The relationship between lean and sustainable manufacturing on performance: literature review

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Abstract

The aim of this paper is to explore and evaluate previous work focusing on the relationship and links between Lean and sustainable manufacturing. Several frameworks are explored and discussed. Their relationships include correlation, overlapping area, difference, integration and classification based on sustainability dimensions. This paper also examines impact of lean and sustainable manufacturing to improve performance. Many evidences suggested that Lean is beneficial for Sustainable manufacturing, dominantly on perspective environment and economic aspect. This paper identify major research gaps for integrated lean and sustainable manufacturing to improve performance business and modeling as a methodology approach. To do of 58 key research papers have been reviewed for the research contribution, methodologies, country of research, and date of publication. This paper provides a quantitative descriptive analysis and qualitative thematic analysis to provide an analysis of relationship lean and sustainable manufacturing and its impact on performance.

Keywords: lean manufacturing, sustainable manufacturing, performance, literature review

1. Introduction

Many papers that address the connection of lean and green touch on the efficient use of energy (and resources) and the reduction of waste and pollution [1, 2]. Bergmiller and McCright [3] identify the correlation between green operations and lean results. The relationship between total lean results and total GWRT (Green Reduction Waste Total) is a remarkable finding that implies that the lean companies in this study who have opted to complement their lean system implementation with a broad set of GWRT are realizing significantly better results in both green and lean manufacturing.
categories than the other lean plants in the study. This finding not only suggests that lean and green systems can co-exist, but provides evidence of synergy, by virtue of the fact that GWRT improve both green and lean results [3].

Verrier et al [8] presents a simple repository based on a sound analysis of the literature and on three questionnaires which can be used by all kinds of companies. This repository enables the companies to measure the correlation between their lean and green actions, and to benchmark their position on lean and green policies in order to identify the best practices to adopt [4]. The results of survey and study of Alsatian SMEs (small medium enterprises) have provided a tool that can be used to target and promote best practices for lean-oriented sustainable development, and to improve competitiveness. In this research, value stream mapping (VSM) as a tool for identifying environmental impacts has been analyzed as well as the measurable effects of 5S, cellular manufacturing, Single-Minute Exchange of Die (SMED) and total productive maintenance (TPM) on the environmental impacts [5]. Brown et al (2009) said that innovation is necessary to the achievement of sustainable manufacturing systems. The transformation will require an in depth knowledge of system wastes that goes beyond the largely time-based wastes (muda) to include muda of the environmental and societal variety [6]. So some researchers developed lean concept to achieve sustainable manufacturing, for example Dombrowski et al [7], Aguado et al [8], Faulkner and Badurdeen [9].

Due to all these reasons this study, we carry out a literature review with a view to identifying the interrelationships between lean and sustainable manufacturing and analysis in the performance on the three key dimensions of sustainability: environment, economy, and social.

2. Method

The aim of this paper is to structure the research field on lean and sustainable manufacturing in the context of relationship, benefit and its effect on performance and point out the most important gaps. Therefore, this review covers academic papers in the period between 2000 and 2014. This review includes the following major research databases: Emerald, Scincedirect, IEEE, Springer and Proquest. The database search yielded hundreds of articles. Each of the articles was examined to ensure that its content was relevant from the perspective of the aims of our research. The examination and selection of the articles is based on the criteria that only those of which main contribution revolves around the interrelationships among Lean and sustainable manufacturing on performance will be selected. The result of this process was that 58 articles were eventually selected for in-depth evaluation. In order to the descriptive analysis we selected categories: year, author’s country, journal, methodology and sustainable dimensions. The results are structured in two parts: firstly, we provide a quantitative descriptive analysis to get an overview on the research agenda on Lean and sustainable manufacturing. Secondly, this paper presents a qualitative thematic analysis to provide an analysis of relationship lean and sustainable manufacturing and its impact on performance.

3. Results of the descriptive analysis

The most important journals for lean and sustainable manufacturing identified are the Journal of Cleaner Production (14), IJPE (4), POM (4), CIRP (4) and followed by IJOPM (3), JIEM (3), JOM (3). The most dominant author’s countries are USA (36%), UK (14%), Germany (7%), and followed by India (5%). Research about lean and sustainable manufacturing seems to have been the object of growing attention from researchers up to 2014. The number of articles published from 2000 to 2014 had been increasing. The drastic increase occurred from 2011 and continued to rise until 2014. The distribution of articles based on date of publications are 2000 (2%), 2001 (4%), 2003 (4%), 2004 – 2006 (2%), 2007 (4%), 2008 – 2009 (5%), 2010 (2%), 20011 (11%), 2012 (13%), 2013 (20%), and 2014 (25%). Based on 58 articles reviewing, the most important source of empirical evidence in the sample is qualitative approaches: survey and case study (34 articles), literature review and conceptual papers 18 articles, modelling 2 articles [10, 11] and multi method 4 articles. Fig. 1 shows the result of descriptive analysis.
4. Results of the thematic analysis

4.1. Relationship between lean & sustainable manufacturing

Some organizations continued to grow on the basis of economic constancy; the others struggled because of their lack of understanding of the changing customer mind-sets and cost practices. To overcome this situation and to become more profitable, many manufacturers turned to “lean manufacturing” (LM). The goal of LM is to be highly responsive to customer demand by reducing waste [12]. King and Lenox [1] found strong evidence that lean leads to waste and pollution reduction [1]. This evidence is reinforced by Rothenberg et al that Lean production or JIT can reduce emission of VOCs by leading to more efficient solvent use in paints [2]. Also Simons & Mason [11] found that there are relationship between lean & emission reduction. Based on these research, studies about links between lean and sustainable are growing rapidly [13].

Corbett and Klassen [12] conclude that environmental issues can improve financial returns by opening up new customers, competitive differentiation (and increasing market share), reducing cost through waste reduction; focus on environmental improvement may create a more system focused approach to management generally [14]. Bergmiller and McCright [3] identify the correlation between green operations and lean results. This study explores the impact of green programs on lean results. Elements of a green operations system are product redesign, process redesign, disassembly, substitution, reduce, recycling, remanufacturing, consume internally, prolong use, returnable packaging, spreading risks, creating markets, waste segregation, and alliances. The lean results elements consisting of quality, cost, delivery, and customer satisfaction, and profitability. This paper found that lean companies which include green practices achieve better lean results than those companies which do not. Winners and finalists of the Shingo Prize for Manufacturing Excellence (America’s pre-eminent Lean designation) from 2000 through 2005 comprise the sample for this study. Moreover, Bergmiller & McCright [15] provide strong evidence of transcendence to Green manufacturing by leading lean manufacturers. The results indicate that the Shingo plants were significantly greener.
in all but one of the twenty-six green manufacturing system measures. The evidence that plants with lean systems yield higher green results supports the philosophical notion of lean and green synergy.

Rothenberg et al [2] show that trade-offs between both practices are inevitable. Clearly, not all lean processes, procedures and waste reduction efforts are positively related to environmental performance or pollution reduction, and lean practices alone will never be enough to address all environmental issues.

Dues et al [16] found the area of overlapping and difference between lean and green manufacturing. The overlap of lean and green paradigm is constituted in the following common attributes: waste and waste reduction techniques, people and organization, lead time reduction, supply chain relationship, key performance indicator (KPI): service level, and that they also share common tools and practices. The differences of the lean and green paradigm lie in: their focus, what is considered as waste, the customer, product design and manufacturing strategy, end of product-life management, KPIs, the dominant cost, the principal tool used, and certain practices as, for example, the replenishment frequency. The analysis of the differences shows the areas in which lean and green practices do not connect yet. However, it is also recognized that for these attributes it is also not impossible to combine lean and green practices.

Upadhye et al [17] tries to highlight the different aspects and benefits of Lean Manufacturing System (LMS) and its implementation in Indian Industries. A model to implement LMS is presented in this paper that includes 10 issues, 11 tools, and 14 results. Organization in global competitive market as well as those wish to achieve sustainable development should strive for lean operations through the application of lean tools and techniques suitable to their situation.

Joint implementation of lean and green practices and their interaction was researched by Galeazzo et al [18]. This paper found that reciprocal interdependencies are more likely to be associated with the involvement of external suppliers and that the simultaneous adoption of lean and green practices ultimately leads to better operational performance. Some research classified in Table 1.

Table 1. Some conceptual research in six classifications

<table>
<thead>
<tr>
<th>Correlation</th>
<th>Integration &amp; Sinergies</th>
<th>Compare &amp; Contrast</th>
<th>Barriers &amp; Drivers</th>
<th>Critical Factors</th>
<th>Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>[19],[20], [21],[22], [25],[28], [26],[33],[16],[35]</td>
<td>[3],[15],[11],[26], [23],[24],[29],[31], [14],[34],[36],[37], [38],[25]</td>
<td>[26]</td>
<td>[17],[22],[27], [30],[32],[27], [28],[23]</td>
<td>[29],[24]</td>
<td></td>
</tr>
</tbody>
</table>

4.2. Impact of lean and sustainable manufacturing on performance : empirical study

Application of lean is not limited to the automotive (71%) sector only, but, it has also found acceptance in a wide range of manufacturing industries: electronics manufacturing [30]; [31], aircraft industry [32], furniture industry [33]; [34], ceramic industry [35], and multi sector [36]; [37]; [38]; [39]; [40]; [41]; [42]. Table 2, 3 and 4 below shows the impact of lean and sustainable manufacturing: contribution, methodology, criteria and result on three bottom line performance.

Table 2. Impact of lean and sustainable manufacturing on operational & environment performance

<table>
<thead>
<tr>
<th>No</th>
<th>Ref.</th>
<th>Contribution</th>
<th>Methodology</th>
<th>Criteria</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>[43]</td>
<td>Impact lean production and sustainable manufacturing on the competitive positions of firms.</td>
<td>Empirical with 3 cases</td>
<td>Manufacturing process, HRM, Supplier vs. profit, WIP, lead time and number of employee</td>
<td>Reduce lead time and WIP</td>
</tr>
<tr>
<td>4</td>
<td>[27]</td>
<td>Environment performance as a driver of superior quality</td>
<td>Surveys of 42 automotive assembly plants</td>
<td>Paint quality vs. resource utilization and emissions</td>
<td>Quality-related tools to environmental issues has implications for quality.</td>
</tr>
</tbody>
</table>
Table 3. Impact of Lean and Sustainable Manufacturing on Operational & Economic Performance

<table>
<thead>
<tr>
<th>No</th>
<th>Ref.</th>
<th>Contribution</th>
<th>Methodology</th>
<th>Criteria</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>[53]</td>
<td>Relationships between operational practices and performance among early adopters of green supply chain management practices</td>
<td>Empirical: survey 186 companies in Chinese manufacturing</td>
<td>GSCM vs. organizational performance moderated quality management &amp; JIT.</td>
<td>Positive relationships in terms of environmental and economic performance</td>
</tr>
<tr>
<td>2</td>
<td>[54]</td>
<td>Impact of integrated lean tools and DES modeling on the environment and financial performance.</td>
<td>Discrete event simulation and Case study</td>
<td>Cell vs. lead time vs. environment performance, recycling vs. profit &amp; Environment performance</td>
<td>Lean and green manufacturing reduce waste and increase profitability.</td>
</tr>
</tbody>
</table>
5. Conclusion

Based on this above discussion, it concludes that it is clear there is the positive impact of lean and sustainable manufacturing on three bottom line performance. Many frameworks developed and empirical studies done to strengthen the synergies. There is lack of clear and adequate measure for lean and sustainable manufacturing. The past research that provide strong evidence that plants with lean systems yield higher green results supports the philosophical of Lean and sustainable synergy. But the research cannot determine how much its impact is. When it is not possible to fully quantify through sustainable measures, lean and sustainable manufacturing on performance and its related core characteristics need to be represented within modeling. However, the numerous approaches relevant research gap have been identified as follows:

- integrated lean and sustainable model to improve performance firm
develop mathematical or simulation modeling for examine impact lean and sustainable manufacturing for performance firm
social performance has not been explored widely.

References
