

Seeing green: achieving environmental sustainability through Lean and Six Sigma

Historically, profitability and efficiency, and more recently, customer satisfaction, quality and responsiveness, have been the dominant concern for organisations (Green *et al.*, 2012; Mohanty and Deshmukh, 1999). In this line, “Lean” and “Six Sigma” have been recognised as the two most prominent strategies used by organisations to attain operational excellence and thus achieve the aforementioned objectives. However, to respond to environmental regulations and the growth of customer demands for products and services that are more environmentally sustainable, companies have now been forced to rethink their objectives and how they manage their operations and processes (Garza-Reyes, 2015a). Instead of seeing things from the perspective of the customer, companies are now learning to see from the perspective of the environment (Wills, 2009). For this reason, some organisations have taken a proactive role in developing cleaner supply chains, manufacturing processes and services as well as designing environmentally sustainable products. This has given birth to the emergence of the “green paradigm” as a philosophy and operational approach to improve the environmental efficiency of organisations and reduce the negative ecological impact of their products and services while still achieving their financial objectives (Garza-Reyes, 2015b). The green paradigm can be considered an initiative (Digalwar *et al.*, 2013) that uses methods such as environmental operations management, also known as green operations (Nunes and Bennett, 2010), reverse logistics (Sarkis, 2003), green supply chains (Sarkis, 2012), green manufacturing (Kleindorfer *et al.*, 2005), among others, to reduce the negative environmental effect of the consumption and production of products and services (Garza-Reyes, 2015b).

As lean manufacturing aims at the elimination of waste in every area of production, design, supplier network and factory management, its compatibility with the green paradigm seems logical. For instance, while lean traditionally focuses on time-based metrics, it can also be used to identify and reduce energy and environmental wastes via the energy-environmental value stream mapping technique (Kuriger *et al.*, 2011). However, despite their primary and similar objective of fiercely targeting the reduction of waste, the green and lean relationship and their combination as an integrated approach has only recently started to be explored (Dües *et al.*, 2013). For this reason, only few theoretical frameworks and empirical examples are available to guide and explain industrialists how to integrate green methodologies into their current lean practices (Garza-Reyes, 2015a; Dües *et al.*, 2013), or vice versa.

On the other hand, quality is more than just achieving capable and reliable processes or manufacturing products free of defects (Madu and Kuei, 1995). In this context, a system’s overall performance should not only be measured on the basis of product quality but also on the basis of environmental sustainability (Kuei and Madu, 2003). Nevertheless, very few researches have correlated the quality and green paradigms. Total quality environmental management (TQEM), a sub-development of TQM, emphasises environmental controls, in industries that are associated with environmental waste (i.e. electronic component and semiconductors manufacturing) (Sarkis, 2003; Raisinghani *et al.*, 2005). TQEM is a method that correlates quality with



green aspects. However, in the case of six sigma, there is very limited evidence of research that has investigated the relationship between six sigma and green initiatives and performance (Garza-Reyes, 2015b). This relationship requires investigation because the quality and environmental sustainability dimensions are considered mutually dependant (Kuei and Madu, 2003).

This special issue (SI) of the *International Journal of Lean Six Sigma (IJLSS)* therefore intends to explore the synergies between the Lean/Six Sigma and green paradigms by presenting the latest research and developments in lean and six sigma, with particular interest in their combination with the green paradigm and their contribution and impact upon creating environmentally sustainable supply chains, processes, services and products. In particular, this SI focuses on theoretical, practical, novel and original contributions investigating the combination and/or impact of the Lean/Six Sigma strategies on environmental initiatives and performance by addressing the following questions:

- Q1. How can lean and/or six sigma be effectively integrated with green strategies and initiatives to support the development, management and improvement of environmentally sustainable supply chains, processes, services and products?
- Q2. How have lean and/or six sigma been used to contribute in achieving greener supply chains, processes, services and products, and what results have been obtained?
- Q3. What green-oriented theoretical frameworks, decision-support concepts, methods and tools have been proposed based on lean and/or six sigma and how have they been integrated as part of the corporate, business or functional strategies of organisations?
- Q4. How can organisations align, adapt and deploy Lean/Six Sigma strategies to effectively respond to and support the current environmental challenges without jeopardising their business success?
- Q5. How can Lean/Six Sigma aid organisations to balance the need for operational excellence and profit gains with that of environmental compliance?
- Q6. What empirical evidence exists of the application of Lean/Six Sigma to improve the environmental performance of organisations?

Six articles that present state-of-the-art research work that spans from a variety of leading edge researchers and practitioners in the area of Lean, Six Sigma and Lean Six Sigma were selected, after two to three rounds of reviews, from the submissions of articles made to this SI. The guest editors had to be very selective as many of the papers submitted were of high quality. The six papers selected include.

Investigating the green impact of Lean, Six Sigma and Lean Six Sigma: a systematic literature review

The purpose of this paper is to investigate, through a systematic review of the existing academic literature, the environmental (green) impact, mainly represented through energy savings and the usage of natural resources, of using quality and operations improvement methods such as Lean, Six Sigma and Lean Six Sigma. The paper shortlisted and analysed 70 articles, from which it concluded that both lean and six sigma can be considered effective methods to support the conservation of resources, combat global warming and saving energy. This paper contributes to the current body of knowledge, as literature exploring the

environmental/green impact of operations and quality management and improvement methods commonly used in industry is still limited and in early stages.

Maintaining sustainable performance in operating petroleum assets via a Lean-Six-Sigma approach: a case study from engineering support services

This paper demonstrates the possibility of maintaining triple bottom line (TBL) sustainable performance in the petroleum industry via a case study. In particular, it presents the utilisation of a Lean Six Sigma concept for investigating one of the underperforming support service activities in an engineering contractor (EC) and to indicate how Lean Six Sigma concepts enable the barriers to maintaining sustainable petroleum operations to be reduced. This paper will be of major interest to practitioners as it addresses the inherent TBL sustainable performance challenges in the petroleum industry that have been caused due to delayed projects. Although the particular focus of the paper centres around the petroleum industry, its approach and findings may also be replicated in other industrial sectors.

Lean six sigma and environmental sustainability: the case of a Norwegian dairy producer

This paper investigates the application of Lean Six Sigma in the continuous process industry, taking insight into the food processing industry; and to evaluate the impact of Lean Six Sigma on environmental sustainability. The authors present observations and experiences from the application of Lean Six Sigma at a Norwegian dairy producer, with the aim of bringing out pertinent factors and useful insights to help understanding how Lean Six Sigma can contribute towards greater environmental sustainability in this type of industry, something that is so far lacking in the academic literature. The paper also makes useful reflections regarding the success criteria that can be used by researchers and practitioners for the effective deployment of Lean Six Sigma, particularly in the continuous process industry. The paper is one of the first contributions which have explored the application of Lean Six Sigma and its effect on environmental sustainability in the continuous process industry.

Green and Lean implementation: an assessment in the automotive industry

This paper proposes an assessment framework to evaluate businesses in terms of the implementation of a green and lean organisation's supply chain. The framework uses key criteria to identify green and lean initiatives, which led to the development of guidelines for each criterion, and the development of a scoring method. The authors validated the framework through a multi-case study approach in the automotive industry. Generally, the study reveals that high scores are derived from a good interaction between green and lean implementation in these companies. This paper's main contribution consists in being one of the first works in providing an assessment framework to evaluate an organisation's supply chain in terms of green and lean implementation.

Impacts of Lean Six Sigma over organisational sustainability: a systematic literature review on Scopus base

This paper carries out a systematic study of Lean Six Sigma impacts on organisations, analysing their relation to organisational sustainability through the TBL perspective. A systematic review of the existent literature on Lean Six Sigma was performed and the identified impacts were later classified as correspondence with three dimensions of organisational sustainability: financial, social and environmental. The paper identified 25 main impacts of Lean Six Sigma and a greater correspondence of Lean Six Sigma over a range of economic results in organisations. However, the paper also found that Lean Six

Sigma has been gradually directing its efforts to meet further perspectives of sustainability, particularly by looking for a better relationship with employees and customers. This paper therefore adds evidence to the current body of knowledge by applying Lean Six Sigma techniques for enhancing sustainability in organisations.

Knowledge-based Lean Six Sigma maintenance system for sustainable buildings

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This paper develops a knowledge-based (KB) system for Lean Six Sigma maintenance in environmentally sustainable buildings (Lean6-SBM). The authors developed the system using the rule base approach of KB system and joint integration with the gauge absence prerequisites (GAP) technique. A comprehensive literature review was conducted to define the main pillars of the framework with a typical output of GAP analysis. The significance of this research is to present a novel use of hybrid KB/GAP methodologies to develop a Lean6-SBM system. The originality and novelty of this approach will assist in identifying quality perspectives while implementing different maintenance strategies in the sustainable building context.

The guest editors of this SI would like to express our deepest gratitude to all the anonymous referees who contributed to the review process of this SI. Without the contribution of these highly qualified and thorough experts, we would have not been able to complete this work successfully. Also, the guest editors would like to thank the Editor-in-Chief of the *IJLSS*, Prof. Jiju Antony, and the Emerald's editorial and publishing team for their continuous support in this endeavour. Finally, the guest editors would also like to recognise the effort of all those authors who considered this SI as a platform to disseminate their work. We had to disappoint some contributing authors due to limited publication space. We wish all those authors every success in publishing their papers in other outlets.

The guest editors and the *IJLSS* hope that this SI will make an excellent reference material and be of great use to academics, researchers and practitioners who wish to better understand the potential effect and role that lean and six sigma can play in tackling one of the most important challenges humankind is currently confronting, i.e. environmental degradation.

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