A framework for the integration of lean, green and sustainability practices for operation performance in South African SMEs

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ABSTRACT
To make small and medium enterprises (SMEs) competitive, they not merely concentrate the results of the operational measures and combine the environmental dimension by adopting lean and green models together. The present literature study proves that lean activities in SMEs have a direct positive effect on green and sustainable practices. However, the combined effect of sustainable, lean, and green has not been investigated empirically. This paper aims to identify the relationship between lean, green, and sustainable practices for environmental development economic efficiency among small and medium-sized enterprises. The structural equation modelling technique was used to examine the direct effect of lean practices on sustainability, with green manufacturing as the mediating variable. The research depends on the collection of data from 210 manufacturing organisations. The result of the study indicates that lean practices directly affect sustainability and confirm that green manufacturing is a significant mediating parameter. These findings will be used to establish a comprehensive model for the sustainable lean, green system to direct small and medium-sized enterprises to achieve sustainable development. The research results can benefit in making the policies for industrial professionals on (SMEs) by focusing on critical issues to help implement and evaluate sustainable, lean, and green practices

1 Introduction
In recent years, many of the world’s leading companies have launched programmes to develop lean production systems. Many have succeeded in improving efficiency, contributing to better quality, profitability, and a better public image (Yadav and Desai 2016; Raval, Kant, and Shankar 2018; Swarnakar and Vinodh 2016; Setijono, Laureani, and Antony 2012). The resulting ‘green’ systems have sometimes led to dramatic reductions in energy consumption, waste generation, and the use of hazardous materials while strengthening the image of businesses as socially responsible organisations (Singh, Brueckner, and Padhy 2015). There is an urgent need to set up regulations related to environmental performance due to the strict implementation of environmental performance regulations due to rising energy prices, pollution, and global warming such as lean and green (Thanki, Govindan, and Thakkar 2016). Lean manufacturing solves problems related to waste reduction by identifying and eliminating non-value-added activities. It is considered one of three strategies to improve organisational performance: efficiency, profitability, and flexibility. (Santos-Vijande, López-Sánchez, and Trespalacios 2012). Green production is an organised, economically, integrated driven method that targets all waste streams related to the design, manufacture, function, and disposal of products and material (Sezen, Cankaya, and Sezen 2013). Today, the concept of sustainability is common and has emerged in all places, including manufacturing. The idea of sustainable production has appeared in the manufacturing industry due to its current practice, which is considered responsible for the present environmental deprivation (Rosen and Kishawy 2012). The definition of sustainable development is the development of meeting present requirements without affecting the ability to satisfy the demands of future generations. It also includes three interdependent but mutually supportive economies, environments, and environments (Khali (2011). Compared with the previous mass production manufacturing paradigm, such as lean and green manufacturing, sustainable manufacturing is the most complex but most challenging manufacturing paradigm (Rosen and Kishawy 2012). Sustainable thinking has been emphasised as a mode of production to integrate economic, environmental, and social aspects. Before this relatively new paradigm, scholars and industry experts strongly demanded the development of sustainable manufacturing performance indicators to monitor actual progress in practice Parris and Kates 2003, Krajnc and Glavić 2003). However, the task of finding a perfect balance in terms of benefits would be vague, confusing and tedious to develop reliable, sustainable manufacturing performance indicators (Fan, Carrell, and Zhang 2010; Amrina and Yusof 2011, December, December)

Many researchers have discussed the lean, green performance (Anvari, Zulkifli, and Yusuff 2013; Segerstedt, Olofsson, and Eriksson 2010; Singh, Brueckner, and Padhy 2015; Wadhwa 2014). For example, some studies have examined the interaction between lean policies and ecological performance. (Rothenberg, Pil, and Maxwell 2001; Yang, Hong,
and Modi 2011). At the same time, some of them have to pay attention to lean and green implementation (Thank et al. 2016, Gandhi, Thanki, and Thakkar 2018). The coordination of lean production and environmental (green) practices can ensure benefits, such as reducing costs, shortening delivery time, improving process and environmental quality, and improving employee morale and commitment (EPA 2007). Wu et al. (2015) proposed that GLS practices positively impact the firm’s performance when practiced individually. In a rapidly changing market environment, challenges from the market, government pressure to decrease the impact on the environment, and consumer attention of environmentally friendly products, companies are pushing to adopt GLS production models (Abreu, Alves, and Moreira 2017; Fercoq, Lamouri, and Carbone 2016).

There are sections in the literature addressing the relationship between lean green sustainable production and efficiency. Also, Garza-Reyes (2015) states that there is limited and uncertain research on GLS practices and organisational performance, and additional research is needed to bridge this gap. Focusing on these research gaps, a proper investigation in manufacturing organisations should be carried out to provide a clear roadmap to implement the GLS sustainable framework for operational performance in SMEs. This study examines the GLS activities in the SME domain and suggests traditional practices. This research is a proprietary study that gives an incentive for organisations to shift from conventional methods to sustainable development through lean, green integration. This study promotes the implementation of GLS practices in the manufacturing industry, which is embodied in achieving the goals set by various organisations and countries to reduce carbon emissions. This research encourages practitioners and industry managers to implement GLS practices and make them more acceptable. The current study offers a GLS integration framework for attaining environmental sustainability and productivity. Hence in this research hypothesis that

H1 Lean manufacturing practices has a positive significance on Green Manufacturing.

H2 Lean Manufacturing practices has a positive significance on Sustainable performance.

H3 Green manufacturing has an indirect relation between lean manufacturing practices and sustainable performance.

The structural equation model (SEM) technique is adopted to examine the relationship between lean, green, sustainable methods to address these research hypotheses. The study results established a combined framework for the sustainable Lean, Green, and sustainable system.

The rest of the article is organised as follows; the next part presents the literature review of GLS manufacturing paradigms followed by the research methodology section. Further, it explains the structural equation modelling diagram and its result analysis and discussion in sections 3, 4.5, and 6 – finally, Discussion and conclusion of the study in parts 7 and 8.

2 Literature review

Section of literature classified in the paradigm of sustainable lean and green manufacturing. The sections describe the importance of each model.

2.1. Lean manufacturing paradigm

In terms of shorter delivery times, lower product costs, and better-quality lean manufacturing, it improves business performance customer satisfaction and makes the organisation more competitive. Various operational performance advantages achieved by SMEs by implementing lean manufacturing are categorised as upstream, downstream, and value stream performance (Panizzolo et al. 2012). Due to financial investments and consultancy costs, SMEs are unwilling to apply lean manufacturing methods. Mathur, Mittal, and Dangayach (2012) highlighted that using a one-minute exchange die tool improves the productivity in make-to-order SMEs Lean promotes the systematic elimination of waste at all levels of the organisation (Panwar et al. 2018). Japanese engineers Taeichi Ohno and Shigeo Shingo came up with the basic idea of lean manufacturing based on the Toyota Production System (TPS) (Kaswan and Rathi 2019). Lean methods can cut down on waste, but they can’t cut down on the negative impact on the environment Agggori 2014). It enhances the performance of the system by increasing revenue and results in good quality items for customers at lower prices (Hair et al. 1998).

Table 1 represents the list of critical lean practices in SMEs as found significant in the literature

| a)5S | b)Kaizen | c) Single minute exchange die (SMED) | d) VisualControl(VC) | e) Value stream mapping (VSM) | f) Cellular Layout (CL) | g) Total productive maintenance (TPM) | h) KANBAN | i) Employee Training (ET) | j) Team Work (TW) | k) Continuous Flow (CF) | l) Lot Size reduction (LSR) | m) Standard Work (SW) | n) Poka Yoka (PY) o) Team Work (TW) |

A study by Singh, Garg, and Sharma (2011) to assess the use of the SMED technique in SMEs has revealed that it reduces installation time. The study also shows that using other lean tools like 5S and Poka-yoke with SMED reduces cycle time and is economically beneficial. The performance indicator should play a more critical role than communication and work as a driving force in corporate policy. Singh, Garg, and Sharma (2010) investigated the policies and strategies of SMEs in India and China and found that SMEs in India are more important for expanding suppliers and improving overall productivity and organisational culture. An overview of the literature on Indian SMEs on the implementation of lean reveals that different views and the need for research to know the organisation’s lean behaviour and the relative significance of various lean methods’ 5S, Kaizen, SMED, Visual Control, Value Stream Mapping, and Cellular Manufacturing.

2.2. Green manufacturing paradigm

The increase in the atmospheric concentration of CO2 contributes to the greenhouse effect. Since many toxic substances are released, and waste is generated during the
managing process, it is necessary to create a development paradigm to minimise the negative impact on the environment. This has guided the development of green manufacturing (GM). The economically viable products produced by green manufacturing have an almost negligible effect on society. A well-designed green manufacturing system can reduce operating costs and increase product value by effectively using raw materials, energy, and labour (Paul, Bhole, and Chaudhari 2014; Sangwan 2011). When customers search for a green manufacturer and its products, it leads to quality product improvements, reduces the cost of the manufacturing process, and increases the company's market share by meeting customer needs. (Deif 2011). Sustainable development provides small and medium-sized enterprises with better opportunities than big companies (Alayón, Sáfsten, and Johansson 2017). Research has confirmed that SMEs require support for their environmental performance in models, tools, approaches, and frameworks (Bhanot, Rao, and Deshmukh 2017; Ghazilla et al. 2015). Lee indicates that literature on manufacturing management widely ignored SMEs' GM practices. SMEs are critical to economic growth, and the drivers and obstacles that motivate and prevent GM implementation in SMEs must be identified (Ghazilla et al. 2015). SMEs in developing and developed countries account for 60–70 percent of harmful emissions (Parker, Redmond, and Simpson 2009; Luthra, Garg, and Haleem 2015). The present tendency is to use GM and lean simultaneously to solve economic and environmental issues (Gandhi, Thambi, and Thakkar 2018). Because of rising energy prices and environmental performance monitoring regulations, SMEs urgently need to develop a GM framework to stay competitive (Thambi, Govindan, and Thakkar 2016). Table 2 lists the environmentally friendly production practices in the literature related to the implementation of GM in SMEs.

(a) Environmental System Management (EMS) b) Assessment of Life cycle (LCA)c) Design for Environment (DFE)d) Control of Environmental emission (EEC)e) Reducing, reusing, and recycling (RRR)f) Green Supply Chain practice (GSC) g) Use of Optimum Natural Resources (ONR) h) ISO14001 i) Use of Environmentally Friendly raw material (EFR.)

From the perspective of implementing GM, SMEs have advantages over large companies. This is because SMEs have unique adaptability in their adaptive structure, which allows them to deal with specialised local markets (Moore and Manring 2009). Small and medium-sized businesses have a minimal environmental impact when looked at individually, but the overall effect of small and medium-sized companies is enormous. (Moore and Manring 2009; Ramayah et al. 2012). Sezen, Cankaya, and Sezen (2013) examined the beneficial effects of GM on the firms' ecological effectiveness and concluded that it contributes to lower raw material prices, to improve productivity, and corporate image. The previous discussion not only promotes the evidence that the application of GM practices can improve production performance but also establishes
a link between the use of green manufacturing methods and its advantages, thereby enabling SMEs to follow green manufacturing.

### 2.3. Sustainable manufacturing paradigm

Today’s most successful manufacturing organisations recognise that being environmentally responsible is not only good for their business but also an integral part of their sales, purchases, and operations. Therefore, it is essential to consider sustainability at all levels of the life cycle of the products produced. Sustainable production is defined as a method of production that reduces waste and reduces environmental impact. These goals are mainly achieved through procedures that affect product design, process design, and operating principles. Different stakeholders of an organisation have different expectations from companies that cannot complete the same goals as suppliers, government agencies, customers, and competitors. ([Zhu, Sarkis, and Lai 2012]). To meet the diverse needs of all stakeholders, companies must work on three basic levels: ‘economic, environmental, and social, which are collectively called the ‘triple bottom line’. People, Profit, and Planet (3BL) is considered the best indicator for assessing an organisation’s sustainable function ([Gimenez, Sierra, and Rodon 2012]). The effectiveness of lean and green management philosophies can be best evaluated from all three sustainability aspects of organisational performance ([Sajan, Shalij, and Ramesh 2017]). (3BL) are the three foundations of sustainability, considering business assessment’s social and environmental value and economic importance. There is a conflict of interest in SMEs; between 3BL entities, they emphasise profits compared to people and the planet ([Wong and Wong 2014]). Sustainability performance, i.e., economic performance, environmental efficiency, and social performance, are interrelated. The company’s adoption of environmental management practices will increase the cost burden of changing the cost structure and reduce profitability ([King and Lenox 2001; Jayaraman, Singh, and Anandanarayan 2012]). However, these investments improve the environmental performance of emissions, waste, on-site waste disposal, and reduced energy consumption. Environmental sustainability must be consistent with the organisation’s profitability, efficiency, customer satisfaction, quality, and responsiveness. Improving the firm’s environmental performance improves its status by committing to reduce its ecological change, which positively affects market performance. ([King and Lenox 2001]). Table 3 lists sustainable practices in the literature related to SMEs.

| Authors | Sustainable practices |
|---------|-----------------------|
| Zhu, Sarkis, and Lai (2012) | x | x | x | x |
| Wong, Ignatius, and Soh (2014) | x | x | x | x | x |
| Jayaraman, Singh, and Anandanarayan (2014) | x | x | x | x | x |
| Sajan, Shalij, and Ramesh (2017) | x | x | x |
| Kamble, Gunasekaran, and Dhone (2020) | x | x |
| Chugani et al. (2017) | x | x | x | x | x | x |
| Ball 2015 | x | x | x | x | x | x | x |
| Garza-Reyes et al. (2016) | x | x | x | x |
| Rothenberg, Pil, and Maxwell (2001) | x | x | x |
| Pampanelli, Found, and Bernardes (2014) | x | x |
| Azevedo et al. (2012) | x | x | x | x | x |
| King and Lenox (2001) | x | x | x | x |

Emission per unit (RPE) h) Reduction in Energy in terms of noise, heat, and radiation (RE) i) Reduction in Solid and Liquid Waste (RLSW).

According to the literature review, it was found that most of the research is only conceptual and can be used to determine GLS factors. Moreover, very few studies on lean, green, sustainability factors have been explored theoretically. There is no report on developing a model based on the structural correlation of GLS factors for operational performance in SMEs. (GLS) is a comprehensive approach that can provide high-quality customer-oriented products by implementing environmental measures and manufacturing sustainable products, thereby improving the organisation’s overall performance. There is no evidence in the literature that the investigated GLS enables identified through the literature review lead to better practical implications. There is no evidence in the literature of an extensive GLS framework applicable to different regions, organisational cultures, and processes. Therefore, advances towards sustainability practices and lack of knowledge of green and lean technologies provide inspiration and direction for current research. In addition, previous research has not provided a roadmap to implement a GLS framework for SMEs, so this research fills this gap.

### 2.4 Integration of lean green sustainability paradigm

Lean manufacturing and green manufacturing can effectively solve the problems of competitive advantage and profitability in today’s highly competitive global market. Benefits of lean and green fusion include ‘production lead time, improved value-added time, low carbon footprint’, i.e., lower greenhouse gas emissions, and entire equipment performance. Lean production and green production show some preliminary evidence in terms of sustainable production. Although lean and green have been shown to influence sustainability, the types of connections between their components are not yet precisely known ([Dornfeld et al. 2013; Helu and Dornfeld 2013]). Since most
construction companies today are already implementing lean or green products, studies should be demonstrating the need for companies to move to a more sustainable production process (Dües, Tan, and Lim 2013). Moreover, Green Lean Six Sigma (GLS) is one of the comprehensive methods to reduce waste and variation in the process while reducing negative environmental impact (Kaswan and Rathi 2019).

Moreover, the Lean approach cannot solve the problem of eliminating defects and environmental issues. At the same time, Green Technology cannot solve the problem of reducing process variability. Therefore, the integrated approach of GLS stands out to decrease waste, reduce environmental damage, and improve process and system efficiency (Banawi and Bilec 2014). Although several standard performance indicators have been developed, the importance or impact among indicators needs to be further investigated to help understand the relationship between sustainability factors. The suggested research design used in this research is presented in Figure 1.

3 Research methodology
To investigate the causal relationship between construct (Figure 1) structural equation modelling (SEM) method was used. SEM is commonly used to represent, evaluate, and verify a hierarchical network of interactions between measured and latent components. The measured variables are described as the number of factors for analysis. The latent factors are usually used to assess all direct and indirect relationships between factors (Shah and Goldstein 2006). Using the SEM method, model analysis can be based on factor analysis and multiple regression. SEM factor analysis can be conducted using confirmatory factor analysis (CFA) and exploratory factor analysis (EFA). EFA is generally applied to examine the latent underlying factors of measuring instruments, and CFA is employed to check the composition of the measured variables (Khaba and Bhar 2018). The measurement scales established to structure the survey questionnaire have favourable psychometric properties from previously published literature. The lean practices (LP), green manufacturing (GM), and sustainable manufacturing practices (SP) measurement responses were composed using a 5-point Likert scale. The maximum points ranged from strongly agree (5) to disagree (1).

4 Questionnaire validity
The questionnaire is written in English and surveyed in three stages to confirm reliability and validity. First, created on DeVellis (2012) guidance, this tool discussed operations validity, clarity, and accuracy with eight experts from industry and academia. The panel consists of two senior academic experts in production and operations management and professors with production technology and management background. The selected expert measured and addressed the subjective validity of the study (Dillman 1978). Secondly, a pilot survey was carried out on 25 graduate students with a master’s degree in engineering management to ensure excellent credibility and relevance. The internal constituency of a questionnaire was measured using Cronbach alpha. Lee Cronbach developed it in 1951, and its value lies between numbers 0 and 1 (Cortina 1993). The high value of alpha represents less error in the questionnaire measurement. The alpha value of 0.70 to 0.90 was recommended for better internal consistency and test homogeneity (Tavakol and Dennick 2011). The Cronbach alpha has been calculated, and projects with low a scores (less than 0.70) have been revised and reorganised, raising concerns about ambiguity, clarity, and applicability to students. Table 4 shows the final measurement items used in the survey.

5 Data analysis
A cross-sectional survey was used to collect data from the list of manufacturing companies. To obtain a representative population sample, 700 manufacturing companies were randomly selected. They were using a follow-up message sent at regular intervals to collect data from respondents. The email included a cover letter asking respondents to answer only if they knew the LP, GM, and SP concepts and had at least a year of work experience in production organisations. The participants of the online survey of the questionnaire were asked to send their answers within four weeks. A brief profile of the experts is provided in appendix 2.

The final sample size for the research was 210 participants, considering resource constraints and data collection on research topics such as LP, GM, and SP.
integration. The sample adequacy was tested using Kaiser-Meyer-Olkin (KMO) test. KMO value above 0.5 indicates adequate sampling (Ramadas and Satish 2018). In this research value of the KMO test was found to be 0.752, and it is above the threshold value; hence it is appropriate for further analysis. A sample of 210 manufacturing organisations was used for confirmatory factor analysis (CFA) and structural equation modelling (SEM). The online survey format was required to answer all questions, without which the respondent was not allowed to submit the questionnaire. This limitation removed the problem of missing data and incomplete surveys, making all survey questionnaires useful for examination. The online questionnaire was carried out from February 16 to 25 May 2020. In the eight weeks before the online survey, a total of 155 surveys were received, and two follow-up notifications were issued. The remaining 55 surveys were received slowly and other reminders must be sent the rest of time (4 weeks). Chi-square value ($\chi^2$), degrees of freedom (df), the goodness of fit index (GFI), adjusted goodness of fit index (AGFI), non-normated fit index (NFI), comparative fit index (CFI), and root mean square error are used to confirm the hypothesised measurement model’ (Carmines and McIver 1981) and Hair et al. 1998). Standardised regression coefficients obtained from the SEM analysis were used to analyse the direct and indirect effects (Shrout and Bolger 2002). All analyses were run through ‘IBM SPSS 25 and IBM AMOS 25’.

5.1 Direct effects of LP on SP and GMP

The SEM study was used to examine the direct impact of LP on SP (H1) and LP on GM (H2). Hypothesis H1 was found to be a positive significant effect LP on SP ($\beta = 0.61$, $p = 0.001$). The assumption that LP has a positive effect on GMP is also validated ($\beta = 0.72, p = 0.001$). $\beta$ coefficient is the magnitude of the change in the effect variable for each 1-unit change in the prediction variable.

5.2 Mediating effect of LP on GM and SP

As shown in Figure 2, the results of the three-construct fully structured model of LP, GMP, and SP show that LP has a positive effect on GMP ($\beta = 0.72, p = 0.001$) and has a significant impact on SP ($\beta = -0.61, p = 0.001$). The SEM study was used to investigate the mediation of GMP in the relationship between LP and SP. The mediating effect of the

### Table 4. Survey results.

| Below lean Manufacturing Practices helps to improve business performance, improve customer satisfaction, and makes the organisation more competitive | Factor Loading | Mean Value | Std Deviation | Cronbach Alpha |
|---|---|---|---|---|
| 5s | 0.823 | 3.28 | 1.32 | 0.78 |
| Kaizen | 0.82 | 3.21 | 1.31 | |
| SMED | 0.721 | 3.05 | 1.48 | |
| Visual Control | 0.825 | 3.45 | 1.2 | |
| VSM | 0.751 | 2.85 | 1.34 | |
| Cellular Layout | 0.621 | 3.45 | 1.54 | |
| TPM | 0.705 | 3.04 | 1.24 | |
| KANBAN | 0.625 | 2.9 | 1.27 | |
| Employee Training | 0.824 | 3.25 | 1.23 | |
| Team Work | 0.874 | 3.54 | 1.05 | |
| Continuous Flow | 0.714 | 3.47 | 1.02 | |
| Lot Size Reduction | 0.758 | 3.85 | 1.2 | |
| Standard Work | 0.854 | 3.96 | 1.03 | |
| Poka Yoka | 0.678 | 3.45 | 1.06 | |
| Team Work | 0.814 | 3.56 | 1.21 | |

| Below green manufacturing practices reduce the operating cost and increase the product value | Factor Loading | Mean Value | Std Deviation | Cronbach Alpha |
|---|---|---|---|---|
| Environmental Management System | 0.825 | 3.54 | 1.02 | 0.81 |
| Life Cycle Assessment | 0.841 | 3.74 | 1.05 | |
| Design for Environment | 0.826 | 3.51 | 1.08 | |
| Environmental Emission Control | 0.879 | 3.61 | 1.07 | |
| Reducing, Reusing and Recycling | 0.863 | 3.72 | 1.01 | |
| Green Supply Chain Practise | 0.795 | 3.76 | 1.04 | |
| Optimum use of Natural Resources | 0.798 | 3.58 | 1.06 | |
| ISO14001 | 0.925 | 3.65 | 1.2 | |
| Use of Environmentally friendly Raw material | 0.915 | 3.64 | 1.05 | |

| Below sustainable manufacturing practices reduce waste and environmental impact | Factor Loading | Mean Value | Std Deviation | Cronbach Alpha |
|---|---|---|---|---|
| Decreased the Cost of Manufacturing | 0.925 | 3.85 | 1.05 | 0.79 |
| Increased the Profit | 0.915 | 3.92 | 1.02 | |
| Reduced the Cost of Waste treatment | 0.845 | 3.91 | 1.04 | |
| Working Condition Improved | 0.812 | 3.85 | 1.03 | |
| Relation among the Labour Improved | 0.865 | 3.75 | 1.11 | |
| Improved Product Responsibility | 0.756 | 3.62 | 1.15 | |
| Reduction in Production Emission per unit | 0.745 | 3.65 | 1.07 | |
| Reduction in Energy in terms of noise, heat, and radiation | 0.765 | 3.51 | 1.08 | |
| Reduction in Solid and Liquid Waste | 0.91 | 3.95 | 1.11 | |
The model was tested and reported the importance of direct and indirect effects using bootstrap in AMOS. The standardised regression coefficient results in Table 5 support the hypothesis (H3), and GM impacts the indirect association between LP and SP. The standardised regression coefficient findings in Table 5 support the hypothesis (H3), and GMPs have a meaningful impact on the mediating link among LP and SP. This research aims to examine the direct impact of LM on GM and SP and explore the effects of GM parameters on the connection between LP and SP. The current research confirmed that the direct effects of LP on GMP and SP have a meaningful impact on the indirect connection between GMP and SP. The previous study claims a positive correlation between LP and GMP on SP (Abreu, Alves, and Moreira 2017; Fercoq, Lamouri, and Carbone 2016; Duarte and Cruz-Machado 2013). However, this study gives empirical verification of this linkage. The LM → GMP → SP mediated path was found to be significant.

6 Structural model results

The complete structural model established for this research includes seventeen factors to examine the combined effect of LP, GMP, and SP. The variables observed represent the underlying latent construct. The hypothesis created for the study is tested using SEM.

7 Discussion on integrating lean-green-sustainable practices for SMEs

Lean green and sustainable manufacturing frameworks (refer to Figure 2) have similar effects on the company’s entire performance. The research results aided in developing the various managerial insight for SMEs. Customer satisfaction and product design quality are the powerful driving force to achieve the desired result for company performance. It helps to make an action plan for the management to adjust their functional and ecological methods to enhance its business
effectiveness without negotiating environmental performance and successfully leading the company towards sustainable production. Lean practices such as TPM, Kaizen, and 5S are the most balanced lean practices for improving the company’s leanness. Total predictive maintenance (TPM) allows maximising equipment efficiency through predictive and preventive strategies. Kaizen ensures cost and quality improvement by eliminating waste. 5S makes a powerful tool to start the development process and requires less investment. Single minute exchange die supports small production in batch sizes, reducing inventory and improving productivity. Managers should prioritise the implementation of these methods to improve delivery efficiency and improve the product’s quality, resulting in an improved lean performance for the company. Pollution and excessive consumption of hazardous gases reflect the company’s poor environmental performance. Managers must initially follow ISO 14001, leading to resource use and waste generation and reducing customer satisfaction. By practicing 3R, it is possible to reduce costs and increase resource efficiency by developing manufacturing processes and products that consume less material and are used in their original form, resulting in better resource performance. Sustainable manufacturing practices (SMP) are also very advantageous. Improving equipment and process efficiency can save energy costs, reduce manufacturing time, reduce waste and material usage. SMP facilitates external coordination and collaboration with several multi-stakeholders like consumers and vendors. It enables organisations to quickly and accurately, and efficiently distribute and exchange information, knowledge, and expertise to organisations members. The exchange of valuable information between members can be seen in several ways that encourage the success of product and process innovations, including quick reaction to mark demand and technological developments and an overall requirement of consumers, vendors, and community in general. GLS manufacturing implementation is the business approach of SMEs and is largely affected by the current market environment. With the pressure from the big organisation, the firm manager can adopt the recommended framework as a guideline for choosing and applying the best lean green and sustainable methods and periodically assess their efficiency using operational drivers and activators of each bundle. The study’s findings will help managers of SMEs know the impact of the integrated GLS framework on the organisation’s performance.

To produce products with high specifications and be environmentally friendly, there is a huge demand for green technology, which minimises the environmental impact. Combining green technology with lean and sustainable manufacturing practices will bring a new approach to improvement. Integrating GLS practices can reduce carbon emissions and provide truly valuable products. Adopting green practices at the initial phase of product design enables the use of eco-friendly packaging components, the design of reusable products, and optimum energy usage during the entire lifespan. Ultimately, it will reduce energy consumption and air pollutant emission. The major criteria for greenness are reduced emission. This may be due to government pressure and adherence to several environmental requirements like pollution prevention standards that are prescribed. Reducing energy consumption has a significant influence on the greenness of the organisation in the present era of the global energy crisis (Thanki, Govindan, and Thakkar 2016)

In addition to the framework, the successful implementation of this integrated approach also requires GLS readiness analysis. Due to a lack of adequate preparation, many new methods failed in the early stages of implementation. Therefore, the enormous need for readiness measures would motivate an organisation to completely adopt the approach from the beginning to the end. The organisation responsible for implementing an inclusive lean, green, and sustainable programme should include these facilitators as the first line of preparation. Proper understanding of the enabling factors and their interactions combined with a comprehensive study of real-world methods makes it easier for organisational managers to identify various loopholes in GLS implementation. The systematic steps of integrating green, lean, and sustainable manufacturing practices into the organisation need deep involvement of every employee, continuous motivation and ability to learn GLS goals-oriented objectives, and patience to transform efforts into profit.

8 Conclusion

GLS manufacturing practices are considered a comprehensive method to simultaneously reduce the negative impact on the environment and produce better standardisation products. Companies need to understand the characteristics and relationships of lean, green, and sustainable implementers to meet the customer’s understanding of environmental regulations and standards. The contributing factors of lean, green, and sustainable elements are modelled and analysed using the SEM approach (Refer to Figure 2). Lean, green, and sustainable enablers make it easier for managers to understand the mutual relationship and linkage between the different enablers. This will be the lead successful Lean, green, and sustainable manufacturing practice program execution. The main implication of this research is to guide industry managers and practitioners by investigating the relationships between various enabling factors, which provide a systematic method to execute and implement the lean, green, and sustainable program. Researchers can generally reproduce similar results for variables and enablers related to their problems by adopting the current approach. Globally, by systematic understanding and implementation of lean green and sustainable programs, society will benefit from reduced environmental degradation in reducing waste and greenhouse gas emissions.

Decision-makers and consultants in any organisation comprising small and medium-sized businesses always face difficulty determining a set of tools and techniques that they must pursue to achieve functional and ecological standard performance. Establishing an integrated, balanced approach practice leads to excellent overall performance and assessing the outcomes. Hence, frequent performance assessments should be conducted to study problems associated with integrating the sustainable, lean, and green paradigm and explore the opportunities for potential growth. This research provides empirical verification of the connection between LP, GMP, and SP. The results show that LP has
a positive influence on GMP and SP. This research was recognised as a critical GMP mediator variable. This research also confirmed GMP as a critical facilitating parameter. Depending on the current challenges for SMEs, the proposed lean-green-sustainable system architecture can serve as an action plan for sustainable-lean-green-implementation. This study promotes sustainable practices by explaining the interaction between lean and green practices and their associated indicators. Factors such as company size, vendors, consumer type, level of automation within the company, type of product, and quality criteria often constrain the implementation of a world-class production strategy like green, lean (Dora et al. (2013); Shah and Ward (2003)). Also, the organisation's structure, policy formulation, and use of possible resources primarily distinguish between the small and medium enterprises and big-sized organisations and have a significant impact on the results of implementing such policies (Dora et al. 2013). The current research focuses mainly on lean and green models related to production SMEs, which may not be directly applicable to a big scale or another industrial sector. Through case-based research, further research can be conducted on applying and verifying the proposed model in particular production S.M.E.s. The current work can be examined further by conducting a large-scale survey of manufacturing firms, and the findings of the present research can be validated further by them. Furthermore, the current work results can be equated to other decision-making methods such as fuzzy PROMETHEE, AHP, and TOPSIS. Future research could further examine the function of GS in enhancing sustainability with Industry 4.0 and investigation and modelling of GS constraints.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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Appendix 1-Questionnaire

| Construct                  | Source                                                                 | Measures                                                                 |
|----------------------------|------------------------------------------------------------------------|--------------------------------------------------------------------------|
| Lean Practices             | Achanga et al. (2006)                                                  | Below lean Manufacturing Practices helps to improve business performance |
| Green manufacturing        | Rose et al. (2011, January, January)                                    | a) 5S                                                                    |
| practices                  | Upadhye, Deshmukh, and Garg (2010)                                      | b) Kaizen                                                                |
| Sustainable manufacturing  | Singh, Garg, and Deshmukh (2008)                                       | c) SMED                                                                 |
|                            | Wadhwa (2014)                                                          | d) Visual Control                                                        |
|                            | Ferdousi and Ahmed (2010)                                              | e) VSM                                                                   |
|                            | Mathur, Mittal, and Dangayach (2012)                                    | f) Cellular Layout (CL)                                                  |
|                            | Womack, Jones, and Roos (2007)                                         | g) TPM                                                                   |
|                            | Pojasek (2003)                                                         | h) KANBAN                                                               |
|                            | Bichenho and Holweg (2000)                                             | i) Employee Training (ET)                                               |
|                            | Garbie (2010)                                                          | j) Teamwork (TW)                                                        |
|                            | Saboo et al. (2014)                                                    | k) Continuous Flow (CF)                                                 |
|                            | Kilpatrick (2003)                                                     | l) Lot Size reduction (LSR)                                              |
|                            | Radnor et al. (2006)                                                   | m) Standard Work (SW)                                                   |
|                            | Gunasekaran, Forker, and Kobu (2000)                                   | n) Poka Yoka (PY)                                                       |
|                            | Singh, Brueckner, and Padhy (2015), Morrow and Rondinelli (2002)       | o) Team Work (TW)                                                       |
|                            | Agan, Acar, and Borodin (2013), Vachon (2007)                          | Below green Manufacturing Practices helps to improve business performance|
|                            | Despesisse, Oates, and Ball (2013)                                     | a) Environmental System Management (EMS)                                 |
|                            | Onsrud and Simon (2013)                                                | b) Assessment of Life cycle (LCA.)                                       |
|                            | Ramayah et al. (2012)                                                  | c) Design for Environment (DFE)                                          |
|                            | Govindan et al. (2014)                                                 | d) Control of Environmental emission (EEC.)                               |
|                            | Rasi, Abdekhoodae, and Nagarajah (2010)                                | e) Reducing, reusing, and recycling (RRR.)                                |
|                            | Phunggrassami (2008)                                                  | f) Green Supply Chain practice (GSC.)                                    |
|                            | Lee (2008)                                                             | g) Use of Optimum Natural Resources (ONR.)                                |
|                            | Zhu, Sarkis, and Lai (2012)                                            | h) ISO14001                                                             |
|                            | Wong, Ignatius, and Soh (2014)                                          | i) Use of Environmentally Friendly raw material (EFR.)                    |
|                            | Jayaraman, Singh, and Anandnarayan (2012)                              | Below Sustainable Manufacturing Practices helps to improve business      |
|                            | Sajan, Shalij, and Ramesh (2017)                                       | performance                                                             |
|                            | Kamble, Gunasekaran, and Dhone (2020)                                  | a) Decreased the Cost of Manufacturing (DCM.)                             |
|                            | Chugani et al. (2017)                                                  | b) Increased the ProfitIP(P)                                             |
|                            | Ball (2015)                                                            | c) Reduced the Cost of Waste treatment (RCW)                              |
|                            | Garza-Reyes et al. (2016)                                             | d) Working Condition Improved (WCI)                                      |
|                            | Rothenberg, Pil, and Maxwell (2001)                                    | e) Relation among the labour Improved (RLI)                               |
|                            | Pampanelli, Found, and Bernardes (2014)                                | f) Improved Product Responsibility (IPR)                                  |
|                            | Azevedo et al. (2012)                                                  | g) Reduction in Production Emission per unit (RPE)                        |
|                            | King and Lenox (2001)                                                  | h) Reduction in Energy in terms of noise, heat, and radiation (RPE)      |
|                            |                                                                        | i) Reduction in Solid and Liquid Waste (RSLW).                            |

Appendix 2 Profile expert summary

| Data collection method       | Survey-based                                                          |
|------------------------------|-----------------------------------------------------------------------|
| The sampling technique used  | Purposive                                                             |
| Sample size                  | 210                                                                   |
| Timeframe                    | Four months (February 2020 -May 2020)                                 |
| Respondent profile           | Plant manager, Manufacture ring Manager, Manufacture ring Manager, Senior Engineer quality control, lean and six sigma |
| Response rate                | 30%                                                                   |