Management and Production Engineering Review
Volume 9 • Number 2 • June 2018 • pp. 69–79
DOI: 10.24425/119526

PRIORITIZATION OF BARRIERS TO LEAN IMPLEMENTATION IN INDIAN AUTOMOTIVE SMALL & MEDIUM SIZED ENTERPRISES

Rupesh Kumar Tiwari[1], Jeetendra Kumar Tiwari[2]

[1] *ITM University Gwalior-India*
[2] *Department of mechanical engineering in SSTC, Bhilai-India*

Corresponding author:
Rupesh Kumar Tiwari
Chhattisgarh Swami Vivekanand Technical University (CSVTU)
Newai, P.O.-Newai, District-Durg, Chhattisgarh – 491107
phone: +918966870069
e-mail: rupeshtiwari9999@gmail.com

Received: 11 February 2018
Accepted: 5 May 2018

Abstract
Lean manufacturing has been the most deliberated concept ever since its introduction. Many organization across the world implemented lean concept and witnessed dramatic improvements in all contemporary performance parameters. Lean manufacturing has been a sort of mirage for the Indian automotive industry. The present research investigated the key lean barriers to lean implementation through literature survey, confirmatory factor analysis, multiple regression, and analytic network process. The general factors to lean implementation were inadequate lean planning, resource constraints, half-hearted commitment from management, and behavioral issues. The most important factor in the context of lean implementation in Indian automotive industry was inadequate lean planning found with the help of confirmatory factor analysis and multiple regression analysis. Further analysis of these extracted factors through analytic network process suggested the key lean barriers in Indian automotive industry, starting from the most important were absence of proper lean implementation methodology, lack of customer focus, absence of proper lean measurement system, inadequate capital, improper selection of lean tools & practices, leadership issues, resistance to change, and poorly defined roles & responsibilities. Though literature identifying various lean barriers are available. The novelty of current research emerges from the identification and subsequent prioritization of key lean barriers within Indian automotive SMEs environment. The research assists in smooth transition from traditional to lean system by identifying key barriers and developing customized framework of lean implementation for Indian automotive SMEs.

Keywords
lean barriers, prioritization, Indian automotive SMEs, confirmatory factor analysis, multiple regression, analytic network process, super decision software.

Introduction

Lean production has been exploited by the large organization to great effect all around the globe to improve their productivity ever since its inception. Despite such a wide spread evidences the SMEs particularly in India is yet to acknowledge its full potential. Researchers argued that lean production system is better suited for the large organization. However most of the research undertaken advocated the applicability of lean philosophy for every kind of industry, regardless of its size [1].

Automotive SMEs are the back bone of Indian economy, contributing significantly to the GDP and providing employment to millions of people in India. Because of the open global economy, Indian automotive SMEs are facing stiff competition. Poor product differentiation & waste management, increasing cost of production & lead time, and lack of access to the latest technical knowhow are some of the crucial issues those Indian automotive SMEs are presently facing. They are in the quest of finding permanent solution to these imminent problems and most of them resort to lean philosophy. Successful and ju-

dicial lean implementation could provide them with sustainable strategic advantage in withstanding and beating the global completion. But many Indian automotive SMEs failed miserably in their attempt to implement lean philosophy because of certain barriers to lean implementation. Though the lean barriers are general in nature and may exist in most of the work environment. But still these need to assessed and customized, applying comprehensive statistical analysis within Indian automotive SMEs environment.

Research started with finding these key lean implementation barriers are with the help of literature survey. Confirmatory factor was applied to validate the model having factors and associated sub factors; those explain key lean barriers to lean implementation in Indian automotive SMEs. After validating the model, multiple regression analysis and analytical network processing (ANP) were applied to rank various factors and sub factors explaining barriers to lean implementation. The current research is useful in identification and prioritization of lean implementation barriers so that the Indian automotive SMEs can identify root cause of lean implementation failure before boarding for lean voyage.

Literature review

Literature related to lean barriers were searched from mostly manufacturing & few service organizations including SMEs across the globe ranging from Europe, South America, and Asia. The idea was to find the most cited lean barriers in variety of organizations. These lean barriers are certain helpful in customizing lean barriers for Indian automotive SMEs.

There is no generalized roadmap available for successful lean implementation. In fact, every organization operates in different industrial segment with different priorities. Thus implementing lean model developed for other organization often led to failure [2, 3]. Identification of key lean barriers is absolutely crucial before proceeding for long lean journey. Half-hearted commitment from management, improper lean planning, resources, and behavior issues are most cited key lean barriers (Fig. 1) [4–7]. The importance of lean barriers may differ according to size & type the organization [8]. An attempt has been made to find associated sub lean barriers those explain these identified key lean barriers in this literature. Different key lean barriers and associated sub lean barriers are quantified to assess their relative importance in context of Indian automotive SMEs using analytical network processing. Literature survey helped in formulation and validation of model of lean barriers for Indian automotive SMEs.

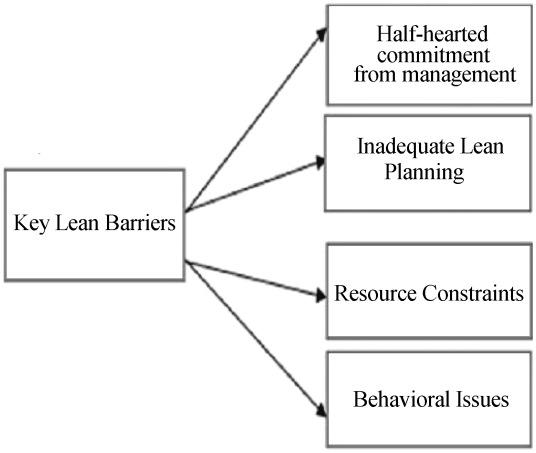

Fig. 1. Conceptual model.

Half heated commitment from management

Lack of support from the top management was cited as key lean barriers. Without a clear and focused commitment from top management, the lean implementation is not going to be successful. Lack of commitment may emerge from management inability to envision the broader picture and happy maintaining the status quo [5]. Unable to manage the change inertia was of the leading barrier often causes lean implementation failure [9]. Leadership was also one the issue to motivate people and putting utmost managerial effort to successfully implement lean system [10]. Leader got vision, hunger, and veracity, to manage changes. Capable leadership creates innovative environment that inculcate culture of innovation which drives away the fear of unknown and facilitate conducive environment for lean implementation [6]. Unable to envision lean manufacturing as a strategic tool was one of the main reasons cited for the failure of lean implementation. One of the objectives of implementing lean philosophy is to achieve noticeable improvement in the organization productivity. If the excess employment is the main cause of reduction in the productivity and suppose the organization go for job cut, workers will resist it. Instead the management should device new methods and install proper monitoring system. Well-defined vision supported with strategy to implement it is absolutely critical for successful lean implementation and its long term viability. There has to be a proper alignment between the vision and strategic to achieve it [11].

Inadequate lean planning

Any successful venture is well supported by fool proof planning. The same is true with lean implementation also. Lean planning is essential for controlled and structured change strategy, which gives you the fair idea about selected lean practices, its estimated cost, and expected time period of lean implementation [12]. Lean planning starts with clearly defining the role and responsibilities of lean implementation. Majority of lean implementation fail because of poorly defined role and responsibility resulting in ambiguity and confusion [5]. Every organization has got its own set of constraints and priorities. Improper selection of various lean tools and practices may have led total failure of lean implementation [13]. Majority of times, the focus of lean implementation is on cost and lead time reduction and productivity improvement. Without appropriate customer focus the full potential of lean cannot be realized. Therefore, lean implementation planning should be structured to ensure customer commitment [14]. Poor organizational structure was also cited as key lean barrier. Well defined organizational structure may aid the managers to allocate correct resources and provide important support to alleviate the effects of different lean barriers [15]. Poor lean methodology was also one of the key lean barriers. Lean methodology provides blue print of lean implementation process, which clearly defines the set activities and its interdependencies for the successful lean implementation [16].

Lean resources

Inability to form proper cross functional team to integrate different functionality of lean implementation was cited as one of the important lean barriers. Cross functional team having a responsibility of performing different tasks require multi skilled employees. Proper training is essential to configure a group of multi skilled worker. Proper training helps to equip the worker with the kind of skills they require for the successful lean implementation. Lean training also helps in better understanding the lean philosophy [9, 17]. Valid lean performance measurement system was essential to facilitate managers taking logical decisions based on certain degree of objectivity. Real world situations are mostly vague because of the subjectivity involved in it [18]. Implementing lean system is a sort of business process reengineering demanding flexing organization, flexible production system, and workers [19]. Finance was one of the important resources for successful completion of any venture including improvement project like lean implementation in SMEs in particular. Management must ensure adequate provision of finance for the smooth implementation of lean manufacturing [9]. Lack of proper technological infra-structure including effective communication was critical in lean implementation. Technological infrastructure provides firm foundation to process of lean implementation by exploiting the knowledge scientifically and objectively [20].

Behavioral issues

Establishing organizational culture which is conducive for smooth transition from traditional to lean is absolutely crucial for lean voyage to be successful. Engagement amongst the employees is essential to foster conducive climate for the team work, one of the key success factors of lean implementation [21]. Employees' empowerment by making them a part of decision making process is key in ensuring employees involvement during lean implementation process. Employees' empowerment not only ensures employees involvement but also motivate workers to implement lean improvement program. Employees' involvement reduces the resistance to change, particularly during the lean implementation process [10].

Analytic network process (ANP)

ANP is similar to its predecessor analytical hierarchical process (AHP) in many sense but broader in scope in comparison to AHP. ANP is the extended version of AHP. AHP build hierarchical structure based on dependency amongst the elements of hierarchy. In most of the situations model can be framed hierarchically showing dependency from higher element to lower elements in the structure. But there can be two way interactions also between the elements of hierarchy. Therefore, in ANP the interaction between the elements are shown with the help of network rather than hierarchy [22]. Each Level in the ANP represented, by a cluster of elements. Elements of one cluster connected to elements of other cluster in known as outer dependency. Interdependency amongst the element of cluster itself is known as inner dependency. Elements of clusters are represented by nodes [23]. Once the model has been framed, next step is to obtain super matrix of ANP. Super matrix gives the complete quantitative picture of the model. Super matrix explains the comparative significance of each of the decision making criterions and sub criterions for each of the criterion by analyzing of interdependencies between them. Usually the development of ANP model and computation is assisted by the software [24].

Super decision software

Super decision software is the useful tool for decision making by converting the subjective assessment into objective assessment. Both AHP & ANP can be implemented using the tool. Since both the techniques apply the similar basic ranking, on the basis of obtaining priorities with the help of pair wise comparison. The comparative importance of factors and sub factors is fed into the system. The software facilitates the synthesis of pair wise comparison matrix and inconsistencies in decision making are adequately taken care off. Thereafter one can generate the super matrix to prioritize the various factors and sub factors to rank them in order to take suitable decision accordingly. Super decision tool is freely available on internet.

Research methodology

Based on literature review the the following figure describes the conceptual model of the key lean barriers (Fig. 1).

Table 1
Description lean barriers.

Lean barriers	Description	Reference
L_1	Absence of cross functional team	[4, 5]
L_2	Absence of valid lean performance measurement system	[18]
L_3	Resistance to change	[19]
L_4	Lack of involvement	[10, 21]
L_5	***Myopic vision of management***	***[5]***
L_6	Poorly defined role & responsibility	[5]
L_7	Absence of proper lean training programme	[9,17]
L_8	Lack of expertise to implement lean philosophy	[19]
L_9	Lack of understanding to lean philosophy	[12]
L_10	Insufficient technological infrastructure	[20]
L_11	Lack of customer focus	[14]
L_12	Poor organizational structure	[15]
L_13	Lack of proper communication system	[20]
L_14	Inflexible work force	[19]
L_15	Inadequate capital	[9]
L_16	Lack of support from top management	[10]
L_17	Lack of vision & strategy to implement	[5, 11]
L_18	Unable to manage change inertia	[9]
L_19	Absence of appropriate lean implementation methodology	[16]
L_20	***Leadership issues***	***[10]***
L_21	Improper selection of lean tools and practices	[13]
L_22	Resistance to change	[6]

The following table describes the summary of the literature survey siting various sub lean barriers having significant impact in varieties of industries including SMEs (Table 1).

Questionnaire development & data collection

The objective of the current study was to determine and evaluate barriers to lean implementation in Indian automotive SMEs, which serve as guidelines for fool proof lean implementation. Research deliberated Indian automotive SMEs mostly centered in Delhi NCR, Mumbai, Pune, Bangalore, Chennai, and Jamshedpur in India, who have either implemented or in the process of lean implementation. Approximately 39 manufacturing facilities have been broadly investigated to determine the barriers to lean implementation. With the objective of defining the barriers a comprehensive questionnaire was framed.

Total 22 lean variables were found through comprehensive literature survey (Table 1). These variables explain the conceptual model and describe various barriers of lean implementation in Indian automotive SMEs. Based on these variable instruments of survey that is questionnaire was developed. It was assumed that these variables are reliable as well as valid measures of barriers to lean implementation, since the variables are found through the literature survey. Furthermore, the questionnaire was synthesized considering the opinion of the panel comprising of lean consultants & academicians. Effectiveness of questionnaire in identifying lean barriers was tested on small controlled group comprises thirteen respondent from four SMEs in Delhi national capital region. The consistency and validity of the questionnaire in identifying lean barriers were statistically tested with the help of Cronbach's alpha & corrected item total correlation coefficient. Since the various lean barriers were cited, extended deep into the hierarchy, the respondent chosen were from top level managers, middle level managers, and workers in key product line in India automotive SMEs having exposure to lean implementation. Indian automotive SMEs (Indian origin) are suppliers of auto major such as: Tata Motors, Mahindra & Mahindra, Ashok Leyland, Hyundai Motors, Suzuki Motors, Honda Motors, Maruti, and Hero Motors. The India automotive SMEs are situated Delhi NCR, Pune, Chennai, Mumbai, and Bangalore. Convenient sample was chosen having total 200 responded (Table 2).

Questionnaire developed using five point Likert scale (1 extremely significant, 2 highly significant, 3 significant, 4 insignificant, 5 highly insignificant) to

gather maximum information from the respondents about the criticality of various lean barriers identified. A brief description of various lean barriers is given to the respondents prior to questionnaire administration, so that they become familiar to purpose of the study. Information mostly collected through telephonic conversation, email, and followed by personal interview with the respondents. Response rate observed was 83%, means nearly 166 responses were received.

Table 2
Structure of respondents.

Engine & Engine parts (Pistons & piston ring, engine volves, fuel injection system, carburrators, cooling systems)	Top level managers-14, Middle level managers-16, workers-20.
Transmission & Steering (Gears, steering system, clutches, axles)	Top level managers-12, Middle level managers-15, workers-17)
Suspension & Breaking system (Break assembly, break linings, shock absorbers, leaf springs)	Top level managers-17, Middle level managers-15, workers-20.
Head lights, wiper motors, dashboard instruments, starter motors, spark plugs, electric ignition system, sheet metal, fan belts.	Top level managers-19, Middle level managers-18, workers-17

Multivariate analysis

Confirmatory factor analysis was done to validate the model as described by Fig. 1. Statistical analysis suggested there was correlation amongst the various elements explaining barriers to lean implementation. Highly correlated variables were grouped under one head known as latent variables or factors (Table 7). Thereafter the correlation amongst the various factors was examined. Statistical analysis suggested correlation amongst the factors. However, the degree of correlation was less than 0.40 and multiple regression was performed to assess the relative importance of these factors taken as independent variables to explain key lean barriers. Model was tested at 5% level of significance for the validity and subsequent generalization. The model was helpful in identification of key lean barriers (Table 8, Table 9).

ANP methodology

It's quite evident from the model of barriers to lean implementation, there are interdependency between the factors (LP, RC, UP, BI) and between sub factors for example (LP2, UM3), (LP4, RC10), (RC3, RC4, RC5), and (RC9, UM1). Means both inner and outer interdependencies exist, hence the ANP was the appropriate choice for valid prioritization of various barriers to lean implementation (Fig. 2).

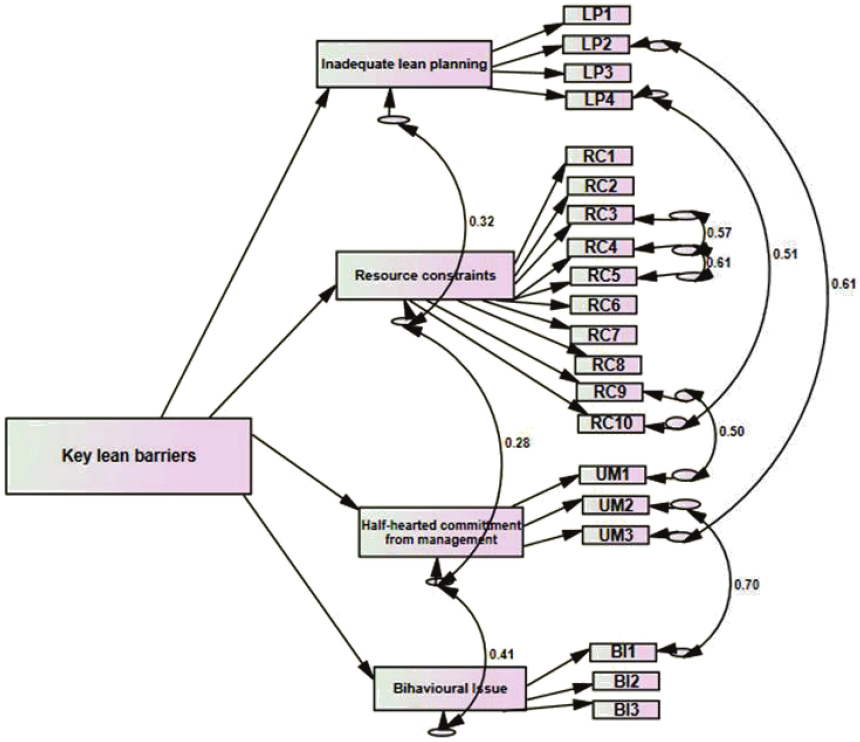

Fig. 2. Model of barriers to lean implementation in Indian automotive SMEs.

Panel of five lean experts were formed having 3 years of hands on experience of lean implementation including SMEs. Panel asked to rate the significance of various factors and sub factors of lean barriers on a scale of 1 to 9. Normalize decision of the panel was used to analyses the problem (Table 3).

Table 3
Basic scale for ANP.

Number	Description
1	Equally significant
2, 3	Moderately significant
4, 5	Significant
6, 7	Highly significant
8, 9	Extremely significant

The following are the steps for conducting ANP:

- Comprehensively understand the problem by keeping in mind the goal, its decision criteria, decision sub criteria, and outcome of the decision.
- Construct judgement matrix for each of the criteria and sub criteria through pairwise comparison of elements in the cluster, considering the inner and outer dependencies of the elements of the cluster.
- Compute weighted and limiting super matrix.
- Rank various attributes of lean barriers associated to the factor using limiting weights. Overall ranking is done using normalise weights.

Data analysis and interpretation

Data collected during the research was analyzed using SPSS (Statistical package for social science) and super decision software. Empirical reliability analysis was done and the value of Cronbach alpha was found to be '0.826' which was more than 0.6. Hence it can be safely assumed that extracted variables provide reliable, valid and consistent measure of barrier to lean implementation in Indian automotive SMEs. Since the value of Bartlett's Test of Sphericity Chi-Square is very high mean the assumption that the correlation matrix amongst the variables is an identity matrix was rejected and the interdependency factor analysis was the appropriate technique to validate the proposed concept. KMO (Kaiser-Meyer-Olkin) test of sampling adequacy was '0.811', which more than 0.6, suggested adequacy of sample selected. Corrected item total correlation for variable L_5 & L_20 was found below '0.3', hence these variables can be excluded to improve the reliability of data collected (Table 1). Significance value observed that is '0.005', which is less than assumed level of significance '0.05', means factor analysis can be performed using these 20 extracted variables (Table 4).

Table 4
KMO and Bartlett's Test.

Kaiser-Meyer-Olkin measure of sampling adequacy		.811
Bartlett's Test of Sphericity	Approx. Chi-Square	3118.026
	df	190
	Sig.	.000

It was quite evident that these four extracted factor to gather explain almost 62% and Eigen value for these factors were more than one. There the extracted factors were stable and significant in explain barriers to lean implementation in Indian automotive SMEs (Table 5).

Table 5
% of variance explained.

Component	Initial Eigen values		
	Total	% of Variance	Cumulative %
1	7.560	37.802	37.802
2	2.050	10.252	48.055
3	1.520	7.598	55.652
4	1.254	6.270	61.922

Lean barriers L_1, L_2, L_7, L_8, L_9, L_10, L_13, L-14, L_15, and L_21 are having high coefficient of correlation with component 1 and these lean barriers are related to lean resources. Hence component 1 can be labeled as resource constraint. Variables L_6, L_11, L_12, and L_19 explained lean barriers related to lean planning. These are associated closely with component 2. Hence component 2 can be labeled as inadequate lean planning. Similarly, component 3 & 4 can be labeled as half-hearted commitment from management and behavioral issues (Table 6).

KMO (Kaiser-Meyer-Olkin) & Bartlett's test did confirm the stability, reliability, and validity of these extracted components. The model for barriers to lean implementation can be framed as (Table 7).

It is evident; there is correlation between the factors. Ideally the factors should be independent in nature, however the maximum value of coefficient is less than '0.4', hence the extracted factor can be assumed to be independent (Table 8).

Relationship between these factors and lean barriers were examined. Lean factors were taken as independent variables explaining lean barriers & lean barriers as dependent variable. The proposed regression model was statistically significant, since F value is very high (103.816) and observed significance value was '.000' less than '0.05'. Individual regression coefficient was also statically significant because high t

Table 6
Rotated component matrix.

	Component			
	1	2	3	4
L_1	**.858**	−.246	−.202	.013
L_2	**.690**	−.181	.269	−.245
L_3	.133	.076	.068	**.851**
L_4	.166	−.193	.194	**.402**
L_6	−.113	**.508**	−.279	.139
L_7	**.844**	−.042	.078	.157
L_8	**.855**	−.186	−.204	.132
L_9	**.905**	−.004	−.029	.137
L_10	**.843**	−.069	−.263	.050
L_11	−.022	**.657**	.297	−.321
L_12	−.076	**.480**	.009	.085
L_13	**.943**	−.149	−.037	.060
L_14	**.807**	−.035	−.178	.193
L_15	**.886**	−.071	−.057	.273
L_16	.015	−.020	**.680**	.078
L_17	−.262	−.074	**.605**	−.072
L_18	−.051	.337	**.545**	.211
L_19	.001	**.717**	−.008	−.193
L_21	**.670**	.118	.104	−.022
L_22	−.174	.504	.214	**.676**

Table 7
Barriers to lean implementation in Indian automotive SMEs.

Key Lean Barriers	Resource Constraints (RC)	Absence of cross functional team (RC1) Absence of valid lean performance measurement system (RC2) Absence of proper lean training programme (RC3) Lack of expertise to implement lean philosophy (RC4) Lack of understanding to lean philosophy (RC5) Insufficient technological infrastructure (RC6) Lack of proper communication system (RC7) Inflexible work force (RC8) Inadequate capital (RC9) Improper selection of lean tools and practices (RC10)
	Inadequate lean planning (LP)	Poorly defined role & responsibility (LP1) Lack of customer focus (LP2) Poor organizational structure (LP3) Absence of appropriate lean implementation methodology (LP4)
	Half-hearted commitment from management (UM)	Lack of support from top management (UM1) Unable to manage change inertia (UM2) Lack of vision & strategy to implement (UM3)
	Behavioural Issues (BI)	Resistance to change (BI1) Lack of involvement (BI2) Lack of motivation (BI3)

Table 8
Correlation between factors.

	LP	RC	UM	BI
UP	1	0.399	0.345	0.125
RC	0.399	1	0.301	0.106
UM	0.345	0.301	1	0.121
BI	0.125	0.106	0.121	1

value excess of '2.50' and low observed level of significance less than '0.05'. The value of R square (0.675) and adjusted R-square (0.668) was almost similar, mean the interdependency between the independent variable can be ruled out. Model explained 67.5% variation in the data. Hence it can be assumed the model is statistically significant, valid and reliable (Table 9).

Table 9
Regression Model.

Variables	Coefficients	t-value	Sig.
Constant	3.117	68.762	.000
Resource constraints	.868	19.102	.000
Inadequate lean planning	.275	6.045	.000
Half-hearted commitment from management	.124	2.736	.007
Behavioural Issues	.114	2.519	.005

R = .822, R-Square = .675, Adjusted R-Square = .668, F = 103.816, Sig. = .000

Table 10
Output super decision software showing normalize & limiting weight of factors & sub factors.

Name	Normalized	Limiting
BI	0.05015	0.025076
LP	0.25307	0.126535
RC	0.46868	0.234340
UM	0.22810	0.114048
BI1	0.70096	0.017578
BI2	0.10615	0.002662
BI3	0.19289	0.004837
UM1	0.70097	0.079945
UM2	0.10615	0.012106
UM3	0.19288	0.021998
LP1	0.12539	0.015866
LP2	0.24113	0.030512
LP3	0.04822	0.006102
LP4	0.58526	0.074056
RC1	0.02574	0.006033
RC2	0.14712	0.034476
RC3	0.09285	0.021758
RC4	0.14605	0.034226
RC5	0.08087	0.018950
RC6	0.04683	0.010974
RC7	0.01505	0.003526
RC8	0.04062	0.009519
RC9	0.15364	0.036004
RC10	0.25123	0.058874

Table 11
Overall priority.

Factors	Rank	Sub Factors	Rank based on associated factor	Overall rank
Resource Constraints (RC)	1	Absence of cross functional team (RC1)	10	17
		Absence of valid lean performance measurement system (RC2)	4	5
		Absence of proper lean training programme (RC3)	6	9
		Lack of expertise to implement lean philosophy (RC4)	5	6
		Lack of understanding to lean philosophy (RC5)	7	10
		Insufficient technological infrastructure (RC6)	9	14
		Lack of proper communication system (RC7)	3	19
		Inflexible work force (RC8)	8	15
		Inadequate capital (RC9)	2	4
		Improper selection of lean tools and practices (RC10)	1	3
Inadequate lean planning (LP)	2	Poorly defined role & responsibility (LP1)	3	12
		Lack of customer focus (LP2)	2	7
		Poor organizational structure (LP3)	4	16
		Absence of appropriate lean implementation methodology (LP4)	1	2
Half-hearted commitment from management (UM)	3	Lack of support from top management (UM1)	1	1
		Unable to manage change inertia (UM2)	3	13
		Lack of vision & strategy to implement (UM3)	2	8
Behavioural issues (BI)	4	Resistance to change (BI1)	1	11
		Lack of involvement (BI2)	3	20
		Lack of motivation (BI3)	2	18

Considering the outer & inner dependencies amongst the observed various factors and sub factors, the following model describes the system of barriers to lean implementation in Indian SMEs. Table 7 describes the interdependencis amongst the observed factors and provides vital informantion for the model development. It is quite evident from the model path coefficient both outer and inner dependencies exists. This model describes the interdependencies both outer & inner and serves as input to analytical network process using super decision software (Fig. 2).

The following table shows the normalize and limiting weight of the various factors and sub factors (Table 10). Using the overall priorities obtained from super decision software, the comprehensive ranking of various factors & sub factors was done based on normalize and limiting weight (Table 11). Lean sub barriers having the highest limiting weight is the top ranked sub barriers & likewise the sub lean barriers within the factors are rannked using normalize weghts. According to the limiting weight, key lean barriers are classified into three groups namely severe lean barriers (Rank 1–9) , moderate lean barriers (Rank 10–13), and not significant lean barriers (Rank 14–20).

Discussion & conclusion

Though, the concept of lean manufacturing has been described comprehensively over the years by different researcher's worldwide since 1990. But the implementation of lean concept is quite an uphill task particularly in the context of Indian SMEs. The current research provides comprehensive list of various factors and sub factors of lean barriers along with their relative importance in Indian automotive SMEs.

The current research demonstrates the implementation of lean concepts was linked with many potential barriers to lean implementation. The confirmatory factor analysis was done to find out the general category of lean barriers known as factors. Four general categories of lean barriers found are namely: Half-hearted commitment from management, inadequate lean planning, resource constraints, and behavioral issues. These factors are in consensus with the research done in the past and also validate the conceptual model (Figure 1). Since these four barriers to lean implementation are extracted through the literature survey & same is validated applying confirmatory factor analysis for Indian automotive SMEs also, we can conclude saying these barriers ex-

ist in variety of industrial environment regardless of its size and type. However, the relative importance of these factors may vary from industry to industry operating in different segment. As far as Indian automotive industry is concerned the most important factor was resource constraints followed by inadequate lean planning, half-hearted commitment from management, and behavioral issues (Table 5). Multiple regression analysis is done to find out the relative importance the factors objectively. Multiple regression analysis suggested similar ranking of the factors objectively which collective explain almost 67.5% of variation (Table 9). But it has also been verified that the extracted factors are not truly independent in nature, hence the applicability of multiple regression for ranking was apprehensive. Analytical network process was applied, considering the interdependency amongst the factors and found similar sort of ranking (Table 10). This may be due to the coefficient of correlation less than 0.40 between the factors.

It can be observed the factors (Inadequate lean planning, Resource constraints), (Half-hearted commitment from management); (Behavioral issues) are related to tactical planning, strategic planning, and operational planning respectively of Indian automotive SMEs. That is why the data has been collected across various levels based on 20 variable found through literature survey.

In order to understand the barriers to lean implementation, it's critical to go the finest level of these factors, which is organizational specific Indian automotive industry to be precise. Comprehensive model describing various lean factors and lean sub factors has been shown (Table 7). Model has been redesigned using super decision software by taking care of dependencies amongst the various lean factors and lean sub factors. Analytical network process methodology was applied to compute the priorities of lean factors and lean sub factors (Table 10).

The top rank barriers to lean implementation were lack of support from top management, absence of proper lean implementation methodology, lack of customer focus, absence of proper lean measurement system, inadequate capital, improper selection of lean tools & practices, lack of vision & strategy to implement, absence of proper lean training program, and lack of expertise to implement lean philosophy. Support from top management, vision & strategy and availability of adequate capital were essential to implement lean philosophy. These key lean barriers were related to strategic planning. At this level firm foundation to lean can be laid by fostering conducive climate to lean implementation and ensuring adequate capital to achieve it. Absence of proper lean implementation methodology, absence of proper lean measurement system, improper selection of lean tools and practices, absence of proper lean training program, lack of expertise to implement lean philosophy, and lack of customer focus were the tactical issues. Tactical issues are often taken care of by middle level managers. It's quite evident from the current study the middle level manages perform vital role in lean implementation in Indian automotive SMEs. Top management is responsible for initiation of lean implementation but responsibilities of overall successful lean implementation lies with tactical managers. Despite having significant contribution to economy, Indian SMEs are continuing to struggle for the access to vital resources including the capital. In the recent past under Indian government "Make in India" policy adequate amount of loan has been offered to the SMEs at very liberal terms and conditions. Issues related to customers can be addressed by formulating lean implementation methodology based on lean functional deployment similar to quality functional deployment driven by customer's requirements. Requirement of valid lean performance measurement system is absolute necessity for selection of various lean tools & practices objectively. Top management must fully support lean implementation program and formulate suitable strategy & mission for smooth transition from traditional to lean philosophy.

According to a study conducted for Malaysian automotive industry in 2012, the top rank barriers to lean implementation were lack of skilled people, lack of awareness about the various tools & practices, lack of effective measurement system, and organization culture. These lean barriers are mostly in consensus to the present study [24].

A comprehensive survey was done to identify and rank the barriers to lean implementation in Polish conditions in 2016. The top rank barriers were lack of management, ignorance of lean tools, the lack of standardization, lack of defined objectives, and lack of training [4]. Which are in agreement to the current study. However, the difference may be due to different conditions and the targeted industry for the study.

Recently a research was carried out to assess the feasibility of lean implementation in Iranian automotive SMEs through the identification of probable lean barriers. The methodology adopted was case study & in-depth interviews. Lean barriers are classified into four broad categories in order of importance were: lack of support from top management, financial capability, lack of employee's skills and expertise, and

organizational culture. Many of them are in consensus to the present study [25].

Potential lean barrier for SMEs operating in electronics & electrical industry were suggested using case study and questionnaire administered survey. Most critical barrier to lean was lack of effective information system, followed by lack of effective senior management, and negative attitude of middle level managers. Which are in line with the present study. But the research carried was crude and not supported by adequate statistical analysis [26].

Key drivers for implementing lean philosophy in Indian SMEs were identified. These drivers are ranked using MCDM. The most important macro level drivers were commitment from top management, followed by technology up gradation, environmental current & future norms, and green brand image [27]. Which are in consensus with the present study. However, the green manufacturing is the integral part of the lean philosophy.

Lack of support from top& middle level management, lack of employee's involvement, lack of skills & knowledge to implement lean philosophy, inadequate resources, poor information and communication system, and absence of strategic relationship with the suppliers were identified as key lean hurdles for the subsidiaries of multinationals operating in Brazil. Finding is by and large in line with the present study [28].

Limitations

Though the utmost care has been taken to formulate the model explaining barriers to lean implementation in India automotive SMEs, but the assessment of real world problems involves lots of subjectivity. Subjectivity has been converted into objectivity during the process of assessment, but no fool proof conversion is available. While generalizing the outcome one has to take into account the amount of subjectivity involves in the process of decision making.

References

[1] Womack J.P., Jones D.T., Roos D., *Machine that changed the world*, Simon and Schuster, 1990.

[2] Bhasin S., *Performance of Lean in large organisations*, Journal of Manufacturing Systems, 31(3), 349–357, 2012.

[3] Radnor Z., Osborne S.P., *Lean: a failed theory for public services?*, Public Management Review, 15(2), 265–287, 2013.

[4] Ulewicz R., Kucęba R., *Identification of problems of implementation of Lean concept in the SME sector*, Ekonomia i Zarzadzanie, 8(1), 19–25, 2016.

[5] Netland T.H., *Critical success factors for implementing lean production: the effect of contingencies*, International Journal of Production Research, 54, 8, 2433–2448, 2016.

[6] Antosz K., Stadnicka D., *Lean philosophy implementation in SMEs – study results*, Procedia Engineering, 182, 25–32, 2017.

[7] Shrimali A.K., Soni V.K., *Barriers to Lean Implementation in Small and Medium-Sized Indian Enterprises*, International Journal of Mechanical Engineering and Technology, 8(6), 2017.

[8] Lodgaard E., Ingvaldsen J.A., Gamme I., Aschehoug S., *Barriers to lean implementation: perceptions of top managers, middle managers and workers*, Procedia CIRP, 57, 595–600, 2016.

[9] Achanga P., Shehab E., Roy R., Nelder G., *Critical success factors for lean implementation within SMEs*, Journal of Manufacturing Technology Management, 17(4), 460–471, 2006.

[10] Garcia-Sabater J.J., Marin-Garcia J.A., *Can we still talk about continuous improvement? Rethinking enablers and inhibitors for successful implementation*, International Journal of Technology Management, 55(1/2), 28–42, 2011.

[11] Dora M., Kumar M., Gellynck X., *Determinants and barriers to lean implementation in food-processing SMEs – a multiple case analysis*, Production Planning & Control, 27(1), 1–23, 2016.

[12] Marodin G.A., Saurin T.A., *Implementing lean production systems: research areas and opportunities for future studies*, International Journal of Production Research, 51(22), 6663–6680, 2013.

[13] Samuel D., Found P., Williams S.J., *How did the publication of the book The Machine That Changed The World change management thinking? Exploring 25 years of lean literature*, International Journal of Operations & Production Management, 35(10), 1386–1407, 2015.

[14] Salonitis K., Tsinopoulos C., *Drivers and Barriers of Lean Implementation in the Greek Manufacturing Sector*, Procedia CIRP, 57, 189–194, 2016.

[15] Malmbrandt M., Åhlström P., *An instrument for assessing lean service adoption*, International Journal of Operations & Production Management, 33(9), 1131–1165, 2013.

[16] Kumar A., *The challenges to the implementation of lean manufacturing*, International Journal of Engineering Science & Advanced Technology, 4(4), 307–312, 2014.

[17] Behrouzi F., Wong K.Y., *Lean performance evaluation of manufacturing systems: a dynamic and innovative approach*, Procedia Computer Science, 3, 388–395, 2011.

[18] Raj T., Shankar R., Suhaib M., *An ISM approach for modelling the enablers of flexible manufacturing system: the case for India*, International Journal of Production Research, 46(24), 6883–6912, 2008.

[19] Esfandyari A., Osman M.R., *Success and failure issues to lead lean manufacturing implementation*, 4th International Management Conference, 4, 1, 134–143, 2010.

[20] Worley J.M., Doolen T.L., *The role of communication and management support in a lean manufacturing implementation*, Management Decision, 44(2), 228–245, 2006.

[21] Widiasih W., Karningsih P.D., Ciptomulyono U., *Development of integrated model for managing risk in lean manufacturing implementation: a case study in an Indonesian manufacturing company*, Procedia Manufacturing, 4, 282–290, 2015.

[22] Zhou J.L., Zhe-Hua B., Sun Z.Y., *Safety assessment of high-risk operations in hydroelectric-project based on accidents analysis, SEM, and ANP*, Mathematical Problems in Engineering, 2013.

[23] Yüksel Ý., Dagdeviren M., *Using the analytic network process (ANP) in a SWOT analysis – a case study for a textile firm*, Information Sciences, 177(16), 3364–3382, 2007.

[24] Sahwan M.A., Ab Rahman M.N., Deros B.M., *Barriers to implement lean manufacturing in Malaysian automotive industry*, Jurnal Teknologi (Sciences and Engineering), 59(SUPPL. 2), 107–110, 2012.

[25] Moradlou H., Perera T., *Identification of the Barriers in Implementation of Lean Principles in Iranian SMEs: Case Study Approach*, Global Journal of Management and Business Research, 2017.

[26] Yogesh M., Chandramohan G., Arrakal R., *Application of Lean in a Small and Medium Enterprise (SME) Segment – A Case Study of Electronics and Electrical Manufacturing Industry in India*, International Journal of Scientific & Engineering Research, 3(8), 1, 2012.

[27] Gandhi N.S., Thanki S.J., Thakkar J.J., *Ranking of drivers for integrated lean-green manufacturing for Indian manufacturing SMEs*, Journal of Cleaner Production, 171, 675–689, 2018.

[28] Goehnera L., Mellob L.C., Bandeira R.A., *Lean Manufacturing Implementation for Multinational Companies with production Subsidiary in Brazil: Development of a Roadmap*, International Journal of Lean Thinking, 7(1), 4–9, 2016.