



Lean manufacturing implementation in Zimbabwean industries: Impact on operational performance

Catherine Maware¹ and Olufemi Adetunji

Abstract

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

Keywords

Toyota Production System, structural equation model, Lean Manufacturing, Lean measurement, TPS house

Date received: 6 November 2018; accepted: 5 June 2019

Introduction

Lean Manufacturing (LM) is a philosophy that has been used by companies to increase competitiveness and organizational performance. It was initially embraced by the manufacturing sector, however, it has been adopted by the service industries such as education Delago, Machado,¹ healthcare,^{2–4} hotel and tourism^{5,6} as well as transport.⁷

The manufacturing sector in Zimbabwe has been struggling in their operations since the introduction of the multi-currency system in February 2009.⁸ This is because the sector is characterized by inadequate funding to improve on its machinery and technology,⁹ and as a result, the growth in real Gross Domestic Product (GDP) has not been stable. For instance, the real GDP increased from 5.4% in 2009 to 16.3% in 2011, fell to 0.6% in 2016 and then increased to 3.7% in 2017.¹⁰ In this environment, companies that successfully implement LM may survive such turbulence better than others. However, the real GDP at constant factor prices for the industry sector improved from negative 0.1% in 2015 to positive 3.7% in 2018¹¹ because companies have been taking advantage of the import

management program that controls the importation of products to increase capacity utilization.¹⁰ Despite the growth of the real GDP at constant factor prices, the industrial sector has also been threatened by imports from South Africa and China which accounted for 2.21 billion USD and 380 million USD, respectively.¹² This has led companies in Zimbabwe to implement LM so as to eliminate waste and improve the quality of their products.¹³

LM philosophy has emerged as a powerful approach that has been used by companies in developing countries to improve their operations. Developing countries such as India,^{14–16} Kuwait,¹⁷ Malaysia,¹⁸ Turkey,¹⁹ Brazil,^{20,21} Thailand,²² Sri Lanka²³ and Indonesia^{24,25} have adopted the philosophy to reduce manufacturing costs so that their

Department of Industrial and Systems Engineering, University of Pretoria, Pretoria, South Africa

Corresponding author:

Catherine Maware, Department of Industrial and Systems Engineering, University of Pretoria, Private Bag X20 Hatfield, Pretoria, South Africa.
Email: cmaware@gmail.com



Creative Commons CC BY: This article is distributed under the terms of the Creative Commons Attribution 4.0 License (<http://www.creativecommons.org/licenses/by/4.0/>) which permits any use, reproduction and distribution of the work without further permission provided the original work is attributed as specified on the SAGE and Open Access pages (<https://us.sagepub.com/en-us/nam/open-access-at-sage>).

products remain highly competitive. In Southern Africa, the effect of LM on operational performance is still under-researched. Studies on the application of LM in these countries include South Africa,^{26–28} Botswana,²⁹ Namibia^{30–32} and Zambia^{33–35}. In Zimbabwe, cases of implementation of LM tools and the impact on individual company performance have been reported. Such companies are found in margarine production,³⁶ bakery,¹³ tile company,³⁷ furniture company,³⁸ plastic manufacturing,³⁹ foundry,⁴⁰ pharmaceutical company,⁴¹ service industry,⁴² battery manufacturing⁴³ and clothing.⁴⁴ This shows that research has been done on implementing LM in Zimbabwe, but the reports have been incoherent, making it difficult to understand how the concept has made an impact on industry-wide operational performance.

Some studies focused on the synergistic results obtained from implementing Lean tools on operational performance. For instance, value stream mapping was used by Gorwondo et al.,¹³ Muvunzi et al.³⁷ and Dzanya and Mukada.³⁹ However, Furlan et al.⁴⁵ and Schroeder and Flynn⁴⁶ state that greater operational efficiency can be obtained when the Lean bundles are implemented simultaneously due to the synergistic effect of various Lean tools. To the best of the author's knowledge, no research has been conducted to show the impact of LM on operational performance across diverse industries in Zimbabwe. This research, therefore, seeks to evaluate the impact of LM on operational performance across Zimbabwean companies.

This article is organized into six sections: the first section is the introduction and a discussion of the problem of interest; the second section gives a literature review of the studies of companies that have implemented LM; the third section is the methodology and describes how the structural model was built. In the fourth section, the results are given; the fifth section gives the discussion of the results, and the article concludes with areas of possible extensions in the sixth section.

Literature review

Historical development of Lean production

The term LM was initially introduced by Krafcik in 1988 and was further made popular by Womack in the book, *The Machine That Changed the World*,⁴⁷ The term was used to compare the Japanese Toyota Production System (TPS) with mass production that was being implemented in the Western economies. After World War II, there was tremendous pressure on material resources and Toyota was not spared.⁴⁸ The company was faced with many labour strikes, recorded a pre-tax loss and was on the verge of bankruptcy in 1950.⁴⁹ This led Taiichi Ohno to introduce the concept of TPS to eliminate waste within the engine machining shop.⁵⁰ As a result, the TPS house has become a well-referenced icon in most industries in the world.⁵¹

LM fundamental principles

LM is built around five basic principles which are value creation, value stream identification, uninterrupted flow, pull production and perfection. Table 1 gives a detailed description of the five lean principles.

Table 1. LM principles.

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

LM: Lean Manufacturing.

Studies of companies that have implemented LM around the world

Kojima and Kaplinsky²⁷ assessed the performance of auto companies in South Africa using Lean Production Index (LPI). The LPI is composed of three elements which are quality, flexibility and continuous improvement. The results indicated that the value of LPI depended on factors such as ownership, access to foreign technology and human resources development. However, buyers and the size of the firm had no impact on LPI. Mapfaira et al.²⁹ studied the

level of LM adoption in manufacturing companies in Botswana. Coping with change and the lower level of skilled personnel emerged as the major drawbacks in successful LM implementation.

Dal Pont et al.⁵² evaluated the impact of total quality management (TQM), just in time (JIT) and human resource management (HRM) practice bundles on operational performance in the high-performance manufacturing international project in 266 companies from countries such as the United States, Spain, Japan, Germany, Sweden, Korea, Italy, Austria and Finland. The results indicated that TQM and JIT had a direct and positive influence on organizational performance and HRM affected performance through the mediating effect of TQM and JIT.

Marodin et al.⁵³ analysed the impact TPM, TQM and JIT have on organizational performances in 64 Brazilian firms. The study concluded that the TQM construct had no influence on operational performance measures. The JIT construct showed a high impact on inventory turnover, while TPM had a positive impact on lead time. Fullerton et al.⁵⁴ studied the correlation between financial performance and the degree of JIT practices adoption in 253 manufacturing firms in the United States. The results suggested that companies that implemented JIT practices extensively realized more profits than those that implemented it less extensively.

Numerous researchers, to name a few, Furlan et al.,⁴⁵ Al-Tahat and Jalham,⁵⁵ Agus et al.,⁵⁶ Hofer et al.,⁵⁷ Rahman et al.⁵⁸ and Vinodh and Joy,⁵⁹ also studied the impact of implementing LM on operational performance.

Lean practices used for implementing LM in Zimbabwe

To the best of the author's knowledge, there is no measurement instrument that has been developed for assessing LM in Zimbabwe. A literature study conducted by Maware and Adetunji⁶⁰ showed that three constructs – JIT, TQM and HRM – were mainly used by researchers to develop qualitative measurement models. They found that these constructs correlated with bundles in the TPS house which are Flow, Jidoka and People integration. While it is generally difficult to select a popular structural model for Lean as a consensus from academic publications, the structural model by Dennis,⁶¹ reproduced in Figure 1, has been adopted for implementing LM by many companies in Zimbabwe. It indicates the five key constructs around which all the Lean activities and tools are built: customer focus/value creation, JIT/flow kaizen, Jidoka/process kaizen, people involvement/integration (internal and external), and standardization and stability foundations.

The TPS house seeks to improve the stability of the manufacturing systems and the company's competitive advantage through satisfying customers. The foundation consists of stability and standardization. Stability allows the pillars (JIT and Jidoka) to be built,⁵¹ while

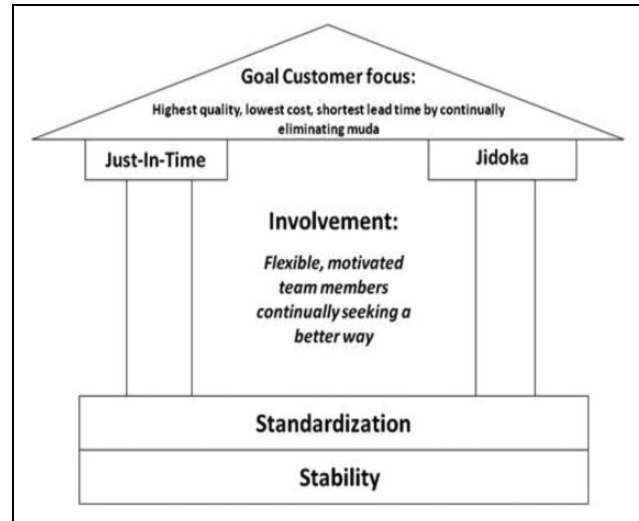


Figure 1. TPS house adopted from Dennis.⁶¹ TPS: Toyota Production System.

standardization enables predictable and stable results. Veech⁶² refers to the Jidoka and JIT pillars as the stop and go columns, respectively. This is because JIT allows the system to flow with minimum inventory, and Jidoka enables the system to stop when any abnormality has been discovered. Jidoka also reduces quality defects thus enabling a complete working system.⁶³ People integration forms the heart of the house and the workforce must be flexible and continually seek for improvement. The roof of the house gives the ultimate goal of LM which is achieving the shortest lead time, lowest cost and best quality.

Measurement models found in literature and practice

The Lean models have focused on either lumping a number of Lean techniques into the same aggregate constructs or applying them individually. When lumped together, they are referred to as bundles, constructs, factors, latent structures and dimensions.^{52,55,64,65} When used individually, they are referred to as tools, practices, techniques, strategies, methods and elements.^{63,66–68} The massive proliferation of Lean models has made the navigation of this domain quite difficult. Many authors have attempted to create models out of this massive pandemonium, but their structures are principally different from one another. It is, therefore, difficult to simply adopt a model from the literature as the acceptable Lean structural model since diverse models have been built by authors. This research will consider the use of Lean bundles in developing a structural equation model.

Overview of structural equation modelling (SEM). SEM can be defined as a technique that allows models of linear relationships to be specified and estimated.⁶⁹ The two parts for SEM models are the measurement component and structural component. The structural model shows the casual

connection between latent variables.⁷⁰ The measurement model is composed of latent variable and their indicator variables. SEM allows researchers to use latent variables to perform path analytic modelling⁷¹ and can validate relationships between measured variables and latent variables.

SEM has been named the second generation of multivariate analysis tools.⁷² It allows confirmatory and exploratory modelling to be performed. SEM gives a set of relationships that are reliable and valid providing a comprehensive explanation of the real scenario⁵⁹; hence, it is well suited for both theory confirmation and theory development. The hypothesis of the model constructed can be assessed against empirical data to show how well it fits the data. To perform SEM analysis, the researcher starts by formulating a theoretical model followed by model specification, parameter specification and fit evaluation.⁷³

The proposed structural model of LM implementation

SEM has been found to be well suited for addressing numerous problems in LM research. It is one of the most preferred methods used for data analysis by operations researchers.⁷⁴ Chin and Newsted⁷⁵ cited that the major benefit of using SEM is its flexibility that allows researchers to test relationships among multiple independent and dependent variables. SEM also allows correlation among measurement errors and test theoretical and measurement assumption against empirical data. It has also been shown that SEM allows a single analysis to estimate multiple and interrelated dependent variables.⁵⁹ A complex system can also be studied allowing casual relationships among latent variables to be explored. This study generally seeks a recursive model.

This section presents the latent variables and hypothesize relationships between them. The TPS house contains constructs, namely stability and standardization, JIT, People integration and Jidoka. Generally, the study seeks to solve a recursive model. The success of LM relies on worker involvement, empowerment and team effort, which are all HRM practices. People integration incorporates a system created to empower employees to continuously improve organizational tasks so as to enhance the efficiency and effectiveness of the company. Employees are responsible for performing the work and implementing changes caused by LM.⁷⁶ They also manage their own processes and solve problems as they arise in the system. Studies by Fullerton et al.⁵⁴ and Dal Pont et al.⁵² showed that the workforce that is flexible and works in teams make a great commitment to JIT and thus, People integration affects JIT. HRM practices such as employee retention, staffing, compensation, training and development also enhance a defect-free process. Researchers such as Dal Pont et al.,⁵² Chandler and McEvoy⁷⁷ and Yang⁷⁸ found a direct and positive impact of HRM on TQM. It is therefore hypothesized that:

H1: People integration dimension is positively related to JIT.

H2: People integration has a positive impact on Jidoka.

H3: People integration is positively correlated to stability and standardization.

Stability and standardization can be defined as the state of the system being able to consistently provide items uniformly with little variations such as demand fluctuation, machine breakdown, human failure and balancing product varieties. Stability and standardization help to reduce interrupted flows because orders are received on time, machines are operated as planned and work standards are followed. The major aim of standardization is to create standards in work methods and processes.⁷⁹ It is also easier to assess the source of the problem when the processes are standardized. The level of LM success will be reduced when stability is not implemented.⁸⁰ Stability and standardization also allow processes to be done in the correct way each time thus ensuring quality products and services are produced. Therefore, the following hypotheses are proposed:

H4: Stability and standardization is positively related to JIT.

H5: Stability and standardization is positively related to Jidoka.

A study by Flynn et al.⁸¹ asserted that JIT performance increased using quality management practices. Similarly, Kannan and Tan⁸² showed that TQM practices had a strong relationship with JIT. Other research studies have also explored the effect of JIT and TQM on firm performance. Shah and Ward,⁸³ Chenhall,⁸⁴ Talib et al.,⁸⁵ Mann and Kehoe,⁸⁶ Sadikoglu and Olcay⁸⁷ and Fullerton et al.⁵⁴ showed that higher financial returns were obtained when a company invests in quality practices. Rahman et al.⁵⁸ showed that JIT and flow had a positive relationship with operational performance in small and medium enterprises and large enterprise companies in Thai. Callen et al.⁸⁸ studied Canadian companies and found that implementation of JIT led to lower variable costs, higher contribution margins and profit. Fullerton et al.⁵⁴ also state that Kanban and JIT purchasing results in increased marginal returns. Therefore, it is hypothesized that:

H6: Jidoka has a positive relationship with JIT.

H7: JIT is positively related to operational performance.

H8: Jidoka positively influences operational performance.

Figure 2 shows the LM structural model developed for evaluating the impact of Lean tools on operational performance.

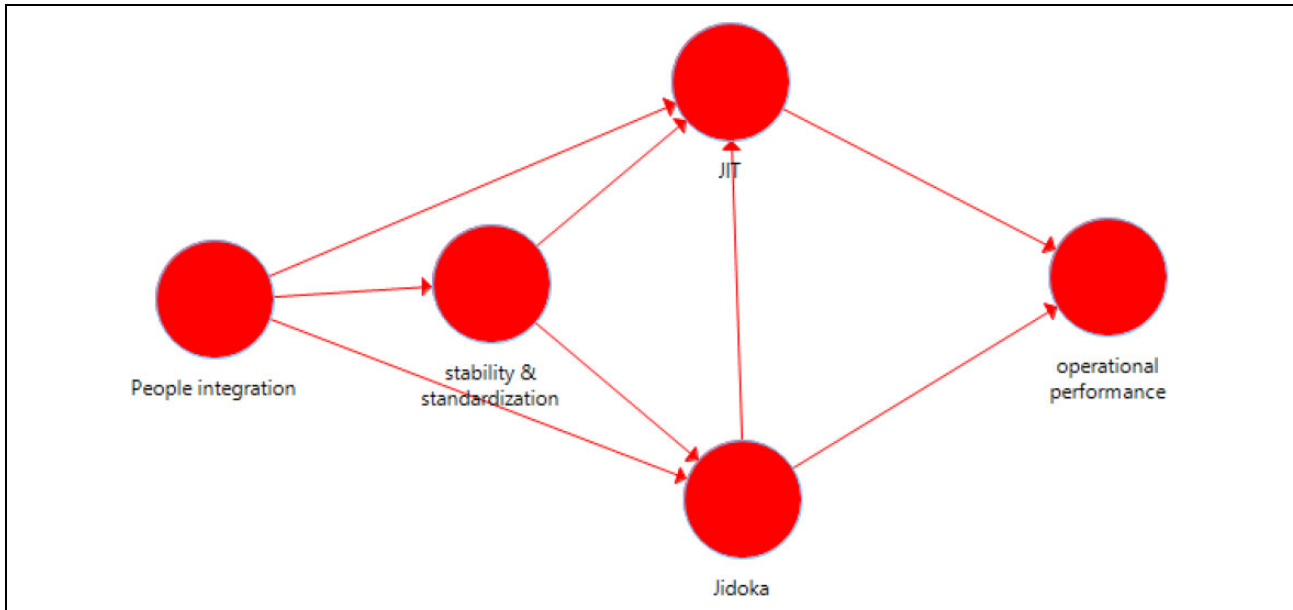


Figure 2. Lean measurement structural model.

Research methodology

Instrument development

A questionnaire was developed for the model to measure the impact of LM constructs on operational performance. The questionnaire was divided into three sections: Section A contained information about the company. Section B was dedicated to questions on the level of adoption of LM constructs in companies. Section C was comprised of questions about the operational performance of the company. The questions were adopted from authors such as Abdallah and Phan,⁸⁹ Cua et al.,⁹⁰ Khanchanapong et al.²² and Shah and Ward,⁹¹ Dal Pont et al.,⁵² Wickramasinghe and Wickramasinghe,⁹² Dora et al.⁹³ and Garza-Reyes et al.¹⁹ These were measured on a 7-point quantitative scale, with 1 = *strongly disagree*; 2 = *disagree*; 3 = *disagree somewhat*; 4 = *undecided*; 5 = *agree somewhat*; 6 = *agree* and 7 = *strongly agree*. Operational performance was evaluated using items from Belekoukias et al.⁶³ and Shah and Ward⁸³ which were speed, flexibility and dependability. A 5-point scale was used for measuring operational performance, with 1 representing *declined more than 20%*; 2, *declined 1–20%*; 3, *stayed the same*; 4, *increased 1–20%* and 5, *increased more than 20%*. A pilot study was done to receive ideas from industry practitioners and academics about the questionnaire. Some items were discarded, modified or added to ensure reliability and construct validity. The items questionnaire developed is shown in Appendix 1.

Data collection procedure

Six hundred manufacturing organizations registered with the Confederation of Zimbabwean Industries⁹ were contacted to respond to the questionnaire. These companies

Table 2. Industry distributions.

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

fell under the plastics, agrochemicals, pharmaceutical, motor, food, steel, beverage, timber, garment, battery, electrical and electronics manufacturing companies. Three hundred questionnaires were distributed by hand, while other companies were reached by sending a Google form link via email. A total of 214 useful and complete responses were received resulting in a response rate of 35.6%. Table 2 lists the distributions of the responses across different industries obtained by the researchers.

Data analysis

Data analysis was done using Statistical Package for Social Sciences (SPSS) version 25 and SmartPLS 3. SPSS was used for exploratory factor analysis. SmartPLS 3 was used for assessing the measurement and structural model. Assessing the measurement model involves evaluating the relationship between LM constructs and their measurement

Table 3. Construct reliability and validity.

	Cronbach's α	rho_A	Composite reliability	Average variance extracted (AVE)
JIT	0.799	0.801	0.869	0.624
Jidoka	0.877	0.880	0.916	0.731
Operational performance	0.651	0.652	0.811	0.589
People integration	0.804	0.808	0.872	0.630
Stability and standardization	0.724	0.724	0.844	0.644

JIT: just in time.

Table 4. Fornell–Larcker criterion.

	JIT	Jidoka	Operational performance	People integration	Stability and standardization
JIT	0.771				
Jidoka	0.674	0.855			
Operational performance	0.392	0.382	0.768		
People integration	0.514	0.570	0.278	0.794	
Stability and standardization	0.574	0.614	0.334	0.501	0.802

JIT: just in time.

items, while assessing the structural model determines the correlation between the constructs.⁹⁴

Assessing the measurement model

Adopting the measurement items from previously published articles ensured high reliability of the questionnaire (Godinho Filho et al.,²⁰ Dora et al.⁹⁵ and Shah and Ward⁹¹). A total of 49 items were initially selected for measuring the five LM constructs. Exploratory factor analysis was used to minimize the number of items for individual constructs and to assess construct validity, thus ensuring a parsimonious representation for the five latent factors: JIT, Jidoka, People integration, stability and standardization and operational performance. Nineteen items were finally selected for the constructs after the preliminary analysis. A Kaiser–Meyer–Olkin value of 0.866 was obtained indicating that the sample size of 214 was adequate. The Bartlett's test of sphericity was significant with a p value <0.001 . Using the factors with the eigenvalue >1 and the shape of the Scree plot to determine the underlying constructs, the analysis confirmed the five-factor structure with a variance of 61.770% explainable by the model.

Cronbach's α was used for assessing internal reliability and consistency of the constructs. The results for each construct were in the range of 0.651–0.877 and were regarded as acceptable to high (Bevilacqua et al.,⁹⁶ Götz et al.⁹⁷ and Malhotra.⁹⁸ The average variance extracted (AVE) should be >0.5 to ensure construct validity (Silva et al.⁹⁹ and Avkiran¹⁰⁰). The AVE values were >0.5 , denoting that the factors constituted more than half of the variance explained by the model. The values for composite reliability shown in Table 3 were all >0.7 , indicating that the constructs had high internal consistency.

The results of the Fornell–Larcker criterion shown in Table 4 indicated that measurement items were highly loaded to their respective constructs thus supporting discriminant validity. Moori et al.¹⁰¹ state that discriminant validity is ensured when the AVE values are greater than the correlation among the factors.

Assessing the structural model

The R^2 values for the endogenous variables ranged from 0.317 to 0.680.¹⁰² state that when the R^2 values are equal to 0.26 they are considered substantial, 0.13 moderate and weak if the values are 0.02. Moori et al.¹⁰¹ also cite Cohen¹⁰² who states that for behavioural studies, 0.26 is considered a large effect. The coefficient of determination (R^2) for Jidoka, JIT, operational performance and stability and standardization were 64.3%, 68.0%, 31.7% and 42.8%, respectively. This showed that JIT, Jidoka and People integration had a good influence on operational performance. Figure 3 illustrates the SEM model showing the structural linkage between People integration, stability and standardization, JIT, Jidoka and operational performance.

People integration had a strong relationship with stability and standardization than with JIT and Jidoka as shown by their structural coefficients which were 0.655, 0.249 and 0.301, respectively. Stability and standardization had a strong relationship with Jidoka than with JIT. The Jidoka construct had a strong relationship with JIT, and this is shown by a high path coefficient of 0.517. The results for total effects showed that people integration has a strong total effect on operational performance (0.374), followed by JIT (0.358), stability and standardization (0.333) and Jidoka (0.223). The results also support other findings from authors.^{45,52,53,56–58,63,68,92,103–105}

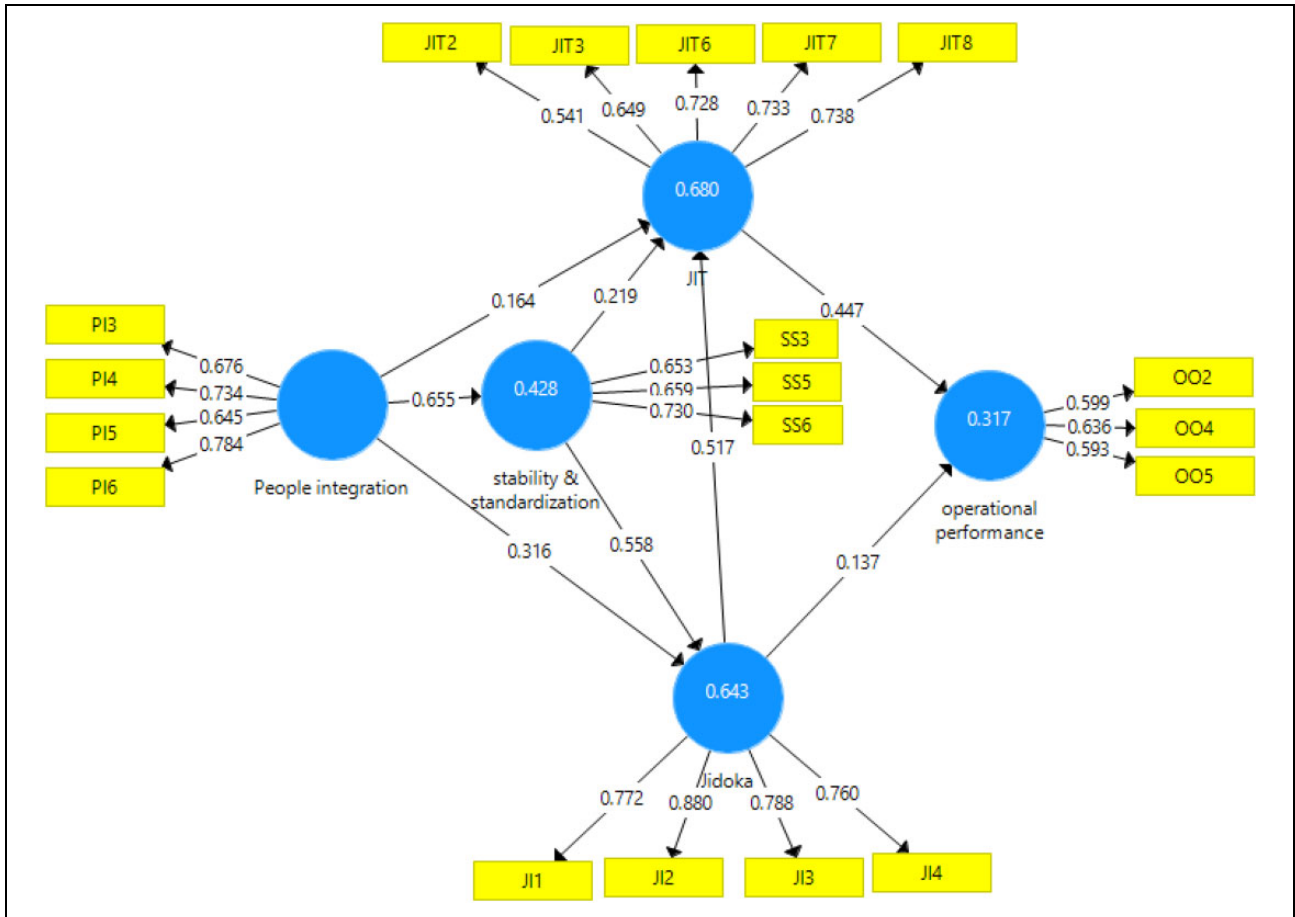


Figure 3. SEM model. SEM: structural equation modelling.

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

	Original sample (O)	Standard deviation	T-statistics	p Values	Hypothesis	Decision
JIT → operational performance	0.248	0.101	2.468	0.014	H6	Supported
Jidoka → operational performance	0.215	0.109	1.974	0.048	H7	Supported
People integration → JIT	0.514	0.062	8.321	0.000	H1	Supported
People integration → Jidoka	0.570	0.054	10.640	0.000	H2	Supported
People integration → stability and standardization	0.501	0.058	8.687	0.000	H3	Supported
Stability and standardization → JIT	0.423	0.068	6.257	0.000	H4	Supported
Stability and standardization → Jidoka	0.439	0.063	6.922	0.000	H5	Supported

JIT: just in time.

The *t*-statistic and the *p* values in Table 5 fail to reject any of the hypotheses. This indicates that all the hypotheses were supported, and the model could be used for evaluating the impact of implementing LM on operational performance.

Discussion

The main objective of the study was to evaluate the impact of implementing LM tools such as People integration,

stability and standardization, JIT and Jidoka on operational performance in companies across Zimbabwe. The results supported all the hypotheses that were developed showing that the LM tools can enhance operational performance. Several studies conducted in developing countries have shown that LM tools adoption results in the improvement of operational performance. Researchers such as Eswaramoorthi et al.,¹⁵ Khanchanapong et al.,²² Nawanir et al.²⁴ and Marodin et al.⁵³ have shown that the adoption of LM has given manufacturing companies a competitive edge

through yielding positive results. Shrafat and Ismail¹⁰⁶ concluded that limited research has been conducted on LM in developing countries. Marodin et al.⁵³ stated that developed countries often face difficulties to become Lean due to the changes in the market orientation. This study therefore, adds to the current discussion of the impact of LM in developing economies.

It has been said that people are the backbone for successful implementation of LM.⁶¹ The results indicated that there was a need to educate employees on the importance of implementing LM since every system is managed and driven by people. This suggests that managers should invest in training employees so that they can drive the LM implementation program. People integration had a positive relationship with JIT and Jidoka indicating that workers strived to enhance the flow of materials and quality of items produced. Stability and standardization also had a huge impact on JIT than Jidoka. A stable and standardized system increases the speed of manufacturing because the flow of materials is less interrupted across the production floor. Standardization also helps to set quality criteria for different operations along the value chain. Jidoka and JIT had positive relationships with operational performance. This is because when high quality materials and products flow through the system, operational performance is enhanced. The performance improvement variables that were greatly influenced were speed, flexibility and dependability. The path coefficients on operational performance showed that flexibility had the greatest contribution to LM, followed by speed and dependability.

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

Conclusion

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

performance construct was influenced by the four constructs in the TPS house.

People integration acted as a prerequisite upon which other constructs were built. People have been described by Dennis¹⁰⁷ as the wind that drives the Lean sail. People management is important for ensuring the pillars (flow and Jidoka) and foundation (stability and standardization) of LM are achievable. The purpose of stability and standardization is to create an environment in which LM can be applied.¹⁰⁷ When variability is too high in the Lean system, getting results from implementing Lean becomes difficult. Hence, the extent to which the various functional areas, as well as products of the system are standardized leads to successful implementation of LM.

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


Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship and/or publication of this article: This study is part of the research being conducted towards achieving a PhD. The authors would like acknowledge the support received from Organization for Women in Science for the Developing World (OWSD) and Swedish International Development Cooperation Agency (SIDA).

ORCID iD

Catherine Maware  <https://orcid.org/0000-0002-9991-1511>

References

1. Delago LC, Machado ME, de Brito FO, et al. Learning lean philosophy through 3D game-based simulation. In: *Winter Simulation Conference (WSC)*, VA, USA, 11–14 December 2016, pp. 3385–3392. IEEE.
2. Kovacevic M, Jovicic M, Djapan M, et al. Lean thinking in healthcare: review of implementation results. *Int J Qual Res* 2016; 10: 219–229.

3. Miller R and Chalapati N. Utilizing lean tools to improve value and reduce outpatient wait times in an Indian hospital. *Leadership Health Ser* 2015; 28: 57–69.
4. Andersson R, Hilletoft P and Hilmola OP. Lean implementation in the geriatric care sector in Sweden. *Int J Six Sigma Compet Adv* 2015; 9: 56–71.
5. Rauch E, Damian A, Holzner P, et al. Lean hospitality – application of lean management methods in the hotel sector. *Proc CIRP* 2016; 41: 614–619.
6. Vlachos I and Bogdanovic A. Lean thinking in the European hotel industry. *Tourism Manage* 2013; 36: 354–363.
7. Villarreal B, Garza-Reyes JA, Kumar V, et al. Improving road transport operations through lean thinking: a case study. *Int J Logist Res Appl* 2017; 20: 163–180.
8. Mazhindu K. Propositions for Zimbabwe businesses in managing costs in the multi-currency era. *The Dyke* 2014; 8: 142–155.
9. CZI. *Lean manufacturing, more than just waste elimination*. Harare: Confederation of Zimbabwean Industries, 2016.
10. RBZ. *Quarterly economic review September 2017 reserve bank of Zimbabwe*. 2017, pp. 1–64.
11. Worldbank. *Zimbabwe*. 2018. pubdocs.worldbank.org/en/750841492188177908/mpo-zwe.pdf (accessed 18 September 2018).
12. Bonga WG. Trade balance analysis in Zimbabwe: import and export examination using vector auto-regression model. *MPRA*, 2018. Paper number 89002, pp. 1–14.
13. Goriwondo WM, Mhlanga S and Marecha A. Use of the value stream mapping tool for waste reduction in manufacturing. Case study for bread manufacturing in Zimbabwe. In: *Proceedings of the 2011 International Conference on Industrial Engineering and Operations Management*, Kuala Lumpur, Malaysia, 22–24 January 2011, pp. 236–241.
14. Prasad S, Khanduja D and Sharma SK. An empirical study on applicability of lean and green practices in the foundry industry. *J Manuf Technol Manag* 2016; 27: 408–426.
15. Eswaramoorthi M, Kathiresan GR, Prasad PSS, et al. A survey on lean practices in Indian machine tool industries. *Int J Adv Manuf Technol* 2010; 52: 1091–1101.
16. Jadhav JR, Mantha SS and Rane SB. Roadmap for lean implementation in Indian automotive component manufacturing industry: comparative study of UNIDO model and ISM model. *J Ind Eng Int* 2014; 11: 179–198.
17. Al-Najem M, Dhakal H, Labib A, et al. Lean readiness level within Kuwaiti manufacturing industries. *Int J Lean Six Sigma* 2013; 4: 280–320.
18. Ansah RH and Sorooshian S. Effect of lean tools to control external environment risks of construction projects. *Sustain Cities Soc* 2017; 32: 348–356.
19. Garza-Reyes JA, Ates EM and Kumar V. Measuring lean readiness through the understanding of quality practices in the Turkish automotive suppliers industry. *Int J Product Perform Manage* 2015; 64: 1092–1112.
20. Godinho Filho M, Ganga GMD and Gunasekaran A. Lean manufacturing in Brazilian small and medium enterprises: implementation and effect on performance. *Int J Prod Res* 2016; 54: 7523–7545.
21. Tortorella GL, Vergara LGL and Ferreira EP. Lean manufacturing implementation: an assessment method with regards to socio-technical and ergonomics practices adoption. *Int J Adv Manuf Technol* 2016; 89: 3407–3418.
22. Khanchanapong T, Prajogo D, Sohal AS, et al. The unique and complementary effects of manufacturing technologies and lean practices on manufacturing operational performance. *Int J Prod Econ* 2014; 153: 191–203.
23. Lindskog P, Hemphälä J and Eriksson A. Lean tools promoting individual innovation in healthcare. *Creat Innov Manag* 2017; 26: 175–188.
24. Nawanir G, Kong Teong L and Norezam Othman S. Impact of lean practices on operations performance and business performance. *J Manuf Technol Manag* 2013; 24: 1019–1050.
25. Nawanir G, Lim KT and Othman SN. Lean manufacturing practices in Indonesian manufacturing firms. *Int J Lean Six Sigma* 2016; 7: 149–170.
26. Domingo TM. *The adoption of lean techniques to optimise the on-shelf availability of products and drive business performance in the food industry: a South African manufacturing and retail case study*. Cape Town: University of Cape Town, 2013.
27. Kojima S and Kaplinsky R. The use of a lean production index in explaining the transition to global competitiveness: the auto components sector in South Africa. *Technovation* 2004; 24: 199–206.
28. Rathilall R and Singh S. A lean six sigma framework to enhance the competitiveness in selected automotive component manufacturing organisations. *South African J Econ Manage Sci* 2018; 21: a1852.
29. Mapfaira H, Mutingi M, Lefatshe K, et al. Lean manufacturing adoption and implementation barriers in Botswana manufacturing companies. <http://ujcontent.uj.ac.za> (2014, accessed 14 August 2018).
30. Isack HD, Mutingi M, Kandjeke H, et al. Exploring the adoption of lean principles in medical laboratory industry: empirical evidences from Namibia. *Int J Lean Six Sigma* 2018; 9: 133–155.
31. Mutingi M, Isack HD, Musiyarira H, et al. The impact of lean in medical laboratory industry: empirical studies in Namibia. In: *Proceedings of the World Congress on Engineering and Computer Science*, 25–27 October 2017. San Francisco: USA.
32. Ndinamwene F, Mutingi M, Mbohwa C, et al. Towards improving public procurement process through lean principles: a case of the Agricultural Engineering Division, Ministry of Agriculture, Water and Forestry, Namibia. In: *2016 IEEE international conference on Industrial Engineering and Engineering Management (IEEM)*, Bali, Indonesia, 4–7 December 2016, pp. 1841–1845. IEEE.
33. Chanda MD. The study of the relationship between Kaizen practices and operations’ performance improvement in Zambian manufacturing companies. 25–27 October 2017. San Francisco: USA.

34. Mathew Saili ME. Quality management practices, focusing on the manufacturing industry based in Lusaka, Zambia. In: *Proceedings of the Engineering Institution of Zambia 2017 Symposium*, Avani Victoria Falls Resort, 7–8 April 2017, pp. 307–319. Livingstone, Zambia.
35. Kasongo R. Strategic lean thinking and value management for gravel roads in Zambia. 2015. Munich, GRIN Verlag. <https://www.grin.com/document/310467> (accessed 1 August 2018).
36. Goriwondo WM and Maunga N. Lean six sigma application for sustainable production: a case study for margarine production in Zimbabwe. *International Journal of Innovative Technology and Exploring Engineering* 2012; 1: 87–96.
37. Muvunzi R, Maware C, Chinguwa S, et al. Application of lean value stream mapping to reduce waste and improve productivity: a case of tile manufacturing company in Zimbabwe. *Int J Appl Innovat Eng Manage (IJAIEM)* 2013; 2: 214–219.
38. Nyemba WR and Mbohwa C. Process mapping and optimization of the process flows of a furniture manufacturing company in Zimbabwe using machine distance matrices. *Procedia Manuf* 2017; 8: 447–454.
39. Dzanya M and Mukada C. Value stream mapping in glide manufacturing: a case study of Insti-Tools in Zimbabwe. *Int J Sci Technol Soc* 2015; 3: 6–10.
40. Madanhire I, Kagande L and Chidziva C. Application of just in time (JIT) manufacturing concept in aluminium foundry industry in Zimbabwe. *Int J Sci Res (IJSR)* 2013; 2: 334–347.
41. Goriwondo WM, Van der Merwe A and Makura T. Enhancing lean manufacturing using the value stream mapping tool in pharmaceutical operations: a case study of a pharmaceutical manufacturing company in Zimbabwe. <http://ir.nust.ac.zw> (2013, accessed 5 August 2018).
42. Gudukeya LK and Mbohwa C. Success factors for manufacturing and service industries in Zimbabwe. In: *International Conference on Management Engineering*, Cape Town, South Africa, 20–21 November, 2013.
43. Karombo MR. An investigation into the implementation of lean six sigma as a tool to enhance organisational performance and competitiveness within the manufacturing sector: a case of Chloride Zimbabwe (2010–2013), Unpublished Master's Thesis, University of Zimbabwe, 2014.
44. Chisosa DF and Chipambwa W. An Exploration of how work study techniques can optimize production in Zimbabwe's clothing industry. *J Text Apparel, Technol Manage* 2018; 10: 1–11.
45. Furlan A, Vinelli A and Dal Pont G. Complementarity and lean manufacturing bundles: an empirical analysis. *Int J Oper Prod Man* 2011; 31: 835–850.
46. Schroeder RG and Flynn BB. *High performance manufacturing: global perspectives*. Hoboken: John Wiley & Sons, 2002.
47. Womack JP, Jones DT and Roos D. *Machine that changed the world*. New York: Simon and Schuster, 1990.
48. Ohno T. *Toyota production system: beyond large-scale production*. Boca Raton: CRC Press, 1988.
49. Fujimoto T. *The evolution of a manufacturing system at Toyota*. Oxford: Oxford University Press, 1999.
50. Holweg M. The genealogy of lean production. *J Oper Manage* 2007; 25: 420–437.
51. Liker JK and Morgan JM. The Toyota way in services: the case of lean product development. *Acad Manage Perspect* 2006; 20: 5–20.
52. Dal Pont G, Furlan A and Vinelli A. Interrelationships among lean bundles and their effects on operational performance. *Oper Manage Res* 2008; 1: 150–158.
53. Marodin GA, Frank AG, Tortorella GL, et al. Lean production and operational performance in the Brazilian automotive supply chain. *Total Qual Manage Bus* 2019; 30: 370–385.
54. Fullerton RR, McWatters CS and Fawson C. An examination of the relationships between JIT and financial performance. *J Oper Manag* 2003; 21: 383–404.
55. Al-Tahat MD and Jalham IS. A structural equation model and a statistical investigation of lean-based quality and productivity improvement. *J Intell Manuf* 2013; 26: 571–583.
56. Agus A, Antony J and Shukri Hajinoor M. Lean production supply chain management as driver towards enhancing product quality and business performance. *Int J Qual Reliabil Manag* 2012; 29: 92–121.
57. Hofer C, Eroglu C and Rossiter Hofer A. The effect of lean production on financial performance: the mediating role of inventory leanness. *Int J Prod Econ* 2012; 138: 242–253.
58. Rahman S, Laosirihongthong T and Sohal AS. Impact of lean strategy on operational performance: a study of Thai manufacturing companies. *J Manuf Technol Manag* 2010; 21: 839–852.
59. Vinodh S and Joy D. Structural equation modelling of lean manufacturing practices. *Int J Prod Res* 2012; 50: 1598–1607.
60. Maware C and Adetunji O. Lean-impact-analysis-assessment-models-development-of-a-lean-measurement-structural-model.pdf. *Int J Mech Aeros Indust Mech Manuf Eng* 2018; 12: 554–561.
61. Dennis P. *Lean production simplified*. New York: CRC Press, 2007.
62. Veech DS. *A person-centered approach to sustaining a lean environment-job design for self-efficacy*. Washington: Office of the Under Secretary of Defense for Acquisition Technology And Logistics, 2004.
63. Belekoukias I, Garza-Reyes JA and Kumar V. The impact of lean methods and tools on the operational performance of manufacturing organisations. *Int J Prod Res* 2014; 52: 5346–5366.
64. Bevilacqua M, Ciarapica FE and De Sanctis I. Relationships between Italian companies' operational characteristics and business growth in high and low lean performers. *J Manuf Technol Manag* 2017; 28: 250–274.
65. Zhou B. Lean principles, practices, and impacts: a study on small and medium-sized enterprises (SMEs). *Ann Oper Res* 2012; 241: 457–474.

66. McLeod AA, Stephens MP and McWilliams DL. Empirical modeling of lean adoption in small to medium size manufacturers. *J Adv Manuf Syst* 2016; 15: 173–188.
67. Fullerton RR, Kennedy FA and Widener SK. Lean manufacturing and firm performance: the incremental contribution of lean management accounting practices. *J Oper Manag* 2014; 32: 414–428.
68. Fullerton RR and Wempe WF. Lean manufacturing, non-financial performance measures, and financial performance. *Int J Oper Prod Man* 2009; 29: 214–240.
69. MacCallum RC and Austin JT. Applications of structural equation modeling in psychological research. *Annu Rev Psychol* 2000; 51: 201–226.
70. Blunch N. *Introduction to structural equation modeling using IBM SPSS statistics and AMOS*. Thousand Oaks: Sage, 2012.
71. Chin WW. The partial least squares approach to structural equation modeling. *Modern Method Bus Res* 1998; 295: 295–336.
72. Fornell C, Lorange P and Roos J. The cooperative venture formation process: a latent variable structural modeling approach. *Manag Sci* 1990; 36: 1246–1255.
73. Swanson RA and Holton EF. *Research in organizations: Foundations and methods in inquiry*. Oakland: Berrett-Koehler, 2005.
74. Shah R and Goldstein SM. Use of structural equation modeling in operations management research: looking back and forward. *J Oper Manag* 2006; 24: 148–169.
75. Chin WW and Newsted PR. Structural equation modeling analysis with small samples using partial least squares. *Stat Strateg Small Sample Res* 1999; 1: 307–341.
76. Weber W. *Betriebliche fortbildung: Empirische analyse betrieblicher und individueller entscheidungen über fortbildung*. Stuttgart: Poeschel, 1985.
77. Chandler GN and McEvoy GM. Human resource management, TQM, and firm performance in small and medium-size enterprises. *Entrep Theory Pract* 2000; 25: 43–58.
78. Yang CC. The impact of human resource management practices on the implementation of total quality management: an empirical study on high-tech firms. *TQM Magaz* 2006; 18: 162–173.
79. Marksberry P. *The modern theory of the Toyota production system: a systems inquiry of the world's most emulated and profitable management system*. Boca Raton: CRC Press, 2012.
80. Sayer NJ and Williams B. *Lean for dummies*. Hoboken: Wiley, 2011.
81. Flynn BB, Sakakibara S and Schroeder RG. Relationship between JIT and TQM: practices and performance. *Acad Manage J* 1995; 38: 1325–1360.
82. Kannan VR and Tan KC. Just in time, total quality management, and supply chain management: understanding their linkages and impact on business performance. *Omega* 2005; 33: 153–162.
83. Shah R and Ward PT. Lean manufacturing: context, practice bundles, and performance. *J Oper Manag* 2003; 21: 129–149.
84. Chenhall RH. Reliance on manufacturing performance measures, total quality management and organizational performance. *Manage Account Res* 1997; 8: 187–206.
85. Talib F, Rahman Z and Qureshi M. The relationship between total quality management and quality performance in the service industry: a theoretical model. *Int J Bus Manage Soc Sci (IJBMSS), MultiCraft* 2010; 1(1): 113–128.
86. Mann R and Kehoe D. An evaluation of the effects of quality improvement activities on business performance. *Int J Quality Reliab Manage* 1994; 11: 29–44.
87. Sadikoglu E and Olcay H. The effects of total quality management practices on performance and the reasons of and the barriers to TQM practices in Turkey. *Adv Dec Sci* 2014; 2014: 1–17.
88. Callen JL, Fader C and Krinsky I. Just-in-time: a cross-sectional plant analysis. *Int J Prod Econ* 2000; 63: 277–301.
89. Abdallah A and Phan C. The relationship between just-in-time production and human resource management, and their impact on competitive performance. *Yokohama Bus Rev* 2007; 28: 27–57.
90. Cua KO, McKone KE and Schroeder RG. Relationships between implementation of TQM, JIT, and TPM and manufacturing performance. *J Oper Manag* 2001; 19: 675–694.
91. Shah R and Ward PT. Defining and developing measures of lean production. *J Oper Manag* 2007; 25: 785–805.
92. Wickramasinghe GLD and Wickramasinghe V. Implementation of lean production practices and manufacturing performance: the role of lean duration. *J Manuf Technol Manage* 2017; 28: 531–549. DOI: 10.1108/jmtm-08-2016-0112.
93. Dora M, Van Goubergen D, Kumar M, et al. Application of lean practices in small and medium-sized food enterprises. *Brit Food J* 2014; 116: 125–141.
94. Hair JF Jr, Hult GTM, Ringle C, et al. *A primer on partial least squares structural equation modeling (PLS-SEM)*. Thousand Oaks: Sage, 2016.
95. Dora M, Kumar M and Gellynck X. Determinants and barriers to lean implementation in food-processing SMEs – a multiple case analysis. *Prod Plan Control* 2015; 27: 1–23.
96. Bevilacqua M, Ciarapica FE and De Sanctis I. Lean practices implementation and their relationships with operational responsiveness and company performance: an Italian study. *Int J Prod Res* 2016; 55: 769–794.
97. Götz O, Liehr-Gobbers K and Krafft M. *Evaluation of structural equation models using the partial least squares (PLS) approach. Handbook of partial least squares*. Berlin: Springer, 2010, pp. 691–711.
98. Malhotra NK. *Review of marketing research*. Bingley: Emerald Group, 2007, pp. 474–488.
99. Silva HRdS, Areco KCN, BandieraPaiva P, et al. Factorial and construct validity of Portuguese version (Brazil) Bergen Facebook Addiction Scale. *Jornal Brasileiro de Psiquiatria* 2018; 67: 110–117.
100. Avkiran NK. *Rise of the partial least squares structural equation modeling: an application in banking. Partial Least*

Squares Structural Equation Modeling. Berlin: Springer, 2018, pp. 1–29.

101. Moori RG, Pescarmona A and Kimura H. Lean manufacturing and business performance in Brazilian firms. *J Operat Suppl Chain Manage* 2013; 6: 91–105.
102. Cohen J. *Statistical power analysis for the behavioral sciences*, 2nd ed. Hillsdale: Erlbaum, 1988.
103. Hong P, Ga Yang M and Dobrzykowski D. Strategic customer service orientation, lean manufacturing practices and performance outcomes: an empirical study. *J Serv Manage* 2014; 25: 699–723.
104. Yang MG, Hong P and Modi SB. Impact of lean manufacturing and environmental management on business performance: an empirical study of manufacturing firms. *Int J Prod Econ* 2011; 129: 251–261.
105. Jayaram J, Vickery S and Droge C. Relationship building, lean strategy and firm performance: an exploratory study in the automotive supplier industry. *Int J Prod Res* 2008; 46: 5633–5649.
106. Shrafat FD and Ismail M. Structural equation modeling of lean manufacturing practices in a developing country context. *J Manuf Technol Manage* 2018.
107. Dennis P. *Lean production simplified: a plain-language guide to the world's most powerful production system*. Boca Raton: CRC Press, 2016.

Appendix I

Survey questionnaire items

Section A: Respondent demographics.

1. What is the type of industry that your organization falls under?
2. What type of process do you use in your organization?
3. How many years has your organization been in business?
4. How many years has your organization implemented lean manufacturing (LM)?

Section B: Impact of lean constructs on operational performance. Show the level of agreement or disagreement with the statement given that describes the level of adoption of LM practices in your organization, 1–strongly disagree; 2–disagree; 3–disagree somewhat; 4–undecided; 5–agree somewhat; 6–agree and 7–strongly agree.

1. The daily production schedule is met every day.
2. The daily production schedule is completed on time.
3. The customers receive just-in-time deliveries from us.
4. The layout of our shop floor facilitates low inventories and fast throughput.
5. The suppliers deliver to us on a just-in-time basis.
6. The employees are encouraged to make suggestions for improving performance at the plant.
7. The employees receive training to perform multiple tasks.
8. The employees are cross-trained to fill in for others, if necessary.
9. During problem solving sessions, an effort is made to get all team members' opinions and ideas before making a decision.
10. A large percent of the equipment or processes on the shop floor are currently under statistical quality control.
11. There is extensive use of statistical techniques to reduce variance in processes.
12. The control charts are used to determine whether the manufacturing processes is in control.
13. The processes in the plant are designed to be "foolproof".
14. The visual controls placed on the boards where workers can easily identify them.
15. There are clear, standardized and documented process instructions which are well understood by the employees.
16. The machine uptime is adequate to produce customer demand.

Section C: Operational/organizational performance. How would you measure the performance of your organization since you implemented LM? 1–declined more than 20%; 2–declined 1–20%; 3–stayed the same; 4–increased 1–20% and 5–increased more than 20%.

1. Speed (rate of response to customer query, frequency of delivery and adherence to cycle time)
2. Flexibility (ability to do the following; change production schedules, modify part, build the system and expand it and introduce new products)
3. Dependability (adherence to schedule, number of orders delivered on time)