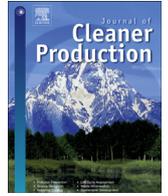




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Exploring the role of lean thinking in sustainable business practice: A systematic literature review

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ABSTRACT

The shift towards sustainable manufacturing processes and products has influenced business organizations to improve their environmental performance and efficiency. 'Lean thinking' has evolved to 'lean and green thinking' as a targeted intervention for organizations to implement sustainable business models that reduce waste and improve material efficiency, and subsequently minimise costs. The lean and green concept however is still relatively new and it remains unclear for many as to how exactly lean thinking can contribute to the sustainability transformation of organizations. The objective of this research was to undertake a systematic literature review of how the implementation of lean and green initiatives could lead to sustainable business practice. This article includes an analysis of both conceptual and empirical research papers discussing various industrial contexts, and evaluation of: a) the impact of lean methods on environmental performance; and b) the variety of integrated lean and green models. The review highlights the *ad hoc* and limited use of lean thinking within corporate sustainability initiatives and the authors establish a 'lean and green matrix' that identifies opportunities to embed lean and green practices in five common work streams including waste, energy, emissions, water and chemical management. In addition to comparing different industries and their systems, this review provides a reference point for further investigation into lean and green practices. The findings contribute to the authors' research agenda that aims to develop a replicable system for holistically exploring strategies in corporate environmental management and prioritising the most appropriate lean methods. It is proposed that industrial practitioners could benefit from such a system, which could transform their organization's performance through well-integrated and aligned sustainable business practices.

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1. Introduction

Lean thinking is a business approach that delivers better value for customers by removing non-value-adding activities (Womack and Jones, 2010). The 'lean' concept evolved from the shop floors of Japanese manufacturer, Toyota Motor Corporation, which focussed on the reduction of waste in operations (Herron and Hicks, 2008; Ōno, 1988). The authors of the influential publication *The Machine that Changed the World* (Womack et al., 1990), coined the term "lean manufacturing", and "lean production", and furthered momentum behind the lean movement.

As the concept evolved, there was an increasing interest in the role of lean thinking processes in achieving sustainability outcomes

(Fliedner and Majeske, 2010; Garza-Reyes, 2015). Over the last decade in particular, increasing pressures from government, regulatory bodies and society have led companies to align business practices with environmental sustainability principles. Sustainable business models such as the Management Helix (Smith et al., 2010) have been used as targeted approaches to incorporate sustainability concepts into decision making and to reduce negative impacts on both the environment and the society (Boons and Lüdeke-Freund, 2013; Stubbs and Cocklin, 2008). Within the manufacturing sector, 'lean manufacturing' is an emerging approach used in sustainable business models, to maximise material and energy efficiency (Bocken et al., 2014).

Over the last two decades, lean manufacturing processes evolved with implementation of pull mechanisms for efficient material flow (Womack and Jones, 1996), visualising waste through value stream mapping tools (Hines and Rich, 1997), having positive correlation with environmental activities and 'environmentally

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sustainable' initiatives (Chiarini, 2014; King and Lenox, 2001) and to have synergistic results on operational and environmental performance (Amani et al., 2015). However, there is still a gap in the literature about ways in which lean thinking can contribute to environmental outcomes and transform operations to 'sustainable business practice' defined as *business behaviour that leads to a net overall increase in the different forms of capital associated with sustainable development*" (Moser, 2001). Instead, much of the research has focused on exploring specific lean models and approaches in isolation, for example: reducing volatile organic compounds (Rothenberg et al., 2001), efficient energy use (Ball, 2015), reducing carbon footprint (Ng et al., 2015), and waste management (Kurdve et al., 2015; Maxwell et al., 1998).

Within this context, this review aimed to explore the evolving relationship between lean and green concepts. In the following sections, the authors present a summary of lean methods discussed in the literature and their effects on conventional categories of environmental sustainability work streams spanning waste, energy, emissions, water and chemical management. Within the lean and green context, this study considers the role of lean thinking in sustainable business practice, enquiring into, 'what are the lean methods that can be applied to environmental sustainability work streams', 'do these lean methods impact upon environmental performance' and 'what are the emergent lean and green models and its application?'

These questions were addressed through a systematic literature review exploring how lean methods influence sustainable business practice, and how process efficiency and environmental performance could co-exist. Specific lean methods were identified and their impact on environmental performance evaluated. The authors provide an extensive review and categorization on the conceptual and empirical types of lean and green models that are being used for business process improvement, which the authors anticipate will enable organizations to enhance the contribution of lean thinking to overarching sustainable business practice goals.

2. Research method

The relationship between lean methods and 'green methods' (i.e. environmental sustainability initiatives) was evaluated to identify the potential for lean thinking to deliver environmental outcomes that contribute to the aspirations of sustainable business practice. Going beyond an expert review which would be limited by an *ad hoc* literature selection (Kitchenham et al., 2009), a systematic literature review was chosen to address the research questions, including an explicit, transparent and well-defined methodology to review research findings. The systematic review was conducted in five consecutive phases to ensure rigour and transparency of the method (Denyer and Tranfield, 2009b) as shown in Fig. 1.

Similar systematic literature reviews have previously been used in other related research fields including sustainability (Ceulemans et al., 2015) and in lean and green discourses (Garza-Reyes, 2015). Table 1 presents a summary of the selection criteria used for the review, which are expanded in Section 2.1.

2.1. Extraction of relevant papers, timing and search terms

Describing the review process along with selection criterion, search terms and databases ensures transparency of the method (Saunders et al., 2012). As an initial step in a systematic review of the literature it is important to establish the: (1) the literature sources [i.e., outlets to be searched (Webster and Watson, 2002)] and (2) the search strategy [i.e., the choice of search terms during the article selection process (Levy and Ellis, 2006)]. Sources of literature were located by checking the results of a defined search string in various publishers' electronic databases and thereby refine the articles relevant to the review scope. Articles were extracted from numerous electronic databases to acquire an in-depth understanding of the existing relationships between lean and green philosophies and potential areas for future research. As this is a transdisciplinary review it was important to examine both business and science databases to meet the review scope. Electronic databases included Science Direct (Elsevier), ABI Inform Global (ProQuest Direct), EBSCOhost databases, Wiley Online Library (Wiley), Emerald Insight, Scopus, Web of Science and Google scholar. Although the use of some databases created an overlap in the search results, this process ensured the validity of the methods since all of the information from business and science perspectives was captured.

Academically refereed, full-text journal and conference papers on the lean and green phenomena were sought using clearly defined search strings (key words from Table 1) in the environmental sustainability domain. Peer reviewed journals are the most useful of all primary and secondary literature sources and research-oriented conference proceedings are also very useful to critically review the literature (Saunders et al., 2012). These were therefore targeted in the search while unpublished working papers, industry reports, magazines and dissertations were excluded. The authors used the C-I-M-O (context-intervention-mechanism-outcome) framework (Briner and Denyer, 2012) to identify the inclusion and exclusion criteria of the search strings and as a strategy to evaluate the relevance of each item of literature.

The key terms 'sustainable business practice' and 'lean thinking' embrace an extensive range of sub-topics and therefore a significant number of search strings were required. The search terms were listed considering the phenomena which needs further investigation. The search strings such as '(lean thinking) AND (sustainab*)', '(lean) AND (green)', '(lean) AND (environment*)', etc. were used following the key words given in Table 1. These terms were used in conjunction with industry, manufacturing, business sector, model, framework in order to find articles covering the combination of these topics. Besides sustainability, the terms 'waste management', 'chemical management', 'water management', 'emissions management', 'energy management' were used since they are closely related to sustainability work streams. In this way an example of a search algorithm used was: '(lean thinking) OR (lean manufacturing) OR (lean production)' AND '(green) OR (environment*) OR (sustainab*)' AND '(waste management)'. This defined a specific scope for the search and exclusion of papers which did not include both search terms or link between lean and

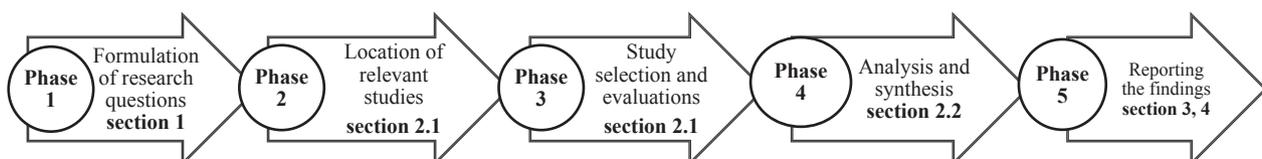


Fig. 1. Five phases of the literature review (phases adapted from (Denyer and Tranfield, 2009b) 681–686).

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