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The impact of Lean Six Sigma tools on organisational performance: A literature review

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Abstract

In order to achieve, not only a competitive advantage in their markets, but to meet customer expectations and make a higher profit, manufacturing and assembly organisations strive to improve their performance, by reducing tact time and eliminating wastes and defects. Recent research results suggest that, if implemented appropriately, Lean tools and Six Sigma can have a positive impact on organisational performance. However, lack of top management commitment, communication, training, education and limited resources, are just a few factors of failure, usually underlined by the majority of academics in the field. Thus, it could be argued that many gaps and limitations regarding the implementation of Lean and Six Sigma tools still exist, and that there is a need for future research on how they affect organisational performance. To make a contribution to the relevant subject, this paper synthesizes previous studies and research results. The following research is based on a literature review of relevant papers that were published on Lean, Six Sigma and organisational performance, in the period of ten years. Consequently, relevant gaps in literature are discussed, along with research limitations and guidelines for future research.

Key words: *Lean tools, Literature review, Organisational performance, Six Sigma*

1. INTRODUCTION

Lean Six Sigma is a concept that derived from integrating Lean manufacturing with Six Sigma process improvement philosophy. Lean and Six Sigma are similar concepts, both classified under the umbrella of process improvement programs, along with business process re-engineering, theory of constraints and Total Productive Maintenance [1].

Despite their similarities, there are some important distinctions between their approaches, sets of tools and techniques and improvement objectives. However, many authors point out that integration of Lean with Six Sigma helps organisations to achieve more effective improvements than their individual application [2]. Thus far, Lean Six Sigma has been recognised among many authors as one of the most effective methodologies and hailed as a cost reduction mechanism.

Literature on Lean Six Sigma emphasises that positive effects on organisational performance are largely influenced by the implementation factors. However, it could be argued that there is a consensus among academics about which factors are crucial to a successful implementation of Lean Six Sigma programs. Thus, this paper aims to examine what specific success factors are identified in the covered articles and what is their impact on organisational performance.

Majority of reviewed papers uses qualitative research to examine the impact of Lean Six Sigma on organisational performance. In most cases qualitative data was collected through surveys and interviews. Very few authors used physical measurements of performance indicators. Results show that implementation of Lean Six Sigma delivers many benefits for the organisation. Still, none of the key factors provide equal results in performance improvements. Consequently, there is a need for future research about crucial factors of Lean and Six sigma success and how they might be beneficial for the organisation, with respect to the specifics of organisational performance and improvement programs.

The structure of this paper is organised as follows: Section 2 represents the theoretical background behind Lean Six Sigma and what research approach is predominantly used to describe its correlation to organisational performance indicators. Section 3 describes the research design used in this literature review and the inclusion criteria for selected articles. Section 4 presents findings on specific success factors for Lean Six Sigma implementation and their impact on organisational performance.Conclusions and future research recommendations are given in Section 5.

2. THEORETICAL BACKGROUND

2.1 Lean Six Sigma approach

Among other benefits, Lean and Six Sigma can help organisations to increase quality of the products and reliability of the processes [3]. Lean tools and techniques focus on streamlining processes and emphasise process flow, while Six Sigma practices concentrate on process defects. Lean approach addresses the visible problems in processes such as inventory, material flow and safety, whereas Six Sigma is more concerned with less visible problems, for example, operation variations [1].

Lean is a philosophy with a purpose to eliminate non-added value activities. These non-added value activities are considered as wastes, usually classified into three different groups: Muda, Muri and Mura. Muda includes wastes such as: over-production, defects, over-processing, waiting, unnecessary transportation, inventory and motion. Recently, two more wastes under the titles „underutilization of creativity of people“ and „environmental wastes“ are also recognised [4]. Muri refers to wastes such as “overburden”, work that creates overload for the team members or processes, while Mura is specified as “unevenness”, meaning workload is not balanced.

Six Sigma is recognised as a method that provides tools and techniques for continuous improvements of organisational processes, such as statistical process control, process capability analysis, error proofing and a structured problem solving method known as ‘define measure analyse improve control (DMAIC). These tools are used to help organisations understand and manage process variations [5, 6, 7]. Six Sigma was developed and applied for the first time in Motorola in the mid 80's. Six Sigma gained a lot of attention when this company won Baldridge National Quality award in 1988, for the outstanding achievements in product quality improvement programs [7].

Combining Six Sigma objectives (shifting process average, reducing process variation, finding best operating conditions, robustness in products and processes) with Lean objectives (reducing waste, eliminating activities that do not add value and reduction of cycle times) also leads to increased capability to manage instabilities of organisational processes [7]. In most cases, authors agree that Lean Six Sigma helps organisations to produce significant bottom-line savings in production [2, 3, 4].

2. 2 Organisational performance

Both quantitative and qualitative approaches can be used to evaluate organisational performance. To name a few, qualitative techniques include Pareto charting, control chart analysis, regression modelling, multi-variable studies and design of experiments (DoE). Qualitative techniques include interviewing, expert opinion, brainstorming, hypothesis-generation, VSM and cause and effect matrix [7].

Relevant literature provides a comprehensive set of assesment measurements for organisational performance [e.g. 8]. Usually, they are based on four perspectives, proposed by Kaplan and Norton (1992). These are: financial, customer, internal business process and the perspective of innovation and learning growth. Thus, these perspectives are adopted to constitute research framework of organisational performance indicators.

3. RESEARCH DESIGN

This narrative literature review covers 24 selected articles, from prominent science-cited journals. Distribution of the articles and covered journals is given in Table 1.

The list of papers is built upon a time frame between 2008 and 2017. Criteria for paper inclusion were articles with the „Lean“, „Six Sigma“ and „Performance“ in their tittle, abstract, as well as keywords, limited to „engineering“, „management“, „manufacturing“ and „assembly“.

Table 1. Distributions of the articles with respect to journals

International Journal of Production Research	4
International Journal of Automotive Technology	1
Production Planning & Control: The Management of Operations	1
The TQM Journal	2
European Journal Industrial Engineering	1
Journal of Productivity and Performance Management	1
International Journal of Construction Management	1
Quality Engineering	1
Journal of Quality & Reliability Management	4
International Journal of Lean Six Sigma	4
Quality Management Practices	1
Journal of Operations Management	1
Journal of Manufacturing Technology Management	1
Journal of the Decision Science Institute	1
Industrial Management & Data Systems	1
Total	24

To achieve comprehensiveness in literature coverage, a balanced approach between recently published papers (50% - from 2013 to 2017) and older articles (50% - from 2008 to 2012) was taken. The citation rate for papers between 2008 and 2012 is set to 30. Similarly,

at least 5 citations was the limit for papers from 2013 to 2017. Due to the limited access to databases, a number of papers which met these criteria were omitted from the final selection.

4. FINDINGS

4.1 LSS implementation success factors

Every improvement should begin with the active participation of top management. Many studies have revealed that strong leadership and commitment from top level management is critical for the success of Lean Six Sigma improvement programs [1, 6, 9, 10, 11, 12, 13]. Such improvements should be carried out with decentralisation of decision making process between top management and employees. However, it is very important to avoid any incongruence in management and employees' interpretation of organisational vision, as it may result in substantial degradation in performance [5, 6, 9, 11, 12]. Shortcomings in sustaining improvements can be overcome by defining a long-term plan on strategy and tactics before an improvement project starts [7]. Top management should also provide the platform to foster future leaders and nourish top talents, in order to ensure company growth and success [7, 11]. In medium-sized and large companies, the delegation of responsibility is more visible and it plays an important role in the implementation of aforementioned changes [9]. Thus, attention to the human side is necessary for sustained improvement results [2, 7, 9]. Creating a change culture heavily relies on the motivation of individuals to overcome resistance to such changes. The importance of sense for urgency is vital, given that it increases the likelihood of success [7]. Finally, such changes require adequate supporting infrastructure by the organisational management, in every phase of Lean Six Sigma implementation initiatives [7, 11, 12, 14].

Education, training and employee involvement are also significant for effective implementation of Lean Six Sigma [5, 6, 9, 12, 14]. It is important to emphasise organisational learning rather than the individual development [6]. A study on UK SMEs revealed that in-house training is most common method for employee education. Other mechanisms for organisational learning are: seeking external help of consultants, attending conferences, self education, and residing on mediums such as books/research articles and internet [9]. Also, many authors highlight that Lean Six Sigma requires clear communication between employees, on all organisational levels [7, 11, 12, 14, 15, 16, 17]

Some authors underline the importance of facilitators [6]. Facilitator's competence can be evaluated through his interpersonal and technical skills and ability to influence cultural and workplace change. Improvement programs are run project-by-project. To create a common improvement methodology, organisations have to create an integrated system for managing projects. Many academics point out that nothing is more important that the project selection. The project selection process identifies the right personnel and tools to be used [1, 6, 7]. Literature provides three generic categories of project selection criteria:

(1) Business benefits: impact on meeting external customer requirements; financial impact; and impact on core competencies.

(2) Feasibility: resources required; complexity; and expertise available.

(3) Organisational impact: cross-functional benefits and learning benefits.

Some authors recommend that project portfolio management is a good practice for managing improvements [4, 7]. The objectives of project portfolio management are to determine what are the optimal resources for delivery and schedule activities to achieve organisational goals. Every Lean Six Sigma project requires careful planning and clearly defined road-maps [4, 17]. Without such measures, it is difficult to detect occurrence of production defects and idles in production process. Performance evaluation requires standardisation and appropriate measurement system [18]. More importantly, this system needs to be periodically validated.

Table 2. Synthesis of LSS implementation success factors

Factors relating to top management and leadership	
Top management leadership, engagement and commitment *Defined organisational direction and improvement goals* *Long term plan for sustaining the improvements* *Delegation of authority and leadership development* *Structured approach to Black Belt selection* *Supporting employee empowerment, rewards and recognition* *Attention to the human side in a culture of change* *Incorporating a sense of urgency*	[2, 5, 6, 7, 9, 11, 12, 14, 16, 19]
Factors relating to supporting infrastructure and resources	
Financial capability *Supporting organisational infrastructure* *Allocation of people, time, money and other resources* *Cross-functional team structures* *Employee engagement* *Personnel skilled in improvement* *Linking Lean Six Sigma to suppliers* *Linking Lean Six Sigma to customers*	[1, 4, 5, 7, 9, 11, 12, 14, 16]
Factors relating to competence, communication and culture	
Organisational belief and culture *Mechanisms for knowledge sharing and transfer* *Communication and assessment on LSS* *Best practices sharing and benchmarking* *Established LSS dashboard* *Employee development, education and training program* *Evaluation of LSS methodology, tools and techniques understanding* *Networking with Government and Academia*	[1, 2, 5, 6, 7, 9, 12, 14, 16, 17]

Factors relating to competencies of a deployment facilitator (Black Belt, Master Black Belt)	
The technical skills level of the deployment facilitator *The interpersonal skills level of the deployment facilitator* *The level of influence of the deployment facilitator*	[6, 11]
Factors relating to improvement program	
A structured approach to project planning *Project prioritisation and selection* *Defined project scope* *Project portfolio management* *Project management skills* *Project team selection* *Identification of the problem or the opportunity for improvement* *IT support* *Integration with ISO standards*	[1, 2, 4, 7, 9, 11, 12, 14, 16, 17, 19, 20]
Factors relating to performance evaluation	
Development of current state map *Focus in metrics* *Standardisation of processes* *Standardisation of improvement methods* *Verified measurement system* *Documenting the improvements made to the process* *Time data collection for the improved processes* *Quality information and analysis* *Ad hoc process analysis and error proofing* *Auditing aspects of the improved process*	[2, 4, 14, 17, 19]

To detect problems with measurement system, many statistical tools can be applied, such as: statistical process control, intra class correlation, gage repeatability and reproducibility etc. Table 2 presents a synthesis of specific success factors for Lean Six Sigma implementation identified in the relevant literature.

4.2 Organisational performance indicators

In order to evaluate progress towards the organizational goals, managers need to focus on both, financial and non-financial measures. Given the diversity in improvement programs and organisational objectives, it is difficult to develop standardised frameworks for Lean Six Sigma, as well for the performance measurement systems [8]. Thus, many authors have strived to derive some level of unification. For example, a comprehensive set of measures for organizational performance is proposed by Habidin and Yusof (2012). The results of their study is given in Table 3. Other authors also evaluated the effects of Lean Six Sigma on organisational performance through various indicators, predominantly focusing on financial and internal business process performance.

In most cases, internal business process performance was evaluated through productivity [9, 11, 13, 16], scrap rate [9, 13, 17], OEE [4, 21], and machine downtime [4]. It is often followed by the waste reduction and defects rate measures. Other mentioned measures are variation [22], first time yield [23], quality of products [11, 16], mean time to repair, lead time, process capability [4], cycle time [9, 13] and speed [3]. In case of financial performance, many scholars were focused on profitability [3, 8, 9, 11, 14, 16], and manufacturing costs [3, 9, 11, 14, 19]. Sales growth [9, 13, 19], return on assets [2, 16, 19], and sales revenue [2, 16, 19] were also mentioned in these studies. Beside mention ones, it is worth of noting that customer relationship was observed through delivery time [3, 9, 13, 16], market share and export [11, 16], customer complaints [9, 13], sales data and customer retention [9]. Innovation and learning growth performance though flexibility [3, 11, 16], capacity to develop a competitive profile [11, 16], innovation [3] and employee complaints [9, 13].

Table 3. Organizational performance measures [8]

OP measure	Items
Financial	Operating income, sales growth, ROI, cash flow, sales revenue, manufacturing cost, economic value added and capital efficiency
Customer	Market share, customer satisfaction, loyalty and retention rate, number of warranty claims, of shipments returned due to poor quality and number of overdue deliveries
Internal business process	Material efficiency variance, the ration of good output to total output at each production process, lead time, improvement of workers efficiency, quality of the purchase item, plant utilization, relation with vendor, rate of material scrap loss, defect rate, setup and changeover time, cycle time, inventory, redesign plant layout and forecasting errors
Innovation and learning growth	Number of new patents, number of new product launches, quality of professional/technical development, quality of leadership development, new market development, new technology development, level of employee satisfaction and level of health and safety per employees (e.g., accidents, absenteeism and labour turnover)

4.3 Impacts of Lean Six Sigma implementation on organisational performance

A prominent study on Lean Six Sigma implementation shortcomings in UK SMEs followed 96 organisations, from various manufacturing industries, during a five year period [24]. The purpose of this study was to examine the influence of the adoption level of Lean Six Sigma on improvements of organisational performance. The authors have conducted two surveys; the first one was aimed to examine the initial state in levels and extent of Lean Six Sigma, while the second one is used to observe changes in organisational performance. Analysis of the initial survey showed that these organisations fall into three distinct categories, based on their business type, level of Lean Six Sigma activity and characteristic performance. These categories are

presented as follows: First category consists out of organisations seen as higher performers, with highly advanced approach based upon a continuous culture of business process improvement. These organisations make just over 11% of the sample. Second category presents organisations that are aware of Lean Six Sigma and have reasonably good investments in its implementation. Further, the authors highlight that these organisations are obtaining a good turnover, but poor profitability, due to the limited knowledge in achieved gains. This is where the second survey comes along; to ascertain whether these organisations had actually migrated into the first category. The majority of the sample (64%) fell into the third category, consisting of organisations with various level of performance, limited Lean Six Sigma activities and no structured approach in process improvement programs. Lean Six Sigma was studied in isolated business improvement; in production design, as well in the traditional production environment setup. Final survey also investigated whether some of the organisations belonging to this category started to move towards the higher Lean Six Sigma levels.

Final survey analysis showed only small shifts of organisations from one category to another. Migration of organisations from third category to second was seen in 15% of the cases (i.e. 9 organisations). Only one organisation from the second category migrated towards the first. These organisations make only 4-6% of the sample. On average, 13% of organisations had shown a significant development of their Lean Six Sigma systems. Organisations that have not made the move into the next category were limited for a number of reasons: Lean Six Sigma was not being fully developed, internal manufacturing systems was not being fully synchronised, etc. Whilst there would appear that there is limited inter-category migration, there has been progress over the five years period, however, such changes will take some time to develop. A general discussion of survey findings indicates the following: many of the companies that were attempting to implement Lean Six Sigma have failed, due to inability to develop a cultural change to drive the implementation forward. Consequently, these organisations did not find strong reasons for its implementation. Many organisations from the second category that achieved limited success found Lean Six Sigma to be a risky investment. They did not fully appreciate that it can assist the organisation in improving business performance and customer satisfaction. Final conclusions pointed out that the implementation phase is the most difficult, due to the various shortcomings in project selecting and planning improvement strategy. Top management commitment and realistic expectations had been found to be the most critical success factors. This is supported by the majority of reviewed papers [1, 6, 7, 8, 9, 11, 12, 14, 16] Literature shows other factors crucial to the success of Lean Six Sigma programs. That is, firstly, linking Lean Six Sigma to business strategy, organisation's financial capability, effective communication, assessment on Lean Six Sigma best practices, sharing such practices along with benchmarking activities, Lean Six Sigma dashboard, methodology understating, tools and techniques utilization, project prioritization and selection, project measurement, reviews and tracking, team selection, and finally, linking Lean Six Sigma with customer requirements [11, 12]. A review on performance improvements obtained through Lean Six Sigma indicates largest impact on organisational capability to meet delivery deadlines, followed by increased quality of products, shorter production cycle and delivery of products to consumers [3, 9, 13, 16]. Some authors found significant improvement on performances such as: first time yield, lead time, defects per unit, process capability, resulting in smooth process flow and substantial savings to the organisation [4]. Many authors conclude that Lean Six Sigma can serve as a major tool to reduce defects, manage variation and waste [4, 9, 11, 13, 16, 17, 21]. In particular, implementation of Lean Six Sigma in construction industry have yielded tangible benefits through reduction of defective weld - schedule delays, caused by unexpected downtime, due to the loss of production capability and rework/repair rate were significantly reduced [17]. Among mentioned ones, benefits are also reflected in the energy usage reduction [21]. Predominant opinion of selected authors is that organisation can have benefits from deployment of Lean Six Sigma. Such benefits are reflected in cost reduction of manufacturing phases [2, 3, 4, 9, 11, 13, 16].

5. FUTURE RESEARCH AND CONCLUSION

Some authors argue whether Lean Six Sigma approach is merely a „buzz word", in an endless stream of proposed business improvement methodologies. We argue that an organisation can have certain benefits from Lean Six Sigma approach, through adding new concepts, methods and tools, which can result in increase of organisational performance. However, there is a need for a more comprehensive multiple case study that would provide an effective guide for the implementation of Lean Six Sigma, with respect to organisation size and specifics of organisational performance. We conclude that, in practice, Lean Six Sigma is seen as a manufacturing improvement methodology, rather than a management philosophy.

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