The Impact of Lean Practices on the Operational Performance of SMEs in India

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ABSTRACT

Purpose: *Although lean thinking is deemed to be a gold standard of modern production management, a lot of scepticism still remains regarding its applicability in small and medium-sized enterprises (SMEs). This paper aims to understand the perception of lean in SMEs and establish the relationship between lean adoption and operational performance.*

Design/Methodology/Approach: *With the help of a survey, data was collected from 425 SMEs in India and analyzed using structural equation modelling (SEM).*

Findings: *Operational performance of the firms was found to be positively related to lean implementation.*

Originality/Value: *This study also furnishes practitioners with a better understanding of lean thinking in SMEs and its impact on performance.*

Keywords: Lean Thinking; Small and Medium-sized Enterprises; Operational Performance; Lean manufacturing

1. INTRODUCTION

Toyota developed the Toyota Production System (TPS) in Japan. This concept evolved into lean manufacturing (Krafcik, 1988) in the USA and then diffused to other developed economies. Although numerous studies have reported the significant benefits of lean adoption in large enterprises (Shah and Ward 2003; Shah and Ward 2007; Belekoukias et al. 2014; Bevilacqua et al. 2017), a lot of scepticism still remains regarding its impact in small and medium-sized enterprises (SMEs). The benefits of lean adoption need to be fully considered and evaluated in SMEs. Similarly to lean research in general, lean adoption in SMEs has recently gained attention in developing countries such as India, where SMEs account for 45% of exports, 45% of the total manufacturing output and employment to over 80 million people (MSME 16).

A few lean implementation case studies in SMEs can be found in the literature (Kumar *et al.* 2006; Upadhye *et al.* 2010; Panizzolo *et al.* 2012; Arya and Jain 2014; Vinodh *et al.* 2014; Arya and Choudhary 2015; Gupta and Jain 2015) principally focusing on the level of implementation and the development of presentational and analytical frameworks. However, the literature concerning the impact of lean adoption on operational performance in SMEs is limited. Thus, there is a strong need for further investigation into the relationship between lean implementation and operational performance in SMEs. Here, in this research, a twofold attempt is made to fill the gap by first assessing the degree of adoption of lean practices in SMEs and, subsequently, analyzing the impact of lean practices on the operational performance of SMEs. A survey of 425 Indian SMEs was carried out, and the data was analyzed using a Structural Equation Modelling (SEM) approach. It was found that a limited number of lean practices are being implemented by Indian SMEs but this partial lean implementation is having a positive impact on operational performance.

The paper is organised as follows: the next section focuses on the extant literature on lean in SMEs and the development of the research hypotheses. The research methodology is discussed in section 3. The analysis of results is presented in section 4 and further discussed in section 5. The paper concludes with a description of the implications and limitations of the study.

2. REVIEW OF LITERATURE AND HYPOTHESES DEVELOPMENT

The generic nature of the basic principles of lean viz. the elimination of waste, value enhancement, and customer satisfaction make them applicable not only to large enterprises (LEs), but also to SMEs (Hu et al. 2015). The literature provides some evidence to support this view. Motwani (2003) demonstrated a case study of lean implementation in a medium-sized automotive manufacturing company and reported improvements in performance measures such as cycle time, setup time, inventory and product development lead time. Kumar *et al.* (2006) implemented a lean sigma framework in an Indian SME. This framework comprised of value stream mapping (VSM), workplace organization (5S), total productive maintenance (TPM) and mistake proofing practices which were found to result in reduced defects, improved overall equipment effectiveness (OEE), and financial savings. Slomp *et al.* (2009) investigated how lean production control principles can be used in low-volume, high-variety, and make-to-order job shops. The authors presented a case study of an SME manufacturing electrical power distribution and control equipment and demonstrated that the implementation of lean reduced flow time and increased service level with on-time delivery performance improving from 55 to 80 %. Similarly, Upadhye *et al*. (2010) implemented kaizen, just in time (JIT), VSM, 5S, statistical quality control (SQC), preventive maintenance, total employee involvement, and single minute exchange of dies (SMED) in an SME and found reduced rejection rate, inventory, and cost and increased OEE, productivity, and on-time delivery. Vinodh *et al.* (2011) recorded increased OEE and reduced machine downtime, rejection rate and inventory after implementing cellular manufacturing, TPM, 5S, total quality management (TQM), setup time reduction, and kanban lean practices in an Indian automotive valves manufacturer. Panizzolo *et al.* (2012) presented four case studies of Indian SMEs that had deployed a lean strategy to drive significant improvement in manufacturing performance. Similarly, Danese *et al.* (2012) tested the effect of JIT production and JIT supply on efficiency and delivery. With the help of a structural equation modelling approach, Vinodh and Joy (2012) presented a correlation between lean practices and its contribution in improving organisational performance. Arya and Jain (2014) reported a case study of kaizen adoption in an Indian machine vice manufacturing company and observed reduced processing time.

Vinodh *et al.* (2014) used a lean sigma framework to implement 5S, kanban, work study techniques, mistake-proofing, and TPM, and demonstrated significant improvement in key operational metrics. Vlachos (2015) considered the adoption of lean in UK-based food supply chains and developed a lean action plan for food SMEs. Similarly, Manfredsson (2016) employed lean principles in a textile SME and identified an overall positive effect.

Researchers have also estimated the financial benefits of implementing lean in SMEs. Thomas *et al.* (2016) applied a lean six sigma framework to a medium-sized UK aerospace manufacturing organisation and noticed improvement in on-time delivery by 26.5% and build time reduction by 20.5%. Likewise, Panwar et al. (2017) demonstrated that the adoption of lean practices results in a positive impact on inventory control, waste elimination, cost reduction, productivity, and quality improvement. Overall, such positive studies are scarce but the review does demonstrate that there is sufficient case study evidence to suggest that the application of lean practices in SMEs can have a positive impact on operational performance. However, as the majority of the research has adopted a case study approach, the literature lacks a comprehensive empirical analysis of the research in the field. In India, most of the studies presented the implementation of a small number of lean practices in SMEs, and so the literature fails to provide a convincing or comprehensive perspective on the degree and the effects of lean adoption in Indian SMEs. In this paper, we attempt to address this research gap.

2.1 Hypotheses development:

The previous section demonstrates the application of a limited number of lean practices in SMEs. Mathur *et al.* (2012) suggested that SMEs should implement lean practices that are simple and inexpensive to use. Similarly, Bamford *et al.* (2015) conducted two case studies and found a partial adoption of lean. Further, Chaplin *et al.* (2016) recommended a "lean-lite" approach (limited number of lean practices) for SMEs because of their limited financial and knowledge resources. With the help of a survey of Brazilian SMEs, Filho *et al.* (2016) concluded that SMEs are only implementing a few lean practices in a fragmented manner. The authors found only three lean practices (out of ten that were examined) represented the core of lean implementations in Brazilian SMEs. Thus, due to the limitations of resources, knowledge and manpower, SMEs are not able to adopt full lean thinking. Therefore, rather than adopting full lean, SMEs are implementing selected lean practices in their organizations. To investigate the status of lean and to check the extent of lean adoption in Indian SMEs, we proposed the following hypothesis:

H1: SMEs adopt a limited number of lean practices.

Although a small number of lean case studies have demonstrated a positive effect on operational performance, full empirical testing is absent in the literature. For the large enterprises, numerous scholars have tested the effect of lean adoption on operational performance. On the other hand, we found only one study for SMEs, i.e. Filho et al. (2016). Our research aims to contribute to this gap, studying the impact of lean on operational performance in the context of SMEs. This led to the following hypothesis:

H2: Lean has a positive impact on operational performance.

3. RESEARCH METHODOLOGY

Firstly, a survey instrument was developed by using prior literature and the inputs from experts. Secondly, the survey was distributed to the target population (SMEs of fifteen states in India), and the responses were collected. Further, to test the hypotheses, the collected data was analysed using Structural Equation Modelling (SEM) and subsequently the findings were drawn.

After reviewing the plethora of literature, the survey instrument was designed to test the hypotheses. Hence the survey instrument used in this study is basically a revised version of the instruments used in prior studies. The questionnaire was organized into three sections: the first section included the organizational information and the respondent's profile, the second included the questions related to the implementation of lean practices, and the third section was dedicated to the operational performance of the SMEs. Organisational information included location, sector, production type, number of employees, and investment in plant and machinery. The respondent's profile included department, time in the company and position.

Based on the literature, ten lean practices (constructs) were identified: customer involvement, employee involvement, supplier involvement, pull system, 5S, total productive maintenance (TPM), statistical process control (TPM), single minute exchange of die (SMED), visual management, and production leveling (Table 1). The ten constructs, with their variables, are shown in Table 3. A seven-point scale (1-not adopted/ not known; 2-planning for adoption in at least one area, 3-initial implementation phase initiated in at least one area, 4-started successfully in at least one area, 5-in practice effectively in at least one area for less than 1 year, 6-in practice effectively in at least one area for more than 1 year, and 7-in practice effectively for the entire organisation) was developed to measure the level of adoption of lean practices in the surveyed SMEs. Five measures, identified from the literature, were used to measure operational performance (Table 2). Similar to the adoption of lean practices, the operational performance variables were measured on a seven-point scale (1 - do not agree to 7 - fully agree).

Table 1: Measures of Lean Practices

Lean Practices	Present study	Shah and Ward (2003)	Hofer et al. (2012)	Filho et al. (2016)	Panwar et al. (2018)
Customer involvement	X	X	X	X	
Employee involvement	X	X	X	X	X
Supplier involvement	X	X	X	X	X
Pull system	X	X	X	X	X
5S	X				X
Total productive maintenance	X	X	X	X	X
Statistical process control	X	X	X	X	X
Single minute exchange of dies	X	X	X	X	X
Visual management	X				X
Production leveling	X	X		X	X

Table 2: Operational performance measures

Operational performance measures	Present study	Shah and Ward (2003)	Filho et al. (2016)	Panwar et al. (2018)
Inventory levels	X			X
Defect levels	X	X	X	X
Productivity	X	X	X	X
Production wastes	X	X	X	X
Production costs	X	X	X	X

Table 3: List of survey items, means, standard deviations and Cronbach's alpha

Construct	**Variable code**	**Variable**	**Mean**	**SD**
Customer involvement	CI_1	We are in close contact with our customers.	5.73	1.107
	CI_2	Customers give feedback on quality and delivery performance.	4.53	1.304
	CI_3	Customers are actively involved in current and future product offerings.	5.55	1.230
	CI_4	Customers frequently share demand information.	4.64	1.310
Employee involvement	EI_1	Shop floor employees are actively involved in problem solving.	4.65	1.097
	EI_2	Shop floor employees are actively involved in process improvements.	4.73	1.205
	EI_3	Shop floor employees regularly provide suggestions for improvement.	4.18	1.140
	EI_4	Shop floor employees undergo cross-functional training.	4.03	1.137
Supplier involvement	SI_1	We give our suppliers feedback on quality and delivery performance.	2.51	1.017
	SI_2	We strive to establish long-term relationship with our suppliers.	2.47	1.014
	SI_3	Our key suppliers are located in close proximity to our plant.	2.43	1.043
	SI_4	We take active steps to reduce the number of suppliers in each category.	2.47	1.054
Pull system	PS_1	Production is pulled by shipment of finished goods.	3.26	.996
	PS_2	Production at workstations is pulled by the demand of the next station.	3.84	1.329
	PS_3	We use Kanban, squares or containers of signals for production control.	3.61	1.338
	PS_4	We use a pull system to control the production rather than a schedule prepared in advance.	3.53	1.236
5S	5S_1	Only the materials which are actually needed are present in the work area.	4.74	1.234
	5S_2	Only tools and hand tools which are needed are present in the work area.	4.97	1.254
	5S_3	Locations for all production materials are clearly marked out and the materials are stored in the correct locations. Areas for WIP (work-in-process parts) are clearly marked.	4.12	1.267
	5S_4	Work areas, storage areas, aisles machines, tools, equipment and offices are clean/neat and free of safety hazards.	4.73	1.382
	5S_5	Regularly scheduled housekeeping tours and periodic self-assessments (5S audits) are conducted.	4.75	1.306
Total Productive Maintenance	TPM_1	We maintain all our equipment regularly.	4.30	1.124
	TPM_2	We maintain records of all equipment maintenance activities.	4.96	1.359
	TPM_3	We ensure that machines are in high state of readiness for production at all the time.	5.21	1.291
	TPM_4	Operators are trained to maintain their own machines.	5.24	1.330
Statistical process	SPC_1	Charts showing defects are used as tools on the shop floor.	4.55	1.347
	SPC_2	We use diagrams like cause & effects (fishbone) to identify	4.12	1.138

		causes of quality problems		
	SPC_3	We conduct process capability studies before product launch.	4.81	1.294
	SPC_4	We use statistical techniques to reduce process variance.	4.80	1.348
Single minute exchange of dies	SMED_1	We are working to lower set-up time in our plant	3.42	1.004
	SMED_2	We have short set-up times for equipment in our plant	4.15	1.349
	SMED_3	Operators perform their own machines set-ups.	3.83	1.084
	SMED_4	Operators are trained on machine set-up activities.	3.92	1.365
	SMED_5	We emphasize the need to place all tools in a convenient area to the operator.	3.86	1.524
Visual management	VM_1	Equipment are identified with signages	3.20	1.341
	VM_2	Process parameters are displayed on the shop floor.	3.13	1.290
	VM_3	Manufacturing performance is displayed on the shop floor.	3.12	1.257
Production levelling	PL_1	We mix production on the same machines and equipment..	4.47	1.286
	PL_2	We emphasize the need for an accurate forecast to reduce variability in production.	5.05	1.400
	PL_3	Each product is produced in a relatively fixed quantity per production period.	4.15	1.238
	PL_4	We emphasize the need to equalize workloads in each production process.	4.15	1.328
	PL_5	We produce by repeating the same combination of products from day to day.	4.49	1.284
	PL_6	We always have some quantity of every product model to respond to variation in customer demand.	5.29	1.310
Operational performance	OP_1	We have low inventory levels (raw material, WIP and finished goods)	4.39	1.573
	OP_2	We have low defect levels.	3.78	1.068
	OP_3	Our productivity is high.	3.57	1.096
	OP_4	We have low lroduction waste.	4.01	1.320
	OP_5	Our production costs are predictable.	4.64	1.500

Content validity of the questionnaire was confirmed by pre-testing it on an expert team. The team consisted of four academics (two professors, one associate professor and one assistant professor who have PhDs in lean and lean-related topics and have experience ranging from 5 to 15 years) and three practitioners (SME owner-managers). The questionnaire was updated as per the suggestions of the expert team. A pilot testing was performed with thirty SMEs, randomly selected from the population. Each of the thirty responses were received from personal visits, and three questions were modified as per their feedback.

The survey was carried out in SMEs covering fifteen states: Andhra Pradesh, Bihar, Delhi, Goa, Gujarat, Haryana, Jharkhand, Madhya Pradesh, Maharashtra, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh, Uttrakhand and West Bengal in India. The survey was conducted from June 2017 to October 2017. The survey companies were randomly identified from the database of the Confederation of Indian Industries (CII). The questionnaire was sent via email to 1284 companies followed by telephonic follow-up and personal visits resulting in 425 usable responses (response rate 33 percent). The response rate of 33 percent is well above the recommended rate for an empirical study in operations management (Malhotra and Grover, 1998; O'Leary-Kelly and Vokurka, 1998).

The early and late responses were compared and no significant differences found between the groups, which suggested no confirmation of non-response bias in the survey responses. Structural equation modeling (SEM) requires setting a prior sample size based on the latent and observed variables and through a power analysis (Hair *et al.* 2013). As per the recommended sample size calculator for SEM (Soper, 2017), 238 is sufficient for reliable results at the anticipated effect size of 0.3, 90 percent desired statistical power level and 0.05 probability levels. Hence, our sample was adequate for further analysis. The missing data rate was very low and adjusted by substituting with mean values. Correlation and linear regression were performed using SPSS software. Further, the SEM analysis was performed using AMOS software. The SEM analysis allowed the recognition of causality and to investigate the interrelationship between the constructs. The results from the SEM are provided in the next section.

4. RESULTS

In this research, the maximum likelihood estimation approach was used for SEM analysis. This approach is an iterative estimation procedure based on maximizing the probability (likelihood) that the observed co-variances are drawn from the population assumed to be the same as that reflected in the coefficient estimates (Kline, 2015). The majority of the studies (68.9%) in the area of operations management have used such an approach (Shah and Goldstein, 2006). A two-step approach was used involving confirmatory factor analysis (CFA) for evaluating the measurement model followed by testing the structured model. The two steps are explained below.

4.1 Confirmatory Factor Analysis

To assess the quality of the measurement model, convergent validity, composite reliability, communality, and discriminant validity were measured. The convergent validity is the level to which a latent construct describes the variance of its measurements. The average variance extracted (AVE) is a dimension of convergent validity. Composite reliability is a measure of internal consistency assessed by Cronbach's alpha. Communality explains the degree to which the variation in an item is explained by the construct and is referred to as variance extracted from the item. The discriminant validity (DV) is the degree to which a factor is really different from the other factors and also the degree by which an item is related to a construct (Hair et al. 2013). The reference values for these statistical quality measures are presented in Table 4.

Table 4: Statistical quality measures

Measure	Value	Reference
Number of manifest variables per latent variable	≥3.0	Flynn et al. 1990; Malhotra and Grover 1998; Shah and Goldstein 2006; Hair et al. 2013
Cronbach's alpha of latent variable	≥0.7	
Average variance extracted of latent variable	≥0.5	
Composite reliability of latent variable	≥0.7	
Communality of latent variable	≥0.5	
Loading of latent variable	≥0.7	
Loading of manifest variable	≥0.7	

To evaluate fitness of the model, fit indices viz. χ^2 /df (df=degree of freedom), normal fit index (NFI), comparative fit index (CFI), goodness of fit (GFI), adjusted goodness of fit (AGFI), root mean square residual (RMR), and root mean square of error approximation (RMSR) were used. A good fit model should have the values of GFI, AGFI, NFI, and CFI close to 1 or greater than 0.9 and the values of RMSEA $\leq$ 0.5 (Byrne 2013; Kline 2015). According to Schermelleh-Engel *et al.* (2003), a value of RMR between 0.05 and 0.10 is considered good.

The values of the statistical quality measures are presented in Table 5. Based on reference values and actual values of the measures, two constructs, supplier involvement and visual management, were dropped from the structural model. Moreover, the goodness of fit indices for the remaining eight constructs were under an acceptable range which was considered for the further analysis.

Table 5: Testing the quality of the first-order structural model

First order latent variable	Manifest variable	Manifest Variable loading	P value	R^2	AVE	CR	α	CO	Construct loading	P value
CI	CI_1	0.713	0.000	0.778	0.529	0.818	0.723	0.529	0.892	0.000
	CI_2	0.721	0.000							
	CI_3	0.740	0.002							
	CI_4	0.736	0.000							
EI	EI_1	0.715	0.001	0.745	0.577	0.844	0.782	0.577	0.862	0.000
	EI_2	0.736	0.000							
	EI_3	0.743	0.000							
	EI_4	0.839	0.002							
SI	SI_1	0.731	0.001	0.426*	0.551	0.830	0.723	0.551	0.652*	0.056*
	SI_2	0.782	0.002							
	SI_3	0.734	0.008							
	SI_4	0.722	0.006							
PS	PS_1	0.734	0.000	0.683	0.602	0.857	0.802	0.602	0.812	0.001
	PS_2	0.794	0.000							
	PS_3	0.829	0.001							
	PS_4	0.743	0.004							
5S	5S_1	0.749	0.004	0.582	0.555	0.861	0.799	0.555	0.753	0.008
	5S_2	0.785	0.002							
	5S_3	0.726	0.002							
	5S_4	0.712	0.001							
	5S_5	0.753	0.000							
TPM	TPM_1	0.723	0.000	0.723	0.583	0.848	0.729	0.583	0.849	0.000
	TPM_2	0.742	0.000							
	TPM_3	0.762	0.000							
	TPM_4	0.824	0.000							
SPC	SPC_1	0.705	0.000	0.782	0.554	0.832	0.699	0.554	0.904	0.002
	SPC_2	0.725	0.000							
	SPC_3	0.797	0.001							
	SPC_4	0.748	0.001							
SMED	SMED_1	0.757	0.000	0.563	0.587	0.876	0.836	0.587	0.746	0.001
	SMED_2	0.760	0.000							
	SMED_3	0.780	0.000							
	SMED_4	0.721	0.000							
	SMED_5	0.812	0.000							
VM	VM_1	0.921	0.016	0.482*	0.850	0.944	0.926	0.850	0.682*	0.062*
	VM_2	0.916	0.008							
	VM_3	0.929	0.062*							
PL	PL_1	0.724	0.000	0.642	0.528	0.870	0.733	0.528	0.780	0.000
	PL_2	0.720	0.001							
	PL_3	0.712	0.002							
	PL_4	0.780	0.001							
	PL_5	0.723	0.001							
	PL_6	0.702	0.000							

Where: AVE: average variance extracted; CR: composite reliability; α: cronbach's alpha; CO: communality;

4.2 Structural equation model

In order to assess the lean tools and operational performance relationship it was imperative to create a second-order structural model. In the structural model, a second-order latent construct, 'Lean', was created by means of a reflective construct model. The primary condition for this type of modeling is that all first-order latent variables should have a significant correlation. Table 6 presents the correlations between lean practices (first-order latent constructs). It can be seen that 91 percent and 64 percent correlations are significant at the level of 0.05 and 0.01 respectively. Thus the analysis suggests the existence of a second-order latent construct.

Table 6: Pearson correlations between first-order variables (lean practices)

Constructs	CI	EI	SI	PS	5S	TPM	SPC	SMED	VM	PL
CI	1.00									
EI	0.47**	1.00								
SI	0.18*	0.11	1.00							
PS	0.19*	0.18*	0.15*	1.00						
5S	0.34**	0.33**	0.09	0.29**	1.00					
TPM	0.52**	0.36**	0.18*	0.32**	0.35**	1.00				
SPC	0.50**	0.39**	0.11	0.25**	0.36**	0.58**	1.00			
SMED	0.32**	0.21**	0.16*	0.43**	0.38**	0.21**	0.24**	1.00		
VM	0.35**	0.08	0.18*	0.24**	0.18*	0.15*	0.16*	0.15*	1.00	
PL	0.51**	0.24**	0.19*	0.28**	0.36**	0.56**	0.59**	0.25**	0.23**	1.00

** Correlation is significant at the level of 0.01(2-tailed) 29 out of 45

* Correlation is significant at the level of 0.05(2-tailed) 12 out of 45

After introducing the second-order construct (lean), the goodness-of-fit indices for the structural model were χ^2 /df=1.423, GFI = 0.902, AGFI = 0.923, RMR = 0.021, NFI = 0.913, CFI = 0.966 and RMSEA = 0.032 and were found to be within acceptable limits. The operational performance construct was also subjected to CFA and was also found to be satisfactory. The final structural model was constructed as shown in Figure 1. Quality measures for the model are presented in Table 7. The model was found to be appropriate for all the statistical quality measures. Goodness of fit indices for final model were χ^2 /df=1.247, GFI = 0.942, AGFI = 0.893, RMR = 0.014, NFI = 0.892, CFI = 0.966 and RMSEA = 0.008. These results validate the proposed model. Loadings for different relationships in the model are shown in Figure 1. The relationship between lean thinking and operational performance is positive, and the loading between the lean and OP constructs was 0.890 which is statistically significant (R^2 = 0.8; p-value = 0.001). From our results, we can say that the implementation of lean practices (customer involvement, employee involvement, pull system, 5S, total productive maintenance, statistical process control, single minute exchange of dies, and production leveling) are positively associated with the operational performance of SMEs.

Table 7: Testing the quality of the structural model

Constructs	AVE	CR	α	CO
CI	0.529	0.818	0.723	0.529
EI	0.577	0.844	0.782	0.577
PS	0.602	0.857	0.802	0.602
5S	0.555	0.861	0.799	0.555
TPM	0.583	0.848	0.729	0.583
SPC	0.554	0.832	0.699	0.554
SMED	0.587	0.876	0.836	0.587

PL	0.528	0.870	0.733	0.528
Lean	0.502	0.845	0.835	0.502
OP	0.583	0.873	0.775	0.583

Where: AVE: average variance extracted, CR: composite reliability, α: cronbach's alpha, CO: communality

Please insert Figure 1 here

5. DISCUSSION

In this study, an attempt was made to measure the degree of lean adoption in SMEs. The constructs - customer involvement, employee involvement, pull system, 5S, total productive maintenance, statistical process control, single minute exchange of dies, and production leveling were found to be utilized as a central part of lean thinking in SMEs. However, the constructs - supplier involvement and visual management are not perceived as part of lean thinking in SMEs. Therefore, our first hypothesis: "*SMEs adopt a limited number of lean practices*" is found to be true. This finding is in line with the case studies (Kumar *et al.* 2006; Upadhye *et al.* 2010; Vinodh *et al.* 2011; Panizzolo *et al.* 2012; Arya and Jain 2014; Vinodh *et al.* 2014) and an empirical study by Filho et al. (2016) for Brazilian SMEs. These results, however, are in contrast to large enterprises which suggest the adoption of lean practices in an integrated manner. The reasons for partial implementation of lean in SMEs may be lack of resources (Achanga *et al.* 2006; Dora *et al.* 2016; Abolhassani *et al*. 2016), lack of knowledge and expertise (Hu *et al.* 2015; Marodin and Saurin 2015;) and resistance to change (Abolhassani *et al*. 2016; Dora *et al.* 2016; Marodin and Saurin 2015).

One of the objectives of the current research was to assess the impact of lean implementation on the operational performance of SMEs. From our results, we can say that the implementation of lean practices is positively associated with the operational performance of SMEs. This study supports the common perception of researchers that lean adoption has a positive impact on the operational performance of the organization (Shah and Ward 2007; Panwar *et al.* 2018). Further, it may be concluded that the positive impact of lean on operational performance in SMEs can be observed even when the lean practices are implemented in a partial manner.

The characteristics of SMEs make them different to large enterprises. For instance, the organizational structure of SMEs is typically very simple with very few levels, resulting in high visibility and accessibility of its top management to the lowest level (Carlos 2007; Laufs *et al.* 2016). Traditionally, SMEs utilize simple operational planning and control systems, and their operations and activities are not governed by formal rules (Ates and Bititci 2011; O'Reilly *et al.* 2015). Further, most of the SMEs are results–oriented, and favourable to new change initiatives and innovations (Carlos 2007). These characteristics create a positive environment for the implementation of lean. The consequence of such characteristics is that SMEs are implementing lean and gaining benefits from doing so even with limited finances, resources, training and skills.

6. CONCLUSION, IMPLICATIONS AND LIMITATIONS

The objective of the paper was to measure the degree of lean adoption in SMEs and to test its impact on operational performance. The SMEs have been found to primarily use eight practices, viz., customer involvement, employee involvement, pull system, 5S, total productive maintenance, statistical process control, single minute exchange of dies, and production leveling resulting in a positive impact on the operational performance. Hence, we may conclude that the adoption of lean thinking in SMEs is likely to make a significant contribution to operational performance. The results suggest that even with the limited number of implemented practices, lean may help to enhance the operational performance in SMEs. The outcomes of this study are consistent with the findings of Panwar et al. (2018), Bevilacqua et al. (2017) and Belekoukias et al. (2014). Our work fills the gap in the literature regarding the effect of lean implementation on the performance of SMEs. The methodologies adopted in this study are well grounded in the literature, and the outcomes are consistent with existing research.

Apart from contributing to the literature, this study is also valuable for practitioners because it suggests that even a partial implementation of lean may be beneficial for SMEs. This study found that although SMEs have not adopted all the practices which come under the umbrella of lean, however, the limited number of practices adopted has resulted in positive results. Eventually, the findings of the study will motivate the practitioners in SMEs to explore the adoption of lean. The finding of the study can assist the managers of SMEs in planning for a successful lean transformation. The practitioners in SMEs are also advised to take up practices such as customer involvement, employee involvement, pull system, 5S, total productive maintenance, statistical process control, single minute exchange of dies, and production leveling for the succesful implementation of lean in their organization. However, the managers should affirm the suitability of these practices within the charactersitics of their company.

Lastly, the study should be viewed with some limitations and caution is suggested when interpreting the results. Although our sample size was adequate and representative it is limited to an Indian context. Further research is required in a more diverse context to confirm the generalization of the results. It is worthwhile to extend the study to different SME sectors. The impact of lean implementation is not only limited to operational performance; it also enhances the financial, social and environmental performance (Yadav et al., 2018). Therefore, the empirical study may be extended to verify the impact of lean on sustainable performance.

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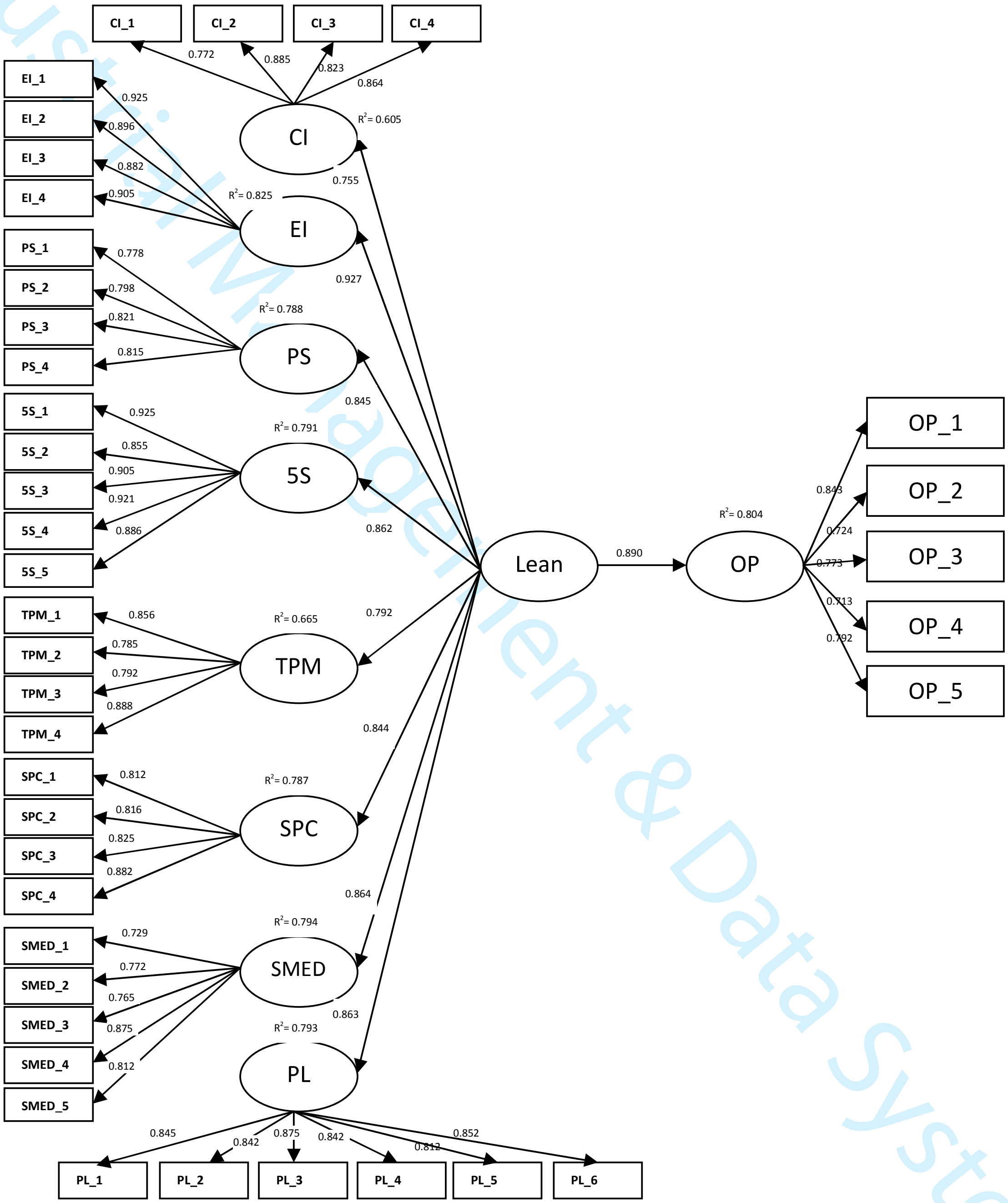

Figure 1: Structural Equation Model Results

Table 1: Measures of Lean Practices

Lean Practices	Present study	Shah and Ward (2003)	Hofer et al. (2012)	Filho et al. (2016)	Panwar et al. (2018)
Customer involvement	X	X	X	X	
Employee involvement	X	X	X	X	X
Supplier involvement	X	X	X	X	X
Pull system	X	X	X	X	X
5S	X				X
Total productive maintenance	X	X	X	X	X
Statistical process control	X	X	X	X	X
Single minute exchange of dies	X	X	X	X	X
Visual management	X				X
Production leveling	X	X		X	X

Table 2: Operational performance measures

Operational performance measures	Present study	Shah and Ward (2003)	Filho et al. (2016)	Panwar et al. (2018)
Inventory levels	X			X
Defect levels	X	X	X	X
Productivity	X	X	X	X
Production wastes	X	X	X	X
Production costs	X	X	X	X

Table 3: List of survey items, means, standard deviations and Cronbach's alpha

Construct	Variable code	Variable	Mean	SD
Customer involvement	CI_1	We are in close contact with our customers.	5.73	1.107
	CI_2	Customers give feedback on quality and delivery performance.	4.53	1.304
	CI_3	Customers are actively involved in current and future product offerings.	5.55	1.230
	CI_4	Customers frequently share demand information.	4.64	1.310
Employee involvement	EI_1	Shop floor employees are actively involved in problem solving.	4.65	1.097
	EI_2	Shop floor employees are actively involved in process improvements.	4.73	1.205
	EI_3	Shop floor employees regularly provide suggestions for improvement.	4.18	1.140
	EI_4	Shop floor employees undergo cross-functional training.	4.03	1.137
Supplier involvement	SI_1	We give our suppliers feedback on quality and delivery performance.	2.51	1.017
	SI_2	We strive to establish long-term relationship with our suppliers.	2.47	1.014
	SI_3	Our key suppliers are located in close proximity to our plant.	2.43	1.043
	SI_4	We take active steps to reduce the number of suppliers in each category.	2.47	1.054
Pull system	PS_1	Production is pulled by shipment of finished goods.	3.26	.996
	PS_2	Production at workstations is pulled by the demand of the next station.	3.84	1.329
	PS_3	We use Kanban, squares or containers of signals for production control.	3.61	1.338
	PS_4	We use a pull system to control the production rather than a schedule prepared in advance.	3.53	1.236
5S	5S_1	Only the materials which are actually needed are present in the work area.	4.74	1.234

	5S_2	Only tools and hand tools which are needed are present in the work area.	4.97	1.254
	5S_3	Locations for all production materials are clearly marked out and the materials are stored in the correct locations. Areas for WIP (work-in-process parts) are clearly marked.	4.12	1.267
	5S_4	Work areas, storage areas, aisles machines, tools, equipment and offices are clean/neat and free of safety hazards.	4.73	1.382
	5S_5	Regularly scheduled housekeeping tours and periodic self-assessments (5S audits) are conducted.	4.75	1.306
Total Productive Maintenance	TPM_1	We maintain all our equipment regularly.	4.30	1.124
	TPM_2	We maintain records of all equipment maintenance activities.	4.96	1.359
	TPM_3	We ensure that machines are in high state of readiness for production at all the time.	5.21	1.291
	TPM_4	Operators are trained to maintain their own machines.	5.24	1.330
Statistical process control	SPC_1	Charts showing defects are used as tools on the shop floor.	4.55	1.347
	SPC_2	We use diagrams like cause & effects (fishbone) to identify causes of quality problems	4.12	1.138
	SPC_3	We conduct process capability studies before product launch.	4.81	1.294
	SPC_4	We use statistical techniques to reduce process variance.	4.80	1.348
Single minute exchange of dies	SMED_1	We are working to lower set-up time in our plant	3.42	1.004
	SMED_2	We have short set-up times for equipment in our plant	4.15	1.349
	SMED_3	Operators perform their own machines set-ups.	3.83	1.084
	SMED_4	Operators are trained on machine set-up activities.	3.92	1.365
	SMED_5	We emphasize the need to place all tools in a convenient area to the operator.	3.86	1.524
Visual managem ent	VM_1	Equipment are identified with signages	3.20	1.341
	VM_2	Process parameters are displayed on the shop floor.	3.13	1.290
	VM_3	Manufacturing performance is displayed on the shop floor.	3.12	1.257
Production levelling	PL_1	We mix production on the same machines and equipment..	4.47	1.286
	PL_2	We emphasize the need for an accurate forecast to reduce variability in production.	5.05	1.400
	PL_3	Each product is produced in a relatively fixed quantity per production period.	4.15	1.238
	PL_4	We emphasize the need to equalize workloads in each production process.	4.15	1.328
	PL_5	We produce by repeating the same combination of products from day to day.	4.49	1.284
	PL_6	We always have some quantity of every product model to respond to variation in customer demand.	5.29	1.310
Operational performance	OP_1	We have low inventory levels (raw material, WIP and finished goods)	4.39	1.573
	OP_2	We have low defect levels.	3.78	1.068
	OP_3	Our productivity is high.	3.57	1.096
	OP_4	We have low lroduction waste.	4.01	1.320
	OP_5	Our production costs are predictable.	4.64	1.500

Table 4: Statistical quality measures

Measure	value	Reference
Number of manifest variables per latent variable	≥3.0	Flynn et al. 1990; Malhotra and Grover 1998; Shah and Goldstein 2006;
Cronbach's alpha of latent variable	≥0.7	
Average variance extracted of latent variable	≥0.5	

Composite reliability of latent variable	≥0.7	Hair et al. 2013
Communality of latent variable	≥0.5	
Loading of latent variable	≥0.7	
Loading of manifest variable	≥0.7	

Table 5: Testing the quality of the first-order structural model

First order latent variable	Manifest variable	Manifest Variable loading	P value	R^2	AVE	CR	α	CO	Construct loading	P value
CI	CI_1	0.713	0.000	0.778	0.529	0.818	0.723	0.529	0.892	0.000
	CI_2	0.721	0.000							
	CI_3	0.740	0.002							
	CI_4	0.736	0.000							
EI	EI_1	0.715	0.001	0.745	0.577	0.844	0.782	0.577	0.862	0.000
	EI_2	0.736	0.000							
	EI_3	0.743	0.000							
	EI_4	0.839	0.002							
SI	SI_1	0.731	0.001	0.426*	0.551	0.830	0.723	0.551	0.652*	0.056*
	SI_2	0.782	0.002							
	SI_3	0.734	0.008							
	SI_4	0.722	0.006							
PS	PS_1	0.734	0.000	0.683	0.602	0.857	0.802	0.602	0.812	0.001
	PS_2	0.794	0.000							
	PS_3	0.829	0.001							
	PS_4	0.743	0.004							
5S	5S_1	0.749	0.004	0.582	0.555	0.861	0.799	0.555	0.753	0.008
	5S_2	0.785	0.002							
	5S_3	0.726	0.002							
	5S_4	0.712	0.001							
	5S_5	0.753	0.000							
TPM	TPM_1	0.723	0.000	0.723	0.583	0.848	0.729	0.583	0.849	0.000
	TPM_2	0.742	0.000							
	TPM_3	0.762	0.000							
	TPM_4	0.824	0.000							
SPC	SPC_1	0.705	0.000	0.782	0.554	0.832	0.699	0.554	0.904	0.002
	SPC_2	0.725	0.000							
	SPC_3	0.797	0.001							
	SPC_4	0.748	0.001							
SMED	SMED_1	0.757	0.000	0.563	0.587	0.876	0.836	0.587	0.746	0.001
	SMED_2	0.760	0.000							
	SMED_3	0.780	0.000							
	SMED_4	0.721	0.000							
	SMED_5	0.812	0.000							
VM	VM_1	0.921	0.016	0.482*	0.850	0.944	0.926	0.850	0.682*	0.062*
	VM_2	0.916	0.008							
	VM_3	0.929	0.062*							
PL	PL_1	0.724	0.000	0.642	0.528	0.870	0.733	0.528	0.780	0.000
	PL_2	0.720	0.001							
	PL_3	0.712	0.002							
	PL_4	0.780	0.001							
	PL_5	0.723	0.001							
	PL_6	0.702	0.000							

Where: AVE: average variance extracted; CR: composite reliability; α: cronbach's alpha; CO: communality;

Table 6: Pearson correlations between first-order variables (lean practices)

Constructs	CI	EI	SI	PS	5S	TPM	SPC	SMED	VM	PL
CI	1.00									
EI	0.47**	1.00								
SI	0.18*	0.11	1.00							
PS	0.19*	0.18*	0.15*	1.00						
5S	0.34**	0.33**	0.09	0.29**	1.00					
TPM	0.52**	0.36**	0.18*	0.32**	0.35**	1.00				
SPC	0.50**	0.39**	0.11	0.25**	0.36**	0.58**	1.00			

SMED	0.32**	0.21**	0.16*	0.43**	0.38**	0.21**	0.24**	1.00		
VM	0.35**	0.08	0.18*	0.24**	0.18*	0.15*	0.16*	0.15*	1.00	
PL	0.51**	0.24**	0.19*	0.28**	0.36**	0.56**	0.59**	0.25**	0.23**	1.00

** Correlation is significant at the level of 0.01(2-tailed) 29 out of 45

* Correlation is significant at the level of 0.05(2-tailed) 12 out of 45

Table 7: Testing the quality of the structural model

Constructs	AVE	CR	α	CO
CI	0.529	0.818	0.723	0.529
EI	0.577	0.844	0.782	0.577
PS	0.602	0.857	0.802	0.602
5S	0.555	0.861	0.799	0.555
TPM	0.583	0.848	0.729	0.583
SPC	0.554	0.832	0.699	0.554
SMED	0.587	0.876	0.836	0.587
PL	0.528	0.870	0.733	0.528
Lean	0.502	0.845	0.835	0.502
OP	0.583	0.873	0.775	0.583

Where: AVE: average variance extracted, CR: composite reliability, α: cronbach's alpha, CO: communality