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Does lean mean green?

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ABSTRACT

This Special Volume of the Journal of Cleaner Production is dedicated to examining the interrelationships among lean, green, and sustainability. With the overarching goal of accelerating progress towards sustainability, the articles contained in this volume focus on various aspects of the connections between the application of lean methods and tools, and the adoption of green initiatives. In that context, are there synergistic benefits of simultaneously adopting both, or does adoption of one lead to rapid adoption of the other? Some authors proposed new frameworks and methodologies that will facilitate further studies and assessments in the swiftly developing field of lean and green integration, while others focused upon conducting literature reviews and drawing interpretations. Additionally, several authors dealt with the application of lean and green tools and methodologies. Covering a diverse array of topics, ranging from airline mergers, eco-design, nuclear waste management, and aged care, to the demand for e-bikes, the articles included in this Special Volume offer stimulating and thought-provoking material for practitioners, managers and researchers in actual and potential applications of Lean and Green to help society make the transition to more sustainable societal patterns.

1. Introduction

The Industrial Revolution marked a major turning point in the evolution of the human species, with the global population having increased from a few hundred million before the revolution to an estimated 7.2 billion currently (Census Bureau, 2014). Our societies are increasingly beset by problems of poverty and inequity, climate change, and an annual, net human population growth rate of approximately 70 million. Consequently, it is imperative that we conserve our resources and take steps to alleviate the growing burden on our environment.

While industrial activities are vital to the progress and development of mankind, they inevitably lead to undesirable impacts on the environment; hence the need to improve efficiency and effectivity so that our needs can be fulfilled at levels appropriate to the ecosystem's carrying capacity. Allenby proposed the "industrial ecology" approach to development, which views technological evolution as something that is necessary but needs to be controlled, through the development and adoption of environmentally appropriate technologies (Allenby, 1992). Industrial ecology has also been defined as "a systems view of the interactions between industrial and ecological systems" (Nemerow et al., 2009).

The U.S. Energy Information Administration reported a global energy use of 153,569 TW-hours (TWh) in 2011. Of this, about 51% (or approximately 78,000 TWh) was consumed by the industrial sector (US EIA, 2014). According to the Local Government Management Board (UK), "Environmentally sound waste management must go beyond the mere safe disposal, or recovery, of wastes that are generated and seek to address the root cause of the problem by attempting to change unsustainable patterns of production and consumption." Authors of Agenda 21 defined "sustainable production and consumption" as a strategy that ensures healthy industrial development in the future at viable and maintainable levels. Growing energy demands by China, India and the Middle East have led to increased global energy production, with a consequential increase in global warming emissions. The International Energy Agency's World Energy Outlook 2012 stated that global energy-related emissions of carbon dioxide (CO_2) – the principal greenhouse gas, reached a record 31.2 giga tonnes (Gt) in 2011 (IEA, 2012) representing by far the largest source (around 60%) of global greenhouse-gas emissions (measured on a CO2-equivalent basis). Though global estimates of industrial solid waste generation are not fully available, the U.S. EPA reported that industrial facilities

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in the US annually generate and dispose of 7.6 billion tons of industrial solid wastes. Measures adopted to reduce the overall burden on the environment and humans, including more efficient management of materials and energy resources, are steps in the direction of a more sustainable future.

With industrialization came the need for boosting productivity and increasing profitability. Lean thinking is based upon a mindset of "continuous improvement" aimed at reducing waste and eliminating activities that do not add customer value. While lean initiatives are primarily focused on maximizing productivity by increasing output per unit of input, conserving resources, reducing waste, and minimizing costs, green initiatives are concerned with protecting the environment as well. They include eco-product design, design for the environment (DfE), design for re-use, remanufacture and recyclability, reduction or elimination of toxic materials, and the use of environmentally friendlier raw materials. Green initiatives also include life-cycle based assessments, to understand the overall cradle-to-grave environmental implications of a product, process, or service.

In this era of increasing environmental responsibility, it makes good business sense to implement *green initiatives* in addition to *lean ones*. Earlier, business leaders looked upon compliance with environmental regulations as an extra cost and an accounting burden. However, they have now begun to increasingly adopt prevention-oriented environmental practices on an ongoing basis (Miller, 2008), with environmental performance beginning to occupy an important place in product development, along with functional performance.

Given current global conditions, with rising raw materials costs, increasing costs of transportation, a tight credit market, numerous countries having severe economic problems, increasing global competition, and risks from climate changes, it is increasingly essential that all companies engage in eco-efficient lean and green manufacturing due to the competitive advantages and enhanced profitability.

Manufacturers that are already on the *lean production path* are beginning to realize that *lean to green* is a natural progression, and that monetary savings can be realized not just by the implementation of lean practices but by implementing cleaner production methods as well. For instance, eliminating the use of toxics through product or process re-design could mean reduced worker health and safety risks, reduced risks to consumers and lower risk of product safety recalls. Lean practitioners who are successful in reducing process wastes in manufacturing often find more opportunities to reduce waste throughout the life cycle of the product, thereby having a possible *domino effect* on the entire supply chain.

Section 2 of this paper provides the readers a "sneak peek" into the contents of this Special Volume, by providing highlights and salient features of the forty-three articles contained in it. The articles are classified under three distinct categories: (i) Models, Frameworks and Methodologies; (ii) Literature Reviews; and (iii) Case Studies and Implementation. Additionally there are a few articles that address other interesting issues that do not specifically fall under any of these categories, which are grouped within (iv) as Unique Perspectives.

2. An overview of articles in this special volume

This special volume has brought together a complementary mix of opinions, research, and discussions on the topics of lean and green, and how they relate to sustainability. The topics covered range from new models, frameworks, and methodologies to extensive literature reviews, case studies, applications of lean tools, and examples of the assessment and beneficial implementation of green practices.

2.1. Models, frameworks, and methodologies

Faulkner and Badurdeen (2014) have extended Value Stream Mapping (VSM), an important technique used in lean manufacturing to identify non-value added activities or wastes, to include metrics for evaluating the environmental and societal sustainability performance of a manufacturing line. This was done by developing and testing a new modified methodology called 'sustainable' Value Stream Mapping or Sus-VSM. Subsequently Sus-VSM was applied to three case studies conducted by Brown et al. (2014), which are discussed later.

Pampanelli et al. (2014) proposed a five-step Lean and Green Model, which has been designed to be implemented at the manufacturing cell level. A manufacturing cell is a grouping of machines and other resources according to the products or parts they produce. The model integrates lean and green approaches as part of a continuous improvement process. The basic premise of the application of this process is a pre-requisite that the manufacturing cell to which it is applied should already have lean manufacturing in place, with a mature capability of using and applying lean tools.

Prendeville et al. (2014) presented a model for eco-innovative material selection, SPICE, from case studies in New Product Development, conducted at a sustainability-focused furniture design business. By linking stakeholders, material selection, ecodesign and trade-offs, SPICE enables strategic design management and material selection for eco-innovation.

A new approach, Waste and Source Analysis (WASAN), developed by Shaw and Blundell (2014), while working with UK's nuclear regulators, has been described and applied to a case study of radiological waste management, along with a framework to think through the behavioral, knowledge, materials, processing and systemic (BKMPS) causes of waste generation.

Another framework proposed by Wong and Wong (2014), the "lean ecosphere" framework, addresses human integration in lean for sustaining operations. Analytic Network Process (ANP) and Interpretive Structural Modeling (ISP) techniques were used to develop the model, and the framework applied to a case study of a multinational semiconductor manufacturing company. After implementation, it was found that there were fewer cases of employees' dissatisfaction, less conflicts among departments, and more cohesiveness among employees. In addition, the company's profits increased.

Clune and Lockery (2014) introduced a creative problem solving process to develop sustainability strategies, by using streamlined life-cycle assessment (LCA) and design thinking, referred to as the Double Diamond method; they have demonstrated its application to the study of environmental impacts associated with the aged care sector in Melbourne, Australia.

Verrier et al. (2014) developed and applied a framework for Lean and Green management, which enables a consortium of companies to benchmark their lean and green practices. Their work is based on a literature review and a case study involving 21 Alsatian industrial companies. An oligopoly model was proposed by Hu et al. (2014) to study the competition between green and ordinary products. An oligopoly situation is that of limited competition, in which a particular market is controlled by a small group of firms. Their study was designed to provide guidelines for green producers to understand the underlying factors that determine the competitiveness of green products in the market, and to provide insights for decision-makers on ways to use tax policies and subsidies as leverage for promoting green products.