Assessment of the Lean frameworks and Barriers in implementing Lean Manufacturing in South African Manufacturing Industries.

By

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Abstract

Global competition and high customer expectations have forced manufacturing organizations to always consider ways in which they can be competitive, adaptive, and resilient in the face of change. Lean manufacturing is one of the most common improvement initiatives that businesses explore to improve their operations and reach targeted business goals such as financial savings, reduced inventory, reduced turn-around time, and manufacturing flexibility, to mention but a few.

Literature is replete with studies on the drivers of Lean success, Lean barriers and enablers, and Lean frameworks. However, a gap was identified from reviewing previous Lean research, where it was observed that while there has been diverse studies on Lean implementation barriers and enablers and their impacts on operational performance, on the development of various implementation frameworks for Lean, and on the review and classification of these framework based on different criteria such as practicality, amongst others, there has not been research that considers the interdependence of these concepts, specifically the relationship between the Lean enablers and the design of Lean frameworks.

Consequently, a model was developed in the current study, using Partial Least Squares Structural Equation Modelling (PLS-SEM), to hypothesize the relationships between the three variables: Lean framework design effectiveness, Lean implementation enablement, and business operational success. Data was collected using a survey that was distributed across different manufacturing fields. The research questions were developed with justification from literature and SmartPL4 software was used for the analysis of the data.

The main findings are that there exists a relationship of considerable strength between Lean enablers and the design of Lean framework. Furthermore, Lean implementation enablement has a positive influence on business operational success. These findings are important because they highlight the importance of organizations implementing Lean to be Lean-ready by considering Lean enablers. This applies for both managers and practitioners of Lean. The relationship between Lean enablers and Lean framework design shows the importance for designers of frameworks to organically design framework and consider the enablers of Lean, as opposed to simply modifying existing frameworks by trying to improve their shortfalls, without reflecting on what positions their organizations are for the success of their Lean implementation.

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Chapter 1: Introduction

1.1 Introduction

Local and global markets have become highly competitive, accelerated by the rapid technological growth, innovations that cross-link industries, high customer expectations and globalization (Gurumurthy & Kodali, 2008). This level of competition is observed in various sectors, from education, to entertainment, and inevitably, to businesses. The manufacturing industry, in particular, is pressured by the demand to be competitive and relevant with the changing landscape of growing customer preferences and universal-rated business practices.

These changes have forced a lot of companies out of their comfort zone, to consider alternative ways of doing business by means of management change initiatives, with the aim of yielding better measurable results using established indicators of operational success, like cost, speed, dependability, quality, and flexibility (Belekoukias et al., 2014). Measures of operational performance have helped companies quantify the gain of their improvement initiatives and to understand how to adjust their efforts to align with their business strategies and objectives.

The manufacturing industry of every economy is important because of its ability to drive varying levels of development. A further advantage of the manufacturing sector is two-fold. Firstly, it forms the backbone of most businesses in the services sector such as logistics, consulting, and healthcare (Szirmai and Verspagen, 2015). Secondly, the manufacturing industry presents a rich opportunity for innovation to advance and commercialize, and for cultivating technological growth as other industries take advantage of its evolution (Szirmai and Verspagen, 2015; Wang et al., 2019). The ability of this particular industry to intersect with others is more than sufficient reason to consider how to improve it to maximize the benefits gained from it at the organizational and economic levels.

There is a surfeit of initiatives for business improvement from which organizations can choose. Some initiatives such as flexible manufacturing systems, Supply Chain Management (SCM) and Computer Integrated Manufacturing Systems (CIMS) have been described as 'technically sophisticated', while others such as Theory of Constraints (TOC), Six-Sigma (6σ), and Lean Manufacturing (LM) have been categorized as management and people-centric (Gurumurthy & Kodali, 2008; Anand & Kodali, 2008). The interest of this research is in the practice of Lean manufacturing and the various aspects that influence its success or failure in organizations. It has been considered to be more universal compared to other business transformation methods and comes across as more encompassing, as will be unpacked further in the research. The main driving idea behind Lean manufacturing is the elimination of any non-value adding part of the process that is considered waste in the making of the final product.

1.2 Problem Background

The practice of Lean Manufacturing has gained momentum globally over the years in academic research and industrial practice due to its proven history of plausible benefits to manufacturing organizations (Rose et al., 2011). Benefits such as reduced production costs, lower inventory levels, flexibility, and improved customer satisfaction have automatically advocated for Lean manufacturing across various industries, beyond the automotive industry from which it originated (Rose et al., 2011; Vinodh and Joy, 2012). As of late, researchers have also delved into how small and medium enterprises (SMEs) can leverage Lean Manufacturing to fast-track their growth and become as competitive as large organizations (Filho et al., 2016; Shrimali and Soni, 2017; Rose et al., 2011).

In all its glory, however, Lean manufacturing comes with challenges that result in most companies failing to experience the full benefits of the principle. It is reported that about 90 % of companies that implement Lean manufacturing globally, are unsuccessful or only partially successful (Cookie and Govender, 2018). This is an alarming statistic on failure for a principle that is deemed universal and highly beneficial. This observation has further prompted researchers to explore what could enable the success of Lean, while they gain cognizance of the hindrances to its success. The most quoted reasons for failure of Lean implementation are lack of support from management, and lack of understanding and skills necessary to implement Lean successfully, which if flipped, can be considered enablers for the success of Lean implementation (Shrimali and Soni, 2017; Bayhan et al., 2019).

The south African economy has not been growing at an appreciable rate considering the history of unequal socio-economic parities. In 2021, South Africa experienced a GDP decline of 1.5 percent, which was heavily influenced by the decline in contributions by the manufacturing sector, apart from the mining and trade sectors (Statistics SA, 2021). The role of manufacturing in South Africa is significant because of its ability to drive economic growth and influence international trade through export-inclined manufacturing (Rodrik, 2008). The blight of unemployment in South Africa diminishes its economic status greatly. In the fourth quarter of 2021, the unemployment rate in South Africa was 35.4 percent (Stats SA, Labour Force Survey 2021). Yet, the manufacturing sector has the potential to aid the capacitation of the workforce for improved economic activity. Rodrik (2008) describes manufacturing as "a sector with the highest labour productivity in the economy".

Manufacturing organizations in South Africa, thus, have great responsibility in helping to sustain the economy, while they also have to emerge from the pressures of global competition. For this reason, manufacturing organizations need to consider better ways in which they can operate through the implementation of Lean practices. Cookie et al. (2018) have observed the lack of extensive research on Lean Manufacturing in developing economies. Mangaroo-Pillay et al. (2020) supported this claim by acknowledging the limited research on the topic in South Africa. Some of the industries that have experimented with Lean application include the automotive and clothing industries (Rathilal and Singh, 2011; Mund, 2011; Chimoro and Sebele, 2015), and the services sectors of hospitality and health (Cookie & Govender, 2018; Nwobodo-Anyadiegwu et al., 2020).

Considering how broad the manufacturing sector in South Africa is, the current research outputs and practice of Lean manufacturing are not inclusive and do not provide sufficient ground for others to explore the practice of Lean. The need to fill the gap of a knowledge base in the South African manufacturing context is made more apparent by the various challenges that Lean practitioners experience globally, such as lack of sufficient understanding of the Lean practice, lack of resources, poor transitioning guidelines, and resistance to change from employees and managers among others (Bahyan et al., 2019; Chimoro et al., 2015; Kumar and Kumar, 20214; Bamber and Dale, 2000).

1.3 Problem Statement

Lean Manufacturing has the ability to enable organizations to experience sustained benefits with regard to achieving business objectives and be on par with the rest of the world. However, a lot of challenges have been reported which leads to Lean practitioners either losing interest in this philosophy or improvising outside of the scope of Lean in order to see some form of results from their efforts (Mostafa et al., 2013; Deros et al., 2006). In addition to challenges related to workforce competency, technical and technological, and financial resources, the lack of detailed Lean implementation frameworks have been found to contribute to the failure of Lean efforts in industry. Challenges such as the inability of frameworks to comprehensively summarize and guide practitioners on the order of use of the Lean tools and methods is a barrier (Mostafa et al., 2013; Anand and Kodali, 2009).

Also, Lean frameworks are important as guidelines for managers and practitioners to translate the Lean philosophy into practice in organizations. With the extensive research done on barriers and enablers to implementing Lean Manufacturing, there has been a gap where designers of Lean frameworks overlook the challenges and enablers to implementing Lean Manufacturing. This is a missed opportunity to design frameworks that can make the implementation of Lean adaptable, flexible, applicable for a wide range of environments, and less prone to failure. Lean challenges or barriers are factors that make it difficult to implement the Lean practice successfully, while Lean enablers are factors that enable and improve the successful implementation of Lean Manufacturing; and these two are the flip sides of the same issue.

The manufacturing space in South Africa is of particular interest because of its impact on the economic status and the opportunities it presents from the perspective of global trade and competitiveness, innovation, and strong economic participation through employment capacitation (Wang et al., 2019; Szirmai and Verspagen, 2015; Rodrik, 2008).

1.4 Research question

Consequent to the foregoing, this research answers the following questions:

(i) *How does the design of Lean frameworks influence factors that enable the successful implementation of Lean Manufacturing?*

(ii) *What are the joint impacts of Lean frameworks and Lean enablers on the performance of organizations that implement Lean?*

A model was developed using three main variables of interest, namely: Framework Design Effectiveness (FDE), Lean Implementation Enablement (LIE), and Business Operational Success (BOS). Framework design effectiveness (FDE) is a variable that addresses the process of designing a framework with elaborate detail, clarity, and practicality to implement Lean successfully. Lean implementation enablers are factors that readily make implementing Lean a smooth process and help to ensure that the gains are sustainable (Hore, 2019). Furthermore, Lean enablers create an environment that is able to support and make possible the success of Lean implementation.

This study further seeks to test the following hypothesis which have emerged from the developed model:

H1: Framework Design Effectiveness (FDE) positively influences Lean Implementation Enablement (LIE).

H2: Framework Design Effectiveness (FDE) positively influences Business Operational Success (BOS).

H3: Lean Implementation Enablement (LIE) positively influences Business Operational Success (BOS).

1.5 Research objectives

The objectives of this research are as follows:

- To test the three hypotheses (i.e., H1, H2, and H3) against data collected from industry within the South African manufacturing sector. (The data was collected by means of a survey for Structural Equation Modelling (SEM) purposes, and analyzed with the SmartPLS software).
- To create opportunity for dialogue and further study by other researchers on the design of Lean frameworks and other variables that influence it. (Some insight will also be gained into the South African manufacturing environment).

1.6 Contribution to knowledge

There has been a lot of research on Lean frameworks (Deros et al., 2006; Rose et al., 2010; Anand and Kodali, 2009; Mostafa et al., 2013), and barriers and enablers of Lean (Bahyan et al., 2019; Bamber and Dale, 2000; Hore, 2019; Kumar and Kumar, 2014; Caldera et al., 2019; Bento and Tontini, 2018; Viagi et al.,2016). However, to the author's best knowledge, no study has explored the link between Lean framework design and Lean enablers, and their joint impact on the operational performance of organizations that implement Lean. Therefore, the study contributes to the body of knowledge on Lean Manufacturing by exploring the said relationship, and further expanding on literature focused on Lean manufacturing in South Africa.

1.7 Thesis framework

The dissertation is divided into six sections as illustrated in Figure 1.

Chapter 1: Introduction	• Briefly describes the role of Lean Manufacturing. • Introduces the problem, research questions and contributions to the body of knowledge.
Chapter 2: Literature Review	• Describes the philosophy of Lean Manufacturing, and brief history. • Highlights various factors related to Lean Manufacturing. • Context on the South African Manufacturing and the Lean practice.
Chapter 3: Research Methodology	• Describes the method used for model development, data collection, and analysis.
Chapter 4: Model Development and Data Collection	• Presents model development and collection of data.
Chapter 5: Results and Discussion	• Presents a detailed discussion on the results of the study.
Chapter 6: Discussion	• Presents a discussion of the results and their implications
Chapter 7: Conclusion	• Contains a summary and conclusion of the study • Presents implications of the study for industry practitioners and Lean researchers

Chapter 2: Literature Review

2.1 History and Overview of Lean Manufacturing

One of the earliest definitions of Lean Manufacturing was provided by Krafcik (1988), which defined it as a way of using less resources to make a product; this meant using half of the production time and half of the materials and workmanship. This definition by Krafcik (1988) further stipulated that inventory and defects should be kept at the lowest, while product diversification is also prioritized. Other researchers have continued to build up literature on the definition of Lean as we know it today, which is to minimize or eliminate waste, and increase productivity by doing more with less (Womack and Jones, 2003; Panwar et al., 2017; Rose et al., 2011).

The Lean Manufacturing philosophy originated in the automotive industry, as the groundwork for its development was laid by the Toyota Production System (TPS). The TPS was the brainchild of Taiichi Ohno, who adapted Henry Ford's mass production system to a low-volume, high-variety environment, using less material to improve production output at Toyota (Rose et al., 2011). The success observed at Toyota developed appetite for other industries to also consider Lean Manufacturing. Hence, industries such as aerospace, health sector, Information Technology (IT), logistics, construction, military, and the services industries have also explored the implementation of the Lean philosophy (Kleszcz, 2018; Alsyouf, 2011; Bamber & Dale 2000; Jasti and Kodali, 2014).

Benefits associated with Lean Manufacturing are financial savings that result from reduced costs of production, minimal inventory, and improved productivity. Customer satisfaction is also improved through shorter lead-times, improved quality, and affordability. Furthermore, organizations are able to benefit through improved product variety and processes that are easier to manage and troubleshoot (Rose et al., 2011; Alsyouf et al., 2011; Vinodh and Joy, 2012). These benefits, sustained over time, can see a business being resilient even in the face of uncertainties such as market changes. This also explains why companies would want to consider Lean practice to develop or attain global competitiveness. Waste in the context of Lean Manufacturing is defined as any material or processing that does not add value in the making of the final product from the perspective of the customer.

2.2 Lean Waste Categories

The elimination of waste is central to the Lean philosophy. Seven waste categories have been identified in order for organizations to be able to recognize and address them. The seven types of wastes are: transportation, which is all the movement that can be avoided, whether its equipment or products that are a work-in-progress or completed; inventory, which is stored material or final products not needed by the customer; motion, which is any movement by personnel that can be eliminated without consequence; waiting, whether on resources required to proceed with work or due to poorly defined tasks and delays; over-production, where more product than the customer needs is made; over-processing, in which the product is processed without any additional value added; defects, which refers to products that are sub-par in quality in the customer’s expectations; and underutilization, which refers to idle machinery and a workforce that is not engaged to capacity regarding work (Deros et al., 2012; Govendor and Jasson, 2018; Coetzee et al., 2019; Psomas and Antony, 2019).

Each of the Lean waste categories emphasize the importance of putting customers first, and further encourage efficiency and commitment from employees and management. The Lean wastes are recognizable in other sectors other than manufacturing, which is one of the reasons that Lean has been preferred broadly. For example, Nwobodo-Anyadiegwu et al. (2020) were able to identify the different wastes in the health sector in line with the 7 Lean waste categories; additionally, they proposed a Lean framework for the health sector.

2.3 Qualitative and Quantitative benefits of Lean

Anand and Kodali (2009) refer to the competitive priorities cost, quality, flexibility, and delivery as incomplete in measuring organizational success. They added staff morale, innovation, and productivity as equally crucial for a competitive edge. Often these indicators of competitiveness are what organizations consider as measures of their Lean efforts. Bhamu and Sangwan (2013) have categorised the benefits of Lean into qualitative, the ones that can be measured, and quantitative, which are descriptive in nature.

2.3.1 Qualitative Lean Benefits

Lean benefits have been quantified in order to observe the impact of Lean. Some of the quantitative benefits that have been explored in manufacturing spaces are reduced waste, reduced lead time, lower inventory, improved capacity for high product variability and troubleshooting, and overall financial savings (Bhamu and Sangwan, 2013; Chaple et al., 2017). Lean is also likely to help organizations retain old customers and acquire new ones, leading to a growing market share (Christodoulou, 2008).

2.3.2 Quantitative Lean Benefits

The main benefit of Lean is that organizations become competitive in prices and profits. However, this benefit is a culmination of other advantages realised in different aspects of the business. Some of the quantitative lean benefits are employee involvement, dedicated management, better collaborative efforts between teams or departments, efficient and standardized processes, an improved culture, improved quality, high customer satisfaction, and improved business relationships with external stakeholders (Bhamu and Sangwan, 2013; Govendor and Jasson, 2018).

2.4 Lean Enablers and Barriers

2.4.1 Lean Enablers

Lean enablers are factors that position organizations for the successful and sustainable implementation of Lean in their business (Hore, 2019). Dev and Kumar (2016) and Nwobodo-Anyadiegwu et al. (2020) refer to critical success factors as playing a similar role of enabling organizational readiness prior to a transition or transformation such as one that comes with implementing Lean manufacturing. They have listed factors such as cultural flexibility, understanding of internal and external stakeholder roles, and training of personnel in the principles of Lean, as critical success factors.

Mohammed and Oduoza (2019) have identified 16 Lean enablers from their study, including a clear vision and strategy, development of the people, visual process control, and technological update. A study by Bayhan et al. (2019) also provided 27 Lean enablers which were further categorized into 7 groups: finance, technical, management, workforce, culture, government, and communication. The financial enablers encompass the organization's readiness in terms of a possible budget to invest in implementing Lean, without compromising profits and other financial metrices. The technical enablers refer to the concepts of Lean and their availability, clarity and relevance for managers and practitioners to understand and implement. The managerial, workforce, and cultural aspect involves people in terms of adaptable and involved leadership structure and style, knowledge and skills, and attitude and morale towards change or new initiatives within the organization. Government-related enablers create an environment for open policy discussion and development, incentives and resources within a particular economy, while communication-related enablers creates clarity and understanding of the roles that different stakeholders are supposed to take (Bhamu and Sangwan, 2013; Bento and Tontini, 2018; Bayhan et al., 2019; Caldera et al., 2019).

The most common enablers according to Bayhen et al. (2019) are proper understanding of the Lean requirements, followed by a culture that is receptive to change and support from management. The role of an enabling culture and supportive management is emphasized by Bhamu and Sangwan (2013), Hore (2019), and Anand and Kodali (2009). Other Lean enablers that have been reported are integrated strategies, continuous improvement, and streamlined processes (Caldera et al., 2019; Bento and Tontini, 2018).

2.4.2 Lean Barriers

Research on Lean barriers has sought to understand factors that hinder the success of Lean manufacturing. With the appraisal of Lean success in some organizations, there are many who haven't seen the benefits of Lean despite their best intentions. There are various factors that can hinder the success of Lean, internal or external. Some of the Lean barriers commonly reported are the lack of understanding of the Lean concepts, lack of commitment and support from management, resistance to change by employees, and lack of appropriate skills and resources (Govendor and Jasson, 2018; Anand and Kodali, 2009; Nwobodo-Anyadiegwu et al., 2020).

Takeda-Berger et al. (2020) classified the main Lean barriers and found that the two most common Lean barriers are cultural challenges, and lack of backing from senior managers. These barriers are within the control of organizations; hence it is important to know and understand them in order to prepare for and resolve them. For example, managers in an organization can go through Lean training to learn of the relevance, benefits, and guidelines ('how to') from which understanding, and confidence can be developed for Lean manufacturing and Lean practice in general. With managers on board, they can then influence the culture from the top down to make middle-managers and shop-floor employees receptive of the Lean transformation.

Some Lean barriers are independent of organizations. Consider the role of government in different economies and the impact of policy development on the manufacturing industry and the practice of Lean. Organizations that are bound by stringent governmental regulations do not have opportunities to effect change by themselves. Market volatility also contributes to the level at which organizations benefit from Lean manufacturing; at best organizations can only respond reactively to unprecedented market changes (Jamwal et al., 2019; Bayhan et al., 2019). Nevertheless, part of Lean practice is building organizational resilience.

Lean barriers and Lean enablers are two sides of the same coin because they are similar factors with opposing effects. This is seen in research by Bayhan et al. (2019), where they have identified and grouped Lean barriers and Lean enablers within the same baskets. As mentioned in the previous section, the authors have lumped Lean enablers into financial, technical, managerial, workforce, cultural, government, and communication. This duality in Lean barriers and enablers has also been noticed by Viagi et al. (2016) through the role of managers on the failure or success of implementing Lean manufacturing.

2.5 Lean Tools and Methods

The Lean philosophy has many tools, techniques, and practices developed to facilitate the implementation of the philosophy into an organization. Yadav et al. (2019) refers to these tools, techniques, and practices collectively as 'lean drivers'. Many other researchers have referred to these elements interchangeably as 'practices', 'principles', 'elements', and 'initiatives' (Pereira and Tortorella, 2018; Chaple et al., 2017; Bhamu and Sangwan, 2013; Mostafa et al., 2013). Each of the lean elements is intended to enable organizations to comprehend and channel customer value through the process, eliminate waste, establish a pull system and continuity (Deros et al., 2012).

Some of the lean elements are value stream mapping (VSM), which maps the current and future state of an organization to visualise the places where non-value add activities exist and can be eliminated; 5S which is concerned about the process of sorting, straightening, shining, standardizing and self-discipline; cellular manufacturing which is concerned with systematically sorting product families to create cells for similar types of products; and many others such as Kaizen, Kanban/pull, just-in-time (JIT) and quality circle (Yadav et al., 2019; Alsyouf et al., 2011; Chple et al.,2017).

There is a plethora of these elements in literature. For example, Bhamu and Sangwan (2013) identified 19 Lean elements in their literature study; Psomas and Antony (2019) listed about 25 Lean elements, while Pereira and Tortorella (2018) recoded 19 'practices'. Shah and Ward (2003) have categorised 22 implementation elements into four clusters: total productive maintenance (TPM), total quality management (TQM), just in time (JIT), and human resource management (HRM). Bhamu and Sangwan (2013) suggests that there may be repetition in the lean elements in that, some of the tools and techniques might have different terms, while others overlap in functions.

Due to the integrated nature of manufacturing systems and business processes, it is important that Lean practitioners be cognisant to choose the appropriate tools for their organizations, and the right combination at that. The wrong selection and misuse of any of the Lean tools could result in failed Lean transition efforts (Chaple et al., 2017; Alsyouf et al., 2011). Hence, it is important that Lean practitioners understand the different Lean elements and be able to align them to the needs of their organizations.

However, it can be confusing to managers and practitioners of Lean to make the right decisions given the wide variety of different elements in literature. Furthermore, Anand and Kodali (2009) have noted that there is no clear difference between tools, techniques, principles and techniques, all of which make up the 'elements' according to researchers such as Shah and Ward (2003) and Bhamu and Sangwan (2013). Alsyouf et al. (2011) supported this sentiment by acknowledging that there has been limited research on how to select the appropriate Lean methods. With lack of understanding of Lean concepts cited frequently as a barrier to Lean success, this lack of clarity with Lean elements is a potential stumbling block (Yadav et al., 2019).

In efforts to address the above challenge, Anand and Kodali (2009) identified 65 Lean elements through a literature study, which they categorised according to organizational decision levels, stakeholders, competitive priorities and business functions. This categorization is the feature of the framework they designed, which sought to consolidate the Lean elements and provide some form of a guideline for selection and use. Afterall, frameworks make a helpful vehicle to translate Lean concepts into practice since they are meant to act as guidelines. The roles, requirements, challenges and opportunities related to Lean frameworks are explored in the next section.

2.6 Lean Manufacturing Frameworks

There are frameworks that have been developed for use to implement the philosophy of Lean manufacturing in organizations. The common understanding of framework definition among researchers is that it is a systematic guideline for implementing Lean concepts practically (Anand and Kodali, 2009; Rose et al., 2010).

Aalbregtse et al. (1991) in Deros at al (2006) states that frameworks serve the purpose of communicating the future vision of an organization while enabling detailed understanding of the current state, highlighting areas of concern with potential for significant impact in transforming an organization, and facilitating the process of implementation of the relevant tools for best outcomes. Additionally, Struebing and Klaus (1997) in Deros at al. (2006) highlight the role of an efficient framework as able to guide practitioners on the required actions and correct sequence of steps.

An acceptable framework is generally expected to be well-structured, easy to understand and use, adaptable for different contexts, clear on relevant tools and actions required, practical and having attainable resource requirements (Yusof and Aspinwall, 2000). Medori and Steeple (2000) suggests that part of the design requirements for a framework should include performance measures, coherence between organizational strategy and the competitive indicators such as cost, flexibility and future growth, and a methodological approach.

Different Lean frameworks have been developed to meet various organizational needs and to accommodate the different Lean concepts. For example, Anand and Kodali (2009) have highlighted frameworks such as House of Lean by Dennis (2002), The Toyota Production System and Lean shipbuilding by Liker and Lamb (2000). Alyouf et al. (2011) developed a framework for evaluating the cost efficiency of Lean tools. Deros et al. (2012) proposed a project-based framework for organizational change management.

Deros et al. (2006) have also proposed a conceptual benchmarking framework, after studying benchmarking frameworks by other researchers and categorizing them into two major groups, namely consultant/expert based, and academic/research based. They purport that consultant/expert frameworks are based on experiences of people that have used them practically, while academic/research frameworks are abstract, and concept driven. However, both types of frameworks have been diagnosed as complex and rigid.

Lean implementation frameworks have had their share of criticisms with researchers reporting on various shortfalls, such as the lack of validation and practical application of existing frameworks (Yadav et al., 2019). Lack of clarity on sequence, comprehensiveness, and inclusivity of organizational factors have also been echoed as limiting of Lean frameworks (Anand and Kodali, 2009; Mostafa et al., 2013; Psomas and Antony, 2019).

There is not yet a consensus among Lean researchers and designers about what the best practice is with regard to Lean frameworks. This observation is evidenced by the conflicting opinions of researchers. Some researchers highlight the need for standardized Lean manufacturing frameworks, as they opine that the different definitions and wide range of Lean tools can be confusing for managers and practitioners (Rose et al., 2010; Bhamu and Sangwan, 2013). The different Lean elements need to be consolidated for easy reference, distinction, and selection of relevant ones. This is a valid point considering that misunderstanding of the Lean concepts is one of the main barriers to the success of Lean implementation.

With that said, Anand and Kodali (2009) developed a comprehensive framework, classifying and incorporating 65 Lean elements to address the lack of frameworks that are 'all-inclusive' of the different Lean elements. Additionally, their proposed framework sought to provide clear guidelines on the role of different stakeholders. However, it is said that this framework is complicated for small organizations, considering the simplicity of their structure and limited resources. This is especially the sentiment with small and medium enterprises (SMEs) (Rose et al., 2010; Pereira and Tortorella, 2018; Yadav et al., 2019). This difference of opinion suggests that there is a lack of balance between Lean framework comprehensiveness and adaptability, two requirements of a framework design.

Framework comprehensiveness in the context of Lean refers to a framework that encompasses all Lean elements (i.e., concepts, principles, practices, procedures, tools and techniques) in a structured manner (Anand and Kodali, 2009). Adaptability of frameworks in the context of Lean considers the usability of a framework in different contexts such as different economies (i.e., developed and developing), organizational size (i.e., small versus large), and industry (Yadav et al., 2019). These criteria "promote universality and familiarisation of the lean concept" (Mostafa et al., 2013).

2.7 South African Economy and the role of Manufacturing

The manufacturing sector in South Africa is among the top three industries that contribute to the Gross Domestic Product (GDP), alongside agriculture and trade. However, in 2021, South Africa saw a decline of 1.5% in GDP due to the shrinkage of the manufacturing industry by 4.2%, trade industry by 5.5% and agricultural industry by 13.6% (Statistics SA, 2021). While the manufacturing industry performed slightly better relative to the other industries, it is worth noting that 80 % of its subsectors contributed to its overall decline.

A decline of the contributions of the South African manufacturing to GDP is not a recent phenomenon. It was noted that between 1994 and 2018, contributions of the manufacturing sector to GDP reduced by 7.3 % (Van Dijk, 2002; Rodrik, 2008; Maisiri et al., 2021). This decline is a major concern because of the various ways that the manufacturing sector is dynamic and influential in driving economic growth on various facets.

For one, manufacturing is considered the most productive and labour-intensive sector (Rodrik, 2008, Bhorat and Rooney, 2017). The decline in manufacturing sector correlates to the decline in the fraction of the labour force employed in the sector, with majority of the workforce being semi-skilled or unskilled (Rodrik, 2008). A comparative study by Rodrik (2008) between Malaysia and South Africa on the performance of the manufacturing sector and its effect on employment suggests a strong relationship between high employment, aided by the manufacturing sector, and economic growth. Bhorat and Rooney (2017) support Rodrik (2008)'s observations, stating that many economies that have succeeded in improving have had a lively manufacturing sector.

Vermaak (2008) and van Dijk (2002) have also acknowledged the role of manufacturing in improving the alarmingly high unemployment rate in South Africa. This is critical for a country such as South Africa battling high unemployment rates as one of the main socioeconomic challenges. The unemployment rate in South Africa was recorded at 25.5 % in the first quarter of 2008. This number increased to 34.5 % in the first quarter of 2022 (Stats SA, 2022; Stats SA, 2008). The global phenomenon of the covid-19 pandemic exacerbated the unemployment gap due to the restriction of economic activity; the resulting effect was the shut-down of some business operations and retrenchment of employees by employers in an effort to keep businesses afloat.

However, caution must be taken to consider the shift in technological developments in manufacturing practice which may largely leave the low-skilled without opportunity in the manufacturing job market (Rodrik, 2008). This potential shortfall is also perpetuated by the nature of manufacturing in enabling new technology and supporting innovation (Wang et al., 2019; Tregenna, 2008). As a result, the semi-skilled and highly skilled workforce will be sought after than the low-skilled upon the lack of skills upgrading. If unchecked, this pattern might be counterproductive considering that most of the unemployed population is unskilled. Interestingly, Vermaak (2008) also argued that improvement initiatives such as Lean will affect the level of workforce that is able to adapt to the changes.

The manufacturing sector plays an important role in the economy because of its intersectoral characteristics with other sectors such as the services sector. The services sector in South Africa was reported to be taking over the manufacturing sector in its growth, and contribution to GDP and employment (Tregenna, 2008; Rodrik, 2008). However, Tregenna (2008) concluded in their study that the growth in the services sector runs on the backbone of the manufacturing sector. It is elaborated that the progression of the manufacturing sector towards product specialisation and diversification has given rise to functions of the services sector. Moreover, some of the functions that manufacturing organizations used to manage internally have been deployed from specialist service providers. Hence, this "intersectoral outsourcing" gives rise to the trend of a declining manufacturing sector and a growing services sector (Tregenna, 2008).

The manufacturing sector continues to be a strategic sector for economic growth for the various unique features such as the potential to curb unemployment, the opportunity presented to explore new technology and innovation, and the intersectoral linkages with other sectors. As such, it is critical that policies drawn to facilitate economic growth, factor these elements and enables the manufacturing sector to thrive. For example, Maylasia has been studied closely in comparison to South Africa due to their historic similarities and it was found that Maylasia was able to improve its economy through investment in the manufacturing sector, with strong industrial policy frameworks to support the changes (Rodrik, 2008).

South Africa has had policies such as the National Development Plan (NDP) to attempt to curb the scourge of unemployment, poverty and inequality (National Planning Commission, 2011; Bhorat and Rooney, 2017). There has also been the Black Economic Empowerment (BEE) policy that intends to drive economic participation and inclusion against the background of the segregatory history of apartheid, where black people constitute the majority of the country but were excluded from economic activity. However, the changes experienced because of these policies are not sufficiently impactful, have proven to show loopholes regarding the level of detail to which they are meant to address the problems, and failed to put manufacturing central to the strategy. For example, the BEE policy is implemented as a compliance strategy while the manufacturing industry in particular still has significant barriers to entry for new industrialists. These barriers include capital and access to the value chain in the industry (Goga and Avenyo, 2021).

The role of trade in improving competitiveness and boosting economic growth cannot be overlooked. The manufacturing sector introduces an opportunity in this regard, where local manufacturers make goods that can be exported. Countries such as Brazil and the United States have managed to keep imports to a minimal relative to their overall GDP, at 9.6 % and 12.0 % respectively. This is a stark difference considering countries such as Egypt and South Africa who spend significantly on exports relative to their GPD, with 26.0 % and 25.1 % respectively.

2.8 Lean Manufacturing in South Africa

Research in Lean manufacturing has been explored in South Africa in industries such as the automotive (van de Merwe et al., 2014; Rathilall and Singh, 2011), construction (Maradzano et al., 2019), hospitality (Govendor and Jasson, 2018), healthcare (Nwobodo-Anyadiegwu et al., 2020), banking (Christodoulou, 2008), and clothing (Chiromo et al., 2015). However, Mund (2011) expressed that the pace of Lean adoption in South Africa is slow and appealed to organizations with a global presence who are already on a journey to improve their operations. Mund (2011) further suggested the establishment of structures for consultation and knowledge-sharing to facilitate the adoption of Lean practice in South Africa.

The Lean Institute Africa exists as a significant specialized unit of the Business School of the University of Cape Town. Founded in 2007 and part of the Lean Global Network, it provides Lean training, strives to promote Lean thinking, and research (https://www.lean.org.za/about/). Furthermore, Lean research has trickled in since research by Mund (2011), with researchers such as Chiromo et al., 2015 and van de Merwe et al. (2014) making their contributions.

However, Dondofema et al. (2017) supports sentiments by Mund (2011) that Lean research in South Africa is still in its early stages. This conclusion was made by Dondofema et al. (2017) after their benchmarking study of research on Lean practice in South Africa compared to Russia between the periods 2014 to 2015. Mangaroo-Pillay and Coetzee (2020) reached the same conclusion in their study of Lean implementation frameworks in South Africa; they stated that the lack of wide publications on Lean implementation frameworks prior to 2010 and the noticeably long time-span observed before research publications started trickling in, suggests that Lean implementation in South Africa relatively recent.

Dondofema et al. (2017) further concluded that the research published between 2014 and 2015 was limited to the development of models and frameworks, and application of Lean tools while Russia prioritized the adaptation of the philosophy to their local context. This lack of dynamism in Lean research in South Africa is also echoed by Liker (2004). A lack of understanding by Lean implementers in South Africa is a stumbling block as observed by how Lean tools are applied in fragments while other aspects of it are disregarded (Dondofema et al., 2017). Dondofema et al. (2017) additionally highlights the need for research that zooms in on the assessment, adaptability and extension of Lean concepts.

Subsequently, research has not improved much in terms of focus since the publication of Dondofema et al. (2017) on the shortfalls of Lean research in South Africa. For example, Govendor and Jassons (2018) published a paper that introduces tools that can be used in the hospitality sector in South Africa after assessing the opportunities and challenges through a literature study. This research aimed to guide the hospitality sector on how they can benefit from Lean practice. However, the focus has been on Lean tools, not on adaptation and expansion of the Lean concepts.

Maradzano et al. (2019) conducted a theoretical study on existing Lean tools, in order to identify which of the tools can be considered in the construction sector. From their study, a Lean implementation framework was developed for application in the electrical and engineering context of construction. Mangaroo-Pillay and Coetzee (2020) did a systematic literature review to categorise the different Lean implementation frameworks in South Africa. It was concluded that there is a variety of frameworks depending on purpose and users. The iterative nature of Lean implementation was also highlighted. Again, this study focused on Lean tools and the development of a framework as opposed to insight and flexibility as far as the South African construction sector is concerned.

Research by Nwobodo-Anyadiegwu et al. (2020) provides an assessment to analyse the readiness of organisations in the South African health sector. They reviewed literature on Lean practice in the health sector and identified readiness factors – "the availability and extent of preparatory elements for a lean journey", relevant to the health care sector in South Africa. Although this form of research was still concerned with some form of tool, it provides an important approach to consider for Lean research, i.e., the adaptability of the Lean philosophy.

Coetzee et al. (2019) conducted a study that evaluated the "Respect for People (RFP)" principles used in Japan, to understand the usability, and if needed, adaptability of the principles. It was concluded that the RFP principles were all applicable in the South African context, with additional themes unique to South Africa identified. This study is one step in the direction of diversifying the focus of Lean research, and in particular in the manufacturing sector.

The different researches done in South Africa, which have been deemed to focus more on Lean tools, methods and frameworks, are breeding ground for more research that tackles other aspects of the Lean philosophy in various sectors of the South African economy.

Chapter 3: Research Methodology

Structural Equation Modeling (SEM) is a statistical method that is used to determine the validity of a predetermined model using either raw data or secondary data. Although it has similar features to other statistical approaches such as multiple regression and analysis of variance (ANOVA), SEM is preferred for its ability to handle complex models with more options for processing software than the comparable methods. An additional advantage of SEM is that it incorporates measurement error in modeling and allows for interpretation of multiple statistical checks (Shah and Goldstein, 2005; Weston and Gore Jr, 2006).

In recent years, operations management research has been catching up with the leading research fields of psychology and marketing in the use of SEM (Hair et al., 2019). This method is a combination of path analysis and factor analysis, which mirror the segments that make up SEM analysis, namely the measurement model and the structural model (Weston and Gore Jr, 2006). The measurement model quantifies the relationships between observed variables and the constructs; the structural model on the other hand, measures the strength of the relationships between the constructs themselves (Weston and Gore Jr, 2006).

3.1 Generic SEM Structure and Variables

The two sub-components of the SEM structure and related terminologies to describe variables are explained under this section. As previously stated, the SEM model consists of the measurement model and the structural model, as shown in Figure 1.

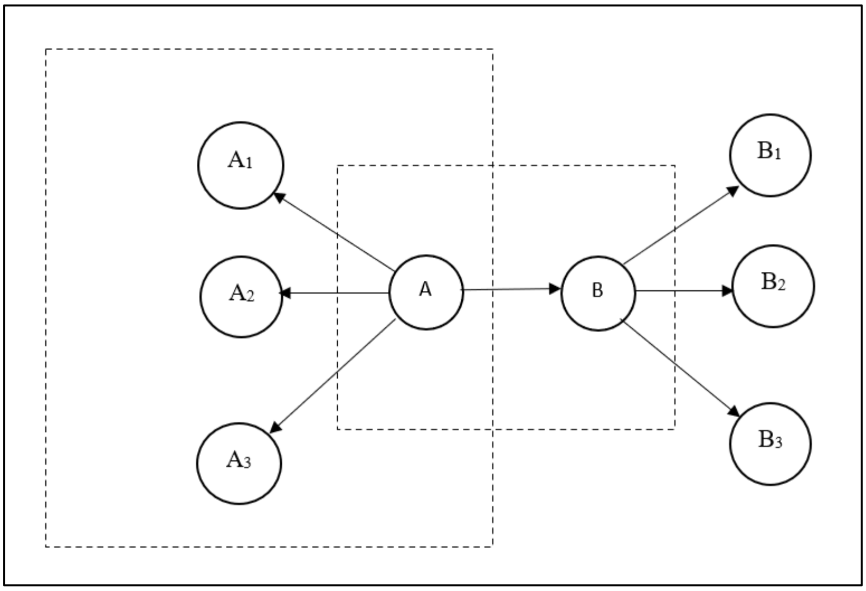

Figure 1: Basic generic structure of SEM model (*Hair et al., 2019*).

In Figure 1, the section with variables A, A_1, A_2, and A_3 represent the measurement model, referred as the outer model. The section with variables A and B represents the structural model, otherwise referred to as the inner model. The variables A and B in Figure 1 are called unobserved or latent variables, this is because they cannot be measured directly as they are hypothetical in nature. Resultantly, they are measured through the manifest variables (or, measured variables), represented by A_1, A_2, and A_3, B_1, B_2, and B_3 in Figure 1.

3.2 Measurement model vs Structural model

The difference between the measurement model and the structural model is explained in this subsection, with reference to Figure 1 where relevant.

3.2.1 Measurement model

The measurement model is also referred to as the outer model and it measures quantifiable variables which in turn inform researchers on the behaviour of the latent variables. There are two approaches to the measurement model, namely the formative measurement model and the reflective measurement model. In a formative measurement model, the arrows point from the indicator variables to the latent variables, showing a causal relationship in that order (Hair et al., 2021). In the case of a reflective model, the arrows point from the latent variables to the indicator variables, predicting a causal relationship in this direction. Such indicator variables have associated errors. Figure 1 shows a reflective measurement model in the generic diagram as all arrows are pointing from each latent variable to its associated indicator variables.

3.2.2 Structural model

The structural model is also referred to as the inner model or path model and it shows the relationship between the latent variables and their path relationships. The sequence of the structural model is from left to right. The variables on the left side of the model are independent variables, also referred to as exogenous latent variables. Variables on the right are dependent variables, also referred to as endogenous latent variables. Variables are able to serve as both independent and dependent variables if they are situated in the middle of causal variables and other dependent variables; in this case they are also called endogenous.

3.3 Covariance-Based (CB) SEM vs Partial Least Squares (PLS) SEM

The SEM is considered a second-generation technique as it resolves many shortfalls that were experienced with older techniques, such as the inability to account for measurement errors and limitation to work with only observable variables (Hair et al., 2021). The two most common

SEM methods are covariance-based SEM (CB-SEM) and Partial Least Squares SEM (PLS-SEM). The following subsections discuss each of these methods.

3.3.1 CB-SEM

The CB-SEM is a method that regards constructs of a model as common factors that explain the covariance between its respective indicators, hence it is also referred to as common-factor-based. This method supports the principle that governs reflective measurement models, where indicators and their covariance are assumed the result of associated constructs.

Fundamentally, CB-SEM is able to handle formative measurement models in addition to reflective ones. However, the use of CB-SEM on formative measurement models requires that predetermined regulations be followed in order to make a complete estimation of model parameters. But these predetermined regulations for using CB-SEM to handle formative measurement models have been critiqued for their inconsistencies with theory (Hair et al., 2021).

3.3.2 PLS-SEM

The PLS-SEM is regarded as composite-based because the underlying assumption for this method is that the indicators of a measurement model are combined linearly to form composite variables. The composite variables are assumed to be an exhaustive representation of the constructs, and therefore of the latent variables.

The composite-based approach of the PLS-SEM complements the philosophy of the formative measurement model; however, it is also reputable for equally handling reflective measurement models with ease. Some of the main characteristics of PLS-SEM is its ability to account for measurement errors and reduced uncertainty, and the ability to handle complex models.

3.3.3 PLS-SEM over CB-SEM

The PLS-SEM method was chosen over the CB-SEM method for a number of reasons. The PLS-SEM method is more reliable for both formative and reflective measurement models without ambiguous rules, and without introducing uncertainties. It is also able to account for measurement errors and can give unique answers from its estimations, making it reliable. One of the greatest advantages of PLS-SEM is its ability to accept much smaller sample size and its consistency at large property.

One of the major strengths of the PLS-SEM method is the ability to utilise all of the indicator's variance to estimate model relationships while making the prediction of dependant variables central. On the other hand, CB-SEM only focuses on the covariance between measurement and structural indicators, while grossly neglecting variable prediction (Hair et al., 2021).

3.4 Important considerations in using PLS-SEM

3.4.1 Data Collection

Data collection in the current study was conducted in the form of a survey questionnaire, with questions developed based on literature and revised by other Lean experts in academia. The questionnaire was also checked and approved by the ethics and compliance office at the University of Pretoria. Online platforms and door-to-door distribution were done to reach a wide range of research participants in manufacturing spaces with appreciable organizational exposure or understanding with technical background in Lean.

Weston and Gore Jr (2016) noted the lack of common agreement among researchers regarding the recommended sample size for SEM analysis. However, large data is encouraged for abnormally distributed data. Some researchers have argued that sample size is dependent on model complexity, and targeted statistical power. Hair et al. (2018) recommends that researchers consider model structure and complexity, expected accuracy levels, and the potential effect size.

To handle missing data points, it is recommended that an observation be removed if the amount of missing data on a questionnaire is above 15 %; the same can be applied if a high fraction of responses is missing for a specific construct (Hair et al., 2017). The data processing in this study presented little concern about missing data points. Missing data points were minimal and were replaced with a place-holder value in the software of analysis.

3.4.2 Model validity

Collinearity is a measure of the uniqueness of each contributing variable to the model. Multicollinearity would imply that variables are redundant, which means there are more variables measuring the same thing. In this case, other redundant variables can be eliminated since they do not add any significance to the model.

Factor loadings are used to assess whether the indicators in the model are loading without any bias to other factors other than their own. This confirmatory analysis enables researchers to identify whether the model needs to be revised and based on the outcomes of the loadings. The model in the current research was revised after the factor loadings indicated that some factors loaded higher on other factors than their own. This correction resulted in an improved the model which then loaded as expected (i.e., higher for its own factors than on other factors).

3.4.3 Criteria for Evaluation

The measurement model and the structural model are evaluated using different criteria which are explained in this subsection along with their criteria. Additionally, bootstrapping is discussed as a relevant method for checking some of the parameters of interest in the analysis of the model.

Evaluation of the measurement model

Criteria used to assess the measurement model enables researchers to check the strength of relationships, internal consistency, convergent validity, and discriminant validity. The outer loadings measure the strength of the relationship between measured variables and has a minimum threshold of 0.708, the higher the loading, the stronger the relationship.

The internal consistency is checked using Cronbach's Alpha, which has a minimum limit of 0.70 and a maximum of 0.95. The composite reliability is used as an additional check to Cronbach's Alpha and should be between 0.70 – 0.95. convergent validity is evaluated using the Average Variance Extracted (AVE), expected to be above 0.50 for a model that has converged.

The discriminant validity is assessed using the Fornell-Lacker (FL) criterion and cross-loadings. The Fornell-Lacker (FL) requires higher values of the AVE square roots for constructs than other constructs. The cross-loadings need to weight significantly for their own variables; and Heterotrait-Monotrait (HTMT) Ratio with a maximum threshold of 0.90 (Hair et al., 2019) also needs to be satisfied. Additionally, confidence intervals can also be used as a final check for the model after the process of bootstrapping.

Evaluation of the structural model

The criteria used to assess the structural model enable researchers to check collinearity, the model's predictive power, the effect of the variable measuring the predictive power on each exogenous construct, and the model's predictive relevance.

Collinearity is assessed using the variance inflation factor (VIF), and is expected to be less than 5. The model's predictive power is assessed using the coefficient of determination R^2 with 0.75, 0.50, and 0.25 being significant, average, and weak respectively; the values of f^2 measure measures the impact of every exogenous construct on the coefficient of determination R^2; the

Stone-Geisser Q^2 is used to measure the predictive relevance of the construct with larger values implying a strong predictive power (i.e., 0 small, 0.25 medium, and 0.50 large) (Hair et al., 2019).

Bootstrapping

Bootstrapping is a technique for testing the significance of all path coefficients. It involves randomly sampling repetitively with replacement from the original samples (Hair et al., 2021). This technique is important for highlighting the significance of the path coefficients when analysing the paths to understand the hypothesized relationships.

Chapter 4: Model Development and Data Collection

This chapter introduces the proposed model and its variables, as well as the data collection procedure and statistical summary of the data collected.

4.1 Model Development

This section explains the variables identified in this study in detail, and the process of the development of the proposed model.

4.1.1 Model Variables

The variables defined and used to develop the model in this research are:

- Framework design effectiveness (FDE)
- Lean implementation enablement (LIE) and
- Business operational success (BOS)

Framework design effectiveness (FDE) is a variable that addresses the process of designing a framework with elaborate detail, clarity, and practicality for anyone adopting the framework to do so with a better understanding and improved chances of succeeding.

Lean implementation enablers have been described by Hore (2019) as factors that make it possible to implement Lean manufacturing successfully and continue to support the changes and benefits in the long-term. Therefore, this definition is the reference point for the variable as considered in the model to be described.

For the purpose of this research, Business Operational Success is defined as the extent to which the business is able to improve its performance subsequent to their implementation of the Lean principles and techniques, since that is about the main goal of lean implementation. Consequently, the variable is measured by indicators identical to performance variables, but based on changes in this performance, hence, the level of change in the performance level is considered the level of success of the lean implementation

Since one of the main motivations for businesses to consider Lean is the desire to improve their operational performance, it is the success of these operational objectives that become indicators of whether companies are doing well from a business perspective (Belekoukias et al., 2014; Bento and Tontini, 2018). The most common measures of business performance are cost, speed, dependability, quality and flexibility (Belekoukias et al., 2014). Success with implementation of lean implies improvement in this performance, hence, changes in these performance levels have been used to measure the extent of success derived from lean implementation. For these reasons, the variable of business operational success is considered relevant in this study and model.

4.1.2 Model Development Process

The design of Lean frameworks requires the consideration of enablers through identifying and understanding the enablers and incorporating them into the design of the framework from a conceptual level. It is important to consider this relationship because many organizations experience challenges in implementing Lean, yet frameworks that exist have not proven sufficient to help Lean practitioners succeed in the pursuit of Lean. Thus, it is important to consider factors that create an environment suitable for Lean success, which can also aid the sustenance of Lean benefits.

Anand and Kodali (2009) have studied a wide range of Lean Manufacturing frameworks from which they identified the limitations of these frameworks, such as a lack of comprehensiveness, vagueness, and poor coherency with the various Lean elements. The effect of poorly designed frameworks is linked to a series of other barriers, such as a lack of understanding and enthusiasm for Lean practice among management and employees, a factor that is critical for the success of Lean (Chaple et al., 2017). Researchers such as Jamwal et al. (2019) and Mostafa et al. (2013) have expressed similar observations about the role of understanding Lean frameworks and their impact on the success or failure of Lean implementation. Lean frameworks that have been designed comprehensively will contribute to a better understanding of the application of Lean by practitioners and managers of the Lean initiative. Therefore, the following hypothesis is proposed:

H1: Framework Design Effectiveness (FDE) positively influences Lean Implementation Enablement (LIE).

Furthermore, the success of implementing Lean Manufacturing depends on the correct understanding of Lean frameworks, tools, and methods. The combination of tools and methods is informed by the frameworks selected, which act as guidelines for the successful implementation of Lean. The usefulness of a framework thus plays a critical role in the Lean journey of any organization. With this said, the main indicators of Lean success are waste reduction, improved quality, and reduced inventory, which speak to the most common measures of business operations.

Belekoukias et al. (2014) have linked the level of Lean implementation success and operational success, reporting that Lean tools and methods have helped organizations in their operations. Yet, the choice and combination of Lean tools and methods are informed by choice of Lean frameworks. Furthermore, the design of Lean frameworks is known to impact the level of Lean success post implementation (Anand and Kodali, 2009). Therefore, the relationship between the design of Lean frameworks and the success of business operations is hypothesized as follows:

H2: Framework Design Effectiveness (FDE) positively influences Business Operational Success (BOS).

Also, improvement in the performance of business operations depends on the environment created to cultivate the success of achieving every business goal. The contemporary measures of operational success, namely cost, speed, dependability, quality, and flexibility, also mirror the indicators and commonly cited benefits of Lean such as waste elimination, improved efficiency, reduced cost, and shorter delivery times, among others (Alsyouf et al., 2011; Kumar & Kumar, 2017). The environment for the success of these operational performance measures is created by Lean enablers, factors that improve the success of Lean implementation.

Belekoukias et al. (2014) confirm that Lean manufacturing is an effective management approach to improve organizational performance. Hence, promoting Lean enablers such as allocation of resources (financial, technological), aligning existing projects with new initiatives, and training personnel on Lean puts organizations in a better position to succeed with Lean implementation. The effect has an impact on the operational success of a business. Therefore, the following relationship is hypothesized between factors that enable Lean success and the business operational success:

H3: Lean Implementation Enablement (LIE) influences Business Operational Success (BOS).

Figure 2 shows the proposed structural model used to evaluate the relationships between Lean framework design, Lean implementation enablement, and business operational success.

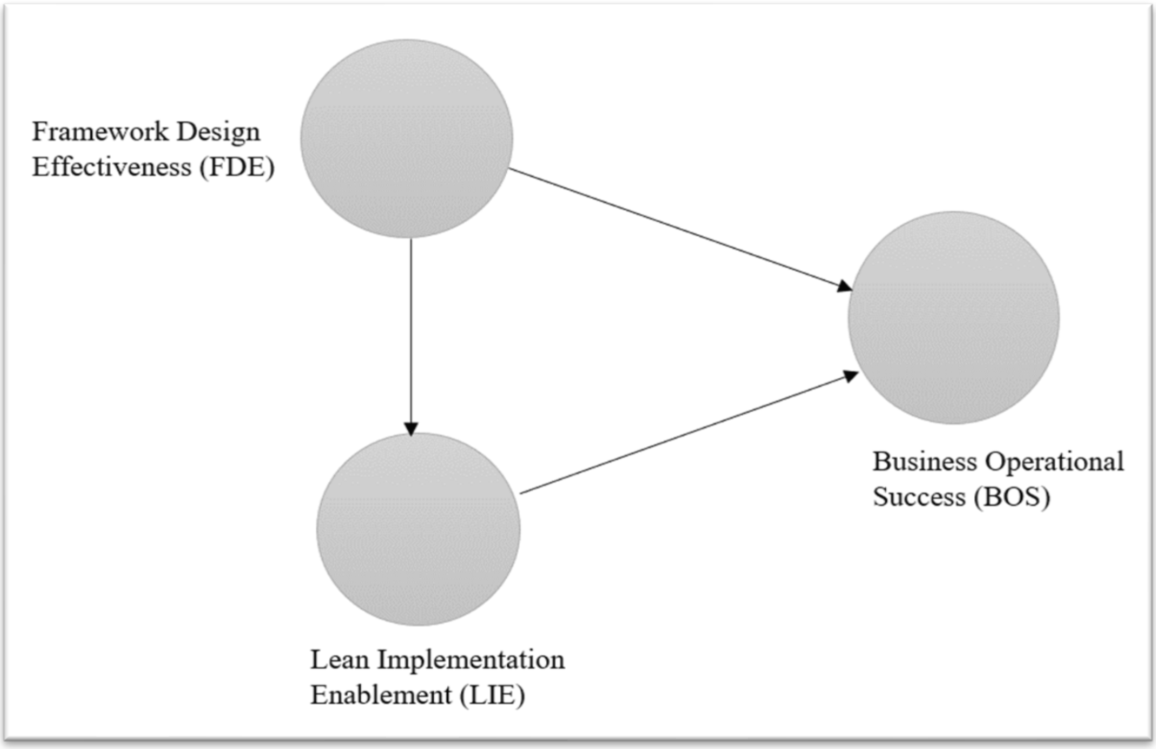

Figure 2: Proposed structural model.

4.2 Data Collection

Data was collected in the form of a survey with a questionnaire. The survey questionnaire was divided into three main subsections. The first section (Section A) consisted of questions about the demographic data of the participants. Section B consisted of leading questions that help determine whether Lean Manufacturing has been implemented before by organizations of the survey participants, and the time window. Finally, section C contained questions about the organization's experience with implementing Lean manufacturing.

The questions in Section C were designed through the use of literature by other researchers such as Alsyouf et al. (2011), Mostafa et al. (2013), and Shang and Pheng (2014) as guidelines. A five-point Linkert scale was used to measure the responses to each question, with 1 = *Strongly disagree*, 2 = *Disagree*, 3 = *Neither*, 4 = *Agree* and 5 = *Strongly agree*. Survey participants selected the option that best represents their opinion. The survey was sent to Lean researchers in academia for initial feedback to ensure the clarity, relevance, and usefulness of the questions in achieving the objectives of the study. The questions of the survey are included in Appendix 1.

2.1. Data Collection Procedure

The survey instrument was distributed through contacts from online professional communities, peer researchers, recommended individuals from social circles, websites of companies and public directories, and door-to-door visits to some companies. The survey was distributed by sharing the link and QR code.

2.2. Data Analysis

Over 280 direct contacts were made via different communication media, including calls, emails, and direct messaging on social media platforms. This excludes online professional communities in which targeted participants may have contributed, missed, or ignored the survey or were not relevant to contribute meaningfully to the study. The response rate observed was 34.48 %, based on direct contacts made. The total number of responses recorded was 100, and one response was removed due to over 80% of responses being blank. As a result, a total of 99 responses were processed.

The research was not limited to a specific manufacturing sector. The roles of survey participants can be summarized into four broad categories: engineers, managers, consultants, and others. Table 1 shows the split of these categories, with engineers making a significant fraction of the participants. Managers included individuals that take on roles from the technical executive, business manager and production manager. The input of consultants was particularly interesting because most are in business development, continuous improvement, and engineering consultancy, in environments that require appreciable training or understanding of the technical details of Lean implementation. The category, "other", refers to other roles, such as chemists and operators that were trained to apply Lean principles too, but each category was too low in number to make a different category other than the ones already stated.

Table 1: A summary distribution of the professional roles of survey participants.

Engineers	Managers	Consultants	Other
43.96 %	32.97 %	20.88 %	2.19 %

The specific sectors within manufacturing varied and included chemicals, FMCG and food, and automotive and machinery, among others. Input from survey participants in the mining sector were also recorded; these were considered on the basis that such participants are exposed to the operations of mineral processing, where raw materials can be taken through a process from the beginning to the end to make a final product. Table 2 reports the percentage distribution of these industries. Similarly, the services category is specific to industrial operations of some form; this was an important consideration in sourcing survey participants. The “Other” category lumps up the various ways participants have preferred to describe the industry that best represents their organizations. The wide range of descriptions received has made it challenging to categorize these.

Table 2: Distribution summary of the industries that participated in the survey.

Industry description	**Percentage (%)**
Chemicals	16
Petrochemicals	8
FMCG + Consumables (food)	17
Automotive + Machinery	17
Glass and non-metallics	7
Mining	12
Construction (manufacturing)	4
Services (consulting)	9
Other	10

Chapter 5: Results and Analysis

The results of the measurement model and the structural model are presented in this section. Before the results are presented, a brief discussion is presented on the process taken to obtain a clean factor structure of the model, i.e. in the state used for the final analysis. Figure 3 shows the PLS-SEM model that has been developed with all of the original items which are introduced based on literature.

Framework design effectiveness has a total of 8 items, Lean implementation enablement has 9, and business operational success has 11 items in total. The cross-loadings analysis was done to check whether each item contributes uniquely to the measurement of the model. Items that failed to load heavily on any construct were removed to improve the model to that in Figure 4.

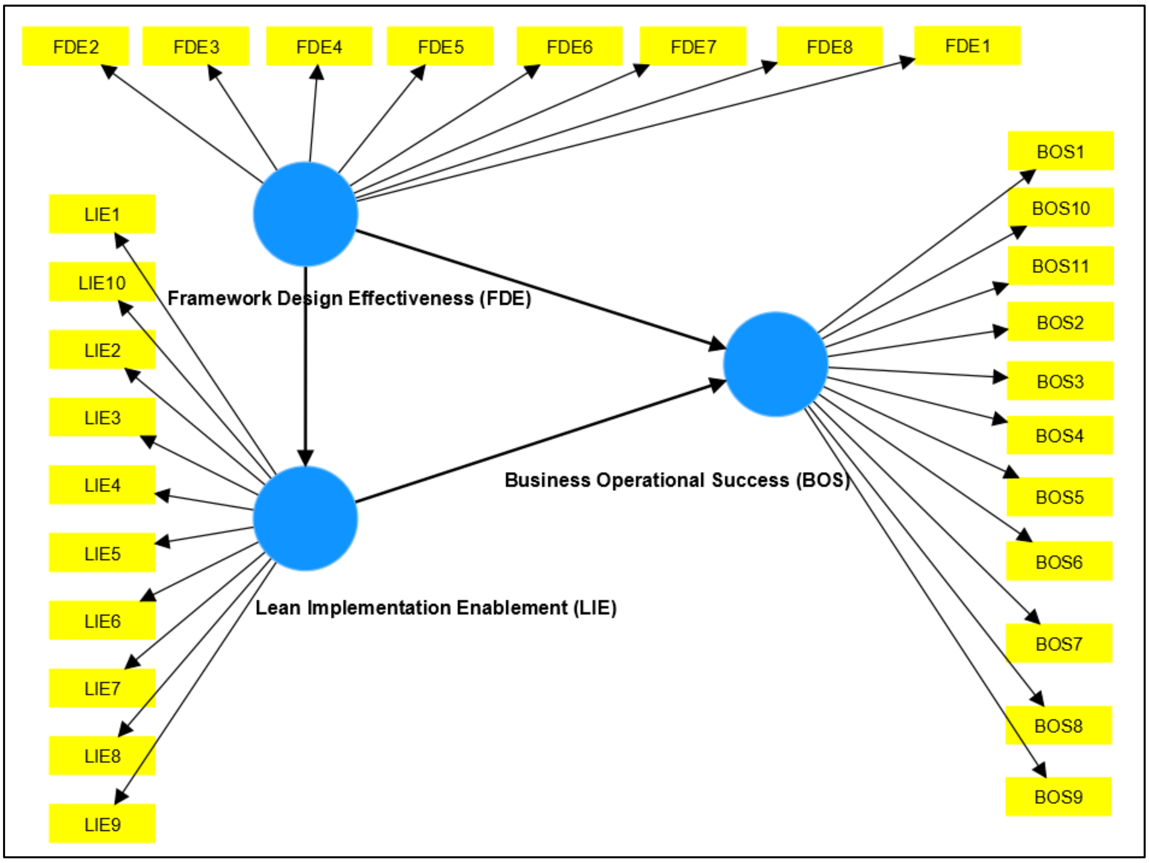

Figure 3: The full SEM model pre-measurement model evaluation.

Figure 4 represents the model that was used for the rest of the analysis in this section, after removing items that showed ambiguity in their loading pattern. This should not cause any problem since the constructs were measured reflectively, and content validity was maintained throughout this process as the usefulness and completeness of remaining items were validated throughout this process. After the reduction in the number of items adopted, framework design effectiveness has 5 constructs, Lean implementation enablement has 8, and business operational success has 5 constructs in total.

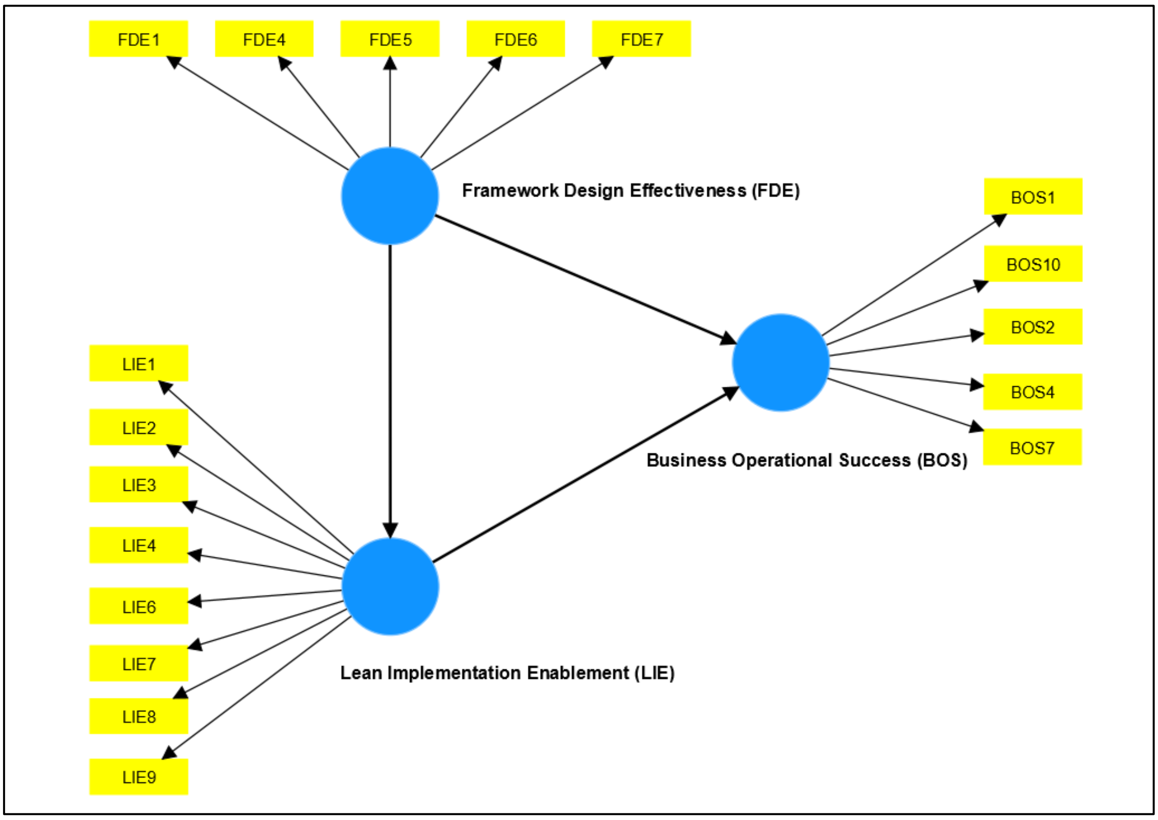

Figure 4: The final SEM model.

5.1 Assessment of the Measurement Model

The measurement model is assessed for internal consistency, convergent validity, and discriminant validity.

5.1.1 Internal Consistency Check

5.1.1.1 Outer Loadings

Outer loadings for the model were assessed and compared to the minimum threshold of 0.70 (Hair et al., 2019). Figure 5 shows the results of the model with each item and its loading. It is observed that the items for business operational success load well on their latent variable, as they all exceed the minimum threshold of 0.70. The items for framework design effectiveness load very well on their latent variable too, as they also exceed the minimum of 0.70. For the latent variable, Lean implementation enablement, three items out of eight load below the expected minimum threshold, with values of 0.575, 0.684, and 0.679. Since only a few out of all the items are slightly below the limit, they are still acceptable, although the higher strength of that relationship, the higher the loading values should also be.

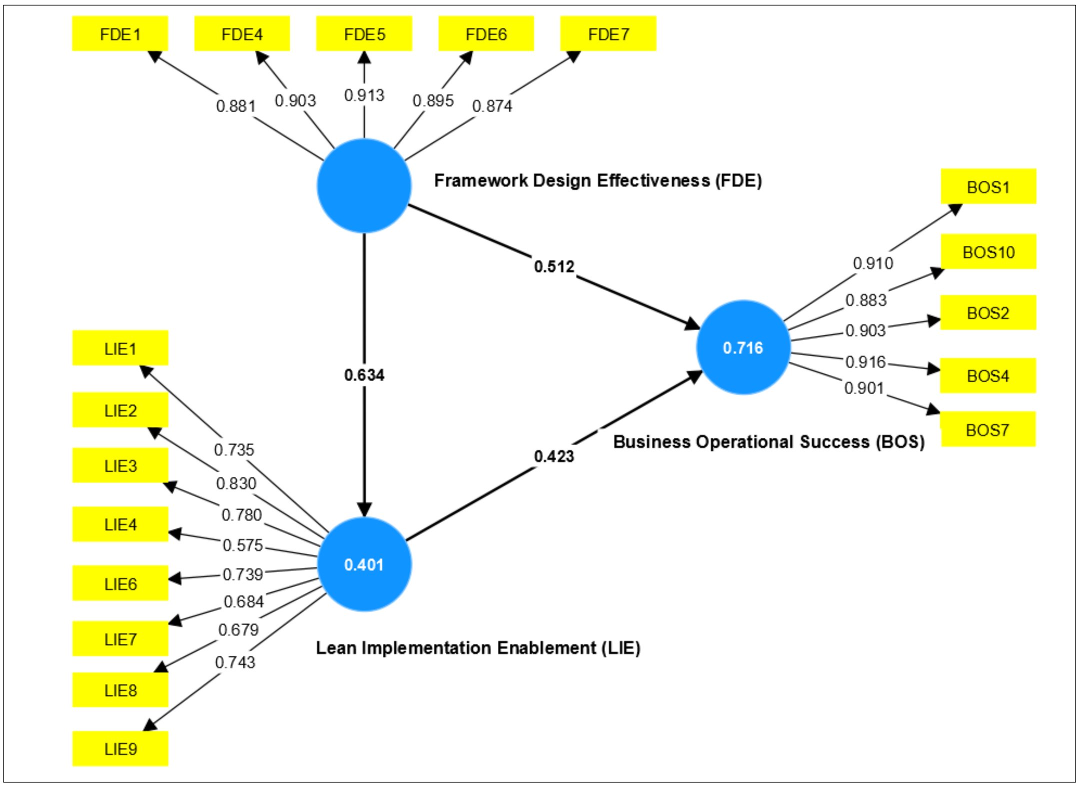

Figure 5: The proposed structural equation model.

5.1.1.2 Cronbach's Alpha

Cronbach's Alpha is traditionally used to check for internal consistency. It is, however, considered to be more conservative compared to the Composite Reliability criterion, which will be used in subsequent sections of the analysis. The Cronbach's Alpha is acceptable in the range of 0.60 to 0.70 for exploratory research, decent in the range of 0.70 to 0.90 for advanced research, and not desirable to be above 0.95. Cronbach's Alpha above 0.95 is said to have likely resulted from indicator variables not being unique among themselves, thereby making the construct measures possibly invalid (Hair et al., 2019; Benitez et al., 2019).

Table 3 shows the results of the Cronbach's Alpha and the Composite Reliability of the model. The Cronbach's Alpha values of 0.943, 0.937, and 0.892 for Business Operational Success, Framework Design Effectiveness, and Lean Implementation Enablement respectively are below the maximum threshold of 0.95 and can be considered fairly high.

Table 3: Results for Cronbach's Alpha and Composite Reliability of the model.

	Cronbach's Alpha	Composite reliability
Business Operational Success (BOS)	0.943	0.944
Framework Design Effectiveness (FDE)	0.937	0.938

Lean Implementation Enablement (LIE)	0.892	0.892

5.1.1.2 Composite Reliability

The acceptability criterion for Composite Reliability is similar to that of Cronbach's Alpha. Table 3 displays the results for the Composite Reliability. It is observed that the Composite Reliability values of the model are below the maximum threshold of 0.95, with 0.938 for Framework Design Effectiveness, 0.897 for Lean Implementation Enablement, and 0.944 for Business Operational Success. These results confirm the internal consistency of the measurement model.

5.1.2 Convergent Validity

The Average Variance Extracted (AVE) values are used to assess the convergent validity of the model. The minimum threshold of 0.50 is used as a guideline. Table 4 reports the AVE values of the model. All the AVE values are above the threshold of 0.50, confirming that the model converges. The highest AVE value is 0.815, and the lowest is 0.524.

Table 4: Average Variance Extracted (AVE) values.

	Average Variance Extracted (AVE)
Business Operational Success (BOS)	0.815
Framework Design Effectiveness (FDE)	0.798
Lean Implementation Enablement (LIE)	0.524

5.1.3 Discriminant Validity

The Fornell-Larcker criterion, cross-loadings, and Heterotrait-Monotrait ratio (HTMT) are used to assess the discriminant validity of the model. These criteria are estimates of whether the constructs can measure unique concepts.

4.1.3.1 Fornell-Larcker Criterion

The Fornell-Larcker criterion results are given in Table 5. This criterion requires that "the square roots of the AVEs for the reflective constructs be higher than the correlations of these constructs with other latent variables in the path model" (Hair et al., 2016). The square roots of the AVEs for this model are each above those of their correlations with other latent variables, except Lean Implementation Enablement. This outcome does not meet the Fornell-Larcker criterion, and for this reason further analysis was done using cross-loadings, discussed in the next section. This observation could possibly be due to some level of cross-correlation between Lean Implementation Enablement and Business Operational Success.

Table 5: Fornell-Larcker criterion results.

	Business Operational Success (BOS)	Framework Design Effectiveness (FDE)	Lean Implementation Enablement
Business Operational Success (BOS)	0.903		
Framework Design Effectiveness (FDE)	0.780	0.893	
Lean Implementation Enablement (LIE)	0.748	0.634	0.724

5.1.3.2 Cross-Loadings

The cross-loadings of the constructs were observed and are reported in Table 6. The criterion used for cross-loading is that "the loading of an item on its assigned construct should be higher than all of its cross-loadings with other constructs." (Hair et al., 2019). All the loadings correlate well with their assigned constructs in the reported cross-loading table. Based on the observation with the cross-loadings, it can be concluded that each item contributes uniquely to measuring their constructs in the model.

Table 6: Cross-loadings of the constructs.

	Business Operational Success (BOS)	Framework Design Effectiveness (FDE)	Lean Implementation Enablement (LIE)
BOS1	0.910	0.687	0.693
BOS2	0.903	0.749	0.675
BOS4	0.916	0.705	0.671
BOS7	0.901	0.681	0.642
BOS10	0.883	0.696	0.691
FDE1	0.631	0.881	0.551
FDE4	0.731	0.903	0.543
FDE5	0.702	0.913	0.603

FDE6	0.700	0.895	0.540
FDE7	0.714	0.874	0.591
LIE1	0.651	0.553	0.735
LIE2	0.680	0.587	0.830
LIE3	0.670	0.557	0.780
LIE4	0.244	0.199	0.575
LIE6	0.393	0.409	0.739
LIE7	0.426	0.350	0.684
LIE8	0.471	0.363	0.679
LIE9	0.555	0.452	0.743

5.1.3.3 Heterotrait-Monotrait Ratio (HTMT)

The Heterotrait-Monotrait ratio (HTMT) is considered about the most reliable measure for checking discriminant validity, compared to the Fornell-Larcker criterion and cross-loadings. The HTMT criterion has a maximum threshold of 0.85. Table 7 reports the HTMT values obtained for the model, all of which are below the maximum threshold.

Table 7: HTMT results.

	Business Operational Success (BOS)	Framework Design Effectiveness (FDE)	Lean Implementation Enablement (LIE)
Business Operational Success (BOS)			
Framework Design Effectiveness (FDE)	0.828		
Lean Implementation Enablement (LIE)	0.776	0.660	

Bootstrapping was considered to check whether the HTMT values were significantly different from one. This was done by means of checking the bootstrap confidence intervals. Table 8 reports the confidence intervals after bootstrapping. Each of the three constructs has confidence intervals within specification; this confirms that the HTMT values are significantly below one.

Table 8: Confidence intervals after bootstrapping.

	Original sample (O)	Sample mean (M)	Bias	2.5 %	97.5 %
Framework Design Effectiveness (FDE) → Business Operational Success (BOS)	0.512	0.503	-0.008	0.358	0.674
Framework Design Effectiveness (FDE) → Lean Implementation Enablement (LIE)	0.634	0.643	0.010	0.490	0.731
Lean Implementation Enablement (LIE) → Business Operational Success (BOS)	0.423	0.431	0.007	0.255	0.564

5.2 Assessment of the Structural Model

Assessment of the structural model consists of checking for predictive capabilities and analyzing the relationships between the constructs. The model was checked for collinearity, path coefficients was analyzed, the model's predictive power was evaluated, and lastly, the predictive relevance was evaluated.

5.2.1 Collinearity Check

Collinearity is assessed using variance inflation factor (VIF) values. Predictor constructs with VIF values above 5 are considered as having critical collinearity levels. Table 9 reports the VIF values of the construct, and they are all below the value 5. It can be concluded that collinearity is not an issue for the model under consideration.

Table 9: Inner VIF values.

	Business Operational Success (BOS)	Framework Design Effectiveness (FDE)	Lean Implementation Enablement (LIE)
Business Operational Success (BOS)			
Framework Design Effectiveness (FDE)	1.671		1.000
Lean Implementation Enablement (LIE)	1.671		

5.2.2 R^2 Values and Path Coefficients

The R^2 is the coefficient of determination, and it is a measure of the structural model's predictive power. Higher values of R^2 are considered to demonstrate high predictive power. According to Hair et al. (2021), the general guideline is that R^2 values of 0.75 are considered substantial, 0.50 moderate, and 0.25 weak. The R^2 values were found to be 0.715 for Business Operational Success and 0.401 for Lean Implementation Enablement. These values are considered moderate, thus demonstrating a good predictive power of the structural model.

The path coefficients show the strength of the relationships between the latent variables. Higher coefficient values are considered to demonstrate a strong relationship between variables. Table 10 reports the path coeffcients between the latent variables. The relationships between BOS and FDE is moderate with a value of 0.512, as with BOS and LIE with a value of 0.423. The relationship between LIE and FDE is strongest in comparison, with a path coefficient value of 0.634.

Table 10: Path coefficients of the structural model.

	Business Operational Success (BOS)	Framework Design Effectiveness (FDE)	Lean Implementation Enablement (LIE)
Business Operational Success (BOS)			

Framework Design Effectiveness (FDE)	0.512		0.634
Lean Implementation Enablement (LIE)	0.423		

5.2.3 Effect Size f^2

The effect size, f^2, seeks to measure the effect of each exogenous construct on the R^2 values. According to Hair et al. (2019), the criterion for the effect size is that 0.02 is a small effect, 0.15 is medium, and 0.35 is a large effect. Factors with effect size values smaller than 0.02 are considered to be of no effect. Table 11 reports the f^2 values. Framework Design Effectiveness and Lean Implementation Enablement, in relation to Business Operational Success, have f^2 values of 0.551 and 0.377, respectively, demonstrating strong effects according to the criterion. Framework Design Effectiveness in relation to Lean Implementation Enablement has a f^2 value of 0.671, demonstrating that the factor has a strong effect on the endogenous variable.

Table 11: The Effect Size f^2 values.

	Business Operational Success (BOS)	Framework Design Effectiveness (FDE)	Lean Implementation Enablement (LIE)
Business Operational Success (BOS)			
Framework Design Effectiveness (FDE)	0.551		0.671
Lean Implementation Enablement (LIE)	0.377		

5.2.4 Significance of the path coefficient

In this section, the significance of the path coefficients is analyzed. The path coefficients in this model were found to be 0.512 between framework design effectiveness and business operational success, 0.423 between Lean implementation enablement and business operational success, and 0.634 between framework design effectiveness and Lean implementation enablement. The path coefficients indicate the strength of the relationships, while the significance test indicates whether the relationship strength is a chance observation. This significance is tested by means of bootstrapping, from which confidence intervals are obtained and used to check the path coefficients.

Table 12 reports the confidence interval values after the bootstrapping procedure. Each latent variable has the lower and upper limits of its confidence intervals well above zero at the 95 percent level. This implies that their estimates could not have been zero; hence, they are all significant. The results of bootstrapping further show that the relationships proposed in the model have significant weight and that the relationships do not exist by chance.

Table 12: Results of the confidence intervals after bootstrapping for the structural model.

	Original sample (O)	Sample mean (M)	Bias	2.5 %	97.5 %
Framework Design Effectiveness (FDE) → Business Operational Success (BOS)	0.512	0.503	-0.008	0.315	0.648
Framework Design Effectiveness → Lean Implementation Enablement (LIE)	0.634	0.643	0.010	0.638	0.806
Lean Implementation Enablement (LIE) → Business Operational Success (BOS)	0.423	0.431	0.007	0.275	0.601

5.2.5 Blindfolding and Predictive Relevance Q^2

The Stone-Geisser's Q^2 value is a measure of predictive accuracy of the model. The blindfolding procedure is used to determine the ability of the model in predicting values that are not part of the original data. Hair et al., (2019) stipulates that "Q^2 values larger than zero for a specific reflective endogenous latent variable indicate the path model's predictive relevance for a particular dependent construct." Both endogenous latent variables, Business Operational Success and Lean Implementation Enablement have Q^2 values of 0.601 and 0.377, respectively, which are above zero and establishes the predictive relevance of the model.

Chapter 6: Discussion

The proposed model suggested hypothetical relationships between the constructs Lean Framework Design Effectiveness, Lean Implementation Enablement, and Business Operational Success. From the results, it was found that the relationships actually exist between the constructs, with the Framework Design Effectiveness having the strongest relationship to Lean Implementation Enablement as shown by the high loading of the path compared to other relationships. This finding suggests that the extent to which Lean frameworks are designed in terms of simplicity, comprehensiveness and adaptability for different organizations has a positive influence on the preparedness of Lean adoption by organizations. Additionally, it is clear from the relationships observed that the use of frameworks by organizations positively influences the ability of organizations to achieve their operational improvement targets.

Studies that have designed frameworks by simply recreating existing framework with minor improvements show lack of robustness in the design of frameworks overall. Furthermore, this iterative design of frameworks continues to highlight the gaps found in existing frameworks. For example, the study by Coetzee et al. (2019) was concerned that the application of Lean overlooks the role of people, and thus explored the Respect for People (RFP) principle to accommodate the people element. Yet, the people element is cited as the most common barrier to Lean success, and the most common key success factor in succeeding with the philosophy as far as management and employees are concerned.

The internal consistency of the model was confirmed using Cronbach's Alpha and composite reliability. The convergent and discriminant validity of the model were also acceptable as indicating the model's reliability in uniquely measuring variables and giving results that are conclusive. This is important because the data collected validates the existence of the proposed relationships. Furthermore, the model has a moderate predictive power and predictive relevance, suggesting that its useability is acceptable.

The cross-loadings were used to check the uniqueness of each contributing variable to the latent variables, and all cross-loadings loaded well with itself than with any other construct. The existence of the confirmed relationship between the constructs, Lean Framework Design Effectiveness and Lean Implementation Enablement, and Business Operational Success introduces an opportunity for designers of Lean frameworks, to collaborate with each other and with organizations to understand how to account for the complexities that result from the implementation of Lean. It also challenges Lean framework designers to understand the challenges, the context in which they happen, and consider opportunities for preparations prior to Lean implementation.

The path weights for Framework Design Effectiveness and Business Operational Success are strongest compared to those of Lean Implementation Enablement, which has most of the path weights that are average. This observation suggests that constructs used to measure the Framework Design Effectiveness and Business Operational Success were strongly related to these latent variables. Moreover, Framework Design Effectiveness had the strongest direct positive relationship with Lean Implementation Enablement than with Business Operational Success. However, Framework Design Effectiveness had the strongest direct positive relationship to Business Operational Success compared to the indirect relationship with the same variable through Lean Implementation Enablement as the mediating variable. In addition, Framework Design Effectiveness relates more strongly to Business Operational Success than Lean Implementation Enablement through direct relationships. These observations suggest that Framework Design Effectiveness plays an important role in the success of business operations and the factors which enable Lean implementation success.

The coefficients of determination ranged from moderate, with Business Operational Success having the highest value and hence close to substantial, demonstrating a high predictive power of the model. The effect size of each exogenous construct on the R^2 values is large for all three latent variables, the highest observed between Framework Design Effectiveness and Lean Implementation Enablement. The Stone-Geisser's Q2 has confirmed the predictive accuracy of the model with positive values well above zero for the endogenous latent variables, Lean Implementation Enablement, and Business Operational Success, with Business Operational Success being the highest.

Chapter 7: Conclusion

7.1 Project objectives, method, and findings

The purpose of the study was to assess the existence of, and if any, the extent of the relationship between Lean Framework Design Effectiveness and Lean Implementation Enablement, Lean Framework Design Effectiveness, and Business Operational Success, and Lean Implementation Enablers and Business Operational Success. The study also wanted to establish the joint impacts of Lean frameworks and Lean enablers on the organizational performance. The hypothesized relationships were developed using the PLS-SEM method.

Data was collected in the form of a survey, and it was analyzed using SmartPLS. Analysis of the data confirmed empirically that the theoretical model proposed between Lean Framework Design Effectiveness, Lean Implementation Enablement, and Business Operational Success exists. The joint impacts of Lean frameworks and Lean enablers on the organizational performance is moderate. The model proposed was also confirmed to be reliable based on selected check-criterion such as Cronbach's Alpha, composite reliability, AVE, cross-loadings, HTMT, and the Stone-Geisser.

7.2 Implications for industry practitioners and recommendations

The contribution made by the current study is important in understanding the existence and impact of the relationships between the design of Lean frameworks, Lean enablers, and business operational success. It creates awareness and a reference point for Lean practitioners to consider factors that create an environment that allows Lean implementation to be successful in their organizations. It will help them with aligning Lean requirements to business objectives for improved Lean success and sustained Lean benefits. Lean practitioners will also gain better understanding of the Lean practice once they understand what sorts of factors influence its success or failure.

7.3 Implications for Lean researchers

The findings in this study are a step in the right direction to explore and expand the philosophy beyond the application of tools and methods as has been in previous research within South Africa. Researchers have an opportunity to design Lean frameworks that connect to factors which create an environment in organizations in which Lean implementation can succeed.

The limitation of the current study is similar to Vermaak (2008) in that, it was conducted in the context of the South African manufacturing sector. Furthermore, this study did not represent all subsectors of manufacturing in South Africa and did not differentiate between large organizations and small and medium enterprises (SMEs).

7.4. Suggestions for further studies

Further studies can explore the level the balance between flexibility and consistency in the development of frameworks, with the effort to ensure that frameworks that are designed are practical and relevant to the ever-evolving nature of work and business practice. Researchers can also consider data that is representative of a larger geographic representation beyond South Africa. It is also worth noting that this considering Lean practice is ever so critical considering the disruptive nature of technology and as businesses strive to save on already limited resources.

Researchers can also explore this topic in consideration of moderators such as industry types, company size, the time the company has been in operation, and gender, with extensive data collection that spans wider geographic coverage for elaborate insights. Researchers can also consider the role of economic structure, and the level of influence of external limitations such as industry policies and industry practice

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Appendix A

Survey questions.

Section A: Demographics

1. Job description
2. Number of years in the organization
3. Number of years in the current role
4. Type of industry
5. Number of years the organization has been in business
6. Number of employees in the organization

Section B: Leading Questions

Definition of Lean Manufacturing: Lean Manufacturing is a management system that seeks to improve productivity, while minimizing or eliminating waste.

1. Has your organization implemented Lean Manufacturing or Lean principles before?
2. If yes, to the question directly above, did your organization use a framework in implementing Lean?

Section C: Questionnaire

The five-point Linkert Scale is used, with 1 = Strongly disagree, 2 = Disagree, 3 = Neither, 4 =Agree and 5 = Strongly agree. Kindly select the option that represents your opinion best.

1. We were able to identify a framework that is suitable for our organization and industry.
2. The framework helped us to choose the right tools in the initial stage of implementation.
3. The use of a framework ensured that we **clearly/easily understand** how to improve the initial state of the organization.
4. The selection of proper tools through the use of a framework resulted in **noticeable improvements**.
5. Our organization was able to **adapt** the chosen framework to our business environment.
6. The chosen framework to implement lean has minimized/ reduced variability in processes.
7. The framework chosen considered both the technical aspects and the social aspects of lean implementation.

8. Our organization has adopted a second lean framework to make up for the shortfalls of the initially selected framework.
9. Our management supports new improvement initiatives such as lean manufacturing.
10. Our organization invests in training of personnel/employees to implement lean successfully.
11. Our organization is supportive and willing to make initial capital investment to implement lean.
12. The employees in our organization are open to a new/different way of doing things.
13. Our employees are not resistant to change.
14. Our organizational structure supports the autonomy of employees.
15. Our top management communicates effectively with lower-level employees.
16. Our organization is constantly seeking to identify unmet business needs and growth opportunities.
17. Our business has efficient systems and processes in place to manage relationships with external partners (i.e., customers, suppliers, accreditation bodies, etc.)
18. Our organization demonstrates enough understanding and commitment to implement lean successfully.
19. Lean implementation has improved our organization’s product conformance.
20. Lean manufacturing principles have helped reduce inventory.
21. Lean manufacturing has enabled our processes to be flexible (in terms of product types, changing from one process or formulation to the other, etc.)
22. Lean manufacturing has improved on-time delivery of our products to our customers.
23. Lean manufacturing implementation has reduced customer complaints.
24. The opinion of the manufacturing plant’s management for the performance of the plant compared to competitors is confident.
25. Lean manufacturing implementation has resulted in improved plant capacity.
26. Lean manufacturing implementation has reduced cycle time or lead time.
27. The number of defects per production shift has reduced since lean implementation.
28. Our organization has been able to record financial savings as a result lean practice.
29. Minimal breakdowns and equipment failures have been less since the implementation of lean practice.