

TOWARDS GREEN THROUGH LEAN/LEAN SIX SIGMA APPROACHES: A LITERATURE REVIEW AT SERVICE INDUSTRY

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Abstract

In the last decades, sustainable development have increasingly gained importance to service industry and lean/Six Sigma approaches are becoming more and more outstanding in order to improve sustainability performance. In the post-modern era the integration between those approaches are necessary in order to aid organisations to balance the need for operational efficiency in their production and service systems with environmental commitment and social fairness. Because of that, Lean Six Sigma practices are progressively becoming widespread in studies about service, as way to improve quality, efficiency, effectiveness and sustainability of services. The purpose of this paper is to critically review the Lean and Lean Six Sigma (L6σ) methodologies and highlight their importance to achieve sustainable development in service industry. To do this, a systematic literature review (SLR) of the subjects under investigation was conducted. We examine the compatibility and divergences of the green, lean and Six Sigma concepts and implications regarding its sustainable implementation in service industry. The study has two major contributions. First, it is one of the first researches that investigate the potential benefits of integrating green, lean and Six Sigma in service sector. Second, it supports and expands current literature, providing both academicians and practitioners a better panorama to understand the present status of L6σ for achieving sustainability in service sector.

Keywords: Lean Six Sigma, sustainable development, service Industry

Clasificare JEL : L80, O14, Q01, Q55

1. Introduction and context of the study

Sustainable concerns have increasingly gained importance in practice and academic discussions over the last decades. In addition to, in the post-modern era there is a growing pressure to improve quality, efficiency, effectiveness and sustainability of services, an industry which accounts for more than 50% of gross domestic product in the big economies around the world.

In the last decade, academics and practitioners have extensively cited the benefits of Lean implementation to the service industry. Most of these studies were applied in healthcare (e.g. laboratories chain, hospitals, nursing and surgery), insurance companies, software giants to educational institute, within both public and private sectors.

Nowadays, although the integration between lean thinking and Six Sigma become more popular among the manufacturing industry, the Lean Six Sigma (L6σ) practices are progressively becoming widespread in studies about service. The L6σ incorporates the principles of speed and immediate action of Lean thinking with the vision of Six Sigma of quality without defect and reduction of the impact of the variation in the times of queue; It attacks the hidden costs of complexity and is a mechanism that seeks the engagement of all for joint reach and without trade-offs of quality, speed, and cost [1]. However, the service industry still has few studied about the

L6 σ and even less regarding the sustainable development (SD). Thus, there is lack of studies about ways of achieve the SD in services through L6 σ .

The purpose of this paper is to critically review the Lean Six Sigma methodology and highlight its importance to achieve sustainable development in service industry. To do this, a systematic literature review (SLR) of the subjects under investigation was conducted. This review explores the following questions:

- (1) What are the compatibilities and divergencies between green, lean and Six Sigma in service industry?
- (2) What are the main implications of Lean and L6 σ for achieving green services?

The study is organized into four sections as follows. The next section presents methodological procedures employed in the systematic literature review. Then the findings from the literature review are presented in Section 3, which shows the thematic synthesis analysis. Finally, in Section 4 we have the discussions and conclusions of this research.

2. Background

Since the 50's, lean principles of the Toyota production system have evolved, and have been implemented successfully by the Toyota Motor Company [2]. They were formed by two main conceptions: Just-in-Time flow (producing according to the demand) and Jidoka automation (man-machine separation, in which a single operator manages several machines).

Lean Thinking offers a unique methodology, which is to do more with less – less human effort, less equipment, less staff and less space – in order to achieve the real needs of its clients. It results in the elimination of waste through more efficient processes, and that generates the essential capabilities a customer values [3].

Six Sigma was created in the 1980's by Bill Smith at the Motorola Corporation, and seeks to reduce errors and defects by applying the DMAIC (Define, Measure, Analyze, Improve, and Control) methodology. Six Sigma is a highly disciplined process that helps organizations focus on delivering lower-cost products with improved quality and reduced cycle time, where Sigma represents a statistical term that measures the extent to which a given process deviates from perfection and Lean Six Sigma is a methodology of process improvement used in organizations of international standard in order to eliminate waste in the processes and deliver products and services with extreme quality to its clients [4].

Moreover, Six Sigma can help in developing skills, improving knowledge and skills, improving employee morale and the ability to use a wide range of tools, techniques and has the following advantages over total quality management: Establishing zero defaults targets, creating the DMAIC process improvement cycle, and intensive use of statistics and data to make managerial decisions and reduce process variation [5].

However, by focusing on process improvement and variability reduction, Six Sigma programs do not guarantee a sustainable competitive advantage, and mechanisms need to be developed that address innovation and product differentiation, the pattern of change in the customer base, and uncertainty Environmental, while improving organizational processes, considering radical changes and the formation of new markets and / or customers [6]. Because of that, it is essential to merge the two methodologies to reduce cost and complexity [7].

3. Methodology

In this paper was conducted a systematic literature review in order to locate relevant existing studies based on prior formulated research questions, to evaluate and synthesize their respective contributions. This SLR consists of five consecutive phases: (a) formulation of the question, (b)

location of studies, (c) evaluation and selection of studies, (d) analysis and synthesis, and (e) reporting and use of the results [8].

Identifying the keywords is extremely critical to a comprehensive and unbiased review. The search is limited to a set of key words ('Lean', 'Six Sigma', 'Lean Sigma', 'Lean Six Sigma', 'LSS', 'Environment', 'Sustainable', 'Sustainability', 'green', 'green Lean Six sigma', 'green LSS', 'Sustainable Lean Six Sigma' and 'Service'). We searched these keywords in the following databases: Scopus, PubMed, Emerald, Taylor and Francis, IEEE Xplore and Wiley Publication. The conducted research had combined the search terms into title, abstract or keywords, limited to papers published in peer-reviewed journals up to March 2017, when they were available. Additional papers were identified by reading the papers included in the review. 272 records were identified through databases searching. Then, they were refined by titles/abstracts screening analysis and 207 records were excluded. Following that, 65 articles were analyzed in depth in an iterative process. Based on the full text analysis, a total of 43 articles complied with the selection criteria. Hence these were all the articles that, to a certain extent, referred to Lean, Six Sigma or Lean Six Sigma related to sustainable development in services.

In the next stage, researchers discussed and created a database using Microsoft Excel. There was a synthesis analysis, in which individual articles were categorized and organized by concepts.

4. Summary of results

Table 1 indicates some of the main compatibilities and divergences between Lean, Six Sigma and green in the Service Industry, including general points for all sectors.

Table no. 1 Compatibilities and divergences between green, lean and Six Sigma

Compatibilities	Ref.	Themes
Lean and green maintain synergies related to waste reduction, lead time reduction, product design and the use of various approaches and techniques to manage people, organisations and the supply chain;	[8]	Lean and green
Lean facilitates sustainability, and people integration is the key to lean success, which drives the organization towards sustainable operations management. Sustainable processes reduce ecological impacts and may eliminate wasteful depletion of scarce resources. The synergies from the horizontal and vertical directions of human integration can lead to value creation in the organization;	[9]	Lean and green
Just like Lean, Green advocates the elimination of seven wastes: unnecessary usage of water, unnecessary power usage, exploitation of resources, pollution, litter, greenhouse effects and eutrophication	[10]	Lean and green
Lean and Green can be also integrated into other models like ISO 9001 and 14001	[11]	Lean and green
lean tools and practices may facilitate the focus on sustainability at the operational level	[12]	Lean and green
The use of the DMAIC (define-measure-analyse-improve) model can provide Green Lean with a more specific and holistic project-based orientation to the implementation of Green Lean initiatives. They identified a set of keys to management to ensure the effective and successful implementation of Green Lean Six Sigma initiatives: (i) leadership and people, (ii) Green and Lean Six Sigma tools, (iii) continuous process improvement, (iv) strategic planning, (v) stakeholders, (vi) results and knowledge management.	[13]	Lean, Six Sigma and green
Divergences	Ref.	Themes
Sustainability is concerned with the capability of meeting those needs in the present and future (efficacy, effectiveness and ethics), whereas lean is more oriented to delivering products or services with the minimum use of resources (efficiency and effectiveness)	[14]	Lean and green
While lean is more concerned with respecting people, including customers and employees, sustainability appears to expand the concern by seeking the well-being of all stakeholders in the long term.	[14]	Lean and green

Green is focused on environmental performance, Lean is focused on waste and its elimination and Six Sigma focuses on the continuous improvement of quality of products and services in an organisation by minimising the defects.	[15]	Lean, Six Sigma and green
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5. Discussion and Conclusions

Table 2 portrays some implications about how different services could achieve green through lean and lean six sigma.

Table no. 2 Implications for achieving green

Sectors	Recommendations	Ref.
Education	Courses should combine lean and green thinking to teach lean and green concepts and approaches, and also integrate studies such as green productivity, eco-efficiency, eco-effectivity, and sustainable business practices. University schools of business and engineering could be ideal candidates for incorporating these curricular changes.	[16]
General	It is important that employees have a deep understanding of the concepts underpinning green and lean practice and the employee development processes must be linked to the overall green and lean transformation process, because human capital is at the very core of green and lean practice.	[17]
Air	It is important to reduce fuel consumption by eliminating network redundancy and by reorganizing hub networks, and balancing this against possible service level degradation.	[18]
Sales	Green may be a useful support to Six Sigma as a programme that helps to save resources.	[19]
Food processing	Lean Six Sigma might be successfully applied in the food processing industry through VSM-DMAIC, in which the value stream mapping – is used to identify the type of waste and the DMAIC improvement cycle was applied in order to understand and address the wastes by applying relevant Lean and Six Sigma tools. Also, L6 σ can be effectively applied in the food processing industry as a contributor toward the environmentally sustainable fresh food supply chain.	[20]
Information and Communication Technologies (ICTs)	In this age of science and information, it is important to build bridges between disciplines, between academics and industry. More specifically, the field of Life Cycle Assessment (LCA) can adopt and apply a substantial amount of tools and lines of thought from operational management such as the Lean heritage and six sigma and vice versa.	[21]
Heathcare	While lean approach is used to reduce the use of water, materials and pharmaceuticals in medication processes, without, however, undermining patient safety, Six Sigma approach is used to monitor actions before and after interventions and improve medication processes from the point of view of environmental sustainability. Thus, they must complement each other and the L6 σ is method by which hospitals can control costs, reduce the likelihood of errors and improve patient safety and health care quality, promoting sustainability practices yields not only environmental benefits, but also economic ones for the institution.	[22]

As stated by [23] more than reach cost reduction and failures correction, we expect that green L6 σ service focus on a cultural change, bringing a new sense of discovery, experience and or re-discovery internally and externally, maximising a collaborative value creation, developing new behaviors and skills for employees and delivering environmental-friendly services to the clients.

Moreover, the both cultural change and implementation of L6 σ tools and principles can ensure sustainability and critical aspects as respect for people and employee engagement depends on responsibility along with ownership, human-centric approach, deeper problem-solving capabilities and cross-functional relationship, which are fundamental for continuous improvement [24].

Therefore, this research aims to contribute to the scientific community on the theme studied, since it present a representative selection of international research in interdisciplinary area as it is a relevant issue in which there is a dialogue of sustainability science, business management and industrial engineering, enabling the researchers to contribute with relevant research.

6. Bibliography

- [1] **George, M.L.**, Lean Six Sigma for service: how to use Lean speed and Six Sigma quality to improve services and transactions. New York, McGraw-Hill, 2003;
- [2] **Aziz, R.F., Hafez, S.M.**, Applying lean thinking in construction and performance improvement. Alexandria Engineering Journal, Vol. 52, no.4, pp. 679-695, 2013.
- [3] **Comm, C.L., Mathaisel, D.F.X.**, A case study in applying lean sustainability concepts to universities. International Journal of Sustainability in Higher Education, Vol. 6, no.2, pp. 134-146, 2005.
- [4] **Popa, A., Ramos, R., Cover, A., Popa, C.**, Integration of Artificial Intelligence and Lean Sigma for Large-Field Production Optimization: Application to Kern River Field. Proc. SPE Annual Technical Conference and Exhibition, 2005.doi:10.2523/97247-MS
- [5] **Franchetti, M.J.**, Lean Six Sigma for Engineers and Managers. 2015.
- [6] **Parast, M.M.**, The effect of Six Sigma projects on innovation and firm performance. International Journal Project Management. Vol. 29, pp. 45–55. 2011.
- [7] **George, M.L.**, Lean Six Sigma: Combining Six Sigma Quality with Lean Production speed, McGraw Hill, 2002.
- [8] **Garza-Reyes, J.A.**, Green lean and the need for Six Sigma. Int. J. Lean Six Sigma 6, 226–248, 2015; doi:10.1108/IJLSS-04-2014-001
- [9] **Wong, W.P., Wong, K.Y.**, Synergizing an ecosphere of lean for sustainable operations. J. Clean. Prod. 85, 51–66, 2014; doi:10.1016/j.jclepro.2014.05.093
- [10] **Chugani, N., Kumar, V., Garza-Reyes, J.A., Rocha-Lona, L., Upadhyay, A.**, Investigating the green impact of Lean, Six Sigma, and Lean Six Sigma: a systematic literature review. International Journal of Lean Six Sigma Iss International Journal of Lean Six Sigma. 2017; doi:10.1108/IJLSS-11-2015-0043
- [11] **Kurdve, M., Zackrisson, M., Wiktorsson, M., Harlin, U.**, Lean and green integration into production system models e experiences from Swedish industry. J. Clean. Prod. 85, 180e190. 2014; <http://dx.doi.org/10.1016/j.jclepro.2014.04.013>.
- [12] **Verrier, B., Rose, B., Caillaud, E., Remita, H.**, Combining organizational performance with sustainable development issues: the Lean and Green project benchmarking repository. J. Clean. Prod. 85, 83–93. 2014; doi:10.1016/j.jclepro.2013.12.023
- [13] **Cherrafi, A., Elfezazi, S., Chiarini, A., Mokhlis, A., Benhida, K.**, The integration of lean manufacturing, Six Sigma and sustainability: A literature review and future research directions for developing a specific model. J. Clean. Prod. 139, 828–846, 2016; doi:10.1016/j.jclepro.2016.08.101
- [14] **Martínez León, H.C., Calvo-Amodio, J.**, Towards lean for sustainability: Understanding the interrelationships between lean and sustainability from a systems thinking perspective. J. Clean. Prod. 142, 4384–4402, 2017; doi:10.1016/j.jclepro.2016.11.132
- [15] **Kumar, S., Luthra, S., Govindan, K., Kumar, N., Haleem, A.**, Barriers in green lean six sigma product development process: An ISM approach. Prod. Plan. Control 27, 604–620, 2016; doi:10.1080/09537287.2016.1165307
- [16] **Dhingra, R., Kress, R., Upreti, G.**, Does Lean mean Green? J. Clean. Prod. 85, 1–7. 2014; doi:10.1016/j.jclepro.2014.10.032

- [17] **Zhan, Y., Tan, K.H., Ji, G., Chung, L., Chiu, A.S.F.**, Green and lean sustainable development path in China: Guanxi, practices and performance. *Resour. Conserv. Recycl.* 2015; doi:10.1016/j.resconrec.2016.02.006
- [18] **Ryerson, M.S., Kim, H.**, The impact of airline mergers and hub reorganization on aviation fuel consumption. *J. Clean. Prod.* 85, 395e407, 2014; <http://dx.doi.org/10.1016/j.jclepro.2013.12.032>.
- [19] **Wei, C. C., Sheen, G. J., Tai, C. T., and Lee, K. L.** Using Six Sigma to improve replenishment process in a direct selling company. *Supply Chain Management: An International Journal*, 15(1), 3-9, 2010;
- [20] **Powell, D., Lundebj, S., Chabada, L., Dreyer, H.**, Lean Six Sigma and environmental sustainability: the case of a Norwegian dairy producer. *Int. J. Lean Six Sigma* 8. doi:10.1108/IJLSS-06-2015-0024, 2017;
- [21] **De Soete, W.**, Towards a Multidisciplinary Approach on Creating Value: Sustainability through the Supply Chain and ERP Systems. *Systems* 4, 16, 2016; doi:10.3390/systems4010016
- [22] **Furukawa, P. O., Cunha, I. C. K. O., Pedreira, M. L. G., Marck, P. B.**, Environmental sustainability in medication processes performed in hospital nursing care. *Acta Paul Enferm.* 29(3):316-24. 2016;
- [23] **Suárez-Barraza, M. F., Smith, T., and Dahlgard-Park, S. M.**, Lean Service: A literature analysis and classification. *Total Quality Management & Business Excellence*, 23:3-4, 359-380, 2012;
- [24] **Gupta, S., Sharma, M., Sunder M.,V.**, Lean services: a systematic review. *International Journal of Productivity and Performance Management*, Vol. 65 Iss 8 pp. 1025 - 1056, 2016; Permanent link to this document: <http://dx.doi.org/10.1108/IJPPM-02-2015-0032>