Lean Manufacturing and Organizational Performance: A systematic Review of the State of the Art Literature

Rohit Sharma*, Anish Sachdeva and Ajay Gupta
Department of Industrial and Production Engineering
Dr B R Ambedkar National Institute of Technology
Jalandhar, Punjab, India.
*vasudeva_rohit@yahoo.co.in

Abstract

Lean manufacturing techniques are nowadays being utilized by diverse sectors of organizations both in manufacturing as well as service sectors so as to enhance their productivity and be competitive globally. It has been established that Lean manufacturing techniques do have a significant impact on sundry aspects of organizational performance. This has been empirically investigated by various researchers. In this paper, an endeavor has been made to systematically compile the work carried out by the researchers in the area of Lean Manufacturing and its impact on Organizational Performance. Moreover, future research aspects in the Lean manufacturing scenario have also been explored.

Key Words - Lean Manufacturing, Just in Time, Organizational Performance.

Introduction

In the past decade due to incrementing ecumenical competition manufacturing as well as service sector companies globally have radically transmuted their manufacturing practices to amend their competitiveness. In pursuing this goal they have adopted a number of advanced techniques, such as just-in-time, total quality management, lean manufacturing, flexible manufacturing systems, process improvement, and design for manufacturability, to denominate a few. The objectives of all these programmes have been to reduce cost, improve quality, reduce cycle time, and increment flexibility on the factory floor (Modarress *et al.,* 2005).

Lean Manufacturing was developed by Toyota Motor Company to address their concrete needs in a restricted market in times of economic trouble. These concepts have been studied and proven to be transferrable and applicable to a wide variety of industries (Duque and Cadavid, 2007). The concept of lean manufacturing was developed for maximizing the resource utilization through minimization of waste, later on lean was formulated in replication to the fluctuating and competitive business environment. Due to rapidly transmuting business environment the organizations are coerced to face challenges and involutions. Any organization whether manufacturing or service oriented to survive may ultimately depend on its competency to systematically and continuously respond to these vicissitudes for enhancing the product value. Consequently value integrating process is obligatory to achieve this perfection; hence implementing a lean manufacturing system is becoming a core competency for any type of organizations to sustain (Sundar *et al.,* 2014). Lean manufacturing or withal kenned as lean production has been one of the most popular paradigms in waste elimination in the manufacturing and service industry. Many firms have cherished the benefits to practice lean manufacturing in order to enhance quality and productivity (Wahab *et al.,* 2013).

Lean manufacturing is gaining popularity as an approach that can achieve consequential performance amelioration in the industry. However, the application of lean manufacturing is not a facile process. To reach the caliber of full implementation of lean manufacturing takes a long time and during that time the continuous improvement must be made (Susilawati *et al.,* 2015). To become and remain competitive, companies must adopt evolving strategies. Lean Manufacturing is one such strategy utilized in several industrial companies. It is predicated on the identification and elimination of waste in sundry production processes (Verrier *et al.*, 2014). Moreover, manufacturing firms operating in rapidly transmuting and highly competitive markets have embraced the continuous process improvement mindset. They have worked to ameliorate quality, flexibility, and customer replication time utilizing the principles of Lean mentally conceiving. To reach its potential, lean must be adopted as a holistic business strategy, rather than an activity isolated in operations. The lean enterprise calls for the integration of lean practices across operations and other business functions (Rosemary R. Fullerton, 2014).

The "lean" approach has been applied more frequently in discrete manufacturing than in the continuous/process sector, mainly because of several perceived barriers in the latter environment that have caused managers to be reluctant to make the required commitment (Fawaz and Rajgopal, 2007). The purport of lean approach is to promote continuous improvement culture within a business. Categorically, lean approach describes a work philosophy already utilized by many manufacturers. Lean approach considers the expenditure of resources, for any goal other than the production of value for the terminus customer to be wasteful (Brasco *et al.*, 2014). Incrementing ecumenical competition is coercing manufacturing organizations to transform their manufacturing pattern from mass manufacturing to lean manufacturing. Lean manufacturing is fixated on the elimination of waste there by enabling cost reduction (Vinodh and Chintha, 2011; Vinodh and Balaji, 2011).

Lean manufacturing involves a variety of principles and techniques, all of which have the same ultimate goal: to eliminate waste and non-value- added activities at every production or service process in order to give the most gratification to the customer (Hodge *et al.*, 2011). Due to the prosperity of lean manufacturing, many companies are fascinated with implementing a lean production system. Lean manufacturing techniques include the leveled production, pull mechanism (Kanban), take time etc. These principles have mainly been applied in high volume flow shop environments where orders move through the production system in one direction in a constrained number of identifiable routing sequences (Slomp, *et al.*, 2009). Some of the important lean manufacturing tools and techniques have been summarized in the next sub section.

1.1 Tools and Techniques of Lean manufacturing

The successful use of lean manufacturing (LM) practices requires more than the use of tools. Although manufacturing facilities worldwide use LM practices, dimensions of a nation's culture may moderate LM's effect on operating performance (Kull *et al.*, 2014). Some of the important tools with regards to research being carried out have been discussed briefly here.

Lean manufacturing has been the buzzword in the area of manufacturing for past few years especially in Japan. The Kanban system is one of the manufacturing strategies for lean production with minimal inventory and reduced costs. However, the Kanban system is not being implemented widely by manufacturing companies (Rahman *et al.*, 2013).

Value Stream Mapping (VSM) is one of the key lean tools used to identify the opportunities for various lean techniques. Value stream mapping (VSM) is a valuable tool for describing the manufacturing state, especially for distinguishing between those activities that add value and those that do not. It can help in eliminating non-value activities and reducing the work in process (WIP) and thereby increase the service level (Taho Yang *et al.*, 2014). Since the development of the original value stream mapping (VSM) by Taichi Ohno at Toyota, a number of authors have suggested several additional VSM tools to understand and improve the value stream through waste reduction. (Ramesh and Kodali, 2012). The contrast of the before and after the Lean Production initiatives is to determine managers potential benefits such as reduced production lead-time and lower work-in-process inventory. As VSM involves in all of the process steps, both value added and non-value added, are analyzed and using VSM as a visual tool to help see the hidden waste and sources of waste. A Current State Map is drawn to document how things actually operated on the production floor. Then, a Future State Map is developed to design a lean process flow through the elimination of the root causes of waste and through process improvements. An Implementation Plan then outline details of the steps needed to support the Lean Production objectives (Rahani and Ashraf, 2012). Moreover, Value stream mapping (VSM) has become a popular implementation method for Lean manufacturing in recent years. However, its limitations such as being time-consuming, its inability to detail dynamic behavior of production processes and to encompass their complexity, have spurred to turn to simulation. (Liana and Landeghem, 2007).

The ideas of Group Technology and Cellular Manufacturing have been a research topic for decades. Although widely implemented in assembly, the principles of flow production as central element of Lean Production have not often been transferred successfully to machining areas yet. In times of continuously rising hardware complexity Cellular Manufacturing is an alternative approach to enable both, flow production and volume flexibility in machining (Metternich *et al.,* 2013). Further, Cellular Manufacturing has been proven to be an economic and efficient lean approach bringing flexibility into machining areas (Seifermann *et al.,* 2014).

In lean manufacturing environments, cross-training is often used to achieve multi-skilling in order to increase flexibility in meeting fluctuating demand, to create a shared sense of responsibility, and to balance workload between cross-trained workers (Thomas McDonald *et al.,* 2009). Furthermore, Lean manufacturing has been mandated by higher level management as a tool to be used in waste reduction. (Green *et al.,* 2010). Lean strategies have been developed to eliminate or reduce waste and thus improve operational efficiency in a manufacturing environment. (Amin and Karim, 2013). Lean operations are characterized by the elimination of obvious wastes occurring in the manufacturing process, thereby facilitating cost reduction (Vinodh and Chintha, 2011; Vinodh and. Balaji, 2011). Lean manufacturing methodology has been implemented in both manufacturing as well as service sector nowadays. Some idea about its implementation in the industries in India and barriers to its implementation has been discussed in the following sub sections.

1.2 Lean Manufacturing in Industries

Traditionally, the lean paradigm has been applied to discrete manufacturing of items that can be facilely put together and taken apart. The process industry, on the other hand, transforms raw materials into cohesive units that are rudimentally coalesced into a final product with components that cannot be disassembled and then reassembled. The current lean literature provides numerous commendable examples of theory and practices of lean principles in discrete manufacturing. However, its application in process industry is inhibited. Furthermore, there is no systematic accounting of the lean literature in this sector, which may have contributed to lesser cognizance in the industry (Panwar *et al.,* 2015). Moreover, to stay competitive, many textile manufacturers have sought to amend their manufacturing processes so that they can more yarely compete with overseas/global manufacturers. It is worth to identify different techniques and principles of lean (Hodge *et al.,* 2011). It was found that lean practices associated with the elimination of waste are consistently utilized for amending manufacturing performance throughout the taxonomy of process industries but practices associated with other lean principles are inconsistently applied (Lyons *et al.,* 2013).

1.3 Lean Manufacturing in India

India is emerging as an incipient manufacturing destination and many companies are seeking ways to increment the value of their products and services by eliminating dispensable processes and wasteful practices from their production systems. The potent lean manufacturing approach that has proved prosperous as an operations model in developed economies, as well as in some sizably voluminous Indian companies, is now increasingly being apperceived by the small and medium-size enterprises (SMEs) (Panizzolo *et al.,* 2012).

1.4 Barriers to Lean Manufacturing

The innate characteristics of aliment industries, such as compulsory quality assurance requisites, low shelf life of pabulum products and the astronomically volatile demand and supply presented barriers to lean manufacturing adoption. In integration, the challenges of 'change' in an SME environment are distinct from those faced by sizably voluminous organizations. The diminutive size of the plant, the traditional setup, and inflexible layout make it arduous to implement lean manufacturing in pabulum-processing SMEs. Many studies have explored lean constructs and tools, while far fewer have explored the crucial element of genuinely implementing these (Dora *et al.*, 2016).

In the next section a brief methodology has been discussed about the collection of the research papers for the review and its descriptive statistics has also been discussed.

2. Descriptive analysis of the Data Base

A total of 55 articles have been compiled with specific selection criteria in this review. These articles all are related to lean manufacturing implementation and its impact upon organizational performance which included both operational as well as business performance parameters (refer table 1 and 2).

2.1 Sources of Data Base

Figure 1 to 5 represents the bifurcation of the articles selected from different journals and conferences. Figure 1 shows the proportion of the articles taken from international journals (84 %) and international conference proceedings (16 %).

Figure 2 shows the number of articles taken from different international journals. The international journals included for the review paper are viz. International Journal of Production Research (IJPR)-; Journal of Manufacturing Systems (JMS) ; Int. J. Production Economics (IJPE); Supply Chain Management: An International Journal (SCMIJ); Journal of Cleaner Production (JCP); Journal of Manufacturing Technology Management (JMTM); Production Planning & Control (PPC); Journal of Operations Management (JOM); International Journal of Advance Manufacturing Technology (IJAMT); Robotics and Computer-Integrated Manufacturing (RCIM) and International Journal of Productivity and Performance Management (IJPPM).

Figure 3 represents the number of articles considered for the review year wise since 2001 till 2016. Figure 4 shows the number of article taken from different data base. The database included Taylor and Francis, Elsevier, Springer, Emerald and Google scholar. Figure 5 represents the number of articles referred from the various international conference proceedings.

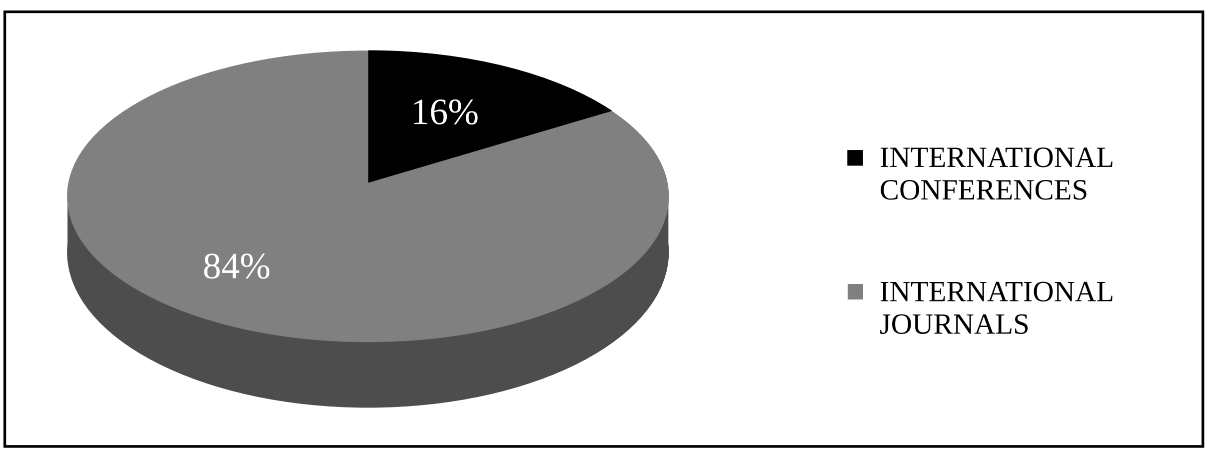

Figure 1: Proportion of the articles taken from international journals and international conference proceedings.

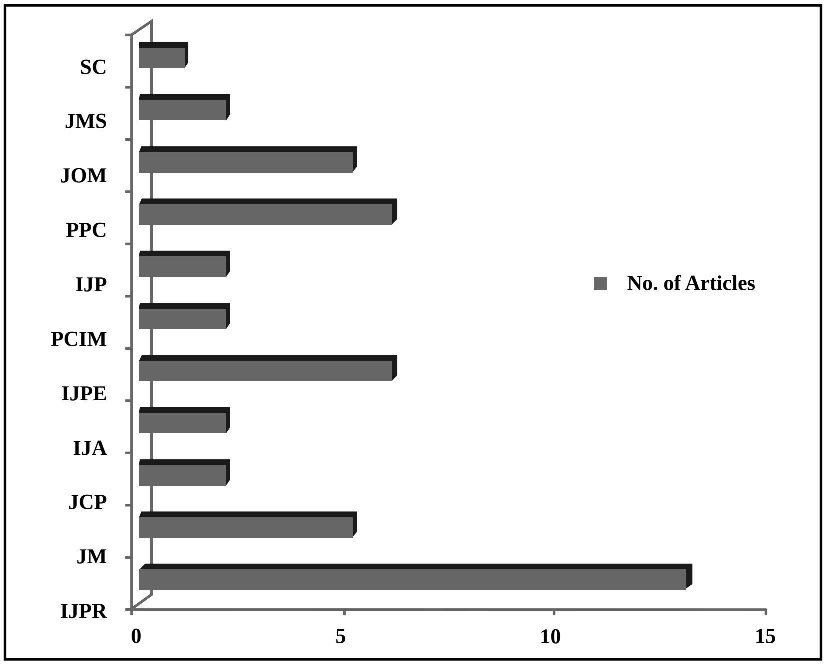

Figure 2: The number of articles taken from different international journals.

Note: IJPR - International Journal of Production Research; JMS - Journal of Manufacturing Systems; IJPE - Int. J. Production Economics; SCMIJ - Supply Chain Management: An International Journal; JCP - Journal of Cleaner Production; JMTM - Journal of Manufacturing Technology Management; PPC - Production Planning & Control; JOM - Journal of Operations Management; IJAMT - Int J Adv Manufacturing Technology; RCIM - Robotics and Computer-Integrated Manufacturing; IJPPM - International Journal of Productivity and Performance Management.

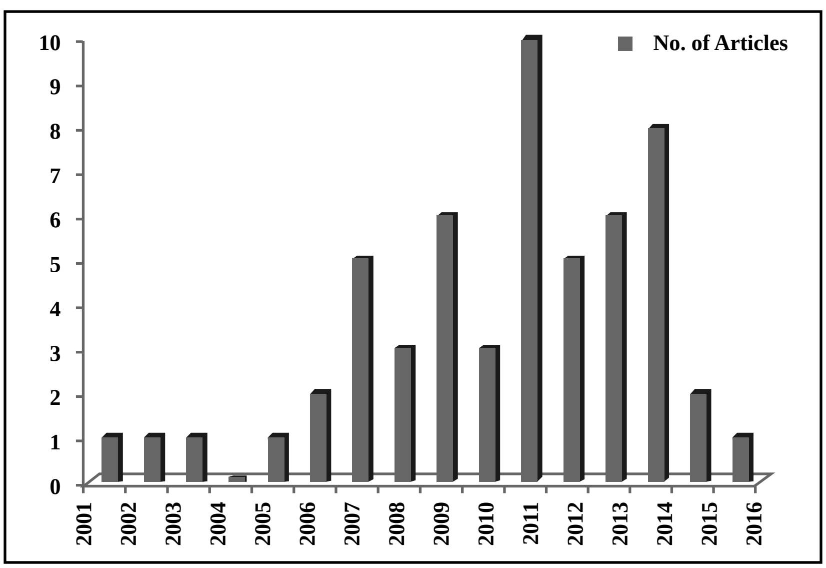

Figure 3: The number of articles considered for the review year wise since 2001 till 2016.

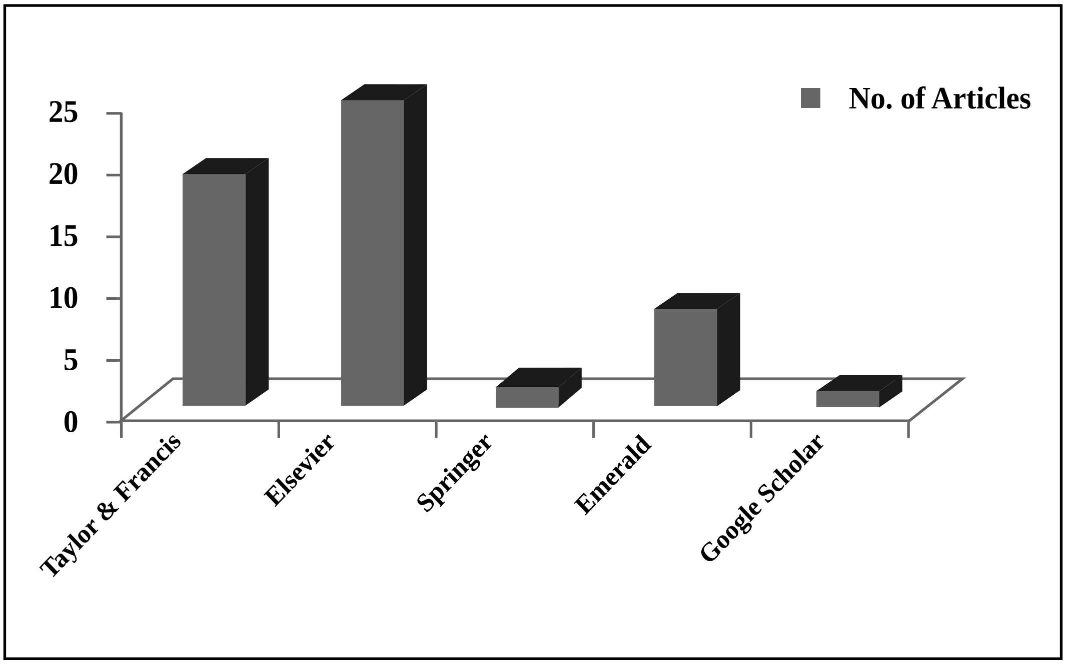

Figure 4: The number of article taken from different data base.

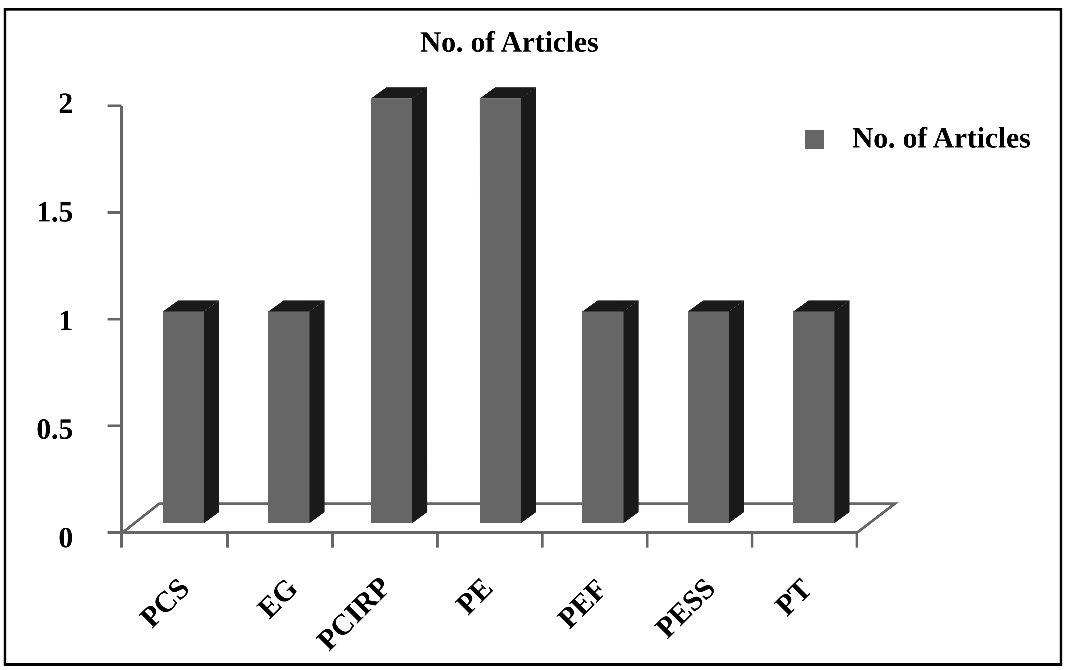

Figure 5: The number of articles referred from the various international conference proceedings.

Note: PCS - Procedia Computer Science; EG - Estudios Gerenciales; PCIRP - Procedia CIRP; PE - Procedia Engineering; PEF - Procedia Economics and Finance; PESS - Proceedings 14th European Simulation Symposium SCS Europe BVBA; PT - Procedia Technology.

3. Lean Manufacturing Techniques and Organizational Performance

After an extensive literature review of the papers on lean tools and performance measures for the last decade, it has been analyzed that the research conducted could be divided in the following three categories. Some authors have discussed lean tools and performance parameters comprehensively (discussed in section 3.1), Other authors used case studies in their research (discussed in section 3.2) and some of the authors used simulation as a tool to study some specific lean tools with their impact on performance (discussed in section 3.3). These are discussed briefly as follows:

3.1 Lean Manufacturing and its impact on Organizational Performance

While discussing the lean manufacturing techniques and its impact on various performance measures, different authors have analyzed different techniques of lean manufacturing with their relationship with various measures of organizational performance. Some authors have considered operational performance (Belekoukias *et al.,* 2014) while others have used business performance as well (Rahman *et al.,* 2010; Gusman Nawanir *et al.,* 2013). In this section some of the vital work done by various authors in the field of lean manufacturing and organizational performance has been considered. Impact of lean manufacturing techniques on operational performance (section 3.1a) and business performance (section 3.1b) as summarized by various researchers has been discussed briefly here.

3.1 (a) Lean manufacturing and its impact on Operational Performance

It is worth to analyze lean manufacturing practices in different industries and to identify the critical factors for its successful implementation. Despite the fact that lean manufacturing has been frequently promoted as a means of improving business competitiveness, little empirical evidence exists in the literature validating its positive link with organizational performance. Lean manufacturing practices not only help in reducing the number of defects but also reduces the cost of production (Vinodh and Joy, 2012). It has been found that lean production principles can be successfully implemented in a high-variety/low-volume context. Implementation of the lean principle can lead to reduction in flow times and an increase in the service level with on-time delivery performance improving from 55 to 80% (Slomp *et al.,* 2009). Moreover, evidence has suggested that lean methods and tools have helped manufacturing organizations to improve their operations and processes. However, the real effect of these methods and tools on contemporary measures of operational performance, i.e. cost, speed, dependability, quality and flexibility, is still unclear (Belekoukias *et al.,* 2014). The lean manufacturing techniques like JIT and autonomation have the strongest impact on operational performance while kaizen, TPM and VSM seem to have a lesser effect on it (Belekoukias *et al.,* 2014).

Shah and Ward (2007) analyzed ten main components of lean manufacturing viz. supplier feedback, supplier JIT, supplier development, customer involvement, Pull, Flow, Setup time, SPC, Employee involvement and TPM. Wee and Wu (2009) in their study of lean supply chain, analyzed lean tools viz. Value Stream Mapping (VSM), PDCA, Root Cause Analysis, JIT/Kanban (Pull system), Error Proofing (Pokayoke) and Total Productive Maintenance (TPM). A case study (Ford Motor Company) was used to analyze these lean tools/techniques and their effects on performance measures viz. quality, cost, lead time. It was found that with the application of these lean tools (standardized operations, level production, operation division, and continuous improvement), value added time increased significantly, whereas non value added time, labor cost, lead time and inventory level got reduced (refer table 1).

On the other hand, Rahman *et al.* (2010) studied the impact of JIT, waste elimination and flow management comprising of 13 lean manufacturing practices on performance parameters. It was found that with the implementation of these lean manufacturing techniques, delivery time and cost of products got reduced, whereas increase in customer satisfaction and overall productivity were also observed.

Demeter and Matyusz (2011) used Lean practices viz. JIT (Kanban Pull, small lot size and JIT delivery), TQM (SPC, Pokayoke and SMED equipment), TPM and HRM (employee motivation and multi-tasking) and contingency factors (production system, order type and product type) together and analyzed their impact on inventory turnover and overall equipment effectiveness (OEE). They also emphasized that TQM and TPM as the two pillars of JIT manufacturing system (refer table 1).

Moreover, Gusman Nawanir *et al.* (2013) found that it is vital to analyze the interrelationship between lean manufacturing techniques and their impact on operational and business performance. It is quite evident from previous research that lean practices should be implemented holistically. The authors utilized Lean Practices viz. Flexible resources, Cellular layouts, Pull system/kanban, Small lot production, Quick setup, Uniform production level, Quality at the source, Total productive maintenance, Supplier networks (i.e. JIT delivery by supplier, supplier development program, and long term agreement with supplier) with their impact upon Operational performance measures (OP) viz. Quality, Inventory minimization, Delivery time, Productivity (i.e. labor productivity and facility/machine productivity), Cost reduction (i.e. unit manufacturing cost and quality cost) and Business performance measures (BP) viz. Profitability (i.e. profit margin and return on investment), Sales and Customer Satisfaction (i.e. delivery lead time, overall quality of products, responsiveness, and product competitive prices). Lean practices have a positive and significant impact on both operational and business performance. Moreover, it was found that operational performance partially mediates the relationship between lean practices and business performance (refer table 1).

3.1 (b) Lean manufacturing and its impact on Business Performance

Hofer *et al*.(2012) concluded that lean production has vital impact on inventory leanness and financial performance of an organization. Inman *et al*. (2011) found that JIT production and JIT purchasing has a significant impact on operational and market performance of organizations (refer table 2). Thomas *et al.* (2009) developed and implemented integrated Lean Six Sigma (LSS) in a minuscule engineering company. Lean was utilized for reducing waste and Six Sigma for ameliorating process efficiency (refer table 2).

Fullerton *et al.* (2003) established consequential statistical relationships between measures of profitability and the degree of concrete JIT practices utilized. The evidence provides empirical support to the premise that firms that implement and maintain JIT manufacturing systems will reap sustainable rewards as quantified by ameliorated financial performance (refer table 2).

Fullerton and McWatters (2001) established that implementing the quality, continuous improvement, and waste reduction practices embodied in the JIT philosophy can boost firm competitiveness. JIT implementation amends performance through lower inventory levels, reduced quality costs, and more preponderant customer responsiveness. Moreover, they confirmed JIT as a vital manufacturing strategy to build and sustain competitive advantage (refer table 2).

Table 1: Research Summary of Lean Tools and its impact on Performance Parameters

Authors (Year)	**Lean tools and techniques**												**Performance Measures**						
	7W	**KZN**	**TPM**	**VSM**	**FP**	**5S**	**SMED**	**KB**	**CM**	**FR**	**QMS**	**SP**	**CR**	**IQ**	**IP**	**CTR**	**IM**	**SU**	**DLT**
Belekoukias *et al.*(2014)	√	√	√	√	√								√	√	√	√			√
Gusman *Et Al.*(2013)			√				√	√	√	√	√	√	√	√	√		√		√

Demeter and Matyusz (2011)	√		√		√		√	√		√						√	√		√
Gurumurthy and Kodali (2011)		√		√	√					√					√	√	√	√	
Behrouzi And Wong (2011)	√											√	√	√		√	√		√
Taj and Morosan (2011)					√				√	√				√		√			√
Rahman*et al.*(2010)	√	√	√		√		√	√				√	√		√				√
Singh and Khanduja (2010)			√			√	√						√		√	√			
Wee and Wu (2009)		√	√	√	√			√					√	√		√	√		√
Thomas *et al.*(2009)	√		√	√		√					√		√	√	√				
Singh and Sharma (2009)				√												√	√		√
Mehmet Cakmakci (2009)							√				√		√	√		√			√
Sahoo *et al.*(2008)				√										√		√	√		
Bhasin (2008)	Lean as a whole													√	√	√	√		√
Shah and Ward	√		√				√	√		√	√	√		√	√	√	√		
Rivera and Chen (2007)	√												√						
Cua, *et* al. (2006)	√		√				√	√		√	√	√	√	√					√
Lian and Van Landeghem (2002)				√				√	√						√		√	√	√

Table 2: Research Summary of Lean Tools and its impact on Performance Parameters

Authors (Year)	Lean tools and techniques												Business Performance Measures			
	7W	KZN	TPM	VSM	FP	5S	SMED	KB	CM	FR	QMS	SP	CR	SALES	PROF	CSAT
Belekoukias *et al.* (2014)	√	√	√	√	√								√			
Gusman *et al.* (2013)			√				√	√	√	√	√	√	√	√	√	√
Hofer *et al.*(2012)			√				√	√		√	√	√		√	√	
Inman *et al.* (2011)	√							√	√	√	√	√		√	√	√
Gurumurthy and Kodali (2011)		√		√	√					√					√	
Behrouzi and Wong (2011)	√											√	√			
Yang *et al.* (2011)	√									√	√			√	√	
Rahman *et al.* (2010)	√	√	√		√		√	√				√	√			√
Singh and Khanduja (2010)			√			√	√						√		√	
Thomas *et al.* (2009)	√		√	√		√					√		√			
Singh and Sharma (2009)				√												√
Sahoo *et al.* (2008)				√												√
Shah and Ward (2007)	√		√				√	√		√	√	√			√	√
Rivera and Chen (2007)	√												√			
Cua *et al.*, (2006)	√		√				√	√		√	√	√	√			

Zhu and Sarkis (2004)	√										√		√			
Fullerton *et al.* (2003)			√				√	√	√	√	√	√		√	√	
Fullerton and McWatters (2001)			√				√	√	√	√	√	√	√		√	

Note: 7W- Seven wastes; KZN- Kaizen; TPM- Total productive maintenance; VSM- Value stream mapping; FP- Fool proofing; 5S- Five S; SMED- Single minute exchange of dies; KB- Kanban; CM- Cellular manufacturing; FR- Flexible resources; QMS- Quality management system; SP- Supplier partnership; CR- Cost reduction; IQ- Improvement in quality; IP- Improvement in productivity; CTR- Cycle time reduction; IM- Inventory minimization; SU- Space utilization; DLT- Delivery lead time; SALES: Sales; PROF: Profitability; CSAT: Customer Satisfaction.

3.2 Lean Manufacturing Techniques and Case Studies

Many researchers used case studies of implementation of some specific lean manufacturing techniques and analyzed their impact on some of the vital measures of organizational performance. In this section, some of the work done by the researchers has been briefly summarized.

Sahoo *et al.* (2008) studied the application of VSM in a forging company and analyzed the impact of VSM on performance parameters viz. forging defects, setup time, work in process (WIP) inventory and lot size. Forging operation variables were optimized to reduce forging defects, setup time, work in process (WIP) inventory and lot size (refer table 1).

Whereas Doolen *et al.* (2008) measured and evaluated the impact of Kaizen on organizational performance. Two Kaizen events were studied in a single organization utilizing both quantitative (survey) and qualitative (interview) data. Results of the two Kaizen events held within almost the same period were compared. Two Kaizen events viz. Tooling Release Kaizen (TRK) and Inspection Kaizen (IK) were analyzed. It was found that TRK although initially was not having a very strong impact yet the effects became very strong with time; whereas in the case of Inspection Kaizen (IK), the effects were very strong initially but the effects could not be sustained for a long period. It was found that there existed no significant difference for IK participants in both attitude and impact on participant measures between time 1 and time 2.

Likewise, Cakmakci Mehmet (2009) in their study used Single Minute Exchange of Dies (SMED) technique for continuous process improvement in an automobile company. Similarly Singh and Sharma (2009) used VSM as a vital Lean manufacturing technique in a case study (railway industry for piston component assembly). From their studies, they concluded that application of VSM results in significant reduction in lead time, process time, work in process (WIP) inventory and manpower requirement (refer table 1).

Singh and Khanduja (2010) on the other hand utilized Lean tools viz. 5 S, SMED and TPM in a foundry (Small and Medium Enterprise, SME). 5S and SMED were used to eliminate unwanted activities, externalize internal activities respectively. Whereas TPM was used to improve overall equipment effectiveness, overall production cycle time, productivity and profitability. The authors also used Pareto analysis, root cause analysis, method study to analyze the existing setup procedures. Moreover, Ishikawa diagram was also utilized in root cause analysis. Setup time was found to be a function of setup labor cost, lost production cost and energy cost (refer table 1).

Gurumurthy and Kodali (2011) utilized VSM with simulation software. Design of Lean Manufacturing system was done by using VSM with simulation in a case study. Lean tools viz. process improvement, layout change, job enlargement and line balancing was used. It was observed that distance travelled by part (raw material to finished good), inventory level, manpower requirement, floor space required and cycle time got reduced; whereas productivity was increased with the utilization of these lean manufacturing techniques (refer table 1).

3.3 Lean Manufacturing Techniques with Simulation and Modelling

Some of the researchers have simulated the models based upon their ideas generated through their industrial experience and case studies. In this section some of the important simulation and modeling done by various authors has been discussed briefly.

Lian and Landeghem (2002) applied VSM with simulation. The authors investigated Lean manufacturing techniques like cellular manufacturing, pull system, one piece flow. Computer aided simulation (Arena software) was used to analyze the impact of VSM on key performance measures viz. throughput, work in process (WIP) inventory, Lead time and space utilization (refer table 1).

Herron and Braiden (2006) described a QFD model which was developed to direct and generate productivity improvement in a group of manufacturing companies. The companies of all sizes including Small and Medium Enterprises (SMEs) and from a cross-section of industries and abilities with regard to manufacturing were considered for analysis. Whereas, Dhafr Nasreddin *et al.,* 2006 developed and presented a methodology for quality improvement in manufacturing organizations. The methodology comprised a model for the identification of various sources of quality defects in the product. The model included an analysis tool in order to calculate defect probability, a statistical measurement of quality and a lean manufacturing tool to prevent the occurrence of defects in a product. The authors used lean manufacturing practices viz. JIDOKA, Process attribute chart (PAC), Defect analysis matrix (DAM) technique and SPC. A process attribute chart was introduced to monitor the defects every hour. Upper and lower control limits were given and an SPC graph was plotted every hour for the three major defects. From a ten weeks study after implementing changes, there was a 9% reduction in defects.

On the other hand, Rivera and Chen (2007) utilized cost time profile (CTP) as a tool for evaluation of improvement achieved by implementation of lean manufacturing techniques. By the term improvement it was meant as reduction in cost time investment (CTI). The authors utilized Lean manufacturing techniques viz. JIT, waiting time reduction, activity cost/time reduction and material cost reduction. It was established that with the implementation of these lean manufacturing techniques, a significant impact on cost reduction has been observed. Reduction of CTI for any production process could be possible with the use of their methodology and model developed. Moreover, they established CTP as a replacement for VSM. VSM is static where as CTP is dynamic (refer table 1).

4. Conclusions and Future Scope

In today's competitive scenario, every organization wants to reduce their product/service cost while ameliorating quality so as to survive in the market. More and more emphasis has been given to increase productivity on perpetual substratum. Lean manufacturing techniques avail to achieve these. Lean manufacturing techniques avail in to ameliorate operational performance of the industries (Gusman *et al.,* 2013; Belekoukias *et al.,* 2014; Rahman *et al.,* 2010; Shah and Ward, 2007) which can lead to enhance the business performance of the companies (Gusman *et al.,* 2013; Belekoukias *et al.,* 2014; Rahman *et al.,* 2010; Yang *et al.,* 2011) as well as. In developing countries like India, the research in this field could prove to be of very much consequentiality for manufacturing as well as service sector.

So, there is a desideratum to study the impact of a comprehensive set of tools/ techniques of lean manufacturing on sundry organizational performance parameters. Similarly, sundry techniques need to be ranked according to their impact on working of organizations. Interrelationship among the various techniques needs to be established in the developing countries like India. There is a desideratum to implement lean techniques in the manufacturing companies of developing countries like India and to study the impact of such application. Very little work has been done on analyzing the comprehensive lean manufacturing techniques with reference to their impact upon organizational performance. Moreover, in Indian context, a very few researchers have empirically investigated the impact of lean manufacturing techniques on organizational performance.

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