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Lean implementation within SMEs: A literature review

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Structured Abstract:

Purpose: Lean business ideology has been one of the recent dominant research areas in Operations Management. However, there is a dearth of research focusing on Lean in SMEs. This research contributes to filling this gap by systematically reviewing the literature in relation to the implementation of Lean in SMEs.

Design/methodology/approach: Tranfield et al.'s (2003) systematic review methodology was employed covering three stages: planning, conducting and reporting/dissemination.

Findings: A descriptive analysis of the papers reviewed was provided. From the thematic analysis of the literature four main themes were identified: the scope/type of Lean being adopted by SMEs, how Lean was used in SMEs, the impact of Lean implementation on SMEs and the critical success factors for Lean implementation in SMEs. Key inhibitors and enablers related to firm size when implementing Lean were also identified in the concluding discussion.

Research limitations/implications: Nine recommendations for future research were developed associated with Lean implementation in SMEs.

Practical implications: We suggest SMEs to integrate organisational factors such as employee empowerment and the development of a supportive strategy into their Lean implementation plans. A preliminary "Staircase Road Map" to guide SMEs in implementing Lean has also been developed.

Originality/value: This paper goes beyond previous literature reviews of Lean by systematically and critically evaluating key themes of Lean implementation within an SME environment. It not only provides a Road Map for SME owners/managers who intend to implement Lean, but also provides the academic community with an agenda for future research.

Keywords: Small and Medium Sized Enterprises (SMEs), Lean, literature review

1. Introduction

The modern marketplace is commonly characterised in many sectors by hyper-competition, a state, which has accrued over many years (D'Aveni 1994). Hyper-competition has been driven by the combined impact of macro-forces changing the nature of both supply and demand. On the supply side, environmental factors such as the increasing globalisation and deregulation of commerce have opened up markets to be provided for by a greater volume of companies (Harvey *et al*. 2001). This has combined with the development and adoption of new technologies, which has enhanced the sophistication of supply capabilities (Harvey *et al*. 2001). On the demand side, customers, presented with this increased proliferation and sophistication of choice in supply, are characterised by a growing assertiveness in seeking out better and better values when selecting products and services (Bhamu and Sangwan 2014).

For organisations, hyper-competition has led to a realisation that more demanding rules for business now exist to be successful in the modern age. There needs to be a full recognition of what customers' value combined with a focus on the optimisation of operating processes to effectively compete in serving customers (Bowersox et al., 2000). The "Lean" business ideology (Bhasin 2013), which has been one of the dominant research areas in Operations Management (Voss 1995, Shah and Ward 2003), has thus been turned to by many organisations to guide their mind-set and efforts in addressing these needs. Lean sets out a methodology for being highly responsive to customers' demands whilst constantly challenging costs and wastes throughout supply networks (Bhamu and Sangwan 2014, Shah and Ward 2007). So, it would appear that Lean can be applicable to all sizes of enterprise in their endeavours to become more competitive to sustain, and possibly enhance, their position in the modern marketplace.

Broadly, organisations can be simply categorised into two groups: Large Enterprises (LEs) and Small and Medium sized Enterprises (SMEs). It would appear however, that there is a significantly lower up-take ~~lower take up~~ of Lean in SMEs compared to LEs (Shah and Ward 2003) and that many SMEs are still unfamiliar with Lean implementation (Achanga et al. 2006). Research has indicated that this is due to many factors, which will be further explored and examined in this paper. While several studies that have addressed Lean implementation in general (e.g. Hines et al. 2004, Holweg 2007, Moyano-Fuentes and Sacristan-Diaz 2012), many focus on LEs rather than SMEs (Brown and Inman 1993, Gnanaraj et al. 2010b). So, there is a dearth of research that focuses on Lean in SMEs. This paper focuses on contributing to filling this gap by conducting a systematic literature review of Lean implementation in SMEs. The following research questions guide this study:

- What are the key descriptive characteristics and themes that have emerged within academic studies of Lean in SMEs?
- What are the implications of this research for practitioners?
- What are the future areas of research required to assist SMEs when implementing Lean?

The contributions of this study are threefold: ~~:~~ First, there has been no previous comprehensive, systematic literature review of Lean implementation in SMEs and this study goes beyond previous literature reviews of Lean by systematically and critically evaluating key themes of Lean implementation within an SME environment. Second, a "Road Map" is developed as a result of this systematic review, which guides SME owners and managers in the implementation of Lean. Finally, it provides the academic community with an agenda for future research.

This paper consists of nine sections. After this brief introduction, a literature review is presented in section 2. It is divided into two sub-sections: firstly, a background summary of Lean is provided which briefly covers the history and key features of what Lean stands for. Secondly, some of the pertinent issues that surround the debate of whether Lean is equally applicable to SMEs compared to LEs are raised. Section 3 explains and justifies the research method (i.e. Tranfield et al.'s (2003) systematic review methodology) adopted in this study. Sections 4 and 5 will report on the findings from the descriptive and thematic analysis of the synthesised literature. The discussion of findings is then presented in section 6. Sections 7 and 8 address the implications of this study for academics and practitioners respectively. The final section concludes this study in relation to the three research questions.

2. Literature Review

2.1 Background

Krafcik (1988) initially proposed the term "Lean" based on the Toyota Production System (TPS) in his thesis at Massachusetts Institute of Technology (Shah and Ward, 2007). It was then popularised by two books, "*The Machine that Changed the World*" (Womack et al. 1990) and "*Lean Thinking*" (Womack and Jones 1996).

Lean is a multi-faceted concept that was identified and coined to explain the success of the "Japanese Way of Working" that fuelled their increased competitiveness at the time. Components of the "Lean Idea" include:

- operations concepts, such as zero inventories (Hall 1983), Just-in-Time (JIT) (Karlsson and Åhlström 1996) and small lot sizes (Burcher *et al*. 1996);

- the underpinning of robust quality procedures exemplified by Total Quality Management (TQM) and Total Productive Maintenance (TPM); and,

- a method of working that encourages empowered employee participation which challenges the over-bureaucratic top-down, function orientated organisational structures that had traditionally dominated many "~~western~~Western" organisations (Hines et al. 2010).

Shah and Ward (2003) endorsed this view of Lean, categorising the components of Lean into four "bundles": JIT bundle, TQM bundle, TPM bundle and Human Resource Management (HRM) bundle. To be successful in implementing all these Lean facets in a coordinated, coherent manner, strong leadership and a clear alignment with organisational strategy over many years is required.

In summary, Lean is the antithesis of the mass production approach where competitive advantage is sort through costs advantages derived via economies of scale (large batch runs etc.), but which produces significant inefficiencies between functions. Lean challenges this, focusing the organisation (and their supply chain) around the reduction of what is termed waste (any activity that occurred in the cycle of production that provided no value to customers). Thus, Lean sacrifices the economies of scale of mass production and aims instead to provide superior customer value through holistic process optimisation, both within the organisation and up and down the supply chain.

Lean has various inherent direct advantages that enhance the ability of organisations to successfully compete through being more effective and efficient in their operations. In addition to these more obvious benefits, there are also some notable in-direct advantages that arise from successfully implementing Lean.

- **Closer integration with supply chain members** - Lean demands that supply chain members become inter-dependent and thus it demands that they collaborate to achieve this. This can be extended across many tiers of the chain of supply involving potentially many actors, exemplified by the Keiretsu supply networks in Japan (Lamming 1996). This requires building mutual trust and common ways of working, which can enhance operations across the whole supply chain operation. So, by developing inter-organisational links to support Lean along the supply chain, a more strategic and cooperative way of working, shared amongst supply chain partners, is encouraged.

- **Spin–off benefits of taking a total quality approach** – A pre-requisite of successfully implementing Lean is to have absolute confidence in the robustness and reliability of all processes and product components to ensure zero defects. After all, if there are no buffers, for instance in inventory or time, available to fall back on then any quality problems encountered will have a direct and damaging impact on Lean operations. The spin-off benefit from this is that the total quality emphasis means finished products and services that the customer is exposed to have this total quality characteristic inherently built in too – perhaps it should not be a surprise that still in 2014, according to the JD Power ratings, that the 4 most reliable automotive production plants in the world in terms of car defects are all run by Japanese companies (Associated Press 2014).

- **Lean facilitates a high-velocity of learning** – for organisations that follow the Lean journey, Spear (2009) found that they not only can get ahead of their competitors but that they can sustain this advantage as well. He explained that this was due to Lean organisations being:

- quicker at identifying the key problems that needed rectifying;
- better at solving these problems to build new knowledge; and,
- more effective at sharing this knowledge across the organisation.

Lean organisations also continuously developed these capabilities. The effect is that they are propelled along at a faster learning rate than non-Lean organisations.

Lean clearly has many advantages, both direct and in-direct, for participating organisations, but it has never been an easy concept to define. Indeed, Lean has been interpreted in many different ways by practitioners and academics that mean that there is no real consensus around what Lean specifically stands for or what exact "characteristics should be associated with the Lean concept" (Bhamu and Sangwan 2014).

To help illuminate the breadth of the way Lean can be interpreted by different authors and practitioners, Pettersen (2009), building on Hines et al. (2004) and Shah and Ward (2007), has identified four alternative Lean approaches:

- an operational philosophy – "Leanness";
- a strategic philosophy – "Lean thinking";
- an operational practice – "tool box Lean"
- a strategic practice – "becoming Lean".

So when studying Lean, researchers must be careful and aware that Lean has many different meanings to different people. From our experience however, some of the common features that characterise Lean are as follows:

- continuously identifying and focusing on customers' values;
- aligning the purpose of core and support processes around providing these customer values;
- ensuring the entire organisation is focused on efforts to support the optimization of these processes by removing wastes;
- continually improving the foundations required, such as developing quality capabilities, empowering individuals and teams, and building inter-organisational relationships;
- developing a system-wide mentality to continual improvement.

2.2 The Applicability of Lean to SMEs as opposed to LEs

Lean has been increasingly recognised as a key improvement concept for all types of organisations to enhance their operations. However, a number of authors have argued that the types of organisations who have firstly embarked on the Lean journey and secondly found success in this have been predominately larger organisations (Shah and Ward, 2003 and Bhamu and Sangwan, 2014). This provokes the question of Lean's applicability to SMEs, which are commonly recognised as being crucial to the development of economies across the world.

On a paper on SMEs, it is also useful to examine how SMEs are defined. Again, there is no consensus on definition, as definitions across the world vary (Karlsson and Ahlstrom, 1996). A harmoniously agreed definition is now applied across the European Commission (EC). However, in China SMEs are defined very differently, for example employee numbers should be no more than 999 compared to 250 in the EC, and in the

US the number is 499. Table 1 provides a comparison of SME definitions around the world.

Insert table 1 about here

While note should be taken of the disparities of SME definitions, there is still considerable interest in whether there is a difference in the applicability of Lean between LEs and SMEs (for example, Rose et al. 2013). Is firm size a critical factor in Lean implementation? The paper will aim to contribute to this by developing a fuller understanding of the pertinent issues which surround this debate through reviewing the literature related to SMEs and Lean, including the following areas of interest.

From our discussion above, it is clear that Lean can range from a discrete operational improvement, such as introducing Lean tools on the shop floor to, at the other extreme, a more multi-faceted strategic continuous journey that changes the complete philosophy of the organisation and its supply chain partners. The former understanding of Lean is clearly less complex and time-consuming to implement, so the scope of Lean is an important consideration to cover in the literature review of Lean and SMEs.

Furthermore, the large investment costs (financial, time and effort) involved in implementing fuller versions of Lean could be seen to be in excess of the budgets of SMEs. Other issues related to firm size and resources could include the degree of power or influence an SME possesses in the supply chain they operate within. The SME may also be less able to influence the nature of demand, which some proponents of Lean argue can be an important feature (e.g. levelling off demand variability) (Dowlatshahi and Taham 2009, Rymaszewska 2013).

Other characteristics identified for the successful implementation of Lean include strong and able leadership, with a clear vision and a strong commitment to Lean demonstrated in the organisation's strategy, an empowered workforce with an ethos that supports training, an aligned pay and remuneration system to the Lean endeavour, a well-developed performance measurement system, a supportive organisational culture, a passion for quality and so on. To what extent are SMEs advantaged or disadvantaged in these and other areas in implementing Lean?

There have been a number of reviews of the Lean literature. For example, Hines et al, (2004) reviewed the evolution of Lean, Holweg (2007) looked at the genealogy of Lean production, Moyano-Fuentes and Sacristan-Diaz (2012) developed an overview framework of Lean, and most recently Bhamu and Sangwan (2014) conducted a review of Lean manufacturing literature. However, these reviews have largely focussed on Lean in general or larger enterprises and thus there is a gap in reviewing the literature on Lean that is pertinent to SMEs. Therefore, this review aims to contribute to filling this void by reporting on a literature review which focuses on Lean implementation in SMEs with the purposes of providing insights for practitioners who plan to implement Lean, and also setting an agenda for future research.

3. Methodology

A comprehensive literature review of Lean implementation in SMEs was undertaken to address these research questions. To carry this out, Tranfield et al.'s (2003) systematic review methodology was employed for the following reasons. First, in comparison to the traditional narrative review, the systematic review offers a more transparent, scientific and reproducible procedure for the literature search and analysis (Suarez-

Barraza et al. 2012, Tranfield et al. 2003). Second, although other systematic review guidelines, such as Adolphus (2015), Easterby-Smith et al. (2012) and Seuring and Gold (2012), were considered by the authors, Tranfield et al.'s (2003) methodology, which originally extended the systematic review method from medical science to management research, was selected since it provides clearer and more detailed guidance to assist researchers in how to conduct the literature review and present results (Rashman *et al*. 2009, Thorpe *et al*. 2005). It also gives a more comprehensive discussion about how to analyse the literature. Tranfield et al.'s (2003) methodology has been widely applied in many fields in management research such as organisational learning and innovation (e.g. Becheikh *et al*. 2006, Crossan and Apaydin 2010, Rashman *et al*. 2009), supply chain and operations management (e.g. Chicksand et al. 2012, Grubic and Fan 2010, Suarez-Barraza et al. 2012) and small business management (e.g. Garengo et al. 2005, Johnson and Schaltegger 2015, Macpherson and Holt 2007).

According to Tranfield et al. (2003), the systematic review consists of three stages: the planning stage, conducting stage and reporting/dissemination stage.

3.1 Planning stage

During the planning stage, a review panel was formed. The review panel consisted of four researchers (all authors of the paper), who each had work experience founded in academia and industry. This complied with Tranfield et al.'s (2003) recommendation that the panel is formed from experts working in the field. The panel held four meetings to discuss the focus of the systematic literature review and develop the research questions of this review. Inclusive and exclusive criteria were defined (see table 2).

Insert table 2 about here

Papers (written in English) published in both scholarly and trade journals were included as the authors recognised that many Lean related articles written by scholars are published in trade journals. Newspapers, magazines and reports were excluded as these types of articles were more likely to provide a snapshot of Lean implementation rather than the detailed and in-depth description or discussion the authors were looking for. Working papers were also excluded as these often represent researchers' temporary thinking and are subject to change. The appropriate bibliographic databases and keywords for searching the literature were also identified during the panel meetings. The bibliographic databases employed were ABI/INFORM Global, EBSCO Business Source Premier, Emerald, Scopus and ScienceDirect, the key databases within the field of business and management. Since this study focused on Lean implementation within SMEs, Lean and SMEs were central terms to the literature search. However, as the term "Lean" was developed after 1988, original terms such as TPS and JIT (Samuel, 2011), which as noted above Lean was built upon, were also included as keywords in our research. Additionally, SME is an abbreviation for a small organisation or small business or small company; thus these three terms were also included in our search. The panel provided a useful narrative expertise review to cross-check the robustness and reliability for the method adopted, such as in checking for any significant omissions or over-sights resulting from the selection of search terms, time periods, databases etc. This strengthened the quality of the systematic review process.

3.2 Conducting Stage

To conduct the systematic review, the search strings were constructed based on the search terms identified at the planning stage (see table 3) and each search string was entered in exactly the same way to the bibliographic databases (all searched in abstract,

title and keywords). The number of papers generated from the search totalled 334 papers (the final cut-off date of the literature search being 28 February 2015).

Insert table 3 about here

The title, abstract and keywords of these 334 papers were independently examined by two researchers from the panel for their fit with our research focus. One hundred and seventy one papers were excluded at this point as not being relevant. These included non-academic papers such as 'grey' literature and general commentaries that did not provide insights into the Lean implementation issues in SMEs. A further sixty-two papers were removed as they appeared in more than one database. The abstracts and main body of the remaining one hundred and one papers were then reviewed by the same two researchers independently, which were all either empirical research or conceptual studies. An Excel spread sheet was created to extract the general information including title, the year of publication, authors, journals and other features of these papers covering research focus, Lean implementation approach, research methods, geographic research areas and industry sectors.

Disagreements over filtering or categorisation of papers were highlighted as "unsure" papers, these were then reviewed by the two remaining review panel members and revised suggestions were proposed. Their suggestions and the underlying rationales were discussed among the full panel of four researchers before a consensus decision was reached for each issue. This cross checking of the systematic literature review enhanced the validity of the results.

In the analysis phase, four main themes were identified through the parallel and simultaneous exercise of categorising and sub-categorising the collected papers, in a similar manner to the method used by Suarez-Barraza et al. (2012) in their review of the

Lean service literature. The final categorisation was crosschecked and confirmed by all panel members.

3.3 Reporting and dissemination stage

It is recommended by Tranfield et al. (2003) that the reporting and dissemination stage should cover two parts: a "descriptive analysis" and a "thematic analysis". Based on the Excel spread sheet, a descriptive analysis was conducted to show the "current map" of the collected papers. The second part, the thematic analysis, provided an in-depth look at the four key themes that emerged from the review.

4. Findings: part one - descriptive analysis

This section considers the descriptive analysis of the Lean SME literature. Tranfield et al. (2003) suggest that this should cover the "descriptive account of the field" through a simple categorisation of the literature. The following sections have been identified: research methods; geographic areas and industry sector.

4.1 Research methods

The prominent method employed among the 101 papers was the single case study which accounted for 35% of total published papers (see figure 1) (e.g. Gupta and Brennan 1995, Lummus *et al*. 2006, Sohal and Naylor 1992, Yogesh *et al*. 2012). The survey was the second most popular method representing 32% of papers (e.g. Burns and Rishel 1994, Dora *et al*. 2013, Iris and Cebeci 2014, Lee 1997, Ravikumar *et al*. 2013). The conceptual papers, which focused on developing theoretical frameworks, models or steps to guide SMEs in implementing Lean, accounted for 17% of papers (e.g. St John and Heriot 1993, Wanitwattanakosol and Sopadang 2012).

The field of Lean implementation in SMEs lacks multiple case studies, mixed methods research and action research. There were eleven papers (11% papers) which adopted multiple case studies (e.g. Achanga *et al*. 2006, Stuart and Boyle 2007). There were only four papers (4%) that adopted mixed methods, which combined - large-scale surveys and interviews or case studies (Bhasin 2012, Lee 1997, Timans *et al*. 2012, Yang and Yu 2010). According to Bhasin (2012), the use of mixed methods enables researchers to improve the validity of the findings, from for instance a questionnaire survey, through the triangulation of different data sources. Most recently, Emmitt et al. (2012) adopted an action research method to identify and bring changes to a small construction company through the application of Lean. Following Lewin's (1946) action research processes, Emmitt et al.'s (2012) study provides an in-depth description of Lean implementation and shows how the researchers collaborated with practitioners when implementing Lean.

Insert figure 1 about here

4.2 Geographic areas

Of the 101 papers reviewed 79 indicated the geographic area covered. From the analysis, it is evident that Western areas have dominated previous research with 29% of the papers being US and Canada based, 32% EU based and 8% from Australia and New Zealand (see figure 2). Asia, which plays an important role in the global market, occupied only 28% of studies (e.g. Gunasekaran and Lyu 1997, Kumar *et al*. 2006, Lee 1997, Li *et al*. 2011, Panizzolo *et al*. 2012, Rahman *et al*. 2010, Rose *et al*. 2013, Singh *et al*. 2009, Sukwadi *et al*. 2013). Further analysis of the twenty Asian based studies found the majority to be in India. Surprisingly, there were only two studies which investigated Lean implementation in the region of China, in Wenzhou's manufacturing

companies (Yang and Yu, 2010) and Taiwan's automotive industry (Gunasekaran and Lyu, 1997). The latest information shows that there are more than 10,000,000 SMEs in China, which account for more than 90% of the total number of Chinese enterprises and contribute to 60% of Chinese GDP (Xinhua 2011). Hence, this implies opportunities for research clearly exist in the area of Chinese SMEs and their implementation of Lean. There is also a clear dearth of Lean SME research in other developing areas of the world, such as South America and Africa.

Insert figure 2 about here

4.3 Industry sectors

In terms of industry sectors (i.e. manufacturing/construction, service or cross sectors), 90 of the 101 papers included this information. Unsurprisingly, given the origins of Lean, the manufacturing sector dominated with 84 published papers (93% of papers) (see figure 3). The automotive, mechanical, electrical and electronics manufacturing represented the majority of these (e.g., Gunasekaran and Lyu 1997, Kumar *et al*. 2006, Lee *et al*. 1994, Rose *et al*. 2013, Santacecilia 1992, Thomas and Barton 2011). Other industries, such as the furniture and food sectors were also popular (see Agyapong-Kodua *et al*. 2009, Chen *et al*. 2010, Dora *et al*. 2013, Mo 2009, Nabhani and Shokri 2009,).

Three (3%) papers were related to the service sector (e.g. Lummus *et al*. 2006, Nabhani and Shokri 2009, Seay and Narsing 2013). The remaining papers (n=3, 3%) included both manufacturing and service sectors (cross sectors) and used questionnaire survey-based research (e.g. Kinney and Wempe 2002, Smith *et al*. 2003, Zhou 2012). This plethora of manufacturing related articles could well have been anticipated due to the origins of Lean being in the manufacture of automobiles. However, Alsmadi *et al.*

(2012) note there is an increasing interest in exploring the application of Lean in service-related organisations.

Insert figure 3 about here

5. Findings: part two – thematic analysis

According to Tranfield et al. (2003) the thematic analysis of a literature review should interpret the degree to which there is a consensus or not in terms of the key themes in the relevant literature field and identify the emerging themes and potential future research questions. Four main themes were identified through the parallel and simultaneous exercise of categorising and sub-categorising the collected papers following the method outlined above, in a similar manner to the method used by Suarez-Barraza et al. (2012) in their review of the Lean service literature:

- Theme 1 looked at what scope / type of Lean is identified by the literature as being adopted by SMEs;
- Theme 2 focused on how Lean is implemented in SMEs;
- Theme 3 addressed the impact of Lean implementation on SMEs;
- Theme 4 reviewed the critical success factors for Lean implementation in SMEs.

5.1 Theme 1: What scope / type of Lean is implemented in SMEs?

For the papers that identified a model or process for implementing Lean in SMEs, there was a discernible emphasis on internal operations (table 4). Only one study (Wanitwattanakosol and Sopadang, 2012) was devised to directly consider Lean implementation at the supply chain level including the integration of suppliers. This

supports the findings of Bhasin (2012) in a study of Lean in UK manufacturing organisations where he found that only 20% of small organisations applied Lean to the whole value chain compared to 80% which were internally focussed on their Lean implementation.

Insert table 4 here

In relation to Pettersen's (2009) typology of Lean, it would appear that SMEs are more likely to be operationally focussed, the type of Lean being implemented being commonly an "operational practice" variant or at most an "operational philosophy" type. It is rarely strategic or external to the organisation in terms of linking up and integrating with supply chain partners according to the literature.

This is quite different to what is observed in the literature for Lean in LEs, which is more likely to be a "strategic philosophy" type. Stuart and Boyle's (2007) argument, which points out that Lean implementation beyond the factory floor of SMEs can rarely be found, is a typical manifestation of this. In other words, although Karlsson and Åhlström (1997) contend that the applicability of Lean can be extended to the supply chain of SMEs, there is little evidence of Lean being extended to the supply chain level by SMEs and we still know little about how Lean can be implemented at the supply chain level by them.

5.2 Theme 2: How Lean is implemented in SMEs

Much of the research on Lean in relation to SMEs concentrates on how SMEs implement Lean. The thematic analysis of this is divided into two sub-categories: the approaches to Lean in SMEs and how the Lean approach can be combined with other supporting initiatives.

5.2.1 Theme 2.1: The approaches to implement Lean in SMEs

In the literature it is clear that SMEs can employ a range of approaches and Lean tools to operationalize or facilitate Lean implementation (see table 5).

Insert table 5 about here

There are a wide range of papers (table 5) that highlight the use of Lean tools by SMEs in implementing Lean. For example, this is particularly seen in mapping tools (e.g. Value Stream Mapping, (VSM), the use of Kanban and 5S/6S work place organisation initiatives combined with the use of visual management. Standardised Work and TPM are also fairly popular.

A few other tools are only more fleetingly covered in the SME Lean literature: for example, 5 Whys, Level Scheduling, Kaizen, Small Lot Sizing and Single Minute Exchange of Die (SMED). Bhasin (2012), in his survey, confirms this indicating that LEs are more likely to adopt some of the tools that are seen as less popular for SMEs.

There also seems to be a tendency for SMEs to be more selective than LEs in the range of tools that are adopted in a Lean implementation journey. Mathur et al. (2012) explain this, suggesting that given the financial, time and technical constraints encountered by SMEs, they select Lean tools that are simple and inexpensive to use.

Interestingly, the rationale for the selection and combination of the tools/techniques is absent from most of the Lean SME literature, which given the holistic approach advocated as important for Lean (Hines et al, 2010) to be successfully implemented, would seem to be a notable omission.

5.2.2 Theme 2.2: How the Lean in SMEs approach can be combined with other supporting initiatives

Another aspect of the implementation of Lean by SMEs covered in the literature is the combining of Lean with other supporting initiatives (table 6). The most popular of these is the combination of Lean implementation with Six Sigma. Six Sigma emphasises quality control and improvement through the use of rigorous data collecting methods and statistical analysis (Nabhani and Shokri, 2009), ultimately to reduce both manufacturing and service costs and improve customer satisfaction (Thomas *et al.*, 2009). There is clearly a natural link between Six Sigma and Lean and some SMEs are utilising this. When examining the models and frameworks proposed, it can be found that researchers who link Lean with Six Sigma prefer to develop some specific models (i.e. Lean Sigma models) while others provide frameworks for more general processes or stages for the implementation of Lean in SMEs. For the Lean Sigma model, the focus is integrating some Lean tools into the DMAIC methodology (define measure, analyse, improve and control). For example, Kumar *et al.* (2006), Roth and Franchetti (2010) and Thomas *et al.* (2009) describe how to employ Lean tools, such as VSM and TPM, at each phase of DMAIC. However, such prescribed models are criticised by Gnanaraj *et al.* (2010a). They argue that many SMEs lack the capability to implement Lean Sigma immediately and therefore, in consideration of the deficient characteristics of SMEs, they propose a more realistic model namely, the DOLADMAICS model (Gnanaraj *et al.*, 2010a, p.300). In their model, the deficient characteristics of SMEs can be overcome gradually through five levels (Gnanaraj *et al.*, 2010b; 2012). The DOLADMAICS model considers the reality of SMEs and attempts to operationalise both Lean and Six Sigma in SMEs, but the empirical evidence that supports the full application of this model is limited.

The other popular support area is the use of IT developments to underpin Lean implementation. IT is now pervasive in the operating structures of virtually all modern organisations so systems such as Material Requirements Planning (MRP) and Enterprise Resource Planning (ERP) have to be incorporated in any Lean journey SMEs embark upon. For example, Powell, et al. (2013) propose a model for the IT system to be gradually changed over a long time period to reflect the Lean way of working.

Insert table 6 about here

Other combining approaches including Accounting Method, Cellular Manufacturing, Project Management, Quality Function Deployment (QFD), Theory of Constraints (TOC) and Quick Scan are evident, but attract less attention.

5.3 Theme 3: The impact of Lean implementation on SMEs

As most researchers discuss Lean implementation at a micro level (e.g. the internal production or operation processes in SMEs), it is unsurprising that the dominant objective for Lean implementation in SMEs is waste reduction on the shop-floor. Criteria cited in the literature to indicate this tendency to emphasise efficiency initiatives in Lean SMEs include reductions in inventory, space, time (i.e. changeover time, delivery time, lead time and throughput time) and cost of products. All illustrate the potential positive impact of Lean implementation on SMEs (e.g. Boughton and Arokiam, 2000; Lummus et al., 2006; Chandandeep, 2008). Improvements in quality and productivity (e.g. manpower utilization) are also contended as being important (e.g. Dora *et al*., 2013; Li *et al*., 2011; Roth and Franchetti, 2010; Singh *et al*., 2009)). It is interesting to note that although there is only one study that directly addresses Lean

implementation at the supply chain level (see Theme 1), the criteria used to measure the impact of Lean on SMEs relating to suppliers and customers are confirmed as important in a few studies (e.g. Stamm and Golha, 1991; Sohal and Naylor, 1992; Wadhwa, 2013).

Only one study (Zhou, 2012) directly reports the financial impact (i.e. profit margin) of Lean implementation in SMEs, a clear gap in the research. It partially reveals that there may be a time lag between Lean implementation and its financial benefits, but it also potentially supports Chiarini's (2012) critique of accounting methods as the financial benefits of Lean implementation cannot be reflected accurately by traditional accounting methods.

Another interesting trend is that, although employee involvement and participation, top management support and commitment, training and education and organisational culture change are recognised as important Critical Success Factors (CSFs) for the implementation of Lean in SMEs, as will be discussed in the next section, few researchers have reviewed how these can be improved or changed when conducting a Lean programme. The impact of improved employee motivation, interests and ability (Golhar *et al*., 1990; Gunasekaran and Lyu, 1997; Gupta and Brennan, 1995; Phillips and Ledgerwood, 1994; Sohal and Naylor, 1992, Panizzolo et al., 2012) and employee empowerment (Seetharaman *et al*., 2007) have been studied, but only Manoochehri, (1988) explains organisational culture change by implementing JIT.

Table 7 summarises all this, clearly indicating the bias in Lean SME research in focusing on efficiency compared to effectiveness improvement.

Insert table 7 about here

5.4 *Theme 4: Critical Success Factors (CSFs) of Lean implementation in SMEs*

Only one study (Achanga *et al*., 2006) has a full research aim which focuses purely on investigating the critical success factors for Lean implementation in SMEs. The findings here suggest that leadership and management strategy, financial capability, employee expertise and skills and organisational culture are the critical factors that enable SMEs to achieve a successful Lean implementation.

However, other researchers directly or indirectly discuss the CSFs (see table 8). By examining these papers, a number of trends can be observed. First, employee involvement and participation is an additional point to Achanga et al. (2006). This is cited by Panizzolo et al, (2012 p.785), who state that "the involvement of workers in the continuous quality improvement programmes, expansion of their autonomy and responsibility……have been crucial for improvements in firms' performances". Hines et al. (2010 p.18) agree acknowledging, "the engagement of people on a Lean journey is essential", irrespective of the company size.

Insert table 8 about there

Other factors, such as top management support and commitment, training and education and organisational change (i.e. culture, strategy and vision), are common CSFs, which concur with Achanga et al.'s (2006) findings. Panizzolo et al. (2012) confirm this, identifying top management commitment, and willingness and ability to change an organisation's culture and the development of individual and team skills as being keys for successful Lean implementation in SMEs. Bhamu and Sangwan (2014) agree, but argue this is also important for any organisational size, and hence these are not distinctive SME issues.

"It is important that top executives who run the company are committed both to a long-term vision of adding value to customers and society in general and to developing and involving employees and partners"

Panizzolo et al. (2012, p. 786)

As argued by Mazany (1995), the real issue during the implementation processes is not technical issues but people.

Second, although Achanga et al. (2006) highlight the financial constraints of SMEs, only one other study recognises financial capability as a CSF. This implies that there is not a clear consensus around the importance of the financial capability of SMEs in the successful deployment of Lean implementation.

Third, it is worth noting that the investigation of CSFs extends from the intra-organisational level to the supply chain level as the importance of supplier or customer integration is recognised. For example, Ormsby *et al*. (1994) initially indicate that to successfully implement JIT, small firms are encouraged to foster a cooperative environment among supply chain members. So and Sun (2010) demonstrate the regular use of Lean in SMEs is positively influenced by supplier integration strategies, such as information sharing and the use of e-business. Timans *et al*. (2012) also emphasise the importance of integrating customers and collaborating with supply chain members. Thus the integration of supply chain members, not identified in Achanga et al.'s (2006) study, would seem to be important to add to the list of CSFs.

Finally, communication and personal experience are two further CSFs. Lee (1996) suggests that keeping direct communication between managers and employees contributes to successful JIT implementation. Timans *et al*. (2012) further point out that

in addition to communication, personal experience such as one's past experience of being a quality manager is a new CSF. However, the empirical evidence for these new CSFs is limited. Lee (1996) derives this finding from a conceptual analysis and Timans *et al*. (2012) propose this CSF from one interview.

Perhaps what is required for the successful implementation of Lean in SMEs is a clear road map to guide the Lean journey. This is not cited as a clear summary of CSFs in the papers reviewed. However, some generic frameworks have been developed to allow for the coordinated implementation of Lean tools or practices (see Gupta and Brennan, 1995).

A common feature is to start Lean programmes with developing employees and managers' engagement and education in connection with the introduction of Lean. For example, Chin and Rafuse (1993), Gunasekaran and Lyu (1997) and Van Landeghem (2011) recommend that the implementation process should start with training and educating employees or managers rather than simply implementing Lean tools. Similarly, Chin and Rafuse (1993) believe teaching and learning should be promoted during Lean implementation. Dombrowski et al. (2010) compare and contrast three approaches of learning Lean based knowledge which can be employed at different implementation phases. A synthesised road map to help guide SMEs on lean implementation derived from the findings in this study will be presented later.

6. Is size of firm an enabler or inhibitor of Lean implementation?

SMEs, are self-evidently smaller than LEs. To pull the various strands of pertinent literature together, the fundamental question of does this issue of size impact on SMEs ability to implement Lean can be used to frame our reflective discussion? It would appear from the Lean SME literature that on balance when implementing Lean, both at

an organisation and a supply chain enterprise level, it does, although there are also some factors that are in ~~the~~ favour of SMEs when implementing Lean.

6.1 *Inhibiting Factors*

One of the key inhibitors related to size surrounds the issue of supply chain power. This impacts on the influence SMEs may have in developing reliable supplier networks and their ability to involve suppliers in their Lean endeavours. Dowlatshahi and Taham (2009) and Wilson and Roy (2009) indicate that due to the typical small volumes associated with SMEs, it is difficult for them to negotiate with larger suppliers. For example, Finch (1986) argues the involvement of suppliers and customers around the concept of JIT delivery and uniform workload are infeasible as SMEs lack the negotiating power with suppliers in the market. Manoochehri (1988) develops this argument and points out that to implement JIT entirely, the manufacturer, whatever their size, should be able to:

- stabilise demand;
- manufacture products or components in small lots just in time; and,
- receive raw materials from suppliers in the right quantity at the right time.

However, considering the position of most SMEs in the market, Manoochehri (1988) believes that most SMEs cannot meet the first and third requirements. This means that Lean in SMEs is closer to JIT production (i.e. operations processes improvement by waste reduction) than JIT delivery, where it is extended up the supply chain. SMEs have therefore resorted to encouraging the JIT process, and the wider ambitions of creating the Lean supply chain, rather than enforcing it (see for example Panizzolo et al, 2012).

Karlsson and Åhlström's (1997) study assesses whether the principles of a Lean enterprise can be applied by SMEs. The findings indicate that the majority of principles can be implemented but those relating to procurement and distribution should be adjusted for SMEs. No further study was found within the terms of our literature search which investigate the applicability of Lean based principles in SMEs on their supply chains.

Within the SME organisation itself, poorer processes and quality control systems have also been seen as barriers to Lean implementation at an operational level (Lee, 1996 and 1997). Moreover, the transition of current processes or production systems to a Lean production system can be more problematic in an SME, when a greater proportion of the workforce are deployed in day to day operations. What is critically needed in Lean SMEs is a clear vision of the steps needed to overcome this (see Panizzolo et al., 2012). This should go beyond a direct plan to improve operational issues to also include the more strategic organisational factors needed to support Lean implementation, such as developing employee empowerment and participation in decision making and ensuring a supportive organisational culture for Lean is present (and if not developed). Many of the studies do not place sufficient emphasis on this, concentrating more on the operational level without reflecting on the organisational issues which need to be developed in parallel.

At the financial level, most researchers posit that SMEs lack the funding (Golhar et al., 1990; Ormsby et al., 1994; Lee, 1996; Dowlatshahi and Taham, 2009; Thomas et al., 2009; Mazanai, 2012) and infrastructure/facilities (Boughton and Arokiam, 2000; Panizzolo et al., 2012) needed to implement Lean. The on-going implementation of the full version of Lean can require substantial sums of investment before benefits are realised and SMEs may be more restricted in this regard in terms of available financial

resources or the ability to invest the up-front in the time needed to support training and knowledge development (see for example, Mazanai, 2012). Infrastructure, for example in terms of a well-developed key performance indicator (KPI) system, which could be used to support a Lean initiative, is also recognised as a potential disadvantage for Lean SMEs, who may not have had as much of a need for this kind of system before compared to LEs. In addition, SMEs may be unlikely to be able to afford the deployment of specialist Lean implementers.

From the dimension of the customer, some researchers indicate that demand variability can inhibit Lean implementation. SMEs may have less power with their customer base to influence patterns of demand so that it can become more predictable and stable (Boughton and Arokiam, 2000; Dowlatshahi and Taham, 2009; Rymaszewska, 2013).

6.2 *Enabling Factors*

Firstly, from the supplier side, Karlsson and Ahlstrom (1997) identified that SMEs often have a unique business area they focus upon and therefore supplying agents are more dependent on them because there are no substitute buyers available to them. This power makes them more able to influence suppliers to adopt Lean practices, a counterpoint to some of the inhibitors in this area mentioned above.

Within the SME organisation there are a few enabling factors too when implementing a Lean strategy. Lean requires good communication levels up and down the organisational structure and between functions / departments. This would appear to benefit SMEs in that they are invariably characterised by high levels of group work and a strong ethos of cohesiveness, not restricted by functional boundaries. In smaller organisations communication is easier too, with employees and managers invariably

working more closely together and therefore providing more opportunities for direct communication (Dowlatshahi and Taham, 2009).

The smaller size of SMEs also means that their production systems ~~maybe~~ are more flexible and able to produce in small lot sizes to satisfy various customer requirements (Lee, 1996). This means they ~~maybe~~may be more naturally attuned to the demands of Lean than larger enterprises starting their Lean journey, who ~~maybe~~ are more organised around economies of scale with batch production strategies.

The position of the SME leader may also be an advantage. Often SMEs are privately owned, with the owner taking a long-term perspective and commitment to developing and sustaining their business. This is exactly what is required for a Lean strategy too, so it may help if the owner/leader believes fully in the Lean initiative (Winston and Heiko, 1990). Winston and Heiko (1990) also indicate that the SME owner is often positioned closer to the customers and therefore able to better understand and anticipate their values and needs. They therefore have a better capacity to directly respond to them, critical in any Lean campaign.

Although SMEs may find it harder to self-finance a major initiative such as Lean, Dowlatshahi and Taham (2009) point out that many governments and agencies (in developed and developing countries) provide facilities and financial support specifically dedicated and focussed on SMEs. However, a reliance on an outside agency, such as a consultant, to support a Lean implementation can be problematic (Hu et al., 2014)

The inhibitors and enablers, related to organisational size, for SMEs in Lean implementation is summarised in Table 9.

Insert table 9 about here

On balance, it would appear that although there are a few benefits from being smaller, SMEs are in fact at a disadvantage when it comes to being able to conduct a Lean implementation strategy. In summary, this can be presented in a figurative form indicated in Figure 4. To correct this position, either some of the inhibitors need to be reduced/ removed, or the enablers need to be added to.

Insert figure 4 about here

7. Implications for SME Lean Research

As a result of conducting this review one of our aims was to identify opportunities for further research. We thus propose a number of questions that future research should address.

The first three recommendations stem from the "descriptive" review of the literature. It found that there was a lack of research that utilised mixed method, multiple case study or action research when studying Lean implementation in SMEs. Through a greater use of these research approaches, a deeper and more authoritative understanding of the issues surrounding Lean implementation in SMEs will be established. Second, as research into this topic area has been largely focused on Western countries, there is a need to conduct more Lean and SME implementation research in developing regions of the world, particularly the Asian SME communities. For instance, comparative case studies of SMEs implementing Lean in developed versus developing countries to test the applicability of lean tools in SMEs in developing economies. Thirdly, a characterisation of the current state of Lean and SME research is its focus on manufacturing, perhaps unsurprising given Lean's origins in the automotive

manufacturing sector. However, Lean is increasingly being applied in the service sector, for example in healthcare and educations systems (Samuel et al. 2015), so there is a requirement to carry out more SME Lean implementation research on service based organisations. Although similar to manufacturing organisations in some ways, service organisations are characterised as having more intangible outputs that are more likely to be produced on demand of the customer and also tailored to specific customer wants. It is important to explore more widely how Lean can be best implemented in SME service environments and to develop more cross-sector comparisons between the service and manufacturing sectors.

There remain six recommendations for future research, which stem from the "thematic" review. First, it was evident that previous research has focused largely on the tools and techniques employed when implementing Lean in SMEs. Where Lean tools in SMEs are researched what is needed are more investigations that look into the underlying logic for choosing and deploying them. Beyond this, more research is needed that investigates Lean at higher organisational and theoretical levels, examining issues connected to strategy and philosophy. In particular, research that examines why Lean is adopted by SMEs, how its adoption is incorporated into SMEs' current strategies, and the impact of Lean on business orientation and culture in SMEs would all be worthwhile areas to pursue. Lean can be viewed as a system that has significant implications to the way the whole organisation is organised and run. Comparisons between SMEs and LEs in this regard would be a further useful research contribution.

Taking Lean beyond the SME organisational boundary to the wider supply chain is seen as an important aspect for those organisations that want a fully integrated approach to Lean. This needs to be researched more fully in the SME context. It would appear that SMEs face different challenges in these areas compared to LEs, due to their size and

potential influence: how big an issue is this when implementing Lean?

There is also a theme in our recommendations for future research which relates to the particular financial issues faced by SMEs: research that looks into the financial capabilities of SMEs and how these impact on a Lean implementation strategy as well as the financial benefits of Lean for SMEs. Studies that address the operational benefits beyond efficiency improvement are also required.

Finally, in summary the overall organisational size when implementing Lean has emerged from the literature as a generic and important issue for SMEs. To continue this understanding, greater consideration needs to be given of company size in investigating more fully the differences and similarities that exist in Lean implementation in SMEs compared to their larger counterparts. More empirical studies, including longitudinal studies, which reflect on this would be a helpful avenue for future research to test the critical success factors identified in previous studies and evaluate whether they equally apply to SMEs and LEs through empirical research.

8. Implications for SME Lean Practice

This paper has implications for practitioners. The CSFs of Lean implementation and potential enablers and inhibitors of a successful and sustainable Lean implementation, which practitioners need to be aware of when they embark on their improvement journey, have been identified. Based on these CSFs and the discussion of enablers and inhibitors, a preliminary "Road Map", the "Lean Staircase", which guides SMEs on how to apply Lean has been developed (see figure 5).

Insert figure 5 about here

First, SME owners/managers should fully think through and be prepared to offer their complete commitment to support and engage in Lean implementation throughout the Lean journey in their SME. Since there are different types of Lean (see for instance Pettersen, 2009), SME owners/managers need also at the outset to consider and agree on the type of Lean to be implemented before embarking on the Lean journey. Their selection of the type of Lean also needs to be continually reviewed and revised during the Lean implementation process.

Second, it is important that SME owners/managers recognise that they need to go above the operational level issues when planning their Lean implementation. Organisational level factors, such as the development of a supportive strategy and investment plan (e.g. to consider whether new equipment is affordable or focus should be on improving processes based on existing equipment) are critical factors which need to be included in any Lean adoption plan in SMEs. SMEs have to be resourceful enough to invest in Lean before performance rewards from Lean come through. Linked to this, SME owners/managers are suggested to actively seek funding opportunities and support from externals, such as government agencies and consultants in their Lean journey.

Lean hinges on a successful recognition of what customers value. At the outset of any Lean journey therefore, an intimate understanding of the "voice of customers" should be obtained. This will ensure that SMEs can orientate their Lean progress around a precise understanding of customer value and this will need to be continually revisited as values can be highly dynamic.

SMEs are often flatter organisations in terms of their structure and invariably are organised around more informal working relationships. These characteristics enable more direct and quicker communications between managers and employees. It is more

likely that the concept of Lean will be more efficiently diffused across the SME so total employee engagement is achieved. In addition to communications, training employees is another important task in the Lean implementation programme. However, SMEs are often criticised as lacking in support of knowledge development, which is a requirement for Lean initiatives. In this sense, SME owners/managers may need to consider the involvement of external professionals in their Lean journey.

Before embarking on Lean implementation, it is important for the SME to be confident in the total quality of its processes and its components and finished products. Lean, removes buffers of time and inventory and requires a right first time operation. If quality levels are unreliable, there is a danger that the implementation of Lean will result in serious breakdowns and failures for customers. An audit of quality will give a full appraisal of whether the SME is ready for Lean or not.

Given the limited financial capabilities and human resources possessed by SMEs, some basic and easy-to-use Lean tools, such as 5S/6S, visual management, VSM and Standard Work, can be applied at the outset of their Lean journey along with organisational changes including performance evaluation systems and appraisal criteria. Advanced Lean tools (e.g. TPM) and other supporting initiatives (e.g. IT) that require more resources may need to be adopted at later stages of their Lean journey.

It is worth noting that the SME managers may not observe the improvement of organisational performance until some basic Lean tools have been implemented. This phenomenon is labelled as “performance investment” in the “Road Map”. On the one hand, this reflects on the time lag between Lean implementation and its tangible benefits. On the other hand, it echoes Chiarini’s (2012) critique of the traditional accounting method that inhibits the financial benefits of Lean implementation from

being immediately observed. During the latter "performance improvement" stage, on-going investment is still required, but benefits in performance are being realised too.

SMEs often lack sufficient power to influence their supply chain members (e.g. suppliers) to adopt Lean. Hence, SMEs are suggested to apply Lean internally prior to, where possible, spreading it to their suppliers and the wider supply chain.

Overall, this "Lean Staircase Road Map" suggests that Lean implementation is a long-term journey and SMEs should aim to improve their organisational performance "step by step".

9. Conclusion

SMEs are commonly recognised as being critical to the health of the global economy. Lean, today, is recognised as being a well-respected philosophy to help organisations in their endeavours to compete more successfully. Therefore, the applicability of Lean, with reference to SMEs, is an important topic area to examine, especially as there is a lower up take of Lean by SMEs (Shah and Ward, 2003). The paper has confirmed that there is a dearth of knowledge surrounding the specific issues connected with the implementation of Lean in SMEs compared to LEs. This study has contributed to filling this gap by, for the first time, conducting a comprehensive, systematic review of academic papers in relation to Lean implementation in SMEs.

The review is conducted using Tranfield et al.'s (2003) method of classifying the literature along descriptive and thematic lines. The descriptive analysis shows that the Lean SME research is characterised by a dominance of single case studies and the use of survey research methods. Most Lean SME research has been conducted in the Western context with an emphasis on Lean implementation in small manufacturing

organisations. There are four key themes that have been drawn from the systematic review of the previous research. These themes include, what scope/type of Lean is being adopted by SMEs, how Lean is implemented in SMEs, the impact of Lean implementation on SMEs and the critical success factors for Lean implementation in SMEs. The analysis of these key themes has provided a list of nine areas of future research for academics. A "Lean Staircase Road Map", which guides SME owners/managers to apply Lean in the future, has been developed as a result of this systematic review. It is advocated that this research will help develop the state of knowledge in the subject area and support the converging of divergent views towards a more precise, standardised understanding and approach in researching Lean in SMEs, which is called for by Bhamu and Sangwan (2014).

There are a number of limitations of the research readers should be aware of. Clearly, one limitation of this kind of study surrounds the exact terminology used for the literature search. Some papers relating to Lean and SMEs may therefore have been missed. A further limitation emerged from the systematic review method associated with the accessibility of the literature sources (Easterby-Smith et al. 2012). This study mainly employed five key databases in the field of business management for the literature search and, thereby, theses and book chapters that were not available online may have been overlooked in this review. As more than one researcher was involved in the review panel, another challenge revolved around how to solve any disagreements between the researchers. Tranfield et al. (2003) suggest that the disagreement can be solved through the use of panel meetings. In this study, each "unsure" paper was crosschecked between researchers and the review panel also discussed the rationales for filtering and categorising any "unsure" papers before consensus decisions were reached. However, there is still an element of subjectivity over the eventual decisions reached,

which should be noted as a limitation. Another major challenge in the systematic review surrounds the synthesis of different forms of data (Pittaway et al. 2004) stemming from the range of research methods adopted in the selected papers. While survey methods are more likely to produce quantitative results, most case study methods produce qualitative findings. Hence, a qualitative analysis is applied in this study to categorise and critique the key themes ~~emergingged~~emerging from the literature rather than the meta-analysis, which has been traditionally used in medical science (Tranfield et al. 2003). However, in comparison to a traditional narrative review, this study has provided a more authoritative and comprehensive review of the state of research surrounding the implementation of Lean in SMEs and addressed the three research questions outlined at the beginning of the paper.

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Table 1 Examples of definitions of SMEs in different countries

Country/ Area	**Definition of SMEs**
U.S.	No more than 499 employees (manufacturing sector)
Canada	No more than 199 employees
E.U.	No more than 250 employees
Australia	No more than 200 employees
China	No more than 999 employees (manufacturing sector)

Source: Adapted from Cunningham (2011); European Commission (2011); MIIT (2011)

Table 2 Inclusive and exclusive criteria for literature review

Inclusive criteria	**Reasons**
Papers written in English	Most leading academic journals are published in English
Papers published in both academic and trade journals	The authors recognised many Lean related articles written by scholars are published in trade journals
Papers study Lean implementation issues	This review is designed for Lean implementation
Papers focus on SME	SME is the main focus of this review
Exclusive criteria	**Reasons**
Newspapers, magazines and reports	These types of articles were more likely to provide a snapshot of Lean implementation
Working papers	These often represent researchers' temporary thinking and are subject to change
Papers do not focus on Lean and SME	They do not fit the thematic areas of this review
General commentaries or grey literature	They do not provide sufficient insights into the research area

Table 3 Search strings

Search string combinations	Databases
"small and medium enterprise (SME)" AND "Lean" "small and medium enterprise (SME)" AND "Toyota Production System (TPS)" "small and medium enterprise (SME)" AND "Just in Time (JIT)" "small business" AND "Lean" "small business" AND "Toyota Production System (TPS)" "small business" AND "Just in Time (JIT)" "small organization" AND "Lean" "small organization" AND "Toyota Production System (TPS)" "small organization" AND "Just in Time (JIT)" "small company" AND "Lean" "small company" AND "Toyota Production System (TPS)" "small company" AND "Just in Time (JIT)"	ABI EBSCO Emerald Scopus ScienceDirect

Note: each search string was entered in exactly the same way to the databases

Table 4 Summary of Lean implementation processes and models in SMEs

The scope of the implementation processes	Authors
External – supply chain	Wanitwattanakosol and Sopadang (2012)
Internal – production and operation processes	Kumar et al. (2006); Thomas et al. (2009); Gnanaraj et al. (2010a, 2010b); Roth and Franchetti (2010); Gnanaraj et al. (2012)
	Sohal and Naylor (1992); Chin and Rafuse (1993); Gupta and Brennan (1995); Mazany (1995); Gunasekaran and Lyu (1997); Dombrowski et al (2010); Van Landeghem (2011); Medbo and Carlsson (2013)

Table 5 Summary of Lean tools used in implementation of Lean in SMEs

Lean tools	**Authors**
Mapping (VSM)	Kumar et al. (2006); Lummus et al. (2006); Chandandeep (2008); Agyapong-Kodua et al. (2009); Chen et al. (2010); Roth and Franchetti (2010); Wanitwattanakosol and Sopadang (2012); White and James (2014)
TPM	Gunasekaran and Lyu (1997); Lee (1997); Gunasekaran (1998); Kumar et al. (2006)
5S/6S and visual management	Gunasekaran and Lyu (1997); Gunasekaran (1998); Kumar et al. (2006); Emmitt et al. (2012) ; Rose et al. (2013)
Fishbone diagram	Sohal and Naylor (1992); Thomas et al. (2009)
Kanban	Sohal and Naylor (1992); Lee (1997); Abdul-Nour et al. (1998); Gunasekaran (1998); Roth and Franchetti (2010)
Kaizen	Deb et al. (2010); Rose et al. (2013)
5 Whys	Chen et al. (2010); Deb et al. (2010)
Level scheduling	Sohal and Naylor (1992)
Small lot sizing	Mathur et al. (2012)
SMED	Chin and Rafuse (1993); Mathur et al. (2012)
Standard work	Gunasekaran and Lyu (1997); Chen et al. (2010); Rose et al. (2013)

Table 6 Summary of supporting approaches to implementing Lean in SMEs

Other approaches	**Authors**
Six Sigma	Kumar et al. (2006); Kumar et al. (2009); Thomas et al. (2009); Nabhani and Shokri (2009); Gnanaraj et al. (2010a, 2010b, 2012); Roth and Franchetti (2010); Cheng and Chang (2012); Timans et al. (2012)
IT (MRP, ERP, computer simulation, CAD/CAM and fuzzy system)	Santacecilia (1992); Chin and Rafuse (1993); Li et al. (2011); Achanga et al. (2012); Wanitwattanakosol and Sopadang (2012); Esan et al. (2013); Powell et al. (2013); Iris and Cebeci (2014)
Accounting (ABC accounting and VSM accounting)	Chiarini (2012)
Cellular manufacturing	Boughton and Arokiam (2000)
Project Management	Abdul-Nour et al. (1998)
QFD	Ramaswamy et al. (2002)
TOC	Lee (1997)
Quick scan	Thomas and Barton (2011)

Table 7 Summary of the key criteria for assessing the impact of Lean on SMEs

Efficiency (for example, waste reduction, cost reduction, quality and productivity improvement)		Bevilacqua et al. (2014); Cunha and Alves (2014); Dora et al. (2014); Finch (1986); Kaufman (1987); Manoochehri (1988); Erdem and Massey (1990); Golhar et al. (1990); Stamm and Golha (1991); Sohal and Naylor (1992); Brown and Inman (1993); Phillips and Ledgerwood (1994); Gupta and Brennan (1995); Gunasekaran and Lyu (1997); White et al. (1999); Boughton and Arokiam (2000); Kinney and Wempe (2002); Lummus et al. (2006); Koh et al. (2007); Seetharaman et al. (2007); Chandandeep (2008); Kalafsky (2009); Mo (2009); Singh et al. (2009); Deb et al. (2010); Rahman et al. (2010); Roth and Franchetti (2010); Li et al. (2011); Thun et al. (2011) ; Bhasin (2012) ; Cheng and Chang (2012); Emmitt et al. (2012) ; Mazanai (2012); Mathur et al. (2012); Panizzolo et al. (2012); Zhou (2012); Dora et al. (2013); Rose et al. (2013); Seay and Narsing (2013); Wadhwa (2013)
Effectiveness	Organisational culture	Manoochehri, (1988)
	Employee empowerment	Seetharaman *et al*. (2007)
	Employee motivation, interests and ability	Golhar *et al*. (1990), Gunasekaran and Lyu (1997), Gupta and Brennan (1995), Phillips and Ledgerwood (1994), Sohal and Naylor (1992)

Table 8 Summary of Critical Success Factors

Critical Success Factors	**Authors**
Employee involvement and participation	Chin and Rafuse (1993); Gupta and Brennan (1995); Mazany (1995); Lee (1996); Ramaswamy et al. (2002); Kumar et al. (2009); Panizzolo et al. (2012)
Top management support and commitment	Chin and Rafuse (1993); Lee et al. (1994); Lee (1996); Achanga et al. (2006) ; Kumar et al. (2009); Emmitt et al. (2012); Panizzolo et al. (2012); Rose et al. (2014) ; Timans et al. (2012)
Training and education	Gupta and Brennan (1995); Lee (1996); Ramaswamy et al. (2002); Achanga et al. (2006) ; Kumar et al. (2009); Timans et al. (2012); Dora et al. (2013)
Organisational change (culture, strategy, vision and performance evaluation system)	Achanga et al. (2006) ; Kumar et al. (2006); Panizzolo et al. (2012); Timans et al. (2012); Dora et al. (2013); Ravikumar et al. (2013a,b)
Financial capability	Achanga et al. (2006) ; Ravikumar et al. (2013a,b)
Supply chain integration	Ormsby et al. (1994); Lee (1996); Kumar et al. (2009); So and Sun (2010)
Direct or good communication	Lee (1996); Rose et al. (2014); Timans et al. (2012)
Personal experience	Timans et al. (2012)
Technical factors (ongoing improvement, JIT concepts on shop floor etc.)	Chin and Rafuse (1993)

Table 9 The summary of enablers and inhibitors in terms of organisational size for SMEs in Lean implementation

Dimension		Enabler	Inhibitor
Supplier		Suppliers may be highly dependent on a SME focussing a market niche. (there are no other customers for the supplier to switch to, so SME has more power to influence the Lean agenda) (Karlsson and Åhlström, 1997)	SMEs may lack the market power to influence supplier network in adopting Lean practices(Golhar et al., 1990; Ormsby et al., 1994; Lee, 1996; Lee, 1997; Dowlatshahi and Taham, 2009; Wilson and Roy, 2009; Mazanai, 2012)
Intra-SME	Organisational	Owner's long term commitment to survival and profitability can give Lean the backing and support it may need (Winston and Heiko, 1990)	Potential lack of vision, management commitment and support as the SME leader may be highly involved in day to day operations and other matters (Lee, 1996; Lee, 1997; Panizzolo et al., 2012; Rymaszewska, 2014; Rymaszewska, 2013; Wilson and Roy, 2009; Yogesh et al., 2012)
		Multi-skilled, cross-functional employees better positioned to be able to support Lean process improvement across the organisation (Winston and Heiko, 1990; Lee, 1996)	Lack of support for training and knowledge development required for Lean initiatives (Golhar et al., 1990; Lee, 1997; Dowlatshahi and Taham, 2009; Mazanai, 2012; Panizzolo et al., 2012 Rymaszewska, 2014; Yang and Yu 2010)
		Higher level of group teamwork and cohesiveness, a feature of the Lean way of working (Lee, 1996; Dowlatshahi and Taham, 2009)	Workforce fluctuation (SME employee turnover may be higher so the knowledge of Lean may be more easily lost) (Rymaszewska, 2013; Williams, 1985)
		Ease of communication (Rymaszewska, 2014; Winston and Heiko, 1990)	
	Operational		Poorer process and quality control tools and systems (Lee, 1996; Lee, 1997)
	Financial	Government support more likely to be available (Dowlatshahi and Taham, 2009) – but dependence on outside agencies like consultants to implement Lean can be problematic (Hu et al., 2014)	Lack of sufficient funding and capital (Golhar et al., 1990; Ormsby et al., 1994; Lee, 1996; Dowlatshahi and Taham, 2009; Mazanai, 2012; Rymaszewska, 2014; Thomas et al., 2009;)
			Lack of infrastructure and facilities (Boughton and Arokiam, 2000; Panizzolo et al., 2012)
Customer		More direct contact with customers (Winston and Heiko, 1990)	Less able to influence demand volatility and variability (Boughton and Arokiam, 2000; Dowlatshahi and Taham, 2009; Rymaszewska, 2013)
		Producing in small lots to meet various demand (Lee, 1996)	

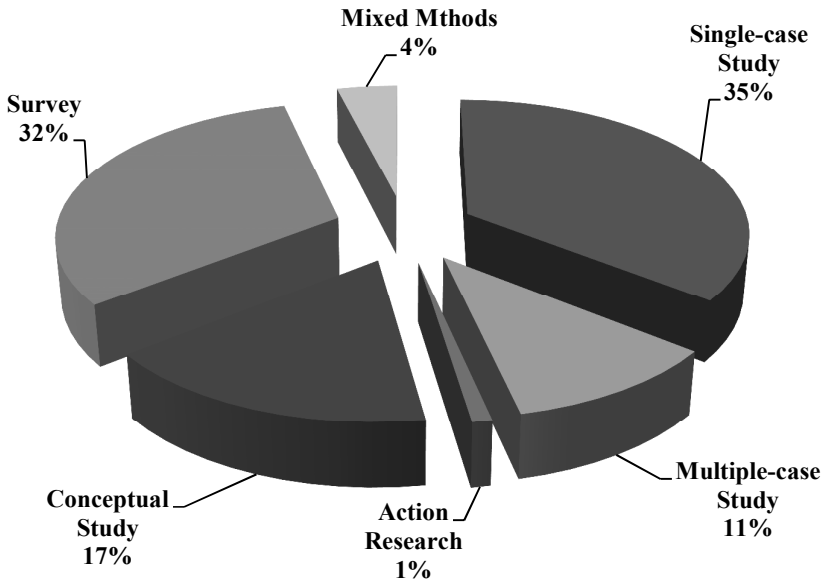

Figure 1 Percentage of papers by research method

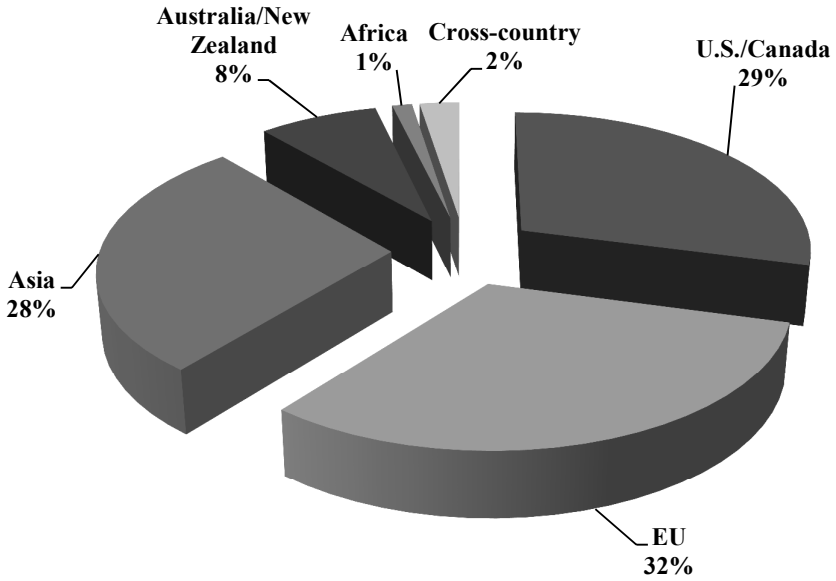

Figure 2 Percentage of papers by geographic area

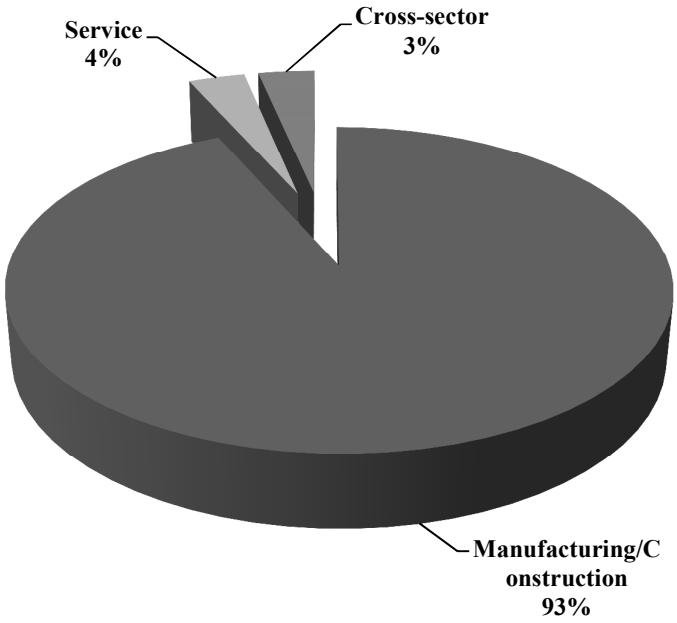

Figure 3 Percentage of papers by industry sector

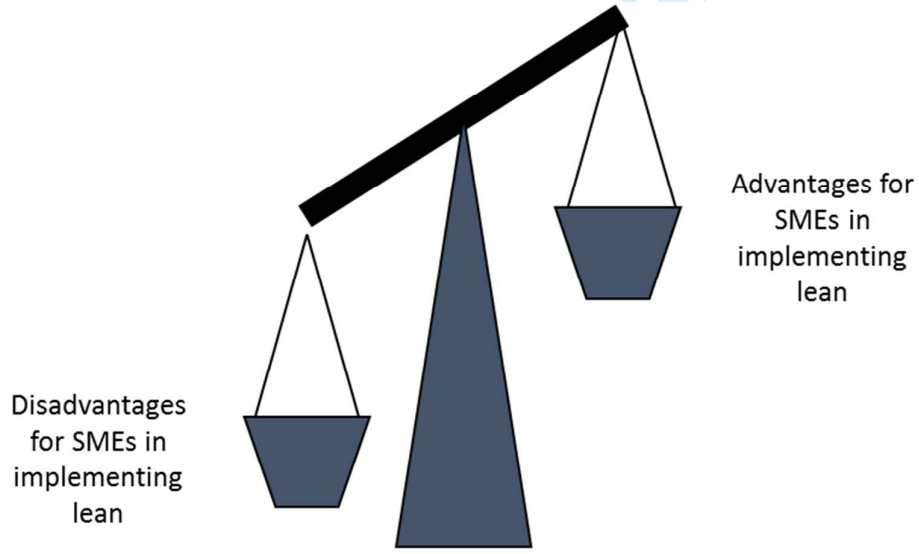

Figure 4: On balance, the disadvantages appear to outweigh the advantages for SMEs compared to LEs when implementing Lean

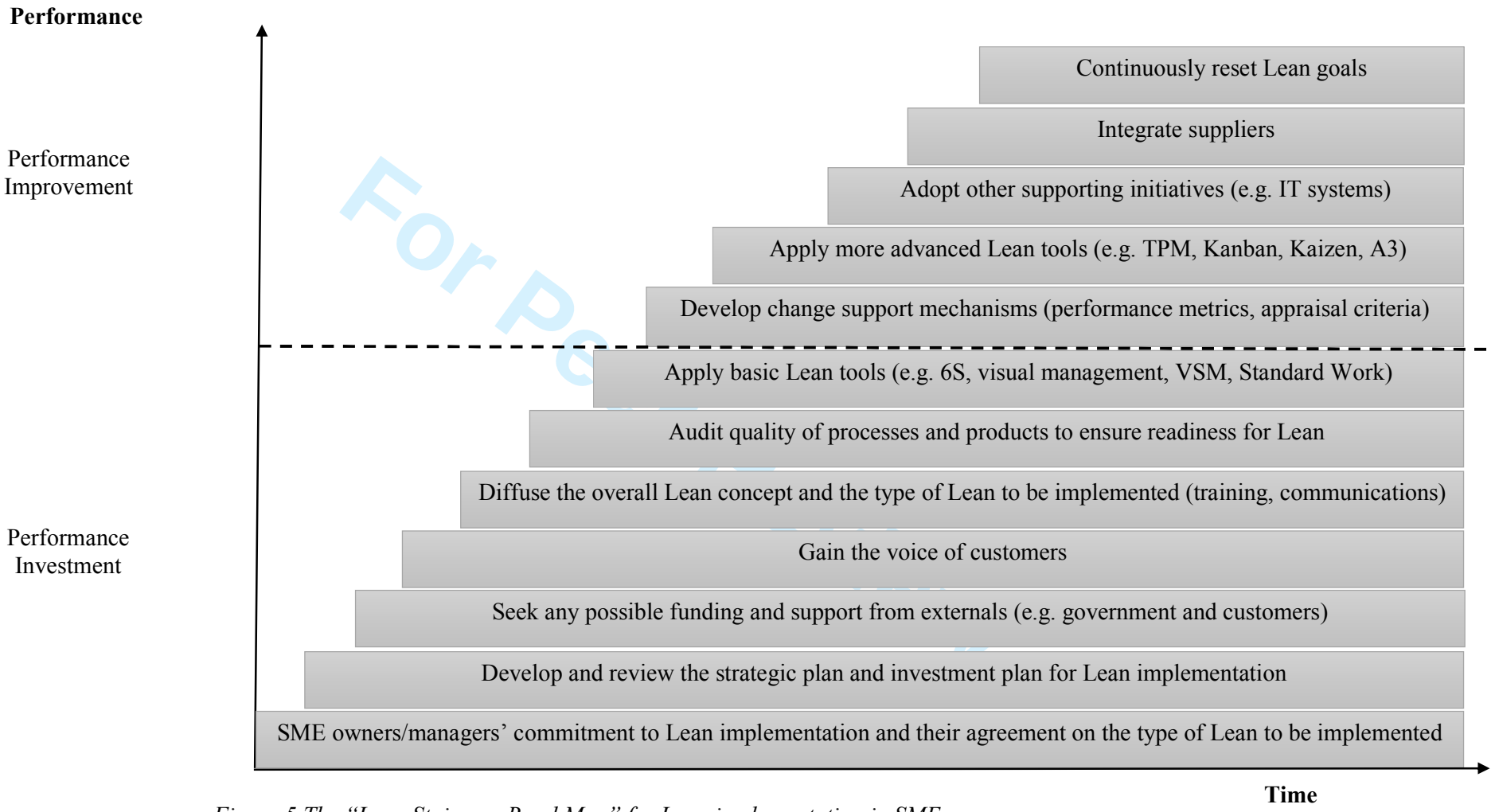

Figure 5 The "Lean Staircase Road Map" for Lean implementation in SMEs

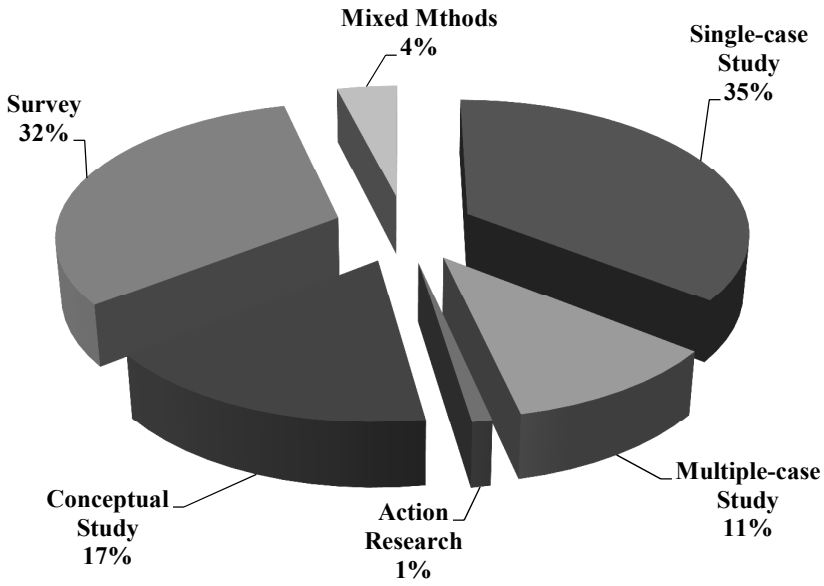

Figure 1 Percentage of papers by research method

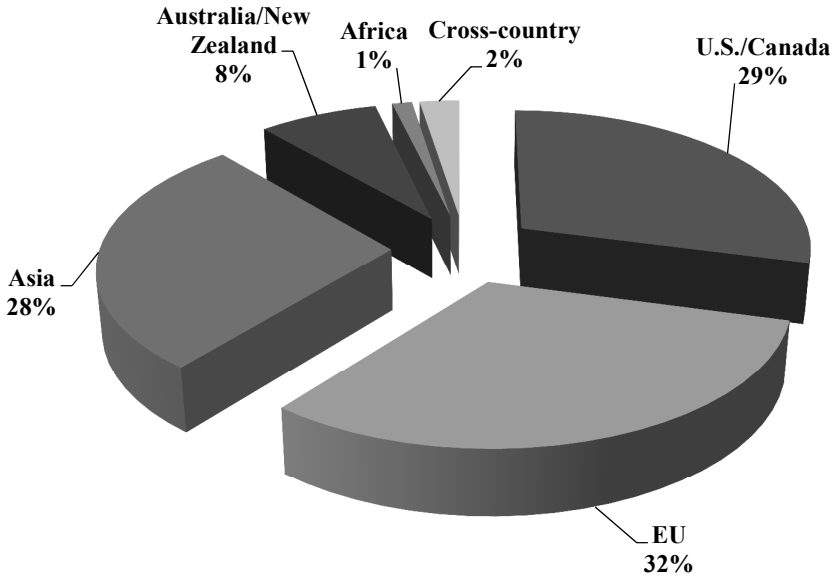

Figure 2 Percentage of papers by geographic area

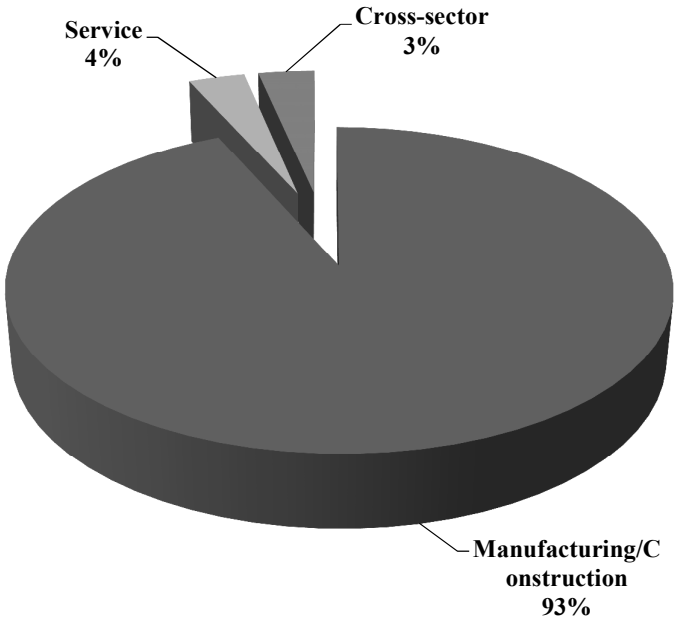

Figure 3 Percentage of papers by industry sector

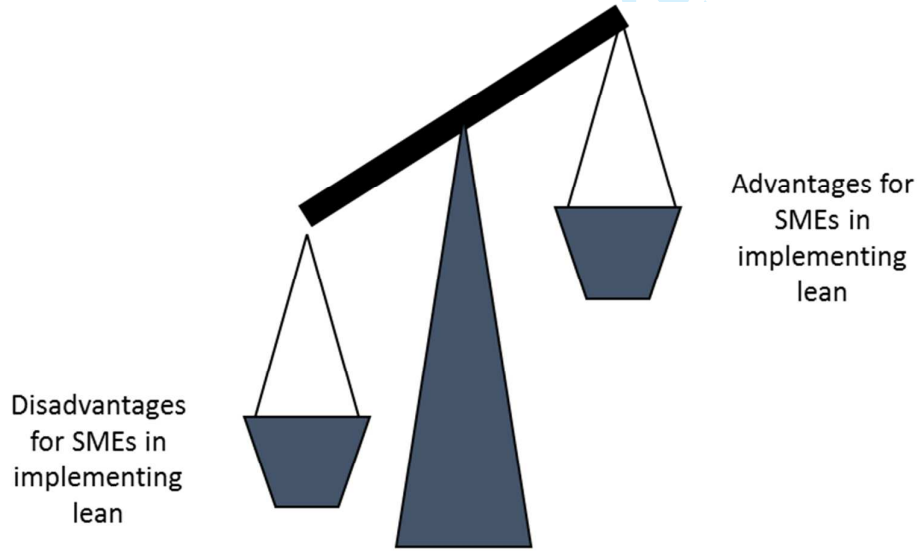

Figure 4: On balance, the disadvantages appear to outweigh the advantages for SMEs compared to LEs when implementing Lean

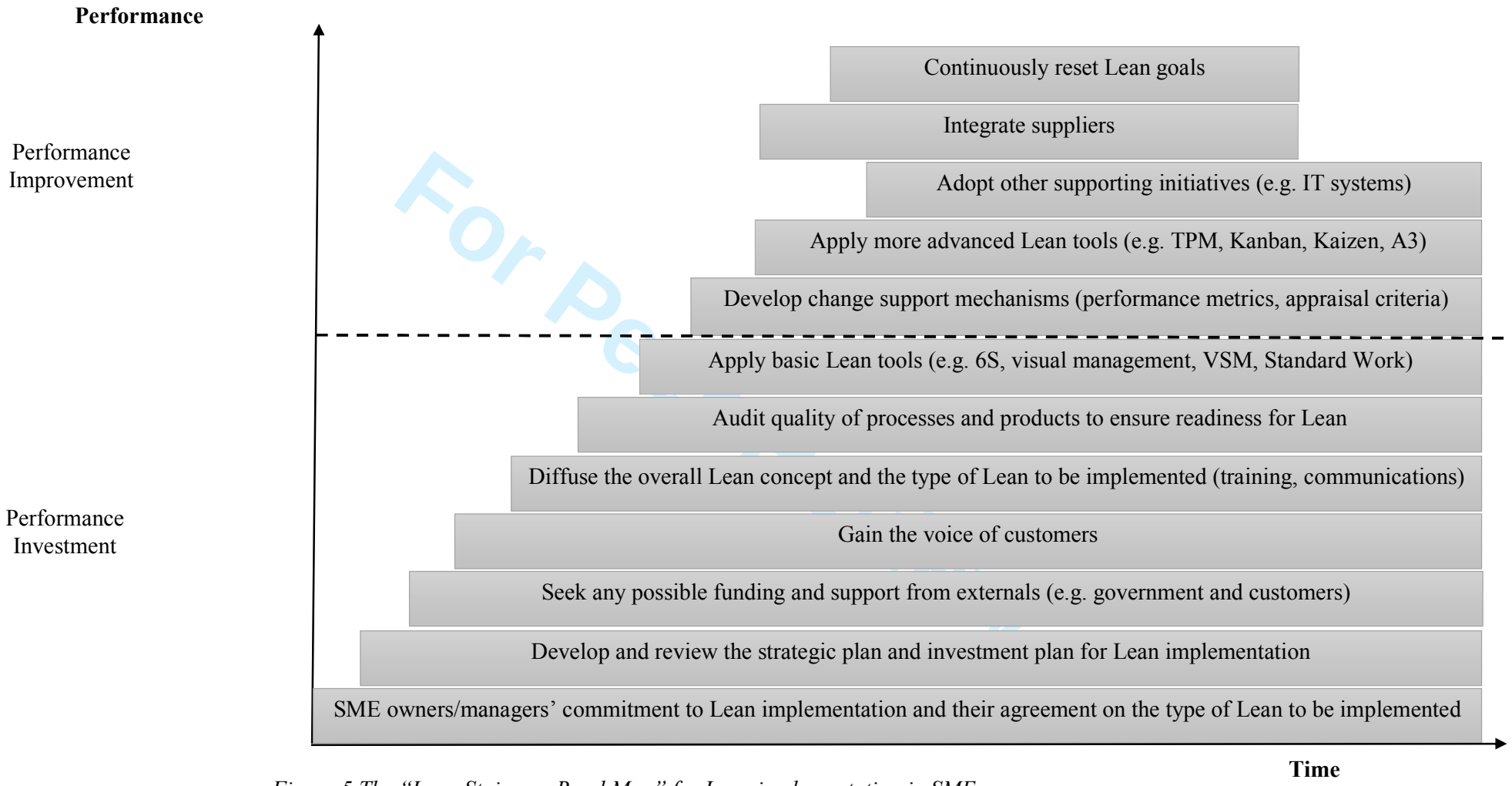

Figure 5 The "Lean Staircase Road Map" for Lean implementation in SMEs

Table 1 Examples of definitions of SMEs in different countries

Country/ Area	**Definition of SMEs**
U.S.	No more than 499 employees (manufacturing sector)
Canada	No more than 199 employees
E.U.	No more than 250 employees
Australia	No more than 200 employees
China	No more than 999 employees (manufacturing sector)

Source: Adapted from Cunningham (2011); European Commission (2011); MIIT (2011)

Table 2 Inclusive and exclusive criteria for literature review

Inclusive criteria	**Reasons**
Papers written in English	Most leading academic journals are published in English
Papers published in both academic and trade journals	The authors recognised many Lean related articles written by scholars are published in trade journals
Papers study Lean implementation issues	This review is designed for Lean implementation
Papers focus on SME	SME is the main focus of this review
Exclusive criteria	**Reasons**
Newspapers, magazines and reports	These types of articles were more likely to provide a snapshot of Lean implementation
Working papers	These often represent researchers' temporary thinking and are subject to change
Papers do not focus on Lean and SME	They do not fit the thematic areas of this review
General commentaries or grey literature	They do not provide sufficient insights into the research area

Table 3 Search strings

Search string combinations	**Databases**
"small and medium enterprise (SME)" AND "Lean" "small and medium enterprise (SME)" AND "Toyota Production System (TPS)" "small and medium enterprise (SME)" AND "Just in Time (JIT)" "small business" AND "Lean" "small business" AND "Toyota Production System (TPS)" "small business" AND "Just in Time (JIT)" "small organization" AND "Lean" "small organization" AND "Toyota Production System (TPS)" "small organization" AND "Just in Time (JIT)" "small company" AND "Lean" "small company" AND "Toyota Production System (TPS)" "small company" AND "Just in Time (JIT)"	ABI EBSCO Emerald Scopus ScienceDirect

Note: each search string was entered in exactly the same way to the databases

Table 4 Summary of Lean implementation processes and models in SMEs

The scope of the implementation processes	**Authors**
External – supply chain	Wanitwattanakosol and Sopadang (2012)
Internal – production and operation processes	Kumar et al. (2006); Thomas et al. (2009); Gnanaraj et al. (2010a, 2010b); Roth and Franchetti (2010); Gnanaraj et al. (2012)
	Sohal and Naylor (1992); Chin and Rafuse (1993); Gupta and Brennan (1995); Mazany (1995); Gunasekaran and Lyu (1997); Dombrowski et al (2010); Van Landeghem (2011); Medbo and Carlsson (2013)

Table 5 Summary of Lean tools used in implementation of Lean in SMEs

Lean tools	**Authors**
Mapping (VSM)	Kumar et al. (2006); Lummus et al. (2006); Chandandeep (2008); Agyapong-Kodua et al. (2009); Chen et al. (2010); Roth and Franchetti (2010); Wanitwattanakosol and Sopadang (2012); White and James (2014)
TPM	Gunasekaran and Lyu (1997); Lee (1997); Gunasekaran (1998); Kumar et al. (2006)
5S/6S and visual management	Gunasekaran and Lyu (1997); Gunasekaran (1998); Kumar et al. (2006); Emmitt et al. (2012) ; Rose et al. (2013)
Fishbone diagram	Sohal and Naylor (1992); Thomas et al. (2009)
Kanban	Sohal and Naylor (1992); Lee (1997); Abdul-Nour et al. (1998); Gunasekaran (1998); Roth and Franchetti (2010)
Kaizen	Deb et al. (2010); Rose et al. (2013)
5 Whys	Chen et al. (2010); Deb et al. (2010)
Level scheduling	Sohal and Naylor (1992)
Small lot sizing	Mathur et al. (2012)
SMED	Chin and Rafuse (1993); Mathur et al. (2012)
Standard work	Gunasekaran and Lyu (1997); Chen et al. (2010); Rose et al. (2013)

Table 6 Summary of supporting approaches to implementing Lean in SMEs

Other approaches	**Authors**
Six Sigma	Kumar et al. (2006); Kumar et al. (2009); Thomas et al. (2009); Nabhani and Shokri (2009); Gnanaraj et al. (2010a, 2010b, 2012); Roth and Franchetti (2010); Cheng and Chang (2012); Timans et al. (2012)
IT (MRP, ERP, computer simulation, CAD/CAM and fuzzy system)	Santacecilia (1992); Chin and Rafuse (1993); Li et al. (2011); Achanga et al. (2012); Wanitwattanakosol and Sopadang (2012); Esan et al. (2013); Powell et al. (2013); Iris and Cebeci (2014)
Accounting (ABC accounting and VSM accounting)	Chiarini (2012)
Cellular manufacturing	Boughton and Arokiam (2000)
Project Management	Abdul-Nour et al. (1998)
QFD	Ramaswamy et al. (2002)
TOC	Lee (1997)
Quick scan	Thomas and Barton (2011)

Table 7 Summary of the key criteria for assessing the impact of Lean on SMEs

Efficiency (for example, waste reduction, cost reduction, quality and productivity improvement)		Bevilacqua et al. (2014); Cunha and Alves (2014); Dora et al. (2014); Finch (1986); Kaufman (1987); Manoochehri (1988); Erdem and Massey (1990); Golhar et al. (1990); Stamm and Golha (1991); Sohal and Naylor (1992); Brown and Inman (1993); Phillips and Ledgerwood (1994); Gupta and Brennan (1995); Gunasekaran and Lyu (1997); White et al. (1999); Boughton and Arokiam (2000); Kinney and Wempe (2002); Lummus et al. (2006); Koh et al. (2007); Seetharaman et al. (2007); Chandandeep (2008); Kalafsky (2009); Mo (2009); Singh et al. (2009); Deb et al. (2010); Rahman et al. (2010); Roth and Franchetti (2010); Li et al. (2011); Thun et al. (2011) ; Bhasin (2012) ; Cheng and Chang (2012); Emmitt et al. (2012) ; Mazanai (2012); Mathur et al. (2012); Panizzolo et al. (2012); Zhou (2012); Dora et al. (2013); Rose et al. (2013); Seay and Narsing (2013); Wadhwa (2013)
Effectiveness	Organisational culture	Manoochehri, (1988)
	Employee empowerment	Seetharaman *et al*. (2007)
	Employee motivation, interests and ability	Golhar *et al*. (1990), Gunasekaran and Lyu (1997), Gupta and Brennan (1995), Phillips and Ledgerwood (1994), Sohal and Naylor (1992)

Table 8 Summary of Critical Success Factors

Critical Success Factors	**Authors**
Employee involvement and participation	Chin and Rafuse (1993); Gupta and Brennan (1995); Mazany (1995); Lee (1996); Ramaswamy et al. (2002); Kumar et al. (2009); Panizzolo et al. (2012)
Top management support and commitment	Chin and Rafuse (1993); Lee et al. (1994); Lee (1996); Achanga et al. (2006) ; Kumar et al. (2009); Emmitt et al. (2012); Panizzolo et al. (2012); Rose et al. (2014) ; Timans et al. (2012)
Training and education	Gupta and Brennan (1995); Lee (1996); Ramaswamy et al. (2002); Achanga et al. (2006) ; Kumar et al. (2009); Timans et al. (2012); Dora et al. (2013)
Organisational change (culture, strategy, vision and performance evaluation system)	Achanga et al. (2006) ; Kumar et al. (2006); Panizzolo et al. (2012); Timans et al. (2012); Dora et al. (2013); Ravikumar et al. (2013a,b)
Financial capability	Achanga et al. (2006) ; Ravikumar et al. (2013a,b)
Supply chain integration	Ormsby et al. (1994); Lee (1996); Kumar et al. (2009); So and Sun (2010)
Direct or good communication	Lee (1996); Rose et al. (2014); Timans et al. (2012)
Personal experience	Timans et al. (2012)
Technical factors (ongoing improvement, JIT concepts on shop floor etc.)	Chin and Rafuse (1993)

Table 9 The summary of enablers and inhibitors in terms of organisational size for SMEs in Lean implementation

Dimension		Enabler	Inhibitor
Supplier		Suppliers may be highly dependent on a SME focussing a market niche. (there are no other customers for the supplier to switch to, so SME has more power to influence the Lean agenda) (Karlsson and Åhlström, 1997)	SMEs may lack the market power to influence supplier network in adopting Lean practices(Golhar et al., 1990; Ormsby et al., 1994; Lee, 1996; Lee, 1997; Dowlatshahi and Taham, 2009; Wilson and Roy, 2009; Mazanai, 2012)
Intra-SME	Organisational	Owner's long term commitment to survival and profitability can give Lean the backing and support it may need (Winston and Heiko, 1990)	Potential lack of vision, management commitment and support as the SME leader may be highly involved in day to day operations and other matters (Lee, 1996; Lee, 1997; Panizzolo et al., 2012; Rymaszewska, 2014; Rymaszewska, 2013; Wilson and Roy, 2009; Yogesh et al., 2012)
		Multi-skilled, cross-functional employees better positioned to be able to support Lean process improvement across the organisation (Winston and Heiko, 1990; Lee, 1996)	Lack of support for training and knowledge development required for Lean initiatives (Golhar et al., 1990; Lee, 1997; Dowlatshahi and Taham, 2009; Mazanai, 2012; Panizzolo et al., 2012 Rymaszewska, 2014; Yang and Yu 2010)
		Higher level of group teamwork and cohesiveness, a feature of the Lean way of working (Lee, 1996; Dowlatshahi and Taham, 2009)	Workforce fluctuation (SME employee turnover may be higher so the knowledge of Lean may be more easily lost) (Rymaszewska, 2013; Williams, 1985)
		Ease of communication (Rymaszewska, 2014; Winston and Heiko, 1990)	
	Operational		Poorer process and quality control tools and systems (Lee, 1996; Lee, 1997)
	Financial	Government support more likely to be available (Dowlatshahi and Taham, 2009) – but dependence on outside agencies like consultants to implement Lean can be problematic (Hu et al., 2014)	Lack of sufficient funding and capital (Golhar et al., 1990; Ormsby et al., 1994; Lee, 1996; Dowlatshahi and Taham, 2009; Mazanai, 2012; Rymaszewska, 2014; Thomas et al., 2009;)
			Lack of infrastructure and facilities (Boughton and Arokiam, 2000; Panizzolo et al., 2012)
Customer		More direct contact with customers (Winston and Heiko, 1990)	Less able to influence demand volatility and variability (Boughton and Arokiam, 2000; Dowlatshahi and Taham, 2009; Rymaszewska, 2013)

Reviewer(s)' Comments to Author:

Reviewer: 1

Recommendation: Minor Revision

Comments:

See comments above.

Additional Questions:

1. Originality and contribution: Does the paper contain new and significant information about theory, practice or application to justify publication? Is the paper relevant to the journal's editorial scope and does it make a significant contribution to the subject area?: ***This revision (R2) has addressed the short-comings identified in the previous review. Specifically, the contributions made by this paper are now highlighted and the research questions addressed have been moved to this section of the paper.***

Overall, this paper presents a very useful review of the literature relating to Lean implementation in SMEs. A road map has been developed and this should be useful to SMEs in their adoption of Lean.

No response required

2. Relationship to Literature and Previous Work: Does the paper demonstrate an adequate understanding of the relevant literature and previous work in the field? Does it cite appropriate and up to date literature sources? Is any significant work ignored?: ***The literature review has been expanded from 91 papers to 101 papers. Tables 4 to 8 provide useful summary of the literature on various aspects of Lean implementation and this will be useful to future researchers and practitioners.***

No response required

3. Methodology and Approach: Is the paper's argument built on an appropriate base of theory, concepts, or other ideas? Has the research or equivalent intellectual work on which the paper is based been well designed? Are the methods employed appropriate?: ***The short-comings in the methodology identified in the previous version have been adequately addressed. Sufficient details are now provided relating to the systematic review methodology employed in this study.***

No response required

4. Results and Conclusions: Are results presented clearly and analysed appropriately? Are there clear conclusions and do they adequately tie together the other elements of the paper?: ***As recommended in the previous review report, appropriate changes have been made and these are acceptable.***

No response required

5. Implications for research, practice and/or society: Does the paper identify clearly any implications for research, practice and/or society? Does the paper bridge the gap between theory and practice? How can the research be used in practice (economic and commercial impact), in teaching, to influence public policy, in research (contributing to the body of knowledge)? What is the impact upon society (influencing public attitudes, affecting quality of life)? Are these implications consistent with the findings and conclusions of the paper?: ***Implications are discussed in a separate/new section and this includes a preliminary road map for Lean implementation in SMEs. Useful suggestions are made in this respect.***

No response required

6. Quality of Communication: Does the paper clearly express its case, measured against the technical language of the field and the expected knowledge of the journal's readership? Has attention been paid to the clarity of expression and readability, such as sentence structure, jargon use, acronyms, etc. Is the length of the paper appropriate for the work it presents?: ***The paper is well written. Few grammatical corrections are necessary as listed below:***

The structured Abstract is missing.

Response: A structured abstract has been provided at the beginning of this paper.

Page 2, line 5: change the wording "lower take up" to 'lower up take'.

Response: the wording has been changed to “lower up take”.

Pg 3, line 1 under section 2.1: add the word 'the' before the words "Toyota production System.

Response: the word “the” has been added before the term “Toyota Production System”.

pg 4: for the first time, write in full TQM, TPM and HRM. Also, in line 7, "western" should be with a capital W.

Response: The full names of TQM, TPM and HRM have been provided and the word “western” has been changed to “Western”.

Pg 5, line 1: add a comma after the word "benefits".

Response: This has been actioned.

Pg 5, line 9: add a comma after the word "chain".

Response: This has been actioned.

Pg 7, 2nd line from bottom: add a comma after SMEs.

Response: This has been actioned.

Pg 8, line 7: add a comma after the word "definition".

Response: This has been actioned.

Pg 8, line 13: add a comma after the word "above".

Response: This has been actioned.

Pg 8, line 17: add a comma after the word "implement".

Response: This has been actioned.

pg 8, 2nd line from bottom: reference is made to "some proponents". Provide references here.

Response: Two papers have been adopted to support our argument and the full references of these two papers have also been provided in the reference list.

Pg 16, 3rd line from bottom: add a comma after the word "SMEs".

Response: This has been actioned.

Page 20: write in full - QFD and TOC.

Response: The full names of QFD and TOC have been provided.

Pg 22, line 11: add a comma after the word "papers".

Response: This has been actioned.

Pg 24, last 2 lines: remove the comma after "SMEs" and add a comma after the word "together".

Response: These have been actioned.

Page 25, line 10: add comma after word "SMEs".

Line 14, add comma after word "entirely".

Response: These have been actioned.

Page 25, line 4: delete the 7th word (the).

Response: These have been actioned.

Page 28, 2nd para: The word "maybe" appears three times. It should be 'may be'. 7th line from bottom - add comma after the word "Lean".

Response: This paragraph has been revised. The first and third “maybe” have been changed to the word “are” and the second “maybe” has been changed to “may be”. A comma has been added after the word “Lean”.

Pg 29, line 4: add a comma after the word "summary". Line 7 from bottom -add comma after the word "approaches".

Response: These have been actioned.

Pg 33, line 10: add a comma after the word "implementation". Line 13 - add comma after the word "unreliable".

Response: These have been actioned.

Page 36, line 9: the word "emerginged" should be 'emerging'.

Response: This has been corrected.