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Could Lean Practices and Process Innovation Enhance Supply Chain Sustainability of Small and Medium sized Enterprises?

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Abstract

Small and medium sized enterprises adopt lean practices (LP) to reduce waste across their organisational value chain, which helps achieve sustainability. Process innovation (PI) has also been applied through cleaner production, environmental management system, eco-design etc. to address both customers' needs and legislations by policymakers. Although prior studies reveal the effect of sustainable practices, LP, and PI on sustainable performance separately less is known on the integrated effect of them on sustainability performance. Moreover, studies on mediating effect of LP and PI on sustainability performance is scant. This is significant as LP and PI are considered to be the enablers for achieving sustainability performance. This research addresses this knowledge gap. The research first theorises a model integrating these four major constructs (Sustainability practices, LP, PI and Sustainability performance) through hypotheses development. Subsequently, using structural equation modelling it is tested whether each of sustainability practices, LP, and PI effect sustainability performances. Additionally, mediating effect of LP and PI between sustainability practices and performances is derived. The study uses data from 119 SMEs within manufacturing industries in the Midlands, UK. Further, a few case studies have been undertaken to validate the findings from quantitative analysis. The overall results show that although sustainability practices, LP and PI help achieve sustainability performance of SMEs supply chain through efficiency and responsiveness respectively, the mediating effect LP is more compared to PI. Moreover, SMEs adopt LP when they are economy focused and implement PI when they are pressurised by customers and / or policymakers.

Key Words: *Small and medium sized enterprises, structural equation modelling, sustainability practices, sustainability performance, lean practices, process innovation.*

1. Introduction

Climate change represents one of the most serious environmental challenges faced by humanity today. Its causes and effects, as well as the potential solutions to this challenge, cut across every nation and sector of the economy, ultimately affecting every human being in some way. The focus of many studies, however, has been on the activities of large international corporations, while less is known about the activities of small and medium-sized enterprises (SMEs) located in different countries, especially in emerging economies (e.g. India, Bangladesh, Thailand, Vietnam), and the factors influencing those activities (Simpson et al., 2004).

SMEs are commonly recognized as making large contributions to the global economy and results in many social benefits. National governments increasingly promote SMEs' development in recognition of the critical role they play in the socio-economy. They have set policies and supporting measures for the purpose of economic development. Departments/Offices assisting SMEs have been set up in most countries in order to develop a policy framework and implementation plan and to act as a coordinating body for the collaboration with other agencies (White, 2012).

While it is widely accepted that SMEs play a significant role in the economic development, they also exert considerable pressure on the environment, not individually, but collectively. SMEs are voracious consumers of resources and energy and the result is a significant generation of waste by-products. Despite this, environmental measures undertaken by SMEs to date have not yielded impressive results, especially when compared to those of large companies (Brammer et al., 2012; Jansson et al., 2017). Available research data suggests that SMEs are responsible for more than 50% of the industrial pollution in the Asia-Pacific region and there are numerous examples which suggest that SMEs contribute significantly to environmental damage and GHG emissions (Hallinan and Jenks, 2003; Williamson et al., 2006). According to the UK environmental agency, eight out of ten pollution incidents in the UK are caused by SMEs.

It is believed that the environmental damage caused by SMEs will grow unless innovative strategies are devised. There are, however, a number of barriers that prevent SMEs from achieving such innovative strategies and these include: a lack of information on the cost-benefits of improving environmental performance, weak external pressure / incentives, lack of internal capacity (e.g. financial resources, human resources, technologies, business processes and R&D activities), weak supporting frameworks and in many cases political indulgence by policy makers (Dey and Cheffi, 2012; Zhu and Sarkis, 2004).

Lean Practices have been adopted by many manufacturing and service companies for waste reduction without sacrificing throughput. There is growing interest in linking LP with environmental sustainability (Martinez-Jurado and Moyono-Fuentes, 2014). LP is economy focused and environmental friendly as philosophically lean management focuses on waste reduction through resource optimisation across the organisational value chain. However, the environmental and social sustainability may not be fully achieved though LP as a few environmental and social practices may be cost intensive (Inman and Green, 2018). Prior literature has successfully linked LP with sustainability (Martinez-Jurado and Moyono-Fuentes, 2014). LP facilitates the adoption of green manufacturing principles and enhances the environmental performance of many manufacturing companies (Piercy and Rich, 2015). Despite the fact that LP contributes to environmental sustainability (Moreira et al., 2010; Vinodh et al., 2011), the findings are still not conclusive, as both positive (King and Lenox, 2001) and negative (Rothenberg et al., 2001) relationships have been found to exist. Moreover, the relationship between LP and social management is also non-conclusive.

Lean practices eliminate waste, enhance quality, reduce costs and increase flexibility across the supply chain (Dey et al. 2018). By implementing LP, economic sustainability is achieved through business growth, enhancing supply chain surplus, and reducing supply chain cost and business risk through joint investment in R&D and technology, reduced inventory, improved products and services quality, and overall reduction of waste across the supply chain (Arkader, 2001). Similarly, LP helps achieve environmental sustainability through collaborative relationship building across all the stakeholders, engaging with suppliers at the early stage of product development, introducing vendor managed inventory and considering environmental criteria along with others for supplier selection. Although Information and Communication Technology (ICT) helps achieve LP across the supply chain, research also reveals that adopting LP before investing in ICT produces better results. Additionally, ICT acts as a catalyst for designing and operating supply chain in collaborating with every stakeholder (Tuomivaara et. al 2017). These help achieving long term economic sustainability of many organisations. Environmental sustainability of the supply chain could be achieved through reduction of emission across the supply chain. It can be concluded that identifying potential conflicts between LP, environmental sustainability and developing solutions to mitigate their negative effects can help lean supply chain to be more responsive and to be more sustainable.

Innovation could be achieved through product, process, and organisational innovation and they are interrelated (Klewitz and Hansen, 2014). Process Innovation (PI) means the implementation of a new or significantly improved production or delivery method (including significant changes in techniques, equipment and/or software) (Klewitz and Hansen, 2014). Cleaner production is an example of process innovation for environmental sustainability. Implementation of an environmental management system (EMS), including ISO 14000, is a typical example of organisational innovation for environmental sustainability. In order to improve sustainability performance of products, eco-design is an overarching concept.

Any organisation has sustainability (economic, environmental and social) practices within their system in certain extent, which has its impact on overall sustainability performance of concerned SME. LP and PI separately and in combination affect sustainability performance. LP is economy focused. Therefore, achieving overall sustainability through lean practices alone enables organisations to emphasize achieving greater economic sustainability. On the other hand, PI is responsiveness focused, which allows organisations to achieve greater environmental and social performance. However, overall sustainability of any organisation is realized through the most appropriate trade-off among economic, environmental and social factors. Although there are studies on the impact of LP and PI on sustainability performance separately (Adams et al., 2016; Bos-Brouwers, 2010; Inman and Green, 2018; Piercy and Rich, 2015), according to authors' knowledge the studies that link impact of combined LP and PI with SMEs' supply chain sustainability performance are scant. Moreover, although prior literatures have established that both lean practices and process innovation are the enablers for achieving sustainability, their combinative impact along with sustainability practices on sustainability performances of SMEs' supply chain remains unexplored.

This paper aims to address this knowledge gap in the relevant research by examining simultaneously two relationships, the one between direct impact of sustainability practices, LP and PI on sustainability performance, as well as that between the sustainability practices and sustainability performance, through mediating effects of both LP and PI separately. In other words, the objectives of this research are to reveal the effect of sustainability practices, LP and PI on sustainability performance, and to test the mediating effect of LP and PI separately between sustainability practices and performance.

The remainder of the paper is structured as follows. The next section encapsulates the study's motivation and outlines prior literature and research gaps. Section 3 develops the hypothesized framework through the formation of a few hypotheses. We present the methodology of this research in section 4. Section 5 presents the main findings. A discussion of the results and findings, along with the theoretical and practical contributions, are presented in section 6. The paper concludes with an outline of overall implications of this research and scope for future research.

2. Literature Review

In the 21st century, the four supply chain trends are converging to create an increasingly complex business environment: moving towards green initiatives; incorporating lean process; process innovation and globalisation. Lean strategies focus on reduction of wastes by helping firms eliminate activities which do not add any value e.g., equipment, space, and inventories across the supply-chain (Corbett and Klassen, 2006). Such waste reduction strategies help firms to improve quality, reduce cost, and improve service to the customers (Larson and Greenwood, 2004). A growing number of firms have adopted lean practices to promote continuous improvement of supply chain operations, e.g. production of goods not yet ordered, waiting time, rectification of mistakes, excess processing, transport, and stock (Jones et al., 1997). The literature on supply chains incorporating lean processes shows the integration of lean and agile practices (Goldsby et al., 2006; Mason-Jones et al., 2000), just-in-time approach to supply chain management (Das and Handfield, 1997), and focuses on specific functional areas of the supply chain including lean logistics (Disney et al., 1997). In the current era, firms have started to promote and incorporate environment friendly practices into their lean supply chain practices. Fliedner and Majeske (2010) state that lean practices help in achieving sustainability by reducing wastes across supply chain and improvement of social sustainability (Govindan et al., 2014). LP impact on environmental sustainability through the adoption of environmental management practices (Florida, 1996). Spear and Bowen (1999) reported that the success of lean implementation will depend upon systematic application of the scientific approaches and principles in the day to day organisational activities. The existing literature is primarily rich in analysing the essence and driving principles of lean practices (Liker, 2004).

While a number of definitions exist for process innovation, it generally refers to the implementation, institutionalization and commercialization of new and creative ideas (Van De Ven, 1986; Smeds, 1994). PI can also be defined as the commercialisation of newly designed and implemented products/processes/services. According to Smeds (1994), preserving uncertainty, experimentation with new ideas (i.e. taking risks), and encouraging creativity among the personnel in the organisation are all building blocks to process innovation in an organisation. According to an interview with a US chief technology officer conducted by Technology Review, PI was considered to be an essential factor to boost economy (Tablot, 2009). Process innovation is driven by economic pressure, and such innovation can create value in terms of social sustainability (Saunila et al., 2018). It has been also shown that may positively improve firms' performance (Lau et al., 2010). Process innovation improves the competitiveness of a firm and has a positive relationship to firms' economic, social, and environmental performances (Zailani et al., 2015). Many organisations have integrated product, process and organisational innovation to achieve greater sustainability performance (Adams et al. 2016). Finally, PI is clearly customers' and regulatory driven.

While considerable research has focussed on green, lean and global issues, to our knowledge none of the existing works have addressed the intersection of the lean practices and process innovation initiatives in a comprehensive way, in particular in relation to the sustainability practices (economic, social, and environmental) of a supply chain, and how all three affect the sustainability performance. This is a critical oversight which will help firms to form a synergy and address important trade-offs, that may arise when there are incompatibilities between strategic initiatives pertaining to LP and PI.

Though, lean practices and process innovation are two driving forces of today's business success, they are fundamentally different concepts, and some aspects of innovation may negatively impact a firm's ability to be successful by incorporating certain types of innovations. For example, should ideas/innovation that do not add value straightaway, but are likely to create value in the future, be eliminated from the current agenda following the lean principles? It is worth investigating, how PI can be promoted by maintaining a good level of lean practices. This will require an investigation into the impact of different supply chain practices on the performance measures. According to Brown and Duguid (2002) business practices and process innovation need to be established at the same time. Lack of practices and creativity will result in less innovative ideas. The authors suggest that a balance between lean practices and innovative processes will help to attain sustainability in the firm.

Due to intense competition, SMEs need to be economy focused with reasonable agility. Many SMEs adopt LP (formally and informally) in order to achieve efficiency that helps them to become environment friendly to a certain extent. SMEs also have adopted various innovations (at the product, process and organizational level), the main driver for which is achieving efficiency. PI is lacking among the SMEs as achieving superior environmental and social performance is perceived as cost intensive. Moreover, supply chain integration through collaboration with customers and suppliers in different tiers are almost absent within SMEs across the world. SMEs only get motivated to adopt superior innovation when they are pressurized by customers and/or policymakers (Dey et al., 2018).

The relationship between sustainable practices and performance in manufacturing industry has been demonstrated by Abdul-Rashid et al. (2016) and Adebanjo et al. (2016) who study the impact of external pressure and sustainable management practices on manufacturing performance and environmental outcomes. Hajmohammad et al. (2013) observe that very few studies address integrated effect of environmental management practices and operation / supply chain systems on environmental performance. The outcome of the review undertaken by Hallam and Contreras (2016) for studying the integration between lean and green reveal that there is a very few empirical studies using primary data sets. They note that an integrated model relating lean and green is lacking. Jabbour et al. (2013) also note that the literature is not conclusive on positive effect of integrated environmental practices and lean operations on performance. Piercy and Rich (2015) demonstrate the relationship between lean operations and sustainable operations. More recently, Inman and Green (2018) test the impact of lean and green supply chain management practices on environmental performance and overall organisational performance. All the aforementioned studies advocate that further work is required for testing the role of new constructs in studying the impact of lean and green on sustainability performance. Moreover, studies on sector specific relationship among the sustainability practices and performance and in specific how SMEs sustainability performance is affected by lean initiatives are scant.

According to Brown and Duguid (2002) business practices and innovation need to be established at the same time. Lack of practices and creativity will result in less innovative ideas. The authors suggest that a balance between practices and innovative processes will help to attain sustainability in the firm. Adams et al. (2016), through a systematic literature review, suggest ways to achieve sustainability oriented innovation using product, process and organizational level innovation. They also point out the lack of research in this area and provide suggestions for more work through empirical research.

In summary, the critical review of prior literature reveals that although the relationship between lean and sustainability performance, and process innovation and sustainability performance have been separately studied, the combined impact of LP, PI and sustainability practices on sustainability performance have not been explored yet. Moreover, whether SMEs get benefit from adopting lean practices and process innovation on top of their normal sustainability practices remains totally unexplored. This research bridges these gaps by examining simultaneously the effects of sustainability practices, LP and PI of SMEs on their sustainability performance.

3. Conceptual Model and Hypotheses Development

Prior literature reveals that LP emphasize on resource efficiency and waste reduction, which in fact contribute to better economic performance through cost reduction (Martinez-Jurado and Moyono-Fuentes, 2014). However, there are instances of lower environmental and social performance of SMEs due to LP as environmental and social practices may be cost intensive (Revell and Blackburn, 2007; Rothenberg et al., 2001). Energy efficiency in operating systems helps achieve lean as well the desired environmental and social targets, and could be the best candidate to achieve overall sustainability of any type of organisation (Viesi et al., 2017). However, capital cost of achieving energy efficiency could be a concern for many organisations and put them away from adopting this. Therefore, it is of interest to examine whether SMEs' managers perceive that lean practices help achieve sustainability performance. Accordingly, we formulate the Hypothesis 1.

Hypothesis 1: *Lean Practices (LP) enhance sustainability performance (SP) of SMEs*

Process innovation (PI) predominantly emphasizes satisfying customers' needs at a minimum cost (Aguado et al., 2013) and is driven by policymakers (Adams et al. 2016). Ideally PI must contribute to achieve synergy between competitive strategies and supply chain strategies, which will on one hand help achieve customer satisfaction in optimal cost and on the other hand fulfil the environmental and social targets (Aguado et al., 2013). This enables SMEs to achieve desired throughput and economic performance in a sustainable way (Abdallah et al., 2011). However, there is very little evidence that PI affects SMEs' environmental and social performance. Prior research also studies the type of process innovation that could enhance achieving environmental and social targets along with desired quality and cost of production (Adams et al., 2016). Therefore, deriving the perception of SMEs' managers on the relationship of PI and sustainability performance is desired. Accordingly, Hypothesis 2 tests whether PI enhances sustainability performance of SMEs.

Hypothesis 2: *Process Innovation (PI) enhances sustainability performance (SP) of SMEs*

Sustainability practices comprise of the economic, environmental and social practices that have impact on the sustainability performance of SMEs (see e.g. Gonzalez-Bonito and Gonzalez-Bonito, 2006). However, the impact of sustainability practices on sustainability performance may vary depending on the type of practices undertaken and additionally, adopting lean practices and process innovation may affect its impact on sustainability performance. Therefore, along with testing the relationship of LP and PI with sustainability performance, impact of sustainability practices on sustainability performance is also studied.

Hypothesis 3: *Sustainability Practices (SPr) enhance sustainability performance (SP) of SMEs*

As noted previously, sustainability practices comprise of economic, environmental and social practices, which have been adopted by every SME to some extent. The latter affect SMEs positively through sustainability performance (e.g. energy consumption, resource efficiency, inventory, business growth, employee wellbeing, job creation, CSR investment etc.). Adoption of lean practices on top of it may enhance SMEs' sustainability performance. However, it depends on how the LP have been adopted and being practiced within a SME. Prior research reveals the impact of lean and green initiatives on environmental and operational performance (Inman and Green, 2018). Malesios et al. (2018) explore the impact of sustainability practices on environmental and social performance. However, the impact of combined lean practices and sustainability practices on sustainability performance remains somewhat unexplored. Therefore, the perceptions of SMEs' managers on the impact of combined sustainability practices and lean practices on sustainability performance is an important aspect for making SMEs lean and green.

In particular, the study – additionally to research hypotheses H1-H3 – seeks to examine another overarching research question – namely could lean, when considered as mediator between sustainability practices and performance, enhance supply chain sustainability performance of SMEs? This leads us to formulate the following research hypothesis that we are going to additionally examine in the remainder of this paper.

Hypothesis 4: *Sustainability practices (SPr) enhance sustainability performance (SP) of SMEs through mediation effects of Lean Practices (LP)*

Similarly, the impact of combination of sustainability practices and process innovation on sustainability performance may be positive and negative depending on how they have been implemented and being operationalized (Adams et al. 2016). Therefore, it is important to reveal the perceptions of the managers on the mediating effect of process innovation between sustainability practices and performance. Accordingly, we formulate the following hypothesis.

Hypothesis 5: *Sustainability practices (SPr) enhance sustainability performance (SP) of SMEs through mediation effects of Process Innovation (PI)*

The five (5) research hypotheses are empirically examined through the theoretical model that realizes in Figure 1.

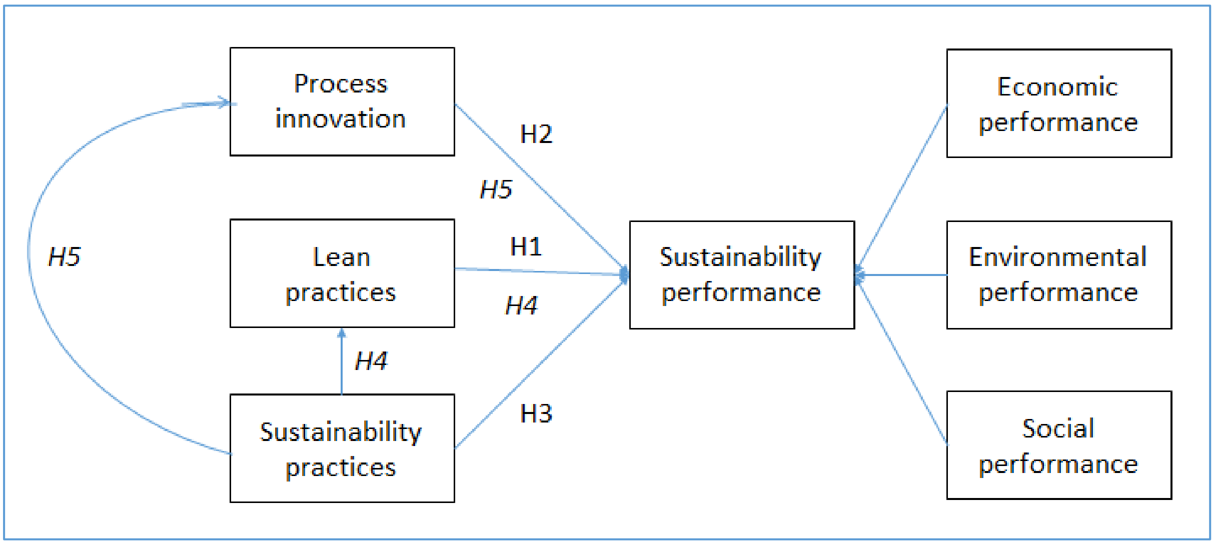

Figure 1: Conceptual model for the association between Lean Practices and Process Innovation with sustainability performance of SMEs.

Sustainability is a multidimensional construct that extends the organizational boundaries of the business entity and covers multiple clusters of sectors and chains of production (Seuring and Gold, 2013). The relevant literature points to several types of sustainability indicators, such as economic, social and environmental (Olugu et al., 2010). In addition, other studies propose the use of operational constructs as suitable strategic constructs for sustainable performance (Dey and Cheffi, 2013; Pagell and Gobeli, 2009). Based on the above hypotheses, the theoretical framework examined in this study was tested through a survey conducted in SMEs in the Midlands, UK. Through an empirical model testing based on this formulation we are going to test whether LP and PI separately help achieve sustainability.

Lean practices focus on cost and waste reduction, process innovation prioritizes customers' satisfaction, and sustainability practices emerge as high priority for the business world and all the key players in the various chains of production (Sancha et al., 2016). There are overlaps among these three major constructs that affect sustainability. Although our objective is to reveal combination of LP and PI we have additionally incorporated sustainability constructs (i.e. economic, environmental and social constructs) as they are common in both LP and PI. The main objective is to examine if the combined lean practices, process innovation and sustainability practices would lead to achieve sustainable performance (economic, environmental and social).

Hypotheses H1 to H3 can be directly empirically tested through the fit of the conceptual model of Figure 1 to a suitable dataset. However, research hypotheses H4 and H5 cannot be tested considering solely the complete model since the mediation effects of the LP and PI factors in the conceptual model are based on the aggregated effect of all three factors, i.e. PI, LP and SPr. The bootstrap approach introduced by Preacher and Hayes (2004) is one of the most widely used methods to test the mediation hypotheses. Hence, hypotheses H4-H5 are examined by the additional bootstrap test.

4. Methodology

The study adopts both quantitative and qualitative approaches to reveal the role of LP and PI for facilitating SMEs to achieve sustainability. In addition to quantitative analysis, qualitative approach through research on case studies can assist in the validation and support of the findings of the quantitative analysis. By providing real examples of how specific approaches and procedures of LP and PI have helped SMEs to achieve sustainability, may strengthen the quantitative analysis results.

4.1 Sample Collection and Data

The data used for the current analysis has been collected from randomly selected SMEs in the Midlands, UK. Specifically, an interview protocol was formed and survey has been designed and conducted to gather both quantitative and qualitative data on sustainability practices and performances of SMEs in the UK. In doing this, initially a workshop was organized with the involvement of selected researchers and owner/managers of a few SMEs to derive the suitable questionnaire for achieving the objectives of the study. Secondly, an initial pre-sample survey was conducted on 20 SMEs in the Midlands, UK. The final data has been collected from a total of 119 British SMEs (Owners/managers). We have chosen SMEs on the basis of their maturity of business and adoption of environmental management system. In particular, we have contacted close to three hundred SMEs in the Midlands of the UK and received around 150 responses, out of which we considered 119 responses eligible for detailed analysis. The sample of SMEs is from manufacturing industries that generally impact environment more than SMEs in other industries. The random sample of SMEs ensures the validity of the results. Demographic information on the collected sample of SMEs is presented in Table 1 below.

Table 1. Sample demographics summary

Title	Percentage	Title	Percentage
Owner	19	**Firm age (years)**	
Production manager	26	Less than equal 5	11
Marketing manager	12	5 – 10	34
Supply chain manager	8	10 – 20	34
Purchasing manager	11	Greater than 20	21
Quality manager	9	**Number of employees**	
Maintenance manager	15	1-50	30
Industry category		51 - 150	40
Primary metal manufacturing	20	151 – 250	30
Fabricated metal product	14	**Respondent location**	
Manufacturing	11	West Midlands	52
Machinery manufacturing	19	East Midlands	48
Electrical equipment and components manufacturing	9	**Years in current position**	
		Less than 5	9
Chemical manufacturing	14	5-10	27
Apparel manufacturing	9	More than 10	64
Wood product manufacturing	4		

In order to capture the perceptions of the SMEs owners and managers on their sustainable supply chain practices and performance, the questionnaires have been completed through interview method. The variables from the questionnaire related to the current analysis are described in Table A1 in the Appendix. All variables have been measured at a 5-point or 10-point likert scale, depending on the specific research question (see Table A1 in the Appendix). Specifically, we measure economic, environmental and social practices and performances through a variety of questions related to these constructs. In addition, we measure Lean Practice through a number of 8 relative questions addressed to the respondents, whereas Process Innovation is obtained by combining four observed items related to the latter process. We must note here, that the observed items utilized in order to form each latent factor are used under a formative perspective, i.e. they have been selected in order to build each time the specific construct based on previous research. All data utilized for the current quantitative and qualitative analyses are available upon request by the corresponding author. A table with descriptive statistics for the collected data analyzed in the current paper is included in the Appendix (Table A2).

4.2 Statistical Analysis

Our main hypothesis is that LP and PI are both important factors that directly influence a SMEs' sustainability performance. In addition, we also examine for the importance of LP and PI as mediators in the sustainability practices/performance relationship. The hypothesized model and an initial visual presentation have already been presented in section 3 of the paper.

For the purposes of the current study we use a model-based approach. In particular, we utilize structural equation modeling (SEM) (Bollen, 1989; Jöreskog et al., 1979) to process the quantitative information of each SME and examine relations between sustainable supply chain practices/performance of SMEs with LP and PI as this is the most appropriate method to derive causal relationships among the various observed variables and latent constructs objectively. All latent constructs used in our analyses are measured via the indicator variables developed from the responses obtained from the interviews with the SMEs' managers (Table A1 in the Appendix). More specifically, in order to test the influence of the various latent variables of interest on sustainability, we fit a single structural equation model, testing all the hypotheses presented in section 3. Structural equation models are a system of regression-type equations to capture complex and dynamic relationships among a set of observed and unobserved variables. The distinguishing feature is that variables here – in contrast to typical regression analysis techniques – can be either directly observed or latent or a mixture of both of these. SEM allows for simultaneously analyzing the relationship of different proxies on the dependent measure. Structural equation models essentially consist of multiple regression equations for both observed and latent items that can be visually illustrated by graphical structures usually known as "SEM diagrams" or "path diagrams". We opted for this statistical methodology due to the certain characteristics of the latter, matching with the specific nature of our data and conceptual model. SEM allows the dependent and independent variables to be either observed or latent (i.e. not directly measurable item), a feature that cannot be addressed e.g. by a typical regression model. Hence, SEM possesses a distinctive characteristic of latent variables being regressed on other latent variables, such as those analyzed in our paper. In addition, SEM allows fitting model structures of different layers, another characteristic of our hypothesized modeling structure. Finally, SEM has the ability of inclusion of more than a single dependent variable, notably the three constructs of economic, environmental and social performance.

Fitting a SEM model with maximum likelihood assumes multivariate normal data. However, with non-normal data such as the ordinal observed variables utilized for the present analysis, there exist alternative methods such as the method of weighted least squares (WLS) (Bollen, 1989; Jöreskog, 1994). Model estimation was performed with the use of the AMOS software (Arbuckle, 2014).

As regards assessing the fit of our SEM model, there exist a large variety of goodness-of-fit measures that are mostly functions of the model's chi-square. We test the validity of our model by using several alternative fit statistics (Marsh and Balla, 1994), Typical examples of such indices are the RMSEA (the Root Mean Square Error of Approximation), NFI (the normed fit index), GFI (the goodness-of-fit index), the AGFI (the adjusted goodness-of-fit index) and the PGFI (the parsimonious goodness-of-fit index), with AGFI adjusting the GFI for the complexity of the fitted model. As a general rule of thumb, for a good fit the indices should be above 0.9, however this cut-off threshold has been often criticized (see, e.g. Marsh et al., 2004; Heene et al., 2011). If the fit of the model is good, NFI, GFI and AGFI should approach one, whereas RMSEA should be small (typically less than 0.05).

5. Data Analysis and Results

5.1 Testing for Validity and Reliability of the Latent Factors of SEM Modeling

In order to empirically test the validity of research hypotheses presented in the introduction section, we have fitted a SEM model by the WLS method to derive the model parameter estimates. For the fit of the SEM model we have used the latter estimation method due to the nature of the collected data.

Prior to SEM, an exploratory factor analysis (EFA) has been performed in order to obtain information about the formulation of the latent factors that are subsequently utilized and test their reliability and validity. Hence, the 10 factors utilized for the SEM analysis are described below, along with the Cronbach's α values (Bollen, 1989) and the percentage of variance of the selected items explained by each of the latent factors:

- 3-item scale factor (Cronbach’s α: 0.622 (low); % of explained variance: 59.40) measuring Process innovation.

- 8-item scale factor (Cronbach’s α: 0.595 (low); % of explained variance: 51.30) measuring Lean practices.

- 2-item scale factor (Cronbach’s α: 0.705; % of explained variance: 82.07) measuring economic practices.

- 3-item scale factor (Cronbach’s α: 0.869; % of explained variance: 91.05) measuring environmental practices.

- 2-item scale factor (Cronbach’s α: 0.78; % of explained variance: 77.9) measuring social practices.

- 2-item scale factor (Cronbach’s α: 0.682; % of explained variance: 72.86) measuring economic performance dimensions.

- 3-item scale factor (Cronbach’s α: 0.731; % of explained variance: 65.27) measuring environmental performance dimensions.

- 2-item scale factor (Cronbach’s α: 0.641 (low); % of explained variance: 64.45) measuring social performance dimensions.

The above results show that in general the utilized factors are exhibiting adequate reliability and consistency, thus are suitable for subsequently conducting SEM analysis and deriving valid results. Also, the hypothesized factors do not suffer from Common Method Bias, since that the total percentage of variance explained by each single factor is higher than 50%.

Additionally, the correlation matrix for the latent constructs used in the current analysis, is presented in the following table (Table 2). The correlation matrix is a useful tool of preliminary analysis as it provides a first inspection of relationships among the latent factors. From the correlation matrix, it is observed that there are moderate to strong associations among the latent constructs. Strongest correlations are between the latent constructs of LP and sustainability performance (correlation coefficient 0.79), LP and sustainability practices (correlation coefficient 0.75) and sustainability practices and sustainability performance (correlation coefficient 0.68). Less correlated to each other appear to be the latent factors of sustainability practices and PI (correlation is non-significant) and LP and PI (correlation coefficient 0.35). In general, the factor of PI appears to be less associated with the rest of the latent factors.

Table 2. Correlation matrix of the constructs.

	1	**2**	**3**	**4**
LP (1)	1			
PI (2)	0.35*	1		
SPr (3)	0.75*	n.s.	1	
SP (4)	0.79*	0.38*	0.68*	1

**Correlation is significant at the 0.01 level.*
n.s.: correlation is non-significant

5.2 Results of SEM Analysis

SEM modeling enables us to obtain the estimates of beta coefficients of the regression equations that relate the latent construct of sustainability performance (response variable) with the selected individual items or latent factors of lean practices, process innovation and sustainability practices constructs (explanatory variables).

In the current sub-section we present the derived results of structural equation analysis. Specifically, the SEM results are summarized in the form of the standardized regression coefficients depicted in the following path diagram (Figure 2). A more detailed presentation of the fitted SEM model can be found in the Appendix (Table A3), including standardized regression coefficients for the associations between the latent constructs, sub-constructs and related observed items.

Fit statistics calculated for the evaluation of the good fit of the SEM model are: RMSEA: 0.16, NFI: 0.901, GFI: 0.954, AGFI: 0.876, PGFI: 0.698. Fit statistics for the examined model show that the path analysis structure tested provided a good fit to the data, since that most of the values are higher or near the borderlines of the acceptable limits, especially when considering the goodness-of-fit measures of NFI, GFI and AGFI. The worst fit indicated by the PGFI index could be attributed to the limited number of data since that the particular index adjusts for sample size.

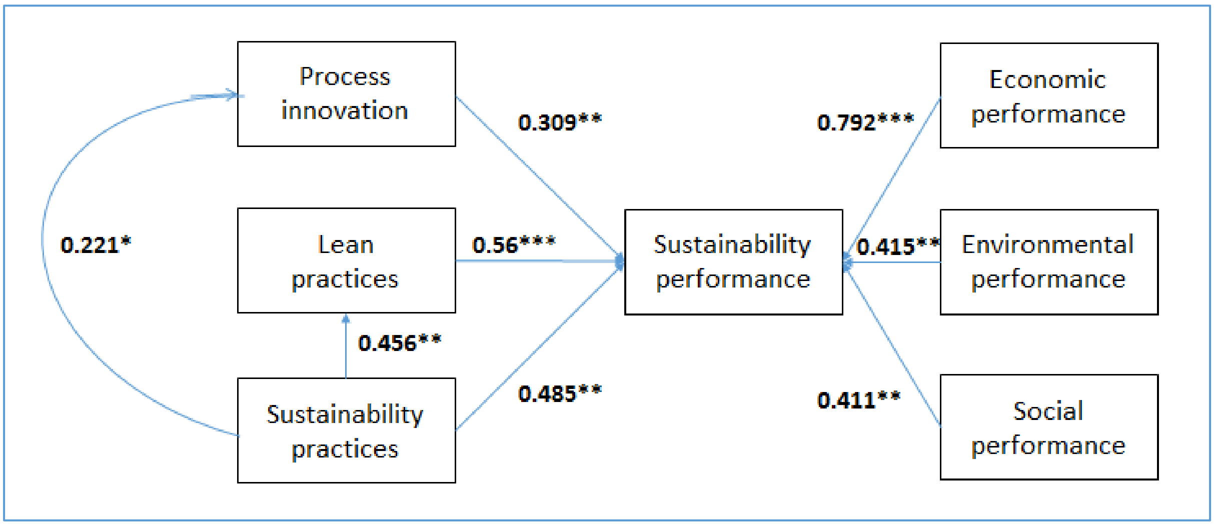

Figure 2: Path diagram of SEM along with standardized regression weights
*** p-value<0.01; ** p-value<0.05; * p-value<0.1; n.s.: non-significant

Next, we turn our attention on the estimates of the fitted SEM model. As one observes from the fit of structural equation model (Figure 2 above), LP is proven to be an important factor for achieving sustainability performance (hypothesis H1). Looking at the regression weights, it is seen that lean practices are highly significantly positively associated with sustainability performance of SMEs (beta coefficient 0.56, p-value<0.01). Similarly, sustainability practices are highly positively related to sustainability performance (research hypothesis H3), with a standardized regression weight of 0.485 (p-value<0.01).

Subsequently, let us see the results of testing research hypothesis 2, where we have hypothesized that Process Innovation enhances the sustainability performance of small and medium sized enterprises. Process Innovation is customers' responsiveness focused and emphasizes on quality over efficiency. The results show that PI is also an important factor for achieving sustainability performance, as the values of regression weights reveal (beta coefficient 0.309, p-value<0.1), however this association is not as strong compared with the effects of lean and sustainability practices.

To examine the validity of research hypotheses H4 and H5 that test the effects of sustainability practices on sustainability performance through the mediation effects of LP and PI, based on the SEM analyses we get the following results.

First, it has been hypothesized that sustainability practices enhance sustainability performance of SMEs through mediation effects of lean practices (Hypothesis H4). Empirical analysis results are indicative of acceptance of this hypothesis, since that according to the model results, the sustainability practices factor is significantly affecting LP (beta coefficient 0.456; p-value<0.05) and further LP does affect sustainability performance.

Next, as regards hypothesis H5 and its support by the data, we cannot be very conclusive since that sustainability practices moderately affect PI (beta coefficient 0.221; p-value<0.1) and PI is a significant moderator for achieving sustainability performance (beta coefficient 0.309).

Turning our attention to the rest of the associations in our empirical model, it is observed that sustainability performance is strongly associated with the sub-construct of economic performance (beta coefficient 0.792, p-value<0.01). Lower, but still statistically significant are the associations between sustainability performance and environmental performance (beta coefficient 0.415, p-value<0.05) and between sustainability performance and social performance (beta coefficient 0.411, p-value<0.05).

In addition to the results in terms of standardized path coefficients obtained by the fit of the SEM models, we further examine the support by our data of the indirect research hypotheses H4-H5, associated with mediating effects of LP and PI through additional testing. Hence, we analyzed and calculated the mediating (indirect) effects through the bootstrap approach and the corresponding results are shown in Table 3. For comparisons, we also include the results of direct effects of Sustainability Practices on Sustainability Performance.

Table 3. Mediation bootstrap test of research hypotheses H4-H5

Effects	**Hypotheses**	**Estimate**	**Significance**
Direct effect	H3	0.485	**
Indirect effect (Through LP)	H4	0.356	**
Indirect effect (Through PI)	H5	0.031	n.s.

** p-value<0.05; n.s.: non-significant

The results of the bootstrap mediation tests showed that the mediation effect of the LP factor is statistically significant at the 5% significance level. On the other hand, however, the test suggested that the mediation effect of PI is non-significant. This outcome adds to the previous results and justifies the latter findings.

5.3 Case Studies

We have undertaken 12 case studies to validate the findings from the quantitative analysis. We present three selected case studies – Surgical kits manufacturing, Gauge calibration and manufacturing, and Engine refurbishment to demonstrate the impact of lean practices and process innovation on the sustainable performance of the specific SMEs. We intend to reveal how closely our survey results match with the case study findings.

The case studies have been undertaken using a structured approach. Firstly, supply chain mapping is carried out in each of participating SME along with analyzing the characteristics of their supply chain and identifying issues and challenges. Both lean practices and process innovation approaches that each SME has undertaken have been captured and their contribution to achieve overall sustainability has been observed. Appendix B demonstrates the qualitative results obtained from the three cases. In the first case (surgical kit manufacturing), although their economic sustainability in recent past was reasonably good, the adoption of lean and process innovation substantially transformed their overall sustainability performance by enhancing both environmental and social performance along with economic sustainability.

The gauge manufacturing and calibration company (the second case) was struggling predominantly with their economic performance as they were not competitive enough due to their logistics issues. When they resolved this through optimization of economic, environmental and social aspects through the adoption of lean practices not only they achieved superior economic performance but also their environmental and social performance enhanced substantially. This reveals that lean practices facilitate SMEs to achieve higher sustainability performance.

The third case (Engine Refurbishment Company) revealed that economic sustainability issues could be addressed through process innovation approach, which will lead to achieve overall sustainability by enhancing economic, environmental and social performance. The question of whether lean practices or process innovation facilitate SMEs more to achieve sustainability was revealed by informal discussions with the participating SMEs' managers. They reflected that although both the approaches help achieve sustainability lean practices being economic focused motivates more than process innovation.

Process innovation is capital intensive and driven by customers and / or policymakers. In view of the above, lean practices affect SMEs more to achieve sustainability than process innovation.

6. Discussion

Business sustainability is achieved through the right combination of economic, environmental and social factors and it is the major concern of today's business. SMEs' sustainability is crucial for every economy as they contribute largely to gross domestic product and additionally employ a major portion of workforce of any economy. However, their environmental and social performances are not impressive (Dey et al., 2018). Therefore, the drivers that contribute to the enhancement of sustainability of SMEs need special attention (see, e.g., Masurel, 2007). Prior studies test and verify the relationship between sustainability practices and performance that helps derive actions to enhance sustainability performance through most appropriate trade-off among economic, environmental and social factors.

Lean practices have been evolved as a philosophy to reduce waste across organisational value chain, predominantly to reduce cost. As lean emphasizes on resource efficiency across the value chain it helps achieve superior environmental performance along with the desired economic performance (Martinez-Jurado and Moyono-Fuentes, 2014). However, the social performance is not assured in lean approach (Inman and Green, 2018), although in practice SMEs might achieve all the desired performances (economic, environmental and social) simultaneously through adopting lean approach depending on how the latter has been adopted in their system. Therefore, it is worth revealing the impact of lean practices on sustainability performance.

Organisational sustainability could be achieved through product innovation, process innovation and organisational innovation – separately or in combination (Klewitz and Hansen, 2014). Innovation that leads to achieve sustainability is customers and/or policymakers driven. In other words, innovation is driven by customers' and policymakers' requirements and pressure respectively. Therefore, innovation makes the supply chain more responsive not efficient. SMEs adopt innovation to achieve sustainability, only when there is a need from their customers or there is pressure from policymakers through regulations. Innovation is capital intensive. SMEs are reluctant to adopt process innovation for achieving sustainability unless they are assured of desired capital budget.

As explained above, both lean practices and process innovation impact sustainability performance of SMEs' supply chain. SMEs adopt LP when they are more efficiency focused and incorporate PI when they are emphasizing on responsiveness for customers and / or policymakers. Although the objective of both the methods is to achieve sustainability there are both similarities and differences in their applications. Lean practices may need process modification and process innovation may result in higher resource efficiency with more capital investment.

Although there are studies that examine the impact of sustainability practices, lean practices and process innovation on sustainability performances separately, research on their combined relationship with sustainability performance is rare. Additionally, there is no study that looks into the mediating effect of LP and PI on the relationship between sustainability practices and performances. This research theoretically contributes to bridge this knowledge gaps.

Concerning the first research question that we have posed in this paper (hypothesis H1), the predictor of lean practices proved highly statistically significant for the sustainability of SMEs. Thus, the results of the analysis at least for the current dataset, completely verify the suggestions of previous theoretical studies, on the argument that LP helps achieve sustainability (Fliedner and Majeske, 2010; Govindan et al., 2014; Florida, 1996).

Process innovation turned out to be statistically significant yet not in the way we would have expected (research hypothesis H2). PI, in contrast to LP, seems to enhance sustainability at a lower degree. Our analyses show that despite the statistically significant importance of process innovation, the latter is less effective in comparison to the Lean Practices for achieving sustainability enhancement. By including both LP and PI as independent variables into the sustainability model we get considerably less regression coefficient estimates for PI. Thus it might be that the influence of the process innovation is suppressed and gauged through this LP variable. Hence, our findings are partly in agreement with previous research (e.g., Lau et al., 2010; Saunila et al., 2018).

The results of testing research hypothesis 3 revealed also an important finding. Concerning the role of sustainability practices on the enhancement of sustainability performance of SMEs, we have found that the hypothesis H3 was fully confirmed, since that it was seen that the role of sustainability practices as predictor of sustainability is rather enhanced, especially when compared to the PI predictor.

As was expected, the Lean Practices that integrates environmental aspects of small and medium sized businesses, such as waste reduction, is a significant mediator for enhancing sustainability of SMEs. The findings of the current study suggest that the dimension of LP towards sustainability must first be adopted in order to further enhance sustainability performance of SMEs through the environmental, economic and social sustainability constructs. The findings are in accordance with common perception and views as well as with relative research on the field (e.g., Abdul-Rashid et al., 2016; Adebanjo et al., 2016).

Finally, another important finding is that the mediation effects of PI have been found to be non-significant for the relation between sustainability practices and sustainability performance, in comparison to LP. This could be due to substantial capital investment for innovation approaches.

SMEs' businesses are challenging due to numerous competition. They often prioritize economic factors over environmental and social for strategic, planning and operational decision-making. Studies show that unless pressurized by the Government and customers, SMEs do not undertake any environmental improvement of their products and processes (Dey et al. 2018). As lean is economy focused many SMEs have adopted the latter to achieve cost reduction within their value chain and to achieve superior environmental performance. Process innovation is capital intensive, forcing many SMEs away from adopting this. However, prior studies reveal that PI leads to higher sustainability. There lies the importance of policymakers' intervention to make funding available to deserving SMEs to adopt PI. It is difficult to achieve social sustainability performance only though lean practices as often this is cost intensive. PI is the means for achieving higher social performance through employee wellbeing, job creation and CSR activities.

The findings of the current study provide useful insights to both policymakers and SME owners/managers to achieve enhanced sustainability performance through combined sustainability practices, lean practices and process innovation. This enables SMEs to be more sustainable by identifying means for their sustainable performance improvement either adopting LP or PI or a right combination of both on top of their normal sustainability practices. Empirical results of the current study establish correlations between criteria for achieving sustainability for SMEs within a specific region, enabling SMEs' managers to take away the characteristics of SMEs sustainability practices and performance with a few assumptions. Therefore, the outcomes of this study would add knowledge to SMEs within the region and beyond. Additionally, the method of deriving the impact of lean practices and innovation process on sustainability performance could be adopted by any SMEs consortium across the World.

In addition, representative case studies of real examples on how specific approaches and procedures of combined LP and PI have helped individual SMEs to achieve sustainability have been presented, strengthening in this way the results derived from quantitative analysis and modeling and providing indicative suggestions to the owners/managers of SMEs on improving their supply chain sustainability performance. The case studies have been adopted not only to validate the findings from SEM analysis and demonstrate the means for achieving SMEs' sustainability performance, but also to show how real SMEs perceive in practice their issues and challenges and deal with it and how - along with economic considerations (cost and quality) - environmental and social aspects could be integrated so as to achieve maximum benefits (i.e. long term sustainability).

For further improvement of the current research we underline some main issues and limitations. Firstly, the sample size of dataset used in the current analysis is relatively small. Since this is the first testing of the proposed theoretical model and corresponding hypotheses, it is important that we assess the validity of the latter with additional data replicating the methodological approach to larger samples – and of different geographical locations – may provide additional insights and reinforce the results of our assessment. Secondly, a future approach focusing on particular industries - besides manufacturing - and sectors may allow specific and more detailed features of lean and innovation practices with regards to how they affect SME sustainability. Another limitation of the study is the border-line fit of the tested SEM model. Although it is anticipated that fit could have been improved by re-fitting the specific model excluding the non-significant components, we did not pursued this in the present study since our main goal was on testing specific research hypotheses. These limitations have been kept outside the scope of this study and could be undertaken in future.

7. Conclusions

Small and medium sized enterprises achieve supply chain sustainability through right trade-off among economic, environmental and social factors across their decision levels - strategic, planning and operational decisions. Sustainability practices, lean practices and process innovation in combination enable superior sustainability performance of SMEs' supply chain. Lean practices are economy focused and therefore, motivate SMEs more to adopt them for achieving sustainability. Process innovation is capital intensive and needs customers' and / or policymakers' intervention for adopting. Lean is more effective to achieve supply chain sustainability than process innovation. Process innovation is customers and regulatory driven. In summary, lean practices and process innovation approaches both assist in enhancing supply chain sustainability but the motivation for adopting each practice varies. Lean practices are more effective for SMEs compared to process innovation. However, capital support for adopting sustainability measures from policymakers may create different perception among SMEs' managers/owners.

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APPENDIX A

Practices	**Performance aspects**
Lean Practices: **1.** All form of waste reduction practices **2.** Total quality management **3.** Total productive maintenance **4.** Statistical process control **5.** Inventory management **6.** Capacity utilization **7.** We use effective supplier relationship management practices (10-point likert scale) **8.** We use effective customer relationship management practices (Practices 1-6 & 8 are measured on a 5-point likert scale)	**---**
Process Innovation: **1.** Eco-design (PROC_INNOV_1), **2.** Green supply chain management (PROC_INNOV_2), **3.** Organizational green strategy (PROC_INNOV_3), (5-point likert scale)	**---**
Economic: **1.** Number of Employees (ECO_PR_1), **2.** Infrastructure (ECO_PR_2). (10-point likert scale)	**Economic:** **1.** Turnover (ECO_PER_1), **2.** Business growth (ECO_PER_2). (10-point likert scale)
Environmental: **1.** Waste management practices (ENV_PR_1), **2.** Energy consumption and emission control (ENV_PR_2), (5-point likert scale)	**Environmental:** **1.** Effectiveness of environmental system (ENV_PER_1), **2.** Waste reduction (ENV_PER_2), **3.** Reduction energy consumption and emissions (ENV_PER_3). (5-point likert scale)
Social: **1.** CSR practices (SOC_PR_1), (5-point likert scale)	**Social:** **1.** CSR performance (SOC_PER_1), **2.** Health and safety performance (SOC_PER_2). (5-point likert scale)

Table A1: Analytical description of the observed items from the SMEs' questionnaire.

Observed items of practices/performance	N	Mean	Standard deviation
LEAN_PR_1	119	2.61	1.62
LEAN_PR_2	119	3.89	1.92
LEAN_PR_3	119	2.64	0.81
LEAN_PR_4	119	2.67	0.79
LEAN_PR_5	119	2.68	1.58
LEAN_PR_6	119	2.52	0.93
LEAN_PR_7	119	5.13	3.57
LEAN_PR_8	119	2.26	1.98
PROC_INNOV_1	119	3.06	1.58
PROC_INNOV_2	119	3.03	1.47
PROC_INNOV_3	119	2.68	0.85
ECO_PR_1	119	5.13	3.57
ECO_PR_2	119	2.27	1.98
ENV_PR_1	119	2.77	1.49
ENV_PR_2	119	2.39	1.03
SOC_PR_1	119	2.20	1.23
ECO_PER_1	119	2.85	2.61
ECO_PER_2	119	2.20	1.62
ENV_PER_1	119	2.20	1.23
ENV_PER_2	119	3.21	1.10
ENV_PER_3	119	2.66	0.89
SOC_PER_1	119	2.31	1.19
SOC_PER_2	119	2.60	0.97

Table A2: Descriptive statistics for the observed items from the SMEs' questionnaire (mean and standard deviation).

Construct	Sub-construct	Observed item	Estimate
Process Innovation		PROC_INNOV_1	0.91
		PROC_INNOV_2	0.923
		PROC_INNOV_3	0.242
Lean Practices		LEAN_PR_1	0.757
		LEAN_PR_2	0.168
		LEAN_PR_3	0.591
		LEAN_PR_4	0.376
		LEAN_PR_5	0.802
		LEAN_PR_6	0.649
		LEAN_PR_7	0.385
		LEAN_PR_8	0.448
Sustainability Practices	Economic Practices	ECO_PR_1	0.717
		ECO_PR_2	0.894
	Social Practices	SOC_PR_1	0.44
	Environmental Practices	ENV_PR_1	0.908
		ENV_PR_2	0.904
Environmental Performance		ENV_PER_1	0.642
		ENV_PER_2	0.483
		ENV_PER_3	0.458
Economic Performance		ECO_PER_1	0.544
		ECO_PER_2	0.840
Social Performance		SOC_PER_1	0.625
		SOC_PER_2	0.462

Table A3: Standardized estimates of SEM analysis

APPENDIX B

Company detail	Sustainability Practices	Sustainability Issues and challenges	Lean Practices	Process Innovation	Sustainability performance	Remarks
Surgical Kits Manufacturer, West Midland Main products: Surgical kits Major customers: National health Services (NHS), UK (75%) and EU distributors (25%) Suppliers: China (80%), UK and EU (20%) Turn over: GBP 50M Number of employees: around 200	**Economic Practices** Good infrastructure (production facility and warehouse for finished products). Adequate manpower for admin., and plant operations. Design, planning, procurement, production, quality, logistics, information, manpower, finance, marketing management processes using standard approaches.	While for the European distributors they have sufficient lead time for delivery in line with their specification, for NHS they need to deliver customized products within 48 hours. As the lead time for manufacturing of the kits is more than 10 days, on anticipation of customers demand, the SME manufactures several customized kits. They need to do so in order to remain ahead of the competition in the	The SME adopted lean practices through integrating capacity, inventory, and procurement (upstream and downstream) management. The following approaches have been undertaken – developing a model for demand forecasting, establishing effective communication with customers so as to forecast demand with least error, developing right inventory policies for raw materials and finished products, and adopting right procurement method. More than 70%	The company has been accredited by both ISO 9000 and 14000. Additionally, through continuous quality improvement, processes and information across the supply chain is integrated to maximise customers' satisfaction and minimise cost. Organisational structure is changed from vertical hierarchy to flat hierarchy so as to enhance	**Economic performance** Productivity has improved substantially Capacity utilisation: 85% Inventory reduction: raw materials (50%) Finished products (70%) Throughput: 15% Business growth: 12% yearly Cost reduction:	Lean practices and process innovation in combination affected the SME's growth and sustainability. The SME had reasonably good sustainability practices in place prior to adopting lean practices and process innovation. Managers agree that adoption of lean practices and subsequent process innovation helped them to enhance their overall performance substantially. They commented that lean practices and process

	Environment Practices Adopted reduce, reuse and recycle approach across the value chain. **Social Practices** Health and safety, and employee wellbeing have been given emphasis. CSR investment is absent.	market. Many of these customized manufactured kits may not be sold at all for several years. This results in large amounts of finished products inventory for the company concerned and made them operating a large warehouse. Additionally, as they procure most of their raw materials from China, in order to reduce risk of supplies they also keep considerable amount of raw materials inventory.	materials are locally sourced. This helped the SME to be efficiency focused at the same time environmental and social concern, which helped them to reduce energy consumption, waste reduction and enhance resource optimization and jobs creation. Additionally, this helped the SME to optimize their warehouse size and manpower.	communication, individual responsibility, commitment, and ownership.	20% **Environmental performance** Overall resource efficiency (80%) Waste reduction: (45%) Energy cost reduction: (35%) **Social Performance:** Accident reduction – zero accident. Employee wellbeing: (10% increase in bonus along with initiating several benefit schemes). 5% of profit goes to CSR funding to develop local communities.	innovation has synergy although they are philosophically different as lean cannot be adopted without substantial process innovation and on the other hand process innovation also need several lean practices in order to be customer focused in economic way.

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East Midland Metrology Limited, Derby Main products: Gauges for railway industry and their calibration services. Major customers: Railway workshops across Britain.	**Economic Practices** Centralised manufacturing and warehousing facility with trained adequate manpower. Two vehicles for logistics support. Manufacturing through both 'pull' and 'push' types depending on customers' order and flexible organisation's policy on inventory. Calibration services are the major chunk of the business, which is very competitive and driven by delivery time. When a client needs calibration of specific gauge they raise indent on specific SME's online system or on their own portal. This should be immediately responded with quote	When a specific gauge needs calibration, the workshop raises an indent via their online system. The SME arrange to collect this from the workshop, brings it to the plant at Derby, calibrate this and returns to the workshop. The cycle time for the entire process is currently seven days. However, the desired lead time from customers is five days. The company currently own two vehicles that are used for the logistics and also deploy third party logistic services providers (e.g. DHL, FedEx, UPS etc.). Their own vehicles remain occupied for 14 hours in a day on average. On time delivery is one of the major critical success factors for their business.	Logistics optimisation has been adopted through application of geographical information system (GIS) specialized in transportation problems (TransCAD®). This resulted not only achieving scheduled delivery (within five days from collection) but average vehicle running hours in a day came down drastically. Additionally, overall cost of transportation was reduced		**Economic performance** Overall productivity has improved substantially Capacity utilisation: 80%. Finished products inventory reduced (80%). Raw materials inventory reduced 70%. Throughput: 25% increased. Business growth: 15% yearly. Cost reduction: 20%. **Environmental performance** Overall resource efficiency (80%). Waste reduction: (15%).	Logistic optimisation through GIS based TransCAD® helped the SME to achieve desired sustainability performance. Logistics cost was drastically reduced, delivery schedules were met, vehicles were not being used more than 8 hrs in a day and 6 days in a week. This affected very positively the environmental performance of the business by reducing carbon footprint considerably. This helped the business to grow significantly, by not only minimising the costs associated with the logistics operation but also acquiring new projects due to enhanced customer satisfaction through on time delivery. Managers agree that adoption of lean practices helped

	that comprises of specification of services, cost and delivery time. If awarded sticking to the delivery time is very crucial to remain competitive along with other criteria. **Environment Practices** There is no effort to logistic optimisation for resource efficiency as energy efficiency. **Social Practices** Not much focused on social aspects.		substantially. This eventually helped reducing carbon footprint of the company in logistics. Additionally, their vehicle operators were also relived from long workdays.		Energy cost reduction: (25%). **Social Performance:** Accident reduction – zero accident. 5% of profit goes to employee wellbeing fund. 5% of profit goes to CSR funding to develop local communities. Job creation (yearly): 3 new jobs.	them to enhance their overall substantially performance.

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Reconditioning Engine, Chesterfield Main products: re-conditioned engines. Major customers: bus and coach companies. Major suppliers: Retails and engine component manufacturers. Turn over: GBP 10M. Number of employees:17.	**Economic Practices** The production facility is inadequate. Business processes: On anticipation of customers' demand, the SME keeps inventory of nine reconditioned engines of varied specifications (make and model). If a specific demand matches with their available finished product inventory, customer's engine downtime reduces substantially and the SME concerned makes money by selling the inventoried products quickly. The broken down engine will be bought by the SME if they are repairable and would be repaired and kept it in the inventory for future use. However, if the demand doesn't match with the existing inventory, the broken	The facility is not adequate. Capacity is limited (currently processes only nine engines). High finish product inventory as on anticipation of customers' demand engines are kept ready although demand uncertainty is very high. Business is quite competitive as many SMEs operate in this industry. Customers' have several choices. One of the critical success factors of this industry is faster services. Supply side is generally manageable with good up-to-date information on spares availability across the major retails and original equipment manufacturers. Achieving higher energy efficiency needs constant updating on technology usage and		Business process has been transformed from 'push' type to 'pull' type through developing long term relationship with client organisations. Instead of selling products (e.g. engines) they have started selling services (e.g. power transmission, which engines provide). Facility has been improved substantially to cope up with this transformation. To deal with additional demand of the customers they have develop collaboration with their competitors and adopted vendor manage inventory policy for spares. The SME implemented telematics in order to monitor their engines' condition on real time basis while in operations with their clients (e.g. Aviva and Stage Coach Bus service providers). The proposed telematics will allow the engine reconditioning SME to monitor the health of the engines while in operations and before their condition reaches to breakdown point suitable measures will be undertaken to reduce the down	**Economic performance** Productivity has improved substantially upon adoption of telematics. Capacity utilisation: more than 90%. Inventory reduction: raw materials (60%). Finished products (80%). Throughput: 15% increased. Business growth: 20% yearly. Cost reduction: 13%. **Environmental performance** Overall resource efficiency (60%). Waste reduction: (45%). Energy consumption	The concerned SME adopted process innovation to address their sustainability issues. The SME had struggled with their economic performance prior to adopting process innovation. Through adopting telematics technology in collaboration with the other supply chain stakeholders they transformed their business to be responsive, efficient and environmental and social friendly.

	down engine will be reconditioned with the procurement of desired components from local retails. Both the business processes are incredibly inefficient as for the first scenario, inventory cost is high and for the second, additional logistics cost and higher unit cost of supplies because of emergency procurement. Although in the first scenario, customers' are somewhat satisfied due to lower downtime of their services to end customers, in the second scenario, high downtime make them utterly dissatisfied. **Environment Practices** Resource efficiency is incredibly low as the business is highly uncertain and to cope up with uncertainty SME intends to keep flexibility that makes	machine replacement. Which is capital intensive. Similarly, other environment friendly approaches need capital investment, which is serious issue as the SME concerned face serious cash flow issue due to high inventory cost. Although the SME concerned develop skill among the local young people but fail to create adequate jobs due to business completion and lack of growth.		time. Additionally, as the company is aware of the engine condition prior to being out of operations, they will make a similar engine ready for the replacement. This will help to achieve almost zero break-down for their clients. This will be a win-win situation for both the client and supplier. The client will be able to serve their customers without any service disruption and the engine reconditioning SME will be able to get assured business from the client. Moreover, the concerned SME also developed collaboration with a few local competitors to enhance their capacity to address the challenge of demand from specific bigger clients as and when required along with substantial improvement of their facilities, infrastructure and resources.	reduced by 10%. **Social Performance:** Five new jobs within the company and 10 more new jobs within the partnering organisations have been created. CSR funding source has been created within the supply chain involving partnering SMEs and Original Equipment Manufacturers (OEMs).	

	them very inefficient. Engine life extension by reconditioning and repairing is itself environment friendly practices. Recycling metal components is part of the system. This industry is energy intensive. However, there is no noticeable energy consumption reduction effort from the company side. There is no waste water treatment facility. Packaging wastes are recycled. **Social Practices** The SME runs apprenticeship scheme to train local people and some of them join in the workforce after completion of their training. Employee wellbeing, and health and safety					

	practices are in place There is no CSR investment.					