Proceedings of the 5th European Conference on Industrial Engineering and Operations Management
Rome, Italy, July 26-28, 2022

Conceptual Model of Integrated Lean-Green Practices and Supply Chain Sustainability for Manufacturing SMEs

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Abstract
Today, competition between supply chains occurs and the existence of SMEs as one of the players in the supply chain cannot be ruled out. In order to win the competition, all supply chain players must have the same direction and objectives. Lean-Green and Sustainability practices have been applied to large companies and provide benefits. However, to the best of our knowledge, only a handful of studies have addressed Lean-Green and Sustainability practices in the SME context. The literature review found that there is a lack of comprehensive empirical research studies investigating the impact of Lean-Green practices on the sustainability performance of SME supply chains. Thus, this paper proposes a conceptual model that is expected to provide an overview of the Lean-Green concept and the sustainability of the SME supply chain for further empirical study in developing deeper knowledge about these two practices.

Keywords
Lean, Green, Sustainability, Supply Chain, SME

1. Introduction
Recently, research in the supply chain management field has tended to incorporate the context of sustainability into business practices. The Brundtland commission's definition of the term "sustainability" is widely recognized. They stated it is a development to meet the needs of the present generation without neglecting the ability of future generations to meet their own needs. This definition emphasizes the distinction between "need" and "limitation", where the limitations of the environment to meet current and future needs (WCED 1987).
In general, the term "sustainability" is related to a quality to maintain the environment and its main focus is the environment. However, in some literature, sustainability is explained in three dimensions or pillars, namely: planet (environment), people (social) and profit (economy), which was later popularized as a triple bottom line (3BL) (Elkington 1994). In simple terms, sustainability can be achieved by balancing the 3BL. The environmental aspect seeks to improve human welfare by conserving the source of raw materials used to meet needs. Environmental preservation is carried out by controlling waste and the use of resources to prevent damage to humans. For manufacturing companies, the typical issues are reducing the use of materials and energy, as well as the resulting waste and pollution. The social aspect tries to get justice in getting welfare, education, health and safety at work (Gualandris *et al.* 2014; M.P. *et al.* 2017). The economic aspect focuses on securing short and long term profitability and the economic viability of the company (Reich-Weiser *et al.* 2008; Resta *et al.* 2016).

Companies focus on only one or two of these 3BL will be feasible in the short term, but if they are to succeed in the long term they must balance economic performance (profit) with protecting the environment (planet) and improving social welfare (people) (Bai *et al.* 2012). This is due to government regulations, high competition, and public pressure that requires companies to balance their sustainability performance which includes all three aspects of the 3BL

(Gordon 2001). Sustainable conditions in the future require a system of approaches that are interconnected and mutually interacting between economic, social and environmental aspects (Rachuri *et al.* 2009).
Several researchers have sought to highlight and integrate social and environmental thinking into their models of sustainable supply chain performance (Hollos *et al.* 2011; Marshall *et al.* 2015; Wu *et al.* 2015). The term "sustainability" in the SCM literature was derived from the term "green supply chain management (GSCM)" in the early conceptualization of business sustainability. Environmental thinking in SCM is aimed at minimizing the ecological and environmental implications of a company's operations on the environment (Chin *et al.* 2015; Zailani *et al.* 2012; Zhu & Sarkis 2004). Employee welfare and organizational CSR initiatives are linked to social sustainability practices in SCM (Anisul Huq *et al.* 2014; Hutchins & Sutherland 2008; Klassen & Vereecke 2012; Sancha *et al.* 2016).

Lean-Green and Sustainability in the supply chain context has become a business practice, especially for large companies, and provides evidence of benefits (Dües *et al.* 2013). However, the existence of SMEs as one of the players in the supply chain cannot be ruled out. Quite a lot of SMEs are vendors or suppliers for large companies. A supply chain can win the competition if all players have the same direction and objectives. Therefore, efforts are needed to encourage SMEs to successfully adopt Lean-Green and Sustainability. This is a challenge in itself in adopting it due to the lack of resources owned by SMEs.

The literature review found a lack of research studies discussing Lean-Green and Sustainability practices in the context of SME supply chains. Therefore, this paper proposes a conceptual model that is expected to provide an overview of the Lean-Green concept and the sustainability of the SME supply chain to be studied further empirically in developing deeper knowledge about these two practices. The following research question are structured to help develop a better concept concerning Lean-Green practices for SME:
RQ: What other constructs or factors could moderate the effect of lean and green practices on the sustainability performance of SMEs supply chain?

2. Methods

First of all, this study reviewed the published literature on Lean-Green and Sustainability with the aim of identifying how all of these practices synergize or integrate in influencing the performance of an organization or its supply chain. As mentioned earlier based on an in-depth literature review, it was figure out that only a handful of studies have focused on the integration of Lean-Green practices and sustainability of supply chain as a joint approach and investigated in-depth the inter-related factors in the SME context. This study will bridge the research gap that focuses on SME supply chain in the manufacturing sector as a medium for integration. All selected articles were further explored to find the drivers (or success factors) and challenges of adopting Lean-Green and Sustainability practices for manufacturing SMEs which can be used as a reference in setting the basis for developing a conceptual framework. A number of challenges for SMEs in adopting Lean-Green and Sustainability practices were mentioned by Siegel *et al.* (2019). They reveal that there needs to be an appropriate strategy for SMEs to adapt and implement Lean-Green. Furthermore, a number of relevant articles or articles that discuss Lean-Green practices in the context of SMEs are reviewed further in order to identify indicators or variables in the development of this research survey instrument in the future. Finally, this study proposes a conceptual model that is expected to provide an overview of the Lean-Green concept and the sustainability of the SME supply chain for further empirical study in developing deeper knowledge about these two practices.

3. Results and Discussion

3.1 Synergy of Lean and Green

Companies that implement green manufacturing produce higher lean performance than other companies have yet to apply it (Bergmiller & McCright 2009). Lean companies are able to go green naturally due to continuous waste reduction efforts. In fact, when compared to data published by Melnyk *et al.* (2003) on the greenness of more than 1100 general factories, lean firms have higher greenness scores. Bergmiller & McCright (2009) concluded based on empirical evidence that companies that implement lean and green are able to achieve better results than when only implementing lean or green manufacturing separately. However, the model developed by Bergmiller and McCright is only a conceptual model that is tested through the company's secondary data.

The finding was confirmed by Wiengarten *et al.* (2013) who conducted a survey of companies in nine European countries. The study finds that lean and environmental practices have a synergistic impact on supply chain

performance. It can provide a foundation for lean companies to start investing in implementing environmental practices. Some of these studies indicate that there is a great opportunity to develop a holistic lean and green integration model.

Nevertheless the integration of lean and green shows positive effects on system performance, several researchers reveal the challenges that companies face in integrating and implementing the two practices. One of the challenges according to Dues *et al.* (2013) in the form of resource constraints. Practitioners feel overwhelmed and impractical to apply lean and green practices with poor quality human resources or resistance to change (status quo). In addition, they also argued that a lack of awareness and responsibility for the environment tends to hinder its implementation. Another challenge raised by Kurdve *et al.* (2014) namely the lack of a strategy in integrating it and difficulties in measuring the sustainability performance itself. Corporate culture and leadership are also challenges and concerns of other researchers (Alves & Alves 2015). Thus it requires success factors to implement it. Table 1 shows the success factors in integrating and implementing Lean-Green based on each researcher's perspective.

Table 1. Success factors for Lean-Green and Sustainability

No.	Success Factors	Description	References
1.	Top management commitment	Commitment and full support from top management in implementing Lean-Green approach	Daily & Huang (2001); Duarte & Cruz-Machado (2013); Wong & Wong (2014); Alves & Alves (2015); Cherrafi *et al.* (2017); Gandhi *et al.* (2018); Siegel *et al.* (2019)
2.	Organizational characteristics and culture transformation	Changed mindset and organizational culture transformation in the implementation of Lean-Green approach	Rothenberg *et al.* (2001); Daily & Huang (2001); Dües *et al.* (2013); Alves & Alves (2015); Cherrafi *et al.* (2016); Siegel *et al.* (2019)
3.	Tools and techniques	Lean-Green tools and techniques	Dües *et al.* (2013); Siegel *et al.* (2019); Duarte & Cruz-Machado (2013); Alves & Alves (2015)
4.	Policy and legislation	Clarify organization policies related to government regulations	Piercy & Rich (2015); Gandhi *et al.* (2018); Thanki & Thakkar (2018);
5.	Measurement and metrics	Sustainability performance metrics in Lean-Green implementation	Daily & Huang (2001); Duarte & Cruz-Machado (2013); Cherrafi *et al.* (2016); Cherrafi *et al.* (2017); Thanki & Thakkar (2018); Siegel *et al.* (2019)
6.	Collaborative synergy	Creating stakeholder value in Lean-Green implementation and sustainability	Daily & Huang (2001); Duarte & Cruz-Machado (2013)
7.	Financial capability	Financial support from a company in implementing Lean-Green	Wong & Wong (2014); Thanki & Thakkar (2018)
8.	Technology upgradation	Applying eco-friendly technology	Gandhi *et al.* (2018)
9.	Training and education	Level of training and education focused on lean practice and or environmental management practice	Rothenberg *et al.* (2001); Daily & Huang (2001); Duarte & Cruz-Machado (2013); Cherrafi *et al.* (2016);

Several research studies show empirical evidence that the integration of lean and green can improve sustainability performance, especially in economic and environmental dimensions, at the operating level. For example, the model proposed by Pampanelli *et al.* (2014) is limited to production cells, so a study is needed to prove the effect of the integration of these two practices on the sustainability performance of an integrated system or supply chain. Nowadays the business paradigm is not as an isolated entity but on the contrary can be more competitive as a network (Min & Zhou 2002). Therefore, in recent times the measurement of sustainable supply chain performance has received

increasing attention due to the complexity of the business environment and the shift in the competitive nature of competing individual organizations to supply chains that compete with each other. This is also a challenge for the growth and development of small and medium enterprises (SMEs).

Another limitation of developing a lean and green integration model lies in the indicators involved and the tools/techniques used. From the literature review of several relevant articles on the discussion of the integration of these two practices in the context of SMEs (see Table 2), Kaizen is the most widely applied Lean practice technique, followed by several other techniques and tools such as 5S or housekeeping, waste reduction, pull system/inventory management, TPM, visual workplace, and so on. Meanwhile, the most widely applied Green practice technique is ISO 14001, followed by other techniques and tools such as 3Rs, environmental emission control, green supply chain practices, life-cycle assessment, and so on. The details can be seen in Figure 1.

Table 2. Lean-Green tools and techniques based on some relevant articles in SMEs context

Tools and Techniques		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Lean	5S/housekeeping		✓	✓	✓			✓	✓		
	Kaizen		✓	✓	✓	✓			✓		✓
	Statistical process improvement				✓					✓	✓
	Single-minute exchange of die (SMED)		✓					✓	✓		
	Visual control/workplace		✓		✓			✓	✓		
	Cellular manufacturing		✓		✓			✓			
	Kanban		✓		✓						
	Waste reduction			✓			✓	✓		✓	✓
	Process centered focus			✓							
	Just in time (JIT)			✓	✓			✓			✓
	Pull production/inventory reduction			✓	✓			✓		✓	✓
	Total quality management (TQM)							✓		✓	✓
	Total productive maintenance (TPM)		✓		✓			✓	✓	✓	
	Overall equipment effectiveness (OEE)							✓			
	Employee involvement/engagement			✓			✓	✓		✓	
	Supplier networks/development							✓		✓	
	Work standardization				✓	✓		✓			
	Value stream mapping (VSM)	✓				✓		✓			
	Quick changeover							✓			
	5 why							✓			
	ISO 9001						✓		✓		✓
	ISO 18001								✓		
	ISO/TS 16949								✓		
	Information sharing			✓			✓				
	Training						✓	✓			
Green	Environmental management system (EMS)		✓				✓			✓	
	Life cycle assessment (LCA)		✓			✓		✓			✓
	Eco-design	✓				✓				✓	
	Design for environment (DFE)		✓					✓	✓		
	ISO 14001	✓	✓				✓	✓	✓	✓	
	Local sourcing							✓			
	Community engagement							✓		✓	
	Reverse logistic							✓			
	Corporate environmental-friendly program	✓								✓	
	Environmental emission control and impact remediation (EEC & IR)		✓			✓	✓			✓	✓
	Green/sustainable VSM				✓			✓			
	Green scoreboard				✓						
	Reducing – reusing – recycling (3R)		✓				✓		✓	✓	✓

Tools and Techniques		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Green SC practices (GSCP)	✓	✓						✓	✓	
	Optimum use of natural resources (OUNR)		✓						✓		

References: 1:Verrier *et al.* (2014); 2: Thanki *et al.* (2016); 3: Sajan *et al.* (2017); 4:Belhadi *et al.* (2018); 5:Oliveira *et al.* (2018); 6: Thanki and Thakkar (2018b); 7: Siegel *et al.* (2019); 8: Thanki and Thakkar (2019); 9:Dey *et al.* (2020); 10: Ali *et al.* (2020)

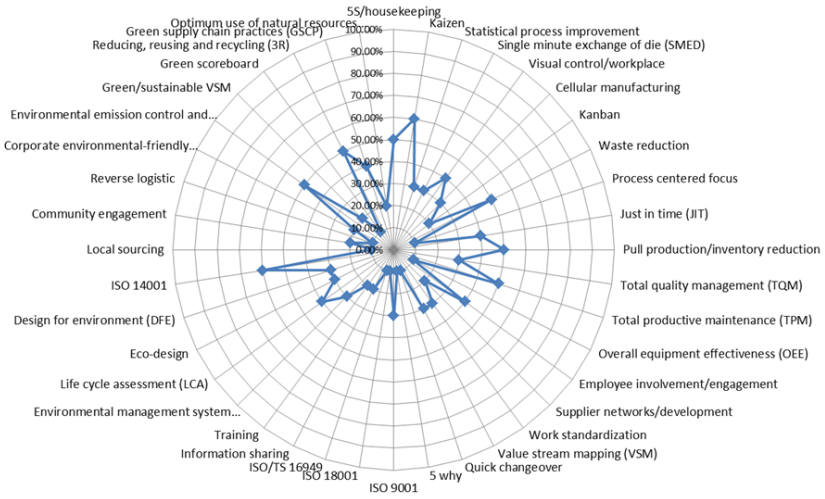

Figure 1. Radar chart of Lean-Green tools and techniques

3.2 Lean and Green Practices in the Sustainable Supply Chain

Lean approach basically focuses on reducing non-value added activities (often called waste) as a management practice to increase actual added value, to meet customer needs and even increase profitability. Several previous studies have repeatedly investigated and reported on improving operational performance through a lean approach. However, Lamming (1995) and Aronsson *et al.* (2011) suggest that lean practices not only have a significant impact on manufacturing operations but also on supply chain management and performance. Supplier-customer relationship management is directly tied to supply chain coordination, which is necessary for lean manufacturing to succeed (Simpson & Power, 2005). Reichhart and Holweg (2007) have extended the concept of lean production to the downstream or distribution level: "We define lean distribution as minimizing waste in the downstream supply chain, while making the right product available to the end customer at the right time and location."

The main focus of Lean Supply Chain Management (LSCM) is to reduce or even eliminate waste along the chain to achieve internal manufacturing efficiencies and setup time reduction, as well as enable production in small quantities and increase profitability, cost reduction, and manufacturing flexibility (Parveen & Rao, 2009). Anand and Kodali (2008) emphasize that LSCM involves integrating all activities from upstream to downstream into a coherent whole.

In contrast to LSCM, Green Supply Chain Management (GSCM) has emerged as an organizational philosophy for achieving corporate profits and market share target by reducing environmental risks and impacts while increasing the ecological efficiency of the organization and its partners (Rao & Holt 2005; Zhu *et al.* 2008). Srivastava (2007) defines GSCM as "integrating environmental thinking into SCM, including product design, material sourcing and selection, manufacturing processes, delivery of final products to consumers as well as end-of-life management of products after their useful lives." It is acknowledged that a green management approach can help reduce costs by more effectively utilising resources like water, energy, and raw materials (Walker *et al.* 2010). Companies will lose potential commercial opportunities and even lose due to rising prices of rare commodities if they do not use resources efficiently. Moreover, to achieve more sustainable business development, environmental issues should be integrated

into SCM instead of most companies having to react to public policies through conventional structures which can only be provided as a series of 'environmental silos' along the supply chain (as seen in Figure 2).

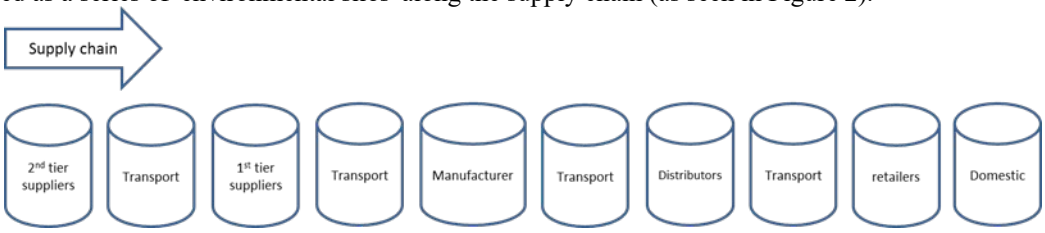

Figure 2. Silo environmental legislation and the supply chain (adapted from Mason *et al.*, 2008)

Lambert & Pohlen (2001) stated that "Lack of appropriate supply chain metrics may compromise customer satisfaction, sub-optimization of organizational performance, missed opportunities to outperform competition and conflicts within the supply chain." Therefore, performance measurement is very important for better SCM (Wong, 2009). It can facilitate inter-understanding and integration among supply chain partners while revealing the strategy effects and potential opportunities in SCM. There are a series of research studies that address the design and implementation of performance measurement in the supply chain context (Cagnazzo *et al.* 2010; C. Yang & Su, 2009). Various sets of metrics and criteria have also been put forth as a way to assess supply chain performance. Askariazad and Wanous (2009) have prioritized supply chain performance measures according to their importance in evaluating value added activities, i.e. supply, manufacturing, physical distribution, and other support activities, across supply chain considering various criteria such as qualitative or quantitative, financial or non-financial metrics. Chan (2003) has proposed a supply chain performance measurement system that includes both qualitative and quantitative measures. Qualitative measures are difficult to be measured and evaluated, such as effective risk management, customer satisfaction, etc. Quantitative performance measures can be measured. These measures seek to evaluate supply chain performance in terms of strategic planning, ordering planning, suppliers, production and delivery.

A research conducted by Mefford (2011) suggests that sustainable business and supply chain development can be achieved by using the two management approaches, Lean and Green. Sustainable business and SC development need to adopt business strategies and activities along the value chain that fulfill the needs of the organization and each of its current stakeholders while protecting, maintaining, and improving the natural and human resources that will be required in the future (Hui Zhang *et al.* 2000). The term sustainable business development has been applied in many cases to individual organizational contexts, but it should also be a concern and priority for supply chain. The sustainability of the supply chain is considered to depend on a variety of SCM challenges, including supplier management to reduce environmental and social risks and enhance economic, social, and environmental performances (Seuring & Müller 2008). Table 3 shows examples of SCOR-based supply chain sustainability performance indicators which can be used as a reference in the development of this research survey instrument.

Table 3. Sustainable supply chain performance based on SCOR which is categorized into the dimensions of cost, time, quality-safety, flexibility, and innovation

Dimensions	Performance measures (KPIs)	Performance effect*			
		OP	EP	Env. P	SP
Cost	• Labor efficiency	X			
	• Cash to cash cycle		X		
	• Savings on environmental costs		X		
	• Energy efficiency of the system			X	
	• Amount of environmental penalties		X		
Time	• Cycle time of purchase order	X			
	• Percentage of late deliveries	X			
	• Length of time to implement environmental programs			X	
Quality and Safety	• Supplier rejection rate	X			
	• Occupational safety rate				X
	• Satisfaction with supplier relationship				X

Dimensions	Performance measures (KPIs)	Performance effect*			
		OP	EP	Env. P	SP
	• Extent of mutual planning cooperation leading to enhanced quality				X
	• Information accuracy	X			
	• Percentage of recycled materials			X	
	• Mutual planning for environmental improvements				X
Flexibility	• Response to product changes	X			
	• Service level	X			
	• Product and service variety	X			
	• Response to environmental programs for suppliers			X	
	• Response to eco-friendly product requests			X	
Innovation	• Knowledge transfer satisfaction				X
	• Technological capability levels	X			
	• Satisfaction with environmental knowledge transfer			X	
	• Environmental technology levels			X	
	• New eco-friendly product development			X	
*OP – operational performance; EP – economic performance; Env. P – environmental performance; SP – social performance					

Source: adapted from Sarkis & Talluri (2002); Shepherd & Günter (2006); Gunasekaran & Kobu (2007); Bai *et al.* (2012)

3.3 Conceptual Model and Hypotheses Development

The conceptual model is constructed and developed by considering an in-depth review of all selected articles, as illustrated in Figure 3. Based on the conceptual model that stands to reveal the relationship between Lean Green Practices and sustainable supply chain performance in Manufacturing SMEs as shown in Figure 4, seven hypotheses are formulated as follows:

Hypothesis 1 (H1): The level of lean practices in Manufacturing SMEs is positively associated with the extent of green practices.

This hypothesis (H1) is supported by the findings of a survey-based study in 309 diverse manufacturing firms conducted by Yang *et al.* (2011) on the relationship between lean practices and environmental (green) management practices. They found that lean manufacturing is an important antecedent of environmental management practices. The observed variables or measured indicators, either in the constructs of lean practice or green practice, will be obtained by adapting and referring to a number of articles such as Wu *et al.* (2015), S. Thanki & Thakkar (2020), Siegel *et al.* (2019), Belhadi *et al.* (2018), Sajan et al. (2017), Thanki *et al.* (2016).

Hypothesis 2 (H2): The impact of the level of lean practices on sustainable supply chain performance in Manufacturing SMEs is mediated by the extent of green practices.

Hypothesis 3 (H3): The level of lean practices in Manufacturing SMEs has a positive impact directly on sustainable supply chain performance.

These two hypothesis (H2 & H3) are supported by the findings of a survey-based study in large chains of four- and five-star UAE hotels conducted by Hussain *et al.*(2019). Their study emphasizes the synergies of lean and green practices and also demonstrates the positive impact of these integrations on sustainable performance. The observed variables or indicators on sustainable supply chain performance in manufacturing SMEs, covering all aspects of the triple bottom line, will be obtained by adapting and referring to a number of articles such as Wu *et al.* (2015); Bai *et al.* (2012); Gunasekaran and Kobu (2007); Sarkis and Talluri (2002); Shepherd and Gunter (2006).

Hypothesis 4 (H4): The association between lean and green practices in Manufacturing SMEs will be moderated by top management leadership & commitment such that the association will be significantly stronger when a high level of top management leadership & commitment is present.

Hypothesis 5 (H5): The association between lean and green practices in Manufacturing SMEs will be moderated by organizational culture transformation such that the association will be significantly stronger when a high level of organizational culture transformation is present.

These two hypotheses (H4 & H5) are supported by the findings of the literature review study conducted by Duarte and Cruz-Machado (2013). Their study revealed that commitment from top management as well as organizational culture are success factors or drivers in lean-green transformation. The indicators on commitment and leadership of top management will adapt and refer to a number of articles such as Zhan *et al.* (2018), Cherrafi *et al.* (2017a), Wong and Wong (2014), Duarte and Cruz-Machado (2013). Meanwhile, indicators on organizational culture transformation will adapt and refer to Zhan *et al.* (2018), Duarte and Cruz-Machado (2013), Alves and Alves (2015), Daily and Huang (2001).

Hypothesis 6 (H6): The association between integrated lean-green practices and sustainable supply chain performance in Manufacturing SMEs will be moderated by collaborative synergy such that the association will be significantly stronger when a high level of collaborative synergy is present.
Hypothesis 7 (H7): The association between integrated lean-green practices and sustainable supply chain performance in Manufacturing SMEs will be moderated by policy initiatives such that the association will be significantly stronger when a high level of policy initiatives is present.

These two hypotheses (H6 & H7) are supported by the findings of a survey study in SMEs conducted by Das & Rangarajan (2020). Their study investigates the positive impact of policy initiatives as well as the synergies of collaborative commitments on sustainability and business growth. Indicators on policy initiatives will adapt and refer to articles such as Das and Rangarajan (2020); Gandhi *et al.* (2018). Meanwhile, indicators on collaborative synergy will adapt and refer to Das and Rangarajan (2020); Zhan *et al.* (2018), Duarte and Cruz-Machado (2013).

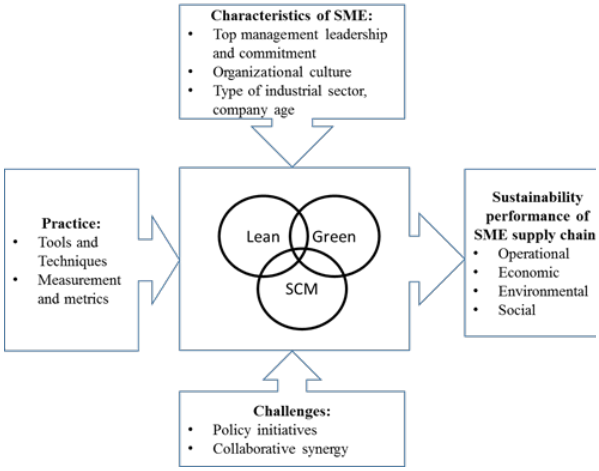

Figure 3. Proposed conceptual model for SME supply chain

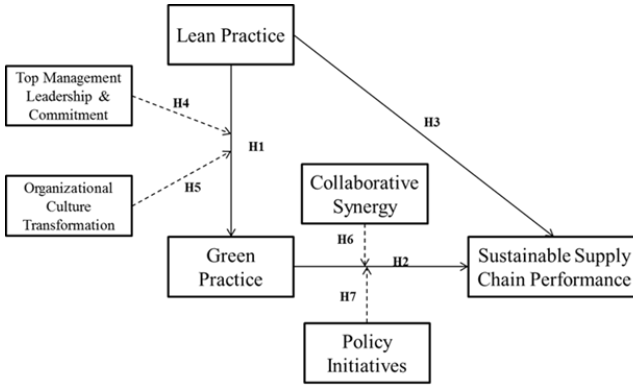

Figure 4. Proposed structured model and its hypotheses

4. Conclusion and Future Research

From the main findings, we propose a conceptual model based on the integration of Lean and Green practices in improving sustainable supply chain performance for manufacturing SMEs. The development of this conceptual "building" and its hypotheses took into account an in-depth review of all selected articles. We found performance criteria involving all aspects of the triple bottom line, such as operational, economic, environmental and social, as well as associated lean and green practices. However, through this framework we try to answer the research questions raised in the introduction to this article. Furthermore, survey indicators will be developed for each construct or latent

variable of this study referring to previous studies. Then, this conceptual model will be investigated empirically in future survey research.

This article is expected to add to the valueable knowledge, especially in the field of Lean-Green practice in improving sustainable supply chain performance for SMEs and to help academic audiences can take advantage of this insight to broaden their understanding of the concept and be motivated to carry out further research. Our conceptual framework represents a relevant practical contribution to provide an overview of the concepts of Lean-Green and Sustainability to develop a deeper knowledge of both practices for practitioners or managers.

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