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IMPLEMENTATION OF A LEAN SIX SIGMA APPROACH IN THE MANUFACTURING SECTOR: A SYSTEMATIC LITERATURE REVIEW

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ABSTRACT

Lean Six Sigma is a continuous improvement methodology that aims to reduce production costs, improve organisational capability, and maximise the value for shareholders. This paper aims to explore the most common themes within LSS in the manufacturing sector, and to identify any gaps in those themes which may be preventing users from getting the most benefit from their LSS strategy. This paper also identifies the gaps in current literature and develops a research agenda for future research into Lean Six Sigma themes. The following research is based on a Systematic Literature Review of 33 papers which were published on LSS in the top journals in the field and other specialist journals, from 2000 to 2012. There are important themes cited in this paper which are; Critical Success Factors, benefits, motivation factors, limitations and impeding factors. However, there are many gaps and limitations that need to be covered in future research.

Keywords: Lean Six Sigma, Manufacturing, Systematic Review

1 INTRODUCTION

Today, Lean and Six Sigma are the most popular business strategies for enabling continuous improvement (CI) in the manufacturing, service and public sectors, and CI is the main goal for any organisation wishing to achieve quality and operational excellence and to enhance performance (Thomas et al. 2009). The integration of the two approaches improves efficiency and accuracy and helps to achieve CI faster than the implementation of each approach in isolation (Salah et al. 2010).

This interest in LSS has led to many attempts to come up with a comprehensive approach to achieve CI. There are noticeable limitations in the fields of research into areas of LSS (Kucner 2009; Chakravorty and Shah 2012; Laureani and Antony 2012; Kumar et al. 2006), but the benefits of applying Lean and Six Sigma in parallel are noted in many case study papers in both the manufacturing and service sectors (Akbulut-Bailey et al. 2012 and Hardeman and Goethals 2011). It is also significant that the number of available papers on LSS, though still small in comparison to other CI tools, is showing exponential growth since the first papers were published in 2003.

1.1 Lean Six Sigma

Lean Six Sigma is not new, it is a combination of Lean Management and Six Sigma methodologies which were first integrated in 1986 in the US-based George group. The term 'Lean Six Sigma' did not appear in literature until 2000 (Timans et al. 2012), and LSS teaching was not established until 2003 (Kubiak 2011). Since that time, there has been a noticeable increase in LSS popularity and deployment in the industrial world; especially in large western organisations such as Motorola, Honeywell and General Electric (Timans et al. 2012; Laureani and Antony 2012) and in some small and medium size manufacturing enterprise (SMEs) (Kumar et al. 2006).

LSS is "a methodology that focuses on the elimination of waste and variation, following the DMAIC structure, to achieve customer satisfaction with regards to quality, delivery and cost. It focuses on improving process, satisfying customers and achieving better financial results for the business" (Salah et al. 2010). Organisations give many reasons for implementing LSS; to improve business performance and operational efficiency for example, especially given the growth of global markets, to improve product quality, reduce production costs and so improve customer satisfaction (Antony 2008; Snee 2010; Laureani and Antony 2012; Jayaraman et al. 2012).

The history of LSS and notable success stories of LSS implementation in the industrial world can be seen in many academic papers by authors such as Chakravorty and Shah (2012) and Thomas et al. (2009). On the other hand, not all organisations can gain real benefits from LSS implementation; a poor attempt at LSS implementation can actually render it ineffective (Jayaraman et al. 2012).

2 METHODOLOGY

This paper explores the most important Lean Six Sigma themes that have been published in academic journals, by systematically reviewing the literature. According to Okoli & Schabram (2010), a Systematic literature review is "a systematic, explicit, comprehensive and reproducible method for identifying, evaluating, and synthesizing the existing body of completed and recorded work produced by researchers, scholars, and practitioners". Tranfield et al. (2003) has stated that systematic review has become a 'fundamental scientific activity'.

To date, only two systematic reviews have been published in LSS, which were carried out by Glasgow et al. (2010) in healthcare, and a general review by Zhang et al. (2012). Authors have argued that there is a clear need for more systematic reviews to be done in the field of Lean Six Sigma, to bridge the gap in previous literature.

This paper is, therefore, going to systematically review all the papers that were published in top journals and specialist journals in Lean, Six Sigma and LSS from 2000 to 2012. It will explore the most common themes that have been published in the field of LSS, and explore the gaps in each theme, in the manufacturing industry. Top journals are determined by using the journal ranking lists in the International Guide to Academic Journal Quality (ABS 2011) and Harzing (2012).

The process and the phases of this approach were adapted from several academic sources, such as Okoli and Schabram (2010) and Tranfield et al. (2003) as shown in figure 1.

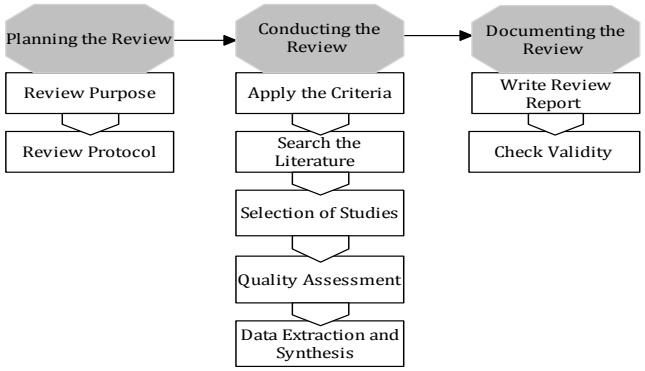

Figure 1: Research phases and process (Okoli and Schabram 2010 and Tranfield et al. 2003)

2.1 Material and outcomes

The 'journal' search for research literature was done through 20 top academic journals and 7 specialist journals in the field of Six Sigma, Lean and LSS, published in seven well known databases such as Emerald, American Society for Quality (ASQ), Elsevier and so on. Search strings were used as follows: [(lean) or (six sigma) or (lean six sigma) or (continuous improvement) or (Toyota production system) or (process management) or (lean management) or (lean thinking) or (lean manufacturing) not service] or [(lean and six sigma) or (lean sigma) and (manufacturing) and (case study)]. Meanwhile, the literature search was limited to the English language only. This search of journals and databases illustrated that there were no research articles related to Lean Six Sigma to be found before 2003. The search results were sorted into Critical Success Factors, benefits, motivation factors, limitations,

impeding factors and future research. The data collected for analysis and the key findings of this paper have been presented in graphical form to make them easier to understand.

During this Systematic Literature Review, 33 papers containing 21 case studies published in the manufacturing sector in various countries (US, UK, India, Netherlands, China and New Zealand) were examined. This paper aims to explore the Lean Six Sigma themes deemed of most benefit to the manufacturing sector, and also to highlight any gaps and give recommendations for future research.

3 RESULTS AND DISCUSSION

3.1 Critical Success Factors for LSS Implementation

CSFs - "those factors that are critical to the success of any organisation, in the sense that if the objectives associated with the factors are not achieved, the organisation will fail" (Timans et al. 2012; Laureani and Antony 2012): organisations can ensure success if they direct their effort and focus onto the critical success factors. Figure 2 presents over 20 different critical success factors that appeared in the 21 case studies. Training and education was the most frequently cited factor, followed by communication and top management commitment and involvement. Other factors such as organisational culture and project selection & prioritisation appeared to be less important. However, CSFs varied from study to study and from company to company as well as between countries. CSFs cited as important in some studies were found to be less important in others; for example, studies in the Malaysian electronic manufacturing service (EMS) industry and the Netherlands SMEs manufacturing found that project selection and prioritisation was insignificant (Jayaraman et al. 2012), on the other hand, this factor was cited as one of the most important by other sources such as Snee (2010). Unique CSFs also emerged, such as; the development of project leader's soft skills, the need to give LSS implementation the time it needs, encourage LSS thinking in employees' daily activities and results sustainability. These variations in CSFs could be as a result of different cultures in different countries, but this gap needs to be bridged by future research.

Figure 2: Critical Success Factors for LSS in the Manufacturing Sector

3.2 Benefits of successful LSS implementation

More than 50 benefits were identified in the 21 case studies, and these are presented in figure 3. The most frequently stated benefits were; increased profits and financial savings (up to $3bn in some cases) (Corbett 2011), increased customer satisfaction (in around 50% of the reviewed papers), reduced costs and significantly reduced cycle time. Kucner (2009) states that in Navy commissioned nuclear aircraft carriers in the US, lead time was reduced from 180 days to 40 days. A number of cases cited a reduction in inventory & in-process waste as well as a reduction in the percentage of production defects. Moreover, three companies achieved Six Sigma levels due to the successful implementation of LSS in their organisations. Six companies experienced reduction in machine downtime and machine setup time. Other benefits such as; identifying different types of waste, development in employee morale towards creative thinking and reduction in workplace accidents as a

result of housekeeping procedures also appeared in a number of cases. The authors observed a rich seam of publications stating LSS benefits in the manufacturing sector, but no studies were found reporting a failure of LSS implementation. There may be many reasons for this; businesses are presumably not keen to spend time and effort preparing studies for publication that only demonstrate failure, or it may be bias in selection of articles for publication by the various journals who only want to report successes. The fact remains that this is a significant omission; publication of detailed analysis of failed implementations or projects would be of great benefit to those businesses contemplating LSS implementation in the future.

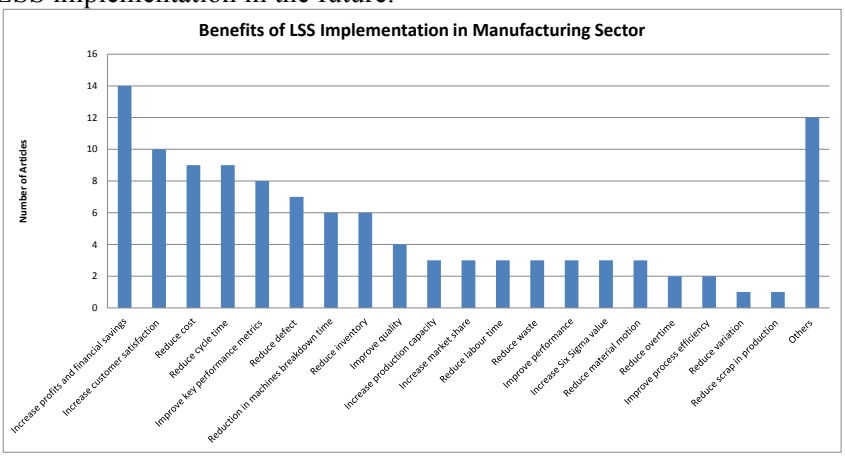

Figure 3: Benefits of LSS Implementation in Manufacturing Sector

3.3 Motivation factors for LSS implementation

17 different factors that motivate manufacturing companies to implement LSS are shown in figure 4. The top 3 are; to improve product quality & manufacturing operations; to increase customer satisfaction, attraction & loyalty & to change the competitive position in the market or to stay in competition in the international market. 6 companies were also motivated to implement LSS to reduce cost by different methods such as; reduce production cost or reduce defects in production. A number of factors have appeared in only one study, for example Chakravorty and Shah (2012) stated that implementation of LSS could improve employee morale. This view is supported by a single case study done by Vinodh et al. (2012) in Rotary Switches Manufacturing in India. This factor needs to be supported by more research to explore the relation between LSS implementation and the human side.

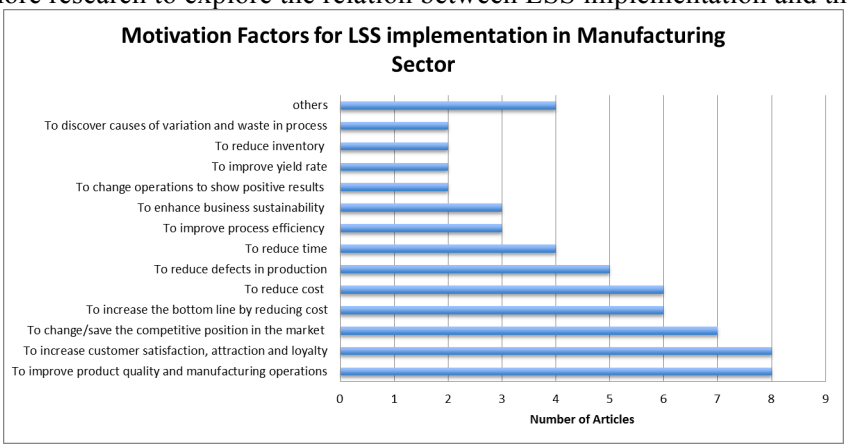

Figure 4: Motivation Factors for LSS implementation in the Manufacturing Sector

3.4 Limitations of LSS

8 fundamental limitations in LSS implementation are shown in figure 5, and these are a rich area for future research. Absence of clear guides for LSS implementation, especially in the early stages came first; practitioners need a clear guide to which strategy should come first; Lean, Six Sigma or LSS (Snee 2010; Kumar et al. 2006), and which tools should be used, when and how (lack of understanding of usage of LSS tools & techniques came third). Lack of LSS curricula was also cited

by many researchers; all argue that strong LSS curricula are needed in order to leverage learning in organisations (Salah et al. 2010). Hence, developing curricula for LSS has emerged in this paper as an area for future research.

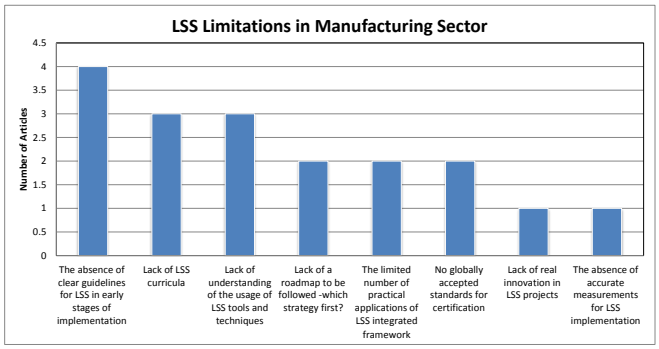

Figure 5: Limitations of LSS in the Manufacturing Sector

3.5 Impeding factors for LSS implementation

The implementation of any LSS programme needs to overcome impediments, and figure 6 demonstrates the 7 major impediments found in this study. The most significant included lack of awareness about LSS benefits in business (Snee 2010), unmanaged expectations and lack of availability of resources (Timans et al. 2012). Given the large amounts of information available about successes from LSS implementation, it is clear that it is a lack of visibility of results rather than lack of tangible results that is at issue here. Other factors included lack of training and coaching, employee reaction towards a new business strategy and convincing the top management about the benefits of LSS in business (Vinodh et al. 2012; Kumar et al. 2006). This last is due to a belief by top managers that investment in quality improvement programmes is no more than wasting money and increasing production cost (Kumar et al. 2006).

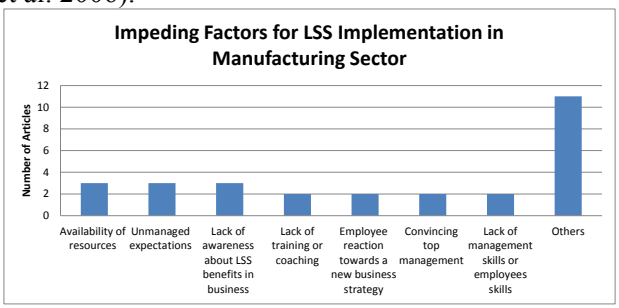

Figure 6: Impeding factors for LSS implementation in the manufacturing sector

3.6 Future research into LSS

The review of the 33 available papers has identified many weaknesses in previous research into LSS, and further work is clearly needed to bridge the gaps in available literature. There are many and varied accounts of successes and benefits accrued by the manufacturing sector, but not one publication reported failure of implementation of LSS in the same sector. It can be argued that publishing failure stories can definitely guide future research effort in the field.

Further investigation and work is needed in areas such as; problem identification; accurate and rigorous measurement systems to both establish a baseline and measure improvements; establishing clear guides to implementation for both managers and practitioners covering which strategy to adopt, and which tools to use, when and how, plus the role and skills of the LSS facilitator, including choosing an appropriate facilitator from inside or outside the organisation (Antony 2008; Kumar et al. 2006; Chakravorty and Shah 2012).

Research is also needed into areas such as the relation between LSS implementation and the human factor, formal training and certification systems and standards for MBBs, BBs and other practitioners, and finally the sustainability of LSS and proof that the integration of Lean and Six Sigma into one strategy really does help businesses to achieve world class results.

4 CONCLUSION

Levels of LSS deployment are increasing, especially in large organisations in the US, UK and the Netherlands, and in some SMEs in developing countries such as India; the number of available LSS publications is increasing accordingly. The application of LSS methodology in 21 case studies in the manufacturing sector has demonstrated the significant benefits that can be gained, and around 30 CSFs are cited in this paper, along with motivation factors. Equally importantly, the limitation and impeding factors which need to be overcome are also stated. There are many gaps in the available literature that need to be covered in future research, and although a great deal of work has been undertaken on individual Lean and Six Sigma themes, in the past there has been little written on Lean Six Sigma as a coherent strategy for business improvement, and this is one of the more immediate gaps that needs to be bridged.

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