constructed a SEM model to test the impact of eight Lean practices on Quality and Productivity Improvement (QPI). The Lean practices considered were Total Quality Management (TQM), root cause analysis, Five S (5S), and quality at the source, visual control and variability reduction. The results showed that these eight practices had a positive relationship with QPI. It is, however, difficult to understand what led to the choice of eight LM practices since more than a hundred practices mentioned in literature.

2.6.2 Higher Level measurement models

Furlan et al. (2011) and Schroeder and Flynn (2002) state that greater operational efficiency can be obtained when the Lean bundles are implemented simultaneously due to their synergistic effect of various Lean tools. Researchers such as Cua et al. (2001),Shah and Ward (2003), Dal Pont et al. (2008), Rahman et al. (2010), Furlan et al. (2011), Vinodh and Joy (2012) and Hofer et al. (2012) developed models to show how different Lean bundles affect the performance of a firm.

Dal Pont et al. (2008) showed the impact of JIT, TQM and HRM practice bundles on operational performance in the High Performance Manufacturing (HPM) international project. Data was collected from 266 companies from countries such as the United States of America, Spain, Japan, Germany, Sweden, Korea, Italy, Austria and Finland. SEM was used to validate the model developed and the results showed that TQM and JIT had a direct and positive influence on organizational performance. HRM affected performance through the mediating effect of TQM and JIT.

Marodin et al. (2017) assessed the impact of eleven Lean practices on organizational performances such as lead time, inventory, quality, on-time delivery and inventory turnover in 64 Brazilian firms. The practices were organized into three constructs which were TPM, TQM and JIT. A regression model was used to test the model and the results showed that the TQM construct did not influence operational performance measures. The JIT construct showed a high impact on inventory turnover whilst TPM had a positive impact on lead time.

2.7 Lean application in Zimbabwe

In response to the demand from competitive pressures from locally produced goods together with the imported one, firms in Zimbabwe have responded by applying LM to cut on wastes, costs and thereby increasing their competitiveness. LM has been implemented in different industries which are involved in processing in the country as outlined below:

Goriwondo et al. (2011) applied VSM which is a World Class Manufacturing tool to reduce waste in a bread manufacturing company in Zimbabwe. In their study involving a baking company, the results indicated a reduction in unnecessary movement of workers, inventory and defects. In another research, Goriwondo and Maunga (2012) used the Lean Six Sigma approach to identify and establish process improvements in margarine manufacturing. The study utilized the Kaizen Blitz approach and the DMAIC (Define, Measure, Analyse, Improve and Control) methodology. The implementation of these methodologies led the value added ratio to improve from 39% to 94% whilst cycle time escalated to 86%.

Goriwondo et al. (2013) used VSM on two productions lines which are Liquids, Creams and Ointments (LCO) and Tabletting 20 in a pharmaceutical manufacturing company in Zimbabwe. The results for applying VSM for the LCO led to the reduction in cycle time by 38% and lead time by 76.4% whilst for the Tabletting line, cycle time and lead time were reduced by 8% and 79.3% respectively. In another study by Madanhire et al. (2013), the application of JIT practices in an aluminium foundry led to an improvement in quality and a reduction operating cost.

Muvunzi et al. (2013) conducted a study to evaluate the application of Lean Value Stream Mapping to reduce waste and improve productivity in a tile manufacturing company in Zimbabwe. With the use of the CSM, areas that needed improvements were identified and the FSM was developed to show the ways to reduce waste. The results revealed that there was an improvement in productivity, and reduction in the number of defects, raw material usage and lead time. Dzanya and Mukada (2015) studied the application of Value Stream Mapping in a glide manufacturing entity in Zimbabwe. The use of that technique led to a reduction in cycle time, labour requirements and processing time. This translated into a significant saving in terms of costs to the firm.

Chisosa and Chipambwa (2018) did an exploration of how work-study techniques could optimise production in Zimbabwe's clothing industry. The study found that there was a need to incentivise clothing manufacturing firms to offer apprenticeship training by collaborating with vocational training institutions so that they enrol students for higher qualifications. The government was implored to provide finance and grant schemes for the training of skilled human resources for the clothing industry as was the case previously to create a pool of people with specific skills. They also discovered that the clothing industry in Zimbabwe was in a deplorable state hence the need for a capital requirement from both the public and private sectors to upgrade industry through training programs that will better prepare industrialists and improve business planning through work-study initiatives in supporting the growth of the clothing industry. It was also reiterated that the government had a primary responsibility of creating a conducive environment to promote and enhance competitiveness through work-study. This could be achieved through collaborating industrialists and policy-makers on issues that will promote development on a long-term basis.

While it is generally difficult to select a popular structural model for Lean as a consensus from academic publications, companies in Zimbabwe use the TPS house to implement LM. This framework has helped many manufacturing companies to adopt the best approach to use during Lean implementation.

2.8 Toyota Production System (TPS) house

The TPS house was first initiated by Toyota and has proved to improve operational performance at this organization. The house shows how to systematically implement LM into an organization to achieve the objectives (highest quality, lowest cost and short lead time) (Ko and Kuo, 2019). Toyota used a house to represent a system. The house depicts that all components of the structure must be in place for it not to collapse (CZABKE, 2008). Hence, it needs a firm foundation, robust pillars and a good roof (Liker and Lamb, 2000). The house contains the foundation, two pillars and a roof. The first pillar is Jidoka, the second pillar is JIT (Ko and Kuo, 2019) and at the centre of the house is people integration.

2.8.1 Stability and standardization

The concept of Stability and standardization enables organizations to achieve consistency in the production processes and to ensure that work is balanced among the workers (Tortorella et al., 2016). Standardization is defined as the establishment of standardized work sheet that shows the current best method to be used by employees to perform various tasks. It gives a detailed description of the content of the work, its sequence and the time it should be accomplished. It can also be a picture that shows the desired state of a process. A standard should be easy to understand, easily seen and recognized by all the workers. The creation of a standardized work aids employees to have discipline in their work (Dennis, 2016), thus making LM have roots in manufacturing enterprises. Other tools that can be used for stability and standardization construct include visual management, Five S (5S) and TPM. Five S will help in the organization of tools and materials within a manufacturing setup whilst TPM aids in ensuring that the machines are always functional.

2.8.2 Jidoka

The term Jidoka was defined by Ohno as "automation with the human touch". It referred to the machine that was able to stop operation by itself (Leong et al., 2019). This technique was invented by Sakichi Toyoda in 1902 when he created a mechanism that was able to stop the looming machine when it detected a broken thread (Chiarini et al., 2018). This enabled a single worker to manage 12looms alone. Jidoka made the machine and workers to end the process once they identified defects (Jainury et al., 2012). Stopping the process ensured that defects were retained within a particular area and corrective actions were implemented. The invention of this principle (autonomation) led Toyota to encourage worker empowerment and teamwork. Similarly, this practice has been used by companies to prevent customers from getting low quality products. The machine stops when it detects some defects and the workers quickly attend to the problem. The Lean tools that can be used for this construct are Poka-Yoke and Root Cause Analysis (RCA). Poka means an unintentional error/ mistake and Yoke means avoidance/ prevention (Lina and Ullah, 2019). A Poka-Yoke is an uncomplicated device that is used to detect or stop a defect from passing on to another stage within a production system. A Poka-Yoke will lessen the burden for a worker to constantly check for errors (Dudek-Burlikowska and Szewieczek, 2009). A warning (light/ buzzer) or the system may be completely shut down when a defect is discovered. RCA is a tool that is used to establish the causes of a problem and finding ways of mitigating and prevent them from occurring (Andersen and Fagerhaug, 2006). Cause and effect diagrams may also be a very useful tool for discovering the causes of the quality problem within a system. The concept of Jidoka works hand in hand with JIT. The production of high quality products will aid the flow of materials within a system.

2.8.3 JIT

JIT production can be described as manufacturing the right product at the correct time in its rightful quantity (Bamana et al., 2019, Pheng and Chuan, 2001). The JIT principle states that production should be initiated when a customer downstream orders for a product. The benefits realized by the customer pulling the product is that it lowers inventory, throughput time and process variability (Van Wyk and Naidoo, 2016). The major tools that help the JIT construct are pull, Kanban and heinjuka/ production levelling. The pull principle ensures that resources are not dedicated to production before the customer demands for a product (Diego Fernando and Rivera Cadavid, 2007). Kanbans are used to initiate the production process. These are visual cards or electronic mechanisms that carry information about the number of parts to be transmitted to the proceeding process. Heinjuka is done to avoid peaks and troughs in the workload of employees thus ensuring that daily production volume is kept constant.

2.8.4 People Integration

People involvement has been described by Dennis (2016)as the “wind that fills the sails”. The human element is a crucial consideration during Lean implementation. The human dimension at Toyota is termed, “The Toyota Way”. It states that worker’s needs are to be respected and understood so that they achieve self-realization thus maximizing their performance (Magnani et al., 2019). The employees are involved in performing tasks and solving problems that may arise in the plant. The tools that strengthen the human involvement dimension are training, kaizen circle and empowerment. Training of employees is also very essential during Lean implementation. Training increases the workers’ knowledge about the processes and their roles in the Lean journey. The people are involved in performing operations and hence must be wholly involved. They also drive the continuous improvement process (Tortorella et al., 2016), and hence should be fully engaged and eager to participate in the Lean journey. As a result, Bicheno and Holweg (2000) state that LM is driven by the behavior of workers which is built through worker training, coaching and demonstration so that they gain self-confidence. Lean managers can also support workers through mentoring.

2.9 Impact of Industrial Clockspeed (IC)

The world we are living in is constantly changing such that many organizations are facing economic turbulence. Organizations that will survive such turbulence are those that can quickly adopt strategies that enhance organizational robustness. Although the world is changing so fast, the rates of change in industries are different. Some industries are moving at a faster speed while others are moving at a slower speed. This is referred to as the concept of Industry Clockspeed (IC). IC is defined as the rate of change products, process technologies and organizational structures of an industry (Peng et al., 2013). The rate at which industry change is very crucial for Lean practitioners since it affects the strategic objectives of organizations. It also affects the organization's competitive advantage (Carter and Jackson, 2019). For example, high IC industries need to be flexible in their strategic objectives since the customer preferences and rate of new product introductions are constantly changing whilst those in the low IC industries can gradually transform their strategies since the rate at which new products are introduced into the market is low. IC is grouped into three aspects which are organizational structures, product and process clockspeed.

2.9.1 Organizational clockspeed

The term refers to the frequency of change of strategic objectives and structures of organizations (Nadkarni and Narayanarni, 2007). Fine (1999) suggested that organizational clockspeed can be measured by the pace at which organizational structures changes. Peng et al. (2013) also used the time taken by an organization to introduce new corporate strategies to measure organizational clockspeed. These strategic changes may be (mergers, acquisitions, internal expansion) and structures (restructuring and changes in top management).

2.9.2 Product clockspeed

It refers to the rate at which new products are introduced into the market, the time-space between such introductions and the obsolescence rates of the existing ones (Fine, 1999, Peng et al., 2013). The electronic industry has been changing so fast such that the rate at which new phones and computers have been introduced into the market is alarming. Whilst the aircraft industry introduces a new model after more than 10years.

2.9.3 Process clockspeed

The term refers to the pace at which machinery and process technologies are being introduced or replaced into the industry. Fine (1999) suggested that process technology can be measured by obsolescence rates of machinery for an organization. The change in television models may also result in a change in process technology within that industry within a few years. Whilst the automobile can last for a period of about 20years. Fine (1996) classified IC organizations as high and low IC industries.

2.9.4 High IC industries

The high IC industries have products that have a short lifecycle. The changes in product, processes and organizational structures occur over a short period of time (Fine, 1996). Mendelson and Pillai (1999) state that high IC industries are characterized by the quick implementation of new products, manufacturing processes, faster development time and numerous changes in organizational structures. The organizations in this category have a temporary advantage because their products frequently change and better products are invented to replace the existing ones. Lean practitioners for high IC industries should strive to be flexible in their strategic schemas (Nadkarni and Narayanan, 2007). There is a need to quickly adopt new strategies to suit operations that constantly changes. Therefore, it becomes difficult for these organizations to safeguard their products so as to gain a large market share because more organizations tend to compete in high IC environments. Managers need to quickly introduce new products, improve their processes, acquire new knowledge and quickly transform so as to match the rate of change of the market where new products are introduced. The market conditions change drastically because customers have a wide number of choices. The decision making time for high IC industries have to be short and organizations should seek for innovative ways to improve the existing products. Additionally, Lean practitioners should make endeavors to reduce production costs.

2.9.5 Low IC industries

The low IC industries manufacture products with a long life cycle. The products, processes and organizational structures for these industries change after a long period of time. Thus, the decision making process for low clockspeeds industries takes long because these firms require a large sum of money to revamp their processes and products. The low IC industry firms can protect their products since their rate of change is not fast. As a result, these firms normally have a sustainable competitive advantage since they can safeguard their products (Nadkarni and Narayanan, 2007). Lean practitioners that operate in the low IC environments need to be persistent in their strategic actions since the industry does not quickly change.

2.9.6 Studies on the impact of IC

Many studies have been conducted on the impact of IC on organizational performance. A study by Mendelson and Pillai (1999) developed a qualitative measurement tool to assess IC for the electronics industry. The metrics used for measuring IC were total revenue obtained by new products introduced, product life cycle duration and the rate at which the product prices were declining. The results revealed that high IC industries had a positive correlation with a greater increasing rate of product redesign and decreased project development times. Additionally, high IC industries had a strong relationship with change in organizational structures.

Peng et al. (2013) studied the moderating effect of product clockspeed on the relationship between customer and supplier integration and plant capability. The outcome showed that there was an insignificant relationship between customer integration innovation capability of a plant. On the other hand, customer integration and product clockspeed had a positive correlation with the innovation capability of a plant. The moderation effect of product clockspeed affected only the association between customer integration and plant innovation and improvement capabilities. No significant moderation effect was found for the relationship between supplier integration and plant innovation and improvement capabilities.

A study was conducted by Meijboom et al. (2007) to evaluate the effect of increasing IC on supply chain coordination in four multinational organizations in the fashion clothing, aviation, building and semiconductors industry. The researchers used the total time of the product life cycle and total revenue earned by selling new products introduced in the past twelve months as constructs for measuring IC. The outcome showed that an increase in IC increased the coordination between organizations in the high IC industries. There was also a decrease in inventory and lead time for these industries. Outsourcing was essential for both low and high IC industries. It was also found that for low and high IC industries, the use of vertical information systems was limited.

2.10 Research Gap

This chapter discussed research that has been conducted to assess the impact of LM on operational performance and the Lean models that have been used to measure the effect of this philosophy. The study has shown that many Lean performance measurement models have been developed in literature which makes it difficult for Lean practitioners to identify and select the appropriate model to use to measure the impact of implementing LM. These modes are also principally different from each other that makes it difficult to compare the results of implementing LM between different organizations. The models developed by researchers were based on the LM practices implemented by organizations. This means that if a company implemented two Lean practices, a model would be created based on these practices. This study observed that no measurement model has been developed based on the TPS house that has been used by Toyota Motor Company to manage LM in its operation.

The majority of Lean practitioners have acknowledged that adopting LM in an organization can yield positive results, however, not all Lean implementations have yielded positive results. Literature has shown that the TPS house contains practices that can be used as a backbone for implementing LM. This house contains stability and standardizations practice that has not been used in any model developed in the literature. The current literature is void of an impact measurement model that uses TPS though this house has been used by many practitioners to implement LM. This study will develop a model that measures the impact of implementing LM on operational performance using the practices found on the TPS house.

The current review of the literature revealed that few studies have been conducted to show the moderating effect on LM implementation. The existing measurement models do not consider how IC act as a moderating variable for the relationship between internal and external LM practices and operational performance. The only study that considered the moderating effect of IC was a study by Chavez et al. (2013). However, the weakness of the study was that the study assessed the moderating effect of IC on the relationship between internal LM practices and operational performance. Research has shown that LM can be successful when internal and external LM practices are implemented. This study will extend the existing literature by developing a Lean measurement model that evaluates the moderating effect of IC on the relationship between internal and external LM practices and operational performance.

2.11 Chapter conclusion

The chapter focused on reviewing the literature on studies that have implemented LM and results obtained from these researches. This section also explained the measurement models that have been used to assess the impact of implementing LM on operational performance. The chapter also illustrated the studies that have been conducted in Zimbabwe for LM. The chapter ends by describing the research gap that motivated the researcher to embark on this study.

Chapter 3: Research Methodology

3.1 Introduction

The chapter gives a detailed discussion of the basic concepts, nature and the structure of SEM. The chapter also explains the steps taken in measuring the impact of LM on operational performance. A description of how PLS-SEM models are assessed is given in this chapter.

3.2 Background of SEM

Structural Equation Modeling (SEM) can be defined as a statistical tool that combines path analysis and factor analysis (Hox and Bechger, 1998). This concept tests the relationships between various constructs for the researcher to gain more understanding of the theory, causes of a problem and how to resolve the problem (Blunch, 2012). This method is therefore, used to substantiate theories. The concept of SEM was first introduced by Joreskog in 1972 (Chin, 1998) and is currently being used in many fields such as psychology, behavioral sciences, social sciences and biological sciences (Fan et al., 1999). Its application has also extended from the social sciences to engineering and has been applied in LM since the early 1990s. This is because the technique allows for testing models using non-experimental and experimental data.

3.3 Composition of a structural model

Structural diagrams are used to show the relationships among variables (Loehlin, 2004, Hair Jr et al., 2016). These variables may be observed or unobserved variables. The unobserved variables are variables that cannot be measured directly (Byrne, 2013) thus are measured through manifest variables. These unobserved variables are also known as constructs or factors and are represented as ovals or circles. For example, this study considers stability and standardization as an unobserved variable. To measure the stability of a Lean system, concepts such as the ability of a company to adjust cycle times and the availability of machinery every day to produce at customer demand can be used.

The measured variables are termed manifest variables or indicators. These variables have well-defined methods of quantifying them. They can be directly measured and in this study, the measured variables are items in a questionnaire. To measure the operational performance of an organization, the speed of delivery of products to customers can be used to quantify its effectiveness. The measured variables are represented as rectangles in the path diagram. The observed and the latent variables may be categorized as either exogenous or endogenous variables.

The exogenous variables are also called independent or source variables. These variables are not affected by other variables in a model. There is no single headed arrow that will go in the independent variable. People integration is an independent variable in this study. This variable will affect stability and standardization, JIT and Jidoka. Hence, arrows will originate from People integration to these variables. The external factors that originate outside the model cause fluctuations in the values of independent variables, hence these changes are not caused by the model (Byrne, 2013).

Endogenous variables are variables that are influenced directly or indirectly by the exogenous variables (Wong, 2013). The changes in the values of dependent variables are caused by exogenous variables thus these changes are explained by the model. In this study, Jidoka is affected directly by People integration or indirectly by People integration via Stability and standardization. A path model also contains mediating and moderating variables.

A mediating variable is a variable that affects the association between the predictor (independent) variable and criterion (dependent variable). When the exogenous variable changes, the mediator variable also changes which in turn affects the endogenous variable. In this study, People integration will not influence operational performance directly. It does so through the mediating effect of JIT or Jidoka. Thus, JIT or Jidoka will explain why or how the link between People integration and operational performance occur. This means that JIT or Jidoka will strongly dominate the relationship between People integration and operational performance.

A moderator is a third variable that affects the direction or strength of the association between the exogenous and endogenous variable. IC is a moderating variable that affects the strength of the relationship between Lean practices and operational performance in this study. The nature of the relationship between LM practices and operational performance varies based on the values of IC. Thus, IC will be responsible for the heterogeneity in the data.

Figure 3.1 shows structural equation model that gives a diagrammatic representation of the variables under the study. It comprises of structural/ inner model and measurement/ outer/external model. The inner model quantifies the relationship between the latent constructs whilst the outer model measures the relationships between the latent and the observed variables

(Henseler and Sarstedt, 2013). The single headed or straight arrows show the causal relationships of one variable on the other variables. When one variable in the tail changes, the variable in the head also changes (Loehlin, 2004). Figure 2.4 shows a diagram for a path model.

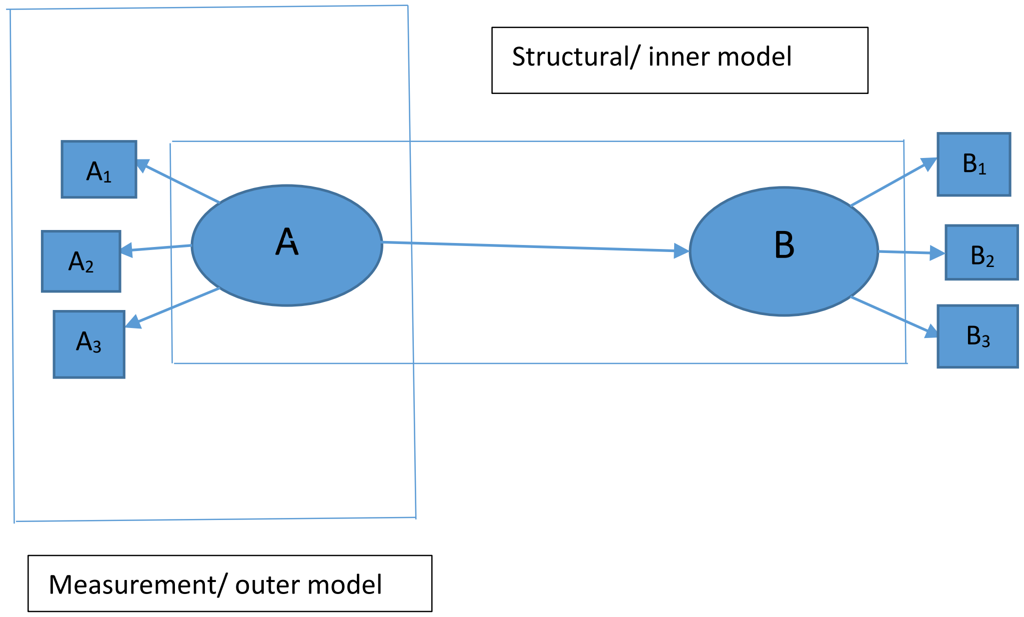

Figure 3. 1: Structural Equation model

Measurement items in the structural equation model are classified as reflective and formative. The reflective items are functions of latent variables, thus any alteration in the latent variable will be seen by the change of the indicators. The formative items are represented by arrows that point towards the constructs. Therefore, any alteration in the formative items will cause the constructs to change.

3.4 General way of representing structural models

A structural equation model can be represented with a graph or an equation. An equation gives a dependent variable as a function of a direct path from independent variables. A graph shows the relationship between variables which are represented as ellipses/circles and rectangles/ squares. The arrows show the causal links whilst two- headed arrows indicate covariation. The major advantage of using a graph is that it easily shows the relationships between variables, thus it becomes easy to communicate the causal links. Figure 3.2 shows a structural equation model for the effect of Lean practices on operational performance.

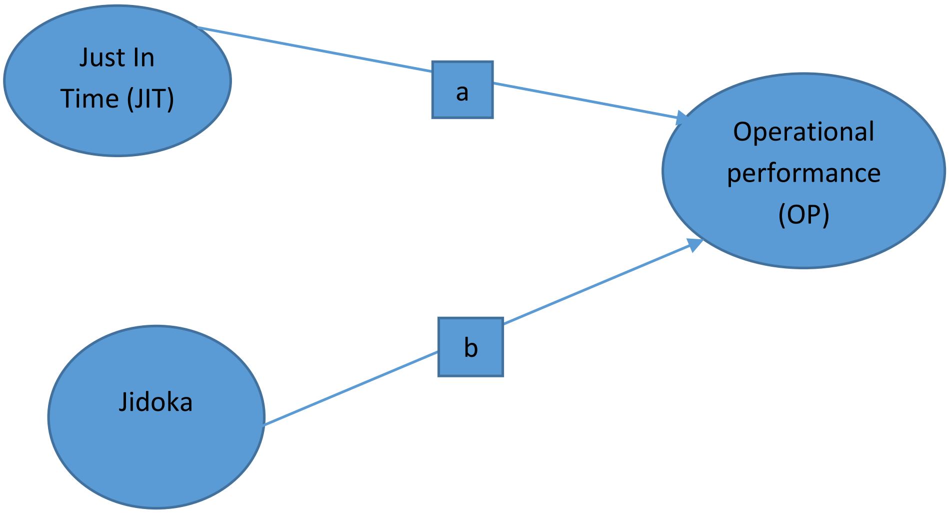

Figure 3. 2: Structural Equation Model

The diagram shows that the operational performance is influenced by two variables which are JIT and Jidoka. The number of equations for a given model is equivalent to the total number of dependent variables. Hence, the score of operational performance is given as an additive function of JIT and Jidoka. The following equation represents the model shown in figure 2.

Operational performance = a(JIT) + b(Jidoka).

The advantage of using equations is that it allows the traditional algebraic calculations to be computed.

3.5 Early approaches to SEM implementation and analytical packages

SEM evolved as a result of Spearman's work in 1904 and 1927 (Tarka, 2018) when he established the first factor model. This model was used to measure cognitive capabilities in people. The statistical relationships obtained from the cognitive capabilities' tests were used to show the level of human intelligence, thus this work helped in the establishment of factor models that were used in the development of measurement models utilized in SEM. The model was later extended by Thurstone in 1935 who used it in higher order determinants. On the other hand, a genetics scientist known as Wright developed path analysis in 1918 and 1930, to estimate structural coefficients for observable variables (Tarka, 2018). He established the causal relationship between measured variables and the diagrammatic symbols that are used in SEM models. He was the first scientist who developed recursive models and was able to assess the direct effect, common causes and indirect effects. Many researchers such as Frisch and Waugh (1933), Blalock (1962) and Issac (1970) promoted the development of SEM in the econometrics, sociology and psychology fields respectively. Duncan et al. (1973) published a conference paper that was titled Structural Equation Models in the Social Sciences for the conference that was held by political scientists, economists, psychologists, statisticians and sociologists which promoted the growth of SEM. The first software program that was developed for SEM was LISREL. This software was developed by Joreskog in 1972 (Tarka, 2018). EQS was developed by Bentler (1985) which can be used on the foundation of syntax, Arbuckle and Wothke (1999) developed Analysis of Moment Structures (AMOS) that used graphical interface which made it easier for the users. In addition to that, Jȯreskog and Sorbȯm developed SIMPLIS in 1996. Other software packages such as MPLUS (Muthén, 1987), GLAMM (Rabe-Hesketh et al., 2004), SmartPLS (Ringle et al., 2005) were later invented. This research uses PLS-SEM for evaluating the impact of LM practices on operational performance.

3.6 History and evolution of PLS-SEM

In 1977, a Swedish Professor known as Herman Wold invented Iterative algorithm which was formerly Non- linear Iterative Partial Least Squares (NIPALS) that was used in the advancement of PLS (Mateos-Aparicio, 2011). This was also followed by the development of Partial Least Squares method called Partial Least Square- Regression (PLS- R) and Partial Least Squares- Path Modelling (PLS- PM). PLS-R evolved to resolve the challenge of multicollinearity in Regression analysis. PLS- PM was developed to replace the Joreskog hard modelling technique called covariance structure analysis. It was termed a soft modeling approach by Wold. The term soft modelling referred to the distributional assumptions of data (Vinzi et al., 2010). It is also flexible and handles models that cannot be assessed using covariance based methods. It should be noted that the term soft does not mean that its estimation techniques are easy to use. This method uses statistical methods for testing complex relationships between measured and latent variables (Vinzi et al., 2010). It uses linear squares to determine the magnitude of the relationship between the variables. PLS- PM is also known as PLS- SEM and this method is used in this research.

3.6.1Benefits of using PLS

The PLS method uses either ratio or interval measurements, thus has been widely used by researchers. This method uses data that is not normally distributed which is not possible with covariance based methods. The method also allows analysis to be conducted using a lower sample size and does not have any demand on the residual distribution (Chin, 1998). When using covariance based methods, the results of model fit becomes very lenient for small sample sizes and uncompromising for large sample sizes (Fan et al., 1999). Thus, model estimation and evaluation becomes more accurate when the sample size is large.

PLS methodology allows researchers to specify measurement and structural models and test them against empirical data. A structural model is first developed from existing theory and data is collected and tested to validate the model. The use of a graphical editor to construct the model makes use of SmartPLS highly favorable. This program converts the drawing into a code that is used for analysis. Thus, the researcher does not need to have high programming skills when using this software package. However, it should be noted that the researcher should understand the programming language so as to avoid unnecessary mistakes when conducting the study. PLS- SEM also allows causal networks to be tested simultaneously (Lowry and Gaskin, 2014).

Formative and reflective measurement models can also be analyzed using PLS-SEM technique. The use of both formative measurement and reflective measurement models in one construct is not possible when using other covariance based methods that utilize software packages such as AMOS, LISREL and EQS. Compared with covariance based SEM, PLS-SEM circumvents standardized loadings bigger than 1, negative estimates of variance and indeterminacy of factors (Barroso et al., 2010). This method uses an iterative algorithm that avoids the identification problem for recursive models. The method also allows different models to be compared using the same empirical data and conclusions can be drawn from the analysis (Tomarken and Waller, 2005). In addition, PLS- SEM can also be used on latent constructs with single items.

3.6.2 Demerits of using PSL- SEM

Although SmartPLS has been greatly adopted for analysis, the method has been considered a less rigorous method for testing causal relationships between latent variables by other researchers (Rönkkö et al., 2016). However, Hair et al. (2014) state that researchers who refer to it as a less superior technique have a vast experience in covariance based methods. Studies conducted by Tenenhaus (2008) revealed that the covariance based methods and SmartPLS give results that are closely similar though some researchers claim that the method gives results that are less superior. The slight variation occurs because SmartPLS start by maximising the parameters for the measurement model and then continues to evaluate the path coefficient.

SmartPLS can only be used for recursive models. Recursive models are models that can only permit single headed arrows which allows the direction of cause to come from a single direction. In addition to that, the method does not use a global measure of goodness like Chi-Square for testing model fit.

3.7 Basic steps in conducting PLS- SEM

The basic steps involved in conducting the PLS-SEM involves:

i. Model Specification
ii. Model constructs operationalization
iii. Development of the data collection tool
iv. Data collection
v. Model estimation (measurement and structural model)

3.7.1 Model specification

This stage involves the representation of the hypothesis as a structural model that shows the order in which the constructs are connected. The sequence in which the constructs are arranged is developed from theory and logic. The left side of the model shows the exogenous variables whilst the left side shows endogenous variables. In this research, people integration is an exogenous variable whilst JIT, Jidoka, Stability and standardization and operational performance are endogenous variables.

3.7.2 Model constructs operationalization

This step involves specifying the relationship between the constructs and the measured variables. The constructs in research are defined in abstract terms. For example, this study uses People integration as a construct. The process of converting People integration into an observable phenomenon is known as operationalization. The observable phenomenon such as the ability of employees to make suggestions, solve their problems and formation of teams may be used to capture this construct. This step captures the exact measurement method used in the study. This stage is very crucial because it determines the usefulness of the results.

3.7.3 Development of a questionnaire

The researcher conducted a literature review to select the items used for constructs. Using items from other studies increased the reliability of the questionnaire since these items would have been tested and validated before. The study utilized a seven-point Likert scale for assessing the impact of LM practices on operational performance whilst a five-point scale was used to measure the moderating effect of IC. The questionnaire was approved by the research ethics and integrity committee for the faculty of Engineering, Built Environment and Information Technology at the University of Pretoria. After the approval, a pilot study was conducted by academics and industry practitioners to check the suitability of the design and the appropriateness of the items for the questionnaire. Some items were removed after the suggestions that were given by experts. A Google form link was also created in order to conduct an online survey. The form contained an introduction that outlined the purpose of the study. The researcher also emphasized that the responses were to be treated confidentially and anonymously. The researcher also outlined that participation in the survey was voluntary and that the questionnaire would take 10- 15mins to complete.

3.7.4 Data collection

Data collection was conducted by distributing the questionnaire by hand and sending a google form link via email. A cover letter was also designed that was sent along with the questionnaire. Two factors were used to select the companies that were to be used for the study. These were the number of employees and the type of industry. Only manufacturing companies with more than 50 employees were considered. After a document analysis, 600 companies that were registered with the CZI were contacted in order to respond to the questionnaire. In total, 300 questionnaires were hand delivered to these companies whilst the remaining were sent via a google form link by email. The questionnaire was administered over a period of 8weeks. After 10weeks, 150 responses were obtained. A reminder was sent and 50 more responses were obtained. A second reminder was sent and 20 more responses were obtained. Out of the 220 responses obtained, 214 questionnaires were completely answered.

3.7.5 Assessment of PLS-SEM results

The two stages in the analysis of PLS-SEM algorithms are the assessment of the of parameters for the outer/ measurement models and the inner/ structural model.

3.7.5.1 Estimation of outer/ measurement models

The measures used for assessing the measurement models are validity and reliability. Reliability can be defined as the degree of an item in a questionnaire to yield the same value each time it is given to respondents (Revicki, 2014). It also measures the extent to which a group questions vary or inter-correlate when measuring a construct. Reliability shows whether measurement items remain stable and dependable when they are repeatedly given to respondents. Composite reliability is used as a measure of reliability. Its values are confined between 0 and 1, with the bigger values normally desired. The value of composite reliability should be between 0.6 and 0.9 (Hair Jr et al., 2016). The values for Cronbach alpha should also be reported when performing PLS-SEM. The desired values for the coefficient should be $\geq$ 0.7 (Gliner et al., 2001).

Validity is used to show if the items in a questionnaire assess the construct it is intended to measure (Taherdoost, 2016). The two main types of validity used by PLS-SEM are discriminant validity and convergent validity. Convergent validity is defined as the level to which items that measure the same construct correlate. The numerical values for Average Variance Extracted (AVE) should be greater than 0.5. Discriminant validity shows the extent to which a construct is distinguished from the other construct. The Heterotrait-Monotrait ratio (HTMT) ratio is used for evaluating discriminant validity. The confidence interval obtained for each construct should not include 1.

3.7.5.2 Estimation of inner/ structural Models

The assessment of the inner model helps to deduce the capability of a model to predict data and shows the relationships between the constructs. The initial step taken in analyzing the inner model is assessing the collinearity between the latent constructs. Collinearity occurs when the degree of correlation between the independent variables is high. This state is not desired since independent variables should be autonomous/ independent. The VIF values lower than 5 are desired (Wong, 2016).

The second step involves assessing the path coefficients for the inner model. The path coefficient shows the level of the relationship between the independent and the dependent variables. The values for the path coefficients lie between 0 and 1, with the values closer to 1 showing a strong relationship. SmartPLS uses bootstrapping to obtain the t and p values that shows whether these relationships are significant. For the two-tailed tests, the critical value is 2.57 at 1% significance level, 1.96 at 5% significance level and 1.65 at 10% significance level (Preacher and Hayes, 2004, Wong, 2016). For the one-tailed tests, the critical values are 2.33 at 1% significance level, 1.65 at 5% significance level and 1.28 at 10% significance level.

The determination of the R^2 values is the third step in analysing the structural model. The R^2 value is also called the coefficient of determination and gives a measure of explained variance in the endogenous variable. This value determines the variance in the endogenous variable caused by the exogenous variable (do Nascimento and da Silva Macedo, 2016). The f^2 effect size is also evaluated during the assessment of the structural model. This value measures the effect of omitting an exogenous variable on the dependent variable during model estimation. The value of 0.02 indicates a weak effect whilst 0.15 shows a medium effect and 0.35 a substantial effect.

The Stone-Geisser's Q^2 is also reported in addition to effect sizes. The blindfolding procedure is used to assess the out of sample predictive power. Values larger than 0 are desired because they show that the model has predictive relevance whilst values smaller than 0 indicate that the model has no predictive relevance. The q^2 effect size is used to evaluate the effect of the predictive relevance of Q^2. It determines the contribution of an exogenous variable to the endogenous variable's Q^2. The values of 0.02 indicate a small effect, whilst 0.15 represent a medium effect and 0.35 shows a large effect of predictive relevance.

3.8 Chapter summary

The study employed a deductive approach in order to achieve the study objectives. The data that was obtained from the survey was used to assess the hypotheses that were derived from the existing theory. Thus, this approach examined the validity of the hypotheses that were stated. The next chapter will describe the impact measurement models found in the literature.

Chapter 4: Lean Impact Analysis Assessment Models: Development of a Lean Measurement Structural Model

4.1 Introduction

The chapter is aimed at developing a model to measure the impact of LM deployment on operational performance. The model will help industry practitioners to assess the impact of implementing Lean constructs on operational performance. It will also harmonize the measurement models of Lean performance with the TPS house that seems to have become the industry standard. The sheer number of measurement models for the impact of Lean implementation makes it difficult for new adopters of LM to select an appropriate assessment model or deployment methodology. A literature review is conducted to classify the models that assess the impact of LM on operational performance. Pareto analysis is used to select the Lean constructs for the development of the model. The model is further formalized through the use of Structural Equation Modeling (SEM) in defining the underlying latent structure of a Lean system. An impact assessment model developed can be used to measure Lean performance and can be adopted by different industries.

4.2 Background of the study

An attempt to evaluate and compare the impact of LM implementation on the performance of the diverse organizations that have been reported to have implemented LM is very difficult and quite unproductive. This is due to the lack of a standard model of implementation of LM as well as the absence of a commonly accepted model of performance measurement. This problem seems to be pervasive across the LM literature and even the industry. This has led to confusion when the new adopters want to implement the improvement philosophy. The purpose of this chapter is to classify the impact assessment models from literature and develop a standard measurement model that can be used by different industries to measure the impact of Lean implementation on operational performance.

A modified version of this chapter has been published in International Journal of Mechanical and Mechatronics Engineering

The reasons for lack of a standard model are that Lean has been treated as an open structure, whereby adopters choose practices that suit their enterprise (Dombrowski et al., 2016). There is no manufacturing practice database for use during Lean implementation (Susilawati et al., 2015), leading to haphazard implementations of Lean practices as organizations rush to become lean. Different companies have implemented different LM practices making it difficult to compare various organizations on the effect of Lean implementation on their operational performance. The adoption of different practices during Lean implementation causes researchers to develop diverse assessment methods. Based on Wan (2006) and Dombrowski et al. (2016), the different impact assessment models that have been developed by researchers can be classified under different categories such as qualitative models (Al-Tahat and Jalham, 2013, Belekoukias et al., 2014, Bevilacqua et al., 2017, Dal Pont et al., 2008, Demeter and Matyusz, 2011), quantitative models (Kumar, 2015, Lacerda et al., 2016, Miller and Chalapati, 2015, Perera, 2016, Prashar, 2014), graphical models (Rivera and Chen, 2007, Gamage et al., 2012), and simulation models (Dombrowski et al., 2016, Abdallah and Phan, 2007, Deaconescu et al., 2016, Yang et al., 2015). McLeod et al. (2016) state that there is no standard that has been set for the use of Lean metrics, thus it becomes difficult to compare the impact of the philosophy among different industries. This has led to confusion about what to do and what to expect when new Lean adopters want to implement the philosophy. This research aims to review the different measurement models of LM that are available in the literature and propose a measurement model based on a construct that seems pervasive from the industry perspective, which is the TPS house (Dennis, 2016). The literature search conducted by researchers showed that most industry practitioners use the TPS house for implementing LM; however, no impact measurement models have been built around the house. The following research objectives were developed after an extensive literature review on LM measurement models:

1. To evaluate the different impact performance models used for measuring Lean implementation success;
2. To develop a Lean impact measurement model that is tied around the TPS house, which seems to be popular in many industries.

The benefit of a standard impact measurement model is that it helps new adopters of LM to anticipate and also assess the impact of LM on their operational performance. Measurement models can also be used to manage organizational leanness since managers would be able to measure its impact on organizational performance and prove if their goals are being met.

Furthermore, Lean measurement models will also help to compare the impact of Lean implementation among different adopters.

4.3 Impact Analysis of LM

In this section, a review of the literature on the models of assessment of the impact of LM implementation on an organization's operational performance is presented. As has been stated earlier on, Lean measurement models can be grouped under four categories which are quantitative, qualitative models, graphical and simulation-based models.

4.3.1 Qualitative Approaches

Qualitative LM measurement models use survey questionnaires to measure the impact of LM tools on an organization. Questions are designed to help LM adopters to assess the impact of LM tools on organizational performance. Researchers advocate for the use of qualitative LM models because of their ability to measure the overall LM implementation success. However, the use of survey questionnaires is subjective because it depends on the individual opinion and hence could be biased. The score obtained from the questionnaire shows the level of compliance between the organization and LM indicator, hence it is not a quantitative score of the real performance of the organization (Wan, 2006). Al-Tahat and Jalham (2013) developed a SEM model to measure the impact of eight Lean tools on Quality and Productivity Improvement (QPI). The eight LM tools considered were quality at the source, poka yoke, variability reduction, kaizen, Total Quality Management (TQM), 5S, visual control and Root Cause Analysis (RCA). The results indicated that the LM tools had a positive relationship with QPI. Belekoukias et al. (2014) conducted a study to show the impact of LM strategies on five performance measures which were quality, speed, dependability, flexibility and cost. The analysis of JIT, autonomation, kaizen, TPM and Value Stream Mapping (VSM) on operational performance was done using SEM, correlation and regression methods. The results suggested that JIT, autonomation, and kaizen had an impact on operational performance, whilst TPM had no impact and VSM had a negative impact. Other authors used multivariate analysis methods such as SEM: (Bevilacqua et al., 2017, Dal Pont et al., 2008, Agus et al., 2012, Fullerton and Wempe, 2009, Shah and Ward, 2003, Vinodh and Joy, 2012, Jayaram et al., 2008, Hong et al., 2014); regression: (Chavez et al., 2013, Marodin et al., 2017); cluster analysis: (Demeter and

Matyusz, 2011); Analysis of Variance (ANOVA): (Zhou, 2012) and hierarchical linear model: (Kull et al., 2014), to show the impact of LM on operational performance.

4.3.2 Quantitative Lean Measurement Models

The quantitative models measure the impact of LM based on observable performance metrics of a company. This method uses types of metrics that are different from the qualitative models for measuring LM success thus allowing decisions to be made. The major advantage of the method is that measurements are more objective, thus does not depend on the evaluator's opinion unlike in qualitative models. However, the disadvantage is that it is difficult to get the data because of protection of company information. A study by Lacerda et al. (2016) presented fictitious results for the cost of labor per hour, the injection machine cost per hour and factory price per meter because of privacy issues.

Perera (2016) used work measurement to assess the impact of 22 LM strategies for a three-wheeler accessory manufacturing entity in SriLanka. Productivity improved by 44.14% after changing the layout and work method. Lacerda et al. (2016) conducted a research to show the impact of VSM in an automotive manufacturing company. From the Time Study results, the author developed and implemented a future state map that reduced cycle time from 370s to 140s and inventory level by 25%. The major disadvantage of the study was that it did not give actual measures for financial benefits. Other researchers such as Kumar (2015), Miller and Chalapati (2015) and Prashar (2014) have also presented quantitative models that show the impact of LM on operational performance.

4.3.3 Simulation-Based Models

Simulation models can be developed to show the impact of LM practices on operational performance for organizations. Discrete event simulation models have been used to measure and analyze the impact of LM practices among themselves, and their effect on the overall system. Abdulmalek and Rajgopal (2007) used simulation to quantify the benefits of applying LM methods for a steel manufacturing company. A simulation package, Arena, was used to analyze the potential impact of the future state map on the performance of the system. They anticipated a reduction in the inventory level and lead time by 90% and 70% respectively. Dombrowski et al. (2016) used systems dynamics to show the impact of the Single Minute Exchange of a Die (SMED) on the overall setup. The system variables were internal setup time and external setup time. The results showed that there was a decrease in setup time by 20% which showed the effectiveness of SMED on the overall system. The major disadvantage of the model was that it analyzed subsections of the system, hence there was a need to create and combine different models to find the mutual interdependence. Studies conducted by Deaconescu et al. (2016), Standridge and Maas (2015) and Yang et al. (2015) also used simulation to show the effect of LM on organizational performance.

4.3.4 Graphical Models

These models give a graphical representation of the process, showing its value-added activities and non-value added activities within the system (Wan, 2006). A study by Gamage et al. (2012) used graphical the method to show the impact of implementing Lean tools for an Apparel production company in Sri Lanka. The Key Performance Indicators (KPI) used were Dock-To-Dock (DTD), raw material on-time delivery, first time through, plant efficiency, fabric utilization ratio, floor space savings, and orders delivered on time and delivered in full. The LM practices deployed caused a 10% reduction in cost, a 20% increase in plant efficiency and the lead time reduction of 30%. A cost-time graph was also developed by (Rivera and Chen, 2007) to illustrate the effect of Lean methods on items such as production activities, material approvals, delays and their relevant costs. The area under the graph showed the cost per unit of time that could be used for the analysis of organizational performance after the implementation of LM. Table 4.I gives the types of measurement models created by authors and their areas of application.

4.3.5 Impact of the Diversity of Lean Measurement Models

There has been an increasing interest by researchers, both in the industry and academia, to measure the impact of LM on the operational performance of an organization. As a result, different measurement models have been built for Lean performance measurement. However, these models are principally different from each other such that it becomes difficult for new LM adopters to select a model to use. Hence, it is important to develop a measurement model that can be used in different industrial sectors to measure the overall performance of LM. The impact of having different measurement models are:

1. It becomes difficult to compare the performance of LM for different companies and in different industrial sectors. This is because different industries implement different

practices, thus an attempt to compare their impact on performance gives problems. Marodin and Saurin (2013) attempted to give the basic and main LM practices, but agreement on these practices is still lacking.

2. It creates confusion because contradictory findings have been postulated by different researchers. The differences in results obtained by researchers may be due to the use of different models.

Table 4. 1: Lean measurement models and areas of application

Author	Model type	Instrument	Techniques /tools/practices/ strategies/methods used	constructs/ bundles/ dimensions	Qualitative Data Type	Quantitative Data Type	Industry used	operational/ organizational measures used
1. (Al-Tahat and Jalham, 2013)	Qualitative	Structural Equation Modelling (SEM)		Poka yoke, variability reduction, kaizen, TQM, 5S, visual control, quality at the source and Root Cause Analysis (RCA)	X		Various industries	Quality and productivity improvement
2. (Belekoukias et al., 2014)		Linear Regression and SEM	JIT, autonomation, kaizen, TPM and Value Stream Mapping (VSM)		X		Manufacturing	Quality, speed, dependability, flexibility and cost
3. (Bevilacqua et al., 2017)		Multi-group structural equation and cluster analysis	Pull production, kanban, SMED, TPM, Heijunka, mixed model, multi-skilled workforce, long term relationship with suppliers, job rotation, employee involvement, training and suggestion schemes.	JIT, HRM, supplier management and TQM	X		Various industries	Finished products managed, customization of products, batch size variation, production lead time, delivery reliability, percentage of finished product, response to warranty claim and percentage turnover
4. (Dal Pont et al., 2008)		SEM	Daily schedule adherence, shop flow layout, supplier responsiveness, JIT deliveries, kanban, setup reduction, small lot sizes, statistical quality control, 5S, small group sessions, poka yoke, teamwork, continuous improvement and training	JIT, TQM and HRM	X		Manufacturing	Unit cost, conformance to product specification, on-time delivery performance, fast delivery and flexibility.

5. (Demeter and Matyusz, 2011)		Cluster analysis and correlation analysis	Pull production, continuous improvement, quality programs, process focus and equipment efficiency.	JIT,TQM and HRM	X		Various industries	Inventory turnover
6. (Dennis, 2007)		Exploratory and confirmatory analysis	supplier/ customer feedback, pull production, quick changeover, total productive/total preventive maintenance, training, team building, production flow, supply chain coordination and involved customers		X		Manufacturing	Quality, inventory minimization, delivery, productivity, cost, sales and customer satisfaction.
7. (Kull et al., 2014)		ANOVA	5S, quality certifications, work standardization, visual management, JIT, TPM, benchmarking, continuous improvement, SMED, process mapping, VSM, cellular layout, one-piece flow		X		Manufacturing	Efficiency and productivity
8. (Shah and Ward, 2003)		SEM	Setup time reduction, Quality improvement and Cellular manufacturing, and	Quality improvement, setup reduction, shop flow employee involvement and cellular manufacturing	X		Manufacturing	Return on sales (ROS)
9. (Marodin and Saurin, 2013)		SEM	Manufacturing cells, standardization, one-piece flow, reduced setup times, reduced lot sizes, 5S, reduced buffer inventories, Kaizen and kanban system.	Simplified and strategically aligned Management Accounting practices (MAP), Visual performance and value stream costing	X		Manufacturing	Net sales, ROS, profit and market share
10. (Vinodh and Joy, 2012)		SEM	Quality management programs, cycle time reduction, agile manufacturing, lot	JIT, TQM, TPM and HRM	X		Various industries	Cycle time, scrap and rework costs, labour productivity, unit manufacturing costs, first-pass yield, and customer lead time

			size reduction, JIT, process capability measurements cross-functional workforce, self directed work teams and flexible, maintenance optimization, bottleneck/ constraint removal, reengineered process, predictive/ preventive maintenance, new process equipment or programs, competitive benchmarking, TQM, , formal continuous improvement, pull system, cellular manufacturing, focussed factory production system, quick changeover, safety improvement programs, planning and scheduling programs,					
11. (Jayaram et al., 2008)		SEM	Employee involvement, JIT flow, supplier development, cellular manufacturing, setup reduction and smooth information flow	Management responsibility, Manufacturing strategy, manufacturing management and workforce and technology leanness.	X		Manufacturing	Cost, quality, flexibility and environment
12. (Abdulmalek and Rajgopal, 2007)		Hierarchical Linear Model (HLM) approach	Cellular manufacturing, process redesign, JIT, manufacturing throughput time redesign, setup reduction, SPC and waste reduction		X		Manufacturing	Cost, quality and delivery
13. (Hong et al., 2014)		SEM	Closer customer relations, value analysis, JIT, design for manufacturability, cellular manufacturing, concurrent engineering, development, setup reduction, supplier	Relationship building, LM and lean design	X		Manufacturing	ROS, return on investment and return on sales

			partnering, supplier and standardization.					
14. (Zhou, 2012)		Regression	Problem-solving, Visual management, Jidoka, TPM, pull production, standardized work, multi-functionality, one piece-flow, setup reduction, andon and production levelling	TQM, JIT and TPM	X		Manufacturing	Lead time, inventory, quality, on time and turnover
15. (Nawanir et al., 2013)		SEM	Employee empowerment, Autonomation, JIT, pull system, workload balancing, quick setup time, small lots, 5S, group technology, improve facility layout, visualization, kaizen, hoshin kanri, employee involvement, QFD, VSM, RCA, TPM, reward system, communication system, management support, performance measurement system, training, employee commitment, and leadership	Process factor, process time reduction, physical structure factor, waste elimination, customer value factor, motivation factor, internal and external customer satisfaction, error prevention and human factor	X		Service	Customer perception of product/service quality, Customer satisfaction, Employees satisfaction and their performance, Employees understanding of the process, identification and elimination of waste, Operational efficiency, Productivity, Reduction in costs, Freeing staff time, Lead time and cycle time and Human errors
16.(Nawanir et al., 2016)		Regression	Quality at the source, small-lot production, cellular layouts, supplier networks, flexible resources, pull system, TPM, quick setup and uniform production level		X		Manufacturing	Profit, sales and customer satisfaction
17. (Marodin et al., 2017)		Regression	Reduced setup time, JIT and equipment and workstation for production.		X		Manufacturing	Quality, delivery, flexibility and cost
18. (Chavez		SEM	Product tracking devices, workforce empowerment,	Strategic customer service orientation, human	X		Different industries	Sales growth and market share, product quality and reliability,

et al., 2013)			continuous improvement, Computer systems, after-sales technical support, customer service support, training, data management systems, autonomous teams and improvement teams.	lean practices and technical lean practices.				delivery speed, manufacturing cost, labour productivity, and employee satisfaction
19. (Nawanir et al., 2016)		Multiple Regression analysis	Uniform production level, supplier networks, small-lot production, cellular layouts, flexible resources, TPM, pull systems, quick set up and quality at the source.		X		Manufacturing	Quality, inventory minimization, delivery, productivity, cost, sales, customer satisfaction
20. (Chin and Newsted, 1999)		SEM and ANOVA	Setup time reduction, Kaizen, Pull production, Poka Yoke, Small lot size, employee suggestion system, inventory reduction, 5 Whys, One-piece flow, Root cause analysis, Value stream mapping, 5 S, Cellular manufacturing, Process improvement and Preventive maintenance.		X		Manufacturing	Product quality, delivery speed, delivery reliability, responding change requests, overall performance, sales growth, return on assets and market share.
21. (Fullerton and Wempe, 2009)		SEM	Small lot sizes, setup time, pull production, short lead time and continuous improvement.	Lean Production, Product Quality Performance and business performance	X	X	Manufacturing	Profitability, market share, return on sales and return on assets
22. (Perera, 2016)	Quantitative	Work measurement	Cell layout, JIT, brainstorming, Ishikawa diagram, Process analysis, Visual management, Teamwork, Value Stream Mapping, Work standardization, 5S, Production smoothing, Takt time/cycle time,			X	Manufacturing	Cycle time

			Ergonomics work and Training.					
23. (Lacerda et al., 2016)		Time study	VSM			X	Manufacturing	Cycle time and inventory level
24. (Kumar, 2015)		Time study	VSM, Kaizen, FMEA and poka yoke			X	Manufacturing	Lead time and productivity
25. (Miller and Chalapati, 2015)		Time study	5Whys, VSM and Root Cause Analysis (RCA)			X	Healthcare	Waiting time
26. (Rivera and Chen, 2007)		Work measurement	VSM, RCA, Kaizen, cause and effect diagram, 5S and 5 Whys			X	Manufacturing	Inventory level and defect rate.
27. (Dombrowski et al., 2016)	Simulation	Systems Dynamics	Single Minute Exchange of a die(SMED)				Manufacturing	Setup time
28. (Yang et al., 2015)		Flexism software and Minitab	5S, TPM and Kaizen			X	Manufacturing	Overall Equipment Effectiveness
29. (Fullerton et al., 2014)		Discrete event Simulation	VSM, Product Quality(PQ) analysis and Pareto analysis			X	Manufacturing	Delivery time
30. (McLeod et al., 2016)		Opt Quest design and optimizing tool	VSM			X	Service	Work in Progress (WIP) and service level
31. (Standridge and Maas, 2015)		Factorial experimental design	Setup time reduction, TPM, pull production, VSM, 5S, visual systems, cellular manufacturing, JIT and Production levelling.			X	Manufacturing	Inventory level and lead time
32. (Abdallah and Phan, 2007)	Graphical		Training, hoshin kanri, SPC, worker empowerment, rewarding culture, VSM, 6S, visual management, error proofing, kanban, kaizen, line balancing, quick changeover and TPM			X	Manufacturing	Dock To Dock (DTD), raw material on-time delivery, first time through, plant efficiency, fabric utilization ratio, floor space savings, delivered on time and delivered in full

4.4 Methodology

A literature review was done to document the impact assessment models published by researchers. The databases used for the review were Science direct, Web of science, Emerald, Google scholar and Metapress. The keywords used for the search were Lean assessment methods, LM, impact measurement models, operational/ organizational performance, LM constructs and LM bundles. Articles were filtered by focusing on publications with LM performance measurement models. It was further noted that some models did not measure the impact of LM practices/ bundles on operational performance, hence they were not considered in the review. Only the articles that contained how LM affected operational/organizational performances were selected and the search yielded 32papers. Instruments that were used to build and measure those models were categorized into four groups which are qualitative, quantitative, simulation and graphical. The study showed that 21papers used qualitative models to measure the impact of LM on operational performance. 47% of the papers under qualitative models used SEM for their analysis; SEM was also selected as an instrument for building this model because of its demonstrated advantage from literature.

A Pareto analysis for Lean constructs was developed in Figure 4.1 in order to select the bundles that would be used for the model development. Three bundles, which are JIT, TQM and HRM were selected for building the model. These bundles are all linked to the TPS house which seems popularly used by most industry practitioners. However, the house contains another construct that is not referenced by most academics, which is standardization and stability; it was also included in this model's development.

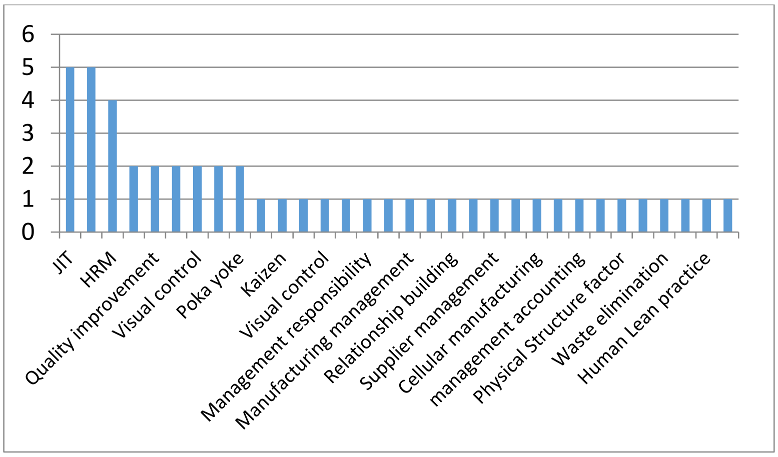

Figure 4. 1: Pareto analysis of the Lean terms

4.4.1 Graphical Representation of Models Reviewed in Literature

The literature search conducted by the authors showed that different impact measurement models have been developed by researchers. Figure 4.2 shows the number of models developed for each instrument used out of a sample of 32papers filtered from literature. The graph shows that ten models were developed using SEM, followed by regression that had five models, cluster analysis and time study had three models each, ANOVA had two, and the rest of the instruments had only one model. This showed that most authors seem to have preferred using SEM. The reason could be that it allowed researchers to use latent variables to perform path analytic modeling (Chin and Newsted, 1999) and can validate relationships between measured variables and latent variables. SEM also gives a set of relationships that are reliable and valid, providing the comprehensive explanation of the real scenario (Vinodh and Joy, 2012), hence it is well suited for both theory confirmation and theory development.

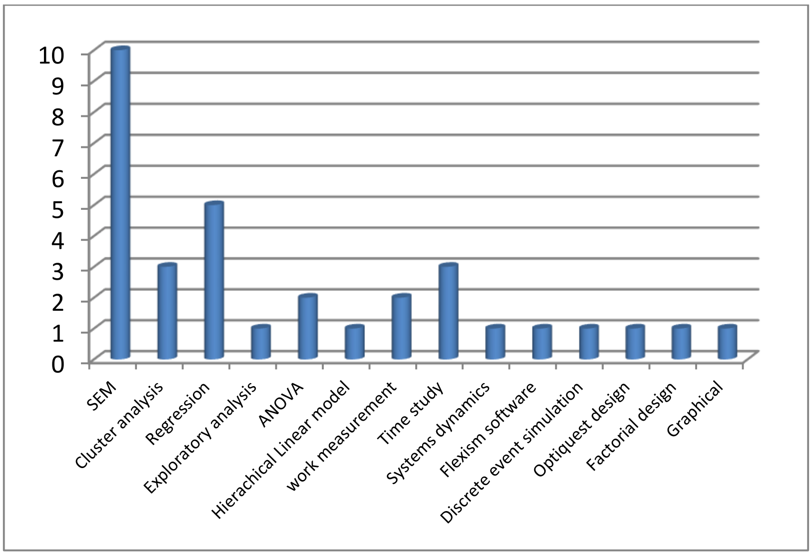

Figure 4. 2: Number of models developed for each instrument

4.4.2 General Overview of Structural Equation Modelling (SEM)

Structural Equation modeling (SEM) can be defined as a statistical modeling technique that amalgamates regression path analysis and factor analysis (MacCallum and Austin, 2000). Pearson et al. (1999) also define it as a technique that allows models of linear relationships to be specified and estimated. Chin and Newsted (1999) state that the major benefit of using SEM is its flexibility that allows researchers to test relationships among multiple predictor and criterion variables and building unobservable latent variables. SEM also allows correlation among measurement errors and test theoretical and measurement assumption against empirical data. It has also been shown that SEM allows a single analysis to estimate multiple and interrelated depended variables (Vinodh and Joy, 2012). Another benefit cited by the authors was that a relationship between sustainable programs and performance outcomes could be analyzed. A complex system can also be studied allowing casual relationships among latent variables to be explored. Hence, SEM was used for the development of the model in this study. The model would be tested in another chapter.

4.5 Model Development

The purpose of implementing LM is to enhance organizational performance through the improvement of the underlying LM latent constructs. The Lean constructs from the literature search were identified, and a Pareto chart for the constructs was conducted leading to the selection of TQM, JIT, and HRM. The constructs correlate to the house of Lean constructs which are Jidoka, JIT/Flow, and People integration, respectively. The mod el developed for measuring the impact of LM implementation on organizational performance is shown in Figure 4.3. The development of the hypothesis is shown in the next section.

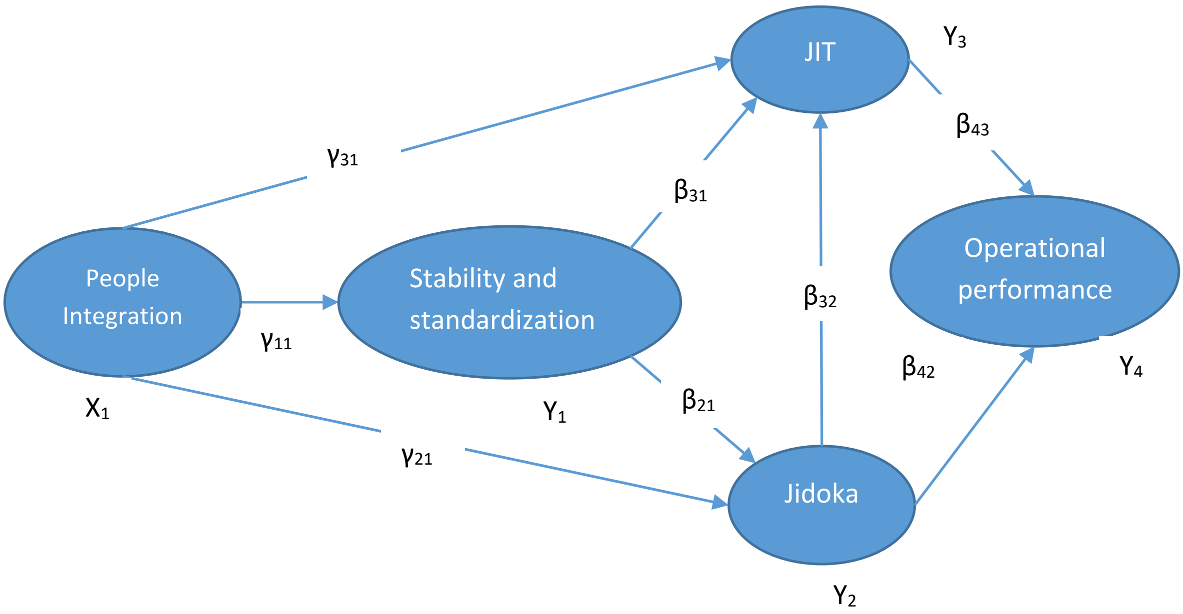

Figure 4. 3: Structural model for impact analysis

4.5.1 People Integration Has a Positive Impact on JIT/Flow

It is important to recognize the impact of workers on the achievement of flow within a system. Pearson et al. (1999) state that Human Resource Management (HRM) practices are important for flow to improve in an organization. A study by Abdallah and Phan (2007) showed that

HRM had a positive impact on JIT. Obamiro (2009) also showed that HRM positively affect JIT, therefore, the researchers hypothesized that HRM had a positive impact on JIT.

H_1: People integration has a positive impact on JIT/Flow

4.5.2 People Integration affects Jidoka

A study by Chandler and McEvoy (2000) showed that HRM positively affects TQM. This is because all processes are conducted and managed by workers. Worker empowerment will allow them to stop the processes when defects are detected and the processes will run efficiently. Yang (2006) showed that HRM practices had a positive impact on TQM in high tech companies in Taiwan. Similarly, researchers such as Daoud Abu-Doleh (2012) and Deshpande et al. (1994) showed that HRM positively affects TQM, hence it is hypothesized that HRM affects TQM.

H_2: People integration has a positive effect on Jidoka

4.5.3 People integration affects Stability and standardization

Human resources form the bloodline of every organization, without employees, operations would not proceed. When the workers are operating their machines effectively and make no mistakes, the production process becomes stable. Employees are responsible for performing the work and implementing changes caused by LM (Weber, 1985). They also manage their own processes and solve problems as they arise in the system. Thus, it is hypothesized that People integration affects Stability and standardization.

H_3: People integration has a positive effect on Stability and standardization

4.5.4 Stability and Standardization Affects JIT/Flow and Jidoka

Stability and standardization is the backbone of flow within any system. When the process is not stable, pieces of information and materials will not flow. Stability enables a predictable process such that the availability of materials, methods, manpower and machines are always consistent. Standardization enables the process to be carried out in the right way each time. This ensures that quality products are produced. Most companies treat stability and standardization as the backbone of flow and reduction of defects. No research has been done to show how stability and standardization affect JIT/Flow and Jidoka, therefore, researchers propose that:

H_4: Stability and standardization affects JIT/Flow

H_5: Stability and standardization affects Jidoka

4.5.5 Jidoka has a positive relationship on JIT

Flynn et al. (1995) showed that TQM influenced JIT performance through the reduction of rework and process variation. This is because there is a continual flow of products when quality is enhanced within a system. In our study, it is hypothesized that TQM has a positive effect on JIT.

H_6: Jidoka has a positive impact on JIT/Flow

4.5.6 Jidoka has a positive impact on operational performance

TQM is aimed at eradicating quality defects within a system. It also focuses on quality processes within all the stages of development and production, thereby aligning products and services to customer needs (Kannan, 2005). A study conducted by Sadikoglu and Olcay (2014) in Turkish firms showed that TQM practices had a positive influence on different performance measures within these firms. Studies by Chenhall (1997) and Mann and Kehoe (1994) have also shown that TQM practices have a direct impact on organizational performance, therefore, it is postulated that Jidoka has a positive effect on operational performance.

H_7: Jidoka has a positive effect on operational performance

4.5.7 Impact of JIT/Flow on Operational Performance

This construct enables inventory and waste reduction as well as space utilization and production of the right item at the right time (Belekoukias et al., 2014). Their study also showed that JIT had a direct and positive impact on operational performance. A study by Dal Pont et al. (2008) also showed that JIT had a positive and direct impact on operational performance. Similar studies by Fullerton et al. (2003) and Rahman et al. (2010) also show the same results, therefore, it is hypothesized that JIT has a positive impact on operational performance.

H_8: JIT has a positive impact on operational performance

4.6 Structural equations for the model

The mathematical equations for the model are given as:

i. $Y_1 = \alpha_1 + X_1\gamma_1 + \varepsilon_1$

ii. $Y_2 = \alpha_2 + X_1\gamma_{21} + Y_1\beta_{21} + \varepsilon_2$

iii. $Y_3 = \alpha_3 + Y_2\beta_{21} + Y_1\beta_{31} + X_1\gamma_{31} + \varepsilon_3$

iv. $Y_4 = \alpha_4 + Y_2\beta_{42} + Y_3\beta_{43} + \varepsilon_4$

These mathematical equations are later tested in Chapter 5 to check if the data collected suit the model prescribed. The major benefit of using SEM was that the equations are computed simultaneously. The results for the mathematical equations are also presented in Chapter 5

4.7 Conclusion

A variety of lean performance measurement models have been described in this chapter. However, it has been perceived that the diversity of these models have caused confusion on how to measure Lean impact on operational performance. The model developed can be used to measure LM performance and can be adopted by different industries. A model for evaluating the impact of LM bundles on operational performance was developed based on the assessment of models discussed in the literature. The model consists of LM bundles that are linked together to form a structural model. The next chapter will explain how the model was used to evaluate the impact of LM practices on operational performance.

Chapter 5: Lean manufacturing implementation in Zimbabwean industries: impact on operational performance

5.1 Introduction

The impact of LM implementation on organizational performance is an ongoing discussion. The effect of implementing LM tools on operational performance across various industries in Zimbabwe, a country with an unstable real Gross Domestic Product (GDP) is evaluated. A structural model of LM that is aligned with the Toyota Production System (TPS) house was proposed. A structured survey questionnaire was used for the collection of data in identified companies. Out of the 600 companies contacted, 214 useful responses were obtained implying a response rate of 35.6%. The structural and operational models were tested using the Statistical Package for Social Sciences (SPSS) and SmartPLS 3. The result indicated that operational performance was improved by implementing the selected LM tools.

5.2 Background of the study

LM is a philosophy that has been used by companies to increase competitiveness and organizational performance. It was initially embraced by the manufacturing sector, however, it has been adopted by the service industries such as education (Delago et al., 2016), healthcare, (Kovacevic et al., 2016, Miller and Chalapati, 2015, Andersson et al., 2015), hotel and tourism (Rauch et al., 2016, Vlachos and Bogdanovic, 2013) as well as transport (Villarreal et al., 2017).

The manufacturing sector in Zimbabwe has been struggling in their operations since the introduction of the multicurrency system in February 2009 (Mazhindu, 2014). This is because the sector is characterised by inadequate funding to improve on its machinery and technology (CZI, 2016), and as a result, the growth in real GDP has not been stable. For instance, the real GDP increased from 5.4% in 2009 to 16.3% in 2011, fell to 0.6% in 2016 and then increased to 3.7% in 2017 (RBZ, 2017). In this environment, companies that successfully implement LM may survive such turbulence better than others. However, the real GDP at constant factor prices for the industry sector improved from negative 0.1% in 2015 to positive 3.7% in 2018

A modified version of this chapter has been published in International Journal of Engineering Business Management

(worldbank, 2018) because companies have been taking advantage of the import management program that controls the importation of products to increase capacity utilization (RBZ, 2017). Despite the growth of the real GDP at constant factor prices, the industrial sector has also been threatened by imports from South Africa and China which accounted for 2.21billion USD and 380million USD respectively (Bonga, 2018). This has led companies in Zimbabwe to implement LM so as to eliminate waste and improve the quality of their products (Goriwondo et al., 2011).

LM philosophy has emerged as a powerful approach that has been used by companies in developing countries to improve their operations. Developing countries such as Kuwait (Al-Najem et al., 2013), Malaysia (Ansah and Sorooshian, 2017), Turkey (Garza-Reyes et al., 2015), Brazil (Godinho Filho et al., 2016), Thailand (Khanchanapong et al., 2014), Sri Lanka (Lindskog et al., 2017) and Indonesia (Nawanir et al., 2016) have adopted the philosophy in order to reduce manufacturing costs so that their products remain highly competitive. In Southern Africa, the effect of LM on operational performance is still under-researched. Studies on the application of LM in these countries include South Africa (Domingo, 2013, Kojima and Kaplinsky, 2004, Rathilall and Singh, 2018), Botswana (Mapfaira et al., 2014), Namibia (Isack et al., 2018, Mutingi et al., 2017, Ndinamwene et al., 2016) and Zambia (Chanda, 2017, Mathew Saili, 2017, Kasongo, 2015). In Zimbabwe, cases of implementation of LM tools and the impact on individual company performance have been reported. Such companies are found in margarine production (Goriwondo and Maunga, 2012), bakery (Goriwondo et al., 2011), tile company (Muvunzi et al., 2013), furniture company (Nyemba and Mbohwa, 2017), plastic manufacturing (Dzanya and Mukada, 2015), foundry (Madanhire et al., 2013), pharmaceutical company (Goriwondo et al., 2013), service industry (Gudukeya and Mbohwa, 2013), battery manufacturing (Karombo, 2014) and clothing (Chisosa and Chipambwa, 2018). This shows that research has been done on implementing LM in Zimbabwe, but the reports have been incoherent, making it difficult to understand how the concept has made an impact on industry-wide operational performance.

Some studies focussed on the synergistic results obtained from implementing Lean tools on operational performance. For instance, Value Stream Mapping (VSM) was used by (Dzanya and Mukada, 2015). However, Furlan et al. (2011) and Schroeder and Flynn (2002) state that greater operational efficiency can be obtained when the LM bundles are implemented simultaneously due to the synergistic effect of various LM tools. To the best of the author’s knowledge, no research has been conducted to show the impact of LM on operational performance across diverse industries in Zimbabwe. This research, therefore, seeks to evaluate the impact of LM on operational performance across Zimbabwean companies.

The chapter is organized into six sections: section 5.1 and 5.2 is the introduction and a discussion of the problem of interest; section 5.3 gives a literature review of the studies of companies that have implemented LM; section 5.4 is the methodology and describes how the structural model was built. In section 5.5, the results are given; section 5.6 gives the discussion of the results and the article concludes with areas of possible extensions in section 5.7.

5.3 Literature review

5.3.1 Historical Development of Lean Production

The term LM was initially introduced by Krafcik in 1988 and was further made popular by Womack in the book, "The machine that changed the world", (Womack et al., 1990). The term was used to compare the Japanese Toyota Production System (TPS) with mass production that was being implemented in the western economies. After World War II, there was tremendous pressure on material resources and Toyota was not spared (Ohno, 1988). The company was faced with many labour strikes, recorded a pre-tax loss and was on the verge of bankruptcy in 1950 (Fujimoto, 1999). This led Taiichi Ohno to introduce the concept of TPS to eliminate waste within the engine machining shop (Holweg, 2007). As a result, the TPS house has become a well-referenced icon in most industries in the world (Liker and Morgan, 2006).

5.3.2 LM Fundamental principles

LM is built around five basic principles which are value creation, value stream identification, uninterrupted flow, pull production and perfection. Table 5.1 gives a detailed description of the five LM principles.

Table 5. 1: LM principles

1. Value creation	LM is implemented in order to create value for the customer through the expenditure of resources. Customers are interested in paying for the value that they get from a product. Therefore, there is a need to eliminate the waste that the customer is not willing to pay for. Organizations need to seek how the customers perceive value for them to be successful.
2. Value stream identification	This involves efficient alignment of all the raw materials, information, processes, machinery and labour required for the production of goods and services. The major role of manufacturers would be to design processes that eliminate all non-value adding activities.
3. Uninterrupted flow	There is a need to manage the flow of resources within the production system so as to reduce the waiting time and traveling distances for workers. A good flow will enable work to progress steadily through the system. This is done through identification of all the delays, interruptions and bottlenecks thereby enhancing reliable delivery.
4. Pull	Pull production enables the manufactures to start the production process based on the demand for the product. This principle enables customers to trigger the manufacturing process rather than making the product beforehand.
5. Perfection	The major goal of implementing LM is to achieve perfection. However, attaining perfection can be obtained through continuously analysing each process for possible improvements. Manufacturers need to know that every process can be improved and a process is never perfect.

5.3.3 Studies of companies that have implemented LM around the world

Kojima and Kaplinsky (2004) assessed the performance of auto companies in South Africa using Lean Production Index (LPI). The LPI is composed of three elements which are quality, flexibility and continuous improvement. The results indicated that the value of LPI depended on factors such as ownership, access to foreign technology and human resources development.

However, buyers and the size of the firm had no impact on LPI. Mapfaira et al. (2014) studied the level of LM adoption in manufacturing companies in Botswana. Coping with change and the lower level of skilled personnel emerged as the major drawbacks in successful LM implementation.

Dal Pont et al. (2008) evaluated the impact of Total Quality Management (TQM), Just In Time (JIT) and Human Resource Management (HRM) practice bundles on operational performance in the High Performance Manufacturing (HPM) international project in 266 companies from countries such as the United States of America, Spain, Japan, Germany, Sweden, Korea, Italy, Austria and Finland. The results indicated that TQM and JIT had a direct and positive influence on organizational performance and HRM affected performance through the mediating effect of TQM and JIT.

Marodin et al. (2017) analysed the impact TPM, TQM and JIT have on organizational performances in 64 Brazilian firms. The study concluded that the TQM construct had no influence on operational performance measures. The JIT construct showed a high impact on inventory turnover whilst TPM had a positive impact on lead time. Fullerton et al. (2003) studied the correlation between financial performance and the degree of JIT practices adoption in 253 manufacturing firms in the USA. The results suggested that companies that implemented JIT practices extensively realized more profits than those that implemented it less extensively.

Numerous researchers such as Al-Tahat and Jalham (2013), Agus et al. (2012), Furlan et al. (2011), Hofer et al. (2012), Rahman et al. (2010) and Vinodh and Joy (2012) also studied the impact of implementing LM on operational performance.

5.3.4 Lean practices used for implementing Lean manufacturing in Zimbabwe

To the best of the author's knowledge, there is no measurement instrument that has been developed for assessing LM in Zimbabwe. A literature study conducted by Maware and Adetunji (2018) showed that three constructs - JIT, TQM and HRM were mainly used by researchers to develop qualitative measurement models. They found that these constructs correlated with bundles in the TPS house which are Flow, Jidoka and People integration. While it is generally difficult to select a popular structural model for LM as a consensus from academic publications, the structural model by Dennis (2007), reproduced in Figure 5.1, has been adopted for implementing LM by many companies in Zimbabwe. It indicates the five key constructs around which all the LM activities and tools are built: customer focus/value creation, just in time/flow kaizen, jidoka/process kaizen, people involvement/ integration (internal and external), and standardisation and stability foundations.

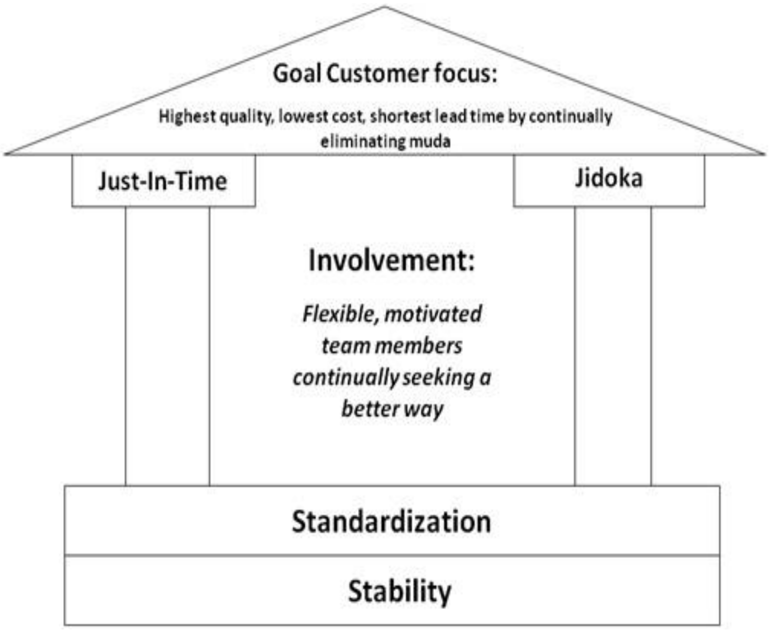

Figure 5. 1: TPS house adopted from Dennis (2007).

The TPS house seeks to improve the stability of the manufacturing systems and the company's competitive advantage through satisfying customers. The foundation consists of Stability and standardization. Stability allows the pillars (JIT and Jidoka) to be built (Liker and Morgan, 2006) whilst standardization enables predictable and stable results. Veech (2004) refers to the Jidoka and JIT pillars as the stop and go columns respectively. This is because JIT allows the system to flow with minimum inventory and Jidoka enables the system to stop when any abnormality has been discovered. Jidoka also reduces quality defects thus enabling a complete working system (Belekoukias et al., 2014). People integration forms the heart of the house and the workforce must be flexible and continually seek for improvement. The roof of the house gives the ultimate goal of Lean manufacturing which is achieving the shortest lead time, lowest cost and best quality.

5.3.5 Measurement models found in literature and practice

The Lean models have focussed on either lumping a number of Lean techniques into the same aggregate constructs or applying them individually. When lumped together, they are referred to as bundles, constructs, factors, latent structures and dimensions (Al-Tahat and Jalham, 2013, Bevilacqua et al., 2017, Dal Pont et al., 2008, Zhou, 2012). When used individually, they are referred to as tools, practices, techniques, strategies, methods and elements (McLeod et al., 2016, Fullerton et al., 2014, Fullerton and Wempe, 2009, Belekoukias et al., 2014). The massive proliferation of LM models has made the navigation of this domain quite difficult. Many authors have attempted to create models out of this massive pandemonium, but their structures are principally different from one another. It is, therefore, difficult to simply adopt a model from literature as the acceptable LM structural model since diverse models have been built by authors. This research will consider the use of LM bundles in developing a Structural Equation model.

5.3.6 Overview of Structural Equation Modelling (SEM)

Structural Equation modelling (SEM) can be defined as a technique that allows models of linear relationships to be specified and estimated (MacCallum and Austin, 2000). The two parts for SEM models are the measurement component and structural component. The structural model shows the casual connection between latent variables (Blunch, 2012). The measurement model is composed of latent variable and their indicator variables. SEM allows researchers to use latent variables to perform path analytic modelling (Chin, 1998) and can validate relationships between measured variables and latent variables.

SEM has been named the second generation of multivariate analysis tools (Fornell et al., 1990). It allows confirmatory and exploratory modelling to be performed. SEM gives a set of relationships that are reliable and valid providing a comprehensive explanation of the real scenario (Vinodh and Joy, 2012) hence, it is well suited for both theory confirmation and theory development. The hypothesis of the model constructed can be assessed against empirical data to show how well it fits the data. To perform SEM analysis, the researcher starts by formulating a theoretical model followed by model specification, parameter specification and fit evaluation (Swanson and Holton, 2005).

5.3.7 The proposed structural model of LM implementation

SEM has been found to be well suited for addressing numerous problems in LM research. It is one of the most preferred methods used for data analysis by Operations Researchers (Shah and Goldstein, 2006). Chin and Newsted (1999) cited that the major benefit of using SEM is its flexibility that allows researchers to test relationships among multiple independent and dependent variables. SEM also allows correlation among measurement errors and test theoretical and measurement assumption against empirical data. It has also been shown that SEM allows a single analysis to estimate multiple and interrelated depended variables (Vinodh and Joy, 2012). A complex system can also be studied allowing casual relationships among latent variables to be explored.

This section presents the latent variables and hypothesizes the relationships between them. The TPS house contains constructs which are Stability and standardization, JIT, People integration and Jidoka. Generally, the study seeks to solve a recursive model.

Figure 5.2 shows the LM structural model developed for evaluating the impact of Lean tools on operational performance.

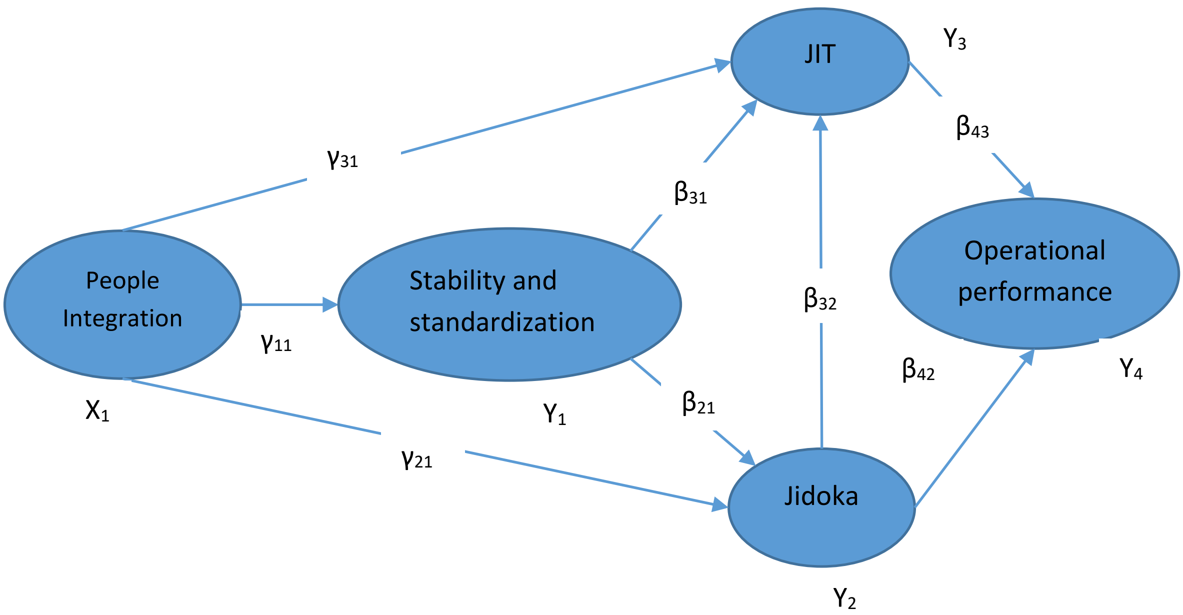

Figure 5. 2: Lean measurement structural model

The success of LM relies on worker involvement, empowerment and team effort which are all HRM practices. People integration incorporates a system created to empower employees to continuously improve organizational tasks so as to enhance the efficiency and effectiveness of the company. Employees are responsible for performing the work and implementing changes caused by LM (Weber, 1985). They also manage their own processes and solve problems as they arise in the system. Studies by Fullerton et al. (2003) and Dal Pont et al. (2008)showed that the workforce that is flexible and works in teams make a great commitment to JIT and thus, People integration affects JIT. HRM practices such as employee retention, staffing, compensation, training and development also enhance a defect-free process. Researchers such as Dal Pont et al. (2008), Chandler and McEvoy (2000) and Yang (2006) found a direct and positive impact of HRM on TQM. It is therefore hypothesized that:

H_1: People integration dimension is positively related to JIT

H_2: People integration has a positive impact on Jidoka

H_3: People integration is positively correlated to Stability and standardization

Stability and standardization can be defined as the state of the system being able to consistently provide items uniformly with little variations such as demand fluctuation, machine breakdown, human failure and balancing product varieties. Stability and standardization help to reduce interrupted flows because orders are received on time, machines are operated as planned and work standards are followed. The major aim of standardization is to create standards in work methods and processes (Marksberry, 2012). It is also easier to assess the source of the problem when the processes are standardized. The level of LM success will be reduced when stability is not implemented (Sayer and Williams, 2011). Stability and standardization also allow processes to be done in the correct way each time thus ensuring quality products and services are produced. Therefore, the following hypotheses are proposed:

H_4: Stability and standardization is positively related to JIT

H_5: Stability and standardization is positively related to Jidoka

A study by Flynn et al. (1995) asserted that JIT performance increased by using quality management practices. Similarly, Kannan and Tan (2005) showed that TQM practices had a strong relationship with JIT. Other researches have also explored the effect of JIT and TQM on firm performance. Shah and Ward (2003), Chenhall (1997), Talib et al. (2010), Mann and Kehoe (1994), Sadikoglu and Olcay (2014) and Fullerton et al. (2003) showed that higher financial returns were obtained when a company invests in quality practices. Rahman et al. (2010) showed that JIT and flow had a positive relationship with operational performance in Small and Medium Enterprises (SME) and Large Enterprise (LE) companies in Thai. Callen et al. (2000)studied Canadian companies and found that implementation of JIT led to lower variable costs, higher contribution margins and profit. Fullerton et al. (2003) also state that Kanban and JIT purchasing results in increased marginal returns. Therefore, it is hypothesized that:

H_6: Jidoka has a positive relationship with JIT

H_7: JIT is positively related to operational performance

H_8: Quality Integration positively influences operational performance

5.3.8 Regression mathematical equations

The model given in Figure 5.2 consists of four equations that are represented below. The mathematical equations for the model are given as:

v. $Y_1 = \alpha_1 + X_1\gamma_1 + \varepsilon_1$

vi. $Y_2 = \alpha_2 + X_1\gamma_{21} + Y_1\beta_{21} + \varepsilon_2$

vii. $Y_3 = \alpha_3 + Y_2\beta_{21} + Y_1\beta_{31} + X_1\gamma_{31} + \varepsilon_3$

viii. $Y_4 = \alpha_4 + Y_2\beta_{42} + Y_3\beta_{43} + \varepsilon_4$

5.4 Research methodology

5.4.1 Instrument development

A questionnaire was developed for the model in order to measure the impact of LM constructs on operational performance. The questionnaire was divided into three sections: Section A contained information about the company; Section B was dedicated to questions on the level of adoption of LM constructs in companies. Section C comprised of questions about the operational performance of the company. The questions were adopted from authors such as Abdallah and Phan (2007), Cua et al. (2001), Khanchanapong et al. (2014) Shah and Ward (2007), Dal Pont et al. (2008), Wickramasinghe and Wickramasinghe (2017), Dora et al. (2014) and Garza-Reyes et al. (2015). These were measured on a 7point quantitative scale with 1 representing strongly disagree; 2-disagree; 3-disagree somewhat; 4-undecided; 5-agree somewhat; 6-agree and 7-strongly agree. Operational performance was evaluated using items from Belekoukias et al. (2014) and Shah and Ward (2003) which were speed, flexibility and dependability. A five-point scale was used for measuring operational performance with 1 representing declined more than 20%; 2-declined 1-20%; 3-stayed the same; 4-increased 1-20% and 5-increased more than 20%. A pilot study was done in order to receive ideas from industry practitioners and academics about the questionnaire. Some items were discarded, modified or added to ensure reliability and construct validity. The items questionnaire developed is shown in Appendix1.

5.4.2 Data collection procedure

600 manufacturing organizations registered with the Confederation of Zimbabwean Industries (CZI) were contacted in order to respond to the questionnaire. These companies fell under the plastics, agrochemicals, pharmaceutical, automobile, food, steel, beverage, timber, garment, battery, electrical and electronics manufacturing companies. 300 questionnaires were distributed by hand whilst other companies were reached by sending a Google form link via email. A total of 214 useful and complete responses were received resulting in a response rate of 35.6%. Table 5.2 shows the distributions of the responses across different industries obtained by the researchers.

Table 5.2: Industry distributions

Type of industry	Number of companies	Sample %
Pharmaceutical	20	9.3
Plastics	20	9.3
Agrochemicals	15	7.0
Automobile	23	10.7
Food	42	19.6
Steel	19	8.9
Beverage	15	7.0
Electrical and Electronics	14	6.5
Timber production	15	7.0
Battery	20	9.3
Garment	11	5.1

5.5. Data analysis

Data analysis was done using SPSS version 25 and SmartPLS 3. SPSS was used for exploratory factor analysis. SmartPLS 3 was used for assessing the measurement and structural model. Assessing the measurement model involves evaluating the relationship between LM constructs and their measurement items whilst assessing the structural model determines the correlation between the constructs (Hair Jr et al., 2016).

5.5.1 Assessing the measurement model

Adopting the measurement items from previously published articles ensured high reliability of the questionnaire (Godinho Filho et al., 2016, Dora et al., 2015, Shah and Ward, 2007). A total of 49 items were initially selected for measuring the five LM constructs. Exploratory factor analysis was used to minimize the number of items for individual constructs and to assess construct validity, thus ensuring a parsimonious representation for the five latent factors: JIT, Jidoka, People integration, Stability and standardization and operational performance. 19 items were finally selected for the constructs after the preliminary analysis. A Kaiser-Meyer-Olkin (KMO) value of 0.866 was obtained indicating that the sample size of 214 was adequate. The Bartlett's test of sphericity was significant with a p-value <0.001. By using the factors with the Eigenvalue > 1 and the shape of the scree plot to determine the underlying constructs, the analysis confirmed the five-factor structure with a variance of 61.770% explainable by the model.

Cronbach's Alpha was used for assessing internal reliability and consistency of the constructs. The results for each construct were in the range of 0.651 and 0.877 and were regarded as acceptable to high (Bevilacqua et al., 2016, Götz et al., 2010, Malhotra, 2007). The Average Variance Extracted (AVE) should be greater than 0.5 to ensure construct validity (Silva et al., 2018, Avkiran, 2018). The AVE values were greater than 0.5 denoting that the factors constituted more than half of the variance explained by the model. The values for composite reliability shown in Table 5.3 were all greater than 0.7 indicating that the constructs had high internal consistency.

Table 5. 3: Construct Reliability and validity

	Cronbach's Alpha	rho_A	Composite Reliability	Average Variance Extracted (AVE)
JIT	0,799	0,801	0,869	0,624
Jidoka	0,877	0,880	0,916	0,731
Operational performance	0,651	0,652	0,811	0,589
People integration	0,804	0,808	0,872	0,630
Stability and standardization	0,724	0,724	0,844	0,644

The results of the Fornell- Larcker criterion shown in Table 5.4 indicated that measurement items were highly loaded to their respective constructs thus supporting discriminant validity. Moori et al. (2013) state that discriminant validity is ensured when the AVE values are greater than the correlation among the factors.

Table 5. 4: Fornell- Larcker criterion

	JIT	Jidoka	Operational performance	People integration	Stability and standardization
JIT	0,771				
Jidoka	0,674	0,855			
Operational performance	0,392	0,382	0,768		
People integration	0,514	0,570	0,278	0,794	
Stability and standardization	0,574	0,614	0,334	0,501	0,802

5.5.2 Assessing the structural model

The R^2 values for the endogenous variables ranged from 0.317 to 0.680. (Cohen, 1988)state that when the R^2 values are equal to 0.26 they are considered substantial, 0.13 moderate and weak if the values are 0.02. Moori et al. (2013) also cite Cohen (1988)who states that for behavioural studies 0.26 is considered a large effect. The coefficient of determination (R^2) for Jidoka, JIT, operational performance and stability and standardization were 64.3%, 68.0%, 31.7% and 42.8% respectively. This showed that JIT, Jidoka and People integration had a good influence on operational performance. The diagram in Figure 5.3 illustrates the SEM model showing the structural linkage between People integration, Stability and standardization, JIT, Jidoka and operational performance.

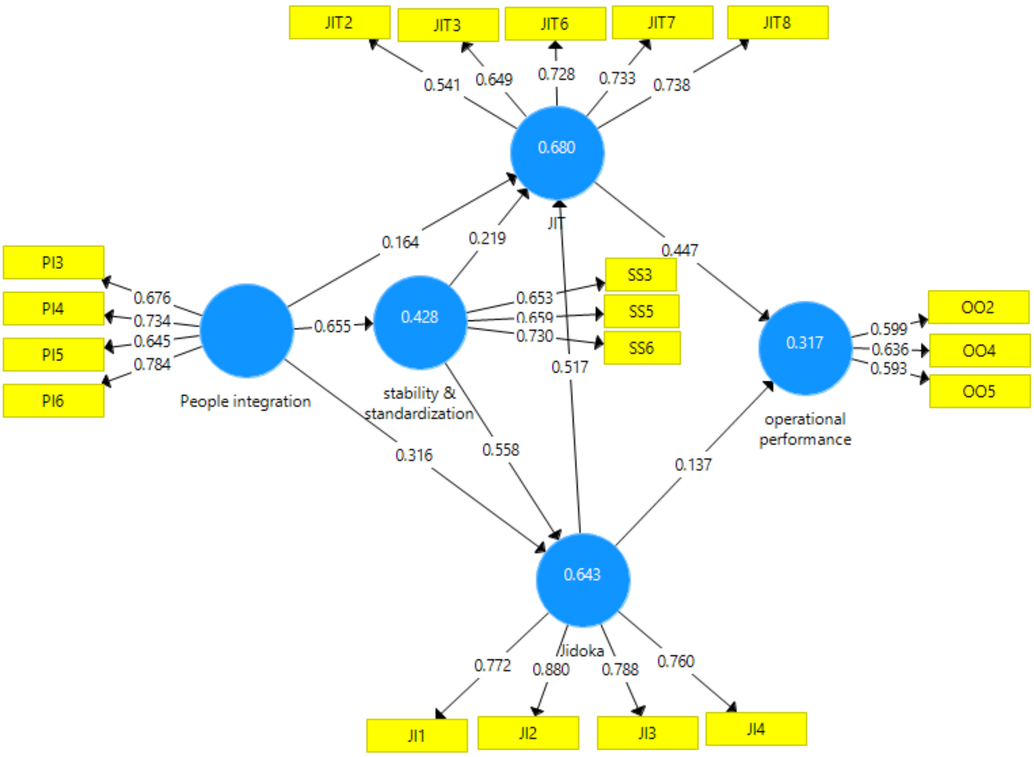

Figure 5. 3: SEM model

People integration had a strong relationship with Stability and standardization than with JIT and Jidoka as shown by their structural coefficients which were 0.655, 0.249 and 0.301 respectively. Stability and standardization had a strong relationship with Jidoka than with JIT. The Jidoka construct had a strong relationship with JIT and this is shown by a high path coefficient of 0.517. The results for total effects showed that people integration has a strong total effect on operational performance (0.374), followed by JIT (0.358), Stability and standardization (0.333) and Jidoka (0.223). The results also support other findings from authors such as (Dal Pont et al., 2008, Furlan et al., 2011, Fullerton and Wempe, 2009, Hong et al., 2014, Wickramasinghe and Wickramasinghe, 2017, Rahman et al., 2010, Yang et al., 2011, Agus et al., 2012, Belekoukias et al., 2014, Hofer et al., 2012, Jayaram et al., 2008, Marodin et al., 2017).

The t-statistic and the p- values in Table 5.5 fail to reject any of the hypotheses. This indicates that all the hypotheses were supported and the model could be used for evaluating the impact of implementing Lean manufacturing on operational performance.

Table 5. 5: T values, P values, standard deviation and decision for the hypotheses

	Original Sample (O)	Standard Deviation	T Statistics	P Values	Hypothesis	Decision
JIT -> Operational performance	0,248	0,101	2,468	0,014	H_6	supported
Jidoka -> Operational performance	0,215	0,109	1,974	0,048	H_7	supported
People integration -> JIT	0,514	0,062	8,321	0,000	H_1	supported
People integration -> Jidoka	0,570	0,054	10,640	0,000	H_2	supported
People integration -> Stability and standardization	0,501	0,058	8,687	0,000	H_3	supported
Stability and standardization -> JIT	0,423	0,068	6,257	0,000	H_4	supported
Stability and standardization -> Jidoka	0,439	0,063	6,922	0,000	H_5	supported

5.6 Discussion

The main objective of the study was to evaluate the impact of implementing LM tools such as people integration, stability and standardization, JIT and Jidoka on operational performance in companies across Zimbabwe. The results supported all the hypotheses that were developed showing that the LM tools can enhance operational performance. Several studies conducted in developing countries have shown that LM tools adoption results in the improvement of operational performance. Researchers such as Nawanir et al. (2013), (Marodin et al., 2017, Khanchanapong et al., 2014, Eswaramoorthi et al., 2010) have shown that the adoption of LM has given manufacturing companies a competitive edge through yielding positive results. Shrafat and Ismail (2018) concluded that limited research has been conducted on LM in developing countries. Marodin et al. (2019) stated that developed countries often face difficulties to become Lean due to the changes in the market orientation. This study therefore, adds to the current discussion of the impact of LM in developing economies.

It has been said that people are the backbone for successful implementation of LM (Dennis, 2007). The results indicated that there was a need to educate employees on the importance of implementing LM since every system is managed and driven by people. This suggests that managers should invest in training employees so that they can drive the LM implementation program. People integration had a positive relationship with JIT and Jidoka indicating that workers strived to enhance the flow of materials and quality of items produced. Stability and standardization also had a huge impact on JIT than Jidoka. A stable and standardized system increases the speed of manufacturing because the flow of materials is less interrupted across the production floor. Standardization also helps to set quality criteria for different operations along the value chain. Jidoka and JIT had positive relationships with operational performance. This is because when high quality materials and products flow through the system, operational performance is enhanced. The performance improvement variables that were greatly influenced were speed, flexibility and dependability. The path coefficients on operational performance showed that flexibility had the greatest contribution to LM followed by speed and dependability.

The major strength of LM implementation in Zimbabwe is that the employees got motivated about the program which made them to be dedicated and hardworking. This management practice has also helped many companies to move forward in continuous improvement of their systems. It was observed that the weakness of LM was that the project was competing for resources with other management programs that were initiated by organizations. The opportunities were that organizations were made to be more competitive since they were able to set and follow standards for their processes once they applied the stability and standardization practice. There was improvement in the quality of products, designs, flow and communication. The implementation of LM also created fear among the workers for job losses through retrenchment, however, the management reassured them that some would be redeployed to other areas.

5.7 Conclusion

The study demonstrated that implementing LM tools results in increase in operational performance variables such as speed, flexibility and dependability. Empirical validation of the structural model was done among 214 companies in Zimbabwe. The study showed that the operational performance construct was influenced by the four constructs in the TPS house.

People integration acted as a prerequisite upon which other constructs were built. People have been described by Dennis (2016) as the wind that drives the Lean sail. People management is important for ensuring the pillars (flow and Jidoka) and foundation (Stability and standardization) of LM are achievable. The purpose of Stability and standardisation is to create an environment in which LM can be applied (Dennis, 2016). When variability is too high in the Lean system, getting results from implementing Lean becomes difficult. Hence, the extent to which the various functional areas, as well as products of the system are standardised leads to successful implementation of LM.

JIT enables the continuous flow of items and materials through the system with a minimum in process inventory. The level and extent of uninterrupted flow of materials through a system is a key characteristic of a Lean system. Jidoka will help to eliminate defects within a production system. It ensures that quality is maintained in all stages of product design, development and production. This in turn, increases the operational performance of organizations. The results also showed that LM can also be successful in an unstable economic environment such as in Zimbabwe. The major limitations of the study were that more companies could have been used for evaluating the model and the model could also be tested in other developing countries in Southern Africa.

Chapter 6: The moderating effect of Industry clockspeed on Lean Manufacturing implementation in Zimbabwe

6.1 Introduction

This chapter focusses on the analysis of the moderation effect of Industry Clockspeed (IC) on the relationship between LM practices and operational performance. A model for evaluating the effect of LM is developed and the moderating effect of IC is taken into consideration as a fundamental variable that affects the causal relationship between LM practices and operational performance. A structural equation model was proposed and investigated across two groups based on IC levels (Group 1: low IC and Group 2: High IC). A structured survey questionnaire was used to collect empirical data from 600 companies listed by the Confederation of Zimbabwean Industries (CZI). A total of 214 usable questionnaires were obtained giving a response rate of 35.6%. The data was analysed using Smart PLS 3 and SPSS version 25. The results revealed that LM practices directly and positively affected operational performance and IC had a positive moderation effect on the relationship between LM practices and operational performance. The results indicated that the structural equation model remained invariant across the groups. This showed that IC had a moderating effect on the relationship between LM practices and operational performance for both low IC and high IC industries. The chapter analysed the moderating effect of Industry Clockspeed (IC) in Zimbabwean industries. The study will provide further evidence to managers on the effect of LM practices on operational performance in developing countries

6.2 Introduction

Lean manufacturing (LM) emerged from the Toyota Production System (TPS) and has been used by many manufacturing organisations to improve productivity. Companies in Zimbabwe have also been part of the quest for eliminating waste in manufacturing processes. Many manufacturing companies have implemented the philosophy in order to reduce production cost so that their products can compete with those that are imported from other countries worldwide. While the economic challenges facing Zimbabwe has hindered most companies from implementing other performance improvement strategies (Goriwondo and Maunga, 2012), LM

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has continued to be applied by many firms in order to boost capacity utilisation and eliminate waste (Goriwondo et al., 2011). However, the effects LM has on operational performance remains largely unknown, causing some managers to be hesitant to adopt the philosophy.

Shrafat and Ismail (2018) state that several researchers have established that more studies need to be conducted to gain an understanding of the effect of LM practices on operational performance in developing countries. The number of studies on LM implementation in developing countries is relatively low compared to developed countries (Panizzolo et al., 2012). Wilson (2009) also states that researchers in developing countries have misled the manufacturers in these countries on the difficulty of implementing LM. This has led companies in developing countries to be sceptical on the benefits of implementing the management practice. This research seeks to evaluate the effect of implementing LM practices in Zimbabwean industries.

Diverse research models with different constructs have been developed to evaluate the effect of LM on operational performance. The objectives of such studies include the evaluation of the effect of LM tools on operational performance, measuring how organizations adopt LM and quantifying the maturity level of LM implementation in different organizations (Santos Bento and Tontini, 2018). Some empirical studies have shown that LM implementation results in increased operational performance (Shah and Ward, 2003) while others have shown that the implementation of LM has little or negative impacts (Bhasin and Burcher, 2006, Browning and Heath, 2009). Many organizations face challenges when trying to implement LM (Chiarini et al., 2018). A review by Negrão et al. (2016) revealed that five studies had shown that LM implementation had a negative impact on operational performance. Institutional and contingency theories may provide insight into some of these contradictions. The institutional theory states that organizations mimic the actions and practices of other organizations because of the pressure to remain competitive. Organizations in the developing countries also seem to have been imitating the Toyota Motor company that has been successful in implementing LM. Most organizations in these countries concentrate on implementing the various LM practices in their organizations, focussing on the production system rather than accepting the LM concept as an organizational philosophy. These different paradigms are referred to as the Lean toolbox and Lean philosophy respectively (Bengt, 2013). Some organizations also rush to implement the LM tools without considering the strategic actions that will make the implementation to be fruitful (Choudhary et al., 2019). Thus, implementing LM can only be successful when the philosophy behind the technique is fully understood (Mårtensson et al., 2019). On the other hand, the contingency theory states that corporations are organized according to external situations. Their effectiveness emanates from fitting organizational characteristics to contingencies (McAdam et al., 2019) which may be the environment they operate in. Therefore, organizations will imitate the structures and actions of other companies to improve their operations depending on the environment within which they are operating.

Related to the contingency theory is the effect of IC. The rate of change within an industry can affect the influence that LM has on operational performance. This is referred to as the impact of Industry Clockspeed (IC). In a high-paced industry, products and processes are constantly changing, hence positive results might not be noticed quickly compared to a low-paced industry. This may imply that the implementation of LM in a slowly changing industry may quickly yield positive results than in the high-paced industry. This is part of the postulations in this work's hypothesis. Part of the challenge faced by the manufacturing sector in Zimbabwe is the effect of IC on their manufacturing processes coupled with globalization that makes the implementation of improvement strategies to be difficult.

There are relatively few studies that have evaluated the effect of IC on the association between LM practices and operational performance. Chavez et al. (2013) analysed how internal LM practices affected operational performance through the moderating effect of IC. Internal Lean practices are tools and methods that address issues inside an organisation. External practices are techniques that are related to customers and suppliers. The results indicated that the internal LM practices positively affected delivery, flexibility and quality. The study used only two internal LM practices (process setup time reduction and JIT), but for successful LM implementation, external practices have to be considered. This study therefore extends the body of knowledge by testing the moderating effect of IC on the relationship between LM internal and external practices and operational performance.

The following questions are addressed:

1. What are the effects of internal and external LM practices on operational performance?
2. Does IC have a moderating effect on the association between LM practices and operational performance?

6.3 Literature review

The review focuses on the studies that have investigated the relationship between LM and operational performance.

6.3.1 LM practices implemented by Zimbabwean industries

The Zimbabwean manufacturing sector has been declining due to a shrinking domestic market, low capacity utilisation, hyperinflation and reduced demand for local products due to high prices (Damiyano et al., 2012, Goriwondo et al., 2011). Faced with such a situation, most companies are implementing LM in order to improve their operational efficiency and production costs in order to be more competitive both locally and internationally. Many organizations have implemented a diverse number of LM practices. The use of Value Stream Map (VSM) in a bakery manufacturing company resulted in the reduction of waste by 25% and a 16% increase in throughput (Goriwondo et al., 2011). In an aluminium foundry company, implementation of Just In Time (JIT) resulted in lower production costs and throughput time (Madanhire et al., 2013). In another study, the implementation of VSM in a margarine manufacturing company led to an improvement in cycle time by 86% (Goriwondo and Maunga, 2012). Goriwondo et al. (2013) also reported that the use of VSM resulted in the reduction of cycle time and lead time for tabletting and liquid creams and ointments for a pharmaceutical company. In another study by Muvunzi et al. (2013), implementation of VSM in a tile manufacturing company led to an improvement in processing times, lead time, cycle time and raw material costs. In a different study by Nyemba and Mbohwa (2017), transportation costs were reduced by 43% in a furniture manufacturing company due to the implementation of process maps. Furthermore, implementation of VSM in a glide manufacturing company led to an improvement in lead time, processing time and manpower utilisation (Dzanya and Mukada, 2015).

Literature review shows that there are few documented researches on the evaluation of LM practices in Zimbabwean manufacturing industry. To the best of the author's knowledge, this is the first study showing how IC acts as a moderating variable for the relationship between LM practices and operational performance in Zimbabwean companies. Pareto analysis was used to rank LM practices mostly used by companies in Zimbabwe. Figure 6.1 shows that four LM practices frequently used in LM implementation were JIT, Jidoka, Stability and standardization and People integration. Practices such as Kaizen, poka-yoke, visual control, Cellular Manufacturing (Avkiran) and Total Preventive Maintenance (TPM) were not frequently used by companies. In addition, practices such as one-piece flow, quick changeover, Statistical Process Control (SPC), setup reduction and line balancing were used less frequently. As a result, JIT, Jidoka, Stability and standardization and People integration were used for developing the model that measured the effect of LM practices on operational performance in Zimbabwean firms.

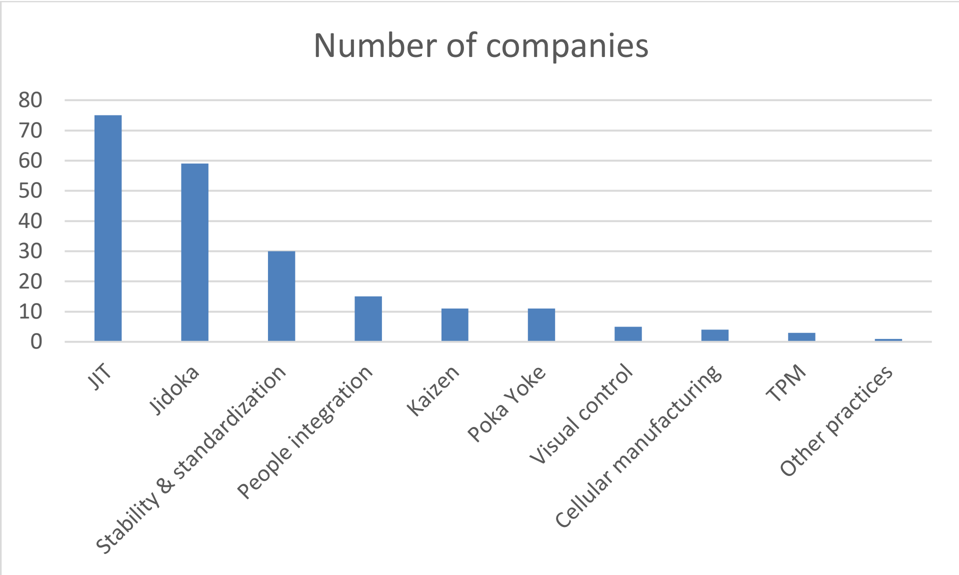

Figure 6. 1: Pareto analysis of LM practices

6.3.2 Relationship between LM practices and operational performance

The application of LM practices is not considered just as an operations management technique but a philosophy that has helped organizations to improve efficiency, effectiveness and cost of their operations (Barnabè and Giorgino, 2017, Spasojevic Brkic and Tomic, 2016, Dubey and Singh, 2015). Shrafat and Ismail (2018) developed a model to assess the impact of LM practices on business performance with operational performance acting as a mediating variable in Jordanian companies. The results revealed that LM practices have a strong and direct relationship with business performance and operational performance. Additionally, operational performance has a strong mediating effect on the link between LM and business performance. Panwar et al. (2018) investigated the effect of implementing LM practices in Indian process industries. The results showed that the adoption of LM practices increased operational and quality performance. In another study of Jordanian companies, Al-Tahat and Jalham (2013) found that implementation of eight lean practices had a positive effect on the Quality Performance Indicator (QPI). Similarly, Belekoukias et al. (2014) examined the impact of five lean practices which were VSM, autonomation, Just In Time (JIT), Kaizen and Total Preventive Maintenance (TPM) on operational performance. The results showed that the implementation of these practices had a significant and positive relationship with flexibility, cost, speed, dependability and quality. Several other studies such as Fullerton et al. (2003), Hofer et al. (2012), Wickramasinghe and Wickramasinghe (2017) and Dal Pont et al. (2008) have also found a positive relationship between LM practices on operational performance.

6.3.3 Institutional theory, contingency theory and Industry clockspeed (IC)

Institutional theory suggests that organizations may adopt performance improvement techniques such as LM in their operations due to mimetic, coercive and normative pressures. Organizations are open systems that are influenced by external environments to comply with certain standards and exhibit organizational legitimacy. As a result, organizations implement LM to increase customer value, reduce manufacturing costs and increase market share. Mimetic pressures describe how organizations copy their competitors in order to outperform them (Gupta et al., 2019, Cavusoglu et al., 2015). Organizations may copy the structures of the competitors in order to improve their performance (Fang et al., 2019). The coercive pressures can be defined as pressures that are exerted by other bodies in order for organizations to satisfy regulations (Fang et al., 2019). Organizations are forced to comply with regulations for them to continue operating and these regulations may act as a basis of formation of associations with other organizations (Iyer, 2019). Normative pressures occur as organizations transform in order to suit the respective industry standards (Iyer, 2019, Cao et al., 2014, Liao, 2018).

The contingency theory states that best practices may be applied relying on the contingencies of the situation. These contingencies may be the external environment, culture or firm size. This theory analyses the organizational issues based on the contextual situation. IC is also one of the contingencies that organizations should consider before implementing LM. IC is defined as the pace/rate of change of an industry caused by factors such as changes in technology and competition (Metanantakul et al., 2018, Wiengarten et al., 2012). Carter and Jackson (2019) also defined it as the degree of change of forces that affect an organisation’s competitive edge.

The concept of IC was first introduced by Fine (1996) and has three components which are the change in processes, products and organisational structure. Process technology measures the rate at which production equipment depreciates in value; product technology measures the rate at which new products are introduced into the market and organisational clockspeed incorporates the rate of change of structures by organisations (Fine, 1999).

High IC industries are characterized by a high rate of new product conception which entails that organisational structures change frequently and the product development time is short (Mendelson and Pillai, 1999). Examples of products that fall under this category include electronics, fashion, cosmetics etc. The slow clockspeed industries have a fairly stable organisational structure, low product obsolescence and process technology replacements rates.

6.3.4 Operational performance

In the last two decades, many journals have published papers that focus on the effect of LM on operational performance. A literature review indicated that a diverse number of variables that measure operational performance have been used by researchers. Santos Bento and Tontini (2018) state that flexibility, quality, delivery and cost are the frequently used items for quantifying operational performance. Table 6.1 gives an overview of the operational performance measurement variables identified by researchers with their references. The table shows that the frequency of use of each variable differs significantly. The variables used frequently were cost, quality and delivery time while demand, defect rate, lot size, cycle time, first yield pass, efficiency, processing time and return on assets were the least referenced variables.

There seems to be a consensus that variables such as quality, cost, speed, flexibility and dependability are popular measures of operational performance. (Knudtzon, 2018, Pozo et al., 2018, Khanchanapong et al., 2014, Belekoukias et al., 2014, Birkie and Trucco, 2016, Dal Pont et al., 2008, Furlan et al., 2011, Taj and Morosan, 2011, Hallgren and Olhager, 2009, Shah et al., 2017, Chavez et al., 2013).

Table 6. 1: Operational performance variables and their references

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1. Inventory	*	*	*	*													
2. Cost	*			*	*	*	*					*	*			*	*
3. Productivity	*			*			*				*		*				
4.Waste reduction	*			*			*			*							
5. Demand	*																
6. Delivery	*		*	*		*		*			*		*				*
7. Quality		*	*		*	*		*			*	*				*	*
8. Lead time			*				*					*					*
9. Turnover			*							*							
10.Space utilisation				*				*									
11. Defect rate				*													
12. Lot size				*													
13. Dependability					*											*	
14. Speed					*											*	
15. Flexibility						*						*				*	*
16. Cycle time							*										
17.First pass yield							*										
18. Efficiency								*									
19. Profit									*	*				*			
20.Customer satisfaction										*			*				
21. Processing time										*							
22. Setup time																	*
23. Sales growth											*				*		
24. Market share											*			*	*		
25.Return on sales														*	*		
26. Return on assets														*	*		

(1) (Panwar et al., 2018) (2) (Marodin et al., 2018) (3) (Marodin et al., 2017) (4) (Panwar et al., 2017a) (5) (Dal Pont et al., 2008) (6) (Furlan et al., 2011) (7) (Shah and Ward, 2003) (8)

(Wickramasinghe and Wickramasinghe, 2017) (9) (Fullerton and Wempe, 2009) (10) (Hadid et al., 2016) (11) (Hong et al., 2014) (12) (Khanchanapong et al., 2014) (13) (Rahman et al., 2010) (14) (Agus et al., 2012) (15) (Yang et al., 2011) (16) (Belekoukias et al., 2014) (17) (Santos Bento and Tontini, 2018)

6.3.5 Model development and hypothesis

A second-order structural model for assessing the effect of LM on operational performance is presented in Figure 6.2. The model consists of one endogenous variable, operational performance and two exogenous variables, LM and IC. A second order construct, LM, was formed from four first-order constructs (JIT, Jidoka, Stability and standardization and People integration). The major aim was to understand how the LM practices affect operational performance with IC as a moderating variable.

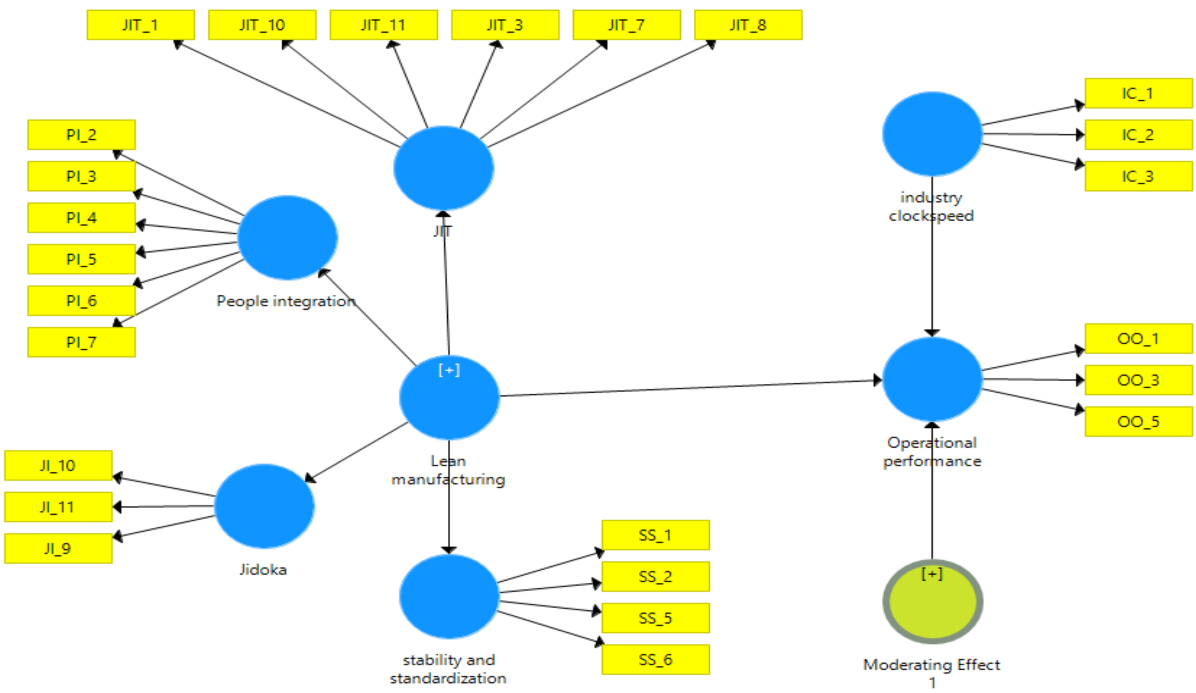

Figure 6. 2: Lean measurement model

6.3.6 Effect of LM practices on operational performance

Many researchers have shown that application of LM practices has a direct and significant relationship on operational performance. This is because implementation of LM results in decreased customer lead time, manpower requirement, process waste, inventory level, improved understanding of the process and stability of the process (Abdulmalek and Rajgopal, 2007, Liker and Meier, 2005, Melton, 2005) which increases operational performance. A study by Rahman et al. (2010) showed that the application of flow management, JIT and waste management practices resulted in increase in operational performance. Demeter and Matyusz (2011) revealed that there was improvement in inventory turnover for companies that implemented LM than in traditional companies. Hofer et al. (2012) averred that LM practices had a direct and significant correlation with financial performance. Additionally, Inman and Green (2018) LM had a direct and positive relationship with operational performance. Other studies that have found a significant and direct relationship between LM practices and operational performance are (Fullerton et al., 2003, Yang et al., 2011, Panwar et al., 2017b, Wickramasinghe and Wickramasinghe, 2017). Therefore, it is hypothesised that;

H_1: LM practices have a direct relationship with operational performance.

6.3.7 The moderating role of IC

For a successful implementation of LM practices, managers should also consider the contingent effect of IC upon their organizations. IC considers the rate of change of products, processes and organisational structure within an industry. This chapter suggests that an environment under which an organisation operates will affect the results of the LM implementation process. In a low IC industry, change occurs at a slow rate and is predictable (Masini et al., 2004). This enables industry structures to be stable, which makes the application of LM practices to be easy since industry practitioners rely on previous knowledge about their firms. In a high IC environment, the pace of change is high and organisational structures are continuously changing. Competition is also high as new organisations emerge, hence companies constantly optimize their processes, products and structures. Organisations that survive in a high IC industry are able to transform from one temporary benefit to another as they partner with suppliers and customers so as to respond quickly to the ever-changing environment. A study by Chavez et al. (2013) revealed that in low IC industries, LM practices have a direct and positive relationship with operational performance than in high IC industries. This study argues that IC will have an effect on operational performance in both low IC and high IC. Organisations in high IC environment need to lower their order processing times in order to deliver products on a just-in-time basis to customers. The following hypothesis was derived from the study;

H_2: There is a significant moderating effect of IC on both fast and slow IC industries.

6.3.8 Mathematical equations for the model

The model that represents the moderating effect of IC for the relationship between LM practices and operational performance is shown in Figure 6.3.

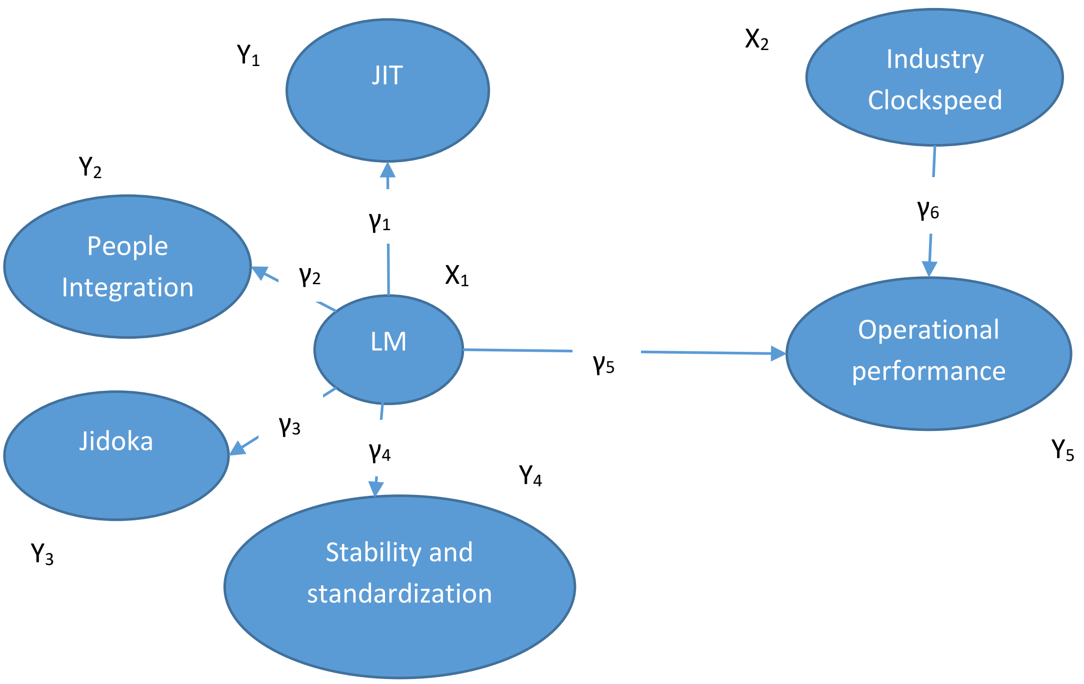

Figure 6. 3: LM structural model

The mathematical equations for the model are given below;

i. $Y_1 = \alpha_1 + X_1\gamma_1 + \varepsilon_1$

ii. $Y_2 = \alpha_2 + X_1\gamma_2 + \varepsilon_2$

iii. $Y_3 = \alpha_3 + X_1\gamma_3 + \varepsilon_3$

iv. $Y_4 = \alpha_4 + X_1\gamma_4 + \varepsilon_4$

v. $Y_5 = \alpha_5 + X_1\gamma_5 + X_2\gamma_5 + \varepsilon_5$

6.4 Research methodology

6.4.1 Questionnaire design

A questionnaire was developed in order to evaluate the effect of implementing LM in Zimbabwean industries. The questionnaire had three sections. Section A had questions on the number of employees, process type and the number of years that the company had implemented LM. Section B contained questions relating to the degree of adoption of LM practices and

Section C had items on the measure of performance of the organisation. The respondents were asked to select the LM practices they had implemented in their organisation. A seven-point Likert scale with 1- strongly disagree, 2- disagree, 3- disagree somewhat, 4- undecided, 5 – agree somewhat, 6 – agree and 7- strongly agree was used to assess the level of adoption of LM practices. The selection of LM practices was based on the study conducted by Maware and Adetunji (2018). The scales used for IC was based on Chavez et al. (2013) and included items on product optional features, models and design changes.

The operational performance variables used for the study were quality, speed, cost, flexibility and dependability. These were identified from studies by (Shah and Ward, 2003, Belekoukias et al., 2014). A five-point scale varying from 1 - declined more than 20%; 2-declined 1-20%; 3-stayed the same; 4-increased 1-20% and 5-increased more than 20% was used. The control variables used in the study were industry type and company size. Only manufacturing companies with more than 50 employees were considered in the study. Four industry practitioners and two academics evaluated the questionnaire to check for relevance, logic, presentation and spellings.

6.4.2 Data collection

Data collection was done by emailing the Google form link and hand delivery of hard (printed) copies to 600 companies listed in the CZI. The authors believed that organisations with more than 50 employees were more likely to implement LM and have a deeper understanding of the philosophy than smaller organisations. The sample involved organisations from the pharmaceuticals, agrochemicals, automobile, steel, timber, battery, plastics, food, beverages, electronics and clothing industries. The authors used the rate of new product introduction, process technology replacements and product development time to categorise the companies into low IC and high IC. Exploratory factor analysis (EFA) was conducted in SPSS to group the LM practices into a higher level LM constructs. This procedure is performed by reducing high dimensional information of observed items into a lower number of constructs (Guo et al., 2019).

A Multi-group analysis approach in Partial Least Squares was used to evaluate the moderating effect of IC on the association between LM practices and operational performance. A multi-group analysis is a method that is used to compare parameters across groups. It also allows to testing if the path coefficients for the two subpopulations are significant (Henseler, 2007). This method allows different groups within a sample to be treated separately. The hypothesis proposed for the study is that by comparing the two sectors with different ICs using Partial Least Squares-Multi- Group Analysis (PLS-MGA), there are no significant differences between the path weights for slow and fast ICs.

Table 6.2 gives the list of companies that responded to the survey questionnaires. The respondents were selected from leaders and managers from the departments of operations, quality management and continuous improvement. The authors believed that these managers have knowledge of both LM implementation and their organisational processes.

Table 6. 2: Industry characteristics

Low industry clockspeed	Number of companies	Sample %	High industry clockspeed	Number of companies	Sample %
Pharmaceutical	20	9.3	Food	42	19.6
Agrochemicals	15	7.0	Beverage	15	7.0
Automobile	23	10.7	Electronics	14	6.5
Steel	19	8.9	Garment	12	5.1
Timber production	15	7.0			
Battery	20	9.3			
Chemical and plastics	19	8.9			

6.4.3 Non-response bias

The non-response bias was examined in order to compare the early and late responses. The extrapolation method by (Armstrong and Overton, 1977) was used to compare the early and late responses. The researchers used five items chosen randomly from the survey questionnaires to compare responses of the first 20 and last 20 respondents using the Chi-square test. The results revealed that the non-response bias for the early responses and late responses had no significant effect with $p < 0.05$.

6.5 Results

6.5.1 Measurement model: Construct reliability and validity

Exploratory Factor Analysis was conducted using SPSS version 25. The results revealed that Bartlett's test of sphericity was significant $\chi^2(214) = 2058.55$ with a p-value of less than 0.001. The total variance of 51.67% was obtained for the six constructs (JIT, Jidoka, People integration, stability and standardization, industry clockspeed and operational performance). The construct reliability of all the factors was above 0.7 indicating that the items of each construct were measuring the same constructs. The values for Average Variance Extracted were greater than 0.5 revealing strong convergent validity for the model. Table 6.3 summarises the results of convergent validity and internal consistency reliability. The confidence intervals for the Heterotrait-monotrait ratio (HTMT) did not include 1, thus all the constructs exhibited discriminant validity (Hair Jr et al., 2016).

Table 6. 3: convergent validity and internal consistency reliability

Construct	Convergent validity	Internal consistency reliability		Discriminant validity
	AVE	Composite reliability	Cronbach's alpha	
	>0.50	0.60-0.90	0.60-0.90	HTMT values
JIT	0.624	0.869	0.799	Does not include 1
Jidoka	0.731	0.916	0.877	Does not include 1
People integration	0.630	0.872	0.804	Does not include 1
Stability and standardization	0.694	0.844	0.724	Does not include 1
Operational performance	0.589	0.811	0.651	Does not include 1
IC	0.555	0.629	0.616	Does not include 1

6.5.2 Results for the overall model

All the VIF values were below the threshold of 5 indicating that there were no collinearity problems within the model. Table 6.4 gives the path coefficients for the inner model. The path coefficient from LM to Operational performance was 0.481 which was fairly high. This indicated that LM practices had a direct and significant relationship with operational performance, supporting H_1. LM had a strong effect on Stability and standardization which showed that the prerequisite for successful implementation of LM is that the processes should be standardized and stable. This was followed by JIT with 0.93. This showed that the creation of flow within the production system was also crucial. The production system should produce products at the right time in the correct quantity. The relationship between LM and People integration and Jidoka were also high with a path coefficient of 0.91 and 0.82 respectively. IC also moderated the relationship between LM practices and operational performance.

Table 6. 4: Path weights for the inner model

Hypothesis	Effect of	On	Path coefficient	p-value	Result
	LM	JIT	0.931	0.00	
	LM	Jidoka	0.820	0.00	
	LM	People integration	0.917	0.00	
	LM	Stability and standardization	0.970	0.00	
H_1	LM	Operational performance	0.481	0.00	Supported
H_2	IC	Operational performance	0.667	0.00	Supported

The R^2 value shows the predictive power of the model. This value indicates the quantity of variance in the dependent variable that is explained by all the independent variables that are connected to it. The R^2 values of 0.25, 0.50 and 0.75 for the dependent variables show a low, medium and high effect of the exogenous variable (Ho et al., 2019, Shariff et al., 2019, Hair Jr et al., 2016). The R^2 values for the dependent variables were all acceptable for the overall model. The R^2 values for the endogenous variables were all high showing that the model had high predictive power. The R^2 value for JIT was 0.687, People integration was 0.841, Jidoka was 0.672, stability and standardization was 0.941 and Operational performance was 0.965. The results revealed that Lean manufacturing was a good predictor of operational performance.

The effect size f^2 of each independent variable was also calculated using the Cohen f^2 formula. The effect size f^2 describes how the value of R^2 changes for the dependent variable when a certain exogenous variable is omitted (Ringle et al., 2015, Wong, 2019). The values of 0.35, 0.15 and 0.02 are considered high medium and small. The effect of excluding LM from the model for the dependent variables such as JIT, Jidoka, Stability and standardization was medium, and high for People integration whilst excluding IC from the model had a medium effect on Operational performance. The predictive relevance of the model is given by Stone-Geisser Q^2 value. All the values for Q^2 were above zero indicating that the model had good predictive relevance. Table 6.5 shows the R^2, f^2 and Q^2 values for the endogenous variables in the model.

Table 6. 5: The R^2, f^2 and Q^2 values for the endogenous variables

Endogenous variable	R^2	Effect size f^2	Q^2
JIT	0.867	0.222	0.353
Jidoka	0.672	0.346	0.375
People integration	0.841	0.390	0.330
Stability and standardization	0.941	0.255	0.346
Operational performance	0.965	0.173	0.126

6.5.3 Multi-group analysis

The Multi-group analysis was used to test the moderating role of IC on the relationship between LM practices and operational performance across the two groups (Group 1: low IC and Group 2: High IC). Table 6.6 shows a multi-group analysis result for the two groups. The results indicated that there were no significant differences in the effect of industry clockspeed on the low IC and high IC groups. This showed that IC moderated the relationship between LM practices and operational performance for both low IC and high IC industries. Thus, H_2 is supported because the structural equation model of LM practices, operational performance and IC does not differ between the groups.

Table 6. 6: Results for the multi-group analysis

	Pooled		Group 1 Low IC		Group 2 High IC		Group 1 vs Group 2
	N= 214		N= 131		N= 83		P value
	Path weight	CI	Path weight	CI	Path weight	CI	
LM→JIT	0.931	0.408-0.656	0.806	0.697-0.873	0.856	0.749-0.906	0.432
LM→ Jidoka	0.820	0.505-0.714	0.680	0.493-0.783	0.767	0.631-0.855	0.358
LM→ People integration	0.917	0.441-0.698	0.782	0.616-0.843	0.836	0.632-0.902	0.456
LM→ Stability and standardization	0.970	0.530-0.694	0.809	0.716-0.867	0.808	0.688-0.876	0.986
LM→ Operational performance	0.481	0.276-0.617	0.296	0.118-0.480	0.420	0.194-0.606	0.388
IC→ Operational performance	0.667	0.413-0.618	0.373	0.123-0.532	0.449	0.083-0.665	0.659

6.5.4 Interaction effects

The graph that shows how IC affect the relationship between LM and operational performance is shown in Figure 6.4 below. The graph shows that the relationship between LM and operational performance becomes strong with higher levels of IC. Whilst at low levels of IC, the graph becomes level or flat. This indicates that the relationship between LM and operational performance becomes weak.

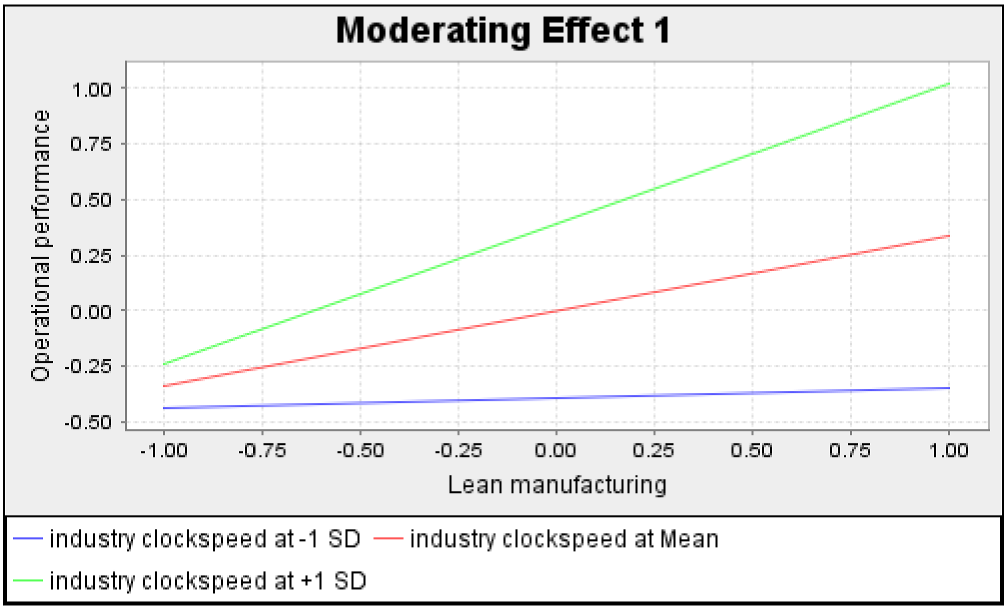

Figure 6. 4: Simple plot slope

6.6 Discussion

The chapter examined a structural model of LM practices, IC and operational performance in manufacturing firms in Zimbabwe. The results revealed that LM practices were significantly and positively associated with operational performance. Furthermore, IC acted as a moderating variable for the relationship. The findings provide further evidence that supports the possible effect of IC on LM. The results also showed that IC had a moderating effect on both low IC industries and high IC industries, which shows that managers should consider the effect of IC when implementing LM practices.

6.6.1 Theoretical implications

There are few studies that have evaluated the moderating effect of IC on the relationship between LM practices and operational performance. A study conducted by (Chavez et al., 2013) is the only chapter that assessed the moderating role of industry IC on LM implementation in Ireland. This chapter expanded the recent work by testing how IC affect operational performance in a developing country. Specifically, the results showed that LM practices are effective for operational performance improvement in both low IC and high IC industries. The study is also supported by (Knudtzon, 2018, Pozo et al., 2018, Khanchanapong et al., 2014, Belekoukias et al., 2014, Birkie and Trucco, 2016, Dal Pont et al., 2008, Furlan et al., 2011, Taj and Morosan, 2011, Hallgren and Olhager, 2009, Shah et al., 2017, Chavez et al., 2013) that show that implementation of LM practices improve operational performance.

6.6.2 Managerial implications

The study has illustrated that LM practices are positively related to operational performance, thus further furnishing managers with proof about the benefits of implementing LM. The study has also shown that LM practices are effective in both low and high IC environments. This contradicts the study by (Chavez et al., 2013) that concluded that LM is more efficient in low IC environments. Furthermore, researchers have categorised industries as low and high IC and managers can benchmark their operations based on the categories and identify LM practices that suit their operations. Evaluation of the moderating effect of IC for companies from developed countries could also help in comparison to the effect of LM implementation between developing and developed countries.

6.7 Conclusion

To the best of authors' knowledge, this is the first empirical study to analyse the moderation effect of IC on the relationship between internal and external LM practices and operational performance in a developing country. The study suggested that implementation of LM practices such as JIT, Jidoka, People integration and Stability and standardization led to an improvement in operational performance. Furthermore, the study has shown that the implementation of LM practices can lead to high operational performance both in low IC and high IC environments. The study can provide empirical evidence to managers in developing countries who are sceptical of implementing LM since some researchers have reported the negative effect of LM on operational performance (Browning and Heath-Brown, 2009, Bhasin and Burcher, 2006). The limitation of this study was that the sample comprised of companies from Zimbabwean industries only. This study can be extended by testing the model with firms from other developing countries. The study can also be extended by increasing the number of LM practices and testing their effect on operational performance. The researchers could also have used more respondents from a single firm so as to guard against the single respondent biasness. The next chapter presents conclusions and areas of further study for the research.

Chapter 7: Conclusions and areas of further study

7.1 Introduction

This chapter provides a summary of the research objectives, impact and findings of the study, the significance of the research, contribution to knowledge limitations of the study and areas of further research. Each of these key areas will be briefly reviewed in the subsequent sections.

7.2 Summary of the research objectives and study areas

This study was aimed at evaluating the impact of implementing LM on operational performance in Zimbabwean industries. While many manufacturing organizations in Zimbabwe have implemented LM, there seems to have been no indication of any work done on assessing how the philosophy has made an impact on operational performance. The objectives of the study were to: review the different types of performance measurement models used for assessing Lean implementation success; assess the impact of LM on operational performance across Zimbabwean companies; and analyze the impact of IC on the relationship between internal and external LM practices and operational performance. A description of the various impact measurement models found in literature was initially given. The models were categorized under quantitative, qualitative simulation-based and graphical methods. The advantages and disadvantages of using each method were highlighted. Pareto analysis was used to select the type of model and the Lean constructs and practices that were used for the study. A qualitative measurement model was used for assessing the effect of LM in Zimbabwean industries because it uses questionnaires that are able to collect data that can also measure views and opinions on impact of implementing LM. The LM practices chosen were People integration, JIT, Jidoka and Stability and standardization. SEM was used for evaluating the model because of its flexibility that allows researchers to test relationships among multiple predictor and criterion variables and modelling unobservable latent variables. The results showed that the LM practices studied enhanced operational performance in Zimbabwean manufacturing industries. The performance improvement variables that were significantly influenced were speed, flexibility and dependability.

The research also assessed the moderating effect of IC on the relationship between LM practices and operational performance. The manufacturing industries were categorized under high IC and low IC industries. The assessment indicated that IC acted as a moderating variable for the association between LM and operational performance for both low and high IC industries. Generally, the implementation of LM encouraged the employees to be dedicated to their work and got motivated to reduce non-value added activities in their processes. Although LM competed for resources with other management programs that were initiated by organizations, its implementation improved the quality of products, product and process design and the flow of materials within the production process.

7.3 Significance of the study

LM has been adopted by many manufacturing organizations in different parts of the world to minimize production costs and remove waste from the production processes. Many researchers have tried to measure the impact of implementing LM and as a result, diverse impact measurement models have been developed. This has led to confusion on how to select a model to use when assessing Lean performance.

The TPS house has been used by Toyota Motor Company in implementing LM and has been successful in operational performance over the years. However, no measurement model to assess the impact of implementing LM on operational performance has been built around the house. This study seeks to develop a qualitative impact measurement model will help organizations to assess Lean performance. This model will also help in comparing the performance of different organizations in different industrial sectors. Furthermore, it becomes easy for new adopters to measure Lean performance in their organizations and assess if objectives are being met.

The development of a model that assesses the moderating effect of IC on the relationship between internal and external Lean practices has also not been considered in the literature. This study extends the existing literature by developing a model that evaluates the moderating effect of IC on LM implementation. The model can be adopted by any manufacturing industry to measure LM performance.

7.4 Contribution of the study

The main contributions of this study are given below:

- An analysis of the impact measurement models that have been used by researchers to measure the effect of implementing LM on operational performance was done. The study selected the Lean practices that were mainly used by researchers to develop assessment models. These practices are linked to the TPS house and the stability and standardization construct that has not been incorporated into the Lean measurement model that was developed and appropriate items to measure this newly added latent variable were identified and incorporated into the popular Lean performance measurement scales available in literature.

- Categorization of the manufacturing industries into low and high industry clockspeed industries. Industry segments were classified according to the rate of change of products, process technologies and organizational structures. Grouping the industries into low and high IC can help Lean practitioners to match and classify their own companies in order to anticipate how LM implementation may significantly affect their operational results subject to their industry speed of change.
- Evaluation of the moderating effect of IC on the relationship between LM practices and operational performance. Most studies in the literature have assessed the impact of LM on operational performance. The only study that evaluated the moderating effect of IC was Chavez et al. (2013). This work extends that research by analyzing the moderating effect of IC on the relationship between internal and external LM practices and operational performance.

7.5 Limitations of the study and areas of further research

This study has some inherent limitations that could inform directions of further research. The first limitation is that the study sample frame consists of companies from Zimbabwean industries only. More companies could have been used for evaluating the model especially because a new latent variable was included in the model. While the data collection process focuses on collection of each company data from a single source in order to guarantee company uniqueness and prevent skewing the data in the direction of some companies that might submit multiple responses, the researcher could have used more respondents from a single firm to guard against the single respondent biases. This can be compared to the single company single respondent approach that was adopted.

This study can also be extended by testing the model with data of firms from other developing countries. The model could also be tested data from more developed countries and compare the results to those of the developing countries. The study can further be extended by increasing the number of LM practices and testing their effect on operational performance. Further research could be done to assess the aspects that may act as inhibitors for fruitful implementation of LM in developing countries.

It would also be interesting to study how the IC model might behave with a reclassification of some of the industries, like moving the automotive from low IC to high IC and food and beverage from high IC to low IC. While the classifications used in this work has been based on that reported by the few researchers that have worked in this field, it is still arguable whether the industries have been appropriately placed in their respective categories, and whether the classification might have influenced the results obtained. This is an area that might be also be worthy of investigation, in addition to the possibility of expanding the scope of industries included in the study.

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Appendix 1

Questionnaire Number:

Cover letter for PhD questionnaire survey

Name: Catherine Maware

University: University of Pretoria

Address: University of Pretoria

Department of Industrial and Systems Engineering
Engineering building 2
Level 3
University of Pretoria
Lynnwood Road
Private bag X20 Hatfield
Pretoria
0028

Dear Respondent

I am a PhD student at the University of Pretoria, in the department of Industrial and Systems Engineering. I am conducting a research titled: Lean manufacturing for quality and performance improvement in Southern African industries. The aim of the research is to develop a model to measure the success of Lean manufacturing deployment. This survey is designed to measure the impact of Lean manufacturing implementation on organizational performance. We believe that the measurement model will help new adopters of Lean Manufacturing to anticipate and also assess the impact of Lean manufacturing on their operational performance. This survey is anonymous and the responses will only be used for research purposes. The questionnaire will take about 15minutes to complete.

Thank you for the time and effort to complete the questionnaire.

Sincerely

Catherine Maware

(PhD student in Industrial and Systems Engineering)

Survey questionnaire items

Section A: Respondent demographics.

1. What is the type of industry that your organization falls under?

2. What type of process do you use in your organization?

3. How many years has your organization been in business?

4. How many years has your organization implemented lean manufacturing (LM)?

Section B: Impact of lean constructs on operational performance.

Show the level of agreement or disagreement with the statement given that describes the level of adoption of LM practices in your organization, 1–strongly disagree; 2–disagree; 3–disagree somewhat; 4–undecided; 5–agree somewhat; 6–agree and 7–strongly agree.

Just In Time: JIT

JIT01 The daily production schedule is met every day.

JIT02 The daily production schedule is levelled.

JIT03 The daily production schedule is completed on time.

JIT04 The pace of production is directly linked to customer demand.

JIT05 The machines are grouped according to the product family.

JIT06 The customers receive just-in-time deliveries from us.

JIT07 The layout of our shop floor facilitates low inventories and fast throughput.

JIT08 The suppliers deliver to us on a just-in-time basis.

JIT09 The suppliers are linked with us by a pull system.

JIT10 The suppliers deliver to us on short notice.

JIT11 The customers have a pull type link with us.

JIT12 We aggressively work to lower setup time in the plant.

JIT13 There are small in-process inventories between different operations.

JIT14 The amount of time spent in processing order is maintained at the minimum possible level.

People Integration: PI

PI01 The employees are encouraged to work together to achieve common goals, rather than encourage competition among individuals.

PI02 The management takes all product and process improvement suggestions seriously.

PI03 The employees are encouraged to make suggestions for improving performance at the plant.

PI04 The employees receive training to perform multiple tasks.

PI05 The employees are cross-trained to fill in for others, if necessary.

PI06 During problem solving sessions, an effort is made to get all team members' opinions and ideas before making a decision.

PI07 The employee teams are encouraged to try to solve their own problems, as much as possible.

PI08 There are few levels in the organizational hierarchy.

PI09 The workers are given incentives, awards and annual bonuses for the elimination of unnecessary steps and process improvement.

Jidoka: JI

JI01 A large percent of the equipment or processes on the shop floor are currently under statistical quality control.

JI02 There is extensive use of statistical techniques to reduce variance in processes.

JI03 The control charts are used to determine whether the manufacturing processes is in control.

JI04 The processes in the plant are designed to be "foolproof."

JI05 There is great involvement of manufacturing and quality people in the early design of products, before they reach the plant.

JI06 Employees work in teams, with members from a variety of areas (marketing, manufacturing, etc.) to introduce new products.

JI07 Quality is our number one criterion in selecting suppliers.

JI08 We use mostly suppliers which we have certified.

JI09 We are frequently in close contact with our customers to get feedback on quality.

JI10 The customer give us feedback on quality and delivery performance.

JI11 We regularly survey our customers' requirements.

JI12 The company strives to improve all aspects of products and processes rather than taking a static approach.

JI13 The workers are empowered to stop the production line if abnormalities occur.

Stability and standardization (SS)

SS01 The standards are simple and easy to understand.

SS02 The company easily adjust work cycles so as to meet demand.

SS03 The visual controls placed on the boards where workers can easily identify them.

SS04 There are standard routes for loading raw materials and removing end products, including a standard picking time.

SS05 There are clear, standardized and documented process instructions which are well understood by the employees.

SS06 The machine uptime is adequate to produce customer demand.

SS07 The company has enough material on hand every day to meet your production needs.

SS08 The company has enough trained employees available to handle the current processes.

Section C: Operational/ organizational performance

How would you measure the performance of your organization since you implemented Lean manufacturing?

1: Increased more than 20% 2: Increased 1- 20% 3: Stayed the same 4: Declined 1-20% 5: Declined more than 20%

1. Quality (the number of non-defective products manufactured).
2. Speed (rate of response to customer query, frequency of delivery, adherence to cycle time).
3. Cost (production cost, labour productivity, utilization of materials).
4. Flexibility (ability to do the following; change production schedules, modify part, build the system and expand it and introduce new products).
5. Dependability (adherence to schedule, number of orders delivered on time).

Section D: Impact of industry clockspeed (IC)

Indicate the level of agreement or disagreement of the rate of change of the items given below with respect to your organization

1: Strongly agree 2: Agree 3: Neutral 4: Disagree 5: Strongly disagree

IC01 The company experienced changes in product models.

IC02 The company experienced changes in design of dominant product model.

IC03 The company experienced changes in product optional features.

Appendix 2

Rotated Component Matrix for the items used in data analysis

	Component					
	1	2	3	4	5	6
JIT_10	.776					
JIT_8	.729					
JIT_1	.723					
JIT_3	.706					
JIT_7	.655					
JIT_11	.650					
PI_3		.750				
PI_5		.742				
PI_6		.722				
PI_4		.706				
PI_2		.646				
PI_7		.623				
SS_2			.902			
SS_6			.879			
SS_1			.671			
SS_5			.665			
OO_2						
IC_1				.852		
IC_2				.817		
IC_3				.793		
JI_10					.764	
JI_9					.753	
JI_11					.697	
OO_4						
OO_3						.674
OO_1						.657
OO_5						.497

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.[a]

a. Rotation converged in 6 iterations.