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Lean implementation in small and medium-sized enterprises: An empirical study of Indian Manufacturing firms

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1. INTRODUCTION

In the present global scenario, manufacturing organizations are mainly facing challenges from two directions. First, advanced manufacturing philosophies are emerging, which the existing methods are becoming obsolete (Jasti & Kodali, 2015). Secondly consumer thinking is changing and loyalty goes beyond a rational decision for superior perceived price-performance ratio. The customers have become more demanding for innovative products and services within a very short period of time and at less price (Tersine & Wacker, 2000; Lau, Jiang, Chan, & Ip, 2002; Ho, Lau, Lee, & Ip, 2005). Essentially to cope up with such challenges, the core idea behind strategy formulation by manufacturing firms nowadays, is to maximize customer value while minimizing waste. Hence, manufacturing firms operating in such rapidly changing and highly competitive market, for the past two decades have embraced the principles of lean thinking (Fullerton, Kennedy, & Widener, 2014). The word "lean" refers to lean manufacturing or lean production as it uses less of everything, compared to mass production (Wahab, Mukhtar, & Sulaiman, 2013). It only uses half of the human effort in the factory, half of the manufacturing space, half of investments in tools and half of the engineering to develop a new product in half of the time (Liker, 1998; Womack, Jones, & Ross, 1990). Also, it requires keeping far less than half the inventory on site, results in fewer defects, and produces a greater and ever growing quality of products (Womack, Jones, & Ross, 1990). Lean strategy is a management approach to manufacturing that strives to make organizations more competitive in the market by increasing efficiency and decreasing costs through elimination of non-value added steps (Garza-Reyes, Oriafige, Soriano-Meier, Forrester, & Harmanto, 2012). Lean manufacturing practices enhance manufacturing productivity by reducing setup times and work in process inventory, improving throughput times, and thus improving market performance (Tu, Vonderembse, Ragu-Nathan, & Sharkey, 2006). Various methods and tools that aim to improve performance of organizations are comprised under the lean strategy's umbrella (Bhasin, 2012). The expression of "continuous improvement" is quite popular in lean manufacturing and the concept is associated mainly with total quality management, total productive maintenance, Just-in-time, six sigma, pull flow, low set up, controlled processes, human resource management and other approaches (McKone, Schroeder, & Cua, 1999).

Several decades have passed since the initial conception of lean manufacturing (Belekoukias, Garza-Reyes, & Kumar, 2014). For decades now, the number of continuous improvement models have been growing based on the concept of improved quality and/or processes aimed at reducing waste, simplifying the production line etc. (Drohomeretski, Costa, Lima, & Garbuio, 2014). In operation research, lean manufacturing practices has been found to have a positive impact on firm's performance (Belekoukias, Garza-Reyes, & Kumar, 2014; Fullerton, Kennedy, & Widener, 2014; Drohomeretski, Costa, Lima, & Garbuio, 2014; Kumar, Soni, & Agnihotri, 2014; Rahman, Laosirihongthong, & Sohal, 2010). Nevertheless, research study done by other researchers (Marvel & Standridge, 2009) argued that few organizations attain significant improvements by applying lean. In the last several years, scholarly journals have published a number of articles that focus on the content of lean production in large organizations or comprise of case studies that concentrate on individual firm experiences. Several lean implementations have been developed (Åhlström, 1998; Hobbs, 2004; 2011; Mostafa, Dumrak, & Soltan, 2013), but these methods are designed for mass production companies (Deflorin & Scherrer-Rathje, 2012; Moeuf, Tamayo, Lamouri, Pellerin, & Lelievre, 2016; White, Pearson, & Wilson, 1999). Hence, the size of the company is an influential factor in the lean implementation (Shah & Ward, 2003; Yang, Hong, & Modi, 2011; Moeuf, Tamayo, Lamouri, Pellerin, & Lelievre, 2016). However, most of the manufacturing firms that have implemented lean, have assessed lean practices in their own unique way. Indeed, when compared to large companies, SMEs have distinct characteristics and specific success criteria related to lean implementation, which differ from large manufacturing setups (Achanga, Shehab, Roy, & Nelder, 2006). Many SMEs in both developed and developing countries have shown reluctance toward adopting lean manufacturing practices for numerous reasons (Husband & Mandal, 1999). Also, SMEs that adopted lean, have given up continuing practicing lean at an early stage, as these firms are unable to identify and determine the success indicators of the adopted lean implementation (Wahab, Mukhtar, & Sulaiman, 2013). Some manufacturing firms misapply the lean practices and the main reason for this scenario lies in their internal issues such as lack of knowledge and their understanding of lean, cultures, skills and so on, leading to 'use of wrong tool to solve a problem', 'use of same tool to solve all of the problem', and 'use the same set of tools on each problem' (Pavnaskar, Gershenson, & Jambekar, 2003; Wahab, Mukhtar, & Sulaiman, 2013). Also, SMEs across various sectors are vulnerable in any economic environment, where there are few barriers to new entrants and where they have little power to dictate to suppliers about their needs (Achanga, Shehab, Roy, & Nelder, 2006). Hence as a result of such vulnerability, an element of conflict with lean management principles practices within SMEs is observed due to lack of expertise that affects several fields like information flow (Iris & Cebeci, 2014), problem solving (Thomas, Barton, & Chuke-Okafor, 2012) and even lean tools (Kumar, Anthony, & Douglas, 2009). According to a research study considering manufacturing SMEs in United Kingdom as sample, the success rate of lean implementation in SMEs was found to be low since it reaches only 10 % (Baker, 2002). This lack of clarity is evident from the multiplicity of inferences drawn with respect to research studies on lean production. Manufacturing has emerged as one of the high growth sectors in India. With "Make in India" ambitious vision of our Honorable Prime Minister of India, small and medium sized manufacturing firms have a golden chance to emerge from the shadow and seize more of global market. To achieve this objective, the Indian manufacturing sector needs to embark on productivity and quality programs to be more competitive in global market. Adoption of lean manufacturing practices is highly capital-asset intensive, and is largely adopted by large organizations in India to reap the tangible benefits in a long run (Seth & Tripathi, 2006; Timan, Antony, Ahaus, & Solingen, 2012; Panizzolo, Garengo, Sharma, & Gore, 2012). Ferocious challenges in competition have prompted many SMEs to adopt lean to enhance firm's efficiency and competitiveness. With its proven success in large companies, lean has become more attractive to many SMEs in the country. But still, the idea of applying lean manufacturing strategy has not been adopted by meaningful numbers of SMEs in the country without any convictions. There is (still) only limited insight into successful implementation of lean manufacturing practices in SMEs. Lean practices in SMEs have a relatively short history, and a lot of important issues and areas are largely untouched in academic research (Zhou, 2012). As very few studies regarding lean implementation in SMEs have been done in the past, a thorough research needs to be carried out, so as to gauge how small and medium enterprises in this country view it, adapt to it, and practice it. Hence motivated by the research gap, this paper makes an empirical attempt to examine the relationship between lean manufacturing implementation practices and performance of small and medium sized Indian manufacturing firms. This research investigated 121 SMEs across India which had implemented lean manufacturing in their firms. Also, the paper provides evidences regarding major lean implementation barriers that are encountered by SMEs in India.

The research paper is organized as follows. In section 2, we review literature about lean barriers, lean manufacturing and its application in India. In section 3, the research methodology employed in the research study is presented. Section 4 is devoted to an in-depth analysis and discussion on major research findings. Finally, section 5 concludes the paper. The practical implications of this study will be important for lean practitioners and entrepreneurs of small and medium sized enterprises.

2. LITERATURE REVIEW

Based on the objective of the paper, a literature review was conducted aiming to collect and analyze all relevant papers in the field by means of structured search for literature. The same is presented under various focused themes/topics. We first describe briefly the concept of lean manufacturing and its adoption & application in SMEs. Next, we move on to literature that specifically focuses on the implementation of lean manufacturing practices in small and medium sized manufacturing enterprises in India. As we seek to understand the adoption of lean manufacturing practices and its impact on Indian SMEs performance over last few decades, we also review literature about major lean barriers encountered by SMEs. These articles are summarized in the following themes.

2.1 LEAN IN PRACTICE IN SMEs

Since 1980s, scholars have been engaged in research to better understand and predict outcomes of lean transformation while practitioners continue their quest to operationalize and apply lean concepts for process and business improvement (Stone, 2012). In the year 1988, a researcher (Krafcik, 1988) initially proposed the term “Lean” based on the Toyota Production System (TPS) in his thesis at Massachusetts Institute of Technology (Shah & Ward, 2007; Hu, Mason, Williams, & Found, 2015), which was then popularized by two books, “The Machine that changed the World” (Womack, Jones, & Ross, 1990) and “Lean thinking” (Womack & Jones, 1996). The main goal of the lean concept is viewed as the reduction in waste and to achieve reduced lead times (Hines, Holweg, & Rich, 2004; Andersson, Eriksson, & Torstensson, 2006; Lyons, Vidamour, Jain, & Sutherland, 2013; Manfredsson, 2016). The majority of research studies on lean identify seven types of fundamental waste: correction, overproduction, motion, material movement, waiting, inventory and processing (Filho, Ganga, & Gunasekaran, 2016). Analysis of lean implementation effects on performance parameters concurs and states that improvement on costs and lead time will occur (Narasimhan, Swink, & Kim, 2006; Hallgren & Olhager, 2009; Pullan, Bhasi, & Madhu, 2013; Wong, Ignatius, & Soh, 2014), supporting the established main goal of lean. Lean production is evidenced as a model where the each and every person of the organization assume a role of thinkers and involvement promotes the continuous improvement and give companies the agility they need to face the market demands and environment changes of today and tomorrow (Alves, Dinis-Carvalho, & Sousa, 2012). Researchers have conducted empirical studies to understand the relationship between lean implementation and improvement in organizational performance of SMEs (Achanga, Shehab, Roy, & Nelder, 2006; Antony, Kumar, & Labib, 2008; Timan, Antony, Ahaus, & Solingen, 2012; Kumar, Khurshid, & Waddell, 2014). SMEs have not given due attention for developing their effective strategies in the past (Singh, Garg, & Deshmukh, 2010). However there appears to be little empirical evidence in publications on the implementation of lean practices and the factors that influence them in SMEs (Bruun & Mefford, 2004; Achanga, Shehab, Roy, & Nelder, 2006; Marodin & Saurin, 2013; Bhamu & Sangwan, 2014; Hu, Mason, Williams, & Found, 2015; Manfredsson, 2016).

Majority of SMEs has simple systems and procedures which allow flexibility and quicker response to customer needs than large organizations (Jain, Bhatti, & Singh, 2015). Lean manufacturing is made up of several tools and techniques, which are used together as continuous improvement devices to identify and eliminate waste while increasing flexibility (Mathur, Mittal, & Dangayach, 2012). Some of these tools and techniques include value stream mapping, 5S workplace organization, total productive maintenance, set-up reduction, Kanban and pull production methods, cellular manufacturing, visual signals and process standardization. Table 1 provides a list of lean practices exercised in SMEs as found in the relevant literature.

[Insert table 1]

Irrespective of how it is perceived, the concept of lean manufacturing has unarguably been reasonably discussed in the context of SMEs in the past few decades by several researchers, to provide evidence on the implementation of lean manufacturing practices that might influence the performance dimensions of SMEs. Unfortunately, many SMEs are still reluctant to apply lean practices to improvise their manufacturing competencies, without sufficient conviction (Achanga, Shehab, Roy, & Nelder, 2006). These enterprises require that the implementation costs and the subsequent benefits of lean manufacturing adoption, be projected upfront before they are able to commit. Therefore, this research paper aims to outline some of the practices that are perceived to be critical in the successful application of lean manufacturing within SMEs community.

2.2 DISSEMINATION OF LEAN ACTIVITIES AND PRACTICES IN INDIAN SMEs

SMEs in both developed and developing economies are defined by a number of factors and criteria, such as location, size, age, structure, organization, number of employees, sales volume, worth of assets, ownership through innovation and technology (Rahman S.□u. , 2001). Indian manufacturing sector are classified into three categories based on their investment in plant and machinery (original cost excluding land and building and the items specified by the Ministry of Small Scale Industries). Enterprises having investment of less than twenty-five lakh rupees are categorized as micro enterprises, enterprises with investment between twenty-five lakh rupees and five crore rupees are categorized as small enterprises, while the enterprises with investment between five crore and ten crore rupees are classified as medium scale enterprises (Ministry of MSMEs, Government of India, 2017). After the globalization of market, SMEs have got many opportunities to work in integration with large scale organization. SMEs perform a critical role in most developing economies, as they are highly flexible and responsive suppliers to large firms, customers of large firms and suppliers to end-user customers in their own right (Aoki, 2008; Kumar, Khurshid, & Waddell, 2014). Any compromise in quality by SMEs could jeopardize the whole manufacturing supply chain, resulting in raising costs because of poor quality (Aoki, 2008; Dora, Kumar, Goubergen, Molnar, & Gellynck, 2013; Kumar, Khurshid, & Waddell, 2014). Recent intense competition across the manufacturing sector requires that firm must excel simultaneously in several areas without trade-off, including innovativeness and responsiveness to their customer (Singh, Garg, & Deshmukh, 2008). Indian SMEs need to restore their competitiveness, as their contribution in the India's GDP is about 22 percent, with a share of almost 40 to 45 percent of manufactured output and exports (Ministry of MSMEs, Government of India, 2017). Hence, small and medium-sized enterprises are very important within India's economic structure, but they are facing significant challenges as present global manufacturing environment is getting increasingly competitive than ever before.

To meet the challenges of offering high standards of quality, cost and delivery to several multinational firms, Indian manufacturing SMEs must implement effective approaches, such as lean manufacturing, to continually and systematically improve their operations (Saboo, Garza-Reyes, Er, & Kumar, 2014). Today India is the place to be for design, development and manufacturing of innovative products and major companies from Europe, USA and Japan are viewing Indian industries as active participants in the entire value chain (Panizzolo, Garengo, Sharma, & Gore, 2012). Application of lean implementation for deploying continuous improvement is increasing largely in the last decade and seems to have become the de-facto approach for industry (Hawkins, 2001; Kumar, Antony, Singh, Tiwari, & Perry, 2006; Anand & Kodali, 2009; Timan, Antony, Ahaus, & Solingen, 2012). Advancements in information technology and business analytics technologies provide unprecedented opportunities for designing, implementing, and expanding lean operation from global companies to small and medium sized enterprises (Singh & Khanduja, 2010; Zhou, 2012; Powell, Riezebos, & Strandhagen, 2013). Realizing the importance of manufacturing as a competitive weapon, the government of India has instituted the lean manufacturing competitiveness scheme for micro, small and medium enterprises to assist firms in reducing their manufacturing costs through improved process flows, better space utilization, scientific inventory management and reduced engineering time (Panizzolo, Garengo, Sharma, & Gore, 2012).

[Insert table 2]

Specifically, in relation to India, there are few empirical research that addresses lean manufacturing and performance linkages in Indian SMEs. Evidence from such research studies shown in table 2 suggest that the dissemination of lean manufacturing in Indian SMEs has been substantial in the automotive, pharmaceutical and metal die-casting & component manufacturing sector. Although lean is becoming popular technique for productivity improvement, SMEs are still not certain of the cost of its implementation and the likely tangible and intangible benefits that they may achieve (Achanga, Shehab, Roy, & Nelder, 2006). Most of these enterprises fear that implementing lean manufacturing is costly and time consuming. In the SMEs, the perceived benefits of lean are low and the management is often reluctant to invest in consultants due to high consultancy fees (Panizzolo, Garengo, Sharma, & Gore, 2012). More generally from the reviewed literature evidences, it is observed that the dissemination of lean manufacturing practices in Indian SMEs could be constrained by lack of in-depth training, inadequate number of qualified lean thinkers and limited lean education-industry association.

2.3 OBSTACLES TO IMPLEMENTATION OF LEAN IMPROVEMENT TECHNIQUES FOR SMEs

The implementation of a lean strategy, like any other productivity improvement initiative, is believed to harbor enormous difficulties (Denton & Hodgson, 1997). For SMEs, the change from traditional manufacturing practices to lean is challenging from both internal and external factors (Filho, Ganga, & Gunasekaran, 2016). Based on literature review, major impeding factors identified in implementing Lean culture within SMEs are listed in table 3.

[Insert table 3]

One of the main goals of implementing a lean strategy is the elimination of everything that does not add value to product or services (Womack & Jones, 1996). Also, it has been proved that not all lean improvement initiatives could be adopted by SMEs (Yusof & Aspinwall, 2000) due to high cost investment factor in the technology. Small and medium sized enterprises, by virtue of their size are likely to struggle with financial, technical and time constraints, which are further amplified by a number of obstacles such as the lack of technical and managerial expertise and human resources deficiencies (Achanga, Shehab, Roy, & Nelder, 2006). Insufficient expertise, unfortunately often results in ad hoc adoption of individual practices, but failure to establish the system-wide philosophy and culture necessary to support such practices (Mathur, Mittal, & Dangayach, 2012). This lack of expertise could be overcome through the use of external consulting, but this option is often not a possibility as organizations would require financial resources to hire consultants, as well as to aid the actual implementation of such ideas. Training of people to utilize the techniques also requires adequate financial resources. Most SMEs are financially inept and harbor poor financing arrangements. Financial inadequacy is therefore a major hindrance to the adoption and subsequent implementation of successful lean manufacturing within SMEs (Achanga, Shehab, Roy, & Nelder, 2006). Another complication in applying lean principles is the relentless, rapid pace of change in technology in most SMEs as they add new capacity and their product design evolve. To cope, companies must give lean initiatives shorter time horizons than they have elsewhere and implement them more swiftly

(Panizzolo, Garengo, Sharma, & Gore, 2012). In some cases, it is perceived by SMEs that application of lean may put their current state of production at risk, resulting in financial losses.

Most researchers suppose that human resources (people) are essential to the implementation of lean, since people are often the key elements in operations (Zhou, 2012). The organizational structures in SMEs is often flat and less hierarchical than in large organization (Antony, Kumar, & Madu, 2005). Flat structure of SMEs and fewer departmental interfaces normally results in a more flexible work environment. Indian small and medium sized manufacturing industry has its own very special problems. The workmen employed in these small industries come from a poor and uneducated background. They learn their work by the informal apprenticeship route, and they grow in their skills by mistakes and practice. Such home-grown workmen, with little or no formal technical training, are the backbone of the SMEs manufacturing ecosystem. More often than not, they are illiterate too, and the work progresses more by verbal instructions, rather than relying on the written document (Mathur, Mittal, & Dangayach, 2012). Also, workmen with low education background shows an inherent resistance to change and adapting to new organized work practices and routines, that seriously affects the speed of lean implementation (Pingyu & Yu, 2010; Aspinwall & Elgharib, 2013). Such an informal climate with flexible work planning (Antony, Kumar, & Labib, 2008) could harm the standardization of process (Bakas, Govaert, & Landeghem, 2011). As per multiple annual surveys by Lean Enterprise Institute (LEI), revealed most enterprises employing lean had a tendency to backslide to old style of traditional practices, thereby further harming the standardization process (Sproull, 2009).

In order to succinctly implement the concept of lean manufacturing successfully within SMEs, the recipient company should harbor strong leadership traits capable of exhibiting excellent project management styles (Achanga, Shehab, Roy, & Nelder, 2006). Managing organizational culture effectively requires clarity in the minds of senior management about the type of culture and specific norms and values that will help the organizations reach its objectives (Singh, Garg, & Deshmukh, 2008). Senior management and culture is also considered an essential area and it is crucial for management to understand and provide sample support to apply lean in the organization (Zhou, 2012). The challenges before senior management is to cultivate an organizational culture that supports lean. Communication and collaboration among employees at both similar & different hierarchical levels but from functional levels areas is very important and critical to ensure that the vision and mission of lean is attainable and shared throughout the company. Many SMEs, by default, reflect in their culture, the personality of senior management personnel and are constrained by this in terms of changes they may be able to make (Achanga, Shehab, Roy, & Nelder, 2006; Nordin, Deros, & Wahab, 2010). A supportive culture and environment in an organization that brings employees to work, communicate and grow together is essential to make lean initiative successful (Zhou, 2012). This should go beyond a direct plan to improve operational issues to also include more strategic organizational factors needed to support lean implementation, such as developing employee empowerment and participation in decision making and ensuring a supportive organizational culture for lean through rewards and recognition (Hu, Mason, Williams, & Found, 2015). Good leadership ultimately fosters effective skills and knowledge enhancement among its workforce.

Since scope for improvement within the organizations with lean implementation is evolving, for further effectiveness, organization could think of newer alternatives of integrating the business activities beyond the organizations boundary. Particularly when dealing with such external relationships, firms do face a challenge of influencing and convincing business associates to restructure business practices to lean, such as to manage inventories in a new and innovative way (Li, Ragu-Nathan, Ragu-Nathan, & Rao, 2006; Zhou, 2012). SMEs may lack the market power to influence business associate networks, particularly suppliers in adopting lean practices (Hu, Mason, Williams, & Found, 2015). For effective quality management of external supplier quality, SMEs should reduce the number of suppliers in their supply base and purchasing should award contracts based on quality rather than strictly on cost (Stanley & Wisner, 2001). No further study was found within the terms of our literature search which investigate the applicability of lean-based principles in SMEs in their supply chain.

3. RESEARCH METHODOLOGY

3.1 RESEARCH DESIGN AND ASSESSMENT TOOL

The research methodology is typically based on the objectives of the research and type of data collected through a semi-structured questionnaire survey. The basic objective of the survey is to assess the present status of lean implementation and identify the challenges faced during adoption and implementation of lean practices in small and medium manufacturing enterprises. In this study, pre-tested constructs from past empirical studies were adapted to ensure validity and reliability of survey-instrument. The prime consideration of the developing the survey instrument was to keep it short and simple, such that it is understood by entrepreneurs and managers of small and medium sized enterprises in India, as most of them are not well-versed with technicality aspect of lean practices. The questionnaire consisted of three parts; (a) the background information of the organization and respondent, (b) the lean manufacturing implementation practices and barriers, and (c) the lean assessment tool consisting of four constructs namely process improvement, waste minimization, flow management and operational performance. The process of developing a questionnaire also included a pilot survey. The measurement instrument was developed from an extensive review of literature on lean manufacturing practices. Experts from industries and academics were also consulted. Majority of the feedback from experts gave positive remarks and certify that questionnaire was acceptable for data collection. To access content validity, the instrument was pretested at several manufacturing plants, before proceeding for final data collection phase.

As identified from the literature review, the lean practices and barriers constructs were set up on Likert scale to measure the extent of lean implementation or identification of impeding factors to lean adoption in the organization. These measures also gave the flexibility to respondents to consider the “Un-familiar” and “not-applicable” option against each lean practice implementation and barrier respectively. The process improvement, waste minimization and flow management constructs were adapted from Shah and Ward (2003) and Rahman et al. (2010). Process improvement construct included six items namely: reduction of inventory, preventive maintenance, cycle time reduction, use of new process technology, use of quick changeover techniques and reduction of set-up times. Waste minimization construct included four items namely: eliminating waste, use of error proofing techniques, use of pull-based production systems and removal of bottlenecks. Flow management included three items namely: reducing production lot size, focus on single suppliers and continuous/one piece flow. The operational performance was adapted from Cua et al. (2006), Konecny & Thun (2011), Kumar et al. (2014) and Bortolotti et. al (2015). The operational performance parameters included six items namely: unit cost of manufacturing, quality conformance, production rate, quick delivery, flexibility to change product mix and flexibility to change volume. For the items measuring practices, the respondents were asked to indicate their agreement or disagreement with the statements provided using five point Likert scales where a value of 5 indicates strong agreement and 1 indicates strong disagreement. For the performance measure the respondents were asked to evaluate firm's performance relative to its competitor. This research approach was adopted to minimize the possibility of bias from subjective answers.

The respondent SMEs were at different stages of lean implementation. In order to identify the lean status of each respondent firm, cluster analysis was performed to segment the manufacturing SMEs into three groups, namely, "Lean beginners" group, "In-transition Lean" group, and "Lean" group for further analysis. Cluster analysis was applied based upon period of implementation of lean practices. The effect of period of implementation of lean practices on operational performance has been assessed by many researchers (Seth & Tripathi, 2006; Zhou, 2012; Singh & Ahuja, 2014; Sahoo & Yadav, 2017). Manufacturing firms with up to three years of lean implementation is coded as "lean beginners" group. During this period, initial investments and efforts are made to overcome initial resistance and efforts are made to overcome initial resistance and to orient organizations as per requirement of approaches (Ahire & Rana, 1995). Similarly, the situation may require developing new performance indicators and various data capturing, measuring and analyzing tools and concepts. This phase normally goes for three years since the beginning of implementation (Ahire, 1996). Manufacturing firms with three to five years of lean implementation is coded as "in-transition lean" group. Manufacturing firms in this period, move from early adoption phase to wide application in various areas, and the firms starts realizing the benefits of lean implementation practices. Manufacturing firms with more than five years of lean implementation is coded as "lean" group. Manufacturing firms in this phase, represent high degree of implementation of lean practices. Over a long period, the benefits accrued from lean implementation drives, give strategic and competitive edge to the manufacturing firms in terms of cost, delivery, flexibility and customer satisfaction in comparison to competitors (Seth & Tripathi, 2006). To analyze the data, computer software, SPSS for window package (Version 20.0) has been used.

3.2 DATA COLLECTION AND RESPONDENT PROFILE

Survey data were collected from 121 small and medium manufacturing firms in India, referring to database, that was obtained from the 2016 SME business directory (Manufacturing) of Small & Medium Business Development Chamber of India. Snowball sampling technique was also used for identification of respondents. The data were collected by visiting the manufacturing firms and interviewing entrepreneurs and managers at different organizational levels. Table 4 shows general background of the respondent companies. All the selected companies have implemented lean manufacturing practices during the last one to ten years. Responses on the survey questionnaire were collected personally through verbal interaction and personal meeting with the respondent, explaining them the context of present research work, its significance and to clarify any doubts/queries, such as to facilitate comprehensive and clear-cut responses. Most of the respondent representing the firm were production and QC/QA personnel. Most of them (69.4%) have been working for more than 10 years in that particular company. They were selected because they have first knowledge and experience and they were directly involved to the implementation of lean manufacturing program in their companies. As a result of cluster analysis, approximately 40 % of the respondent (48 firms) were identified as "lean" firms. Similarly, "lean beginners" firms (n=37) and "in-transition lean" firms (n=36), each constituting approximately 30% of the respondent sample, were identified using cluster analysis.

[Insert table 4]

3.3 CONTENT AND CONTRUCT VALIDITY

Reliability tests were carried out to ensure that the questionnaire was reliable. Reliability measurement is an indication of the stability and consistency of the instrument applied. Cronbach's Alpha was used to test the reliability. The summary of the reliability and validity analysis of the lean assessment tool is presented in table 5. The Cronbach Alpha scores for each construct ranged from 0.71 to 0.77. Since the α values were considerably higher than the 0.60 threshold level, all construct exhibit a high degree of reliability. In the validity test results, the KMO values of all four constructs are varying from 0.67 to 0.82, all exceeding the minimum score of 0.50, demonstrating that all these areas and factors are valid. In summary, it can be concluded that all the areas of interests in the study are reliable and valid.

[Insert table 5]

4. FINDINGS FROM THE SURVEY: ANALYSIS AND DISCUSSIONS

4.1 LEAN MANUFACTURING IMPLEMENTATION STATUS IN INDIAN SMEs

To accurately assess the extent of lean implementation in respondent SMEs, a list of 16 lean tools and techniques were included in the survey. Respondents were asked to indicate on a five-point scale, which tools have been implemented and their level of adoption of lean practices in their organization. The scale ranged from 1 to 5 where 1 = no implementation, 2 = little implementation, 3 = some implementation, 4 = extensive implementation and 5 = complete implementation. Respondent were also given an option of 'un-familiar'. Table 6 presents the mean values and standard deviations of these tools and techniques of all respondents divided into different clusters. Those lean practices having mean score less than 3.0, indicate some level of implementation in the manufacturing firms.

[Insert table 6]

During the early phase of adopting, organization make an effort to integrate lean into existing manufacturing framework. If lean is not introduced properly, then it can lead to more pitfalls than successes. Total preventive maintenance initiative with a highest mean value of 3.94 is the first step toward lean. Lean maintenance practices cut costs and improve production by minimizing downtime. Followed by maintenance functions, many SMEs manufacturing facilities opted the path toward 5S-workplace organization (mean score=3.81), visual control (mean score=3.69) and housekeeping methodology as a part of lean or continuous improvement philosophy. Conceptually, visual control is not the same as 5S but the two ideas are closely linked as both of them are workplace organization practices. Visual control is a lean technique where information is communicated by using vital signals instead of texts or other written instructions. The design is deliberate in allowing quick recognition of the information being communicated, in order to increase efficiency and clarity. Other noticeable lean tools and techniques with a high mean value include lot size reduction, kaizen and set-up time reduction with respective mean scores of 3.50, 3.22 and 3.00. However, the least practiced tools by the 'lean beginners' SMEs in early adoption phase are value stream mapping (mean score = 2.25), poka-yoke (mean score = 2.22), heijunka (mean score = 2.14) and jidoka (mean score = 2.08) with a respective unfamiliarity level of 21.62%, 37.83 %, 27.02% and 32.43% among respondents. These results imply low level of implementation among the respondent firms and also clearly demonstrate lack of knowledge of lean philosophy and its tool, among 'lean beginners' manufacturing SMEs.

Similarly, for the second group of SMEs in transition phase of lean implementation, the top five lean implementation tools and techniques include 5S-workplace organization, total productive maintenance, kaizen (continuous improvement), visual control and SMED (set-up reduction) with a respective mean score of 3.95, 3.92, 3.84, 3.81 and 3.68. There has been an improvement in rank of SMED, as reducing machine setup time in SMEs manufacturing setting, addresses delays and inefficiencies to enhance machine efficiency. This implies that "in-transition lean" firms have better product flexibility manufacturing capability, as compared to "lean beginners" firms. Manufacturing SMEs in the transition phase have also shown adoption of advanced lean tools and techniques that include value stream mapping, employee training and team work, cellular layout, Kanban and Poka Yoke having a respective mean score of 3.41, 3.35, 3.24, 3.19 and 3.11. However, the least practiced tools by the 'in-transition lean' SMEs in transition phase are standardized work/process (mean score = 2.76), quality function deployment (mean score = 2.62), continuous flow (mean score = 2.43) and heijunka (mean score = 2.38) with a respective unfamiliarity level of 16.67%, 22.22%, 19.44% and 33.33% among 'in-transition lean' group respondents. It was evident from the results, that 'in-transition lean' are moving from early adoption phase and exploring wide application of lean practices in various areas. These results imply that the 'in-transition lean' firms have shown shift of focus toward long term strategic continuous improvement initiatives, which is evident from comprehensive application of lean tools but at the same time mixed evidences also indicate limited dissipation of knowledge of lean philosophy among 'in-transition lean' manufacturing SMEs.

Among all of the lean manufacturing practices, 5S-workplace organization methodology is found to be the leading lean practice among 'lean' firms, with a mean score of 4.17. Other lean practices that have been extensively implemented is the total productive maintenance (mean score = 4.04), SMED - set up time reduction (mean score = 3.90), kaizen (mean score = 3.81) and visual control (mean score = 3.73). However, the least practiced tools are the standardized work/process (mean score = 3.17), continuous flow (mean score = 3.13), Jidoka (mean score = 3.04) and Heinjunka (mean score = 2.96) with a respective unfamiliarity level of 4.17%, 6.25%, 12.50% and 10.41%. These least adopted lean tools and techniques demand large investment in equipment and facilities, hence they are not widely adopted by "Lean' manufacturing SMEs. As 'lean' firms become more stable and knowledgeable, they tend to apply more advance lean tools to support the end goal of production system.

4.2 IMPACT OF LEAN MANUFACTURING PRACTICES ON PERFORMANCE MEASURE OF INDIAN SMEs

Pearson's correlation coefficient "r" between organizational lean initiatives and operational performance measures have been computed to ascertain the contribution of specific lean initiatives towards realization of various operational performance indicators. Analyzing the survey data, a correlation analysis shown in table 7, implied that most of lean measures have moderate and significant relationship with operational performance studied. Only those pairs with Pearson correlation "r" ≥ 50 percent and statistically significant at 1 percent level of significance are considered as having a high degree of association. The adoption of process improvement (PI) strategy have exhibited high degree of association (r=0.594) with operational performance measures (OP). The result highlight that all process improvement practices have effectively contributed towards competitive unit cost of manufacturing. Respondent do not find reduction of inventory (PI1) to affect the quality conformance (OP2) and production rate (OP3) parameters. It has also been observed that preventative maintenance (PI2) are found to be closely associated with unit cost of manufacturing(OP1), quality conformance (OP2) and quick delivery (OP4) performance parameters. Preventative maintenance activities in any manufacturing firms improvises equipment reliability, ensuring better upkeep of the production facilities, improving autonomous maintenance capabilities of production operators which leads to streamlining of production system performance, which further addresses major and minor losses/wastages associated with the production system, resulting in improved machine availability and productivity, thereby lowering the unit cost of manufacturing of end product. Such production system can strategically lead to enhancement in the quality of end product and delivery to consumers, which results in enhanced customer satisfaction. It appears that the preventive maintenance (PI2) did not find significant association with the flexibility to change product mix (OP5). This is due to the fact that preventive maintenance activities are most suited for stable manufacturing environment. There are several constraints associated with manufacturing production scheduling with preventive maintenance in random flexible manufacturing environments, which may affect several manufacturing key performance indicators (KPIs). Again, analyzing the correlation matrix, the cycle time reduction (PI3) practices is found to be significantly correlated with quality conformance (OP2) and production rate (OP3) performance parameters. When a cycle time is too close to the takt time, there is little margin for error. Most production processes have some inconsistency in them, resulting in people falling behind the normal pace on occasion. This leads to them rushing, which, in turn can lead to mistakes, thereby affecting the production rate (OP3). Reducing cycle time is a low-cost way to add a bit of a buffer to avoid these sorts of defects by workmen, thereby improving both quality and productivity. Most lean manufacturing firms adopt a policy of making the technology as flexible as possible, such as to ensure production and delivery of variety of products, to cater consumer changing needs. The same is also evident from the analysis results, where the use of new process technology (PI4) is found to have a significant association with flexibility to change product mix(OP5) and quick delivery(OP4). Both lean parameters, usage of quick change-over techniques (PI5) and set-up time reduction(PI6) have exhibited significant linkages with unit cost of manufacturing (OP1), quality conformance (OP2), and quick delivery (OP6). As lean production in SMEs is dependent upon small lot sizes, which are dependent upon quick changeovers and set-up times reduction. If set-ups or changeovers are lengthy, then it is mathematically impossible to run small lots of parts with low inventory because large in-process inventories must be maintained to feed production during changeovers. It is also evident, the purpose of reducing set-up time is not for increasing production capacity, but to allow for more frequent changeovers in order to increase production flexibility (OP5 & OP6). These strategic initiatives are perfectly suited for SMEs, that allows them to produce reasonably priced customized products of high quality that can be quickly delivered to customers.

[Insert table 7]

It has been observed that the implementation of flow management practices (FM) has been found to have moderate impact (r =0.477) on operational performance (OP). Examining the results and based on respondent interaction, it is evident that flow management practices focus is found to be upon the improvement of material flow or management co-ordination cost, with the use of small production run or lot size and reduced coordination efforts by dealing with less suppliers. The adoption of continuous/one flow (FM3) practices have exhibited significant linkage with unit cost of manufacturing (OP1). It means that production cost reduces, as manufacturers attempts to continually improve their processes in an attempt to get closer and closer to true one piece flow, resulting in improvement in production rate (OP3). Small lot production (FM1) is an important component of many lean manufacturing strategies, as it found to be closely associated with unit cost of manufacturing (OP1), production rate (OP3) and flexibility to change volume (OP6). Lot size directly affects inventory and scheduling, thereby improvising rate of production resulting in reduced per unit product cost. Other effects identified from analysis, are less obvious but equally important. Small lots reduce variability in the system and smooth production. They enhance quality, simplify scheduling, reduce inventory, enable Kanban and encourage continuous improvement. Focusing on single supplier (FM2) has been found to be moderately associated with all performance parameters (OP1-OP5) expected for flexibility to change volume (OP6). A sourcing strategy focusing on a single supplier can have many risk due to demand uncertainty and unexpected unresponsiveness of the supplier. For manufacturing SMEs focusing upon flexibility in manufacturing for competitive success, should avoid dependence on single supplier (FM2) to prevent out-of-stock conditions in case of demand shifts. Secondly, to reduce dependability on single supplier, firms should tend to focus on improving internal production capability by investing in new technology, such that in case of demand surge, they do not have to be reliant on single organization.

The result of correlation analysis indicates that the implementation of waste minimization practices (WM) has been found to have moderate impact ($r = 0.545$) on operational performance (OP). Any initiative intended to move the firms to identify and eliminate wastes within a manufacturing system, establishes a working environment through self-managed project teams and problem-solving groups affecting maintenance prevention improvements on production systems and affecting improvements in the reliability of manufacturing systems. This can be attributed to the potential of lean initiatives in eliminating barriers between various organizational functions, promoting a culture of continuous improvement resulting in reduction of rejections (wastage losses), thereby improving manufacturing capabilities leading to optimization of operational cost and reduction of on time delivery problems. Similar observation has been observed in the correlation matrix in the context of Indian manufacturing SMEs, which highlights that the adoption of elimination of waste core strategies (WM1) is found to have significant level of association with unit cost of manufacturing (OP1) and quick delivery (OP4) performance parameters. Error proofing is a structured approach to ensure quality all the way through manufacturing processes through fact-based problem solving. The focus of error proofing is not on identifying and counting defects. Rather, it is on the elimination of their cause: one or more errors that occur somewhere in the production process. With the use of error-proofing technique (WM2), there is an assurance that the end product will be defect free, resulting in improved quality conformance (OP2) and reduced cost of manufacturing (OP1). Interestingly, the use of pull-based production system (WM3) and removing operational bottlenecks (WM4) is found to have significant and moderate level of association with operational performance parameters being studied. Efficient operations within small business is vital for ensuring firm's market competitiveness and financial gain. Anything that impedes the production flow which threatens firm's profitability, should be identified and minimized to the best of interest. Also, it would be imperative that production is being pulled by the customer rather being pushed by the needs or capabilities of the production systems itself. The result is that right mix of products are manufactured and provided in the exact amount needed and when and where they are needed. Effective management of waste minimization practices can maximize production system efficiency, by removing bottlenecks and adjusting system level planning to quickly respond to customer needs without hurting the existing loaded customer orders.

In order to ascertain differences in means, "two-tailed t-test" has been deployed, for establishing the significant contributions by Indian SMEs adopting lean implementation over significant periods of time, as shown in table 8. The table depicts average and standard deviations of extent of lean implementation and operational performance of manufacturing SMEs at different levels of implementation phase. The significant values of t(III/I) and t(III/II) have clearly demonstrated that mean values of organizational parameters of "lean" group are higher than those of "In-transition lean" and "lean beginners" group. In case of t(II/I), most of organizational parameter except "waste minimization" practices of "In-transition lean" group have shown higher mean values compared to "lean beginners" group. This implies, the extent of waste minimization practices is not effectively adopted by "lean beginners" group and "In-transition lean" group, as during the both early adoption and transition phase, most SMEs are focused upon improving manufacturing processes and adopting maintenance related practices. In summary, significant differences were identified among clusters. As the results demonstrate, "lean" manufacturing SMEs have statistically significant higher level of applications of all lean tools and programs, as compared to "lean beginners" and "In-transition lean" manufacturing SMEs, thereby indicating implementation of lean manufacturing practices over reasonable period of time could be instrumental in promoting efficiency and effectiveness.

[Insert table 8]

4.3 LEAN MANUFACTURING BARRIERS IN INDIAN SMEs

To implement lean manufacturing system is not an easy task. For any change in organization to take hold and success, the impeding factors or barriers need to be identified and understood. Failure to access organizational and individual change readiness may result the management to spend significant time, money and energy (Nordin, Deros, & Wahab, 2010). Dealing with resistance to change requires a lot of risk and hard work (Barker, 1998; Stanleigh, 2008; Nordin, Deros, & Wahab, 2010). To accurately identify the factors impeding lean implementation, a list of 13 impeding factors were included in the survey. Respondents were asked to rate the factors that were considered as barrier to lean implementation in their organization on five-point scale, with 1 referring to 'not challenging at all' and 5 as 'very challenging'. Respondents were also give an option of 'not-applicable'. Since the results of lean tools and techniques shows noticeable differences among different groups, cluster analysis was applied to examine the challenges faced by each group. Table 9 presents the mean values and standard deviations of impeding factors faced during lean implementation, of all respondents divided into different clusters. Those lean impeding factors having mean score higher than 3.0, indicate significant barrier to lean adoption in the manufacturing firms.

[Insert table 9]

The top five challenges faced by first group of SMEs in their early phases of lean implementation include attitude of workmen, inadequate knowledge & lean expertise, lack of budget, lack of senior management commitment and risk of disruption in operations having a respective mean score of 4.08, 3.86, 3.70, 3.57 and 3.51. This group consisted of firms, that have used limited lean in their practices. Dealing with such initial obstacles are common to most newly adopting small manufacturers are they are likely to struggle with financial, technical and time constraints. Similarly, for the second group of SMEs in transition phase of lean implementation, the top five challenges faced include attitude of workmen, lack of budget, internal resistance, inadequate knowledge and lean expertise and organizational cultural changes having a respective mean score of 3.92, 3.69, 3.44, 3.31 and 3.22. This is the period during which lean improvement drive get stabilized, but more investment and efforts are made to overcome the initial resistance and to orient organization as per requirement of lean approaches.

For the lean firms, the major challenges to lean implementation include attitude of workmen, backsliding to old ways of working, internal resistance, need of integration with business associates and lack of resources having a respective mean score of 3.52, 3.35, 3.31, 3.27 and 3.25. Over a long period of time, when the manufacturing firms start realizing the benefits of lean implementation with entrenched network externalities barriers and shop floor resistance, the management should focus upon alignment of management initiatives and organizational changes, and make efforts to facilitate better communication and co-operation between all functional departments.

One of the major difference in the Japanese and the Indian industrial societies is the extent of literacy and education of workmen (Mathur, Mittal, & Dangayach, 2012). The Indian industry is different in its character compared to the western and Japanese industry, from where the lean philosophy has originated. Most of the Indian SMEs employ people with low skill levels, and they do not foster the ideology of skill enhancement (Achanga, Shehab, Roy, & Nelder, 2006). Therefore, attitude of workmen is identified as the one of major barriers in the implementation of lean across all clustered groups. Most of lean tools and techniques are based on collection and analysis of data. A basic knowledge of mathematics and statistics is needed to effectively use any of these techniques. This make the adoption of these technique in Indian small and medium manufacturing industries very tricky and impractical (Mathur, Mittal, & Dangayach, 2012). The ability of people to respond and adapt is critical when they face any change in situation (Nordin, Deros, & Wahab, 2010). It is quite natural to encounter resistance from employees, when introducing new lean strategies into any organization, due to thoughts that these new strategies could endangered their job opportunities and poor performance may result in losing their jobs. Such thoughtful threats of insecurities among employees results in resistance to change and adopt innovative practices. Also, reverting to old ways of working may be due to the reason that lean initiatives need addition work and responsibilities, hence employees could resist these changes, even after considerable phases of lean adoption. Lack of lean understanding among workmen is the primary hurdle, which firms can overcome through providing good level of education and proper training regarding benefits of lean practices. Recognition and rewards will serve as incentive and motivation for employee participation and continuous improvement (Govindarajulu & Daily, 2004). But in most cases, actual implementation of such ideas for SMEs is not realized due to financial inadequacy.

Interestingly, "lean beginners" and "in-transition lean" firms recognize inadequate knowledge and expertise as one of the major challenges, as compared to "lean" firms where adoption and dissemination of lean practices is relatively higher. This is because lean manufacturing requires new knowledge and cultural change during both early adoption and transition phase (Nordin, Deros, & Wahab, 2010). Also, significant culture change appears as one of the top challenges in the transition phase, as new practice adoption by the workers are not simple to set up and this is particularly true in labor contexts such as those of developing countries where workers are frequently treated unfairly (Panizzolo, Garengo, Sharma, & Gore, 2012). These results imply that lean concepts and philosophy fundamentally transform's a firm operation, which lead to shocking changes in organization's culture (Zhou, 2012) during the both early adoption and transition phase. As firms are engaged in new adoption of shop floor practices, many senior management personnel do fear that these may lead to disruption in operations resulting in financial and market share loss. Also, senior management people do also feel that investing in lean will increase the cost of production, which they cannot afford to do when facing stiff challenges from its competitor. Lean implementation seems to act as a grassroots effort, and it becomes incumbent upon the internal champion to educate and motivate the senior leadership to adopt lean (Panizzolo, Garengo, Sharma, & Gore, 2012) by citing examples of some Indian companies that have reduced their production cost significantly and enhanced their bottom-line results using the application of lean principles. Ample supports and active involvement ranging from upper management to individual employees is crucial to the success of lean implementation (Zhou, 2012). The creation of a supportive organizational culture is an essential platform for the implementation of lean manufacturing. High-performing companies are those with a culture of sustainable and proactive improvement (Achanga, Shehab, Roy, & Nelder, 2006).

After a considerable level of lean implementation, lack of resources was also identified as one of the impeding factors. Lack of resources cover many aspects such as infrastructural resources, human resources, financial resources, time etc. Financial capacity is a crucial factor in the determination of any successful project. During the early adoption phase and transition phase, it is observed that SMEs lack financial capacity to implement lean production practices, which has surprisingly dropped to much lower rank in "lean" group firms. This is due to fact that the benefits accrued through continuous lean efforts over a reasonable period of time, provide financial avenues, which result in improved financial capacity in a long run.

As the firms become stable and more knowledgeable in the field of lean implementation, they tend to apply more advance lean tools that tends to expand and go beyond the four walls of individual company and is practices in a wider scope involving supply chain partners, such as suppliers, distributors and customers (Zhou, 2012). Interestingly, the need to integrate with other organization is one of the major challenges the "lean" group faces, while it was ranked lower in the other two groups. Rather, a lean supply chain enables a better understanding of the components, dependencies, and risks which enable improved management of material, financial and information flows (Zhou, 2012). Firms do face difficulty in implementation lean tools that concerns convincing external business associates to integration lean into business process (Nordin, Deros, & Wahab, 2010; Panizzolo, Garengo, Sharma, & Gore, 2012). Lean integration is a long-term strategy for improving data quality and organizational processes, that helps the manufacturing firm to identify opportunities to improve business process and performance in constantly changing environment. The reasons for these revelations in this section needs to be examined further by conducting qualitative study in form of case study or action research.

5. CONCLUSIONS

SMEs are commonly recognized as being critical to the health of global economy. The current economic environment in the Indian manufacturing industry is offering a perfect opportunity to SMEs of this country to develop and grow by acting as suppliers of large multinational original equipment manufacturers(OEMs). Given the importance of SMEs, it can be assumed that the rapid adoption of lean practices by SMEs has become an important determinant of success in the global market place. SMEs must be benchmarked with the best in industry practices for continuous improvement (Jain, Bhatti, & Singh, 2015). "Cost reduction without compromising on quality" should be the motto of every manufacturing SMEs, to survive in this competitive global economy. To prosper in today's economic environment, any manufacturing firm must be dedicated to never-ending improvement, and more efficient ways to obtain products or services that consistently meet customer's need. Lean implementation practices can be categorized as roadmap, conceptual/implementation framework, descriptive and assessment checklist initiatives by the manufacturing firms (Mostafa, Dumrak, & Soltan, 2013) to pursue operational excellence and gain a competitive advantage over their competitors.

Evidence from study suggest that implementing lean in small and medium manufacturing firms is by no means an easy task, which is heavily burdened by several internal and external organizational barriers. In addition to identification of the major barriers of implementation of lean manufacturing in Indian SMEs, the paper also investigated the effect of lean manufacturing implementation on Indian SMEs performance. The result provides insights into the extent of lean manufacturing implementation in SMEs in Indian context and provides further evidences that lean practices are significant in enhancing operational performance. The results show that all the three lean constructs are significantly related to operational performance. Both process improvement and waste minimization construct show high level of significance, whereas flow management have shown moderate level of significance with operational performance. One possible reason could be that, 'process improvement' and 'waste minimization' lean implementation in SMEs require less capital investment, and are focused upon hard core maintenance and quality improvement techniques, that optimizes equipment effectiveness, eliminates breakdown and integrates the capabilities of workforce for continuous improvement of production parameters to attain excellence. There is no doubt about the similar relevance of flow management practices which has moderate level of association with operational performance parameters. The reason could be the lack of strategy for integration of information technology and traditional manufacturing process such as MRP (Material Requirement Planning), MRP II (Manufacturing Resource Planning) and ERP (Enterprise Resource Planning), which are extensively used by large scale manufacturers. Nevertheless, the adoption of these system could lead to high production cost as a result of heavy investment in the IT infrastructure, internal training and after-sale service, which is unaffordable to most SMEs. Lean manufacturing implementation requires time, money, energy and full company commitment. The use of rigorous 5S and preventative maintenance appears to be a widespread practice among Indian SMEs. Due to limited resources, it is not possible to apply all lean tools and techniques at one time.

Equally crucial to this study, is also the outcome derived from the analysis of the behavior pattern of certain characteristics of the investigated SMEs. A particular role is recognized to top management commitment, which is instrumental in creating a performance culture to encourage participation and performance of employees. Lack of skill and knowledge on lean practices will cause misapplication, as a result it will fail to deliver expected results and benefits. Securing the full benefits of lean manufacturing requires the organization to concentrate on the entire value chain by specific lean comprehensive tools, wherever applicable and necessary. The evidences of the study can encourage senior managers and entrepreneurs in process of understanding, how lean principles can be practically applied in their business. Further evidence needs to be provided through case studies from developing economies on how effectively lean practices are being adopted and implemented in SMES, particularly in the case of adopting new technologies and dealing with workmen attitude.

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TABLE 1 LEAN MANUFACTURING PRACTICES IN SMES: A LITERATURE REVIEW OF PRACTICES OVER PREVIOUS TWO DECADES

AUTHOR(S) AND YEAR	**LEAN PRACTICES**															
	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**	**N**	**O**	**P**
Filho et al. (2016)		*	*		*	*	*		*	*				*		
Thanki et al. (2016)	*	*	*	*	*	*					*	*				
Manfredsson (2016)			*			*	*		*			*				
Hu et al. (2015)	*	*	*	*	*	*		*	*	*	*	*	*	*	*	
Jain et al. (2015)	*				*		*									
Saboo et al. (2014)		*		*		*	*		*			*				*
Kumar et al. (2014)	*	*						*		*	*	*	*			*
Powell et al. (2013)				*		*		*						*		
Mathur et al (2012)		*														
Timan et al. (2012)	*	*	*		*	*			*		*	*	*	*	*	*
Zhou (2012)	*	*	*	*	*	*			*	*	*				*	*
Panizzolo et al. (2012)	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Singh & Khanduja (2010)	*	*														*
Anand & Kodali (2009)										*	*			*	*	*
Singh et al. (2008)					*											
Chandandeep (2008)												*				
Real et al. (2007)	*								*	*					*	
Bonavia & Marin (2006)		*		*	*		*				*		*		*	
Kumar et al. (2006)	*	*	*	*	*	*		*	*	*	*	*	*		*	*
Achange et al. (2006)							*									
Hawkins (2001)	*		*			*		*		*	*			*	*	
Gunasekaran et al. (2000)	*												*			
Gunasekaran & Cecille (1998)	*	*	*	*		*	*		*							
Lee (1997)	*	*		*		*	*			*			*			

A – 5S (Workplace Organization); **B** – SMED/Setup time reduction; **C** – Visual Control; **D** – Cellular Layout; **E** – Total productive maintenance; **F** – Kanban (Pull production); **G** – Employee training & teamwork; **H** – Heinjunka (Leveling the workload) ; **I** – Continuous flow; **J** – Lot size reduction; **K** – Kaizen; **L** – Value Stream Mapping; **M** – Quality management programs; **N** – Jidoka (Automation); **O** – Standardized Work/Process; **P** – Poka yoke (mistake proofing)

TABLE 2 EXAMPLES OF APPLICATION OF LEAN PRACTICES IN INDIAN MANUFACTURING SMES

AUTHOR(S) AND YEAR	LEAN PRACTICES	INDUSTRY TYPE IN INDIA	IMPACT ON MEASURES
Thanki et al. (2016)	1. Total productive maintenance 2. Work Standardization (5S) 3. Kanban 4. Kaizen 5. SMED 6. Visual Control 7. Value Stream Mapping (VSM) 8. Cellular layout 9. Green Manufacturing	▪ Indian Manufacturing SMEs	▪ Quality ▪ Cost & Productivity ▪ Lead-time ▪ Product design ▪ Firm's Profitability ▪ Brand value ▪ Market position ▪ Customer satisfaction
Jain et al. (2015)	1. Total productive maintenance 2. Work Standardization (5S) 3. Employee training	▪ Irrigation pipe manufacturing	▪ Overall equipment effectiveness ▪ Machine availability ▪ Quality rate ▪ Cycle time
Saboo et al. (2014)	1. VSM 2. Kanban 3. SMED 4. Cellular layout 5. Poka Yoke 6. Training 7. Continuous Flow	▪ Sheet metal and plastic injection molding components	▪ Production lead time ▪ Inventory ▪ Changeover time ▪ Cycle time
Panizzolo et al. (2012)	1. Lean manufacturing (as overall approach)	▪ Surgical disposable needles and syringes ▪ Bearing balls ▪ Iron Handicraft ▪ Automotive brakes and clutches	▪ Overall equipment effectiveness ▪ Overall Plant Efficiency ▪ Upstream value stream performance ▪ Downstream value stream performance
Singh & Khanduja (2010)	1. SMED 2. 5S 3. Poka Yoke 4. Cycle time reduction	▪ Foundry (Metal Casting)	▪ Financial measures
Kumar et al. (2006)	1. Lean manufacturing (as overall approach)	▪ Metal Die-casting Manufacturing unit	▪ Machine downtime ▪ Employee's Confidence ▪ Overall Equipment Effectiveness ▪ Overall Plant Efficiency ▪ Customer satisfaction ▪ Machine set-up time ▪ Number of Accidents at workplace ▪ Financial Measures

TABLE 3 FACTORS IMPEDING LEAN IMPLEMENTATION IN SMES

Challenges/impeding factors	**Supporting Literature**									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Inadequate knowledge and Lean expertise		*	*		*	*	*	*	*	*
Lack of senior management commitment		*		*	*		*	*	*	*
Organizational culture		*			*	*				*
Inability to quantify benefits		*		*						*
Backsliding to old ways of working										*
Lack of resources			*	*	*			*	*	*
Attitude of workmen	*	*			*				*	
Internal Resistance	*		*	*	*		*		*	*
Risk of disruption in operations	*				*			*		*
Lack of budget	*		*			*		*	*	
Lack of clarity across functional groups						*			*	
Poor training				*	*		*		*	
Need of integration with business associates					*				*	*
1 – Kumar et al.(2006); **2** – Nordin et al. (2010); **3** – Ottar et al. (2011); **4** – Timans et al. (2012); **5** – Panizzolo (2012); **6** – Mathur et al. (2012); **7** – Aspinwall & Elgharib(2013); **8** – Kumar et al. (2014); **9** – Hu et al. (2015), **10** – Zhou (2016)										

TABLE 4 RESPONDENT PROFILE

Sample characteristic	Classifications	Total	Percent	Sample characteristic	Classifications	Total	Percent
Respondent position	President/ COO/Director	24	19.8	**Respondent's years of experience with firm**	0–3 years	10	8.3
	Quality manager	29	23.9		4–9 years	27	22.3
	Production manager	42	34.7		10 –15 years	26	21.5
	Lean specialist	6	5.0		16 –20 years	26	21.5
	Others	20	16.6		21–48 years	32	26.4
Firm employees	< 50	37	30.5	**Firm sales (In Indian Rupees)**	< 25 lakhs	12	10.0
	50 –100	26	21.5		25 –100 Lakhs	29	23.9
	101–150	29	23.9		1– 5 Crores	57	47.1
	151–200	8	6.7		5–10 Crores	13	10.7
	> 200	21	17.4		> 10 Crores	10	8.3
Area of industry	Automotive	10	8.3	**Ownership type of Firm**	100 % local	77	63.6
	Electronics parts	21	17.4		100 % foreign	15	12.5
	Electrical parts	15	12.5		Joint Venture	29	23.9
	Chemical	12	10.0	**Number of Operating locations of Firm**	1 – 3	58	47.9
	Packaging	5	4.1		4 – 6	49	40.5
	Food	14	11.6		7 and above	14	11.6
	Polymer products	11	9.0	**Years of Lean Implementation**	< 3 years	37	30.5
	Metal components	8	6.7		3 – 6 years	36	29.8
	Building components	6	5.0		> 6 years	48	39.7
	Industrial equipment	16	13.2	**Quality management system certification**	No certification	47	38.8
	Others	3	2.5		ISO 9001/14001	74	61.2

TABLE 5 RELIABILITY AND VALIDITY RESULTS OF LEAN ASSESSMENT TOOL

Construct	Items	Total Variance explained (%)	Cronbach's alpha	KMO
Process Improvement (PI)	PI1: Reduction of inventory	47.23	0.77	0.82
	PI2: Preventive maintenance			
	PI3: Cycle time reduction			
	PI4: Use of new process technology			
	PI5: Use of quick change-over techniques			
	PI6: Reducing set-up times			
Flow Management (FM)	FM1: Reducing production lot size	57.89	0.76	0.75
	FM2: Focusing on single supplier			
	FM3: Continuous/one piece flow			
Waste Minimization (WM)	WM1: Eliminate waste	63.01	0.71	0.67
	WM2: Use of error proofing techniques (Pokeyoke)			
	WM3: Using pull-based production system (Kanban)			
	WM4: Removing bottlenecks			
Operational Performance (OP)	OP1: Unit cost of manufacturing	43.86	0.74	0.80
	OP2: Quality conformance			
	OP3: Production rate			
	OP4: Quick delivery			
	OP5: Flexibility to change product mix			
	OP6: Flexibility to change volume			

TABLE 6 LEAN TOOLS AND TECHNIQUES APPLIED IN INDIAN SMES

Tools and techniques	No/Little Lean n = 37				In-Transition Lean n = 36				Lean n = 48			
	Rank	Mean	S. D	Unfamiliar (% Respondent)	Rank	Mean	S. D	Unfamiliar (% Respondent)	Rank	Mean	S. D	Unfamiliar (% Respondent)
Kaizen (continuous improvement)	5	3.22	1.24	10.81	3	3.84	1.46	2.77	4	3.81	1.23	2.08
Quality Function Deployment	12	2.42	1.32	13.51	14	2.62	1.38	22.22	11	3.29	1.22	8.33
SMED (Setup time reduction)	6	3.00	1.10	8.10	5	3.68	1.38	8.33	3	3.90	0.90	0
Continuous flow	9	2.67	1.26	16.21	15	2.43	1.01	19.44	14	3.13	1.33	6.25
Total Productive maintenance	1	3.94	1.12	0	2	3.92	1.44	0	2	4.04	1.25	0
Cellular layout	8	2.94	0.89	18.91	8	3.24	1.36	8.33	10	3.40	0.74	0
5S (Workplace Organization)	2	3.81	1.04	0	1	3.95	0.97	0	1	4.17	1.02	0
Lot Size Reduction	4	3.50	1.38	5.40	11	3.08	1.23	5.55	12	3.25	1.16	4.17
Standardized Work/Process	7	2.97	1.28	10.81	13	2.76	1.42	16.67	13	3.17	1.21	4.17
Poka Yoke (Mistake Proofing)	14	2.22	1.33	37.83	10	3.11	1.07	8.33	8	3.54	1.03	6.25
Kanban (Pull system)	11	2.53	1.30	24.32	9	3.19	0.94	5.55	15	3.04	1.23	8.33
Employee Training & Team work	10	2.58	1.48	27.02	7	3.35	1.51	2.77	9	3.48	1.01	2.08
VSM (Value Stream Mapping)	13	2.25	1.18	21.62	6	3.41	1.42	5.55	6	3.71	1.09	4.17
Jidoka (Automation)	16	2.08	1.27	32.43	12	2.89	1.10	13.88	7	3.63	1.28	12.50
Visual Control	3	3.69	1.43	5.40	4	3.81	1.15	5.55	5	3.73	1.32	2.08
Heinjunka (Leveling the workload)	15	2.14	1.15	27.02	16	2.38	1.23	33.33	16	2.96	1.34	10.41

TABLE 7 CORRELATION MATRIX OF OBSERVED MEASURES

LEAN MANUFACTURING		OPERATIONAL PERFORMANCE PARAMETERS						
CONTRUCT	CONTRUCT PARAMETER	**OP1** Unit Cost of Manufacturing	**OP2** Quality Conformance	**OP3** Production rate	**OP4** Quick delivery	**OP5** Flexibility to change product mix	**OP6** Flexibility to change volume	**OPERATIONAL PERFORMANCE (OP)**
PROCESS IMPROVEMENT (PI)	**PI1** Reduction of inventory	0.301**	0.167	0.074	0.239**	0.246**	0.279**	0.594**
	PI2 Preventive maintenance	0.371**	0.357**	0.207*	0.355**	0.174	0.232*	
	PI3 Cycle time reduction	0.218*	0.317**	0.384**	0.264**	0.210*	0.268**	
	PI4 Use of new process technology	0.304**	0.287**	0.243**	0.346**	0.311**	0.221*	
	PI5 Use of quick change-over techniques	0.366**	0.313**	0.038	0.307**	0.206*	0.201*	
	PI6 Reducing set-up times	0.363**	0.394**	0.260**	0.347**	0.253**	0.326**	
FLOW MANAGEMENT (FM)	**FM1** Reducing production lot-size	0.342**	0.190*	0.367**	0.187*	0.136	0.334**	0.477**
	FM2 Focusing on single supplier	0.248**	0.243**	0.271**	0.230*	0.223*	0.163	
	FM3 Continuous/one piece flow	0.404**	0.222*	0.359**	0.167	0.255**	0.204*	
WASTE MINIMIZATION (WM)	**WM1** Eliminate waste	0.351**	0.227*	0.216*	0.303**	0.212*	0.288*	0.545**
	WM2 Use of error proofing techniques	0.330**	0.370**	0.273**	0.217*	0.237**	0.203*	
	WM3 Use of pull-based production system	0.320**	0.261**	0.310**	0.316**	0.249**	0.289**	
	WM4 Removing bottlenecks	0.268**	0.249**	0.300**	0.260**	0.294**	0.256**	

** Correlation is significant at the 0.01 level (two-tailed)

* Correlation is significant at the 0.05 level (two-tailed)

TABLE 8 RESULTS OF TWO-TAILED "T" TEST FOR ORGANIZATIONAL PARAMETERS

Parameters	No/Little Lean (I) n = 37		In-Transition Lean (II) n = 36		Lean (III) n = 48		"t" test (Two-tailed) α = 0.05		
	Mean	SD	Mean	SD	Mean	SD	t(II/I)	t(III/I)	t(III/II)
PI	3.04	0.44	3.16	0.48	3.65	0.50	1.12*	5.90*	4.51*
FM	3.03	0.43	3.14	0.68	3.83	0.64	0.84*	6.57*	4.74*
WM	3.25	0.38	3.27	0.62	4.02	0.59	0.17	6.86*	5.62*
OP	3.06	0.47	3.14	0.44	3.64	0.42	0.80*	6.00*	5.28*

* t-value obtained > t critical at α = 0.05 (two tailed)

TABLE 9 CHALLENGES OF LEAN IMPLEMENTATION FACED IN INDIAN SMES

Challenges to Lean implementation	**No/Little Lean n = 37**				**In-Transition Lean n = 36**				**Lean n = 48**			
	Rank	Mean	S. D	Not Applicable (% Respondent)	Rank	Mean	S. D	Not Applicable (% Respondent)	Rank	Mean	S. D	Not Applicable (% Respondent)
Inadequate knowledge and Lean expertise	2	3.86	1.21	8.10	4	3.31	1.28	5.55	7	3.19	1.25	2.08
Lack of senior management commitment	4	3.57	0.93	10.81	9	2.89	1.37	16.67	8	3.04	1.11	6.25
Organizational cultural changes	9	2.92	1.30	10.81	5	3.22	1.07	11.11	9	3.02	1.38	14.58
Inability to quantify benefits	8	2.97	1.28	13.51	7	3.08	1.30	5.55	13	2.48	1.34	18.75
Backsliding to old ways of working	10	2.84	1.26	16.21	8	2.94	1.12	2.78	2	3.35	1.08	12.50
Lack of resources	6	3.22	1.36	0	10	2.81	1.17	0	5	3.25	1.31	10.41
Attitude of workmen	1	4.08	1.16	0	1	3.92	1.20	0	1	3.52	1.50	0
Internal Resistance	7	3.05	1.45	2.70	3	3.44	1.52	8.33	3	3.31	1.13	6.25
Risk of disruption in operations	5	3.51	1.15	5.40	11	2.69	1.24	11.11	12	2.69	1.36	4.16
Lack of budget	3	3.70	1.27	0	2	3.69	1.47	0	10	2.92	1.22	10.41
Lack of clarity across functional groups	11	2.70	1.02	8.10	6	3.11	1.37	5.55	6	3.21	1.29	8.33
Poor training	13	2.62	1.21	8.10	13	2.47	1.11	0	11	2.90	1.15	16.67
Need of integration with business associates	12	2.41	1.09	21.62	12	2.56	1.32	13.89	4	3.27	1.14	6.25