

SI: KM ‘The Propagation of Lean Thinking in SMEs’

Abstract:

Small and medium enterprises (SMEs) play a pivotal role in economic growth, industrial output, and employment creation in a country. However, SMEs are often ignored by researchers as far as the adoption of lean is concerned in comparison to large enterprises (LEs). Therefore, the literature regarding lean implementation in SMEs is not conspicuous, and many SMEs have only a limited understanding and awareness of lean. This paper offers a comprehensive literature review with a focus on the implementation of lean in SMEs and explores the applicability of lean thinking in such environments. An attempt is made to provide an analysis of lean practices that have been applied in SMEs and critical success factors for lean transformation in SMEs. It also contributes to the field of lean implementation research by proposing a framework for lean in SMEs and identifies the scope of future research.

Keywords: Lean; Small and medium enterprises (SMEs); Literature review; Production management

1. Introduction

After successful implementation in Toyota, lean was adopted by European and American automobile manufacturers (Womack *et al.* 1990). Subsequently, it was adopted in other industrial sectors such as aerospace (Psychogios and Tsironis 2012; Jurado and Fuentes 2014), construction (Liu *et al.* 2013; Vinodh *et al.* 2014;), fabrication and metal processing (Demeter and Matyusz 2010), food processing (Rashid *et al.* 2010; Dora *et al.* 2015; Vlachos 2015), healthcare (Hicks *et al.* 2016), telecommunication and IT (Psychogios *et al.* 2012), service (Radnor and Johnston 2013) and textiles (Hodge *et al.* 2011). Successful application of lean across industries with diverse characteristics has supported the claim of its proponents that lean is a universal production system (Billesbach 1994; Womack and Jones 1996). Researchers and practitioners (Chaplin *et al.* 2016; Fullerton and Wempe 2009; Shah and Ward 2003) have reported the positive impacts of lean on operational, financial, social and environmental performance, ultimately leading to enhanced customer satisfaction.

Lean as a concept has evolved over time, and will continue to do so (Hines *et al.* 2004). Its application, however, has largely been limited to large enterprises for elimination of waste, improved quality and service, reduced total cost and lead time. The application of lean to SMEs,

till now, remains meagre. This scant application raises questions about its suitability to SMEs. This paper tries to answer this question.

It is believed that SMEs are the backbone of the industrial and economic growth of a nation and also make a significant contribution to employment creation (Singh 2011; Singh *et al.* 2010). SMEs are also recognised as important players in large supply chain networks. Increased competitiveness and thin profit margins demand SMEs to produce goods with high quality, variety, flexibility, faster deliveries and lower cost. Unfortunately, they often suffer from low productivity, poor quality, long product development lead times, high inventory, low flexibility, and ultimately poor organizational performance (Gnanaraj *et al.* 2012; Mathur *et al.* 2012; Thakkar *et al.* 2013; Chaplin *et al.* 2016). Therefore, it is imperative to focus on the improvement of SMEs' performance. Ates *et al.* (2013) suggest that SMEs can no longer survive without using intelligent manufacturing processes and management practices. To gain and sustain a competitive advantage and to deal with other problems, it is essential to apply philosophies such as lean thinking throughout supply chains (Jasti and Kodali 2015). The implementation of lean, however, is a challenging task.

Researchers (Achanga *et al.* 2006; Timans *et al.* 2012; Dora *et al.* 2013; Dora *et al.* 2015; Hu *et al.* 2015) have argued that lean implementation requires good leadership, management skills, knowledge, financial capability and learning skills. As most of SMEs lack these skills (Singh *et al.* 2005; Gnanaraj *et al.* 2012; Mathur *et al.* 2012; Thakkar *et al.* 2013; Chaplin *et al.* 2016). Thus, lean implementation to SMEs is more challenging. Although, enthusiastic outcomes have been gained from some reported implementations; such evidence are in scares. Hence, there is a need for further research (Vinodh *et al.* 2014; Vlachos 2015; Dora *et al.* 2015; Alaskari *et al.* 2016; Manfredsson 2016; Thomas *et al.* 2016). Some SMEs have only implemented lean thinking in a partial fashion (Bamford *et al.* 2015; Chaplin *et al.* 2016) and though a few researchers have focused on lean implementation in SMEs, a framework for its implementation is absent in the literature.

A very few studies dealt with lean thinking in SMEs. We believe that having the extent literature review of lean in SMEs will not only create awareness among the practitioners in SMEs but will also help highlight issues needing further academic research. This paper aims to find out the applicability of lean approach in SMEs and presents various characteristics and challenges for the lean transformation of SMEs. It also contributes to the field of lean

implementation research by proposing a framework for lean in SMEs and identifies the scope of future research.

Followed by the introduction, section 2 throws light on the research methodology used in this study and Section 3 tests the applicability of lean in SMEs, while, various lean practices utilized by SMEs are demonstrated in Section 4. The various lean critical success factors for SMEs are presented in Section 5, and section 6 illustrates the impact of lean on SMEs. Framework for lean in SMEs and future scope of research are discussed in section 7. Finally, this paper is concluded in the last section.

2. Small and Medium Enterprises

There is no unified definition of SMEs across the globe, and different parameters such as size, age, the number of employees, annual turnover, sales, and asset value of the organization are used in different countries. Yet, SMEs play a crucial role in developed countries as well as in developing countries. In Australia, this sector contributed around 60% of Australia's industrial value added in 2009/'10 (Australian Government 2011). According to an estimate, 91% of the formal business entities in South Africa are SMEs and contribute 52–57% of GDP. The United States International Trade Commission (2010) reported that SMEs contributed roughly 50% of US private non-agricultural GDP. In India, this sector produces more than 6,000 products contributes about 8% to GDP and 40% of the total exports (Small and Medium Business Development Chamber of India, 2016).

2.1 Comparison of SMEs and LEs

Although SMEs are unable to emulate with LEs regarding investments and economies of scale, this sector has a strong potential to compete on service and value metrics. SMEs are more adaptable and flexible in satisfying customer needs, which most LEs fail to do (Antony *et al.* 2016). In this section, an attempt is made to compare SMEs and LEs by their characteristic and illustrated in table 1.

The organizational structure of SMEs is typically very simple with very few levels, resulting in high visibility and accessibility of its top management to the lowest level (Carlos 2007; Laufs *et al.* 2016). This promotes quicker communication, quick decision making and swift

implementation of management strategies (Kotey 2005; Hudson-Smith and Smith 2007). However, such positives are often countered by a lack of expertise and limited specialization. On the other hand, LEs have a complex structure with high levels of management. The authorities and responsibilities are distributed at different levels.

Table 1 Comparison of SMEs and LEs

Characteristics	SMEs	LEs
Organisational Structure	Flat with few levels, fast communications, quick decision making	Complex hierarchical structure with large number of levels, distributed powers and responsibilities
Organisational Culture and Human Resources	Job insecurity, low trust, poor communication system, lack of expertise, inadequate employees' learning and training, Fewer employees-better relationships, high authority and responsibility, high encouragement of individual creativity	High specialisation and experience, superior communication systems, excellent training facilities, high degree of innovation
Standard and formalized systems	Lower degree of standardisation and formalisation, informal and simple production planning & control, flexible procedures	Standardise and formalised systems, generally rigid procedure, lower variability in production
External links	Limited external contacts, close contacts, easily accessible, able to quick response to partners	Global partners, large customer base, extensive after sale services, long term relationship
Business orientation	Short term orientation, low risk taking ability	Long term orientation, high risk taking ability
Resources	Lack of financial resources and skilled manpower	Economy of scale and high capital investment

Traditionally, SMEs utilize simple operational planning and control systems, and their operations and activities are not governed by formal rules (Ates and Bititci 2011; O'Reilly *et al.* 2015). This simplicity and informality provide flexibility (Hudson-Smith and Smith 2007) and fast response to customers (Towers and Burnes 2008) but can also lead to high variability

and a lack of systematic procedures. Further, LEs adopt standardised and formalised systems and procedures for planning and allocation of resources. These systems are comparatively rapid with lower variability in production.

It is considered that the organizational culture of an SME often reflects the personality of its top executives (Kotey 2005; Laufs *et al.* 2016). Many SMEs are results-oriented, and favourable to new change initiatives and innovations (Carlos 2007). The human resources of SMEs are characterized by wide spans of control across few decision makers, dominant owners, the encouragement of individual creativity (Saunders *et al.* 2013), a small degree of resistance to change and a multi-skilled workforce (Darcy *et al.* 2014). Despite managers having wide-ranging responsibilities, SMEs often struggle to attract adequate financial support (Hudson-Smith and Smith 2007; Ates *et al.* 2013) and inadequate employees' learning and training (Tam and Gray 2016) which sometimes can result in failure of new improvement initiatives. Contrasts to LEs, SMEs are more adaptable and flexible for customer satisfaction. The extent of innovation is less in SMEs and expected to be reasonably innovative only, whereas, LEs experience a high degree of innovation (Antony 2008). LEs have a higher degree of specialisation, experience and superior communication system like ERP. LEs have the facilities to conduct in-house training and can afford to send their employees to attend training programme overseas.

In SMEs, the relationship with suppliers and customers can be characterized by a small number of external interactions, close relations, good accessibility, local markets and quick response to customer feedback (O'Regan and Ghobadian 2004; Darcy *et al.* 2014). LEs have global supply chain partners with large customer base. They have long term relationships with partners and have a high degree of after sale service.

LEs enjoy economy of scale and have large capital investment, which SMEs lack (Gnanaraj *et al.* 2012). Thus, LEs undertake high risk in business and SMEs have a tendency of taking low risk and have short term orientation (Ates *et al.* 2013).

As discussed above large firms have a comprehensive business model, long term orientation, enjoy economy of scale, high risk taking abilities, higher levels of organisational structure and complex decision making. Most of the existing frameworks in the literature on lean implementation are evolved considering the above characteristics thus are biased towards LEs. Contrary to LSs, the SMEs have short term orientation, simple organisational structure, low

risk taking ability, simple decision-making process, resources constraints and flexible production system. Therefore, the operational improvement frameworks for LEs may not be suitable for SMEs. In-fact for operational improvements in SMEs, exclusive framework is imperative.

2.1.1 Challenges of SMEs

SMEs face several challenges in the contemporary competitive scenario. The majority of researchers identified ‘weak educational level of employees’ and ‘communication within and outside the organization’ as the prominent challenges hindering the growth of SMEs (Bhagwat and Sharma 2007; Omerzel and Antoncic 2008; Sharma 2009; Gnanaraj *et al.* 2012). The other challenges responsible for holding back the development of SMEs include ‘inefficient leadership and management skills’, ‘poor productivity and process improvement’, ‘short-sighted vision and goals’, ‘poor access to finance and other resources’ and ‘lacking in new technologies and initiatives’ (Neupert *et al.* 2006; Antony 2008; Pillania 2008; Gnanaraj *et al.* 2012; Mathur *et al.* 2012 Ates *et al.* 2013; Chaplin *et al.* 2016). A range of key papers focusing on the challenges of the growth of SMEs are summarised in Table 2.

Table 2: Challenges (obstacles) of SMEs

Challenges of SMEs	Supporting literature
Ineffective leadership and management skills	Jayawarna <i>et al.</i> 2007, Neupert <i>et al.</i> 2006, Gnanaraj <i>et al.</i> 2012, Thakkar <i>et al.</i> 2013
Short-sighted vision and goals	Tuteja 2001, Singh <i>et al.</i> 2005, Hudson-Smith and Smith 2007, Ates <i>et al.</i> 2013
Weak educational level of employees	Tuteja 2001, Singh <i>et al.</i> 2005, Holden <i>et al.</i> 2007, Omerzel and Antoncic 2008, Gnanaraj <i>et al.</i> 2012

Poor productivity and process improvement	Wessel and Burcher 2004, Maire <i>et al.</i> (2008), Pillania (2008), Mathur <i>et al.</i> 2012
Poor access to finance and other resources	Kock <i>et al.</i> 2007, Pitta 2008, Gnanaraj <i>et al.</i> 2012, Chaplin <i>et al.</i> 2016
Inadequate communication and IT infrastructure	Xiong <i>et al.</i> 2006, Tuteja 2001, Singh <i>et al.</i> 2005, Bhagwat and Sharma, 2007, Sharma 2009
Lack of new technologies and initiatives	Gunasekaran <i>et al.</i> 2001, Hashim and Wafa 2002, Antony 2008

3. Methodology

The systematic literature survey approach employed in this paper is based on Kauppi *et al.* (2013). In this review, we used four databases: Web of Science, Science Direct, Taylor & Francis and Google Scholar. Apart from this, twenty-two academic journals focusing on operations management as well as lean thinking are also included in the review. The keywords were identified based on our prior experience and brainstorming. Keywords included lean manufacturing, lean production, lean thinking, Toyota production system, just in time, JIT, SMEs, Small and medium enterprises, small manufacturing units and the combination of these.

From the initial search from databases and academic journals respectively 8,237 and 2,835 articles were found. The 11,072 articles were reviewed based on the title and/or abstract and if found necessary full text with the pre-specified criteria. Exclusion criteria included repeated articles, low journal quality, articles not containing SMEs' context and publication type (book reviews and anonymous publications). Subsequently, 86 articles were shortlisted based on the above criteria, and after reading the full text eventually, 42 articles were selected. Furthermore, the papers found through the cross-references were also reviewed. This resulted in 4 more relevant articles worth to include in the review. Finally, 46 articles were included in the review.

4. Lean Thinking in SMEs

Academicians and practitioners have suggested that application of lean principles and philosophies are not limited to large enterprises (LEs), but can also be adopted in SMEs. Owing to the basic principles of lean, elimination of waste, value enhancement, and customer satisfaction being generic lean is applicable to SMEs as well. It is argued that as SMEs often have higher flexibility, faster decision making and quicker response to customers, they create a positive environment for lean implementation.

Limited evidence of lean implementation in SMEs can be found in the literature and some of the cases are discussed in this section. Slomp *et al.* (2009) investigated how lean production control principles can be used in low-volume, high-variety, and make-to-order job shops. A case study of an electrical power distribution and control equipment manufacturer was presented. The results demonstrated that the implementation of lean reduces flow time and increases service level with on-time delivery performance improving from 55 to 80 percent. It was concluded that lean principles were beneficial for high variety and low volume production SMEs. Similarly, Panizzolo *et al.* (2012) investigated the adoption of lean in developing countries and examined the lean practices implemented by SMEs. Four case studies of Indian SMEs were presented that had deployed a lean strategy to drive significant improvement in manufacturing performance.

Vinodh *et al.* (2014) used an integrated lean sigma framework to reduce product defects, thereby contributing savings to the organization. The implementation of the proposed framework demonstrated a dramatic improvement in key metrics and substantial financial savings generated by the organization.

Vlachos (2015) developed a lean action plan for SMEs that sheds light on how lean thinking can be applied in the food sector. The aim of this work was to study the adoption and implementation of lean in food supply chains. A case study of a UK-based tea company with operations overseas was demonstrated for an in-depth inquiry of lean adoption. Similarly, Dora *et al.* (2015) adopted a multiple-case-study research approach to provide an insight of lean implementation in SMEs operating in food-processing industries and concluded that the smaller plant, the conventional setup, and inflexible layout make it complex to implement lean in food-processing SMEs.

Thomas *et al.* (2016) applied strategic lean six sigma framework to a medium sized UK aerospace manufacturing company and found improved on-time-in-full delivery to customer by 26.5%, build time reduction of 20.5%, reduced non-value-added time by 44.5% and reduced value added time by 5%. Similarly, Manfredsson (2016) employed lean principles to textile (SME) management area and identified the overall positive effect. Alaskari *et al.* (2016) proposed a framework that can assist SMEs, to select an appropriate lean tool which will maximize benefits from adopting the tool.

Filho *et al.* (2016) tested the lean constructs (practises) in Brazillian SMEs developed for LEs by Shah and Ward (2007). They found only three constructs out of ten are implemented in SMEs. Therefore, the frameworks of lean in LEs may not be suitable for SMEs. Above discussion indicates that although lean is mostly adopted in LEs, but literature doesn't oppose the adoption of lean in SMEs. Some researchers (Thomas *et al.* 2009; Upadhye *et al.* 2010; Alaskari *et al.* 2016; Manfredsson 2016; Thomas *et al.* 2016) successfully employed lean philosophies and principles to enhance the operational performance of SMEs (Hu *et al.* 2015). In the next section, lean practices, which have been adopted in SMEs, are explored.

5. Lean practices in SMEs

According to Zhou (2012), lean tools and techniques applied in SMEs are positively related to firm performance. Literature suggests that the SMEs which have adopted lean have employed a range of lean tools to enhance operational, financial and competitive performance. The lean practices which are important in a SME context and have been mentioned repetitively in the literature are presented in table 3.

Table 3: Lean practices for SMEs

Tools	Authors
Value stream mapping	Kumar <i>et al.</i> (2006), Lian and Landeghem (2007), Roth and Franchetti (2010), Jimenez <i>et al.</i> (2012), White and James (2014)

Workplace organization and visual management	Kumar <i>et al.</i> (2006), Vinodh <i>et al.</i> (2011), Vinodh <i>et al.</i> (2014) Gupta and Jain (2015)
Pull / Kanban	Slomp <i>et al.</i> (2009), Panizzolo <i>et al.</i> (2012), Powell <i>et al.</i> (2013), Vlachos (2015)
Kaizen	Chen <i>et al.</i> (2010), Upadhye <i>et al.</i> (2010), Arya and Jain (2014), Arya and Choudhary (2015)
Changeover Reduction / Single Minute Exchange of Dies (SMED)	Mathur <i>et al.</i> (2012), Jimenez <i>et al.</i> (2012), Dora <i>et al.</i> (2015) Thomas <i>et al.</i> (2016)
Total Productive Maintenance (TPM)	Kumar <i>et al.</i> (2006), Upadhye <i>et al.</i> (2010) Jain <i>et al.</i> (2014), Vinodh <i>et al.</i> (2014),
Quality improvement (QI) tools	Kumar <i>et al.</i> (2006), Vinodh <i>et al.</i> (2011), Gnanaraj <i>et al.</i> (2012), Mathur <i>et al.</i> (2012), Mittal <i>et al.</i> (2012), and Vinodh <i>et al.</i> (2014)

5.1 Value Stream Mapping (VSM)

Kumar *et al.* (2006), Lian and Landeghem (2007), Roth and Franchetti (2010), Jimenez *et al.* (2012) and White and James (2014) found Value Stream Mapping to be the most valuable tool to separate the value added and non-value added activities, and to identify the opportunities for improvements in SMEs. Kumar *et al.* (2006) utilized VSM to map the current situation of a die casting unit which helped in eliminating waste in the process. With the aid of simulation VSM, Lian and Landeghem (2007) generated current and future-state scenarios to see the impact of lean while transforming a part of the production system from push to pull. Jimenez

et al. (2012) used a current state map to identify process wastes in winery units and proposed significant improvements in the process through the envisioning of a future state map. .

5.2 Workplace Organisation and Visual Management

Kumar *et al.* (2006) implemented shop floor 5S to standardize the workflow, to organize the work environment and to assign clear ownership of processes to employees. Parry & Turner (2006) successfully employed visual process management tools in both original equipment manufacturers (OEMs) and small-medium enterprises (SMEs). Vinodh *et al.* (2011) implemented 5S in an Indian automotive valve manufacturing unit and found reduction in wastes. Similarly, Vinodh *et al.* (2014) employed 5S on the shop floor of an Indian rotary switches manufacturing unit. It resulted in a reduction in inventories, and a cleaner environment. Gupta and Jain (2015) stated that the implementation of 5S results in an elevation in overall performance of an SME. The authors found a reduction in tool searching time from 30 minutes to 5 minutes in an SME. Therefore, it can be concluded that the implementation of workplace organization and visual management tools can be productive for SMEs.

5.3 Kanban/ Pull System

Kanban/ Pull systems have been considered as one of the core practices of lean. Slomp *et al.* (2009) implemented a pull system in an electrical goods manufacturing SME and observed a decrement in WIP and an improvement in operational efficiency. In a study of four Indian SMEs, Panizzolo *et al.* (2012), identified that all SMEs used pull systems with Kanbans to streamline the production. Powell *et al.* (2013) and Vlachos (2015) applied Kanban for controlling the supply of materials in four Netherlands-based SMEs and in a UK-based food SME respectively. Hence, it appears that Kanban/ Pull systems are applicable in SMEs as they are in LEs.

5.4 Kaizen

Chen *et al.* (2010) employed a Kaizen tool for a small manufacturing system, which resulted in a 25% reduction in unit cost, 15% reduction in floor space requirement and better communication network. Upadhye *et al.* (2010) implemented Kaizen with some other lean tools at an SME and reported 50% reduction in setup time, 10% increase in machine availability, and 15% reduction in cycle time. The authors also reported 25% reduction in rejections and 15% increase in capacity. Arya and Jain (2014) applied kaizen in an Indian SME

and stated a reduction in process time by 44% and a saving of Rs 64,000 by recovering 80 square feet working area. Similarly, Arya and Choudhary (2015) presented a case of application of Kaizen in a small-machine, vice manufacturing company. The authors reported that after the adoption of Kaizen, inventory access time decreased up to 87%, total distance travelled reduced up to 43% and total time taken by the product trimmed down up to 46%. Therefore it is evident that not only LEs but SMEs have also implemented Kaizen.

5.5 Changeover Reduction / SMED

SMED is a lean tool to reduce the setup time to a single digit. Hodge *et al.* (2011) argued that SMED is applicable in textile SMEs. Moreover, , Mathur *et al.* (2012) utilized SMED to improve productivity in an SME and reported that average time per setup was reduced from 4.07 hrs to 3.15 hrs. With the application of SMED principles, Jimenez *et al.* (2012) observed considerable reduction in setup time in an SMEs. Dora *et al.* (2015) reported that food processing SMEs improved efficiency and productivity with the help of SMED and some other lean tools. Similarly, Thomas *et al.* (2016) found that the application of a SMED approach in a medium-sized, UK-based aerospace manufacturing company resulted in a build time reduction of 20.5%, improved on-time-in-full delivery to customer by 26.5%, reduced value-added time by 5% and reduced non-value-added time by 44.5%. Therefore, it can be concluded that SMED yields similar results in SMEs as it can be in LEs.

5.6 Total Productive Maintenance (TPM)

The execution of Total Productive Maintenance (TPM) not only improves the Overall equipment effectiveness (OEE) of large industries but also enhances the OEE of SMEs by escalating the performance, availability, and quality rate of the machines (Jain *et al.* 2014). Kumar *et al.* (2006) reported that the application of TPM in a die casting unit dramatically improved OEE and resulted in considerable financial savings. Vinodh *et al.* (2014) implemented a lean six sigma framework in a rotary switches manufacturing unit (SME) and observed that machine downtime and idle time at workstations were curtailed significantly. Upadhye *et al.* (2010) implemented TPM in an Indian SME and found a remarkable rise in OEE. Therefore, it can be said that the adoption of TPM in SMEs results in operational performance enhancement.

5.7 QI tools

Generally, SMEs focus on quality and productivity improvement for customer satisfaction and several tools based on simple statistics are available which are frequently used by the SMEs (Mathur *et al.* 2012). These tools include statistical process control (SPC), cause-and-effect diagrams, process capability analysis, Pareto charts, and Poka Yoke. Gnanaraj *et al.* (2012) utilized cause-and-effect diagrams and Pareto charts to identify causes of the problems occurring in the production system. Mittal *et al.* (2012) drew a Pareto chart to assess the cause of rejections in the die casting unit of an SME. Kumar *et al.* (2006), Vinodh *et al.* (2011) and Vinodh *et al.* (2014) also employed cause-and-effect diagram, Pareto charts, and control charts in their respective studies of SMEs. Therefore, QI tools are widely applied in SMEs.

Although, the lean practices discussed above are widely adopted in SMEs, there exists some other lean practices which are also employed in SMEs, but to a limited extent. For example, just-in-time philosophies (Ramaswamy *et al.* 2002 and Dowlatshahi and Taham 2009) are mostly applied in LEs while rarely adopted in SMEs. Possibly, due to the fact that JIT flow depends on production leveling within the organization and this often cannot be achieved in SMEs due to the demand variability. Similarly, we also found from a literature survey that Cellular manufacturing and Jidoka (autonomation) are also rarely utilized in SMEs.

6. Critical Success Factors for Lean Implementation in SMEs

This section outlines some of the factors that are perceived to be critical for the successful diffusion of lean in SMEs. Table 4 presents the critical success factors for lean implementation in SMEs with literature support.

Table 4: Critical Success Factors for Lean Implementation in SMEs

Critical Success Factors for Lean Implementation in SMEs	
<i>Management Commitment and Leadership</i>	Achanga <i>et al.</i> 2006; Worley and Doolen 2006; Panizzolo <i>et al.</i> 2012; Timans <i>et al.</i> 2012; Dora <i>et al.</i> 2013; Dora <i>et al.</i> 2015; Hu <i>et al.</i> 2015

<i>Organisational culture</i>	Panizzolo <i>et al.</i> 2012; Timans <i>et al.</i> 2012; Zhou 2012; Dora <i>et al.</i> 2013; Dora <i>et al.</i> 2015
<i>Training and skills</i>	Achanga <i>et al.</i> 2006; Mathur <i>et al.</i> 2012; Zhou 2012; Timans <i>et al.</i> 2012; Dora <i>et al.</i> 2013; Albliwi <i>et al.</i> 2014; Dora <i>et al.</i> 2015; Hu <i>et al.</i> 2015
<i>Employee involvement</i>	Panizzolo <i>et al.</i> 2012; Hu <i>et al.</i> 2015
<i>Communication</i>	Worley and Doolen 2006; Timans <i>et al.</i> 2012; Hu <i>et al.</i> 2015
<i>Financial capability</i>	Achanga <i>et al.</i> 2006; Zhou 2012; Dora <i>et al.</i> 2013; Chaplin <i>et al.</i> 2016

6.1 Management Commitment and Leadership

In order to secure a successful implementation of lean principles in SMEs, the commitment of top management is vital (Achanga *et al.* 2006; Worley and Doolen 2006; Timans *et al.* 2012; Dora *et al.* 2015). It is a primary responsibility of the management to educate and motivate the employees for the adoption of lean at all levels. It is imperative that top managers are committed to a long-sight vision of performance and enhancement of the employees' involvement in improvement programmes (Panizzolo *et al.* 2012). Furthermore, there should be continuity in leadership philosophies (Dora *et al.* 2013; Hu *et al.* 2015). High-quality leadership eventually promotes knowledge enrichment and effective skills amongst its employees (Panizzolo *et al.* 2012). Albliwi *et al.* (2014) argued that the lack of management commitment and involvement results in the failure of lean implementation in SMEs.

6.2 Organisational culture

It is considered that the organizational culture of an SME reflects the personality of the top executives of the organization (Achanga *et al.* 2006). For successful lean implementation in SMEs, the establishment of encouraging organizational culture is a crucial factor (Panizzolo *et al.* 2012; Zhou 2012; Dora *et al.* 2013). Long-term orientation, strategic teamwork and

excellent communication are vital for a transformation to lean (Dora *et al.* 2015). . Hence, a supportive culture of the organization is imperative for the adoption of lean in SMEs.

6.3 Training and skills

SMEs typically employ a workforce with relatively limited skills and consider training as a luxury (Achanga *et al.* 2006; Mathur *et al.* 2012; Albliwi *et al.* 2014), while a lean transformation requires a high level of expertise and training. Training of SMEs' employees is essential to improve their soft and technical skills (Dora *et al.* 2015). Many other researchers such as Zhou 2012, Timans *et al.* 2012, Dora *et al.* 2013, and Hu *et al.* 2015 also reported skills and training as a critical success factor for the implementation of lean.

6.4 Employee involvement

The engagement and empowerment of employees is also crucial in the lean drive (Hu *et al.* 2015). The adoption of lean practices such as 5S, Kaizen, requires active participation and empowerment of people in the organization (Panizzolo *et al.* 2012). Employee involvement is also necessary to remove cultural barriers and to create the positive environment for the lean transformation.

6.5 Communication

Lean transformation requires clear communication between all the partners of the value stream (Timans *et al.* 2012; Hu *et al.* 2015). Poor communication reflects in low production, poor performance, and sub-standard quality (Worley and Doolen 2006). Communication is frequently cited as a key success factor in the implementation of lean in SMEs (Worley and Doolen 2006; Timans *et al.* 2012).

6.6 Financial capability

Financial capability is considered as a crucial factor for successful completion of any project. Lean implementations require investment in training programmes and consultancy. But it was observed that SMEs have poor financial arrangements (Achanga *et al.* 2006; Zhou 2012; Dora *et al.* 2013; Chaplin *et al.* 2016). Additionally, the financial benefits of lean adoption are achieved over a long period of five years or more which is not always palatable to SMEs. Therefore, financial capability is also an important critical success factor for lean implementation in SMEs.

7. Impact of lean on SMEs

Figure 1 illustrates the various impacts of lean transformation. In order to measure the performance improvement through lean thinking, generally, operational and financial measures are adopted. Operational impacts include reduction in inventory, improvement in the quality of products, waste reduction & increase in flexibility at the operational level, and reduction in cost (Shah and Ward 2003). Measurement and quantification of the operational performance are not a big task for practitioners. Further, operational performance has a positive impact on the financial performance of a firm (Fullerton and Wempe 2009). Financial impacts can easily be observed in increase in profit, revenue growth, market share and total sales.

Contemporary research also focuses on social and environmental impacts of 'lean'. Lean transformation helps social performance viz improving the work routines, working environment, teamwork efforts, and employee empowerment (Chaplin *et al.* 2016). . Impact of lean on environment performance can be seen through energy saving, and reduction in wastage and pollution. Ultimately the impact of a lean transformation can be arranged into one of the four categories i.e. operational, financial, social and environmental impacts.

Operational Impacts	Financial Impacts	Social Impacts	Environmental Impacts
<ul style="list-style-type: none">• Inventory reduction• Quality improvement• Waste reduction• Flexibility improvement• Cost reduction	<ul style="list-style-type: none">• Increment in Profit• Revenue growth• Market share• Total sales	<ul style="list-style-type: none">• improved work routines• employee empowerment• improved working environment• improved teamwork efforts	<ul style="list-style-type: none">• Energy saving• Reduction in waste and• Reduction in pollution

Figure 1: Impacts of lean transformation

The literature was explored to judge the impact of lean in SMEs across areas such as operations, finance, social and environment which will ultimately result in customer satisfaction. Shah and Ward (2003) claimed that lean practices contribute significantly to the

operational performance of a plant. Fullerton and Wempe (2009) described the relationship among lean practices, non-financial measures of performance (operational) and the financial performance of the firm. For SMEs, Zhou (2012) reported improvement in operational and financial performance after transforming to lean. Chaplin *et al.* (2016) also found a positive impact of lean thinking on the social, environmental and financial performance of SMEs.

Kumar *et al.* 2006 proposed a lean sigma framework for SMEs and found that the adoption of a lean sigma framework resulted in reduced defects, improved OEE, and improved savings. Slomp *et al.* 2009 reported that lean implementation led to a reduction in 'flow times', improvement in 'service level' and 'on time deliveries' in an SME. Similarly, Vinodh *et al.* 2011 found that lean thinking positively impacted OEE while decreasing machine downtime, 'rejection rate' and 'inventory' in an Indian automotive valves manufacturing organization. After implementing lean sigma in a rotary switches manufacturing organization, Vinodh *et al.* 2014 stated that the firm gained financial saving by reducing defects and improving OEE. Panizzolo *et al.* 2012 reported four case studies of implementation of lean thinking in SMEs and found considerable impact on performance in the form of improved inventory turnover, reduced setup time, improved on-time delivery, improved OEE and higher customer satisfaction. Jimenez *et al.* 2012 also studied the impact on lean thinking in a wine producing SME and found that the adoption of lean practices resulted in reduced production lead time and inventory, and, improved the distribution of work and physical space. Chen *et al.* (2010), Thomas *et al.* (2009), Upadhye *et al.* (2010), and Thomas *et al.* (2016) also studied the impact of lean thinking on the performance of SMEs and unanimously found a positive relationship between lean adoption and performance improvement.

8. Discussion and way forward

SMEs are facing a number of problems related to productivity, quality, agility, and customer satisfaction, ineffective leadership and management skills, and short-sighted vision and goals (Gunasekaran *et al.* 2001; Antony 2008; Gnanaraj *et al.* 2012; Mathur *et al.* 2012; Thakkar *et al.* 2013). SMEs also face the challenges of weak educational level of employees, poor productivity and process improvement, fewer resources, poor communication and IT, and lacking in new technologies and initiatives. Therefore, operational initiatives for improving production processes are strongly recommended for SMEs. Recently, many researchers have

utilized lean as a solution for these problems faced by SMEs. However, a comprehensive literature review suggests that in the context to SMEs, the application of lean thinking is limited to either the implementation of a small set of lean practices or only a partial implementation of lean (Bamford *et al.* 2015; Chaplin *et al.* 2016).

However, the exploration of the extant literature advocates the applicability of lean thinking in SMEs due to the specific characteristics of SMEs. For instance, SMEs have simple organizational structure which promotes quicker communication, and fast decision making which is an essential requirement for lean transformation (Hudson-Smith and Smith 2007). Similarly, simplicity and informal rules on operational planning in SMEs provide flexibility in production and rapid response to the customer (Ates and Bititci 2011). SMEs are also characterized by instantaneous feedback from customers and the capability for swift response to customers' needs (O'Reilly *et al.* 2015). This flexibility in production planning and effective customer need identification creates a positive environment for lean transformation. The literature also suggests that SMEs also have multi-skilled workforce, creative and innovative environment, high personal authorities and few decision makers which create a positive environment for operational initiatives (Darcy *et al.* 2014). Unified, results-oriented and a corporate mindset culture at SMEs is favorable for lean implementation (Carlos 2007). It is evident from the above discussion that the characteristics of SMEs create a positive environment for lean transformation.

After reviewing the literature on lean in SMEs, we found that practitioners mostly utilize lean practices such as VSM, workplace organization, visual management, Pull/Kanban, changeover reduction/ SMED, TPM and QI tools, while JIT, cellular manufacturing, Andon, and Jidoka are rarely implemented in SMEs.

The literature suggests some critical success factors, for the successful implementation of lean in SMEs, such as management commitment and leadership, organizational culture, training and skill, employee involvement, and communication. The literature in this field also suggests that the implementation of lean in SMEs has a positive impact on a firm's operational performance. Previous studies in this area reported benefits such as inventory reduction, quality improvement, waste reduction, flexibility improvement and cost reduction.

The literature review reveals that the models of lean implementation for LEs are not suitable for SMEs (Chaplin *et al.* 2016). Due to resource limitations in SMEs, only the most appropriate

lean practices are productive instead of implementing full lean, and the selection of appropriate practices depends on the nature of the production process. From the literature review, a theoretical framework for lean in SMEs has been developed which is illustrated in figure 2. This framework consists of the lean practices, critical success factors (CSF), and impact factors. The CSFs are at the bottom of the framework and work as the foundation for lean adoption in SMEs. We propose that for the successful implementation of lean in SMEs it is desirable to deal with the CSFs first. Above the CSFs lean practices are present which are categorised in four groups, i.e. elimination of waste, alignment of production with demand, quality improvement and human resources practices. Implementation of lean practices impacts the performance on four broad areas: operational, financial, social and environmental which are placed at the top in the framework.

A new initiative for production performance improvement in SMEs depends on the top management's commitment and involvement of employees. Therefore, before launching a lean implementation project at SME, the owner's and senior executive's commitment should be ensured. The focus on other critical success factors is also imperative. Further, to remove cultural barriers and to create the positive environment for lean implementation, HR practices such as kaizen should be employed at the initial stages of lean adoption. These practices not only provide the training to employees but also develop an understanding of lean philosophy, principles, and benefits so that the propagation of lean becomes smooth.

Subsequently, VSM should be exercised to analyse the current situation of the system. Since various wastes in the value stream are recognized with the help of VSM, elimination of waste and quality improvement practices should be systematically and sequentially implemented. The sequence of lean practices implementation is critical, and it depends on the key performance indicators. The sequence of adoption of lean practices creates an un-restricted value flow in the organization.

This framework is entirely based on the comprehensive literature review carried out in this study, and can be an effective tool for implementation of lean in SMEs. However, there is always scope for adaptation of the framework according to individual SMEs' needs.

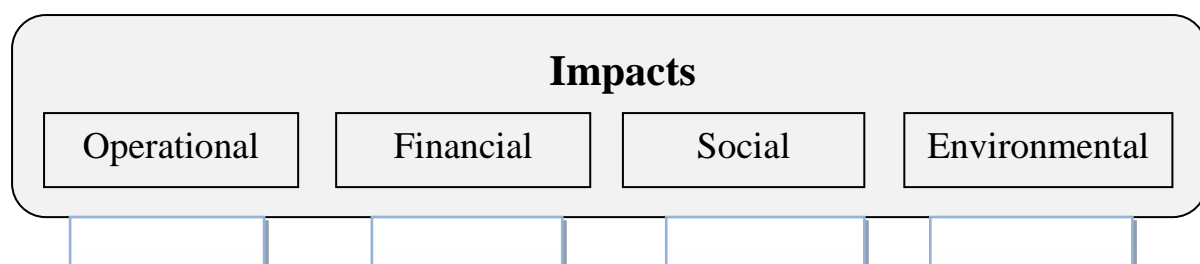


Figure 2 Proposed Framework for Lean in SMEs

8.1 Scope of future research

This review indicates that lean can be an appropriate tool for SMEs to achieve high productivity and quality with lower cost and time. There are, however, some of the issues that need attention for its effective implementation.

- **Frameworks for implementation of lean thinking in SMEs:** In the literature, numerous lean frameworks are available for LEs. For instance Jasti and Kodali (2015) reviewed 131 such lean frameworks. However, researchers do not find them suitable

for SMEs (Chaplin *et al.* 2016; Hu *et al.* 2014). For SMEs, some researcher (Kumar *et al.* 2006; Vinodh *et al.* 2011; Vinodh *et al.* 2014; Thomas *et al.* 2016) have proposed frameworks for lean implementation, however the shortcoming of these frameworks is that they are applicable in a particular type of industry. Therefore, the frameworks proposed for SMEs are not generic. Whereas, for a widespread application of lean in SMEs a generic framework based on the characteristics, limitations, and advantages of SMEs is required to be developed.

- **Leanness measurement models for SMEs:** Abundance of leanness measurement models are present in the literature, but only a few are applicable for SMEs. To assess the degree of leanness and measurement of the state of operations is still required. Therefore future study is required to develop leanness measurement model for SMEs.
- **Supplier involvement:** Although, supplier involvement is found to be imperative to achieve quality and delivery performance; practice of the same is generally lacking in SMEs. Therefore future studies are required focusing on supplier involvement in SMEs.
- **More empirical studies:** Current literature is dominated by case studies in regards to lean implementation in SMEs which suffers the risk of only case-specific results. In this review, we found only one survey-based study (Zho 2012). Therefore, more empirical research is needed to estimate the applicability and status of lean implementation in SMEs, and to reach generalised and valid findings.
- **Focus on developing economies:** Most of the studies in this field are conducted in developed countries (US and UK). In contrast, the studies focusing developing economies are in scarce (Bhamu and Sangwan 2014). Therefore, future research should focus on lean adoption in SMEs in developing countries.
- **Focus on financial, social and environmental impacts:** It was observed that most of the researchers focused on the operational impacts of lean and only a few studied financial impacts of lean in SMEs. Therefore, an exhaustive study on financial impacts of lean in SMEs is required. Additionally, the literature also lacks studies regarding social and environmental impacts of lean in SMEs. Therefore, further studies are needed to address the issue of social and environmental impacts of lean in SMEs.

9. Conclusions

This study brings out the contribution to knowledge made by existing literature pertaining to issues in adoption of lean manufacturing in SMEs. To develop the understanding about application of lean in SMEs, first the literature was explored to extract various characteristics and challenges of SMEs. This study reinforces the finding of previous research that to overcome the contemporary challenges faced by SMEs, lean can probably be a suitable philosophy. This study reveals that some features of SMEs encourage lean adoption while some resist. For instance, on one hand, simple organizational structure and fast decision making facilitates adoption of lean manufacturing whereas lack of awareness, lack of resources, and inadequate commitment restrict the lean adoption in SMEs.

In this study the literature was also reviewed in a view to investigate the adoptability of lean thinking in SMEs. Some researchers successfully implemented lean thinking in SMEs and highlighted the benefits of lean implementation. Therefore, it can be concluded from the critical analysis of literature that the application of lean thinking is fruitful for SMEs. Importantly, this review found that use of all the lean practices is not desired in SMEs, but only some most suitable practices should be employed on the basis of the production and management characteristics (Bamford *et al.* 2015; Chaplin *et al.* 2016). Lean practices such as VSM, Workplace organization, visual management, Pull / Kanban, Kaizen, Changeover Reduction / SMED, Total Productive Maintenance (TPM), and Quality improvement tools are widely implemented in SMEs while other practices have limited application.

An effort was made to identify the various critical success factors for diffusion of lean in SMEs. These critical success factors include management commitment and leadership, organizational structure, training and skills, employee involvement, communication, and financial capabilities. In order to successfully adopt lean in SMEs, these critical success factors should be considered. Furthermore, this study also focuses on the impacts of lean in SMEs and categorizes them in four levels i.e. operational, financial, social, and environmental impacts.

Therefore, to transform the traditional SMEs into lean SMEs is not an easy task, however, it seems to be important in current markets. It is our assertion that to make lean implementation feasible in SMEs it is essential to understand the characteristics of SMEs and accordingly develop a holistic framework encompassing production, process, cultural, financial, managerial and environmental considerations.

References

- Achanga, P., Shehab, E., Roy, R. and Nelder, G. (2006) 'Critical success factors for lean implementation within SMEs', *Journal of Manufacturing Technology Management*, 17(4), pp. 460–471.
- Alaskari, O., Ahmad, M.M. and Pinedo-Cuenca, R. (2016) 'Development of a methodology to assist manufacturing SMEs in the selection of appropriate lean tools', *International Journal of Lean Six Sigma*, 7(1), pp. 62–84.
- Albliwi, S., Antony, J., Lim, S.A.H., and Wiele, T.V., (2014), 'Critical failure factors of Lean Six Sigma: a systematic literature review', *International Journal of Quality & Reliability Management* 31:9, 1012-1030.
- Antony, J. (2008), "Reflective practice: can Six Sigma be effectively implemented in SMEs?", *International Journal of Productivity and Performance Management*, Vol. 57No. 5, pp. 420-423.
- Antony, J., Vinodh, S., Gijo, E.V. (2016), "Lean Six Sigma for small and medium sized enterprises" CRC Press 978-1-4822-6009-0.
- Arya, A.K., and Choudhary, S., (2015),"Assessing the application of Kaizen principles in Indian small-scale industry", *International Journal of Lean Six Sigma*, Vol. 6 Iss 4 pp. 369 - 396
- Arya, A.K., and Jain, S.K., (2014),"Impacts of Kaizen in a small-scale industry of India: a case study", *International Journal of Lean Six Sigma*, Vol. 5 Iss 1 pp. 22 - 44
- Ates, A. and Bititci, U. (2011), "Change process: a key enabler for building resilient SMEs", *International Journal of Production Research*, Vol. 49 No. 18, pp. 5601-18.
- Ates, A., Garengo, P., Cocca, P. and Bititci, U. (2013) 'The development of SME managerial practice for effective performance management', *Journal of Small Business and Enterprise Development*, 20(1), pp. 28–54.
- Australian Government (2011), *Key Statistics – Australian Small Business* (Department of Innovation, Industry, Science and Research).
- Bamford, D., Forrester, P., Dehe, B. and Leese, R.G. (2015) 'Partial and iterative lean implementation: Two case studies', *International Journal of Operations & Production Management*, 35(5), pp. 702–727.
- Bhagwat, R., and Sharma, M.K., (2007) 'Information system architecture: a framework for a cluster of small- and medium-sized enterprises (SMEs)', *Production Planning & Control*, 18(4), pp.283-296.
- Bhamu, J., and Sangwan, K.S., (2014),"Lean manufacturing: literature review and research issues", *International Journal of Operations & Production Management*, Vol. 34 Iss 7 pp. 876 – 940
- Billesbach, J.T., 1994. Applying lean production principles to a process facility. *Production and Inventory Management Journal*, Third Quarter 40–44.
- Carlos Pinho, J. (2007) 'The impact of ownership', *International Marketing Review*, 24(6), pp. 715–734.
- Chaplin, L., Heap, J. and O'Rourke, S.T.J. (2016) 'Could "Lean Lite" be the cost effective solution to applying lean manufacturing in developing economies?', *International Journal of Productivity and Performance Management*, 65(1), pp. 126–136.
- Chen, J.C., Li, Y., and Shady, B.D., (2010) From value stream mapping toward a lean/sigma continuous improvement process: an industrial case study, *International Journal of Production Research*, 48:4, 1069-1086,

Darcy, C., Hill, J., McCabe, T.J., McGovern, P., (2014), "A consideration of organisational sustainability in the SME context", *European Journal of Training and Development*, Vol. 38 Iss 5 pp. 398 – 414.

Demeter, K. and Matyusz, Z. (2010), "The impact of lean practices on inventory turnover", *International Journal of Production Economics*, Vol. 133 No. 1, pp. 154-163.

Dora, M., Kumar, M. & Gellynck, X., (2015): Determinants and barriers to lean implementation in food-processing SMEs – a multiple case analysis, *Production Planning & Control: The Management of Operations* 27:1, pp 1-23.

Dora, M., Kumar, M., Goubergen, D.V., Molnar, A., and Gellynck, X., (2013) 'Operational performance and critical success factors of lean manufacturing in European food processing SMEs', *Trends in Food Science & Technology*, 31(2), pp. 156-164.

Dowlatshahi, S. and Taham, F. (2009), "The development of a conceptual framework for just-in-time implementation in SMEs", *Production Planning & Control*, Vol. 20 No. 7, pp. 611-621.

Filho, M.G., Ganga, G.M.D. and Gunasekaran, A. (2016) "Lean manufacturing in Brazilian small and medium enterprises: implementation and effect on performance, *International Journal of production Research* vol 54 iss 24 pp. 7523-7545.

Fullerton, R.R. and Wempe, W.F. (2009) 'Lean manufacturing, non-financial performance measures, and financial performance', *International Journal of Operations & Production Management*, 29(3), pp. 214–240.

Gnanaraj, S.M., Devadasan, S.R., Muruges, R., and Sreenivasa, C.G., (2012) 'Sensitisation of SMEs towards the implementation of Lean Six Sigma – an initialisation in a cylinder frames manufacturing Indian SME', *Production Planning & Control*, 23(8), pp. 599-608,

Gunasekaran, A., Marri, H.B., MCGauahey, R. and Grieve, R.J. (2001), "Implications of organization and human behavior on the implementation of CIM in SMEs: an empirical analysis", *International Journal of CIM*, Vol. 14 No. 2, pp. 175-85.

Gupta, S., and Jain, S., (2013), 'A literature review of lean manufacturing', *International Journal of Management Science and Engineering Management*, 8:4, 241-249,

Hashim, M.K. and Wafa, S.A. (2002), *Small and Medium Sized Enterprises in Malaysia Development Issues*, Prentice-Hall, Englewood Cliffs, NJ.

Hicks, C., McGovern, T., Prior, G., and Smith, I., (2015), 'Applying lean principles to the design of healthcare facilities', *International Journal of Production Economics*, 170, pp. 677-686.

Hines, P., Holweg, M. and Rich, N. (2004), "Learning to evolve – a review of contemporary lean thinking", *International Journal of Operations & Production Management*, Vol. 24 No. 10, pp. 994-1011.

Hodge, G.L., Goforth, R.K., Joines, J.A. and Thoney, K. (2011), "Adapting lean manufacturing principles to the textile industry", *Production Planning & Control*, Vol. 22 No. 3, pp. 237-247.

Holden, R., Jameson, S. and Walmsley, A. (2007), "New graduate employment within SMEs: still in the dark?", *Journal of Small Business and Enterprise Development*, Vol. 14 No. 2, pp. 211-227.

Hu, Q., Mason, R., Williams, S.J. and Found, P. (2015) 'Lean implementation within SMEs: A literature review', *Journal of Manufacturing Technology Management*, 26(7), pp. 980–1012.

Hudson-Smith, M. and Smith, D. (2007), "Implementing strategically aligned performance measurement in small firms", *International Journal of Production Economics*, Vol. 106 No. 2, pp. 393-408.

Jain, A., Bhatti, R. and Singh, H., (2014), "Total productive maintenance (TPM) implementation practice", *International Journal of Lean Six Sigma*, Vol. 5 Iss 3 pp. 293 - 323

Jasti, N.V.K. and Kodali, R. (2015) A critical review of lean supply chain management frameworks: proposed framework, *Production Planning & Control: The Management of Operations*, 26:13, 1051-1068

Jayawarna, D., Macpherson, A., and Wilson, A., 2007. 'Training commitment and performance in manufacturing SMEs: incidence, intensity and approaches' *Journal of Small Business and Enterprise Development*, 14 (2), pp. 321–338.

Jiménez, E., Tejada, A., Pérez, M., Blanco, J., and Martínez, E., (2012) 'Applicability of lean production with VSM to the Rioja wine sector', *International Journal of Production Research*, 50:7, 1890-1904,

Jurado, P.J.M., and Fuentes, J.M., (2014) 'Key determinants of lean production adoption: evidence from the aerospace sector, *Production Planning & Control: The Management of Operations*, 25(4), pp. 332-345.

Kauppi, K., Moxham, C., Bamford, D.(2013),"Should we try out for the major leagues? A call for research in sport operations management", *International Journal of Operations & Production Management*, Vol. 33 Iss 10 pp. 1368 - 1399

Kock, H., Gill, A. and Ellström, P.E. (2007), "Why do small enterprises participate in a programme for competence development?", *Journal of Workplace Learning*, Vol. 20 No. 3, pp. 181-194.

Kotey, B. (2005) 'Goals, management practices, and performance of family SMEs', *International Journal of Entrepreneurial Behavior & Research*, 11(1), pp. 3–24.

Kumar, M., Antony, J., Singh, R.K., Tiwari, M.K. and Perry, D. (2006), "Implementing the Lean Sigma framework in an Indian SME: a case study", *Production Planning & Control*, Vol. 17 No. 4, pp. 407-423.

Laufs, K., Bombom, M. and Schwens, C. (2016) 'CEO characteristics and SME foreign market entry mode choice', *International Marketing Review*, 33(2), pp. 246–275.

Lian, Y.H., and Landeghem, H.V., (2007), Analysing the effects of Lean manufacturing using a value stream mapping-based simulation generator, *International Journal of Production Research*, 45:13, 3037-3058.

Liu, S., Leat, M., Moizer, J., Megicks, P., and Kasturiratne, D., (2013), 'A decision focused knowledge management framework to support collaborative decision making for lean supply chain management', *International Journal of Production Research*, 51(7), 2123-2137.

Maire, J.-L., Bronet, V. and Pillet, M. (2008), "Benchmarking: methods and tools for SME", *Benchmarking: An International Journal*, Vol. 15 No. 6, pp. 765-781.

Manfredsson, P., (2016) 'Textile management enabled by lean thinking: a case study of textile SMEs', *Production Planning & Control*, 27(7-8), pp. 541-549.

Mathur, A., Mittal M.L. and Dangayach, G.S. (2012) 'Improving productivity in Indian SMEs', *Production Planning & Control*, 23(10-11), pp. 754-768.

Mittal, K., Kaushik, P., and Khanduja, D., (2012) Evidence of APQP in quality improvement: An SME case study, *International Journal of Management Science and Engineering Management*, 7(1), pp. 20-28.

Neupert, K.E., Baughn, C.C. and Dao, T.T.L. (2006), "SME exporting challenges in transitional and developed economies", *Journal of Small Business and Enterprise Development*, Vol. 13 No. 4, pp. 535-545.

O'Regan, N. and Ghobadian, A. (2004), "Short- and long-term performance in manufacturing SMEs: different targets, different drivers", *International Journal of Productivity and Performance Management*, Vol. 53 Nos 5/6, p. 405.

O'Reilly, S., Kumar, A. and Adam, F. (2015) 'The role of hierarchical production planning in food manufacturing SMEs', *International Journal of Operations & Production Management*, 35(10), pp. 1362–1385.

Omerzel, D.G. and Antoncic, B. (2008), "Critical entrepreneur knowledge dimensions for the SME performance", *Industrial Management & Data Systems*, Vol. 108 No. 9, pp. 1182-1199.

Panizzolo, R., Garengo, P., Sharma, M.K., and Gore, A., (2012), 'Lean manufacturing in developing countries: evidence from Indian SMEs', *Production Planning & Control: The Management of Operations*, 23:10-11, 769-788.

Parry, G.C. and Turner, C.E. (2006), "Application of lean visual process management tools", *Production Planning & Control*, Vol. 17 No. 1, pp. 77-86.

Pillania, R.K. (2008), "Creation and categorization of knowledge in automotive components SMEs in India", *Management Decision*, Vol. 46 No. 10, pp. 1452-1464.

Pitta, D.A. (2008), "Case study: product innovation and management in a small enterprise", *Journal of Product & Brand Management*, Vol. 17 No. 6, pp. 416-419.

Powell, D., Alfnes, E., Strandhagen, J.O., and Dreyer, H., (2013), 'The concurrent application of lean production and ERP: Towards an ERP-based lean implementation process', *Computers in Industry*, 64, pp. 324-335.

Psychogios, A.G. and Tsironis, L.K. (2012), "Towards an integrated framework for Lean Six Sigma application: lessons from the airline industry", *Total Quality Management & Business Excellence*, Vol. 23 No. 3, pp. 397-415.

Psychogios, A.G., Atanasovski, J. and Tsironis, L.K. (2012), "Lean Six Sigma in a service context: a multi-factor application approach in the telecommunications industry", *International Journal of Quality & Reliability Management*, Vol. 29 No. 1, pp. 122-139.

Radnor, Z., and Johnston, R., (2013) Lean in UK Government: internal efficiency or customer service?, *Production Planning & Control: The Management of Operations*, 24:10-11, 903-915.

Ramaswamy, N.R., Selladurai, V., and Gunasekaran, A., (2002). Just-in-time implementation in small and medium enterprises. *Work Study*, 51 (2/3), 85–90.

Rashid, A.H.A., Shaari, M.F., Zakwan, N.M.Z. and Basri, N.F.H. (2010), "Lean manufacturing assessment in Malaysia small medium enterprise: a case study", World Engineering Congress, Conference on Manufacturing Technology Management, Kuching, Sarawak, Malaysia, August 2-5.

Roth, N. and Franchetti, M. (2010), "Process improvement for printing operations through the DMAIC Lean six sigma approach", *International Journal of Lean Six Sigma*, Vol. 1 No. 2, pp. 119-133.

Saunders, M.N.K., Gray, D.E., Goregaokar, H., (2013), "SME innovation and learning: the role of networks and crisis events", *European Journal of Training and Development*, Vol. 38 Iss 1/2 pp. 136 – 149.

Shah, R. and Ward, P.T. (2003), "Lean manufacturing: context, practice bundles, and performance", *Journal of Operations Management*, Vol. 21 No. 2, pp. 129-149.

Shah, R. and Ward, P.T. (2007), "Defining and developing measures of lean production", *Journal of Operations Management*, Vol. 25 No. 1, pp. 785-805.

Sharma, M.K., (2009) Receptivity of India's small and medium-sized enterprises to information system adoption, *Enterprise Information Systems*, 3(1), pp. 95-115.

Singh, B., Garg, S.K. and Sharma, S.K. (2010), "Development of index for measuring leanness: study of an Indian auto component industry", *Measuring Business Excellence*, Vol. 14 No. 2, pp. 46-53.

Singh, R.K. (2011) 'Developing the framework for coordination in supply chain of SMEs', *Business Process Management Journal*, 17(4), pp. 619–638.

Singh, R.K., Garg, S.K. and Deshmukh, S.G. (2010) 'Strategy development by small scale industries in India', *Industrial Management & Data Systems*, 110(7), pp. 1073–1093.

Singh, R.K., Garg, S.K. and Deshmukh, S.G., (2005) 'Development of Flexible Strategies by Indian SMEs in Electronics Sector in Emerging Economy', *Global Journal of Flexible Systems Management*, 6(2), pp 15-26.

Slomp, J., Bokhorst, J.A.C. and Germs, R., (2009), 'A lean production control system for highvariety/ low-volume environments: a case study implementation', *Production Planning & Control: The Management of Operations*, 20:7, 586-595

Small and Medium Business Development Chamber of India 2016, Available from: <http://www.smechamberofindia.com/>

Tam, S., and Gray, D.E., (2016), "The practice of employee learning in SME workplaces", *Journal of Small Business and Enterprise Development*, Vol. 23 Iss 3 pp. 671 – 690.

Thakkar, J., Kanda, A., and Deshmukh, S.G., (2013) Supply chain issues in SMEs: select insights from cases of Indian origin, *Production Planning & Control*, 24(1), pp. 47-71,

Thomas, A. J., Francis, M., Fisher, R., and Byard, P., (2016) 'Implementing Lean Six Sigma to overcome the production challenges in an aerospace company', *Production Planning & Control*, 27(7-8), pp. 591-603.

Thomas, T., Barton, R., Chuke-Okafor, C., (2009), "Applying lean six sigma in a small engineering company – a model for change", *Journal of Manufacturing Technology Management*, Vol. 20 Iss 1 pp. 113 – 129.

Timans, W., Antony, J., Ahaus, K., and Solingen, R.V., (2012) 'Implementation of Lean Six Sigma in small- and medium-sized manufacturing enterprises in the Netherlands', *Journal of the Operational Research Society*, 63, pp. 339-353.

Towers, N. and Burnes, B. (2008) 'A composite framework of supply chain management and enterprise planning for small and medium-sized manufacturing enterprises', *Supply Chain Management: An International Journal*, 13(5), pp. 349–355.

Tuteja, S.K., 2001 Partnership for SME development: Ancillarisation/sub-contracting. *Productivity*, 2001, 42(2), pp.247–255.

United States International Trade Commission (2010), *Small and Medium-Sized Enterprises: Overview of Participation in US Exports*, Investigation No. 332–508. USITC Publication 4125, January.

Upadhye, N., Deshmukh, S.G., and Garg, S., (2010) Lean manufacturing system for medium size manufacturing enterprises: an Indian case, *International Journal of Management Science and Engineering Management*, 5:5, 362-375.

Vinodh, S., Gautham, S.G., and Anesh Ramiya R. (2011) Implementing lean sigma framework in an Indian automotive valves manufacturing organisation: a case study, *Production Planning & Control*, 22 (7), pp. 708-722.

Vinodh, S., Kumar, S.V., and Vimal, K.E.K., (2014) Implementing lean sigma in an Indian rotary switches manufacturing organisation, *Production Planning & Control: The Management of Operations*, 25:4, 288-302.

Vlachos, L., (2015) Applying lean thinking in the food supply chains: a case study, *Production Planning & Control: The Management of Operations* 26:16, pp 1351-1367.

Wessel, G. and Burcher, P. (2004), “Six Sigma for small- and medium-sized enterprises”, *The TQM Magazine*, Vol. 16 No. 4, pp. 264-272.

White, G. and James, P. (2014), “Extension of process mapping to identify green waste”, *Benchmarking: An International Journal*, Vol. 21 No. 5, pp. 835-850.

Womack, J., Jones, D. and Roos, D. (1990), *The Machine that Changed the World*, Rawson Associates, New York, NY.

Womack, J.P. and Jones, D.T. (1996), *Lean Thinking*, Simon & Schuster, New York, NY.

Worley, J.M. and Doolen, T.L. (2006), “The role of communication and management support in lean manufacturing implementation”, *Management Decision*, Vol. 44 No. 2, pp. 228-245.

Xiong, M.H., Tor, S.B., Bhatnagar, R., Khoo, L.P. and Venkat, S. (2006), “A DSS approach to managing customer enquiry stage”, *International Journal of Production Economics*, Vol. 103 No. 1, pp. 332-46.

Zhou, B. (2012), “Lean principles, practices, and impacts: a study on small and medium-sized enterprises (SMEs)”, *Annals of Operations Research*, pp. 1-18, doi:10.1007/s10479-012-1177-3.