Cleaner and Responsible Consumption 11 (2023) 100143

Contents lists available at ScienceDirect

Cleaner and Responsible Consumption

journal homepage: www.journals.elsevier.com/cleaner-and-responsible-consumption

Integrated lean-green practices and supply chain sustainability framework

Wilson Kosasih [a,b], I Nyoman Pujawan [a,*], Putu Dana Karningsih [a], Himanshu Shee [c]

[a] School of Interdisciplinary Management and Technology, Institut Teknologi Sepuluh Nopember, Surabaya, Indonesia
[b] Department of Industrial Engineering, Universitas Tarumanagara, Jakarta, Indonesia
[c] Victoria University Business School, Melbourne, Australia

ARTICLE INFO

Keywords:
Lean
Green
Supply chain
Sustainability
SME
Indonesia

ABSTRACT

Integration of lean-green practices has benefited companies in many ways, particularly the large ones. Small and Medium Enterprises (SMEs), as key players within supply chains, should also be encouraged to apply the lean and green practices to support the large enterprises in the supply chain. However, it remains all time challenging for SMEs that operate with limited resources, and often emphasize on short-term goals with rapid turnaround. The impact of green-lean practices on sustainability performance has been investigated earlier, however further study is needed to understand the phenomena in context of SME supply chain. This study examined the moderating effects of top management commitment and leadership (TMCL) and organizational culture transformation (OCTr) on the relationship between Lean Practice (LP) and Green Practice (GP). Further, it investigated the moderating effect of both policy initiative (PI) and collaborative synergy (CS) on the relationship between GP and sustainability performance. The survey-based study analyzed the data from 345 Indonesian manufacturing SMEs using structural equation modeling (SEM) with Smart-PLS. The findings suggest that GP mediates LP to improve sustainability performance of SMEs. TMCL facilitates significantly the adoption of integrated lean and green practices. Meanwhile, OCTr, PI, and CS did not have a significant moderating effect. It means that OCTr does not significantly moderate lean practices for the adoption of green practice. Similarly, results demonstrate that neither PI nor CS moderate the correlation between green practice and sustainability performance of supply chain in manufacturing SMEs. The findings help SME owners or managers to build a comprehensive model of a lean-green system to direct SMEs to achieve sustainable development.

1. Introduction

Due to concern about the depletion of natural resources, financial disparity, and social responsibility, business sustainability has become a significant issue for academia, industry practitioners and policy makers (Siegel et al., 2022; Choudhary et al., 2019; Sezen and Cankaya, 2013). As the triple bottom line (3 B L) of sustainability, i.e., planet (environment), people (social), and profit (economic), has become a strategic necessity, many businesses view sustainable and environmentally friendly operations as critical to value creation and economic growth (Siegel et al., 2019; Bai et al., 2012). However, businesses are under intense pressure to boost quality output, and adaptable to ongoing changes, while minimizing operational costs. It is therefore much effort is paid by companies to balance their performance in relation to economic, social, and environmental factors due to regulations, intense competition, and public pressure (Singh et al., 2021; Choudhary et al., 2019; Bai et al., 2012). Hence, it is necessary to adopt an approach that can help implement these sustainability dimensions and improve the competitive advantage. We call it a Lean-Green model. That means, use lean as a means to achieve green and sustainability (Dües et al., 2013).

While the adoption of green and lean practices are sensible and understandable for large companies, it is also urgent for small and medium enterprises (SMEs) to adopt them (Kosasih et al., 2023a). In many cases, SMEs are inseparable suppliers to large companies, and they are the key participants in these supply chains. If all the participants share the same values and goals, a supply chain can triumph in the competition. Therefore, adopting Lean, Green and Sustainability approach is essential for SMEs. Additionally, SMEs are the dominant players in various industrial sector and contribute significantly to the economic growth. Das and Rangarajan (2020) revealed that SMEs accounted for almost 90% of business globally and generated 50%–60% of jobs worldwide. Referring to Queiroz et al. (2022), there is no global standard definition of SMEs, and the most common classification is based on number of employees and a financial measure.

* Corresponding author.
E-mail address: pujawan@ie.its.ac.id (I.N. Pujawan).

https://doi.org/10.1016/j.clrc.2023.100143
Received 30 September 2023; Received in revised form 13 October 2023; Accepted 13 October 2023
Available online 21 October 2023

The adoption of lean in SMEs also promotes higher operational performance at the upstream to downstream levels (Panizzolo et al., 2012). However, lack of human and financial resources generally prevents SMEs from implementing lean manufacturing. They believe that a sizable investment is required to implement it, both in terms of advancement of technology and human resources. Singh et al. (2010) studied SMEs, particularly in India and China, about their strategies and regulations. They report that Indian SMEs saw the implementation of lean as being more crucial for raising productivity, improving organizational culture, and extending their local supplier networks.

SMEs are responsible for 60%–70% of harmful emissions worldwide (Luthra et al., 2015; Parker et al., 2009). While each SME may have relatively a small impact on the environment, their collective impact is significant (Moore and Manring, 2009; Thekkoote, 2022; Ramayah et al., 2012). To address this issue, the current trend is to adopt a combination of lean and green practices. However, there is a lack of guidance on how SMEs can implement sustainability practices, as most existing frameworks are designed for larger companies. Given that SMEs typically have limited resources, factors such as government support or collaborative initiatives among SMEs and other stakeholders may play a crucial role in achieving sustainable development goals (Gandhi et al., 2018). Urgent action is needed to address the emissions from SMEs, and a tailored framework for SMEs is required to enable them to contribute to sustainability efforts effectively.

This research aims to address the gap in knowledge by empirically investigating the influence of green and lean practices on sustainability performance of supply chain in Indonesia Manufacturing SMEs. Moreover, it examines the moderating effects of top management commitment and leadership (TMCL) and organizational culture transformation (OCTr) on the relationships between lean practice (LP) and green practice (GP). Further, it investigates the moderating roles of policy initiative (PI) and collaborative synergy (CS) on the correlation between GP and sustainable supply chain performance (Sus-SCP) of SMEs. Drawing on a survey-based approach similar to that used by Thekkoote (2022), the study also explores whether GP mediates the correlation between LP and sustainability performance. This article is an extension of the published paper by Kosasih et al. (2023a). Hence, this study addresses the following research questions.

RQ #1: Do LP and GP positively affect SME supply chain sustainability performance?
RQ #2: Does GP mediate the correlation between LP and sustainability performance of SME supply chain?
RQ #3: Do TMCL and OCTr moderate the relationship between LP and GP for SMEs?
RQ #4: Do PI and CS moderate the correlation between GP and sustainability performance of SME supply chain?

This article is structured as follows: Section 2 develops research hypotheses and the conceptual model. Section 3 describes the research method used in this article, while Section 4 presents and addresses the data analysis and results. Then, Section 5 presents and discusses the research findings. Eventually, Section 6 concludes this study and highlights its contributions.

2. Hypotheses development and conceptual model

2.1. Relationship between lean practice and green practice

Lean companies are naturally inclined to adopt environmentally sustainable practices due to their continuous efforts to reduce waste. Melnyk et al. (2003) investigated the level of greenness in more than 1100 factories and it demonstrated that lean firms tend to have higher greenness scores. This finding is supported by Yang et al. (2011), who surveyed 309 diverse manufacturing firms, revealed that LP were a significant driver or precursor for the adoption of GP. Only a few studies focus on discussing Lean-Green in SMEs (Siegel et al., 2022; Yadav et al., 2019; Verrier et al., 2016). Referring to Hu et al. (2015), large organizations are mostly familiar with Lean implementation, with less research into Lean in SMEs. Our literature review highlights several critical LP tools and techniques that have been found to be effective in SMEs, including kaizen, 5 S, waste reduction, inventory reduction, poka-yoke/visual control, total productive maintenance (TPM), work standardization, employee involvement, single-minute exchange die (SMED), and value stream mapping (VSM) (Belhadi et al., 2018; Siegel et al., 2019; Thanki and Thakkar, 2019). Furthermore, our review also identified various GP tools and techniques that SMEs often use to support their environmental sustainability efforts, such as ISO14001, reduce-reuse-recycle (3Rs), life-cycle assessment (LCA), environmental emission control (EEC), green supply chain practices (GSCP), eco-design, and environmental management system (EMS) (Dey et al., 2020; Siegel et al., 2019; Thanki et al., 2016). Hence, we propose this following hypothesis.

Hypothesis 1. **(H1)**: Lean practice is positively related to green practice.

2.2. Relationships between lean practice, green practice and sustainable supply chain performance

A survey-based research conducted by Wiengarten et al. (2013) against companies in nine European countries found that there is a synergistic impact of LP and GP on supply chain performance. This study provides an understanding and foundation for lean organizations to start investing in the adoption of GP. Several studies emphasize the synergy of LP and GP and also show the positive impact of this integration on sustainability performance (Hussain et al., 2019; Pampanelli et al., 2014). The incorporation of the term "sustainability" into SCM exacerbates this problem, because traditional measures or indicators are considered inadequate (Cantele et al., 2023; Beske-Janssen et al., 2015; Schaltegger and Burritt, 2014; Hassini et al., 2012). Supply chain (SC) sustainability performance involves a multi-dimensional construct which includes operational, economic, social, and environmental aspects (Saulick et al., 2023). As a result of business complexity and the shift in competition from inter-organizational to inter-supply chain, recently the measurement of SC sustainability performance has obtained increasing attention from researchers. This is also necessary to elaborate more on SMEs. Thus, we arrive at following hypotheses.

Hypothesis 2. **(H2)**: Green practice mediates the correlation between lean practice and performance of SC sustainability.

Hypothesis 3. **(H3)**: Lean practice positively influences sustainable SC performance.

2.3. Top management commitment & leadership as a moderator in the correlation between lean practice and green practice

Some researchers stated that one of the most challenging issues in an organization is management and leadership (Siegel et al., 2022; Grigg et al., 2020; Alves and Alves, 2015). Albliwi et al. (2014) claimed that projects sometimes fail due to a lack of proper attitude, commitment, and involvement from both top and middle management. Because SMEs frequently emphasize short-term goals in order to get quick results, overarching goals and a well-defined strategy may be lacking (Grigg et al., 2020). Employee resistance is another important challenge, particularly in the integration of continuous improvement programs. Employees are concerned about their job security as new methods are implemented. Zhan et al. (2018) claim that top management demonstrates commitment with their stakeholders and communication among them, as a way to mitigate or reduce risks of time, cost, and environmental. The poor quality of human resources as well as an organization's resistance to change will hamper their adoption of LP and GP (Dües et al., 2013). Thus, we propose this following hypothesis.

Hypothesis 4. **(H4):** Top management commitment and leadership moderates the correlation between lean and green practices in such a way that the positive impact lean practice on green practice is stronger when top management commitment and leadership is implemented.

2.4. Organizational culture transformation as a moderator in the correlation between lean practice and green practice

The SMEs' specific characteristics, such as a lack of human or financial resources, and focus on short-term goals to generate fast results, make it difficult to integrate development initiatives (Yadav et al., 2019). In SMEs, every employee is assigned a crucial responsibility, often more than one, which results in limited human resources available. Therefore SME employees have less time for their routine workload when they are working on additional work or projects (Wessel and Burcher, 2004). As a result, management views training as a waste of time; poor quality of workforce in SMEs is considered as one of the significant failure factors of LP adoption (Albliwi et al., 2014). Many researchers suggest that transformations is likely to be successful when the intended cultural change aligns with the company's value creation goals and overarching strategy (Field et al., 2022). Organizational culture transformation is related to changes in mindset and employee involvement in implementing the Green-Lean approach (Zhan et al., 2018; Alves and Alves, 2015). It is supported by Duarte and Cruz-Machado (2013) who stated that organizational culture is a driver in lean-green transformation. Thus, we propose this following hypothesis.

Hypothesis 5. **(H5):** Organizational culture transformation moderates the correlation between lean and green practices in such a way that the positive impact lean practice on green practice is stronger when organizational culture transformation is implemented.

2.5. Collaborative synergy as a moderator in the correlation between green practice and sustainability performance of supply chain

Santos et al. (2014) suggest that SMEs can only solve resource-constrained difficulties through collaborative synergy. Das and Rangarajan (2020) state that alliances and networks can only be used effectively to address common challenges and achieve inclusive growth if SMEs are ready and willing to share their best sustainability practices with their stakeholders or partners. Referring to Silvia et al. (2013), SMEs play a dominant role in transmitting the sustainability criteria that their customers send them, in such a way that they can effectively disseminate and communicate sustainability practices throughout their entire supply chain. Following Moore and Manring (2009), SME networks will become a critical role in tackling the systemic issues that underpin industrial ecology. Das and Rangarajan (2020) conducted survey-based research on Indian SMEs and found that there was a positive and significant impact from collaborative synergy on their business sustainability and growth. As a result, we arrive at following hypotheses.

Hypothesis 6. Collaborative synergy moderates the correlation between green practice and SC sustainability performance in such a way that the positive impact green practice on SC sustainability performance is stronger when collaborative synergy is implemented.

2.6. Policy initiative as a moderator in the correlation between green practice and sustainability performance of supply chain

According to Das and Rangarajan (2020), previous research has identified a lack of regulatory support and a lack of frameworks and rules as major obstacles to sustainability practice for SMEs in emerging countries. The government requires to interfere through policies while simultaneously encouraging the development of a sustainable management system to make it more workable for SMEs (Jacob et al., 2015). The role of government is critical in this situation. Government policy positively affect on the competitiveness of SMEs. According to Eniola and Entebang (2015)'s study, the performance of SMEs changes depending on the government policy they adopt. Moreover, Gandhi et al. (2018) claim that the synergy between organizational policies and government regulations is a driver for green-lean implementation. A survey based study by Das and Rangarajan (2020) also investigated the positive impact of policy initiatives on business sustainability and growth of Indian SMEs. As a result, policy initiative has had a significant positive impact on the sustainability and business growth of SMEs. Hence, we propose this following hypothesis.

Hypothesis 7. Policy initiative moderates the correlation between green practice and SC sustainability performance in such a way that the positive impact green practice on SC sustainability performance is stronger when policy initiative is implemented.

2.7. Conceptual model

The theoretical-based support conducted in the previous section has provided the basis for developing a conceptual model. The resulting conceptual framework illustrates the correlation between LP, GP, and Sus-SCP, as depicted in Fig. 1. Also, it shows how the moderators (TMCL, OCTr, CS, and PI) and mediator (GP) affect the relationships.

3. Research methodology

3.1. Questionnaire development

The questionnaire consists of seven main variables, namely: 1) Commitment and leadership from top management (TMCL); 2) Transformation of organizational culture transformation (OCTr); 3) Policy initiative (PI); 4) Collaborative synergy (CS); 5) Lean practice (LP); 6) Green practice (GP); 7) Sustainable supply chain performance (Sus-SCP). In initial development, TMCL consists of 8 indicators. OCTr consists of 6 indicators. PI consists of 2 indicators. CS consists of 6 indicators. LP consists of 19 indicators. GP consists of 8 indicators. Meanwhile, Sus-SCP consists of 25 indicators. All questions used a five-point Likert scale, where 1 means "*strongly disagree*" to 5 means "*strongly agree*." For details of the indicators and their sources can be seen in Appendix A.

Prior to the main survey, a pilot survey was conducted with 60 respondents randomly selected from the target population. Feedback from the pilot survey was used to modify the questionnaire to ensure that it was easy-to-understand. Additionally, respondents suggested deleting questions LP12 and LP14 on 'pull system' as SMEs cannot implement pull systems fully. After finalizing the questionnaire, a sample of 680 manufacturing SMEs were invited to participate via email or WhatsApp.

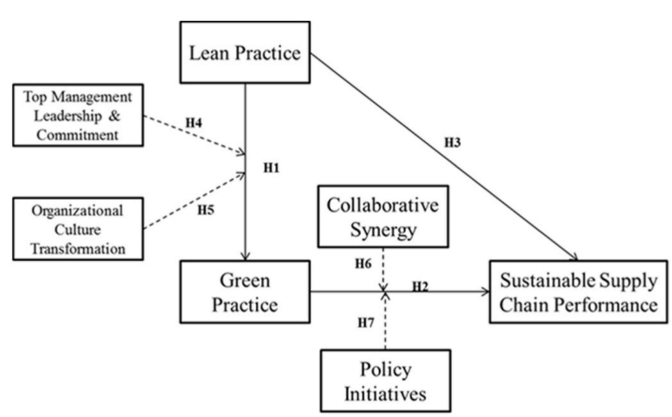

Fig. 1. Conceptual framework.

A total of 345 useable responses were received after follow-up that resulted in a response rate of 50.7%. According to Asadi et al. (2020) and Malhotra and Grover (1998), this response rate exceeds the minimum of 20% that is commonly used in most operations management research studies.

3.2. Sampling and data collection

Data for this study was collected through a survey of SMEs and businesses in Indonesia. In Indonesia, a business is classified as a small business when it has a net worth or assets (not including land and buildings) of 50 million to 500 million rupiahs (in US$, $3205.51 to $32,055.14) and has annual sales of 300 million to 2.5 billion rupiahs (in US$, $19,231.44 to $160,262.01). Medium-sized businesses have a net worth or assets (not including land and buildings) of 500 million to 10 billion rupiahs (in US$, $32,055.14 to $641,048.02) and have annual sales of 2.5 billion to 50 billion rupiahs (in US$, $160,262.01 to $3,205,240.10) (Law of the Republic of Indonesia No. 20, 2008). There are about 864,144 SMEs in Indonesia that contribute to 23.2% GDP, and absorb ±10 million workers (Badan Pusat Statistik, 2019a,b). Therefore, it requires effort to convince SMEs to adopt lean and green practices effectively.

Purposive sampling was used, with the target respondents being owners or managers/supervisors of manufacturing SMEs who have implemented or adopted lean and/or green practices in Indonesia. This study had a total of 345 participants, with 6.1% being owners, 12.5% directors or deputy directors, 62.3% managers, and 19.1% supervisors. These participants worked in various fields, including production (13.9%), PPIC (1.2%), engineering (1.4%), quality (3.8%), purchasing or procurement (4.3%), warehouse and logistics (1.7%), product development (1.2%), project management (1.4%), finance (10.1%), marketing (10.1%), and others (see Table 1). Most of the participants had less than 5 years of work experience (52.5%), while 26.1% had worked between 5 and 10 years, and 21.4% had worked for more than 10 years. Respondents came from both small-sized (29.9%) and medium-sized (70.1%) companies, which is considered representative of the proportion of manufacturing SMEs in Indonesia that have adopted a lean-green approach. The survey participants came from various manufacturing sectors, including food (16.2%), metalworking/fabricated metal products (8.4%), transportation equipment (8.7%), machinery and equipment (7.5%), plastics and rubber products (5.8%), computer and electronic products (5.5%), paper products (4.3%), chemicals (4.3%), furniture (4.1%), apparel (4.1%), and others.

4. Data analysis and results

The partial least squares path modeling (PLS-SEM) is a powerful tool for analyzing data and testing theoretical relationships between observed and latent variables. One advantage of using PLS-SEM is that it can handle complex models with many variables and helps assess both direct and indirect impacts. In this study, the sample size of 345 exceeds the minimum sample size of 200 (Hair et al., 2018). In addition, following Philip et al. (2003), there may be random errors in the measurement model caused by systematic errors due to measurement methods. Therefore, various conformity indices were examined to determine the extent to which the proposed model represents the actual relationship with an acceptable approximation.

4.1. Normality and linearity tests

The data tendency for each indicator is close to the mean, which is indicated by a relatively small standard deviation value. The standard deviation value has a range from +0.77 to +1.26. The distribution of data for each indicator of latent variables tends to skew to the left and is close to normal because the skewness is negative and relatively close to zero. The skewness value has a range from −1.572 to −0.096. Likewise,

Table 1
Demographic characteristics of respondents (N = 345).

Variables		Frequency	Percent	Cumulative Percent
Gender	Male	204	59.1	59.1
	Female	141	40.9	100.0
Years of experience at their current company	Less than 5 years	181	52.5	52.5
	5 years–10 years	90	26.1	78.6
	Greater than 10 years	74	21.4	100.0
Formal education	Primary school	1	0.3	0.3
	Junior high school	3	0.9	1.2
	Senior high school	80	23.2	24.4
	Diploma degree	21	6.1	30.5
	Bachelor degree	221	64.0	94.5
	Magister degree	19	5.5	100.0
Job position	Owner	21	6.1	6.1
	Director	34	9.9	16.0
	Deputy Director	9	2.6	18.6
	General Manager	7	2.0	20.6
	Plant Manager	3	0.9	21.5
	Production Manager	41	11.9	33.4
	PPIC Manager	4	1.2	34.6
	Engineering Manager	5	1.4	36.0
	Quality Manager	13	3.8	39.8
	Product Manager	4	1.2	41.0
	Purchasing/ Procurement Manager	15	4.3	45.3
	Warehouse and Logistic Manager	6	1.7	47.0
	Process Manager	3	0.9	47.9
	HR Manager	10	2.9	50.8
	Project Manager	5	1.4	52.2
	Finance Manger	35	10.1	62.3
	Accounting Manager	15	4.3	66.6
	Marketing Manager	35	10.1	76.9
	Sales Manager	8	2.3	79.2
	IT Support Manager	6	1.7	80.9
	Production Supervisor	7	2.0	82.9
	Other Supervisors	59	17.1	100.0
Industry sector	Food manufacturing	56	16.2	16.2
	Miscellaneous manufacturing	34	9.9	26.1
	Transportation equipment manufacturing	30	8.7	34.8
	Fabricated metal product manufacturing	29	8.4	43.2
	Machinery manufacturing	26	7.5	50.7
	Plastics and rubber products manufacturing	20	5.8	56.5
	Computer and electronic product manufacturing	19	5.5	62.0
	Paper product manufacturing	15	4.3	66.3
	Chemical manufacturing	15	4.3	70.6
	Non-metallic mineral product manufacturing	15	4.3	74.9
	Furniture manufacturing	14	4.1	79.0
	Apparel manufacturing	14	4.1	83.1
	Beverage manufacturing	10	2.9	86.0
	Electrical equipment manufacturing	8	2.3	88.3
	Pharmaceutical and traditional medicines manufacturing	8	2.3	90.6

(continued on next page)

Table 1 (*continued*)

Variables		Frequency	Percent	Cumulative Percent
	Printing and related support activities	7	2.0	92.6
	Leather products and footwear manufacturing	6	1.7	94.4
	Primary metal manufacturing	6	1.7	96.1
	Textile mills	6	1.7	97.9
	Petroleum and coal products manufacturing	4	1.2	99.1
	Wood and wicker products manufacturing	3	0.9	100.0

the sharpness of the curve of the data distribution of each indicator tends to be close to normal (mesokurtic). The excess kurtosis value has a range from −0.869 to +2.706. In this study, the data indicates a normal distribution because the skewness is still between −3 and +3 and the kurtosis is still between −8 and +8 (Sugianto et al., 2023). All indicators imply no multicollinearity because all VIF values are below ten. Based on the results of descriptive statistics, most of the mean values for lean practices are greater than green practices.

4.2. Measurement model, validity and reliability tests

Referring to Hair et al. (2016), all constructs were tested for composite reliability to assess internal consistency. The convergent validity of each latent variable is evaluated through outer loading and average variance extracted (AVE) respectively. Referring to Hair et al. (2016), the factor loading of each measure must have a minimum value of 0.70 so that the convergent validity index can be met. We noticed some loadings did not meet the required conditions, such as LP1, LP9, LP10, LP11, LP13, LP18 on the 'Lean Practice', GP5 on the 'Green Practice', OP3, OP5, OP7, Env-P5, SP1, SP2, SP3, SP4, SP5, SP6 on 'Sustainable Supply Chain Performance'. As a result, some of these measures were removed from the model. Likewise, the AVE value for each construct ranges from 0.508 to 0.795, meaning that all constructs meet the requirement of 0.5 or more (Fornell and Larcker, 1981). According to Hair et al. (2016), all constructs were tested for composite reliability (CR) to assess internal reliability or consistency, where a minimum CR value is accepted at 0.7 or more. All latent variables are found to have met the desired conditions.

The discriminant validity of each research variable was tested based on the Fornel-Larker criteria, where the square root for each AVE itself were greater than the correlations with other constructs (Fornell and Larcker, 1981). Several indicators were eliminated, (such as LP15, LP16, GP6, EP2, OP1, OP6) to meet the discriminant validity of each construct as can be seen in Table 2. Furthermore, in this study, the discriminant validity of each construct was also checked by analysis of loading and cross-loading (Hair et al., 2016), where the loading of each indicator in a construct was higher than in the other constructs. Further, discriminant validity was verified as valid where the square root of AVE in the diagonal are higher than all the inter-construct correlation coefficients indicated below the diagonal.

Table 2
Discriminant validity test.

	CS	GP	LP	OCTr	PI	Sus-SCP	TMCL
CS	**0.802**						
GP	0.733	**0.838**					
LP	0.746	0.678	**0.801**				
OCTr	0.731	0.578	0.688	**0.753**			
PI	0.659	0.547	0.588	0.636	**0.889**		
Sus-SCP	0.764	0.836	0.780	0.626	0.558	**0.803**	
TMCL	0.767	0.735	0.654	0.667	0.584	0.730	**0.866**

Note: Diagonal values are the square root of AVE (refer Table 3 for AVE).

Table 3
Factor loadings, CR and AVE.

Constructs	Items	Factor Loadings	CR	AVE
Top Management Commitment & Leadership (TMCL)	8	Max: 0.922; Min: 0.739	0.960	0.750
Organizational Culture Transformation (OCTr)	6	Max: 0.780; Min: 0.708	0.887	0.566
Collaborative Synergy (CS)	6	Max: 0.877; Min: 0.746	0.915	0.644
Policy Initiatives (PI)	2	Max: 0.938; Min: 0.838	0.883	0.791
Lean Practice (LP)	9	Max: 0.858; Min: 0.734	0.941	0.641
Green Practice (GP)	6	Max: 0.887; Min: 0.772	0.934	0.702
Sustainable Supply Chain Performance (Sus-SCP)	10	Max: 0.863; Min: 0.749	0.948	0.645

4.3. Structural path model

PLS-SEM was used to undertake a path analysis as illustrated in Fig. 2. Referring to Hair et al. (2018), both SRMR estimated and saturated (0.060 and 0.059 respectively) are below 0.08 (the recommended threshold). The χ^2 estimated (=3041.007) is greater than the χ^2 saturated (=3021.570). In this study, RMS_theta is 0.119. Henseler et al. (2014) revealed that a well-fitting model has an RMS_theta value below 0.12 if a higher value indicates a lack of fit. This study uses SRMR, Chi-square and RMS_theta instead of NFI for a goodness of fit determination because NFI might reflect a lack of fit even though other indices demonstrate otherwise. The constructs, items, range of factor loadings, CR and AVE are shown in Table 3.

4.4. Hypotheses testing

The hypotheses were tested using path coefficients together with p-values and t-statistics from bootstrapping results with 5000 subsamples, two-tailed test, significance at 0.05 level, and bias-corrected confidence interval method. The effect of antecedents on GP and on Sus-SCP is identified through PLS-SEM analysis. Table 4 demonstrates a summary of the results of hypotheses testing. The validation or rejection of the hypothesis depends on the results of β, t-value, and p-value obtained from the path analysis. The path coefficient between the independent and dependent variables needs to be significant (t-value >1.96, p-value <0.05 sig. level), so that the hypothesis is accepted. Table 4 and Fig. 3 present the results of the path coefficients and significance level of the relationship that helped supporting/not-supporting the hypotheses.

As shown in Table 4, some of the proposed hypotheses were supported based on the results of $p < 0.01$ for H1 to H3 and $p < 0.05$ for H4. The path relationship between LP and GP was significant ($\beta = 0.368$, $t = 5.516$, $p = 0.000$). Thus, the results show that there is a positive and significant impact of the level of LP on the extent of GP. In addition, this study agrees that there is a significant positive impact of GP on Sus-SCP ($\beta = 0.499$, $t = 11.730$, $p = 0.000$). There is also a significant correlation between LP and Sus-SCP ($\beta = 0.332$, $t = 6.253$, $p = 0.000$). Furthermore, a significant moderating effect of TMCL was found on the correlation between LP and GP ($\beta = 0.097$, $t = 2.016$, $p = 0.044$). The R^2 value of 0.626 for GP means that all antecedent variables account for 62.6% variation in green practice of Indonesian manufacturing SMEs. Likewise, the R^2 value of 0.793 for Sus-SCP means that all antecedent variables account for 79.3% variation in sustainable supply chain performance of Indonesian manufacturing SMEs.

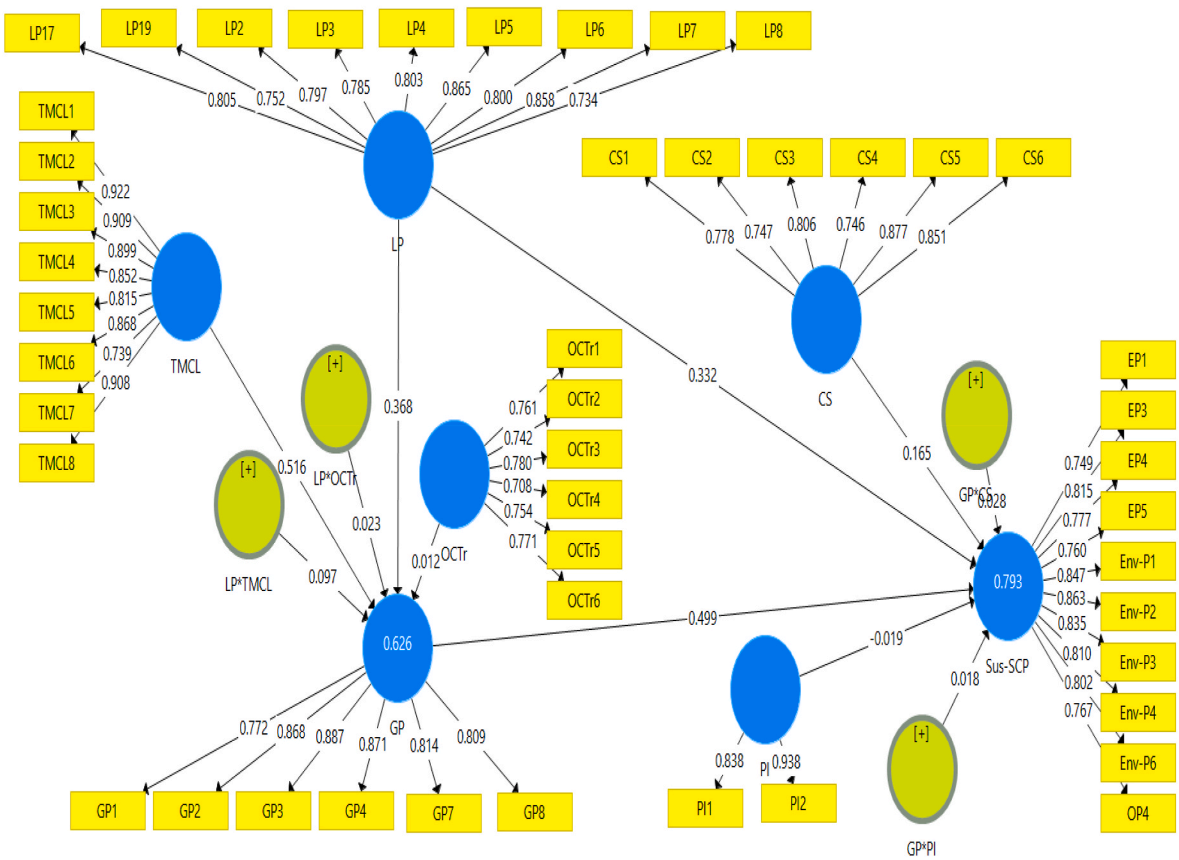

Fig. 2. Outer loadings path model.

Table 4
Results of hypotheses testing.

Hypotheses	Path Coefficient	Sample Mean	Standard Deviation	t-Value	p-Values	Decision
H1: LP - > GP	0.368	0.362	0.065	5.516	0.000***	Supported
H2: GP - > Sus-SCP	0.499	0.501	0.042	11.730	0.000***	Supported
H3: LP - > Sus-SCP	0.332	0.328	0.053	6.253	0.000***	Supported
H4: LP × TMCL - > GP	0.097	0.087	0.047	2.016	0.044**	Supported
H5: LP × OCTr - > GP	0.023	0.028	0.044	0.497	0.619^{ns}	Not supported
H6: GP × CS - > Sus-SCP	0.028	0.027	0.038	0.742	0.458^{ns}	Not supported
H7: GP × PI - > Sus-SCP	0.018	0.017	0.043	0.420	0.674^{ns}	Not supported
Mediation effect: LP - > GP - > Sus-SCP	0.184	0.181	0.037	4.937	0.000***	Supported

Note: **sig. At 0.05; ***sig. At 0.01; ^{ns}non-significant.

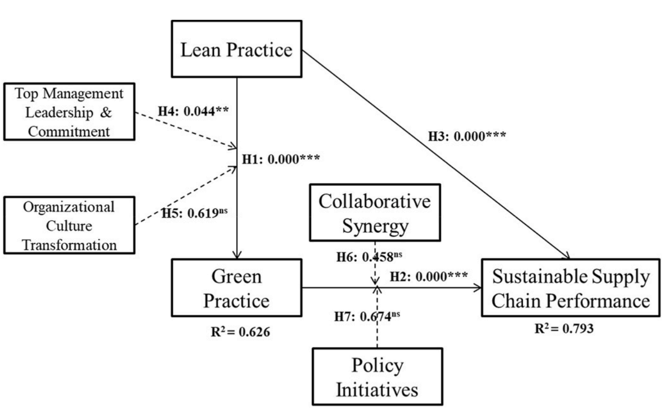

Fig. 3. Path model showing hypotheses testing.

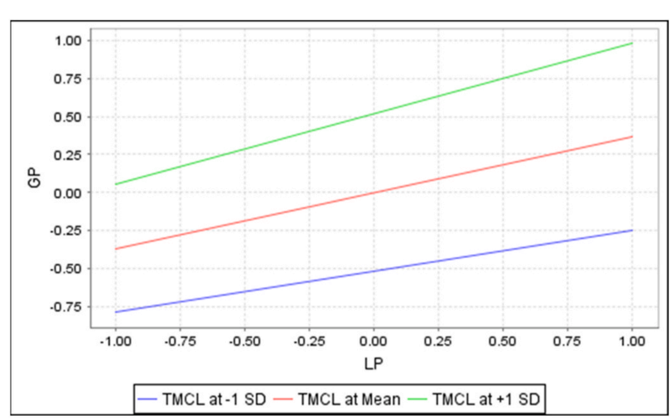

Fig. 4. Simple slopes plot for LP × TMCL.

4.5. Moderator analysis

Based on the simple slopes analysis in Figs. 4–7, green line is one standard deviation below the mean, and blue line is one standard deviation above the mean. Fig. 4 shows that TMCL exerts a positive and significant moderating effect on the relationship between LP and GP because it's sloping bottom to top left to right. The green line is with more TMCL, the blue line is with less TMCL. The effect of LP on GP is positive because this red line the mean is sloping upward, and that positive relationship is amplified or strengthened by TMCL. Thus, the positive effect has a steeper slope positive slope when there is more TMCL.

Fig. 5 demonstrates that the three lines almost coincide with each other and there is an intersection point. OCTr does not moderate the relationship between LP and GP, possibly a very mild positive effect. Nonetheless, the green line with more OCTr is indicated to have a steeper positive effect than the blue line with less OCTr. In other words, the positive relationship between LP and GP is dampened by the low OCTr.

Fig. 6 shows the three lines are parallel or almost parallel, which means there is no real moderating effect, and this is in line with the result of the H6 hypothesis test. If the lines are parallel that means, there's nothing go on even when it obtain a statistically significant moderated effect.

Fig. 7 demonstrates that PI does not moderate significantly the correlation between GP and Sus-SCP because the three lines almost coincide with each other. The positive relationship between GP and Sus-SCP is dampened by the low level of PI. The blue line with lower PI has a negative effect because it has a less steep slope than the green line with higher PI. Whereas if higher PI have a positive effect.

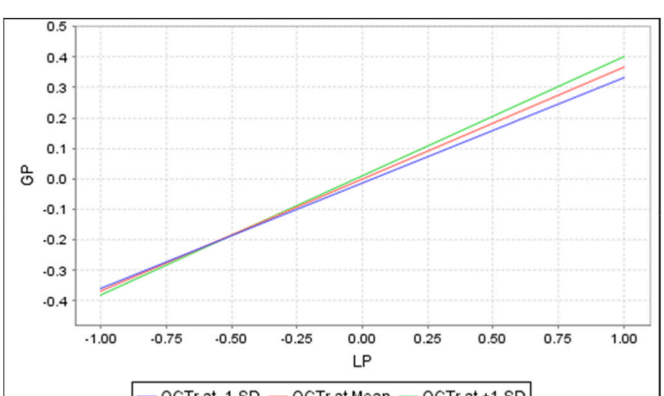

Fig. 5. Simple slopes plot for LP × OCTr.

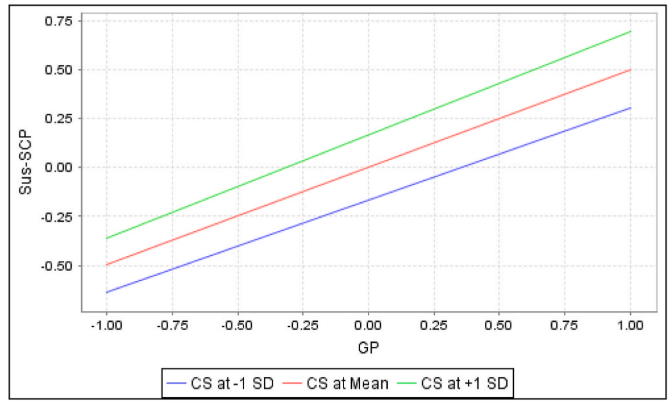

Fig. 6. Simple slopes plot for GP × CS.

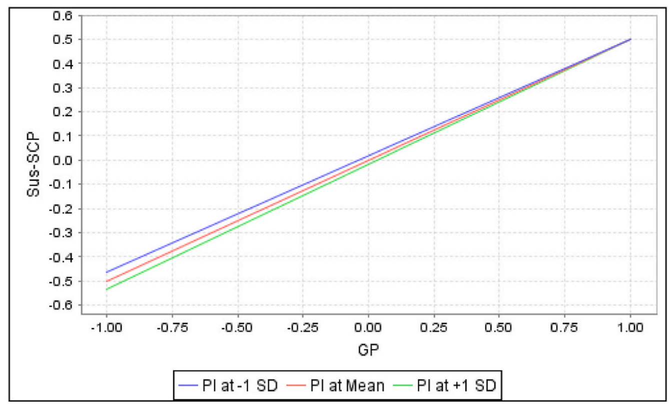

Fig. 7. Simple slopes plot for GP × PI.

5. Discussion

This study investigates the influence of Green-Lean practices on sustainability performance of supply chain in Indonesian manufacturing SMEs. Findings suggest that lean practices are antecedent to the level of green practices for the SMEs in manufacturing. The H1 hypothesis is supported based on the results (β = 0.368, t-value = 5.516, $p < 0.01$). The relationship between lean practice and green practice in this study is in line with the findings of Yang et al. (2011), who suggest that lean practices are an important antecedent of green practices. Melnyk et al. (2003) argue that the continuous waste reduction efforts of lean companies make them naturally green. Duarte and Cruz-Machado (2013) state that synchronization of these two practices focuses on reducing waste, but the point of view of waste from the two practices has different meaning. Therefore, lean can serve as a green catalyst, accommodating companies in complying with environmentally friendly policies and implementing green practices (Thekkoote, 2022). This research results indicate that lean techniques and tools are most widely applied in Indonesian manufacturing SMEs such as 5 S or housekeeping, TPM, SMED, supplier development, work standardization or ISO 9001, and kaizen (this finding is in line with Kosasih et al., 2023b; Siegel et al., 2019). Meanwhile, the most widely applied green techniques and tools in Indonesian manufacturing SMEs include 3 R, design for the environment, eco-design, community or society engagement, environment management system or ISO 14001, and corporate environmental-friendly programs (this finding is in line with Kosasih et al., 2023b; Dey et al., 2020; Siegel et al., 2019).

Results indicate that the level of green practices positively and significantly mediates the effect of the extent of lean practices on SC sustainability performance in manufacturing SMEs. The H2 hypothesis is supported based on the results obtained (β = 0.499, t-value = 11.730, $p < 0.01$). It is mediated by green practices with an indirect effect of +0.183. The results supported the hypothesis H3 (beta = 0.332, t-value = 6.253, $p < 0.01$) thereby the level of lean practices positively and significantly influences the performance of SME SC sustainability. This finding is consistent with Thekkoote (2022), Thanki and Thakkar (2019), Bergmiller and McCright (2009), where they claim that companies which adopt of both lean practice and green practice simultaneously are able to achieve more optimal results than if only adopting lean practice or green practice separately. In addition, green practice as a mediator in the relation of lean practice and SC sustainability performance is in line with the findings of Wiengarten et al. (2013) and Hussain et al. (2019) which demonstrates that lean practice and green practice have a synergistic impact on performance of SC sustainability. This study can provide a foundation for lean companies, particularly manufacturing SMEs, to continuously strive to achieve green and SC sustainability. As environmental awareness continues to increase, it is suggested in this study that manufacturing SMEs need concrete green practices in overcoming environmental problems, developing or marketing environmentally friendly products, and also towards the sustainability of their business or SC performance.

Cantele et al. (2023), Maher et al. (2023), Saulick et al. (2023) suggest that SC sustainability performance is considered insufficient if it only relies on traditional measures or indicators such as economic performance. Therefore, environmental and social performances are also needed to consider in measuring SC sustainability performance. Saulick et al. (2023), Bai et al. (2012), Shepherd and Gunter (2006) claim that performance of SC sustainability includes multi-dimensional constructs which consist of economic, operational, environmental, or/and social aspects. Businesses have realized the importance of preserving the environment, which also provides several benefits for business in addition to its benefits for the environment (Asadi et al., 2020).

Based on the results, performance measures that can be used as key performance indicators (KPIs) and become the main focus for improvement in achieving SC sustainability goals for Indonesian manufacturing SMEs include cost reduction, savings on environmental or CO_2 emission cost, supplier cost savings, return on assets (ROA), response to product changes, air emissions (CO_x or NO_x) reduction, energy consumption reduction, solid waste disposal reduction, and percentage of recycled materials. In this study, there was analysis done separately for each aspect of sustainability performance. The results show that lean practice or lean-green practices positively and significantly affect the SC sustainability performance in Indonesian manufacturing SMEs, not only on economic and operational performances, but also on social and environmental sustainability performance separately. Hence, SME owners or managers have to consider and trade-off both economic and non-economic objectives when making their managerial decisions. According to Asadi et al. (2019), and Gürlek et al. (2017), balancing social and environmental sustainability aspects with economic growth is considered the main goal in the sustainable development of a business and its supply chain.

The positive relation between lean practice and green practice in manufacturing SMEs is amplified (moderated positively and significantly) in the presence of leadership and top management commitment. Based on the results ($\beta = 0.097$, t-value $= 2.016$, $p < 0.05$), the hypothesis H4 is supported. This finding is consistent with the study by Duarte and Cruz-Machado (2013) who stated that top management commitment drives lean-green transformation. Meanwhile, the results obtained ($\beta = 0.023$, t-value $= 0.497$, $p > 0.05$) could not support the hypothesis H5 meaning that organizational culture transformation does not moderate significantly the relationship between lean practice and green practice in manufacturing SMEs. The findings differ from the previous study by Alves and Alves (2015), and Zhan et al. (2018), in a way that practitioners feel overwhelmed to adopt green-lean practices when there is resistance to change. In addition, Dües et al. (2013) also argue that the lack of awareness and sense of responsibility towards the environment tends to hinder its implementation.

The findings also show that collaborative synergy does not moderate significantly the correlation between green practice and SC sustainability performance in manufacturing SMEs. The hypothesis H6 is not supported based on the results obtained (beta $= 0.028$, t-value $= 0.742$, $p > 0.05$). Nevertheless, the finding is in line with previous work from Das and Rangarajan (2020) who claim that collaborative synergies such as establishing partnerships with suppliers and customers, focusing on value creation and maintaining long-term proactive relationships with stakeholders, significantly affect the sustainability performance. In addition, their findings indicate that collaborative synergies affect all three aspects of SME SC sustainability performance, such as economic, environmental and social. Meanwhile, based on the results obtained (beta $= 0.018$, t-value $= 0.420$, $p > 0.05$), the hypothesis H7 could not be supported either. The results show that policy initiative does not moderate significantly the correlation between green practice and SC sustainability performance in manufacturing SMEs. This finding is not in line with previous studies from Borsatto and Amui (2019), Das and Rangarajan (2020), and Zailani et al. (2015) who suggested that appropriate environmental regulations or policies might improve green practices or innovations as well as sustainability performance. However, based on a separate analysis of each aspect of sustainability performance it is found that policy initiatives have a significant and positive impact on social sustainability performance only. On the one hand, Porter and Linde (2000) suggest that appropriate environmental regulation can generate innovative actions or green practices of organizations and lead organizations to change from an obsolete technology model to a clean or environmentally friendly technology model. However, this finding is supported by a study of Siegel et al. (2019) who state that there are a few of challenges in practicing green-lean and sustainability for SMEs, such as weak competence or awareness of environmental concern for human resources and financial weakness as their main problems. In fact, the survey results on the participation of Indonesian SMEs in social and environmental initiatives obtained an average of 3.88 in a scale of 1–5, which means that their level of participation in these initiatives still needs to be encouraged and increased. Accordingly, government regulations on environmental policies should also be taken into account which allows SMEs to be proactive and encourage them to build collaborations with their stakeholders to meet the expectations of beneficiaries such as large companies in the supply chain.

6. Conclusions and implications

6.1. Conclusions

This research examined the influences of Lean Practice (LP), and Green Practice (GP) on performance of SME supply chain sustainability in Indonesia. Further, it investigated how Top Management Commitment and Leadership (TMCL), Organizational Culture Transformation (OCTr), Policy Initiative (PI), and Collaborative Synergy (CS) moderated these relationships. This study is unique in the sense it specifically addresses the SC sustainability of manufacturing SMEs where lean practices have significant effect on green practices. Further, this study shows that green practices play a mediating role in lean practices to improve SC sustainability performance, meaning that manufacturing SMEs that implement better green practices using lean principles are able to improve performance. Moreover, TMCL has a significant moderating effect indicating a better leadership and top management commitment are able to better integrate lean-green practices. However, OCTr does not have a significant moderating effect, which implies that a better transformation of organizational culture does not significantly affect the integration of better lean-green practices. Our study also found that PI and CS did not have a significant moderating effect on the correlation between green practice and SME supply chain sustainability performance indicating that the association was not affected or would not become significantly stronger when high levels of PI and CS were present.

The application of an integrated lean-green system to manufacturing SMEs significantly affect social and environmental sustainability performance separately. The social sustainability of SME supply chains is strongly influenced by two factors. The first is a policy initiative in which the government's role is very important. Based on result of our study, Indonesian SMEs have not had a very high level of participation in social and environmental initiatives. This makes sense and is understandable because SMEs tend to still focus on business continuity due to lack of capability of their human resources and limitation on financial resources. The second factor is collaborative synergies, where they require integrated decision-making mechanisms within a coordinated supply chain. This study recommends that regulations set by the government regarding social and environmental initiatives should also take into account, which enables organizations to be proactive and encourages them to build collaboration with stakeholders. This study does not attempt to assess the adoption level of a lean-green framework on SC sustainability performance over a longer period. Future studies also need to look at the characteristics of manufacturing SMEs for certain industrial sectors by making comparisons through a multiple case study to obtain a more implementable framework. It is also important to study the level of maturity or readiness of SMEs when adopting an integrated lean-green systems framework.

6.2. Theoretical and managerial implications

This research offers many implications. Theoretically, it offers a tailored framework for SMEs to apply lean-green practices and their SC sustainability effectively. The framework seeks to find answers to the research questions addressed in the introductory section of this article. The findings from this empirical study assist SME owners or managers in building a comprehensive lean-green model to guide them towards achieving their SC sustainability. In addition, the findings of this study further clarify that SMEs can improve their sustainability performance by playing an important role in factors such as government support or collaborative initiatives between SMEs and other stakeholders.

Practically, first, sound knowledge and skilled human resources and availability of financial resources are important supporting factors for SMEs to implement a lean-green system in their sustainable development. Therefore, SME managers need to increase both horizontal and vertical collaboration to increase their business competitiveness and growth. Horizontal collaboration is an attempt to consolidate best practices or strengths among various SMEs. This can be in the form of a community or other cluster. Vertical collaboration includes all stakeholders in their supply chain at both upstream and downstream levels including with the government agencies. Second, they also need to develop strategies used by SME managers to direct them towards sustainable development goals. Most SMEs do not yet have risk mitigation and their long-term plans or goals, so it is necessary to prepare a mapping plan to increase their resilience and sustainability.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.clrc.2023.100143.

Appendix A. Survey Questionnaire

No.	Construct	Indicators/items		References
1.	Top management commitment and leadership	TMCL1	Top management demonstrates their commitment and engagement towards green and lean practices	Duarte and Cruz-Machado (2013); Cherrafi et al. (2017); Wong and Wong (2014); Zhan et al. (2018)
		TMCL2	Top management sets strategic and measurable green and lean goals	
		TMCL3	Top management communicates the importance of green and lean to the organization	
		TMCL4	Top management ensures the principles of green and lean practices such as efficiency and waste reduction	
		TMCL5	Top management defines commitment to all stakeholders and communication between them, as a means of reducing cost, environmental and time risks	
		TMCL6	Top management ensures investment to help green and lean transformation	
		TMCL7	Top management ensures legal enforcement and regulates the rules	
		TMCL8	Top management ensures implementation of management systems to assist green and lean implementation	
2.	Organizational culture transformation	OCTr1	The company involves every employee such as waste reduction, problem solving, and continuous improvement	Duarte and Cruz-Machado (2013); Zhan et al. (2018); Daily and Huang (2001); Alves and Alves (2015)
		OCTr2	The company applies principles such as flexible job responsibilities, cross-functional training, and job enlargement and enrichment	
		OCTr3	The company encourages employees to keep looking for new ways by suggesting innovative ideas	
		OCTr4	The company ensures recognition and rewards for employees	
		OCTr5	The company determines the competencies required for employees	
		OCTr6	The company provides training and education to improve employee skills	
3.	Policy initiatives	PI1	The company has awareness of and compliance with government policies and programs	Gandhi et al. (2018); Das and Rangarajan (2020)
		PI2	The company participates in government social and environmental initiatives	
4.	Collaborative synergy	CS1	The company participates in sharing sustainability best practices within the business community or SME cluster	Zhan et al. (2018); Das and Rangarajan (2020); Duarte and Cruz-Machado (2013)
		CS2	The company always establishes beneficial cooperation (in terms of sustainability requirements) for suppliers and customers	
		CS3	The company is focused on creating value for all their stakeholders, such as investors, suppliers, employees and the communities	
		CS4	The company always fosters and maintains proactive and long-term relationships with all their stakeholders, such as investors, suppliers, customers, and the communities	
		CS5	The company ensures the selection of suppliers or partner companies according to green and lean criteria	

(continued on next page)

(*continued*)

No.	Construct	Indicators/items		References
		CS6	The company encourages suppliers or partner companies to integrate a lean and green approach into their business	
5.	Lean practice	LP1	Only the necessary production equipment and materials are found in the production area	Wu et al. (2015); Sajan et al. (2017); Thanki and Thakkar (2019); Belhadi et al. (2018); Siegel et al. (2019); Thanki et al. (2016)
		LP2	The location for placing materials/production goods is always clearly marked	
		LP3	Work areas, storage warehouses and production equipment must be concise, neat, clean and free from hazards	
		LP4	The production equipment is always ready to use whenever needed	
		LP5	The production equipment is inspected and maintained regularly so that it is safe to use and can operate longer	
		LP6	Production workers in our company are trained to care for and maintain their own production equipment/machines	
		LP7	The production line has spare time for planned maintenance of production machines/equipment	
		LP8	The company uses flexible production machinery/equipment, which requires short setup times when product changes occur	
		LP9	If there is a workplace that is not producing, then our workers can be transferred to another workplace according to their needs and functions	
		LP10	The production personnel are trained to handle several different tasks on the shop floor	
		LP11	If one of the production equipment/machines is damaged, the production can be replaced with another machine to do the same job	
		LP12	The company only produces products/goods/services only when needed by users or customers	
		LP13	Production on each line will be carried out on request from the next production line	
		LP14	The company uses a production system where products/services are produced only in the required quantities (no less and no excessive).	
		LP15	The company suppliers send materials/raw materials according to company needs	
		LP16	The company suppliers deliver materials/raw materials on time and defect-free	
		LP17	The production lines carry out standard operating procedures consistently and very well	
		LP18	The company implements QMS (such as ISO 9001 or ISO/TS 16949) consistently and well	
		LP19	Quality improvement is carried out continuously using the PDCA principle (plan, do, check, action)	
6.	Green practice	GP1	The company always reduces, reuses and recycles non-environmentally friendly production/service materials	Thanki and Thakkar (2019); Verrier et al. (2014); Siegel et al. (2019); Wu et al. (2015); Thanki et al. (2016)
		GP2	The company uses environmentally friendly product/goods packaging	
		GP3	The company designs products/goods/services that are environmentally friendly and involve their suppliers	
		GP4	The company involves the community or society in environmental improvement programs	
		GP5	The company prioritizes local sourcing as its supplier	
		GP6	The company takes back products/items that are worn out, damaged or discarded by customers for recycling or refurbishment or destruction	
		GP7	The company implements EMS (such as ISO 14001) consistently and well	
		GP8	The company always encourages and organizes CSR activities such as reforestation or tree replanting or other corporate responsibility programs towards the environment	
7.	Supply chain (SC) sustainability performance:			
	Economic performance	EP1	The company can reduce operational/production costs at the company in accordance with the targets that have been set	Bai et al. (2012); Wu et al. (2015); Gunasekaran and Kobu (2007); Shepherd and Gunter (2006); Sarkis and Talluri (2002)
		EP2	Market share can be increased according to the set target	
		EP3	The company can save environmental costs or CO2 emission costs better than in previous years	
		EP4	The company always initiates supplier cost savings	
		EP5	Return on assets (ROA) can be increased according to the set target	
	Operational performance	OP1	The company can improve process cycle efficiency (value added ratio) in its production/operational lines	Bai et al. (2012); Wu et al. (2015); Gunasekaran and Kobu (2007); Shepherd and Gunter (2006); Sarkis and Talluri (2002)
		OP2	The company produces consistent and quality products/services (according to the desired standard specifications) with a low defect rate or according to the set targets	
		OP3	The company can minimize the level of customer complaints regarding the quality of our products or services	
		OP4	The company can quickly modify/change products/services or respond to requests for development of environmentally friendly products/services to meet customer needs	
		OP5	The company can provide product/service delivery in a short time or on time according to customer needs	
		OP6	The company can increase production capacity according to customer demand	
		OP7	Information accuracy can be improved compared to previous years	

(*continued on next page*)

(*continued*)

No.	Construct	Indicators/items		References
		OP8	The overall productivity of our production/operational lines is better than in previous years	
	Environmental performance	Env-P1	The company can reduce air emissions (CO_x or NO_x) better than in previous years	Bai et al. (2012); Wu et al. (2015); Gunasekaran and Kobu (2007); Shepherd and Gunter (2006); Sarkis and Talluri (2002)
		Env-P2	The company can reduce energy consumption in its production/ operational lines	
		Env-P3	The company can reduce wastewater generation in its production/ operational lines	
		Env-P4	The company can reduce solid waste disposal in its production/ operational lines	
		Env-P5	The company can reduce or even eliminate the use of hazardous or/and toxic substances	
		Env-P6	The company can increase the use of recycled materials	
	Social performance	SP1	The company always ensures occupational health and safety	Bai et al. (2012); Wu et al. (2015); Gunasekaran and Kobu (2007); Shepherd and Gunter (2006); Sarkis and Talluri (2002)
		SP2	The company can improve the level of employee welfare every year	
		SP3	The company can increase employee satisfaction every year	
		SP4	The company can improve customer satisfaction every year	
		SP5	The company's social reputation can be improved compared to previous years	
		SP6	The company can increase the level of planning with suppliers, communities or/and customers for environmental improvement	

References

Albliwi, S., Antony, J., Abdul, S., Lim, H., Wiele, T.V.D., 2014. Critical failure factors of lean six sigma: a systematic literature review. Int. J. Qual. Reliab. Manag. 31 (9), 1012–1030. https://doi.org/10.1108/IJQRM-09-2013-0147.

Alves, J.R.X., Alves, J.M., 2015. Production management model integrating the principles of lean manufacturing and sustainability supported by the cultural transformation of a company. Int. J. Prod. Res. 53 (17), 5320–5333. https://doi.org/10.1080/00207543.2015.1033032.

Asadi, S., Nilashi, M., Safaei, M., Abdullah, R., Saeed, F., Yadegaridehkordi, E., Samad, S., 2019. Investigating factors influencing decision-makers' intention to adopt Green IT in Malaysian manufacturing industry. Resour. Conserv. Recycl. 148, 36–54. https://doi.org/10.1016/j.resconrec.2019.04.028.

Asadi, S., Pourhashemi, S.O.-S., Nilashi, M., Abdullah, R., Samad, S., Yadegaridehkordi, E., Aljojo, N., Razali, N.S., 2020. Investigating influence of green innovation on sustainability performance: a case on Malaysian hotel industry. J. Clean. Prod. 258, 120860 https://doi.org/10.1016/j.jclepro.2020.120860.

[BPS] Badan Pusat Statistik, 2019a. Statistik Industri Manufaktur Indonesia. ID: BPS RI. Catalog, 6103019.

[BPS] Badan Pusat Statistik, 2019b. Tabel dinamis industri pengolahan [Online]. https://www.bps.go.id. (Accessed 12 September 2021).

Bai, C., Sarkis, J., Wei, X., Koh, L., 2012. Evaluating ecological sustainable performance measures for supply chain management. Supply Chain Manag. 17 (1), 78–92. https://doi.org/10.1108/13598541211212221.

Belhadi, A., Touriki, F.E., El Fezazi, S., 2018. Benefits of adopting lean production on green performance of SMEs: a case study. Prod. Plann. Control 29 (11), 873–894. https://doi.org/10.1080/09537287.2018.1490971.

Bergmiller, G.G., McCright, P.R., 2009. Are lean and green programs synergistic?. In: Proceedings of the 2009 Industrial Engineering Research Conference Miami, FL, May 2009.

Beske-Janssen, P., Johnson, M.P., Schaltegger, S., 2015. 20 years of performance measurement in sustainable supply chain management – what has been achieved? Supply Chain Manag.: Int. J. 20 (6), 664–680. https://doi.org/10.1108/SCM-06-2015-0216.

Borsatto, J.M.L.S., Amui, L.B.L., 2019. Green innovation: unfolding the relation with environmental regulations and competitiveness. Resour. Conserv. Recycl. 149, 445–454. https://doi.org/10.1016/j.resconrec.2019.06.005.

Cantele, S., Russo, I., Kirchoff, J.F., Valcozzena, S., 2023. Supply chain agility and sustainability performance: a configurational approach to sustainable supply chain management practices. J. Clean. Prod. 414, 137493 https://doi.org/10.1016/j.jclepro.2023.137493.

Cherrafi, A., Elfezazi, S., Garza-Reyes, J.A., Benhida, K., Mokhlis, A., 2017. Barriers in green lean implementation: a combined systematic literature review and interpretive structural modelling approach. Prod. Plann. Control 28 (10), 829–842. https://doi.org/10.1080/09537287.2017.1324184.

Choudhary, S., Nayak, R., Dora, M., Mishra, N., Ghadge, A., 2019. An integrated lean and green approach for improving sustainability performance: a case study of a packaging manufacturing SME in the U.K. Prod. Plann. Control 30 (5–6), 353–368. https://doi.org/10.1080/09537287.2018.1501811.

Daily, B.F., Huang, S., 2001. Achieving sustainability through attention to human resource factors in environmental management. Int. J. Oper. Prod. Manag. 21 (12), 1539–1552. https://doi.org/10.1108/01443570110410892.

Das, M., Rangarajan, K., 2020. Impact of policy initiatives and collaborative synergy on sustainability and business growth of Indian SMEs. Indian Growth Dev. Rev. 13 (3), 607–627. https://doi.org/10.1108/IGDR-09-2019-0095.

Dey, P.K., Malesios, C., De, D., Chowdhury, S., Abdelaziz, F. Ben, 2020. The impact of lean management practices and sustainably-oriented innovation on sustainability performance of small and medium-sized enterprises: empirical evidence from the UK. Br. J. Manag. 31 (1), 141–161. https://doi.org/10.1111/1467-8551.12388.

Duarte, S., Cruz-Machado, V., 2013. Modelling lean and green: a review from business models. Int. J. Lean Six Sigma 4 (3), 228–250. https://doi.org/10.1108/IJLSS-05-2013-0030.

Dües, C.M., Tan, K.H., Lim, M., 2013. Green as the new lean: how to use lean practices as a catalyst to greening your supply chain. J. Clean. Prod. 40, 93–100. https://doi.org/10.1016/j.jclepro.2011.12.023.

Eniola, A.A., Entebang, H., 2015. Government policy and performance of small and medium business management. Int. J. Acad. Res. Bus. Soc. Sci. 5 (2), 237–248. https://doi.org/10.6007/IJARBSS/v5-i2/1481.

Field, E., Pears, E., Schaninger, B., 2022. A Single Approach to Culture Transformation May Not Fit at All. McKinsey & Company, New York, United States.

Fornell, C., Larcker, D.F., 1981. Evaluating structural equation models with unobservable variables and measurement error. J. Market. Res. 18 (1), 39–50. https://doi.org/10.1177/002224378101800104.

Gandhi, N.S., Thanki, S.J., Thakkar, J.J., 2018. Ranking of drivers for integrated lean-green manufacturing for Indian manufacturing SMEs. J. Clean. Prod. 171, 675–689. https://doi.org/10.1016/j.jclepro.2017.10.041.

Grigg, N.P., Goodyer, J.E., Frater, T.G., 2020. Sustaining lean in SMEs: key findings from a 10-year study involving New Zealand manufacturers. Total Qual. Manag. Bus. Excel. 31 (5–6), 609–622. https://doi.org/10.1080/14783363.2018.1436964.

Gunasekaran, A., Kobu, B., 2007. Performance measures and metrics in logistics and supply chain management: a review of recent literature (1995-2004) for research and applications. Int. J. Prod. Res. 45, 2819–2840. https://doi.org/10.1080/00207540600806513.

Gürlek, M., Düzgün, E., Meydan Uygur, S., 2017. How does corporate social responsibility create customer loyalty? The role of corporate image. Soc. Responsib. J. 13 (3), 409–427. https://doi.org/10.1108/SRJ-10-2016-0177.

Hair, J.F., Hult, G.T.M., Ringle, C., Sarstedt, M., 2016. A Primer on Partial Least Squares Structural Equation Modeling (PLS-SEM). Sage publications, London.

Hair, J.F., Black, W.C., Babin, B.J., Anderson, R.E., 2018. Multivariate Data Analysis, eighth ed. Cengage Learning, United Kingdom.

Hassini, E., Surti, C., Searcy, C., 2012. A literature review and a case study of sustainable supply chains with a focus on metrics. Int. J. Prod. Econ. 140 (1), 69–82. https://doi.org/10.1016/j.ijpe.2012.01.042.

Henseler, J., Dijkstra, T.K., Sarstedt, M., Ringle, C.M., Diamantopoulos, A., Straub, D.W., Ketchen, D.J., Hair, J.F., Hult, G.T.M., Calantone, R.J., 2014. Common beliefs and reality about partial least squares: comments on Rönkkö & Evermann (2013). Organ. Res. Methods 17 (2), 182–209. https://doi.org/10.1177/1094428114526928.

Hu, Q., Mason, R., Williams, S.J., Found, P., 2015. Lean implementation within SMEs: a literature review. J. Manuf. Technol. Manag. 26 (7), 980–1012. https://doi.org/10.1108/JMTM-02-2014-0013.

Hussain, M., Al-Aomar, R., Melhem, H., 2019. Assessment of lean-green practices on the sustainable performance of hotel supply chains. Int. J. Contemp. Hospit. Manag. 31 (6), 2448–2467. https://doi.org/10.1108/IJCHM-05-2018-0380.

Jacob, H., Johnson, M.P., Stefan, S., 2015. Implementation of sustainability management and company size: a knowledge-based view. Bus. Strat. Environ. 24 (8), 765–779. https://doi.org/10.1002/bse.1844.

Kosasih, W., Pujawan, I.N., Karningsih, P.D., 2023a. Integrated lean-green practices and supply chain sustainability for manufacturing SMEs: a systematic literature review and research agenda. Sustainability 15, 12192. https://doi.org/10.3390/su151612192.

Kosasih, W., Pujawan, I.N., Karningsih, P.D., 2023b. Conceptual model for integrated lean-green practices and supply chain sustainability for manufacturing SMEs. In: *Proceedings Of the 5th European Conference On Industrial Engineering And Operations Management*, pp. 1913–1925. https://doi.org/10.46254/EU05.20220381.
Law of the Republic of Indonesia No. 20 of 2008 Concerning Micro, Small and Medium Enterprises, 5-6.
Luthra, S., Garg, D., D, Haleem, A., A, 2015. Critical success factors of green supply chain management for achieving sustainability in Indian automobile industry. Prod. Plann. Control 26 (5), 339–362. https://doi.org/10.1080/09537287.2014.904532.
Maher, R., Yarnold, J., Pushpamali, N.N.C., 2023. Circular economy 4 business: a program and framework for small-to-medium enterprises (SMEs) with three case studies. J. Clean. Prod. 412, 137114 https://doi.org/10.1016/j.jclepro.2023.137114.
Malhotra, M.K., Grover, V., 1998. An assessment of survey research in POM: from constructs to theory. J. Oper. Manag. 16 (4), 407–425. https://doi.org/10.1016/S0272-6963(98)00021-7.
Melnyk, S.A., Sroufe, R.P., Calantone, R., 2003. Assessing the impact of environment management systems on corporate and environmental performance. J. Oper. Manag. 21 (3), 329–351. https://doi.org/10.1016/S0272-6963(02)00109-2.
Moore, S.B., Manring, S.L., 2009. Strategy development in small and medium sized enterprises for sustainability and increased value creation. J. Clean. Prod. 17 (2), 276–282. https://doi.org/10.1016/j.jclepro.2008.06.004.
Pampanelli, A.B., Found, P., Bernardes, A.M., 2014. A lean & green model for a production cell. J. Clean. Prod. 85, 19–30. https://doi.org/10.1016/j.jclepro.2013.06.014.
Panizzolo, R., Garengo, P., Sharma, M.K., Gore, A., 2012. Lean manufacturing in developing countries: evidence from Indian SMEs. Prod. Plann. Control 23 (10–11), 769–788. https://doi.org/10.1080/09537287.2011.642155.
Parker, C.M., Redmond, J., Simpson, M., 2009. A review of interventions to encourage SMEs to make environmental improvements. Environ. Plann. C Govern. Pol. 27 (2), 279–301. https://doi.org/10.1068/c0859b.
Philip, M.P., Scott, B.M., Nathan, P.P., Jeong, Y.L., 2003. Common method biases in behavioral research: a critical review of the literature and recommended remedies. J. Appl. Psychol. 88 (5), 879–903. https://doi.org/10.1037/0021-9010.88.5.879.
Porter, M., Linde, C., 2000. Green and Competitive: Ending the Stalemate. The Dynamics of the Eco-Efficient Economy. Edward Elgar, Cheltenham/Northampton, pp. 33–55.
Queiroz, G.A., Junior, P.N.A., Melo, I.C., 2022. Digitalization as an enabler to SMEs implementing lean-green? A systematic review through the topic modelling approach. Sustainability 14, 14089. https://doi.org/10.3390/su142114089.
Ramayah, T., Mohamad, O., Omar, A., Marimuthu, M., Leen, J.Y.A., 2012. Green manufacturing practices and performance among SMEs: evidence from a developing nation. In: Green Technologies and Business Practices: *an it Approach*. Malaysia: IGI, Global, pp. 208–225. https://doi.org/10.4018/978-1-4666-1972-2.ch013.
Sajan, M.P., Shalij, P.R., Ramesh, A., Biju, A.P., 2017. Lean manufacturing practices in Indian manufacturing SMEs and their effect on sustainability performance. J. Manuf. Technol. Manag. 28, 772–793. https://doi.org/10.1108/JMTM-12-2016-0188.
Santos, L., Cristiane, A., Pereira, B., 2014. Social responsibility, sustainability and microenterprises: contributions made by a micro-enterprise. Megatrend Revija 11 (2), 123–134. https://doi.org/10.5937/MegRev1403123D.
Sarkis, J., Talluri, S., 2002. A synergistic framework for evaluating business process improvements. Int. J. Flex. Manuf. Syst. 14 (1), 53–71. https://doi.org/10.1023/A:1013827026600.
Saulick, P., Bokhoree, C., Bekaroo, G., 2023. Business sustainability performance: a systematic literature review on assessment approaches, tools, and techniques. J. Clean. Prod. 408, 136837 https://doi.org/10.1016/j.jclepro.2023.136837.
Schaltegger, S., Burritt, R., 2014. Measuring and managing sustainability performance of supply chains: review and sustainability supply chain management framework. Supply Chain Manag.: Int. J. 19 (3), 232–241. https://doi.org/10.1108/SCM-02-2014-0061.
Sezen, B., Cankaya, S.Y., 2013. Effects of green manufacturing and eco-innovation on sustainability performance. Proc.-Soc. Behav. Sci. 99, 154–163. https://doi.org/10.1016/j.sbspro.2013.10.481.
Shepherd, C., Gunter, H., 2006. Measuring supply chain performance: current research and future directions. Int. J. Prod. Perform. Manag. 55 (3/4), 242–258. https://doi.org/10.1108/17410400610653219.
Siegel, R., Antony, J., Garza-Reyes, J.A., Cherrafi, A., Lameijer, B., 2019. Integrated green lean approach and sustainability for SMEs: from LR to conceptual review. J. Clean. Prod. 240, 118205 https://doi.org/10.1016/j.jclepro.2019.118205.
Siegel, R., Antony, J., Govindan, K., Garza-Reyes, J.A., Lameijer, B., Samadhiya, A., 2022. A framework for the systematic implementation of Green-Lean and sustainability in SMEs. Prod. Plann. Control 1–19. https://doi.org/10.1080/09537287.2022.2052200.
Silvia, A., Merce, R., Rosa, C., 2013. SMEs as 'transmitters' of CSR requirements in the supply chain. Supply Chain Manag.: Int. J. 18 (5), 497–508. https://doi.org/10.1108/SCM-04-2012-0152.
Singh, B., Garg, S.K., Sharma, S.K., 2010. Development of index for measuring leanness: study of an Indian auto component industry. Measuring Bus. Excellence 14 (2), 46–53. https://doi.org/10.1108/13683041011047858.
Singh, C., Singh, D., Khamba, J.S., 2021. Understanding the key performance parameters of green lean performance in manufacturing industries. Mater. Today Proc. 46, 111–115. https://doi.org/10.1016/j.matpr.2020.06.328.
Sugianto, I.M., Pujawan, I.N., Purnomo, J.D.T., 2023. A study of Indonesian trucking business: survival framework for land transport during the Covid-19 pandemic. Int. J. Disaster Risk Reduc. 84, 103451 https://doi.org/10.1016/j.ijdrr.2022.103451.
Thanki, S.J., Thakkar, J.J., 2019. An investigation on lean–green performance of Indian Manufacturing SMEs. Int. J. Prod. Perform. Manag. 69 (3), 489–517. https://doi.org/10.1108/IJPPM-11-2018-0424.
Thanki, S.J., Govindan, K., Thakkar, J.J., 2016. An investigation on lean-green implementation practices in Indian SMEs using analytical hierarchy process (AHP) approach. J. Clean. Prod. 135, 284–298. https://doi.org/10.1016/j.jclepro.2016.06.105.
Thekkoote, R., 2022. A framework for the integration of lean, green and sustainability practices for operation performance in South African SMEs. Int. J. Sustain. Eng. 15 (1), 47–58. https://doi.org/10.1080/19397038.2022.2042619.
Verrier, B., Rose, B., Cailland, E., Remita, H., 2014. Combining organizational performance with sustainable development issues: the lean and green project benchmarking repository. J. Clean. Prod. 85, 83–93. https://doi.org/10.1016/j.jclepro.2013.12.023.
Verrier, B., Rose, B., Caillaud, E., 2016. Lean and green strategy: the lean and green house and maturity deployment model. J. Clean. Prod. 116, 150–156. https://doi.org/10.1016/j.jclepro.2015.12.022.
Wessel, G., Burcher, P., 2004. Six Sigma for small and medium-sized enterprises. TQM Mag. 16 (4), 264–272. https://doi.org/10.1108/09544780410541918.
Wiengarten, F., Fynes, B., Onofrei, G., 2013. Exploring synergetic effects between investments in environmental and quality/lean practices in supply chains. Supply Chain Manag. 18 (2), 148–160. https://doi.org/10.1108/13598541311318791.
Wong, W.P., Wong, K.Y., 2014. Synergizing an ecosphere of lean for sustainable operations. J. Clean. Prod. 85, 51–66. https://doi.org/10.1016/j.jclepro.2014.05.093.
Wu, L., Subramanian, N., Abdulrahman, M.D., Liu, C., Lai, K., Pawar, K.S., 2015. The impact of integrated practices of lean, green, and social management systems on firm sustainability performance-evidence from Chinese fashion autoparts suppliers. Sustainability 7 (4), 3838–3858. https://doi.org/10.3390/su7043838.
Yadav, V., Jain, R., Mittal, M.L., Panwar, A., Lyons, A.C., 2019. The propagation of lean thinking in SMEs. Prod. Plann. Control 30 (10–12), 854–865. https://doi.org/10.1080/09537287.2019.1582094.
Yang, M.G., Hong, P., Modi, S.B., 2011. Impact of lean manufacturing and environmental management on business performance: an empirical study of manufacturing firms. Int. J. Prod. Econ. 129, 251–261. https://doi.org/10.1016/j.ijpe.2010.10.017.
Zailani, S., Govindan, K., Iranmanesh, M., Shaharudin, M.R., Chong, Y.S., 2015. Green innovation adoption in automotive supply chain: the Malaysian case. J. Clean. Prod. 108, 1115–1122. https://doi.org/10.1016/j.ijpe.2012.02.008.
Zhan, Y., Tan, K.H., Ji, G., Chung, L., Chiu, A.S.F., 2018. Green and lean sustainable development path in China: guanxi, practices and performance. Resour. Conserv. Recycl. 128, 240–249. https://doi.org/10.1016/j.resconrec.2016.02.006.