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On the Relationship between Lean Practices and Environmental Performance

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Abstract. Lean production has emerged in the past decades as one of the most popular topics in business and manufacturing literature and it is the most extended production paradigm currently applied in industry. Lean production is characterized by five principles (value, map the value stream, flow, pull and continuous improvement) and by the importance of reducing waste (*muda*). Alongside the Lean philosophy, the so-called green strategy has also gained importance in competition between firms. Many companies are trying to develop products that reduce environmental impacts throughout their life cycle. The aim is to reduce resource consumption, to replace hazardous substances, to increase recyclability, to enhance energy efficiency and to bring down CO₂ emissions. Lean and Green production paradigms are both focused on waste reduction and several authors have studied the relationship between Lean and Green practices and the synergic effects of joining these two management approaches. This research carries out a literature review in order to investigate if firms which have applied Lean principles and methods have improved their environmental measures. In particular, the work seeks to highlight which green indicators are more positively affected by Lean practices adoption. The results are synthesized in a final chart which illustrates the main green indicators cited in the literature and shows how these indicators have changed after a Lean transformation program. The research is to be understood as a work in progress and is part of a larger study that the authors are conducting on this topic.

1. Introduction

Lean production system [1] is the most influential production paradigm nowadays with its techniques and methods pioneered between the decades of 1950 and 1960 by Toyota (Toyota Production System) which have become the successors of the mass production practices initiated by Ford. This philosophy is based on the beliefs of "doing more with less", while coming closer and closer and providing customers exactly what they want. In this effort to reduce non value added activities in the whole processes of the company Lean management establishes seven types of waste, also known as *muda* in Lean environments.

On the other hand, the sustainability concept arises as the "development which meets the needs of current generations without compromising the ability of future generations to meet their own needs" [2]. Reasons for adopting sustainability may vary from company to company but all have found that emphasising sustainability improves their profitability, generates greater loyalty and commitment from employees, and cements relationships with customers and suppliers. Consequently, sustainability is an important element of nowadays corporate strategies.

Limiting Sustainability and focusing this concept only in an environmental performance view, arises the notion of Green manufacturing [3] which "aims a continuous integration of environmental improvements of industrial processes and products to reduce pollution to air, water and land; to reduce waste at source; and to minimize risks to humans and other species". According to the US Department of Commerce, sustainable manufacturing is "the creation of manufactured products which use processes that minimize negative environmental impacts, conserve energy and natural resources, are



safe for employees, communities, and consumers and are economically sound” [4]. Among the most important factors of the increasing importance of environmental performance is the rapidly depletion of natural resources that has compelled companies to continuously improve their manufacturing systems for environmental efficiency strategies. Consequently, central to the definition of green production is the theme of waste reduction management. In this perspective it seems that Lean production and Green production have many elements in common since both are focused on reducing waste and increasing efficiency of production processes.

In recent years, several scholars have analysed the possible relationships between the adoption of the Lean paradigm and the improvement of green performance. The results achieved so far are not always homogeneous, some studies strongly emphasize the existence of a positive relationship while others are more cautious by stating that not always adopting Lean practices entails improving green performances.

The objective of this paper is to conduct a literature review aimed primarily at understanding the phenomenon and secondly identify the relationships between the Lean and environmental performance measures. In particular, the literature review has made it possible to understand in detail the impact of adopting Lean practices for each of the environmental measures contained in the model developed by the USA Environmental Protection Agency (EPA). The results are of interest to academics in both the operations management and sustainability areas as well as to business managers designing Lean and sustainable operations and to policy advisors.

2. Literature Review

In order to analyze the relationship between Lean production and sustainability-environmental performance the web document database Scopus was consulted. Moreover, to find the documentation and articles needed for the literature review, the following keywords were searched: Lean and Green or sustainab* (using the asterisk in this word the database will take all the keywords which start with "sustainab", not discarding those referencing the same concept although they are not written equally as the keyword, for example "sustainability" or "sustainable"). These keywords were searched in the title, abstract and keywords of the article in Scopus. The time interval selected starts from 1993 and finishes in 2016, including in this way the most relevant preliminary publications about this topic.

The results obtained searching the keywords mentioned in the database Scopus are shown in Figure 1. In summary, 1897 articles resulted from the database research.

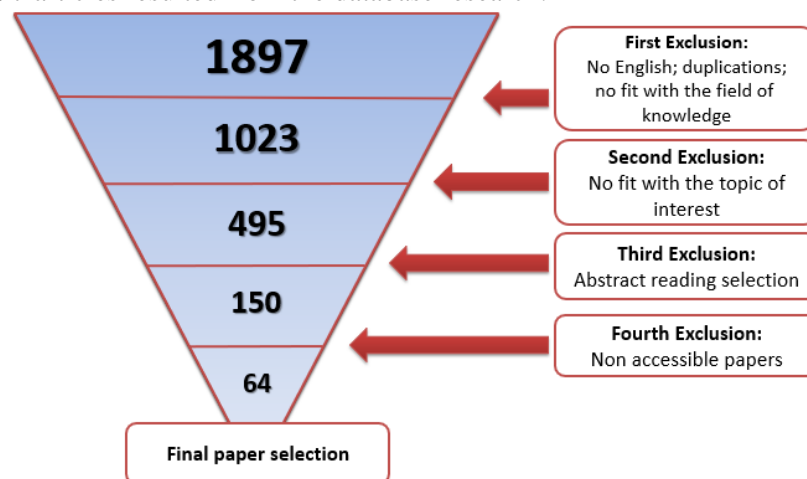


Figure 1. Article selection criteria

Following the steps detailed in Figure 1, from the initial results found in the database and after applying the filters indicated 64 papers were selected for the elaboration of this literature review study. Figure 2 outlines the date of publication of the papers emerging from the literature review. The papers are grouped in five-year periods starting from 1993.

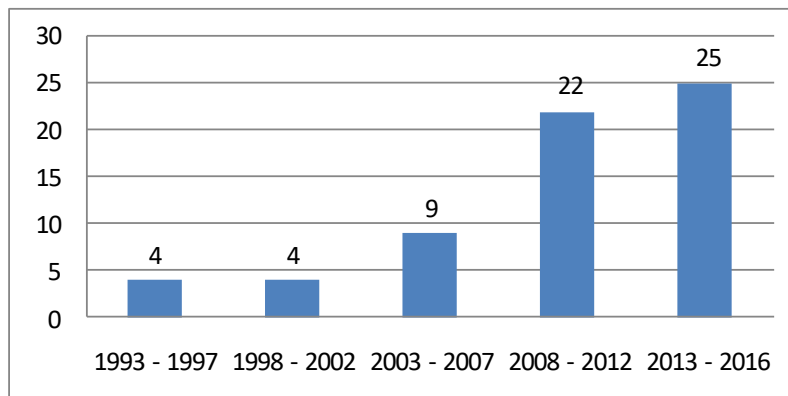


Figure 2. Publication dates of the documents

The data highlight the growing importance in literature of the topic regarding the relationship between Lean and environmental performance, in particular from 2008 onwards.

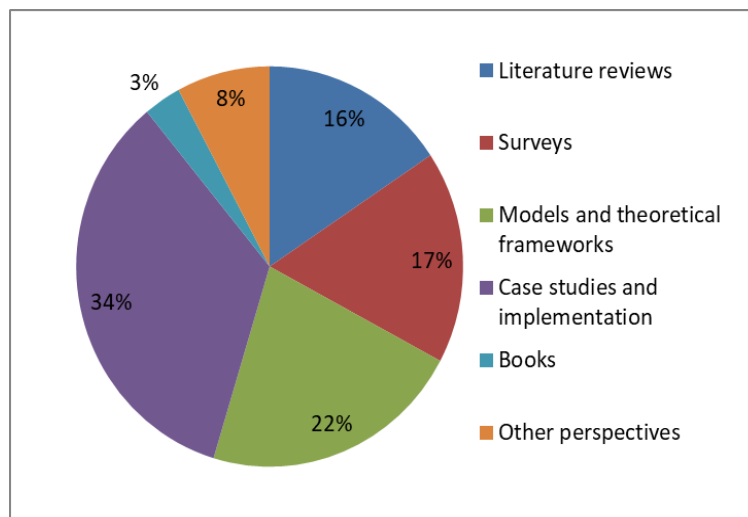


Figure 3. Research methodologies adopted

Figure 3 shows the breakdown of the papers considering the research methodology adopted. In particular, 22 papers out of 64 have employed a single or multiple case study methodology, 14 were models and theoretical frameworks, 11 papers out of 64 have investigated the topic through a survey approach, 10 papers out of 64 have developed a literature review analysis, the rest correspond to 5 manuscripts using other methodologies not comprised in these main categories and 2 books finally.

2.1. The Lean and Environmental Performance Relationship in Literature

The final papers selected have been carefully read and studied. Figure 4 summarizes the results of this analysis.

The overwhelming majority of the studies in literature sustains that Lean has positive effects in the environmental performance of the company [5], [6], [7], [8], [9], [10], [11], [12], [13], [14], [15], [16], [17], [18], [19], [20], [21], [22], [23], [24], [25], [26], [27], [28], [29], [30], [31], [32], [33], [34], [35], [36], [37], [38], [39], [40], [41], [42], [43], [44], [45], [46], [47], [48], [49], [50], [51], [52], [53]. A 12 percent of the papers analysed sustains that Lean may have positive and negative environmental effects; it depends on the practices applied and the indicators measured [54], [55], [56], [57], [58], [59], [60], [61]. Only the 3 percent of the studies declines the positive relationship between Lean and Green production [62], [63]. The remaining percentage specifies those papers that explain both concepts independently but are lacking the study of their relationships [64], [65], [66], [67], [68].

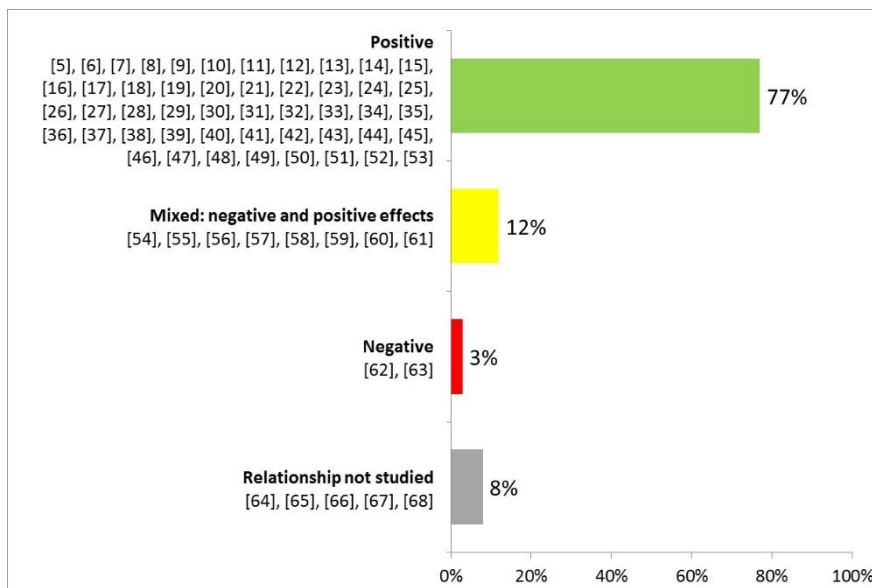


Figure 4. Relationships between Lean and Environmental performance

More in detail, according to the gross body of the literature both Lean and environmental performance activities have a waste reduction connotation. In one hand Lean manufacturing seeks the reduction of non-value added activities and the improvement of efficiency [1]. In the other hand, Sustainability and Green manufacturing have an environmental and ecologist point of view: banish waste in order to achieve pollution and emissions prevention as it is mentioned in one of the three pillars of the Triple Bottom Line (3BL) [2]. In particular, authors like Chiarini [13], King and Lenox [31] and Piercy and Rich [37] verify that the application of some practices composing the Lean transformation path go beyond economic results and Lean waste (*muda*) reduction: these techniques additionally enable the improvement of diverse environmental measures.

Anyway, not all authors agree that there is a positive relationship between Lean production practices and green indicators. As stated for example by Florida [23], Rothenberg et al. [58] and Venkat and Wakeland [63], Lean and Green production are in some cases divergent. Among the causes of this contrast, some authors suggest that the search for greater levels of productivity and efficiency is not coherent with sustainable manufacturing. Furthermore, business growth generally implies more production, transportation, deliveries and stock; these additional activities mean extra wastes in the normal functioning of the company. For example, integration with suppliers via *kanban* [69] requires more frequent deliveries and therefore greater fuel consumption for transport. Another point of reflection is the fact that the financial savings gained by environmental management techniques are not always significant or even non-existent.

However, applying Lean techniques some *blind spots* can arise during their implementation. This means that in addition to the Lean waste reduction and continuous improvement concepts, which frequently produce implicit environmental performance, there are further "hidden" opportunities to achieve this purpose [43]. Moreover, some practices as source reduction, production process improvements and facility downsizing which imply pollution prevention [23] can be enclosed in a Lean thinking view even if they are traditionally framed in the environmental management field.

3. Environmental Measures Presence and Performance in Literature

In this final chapter we focused the attention on the environmental performance measures considered in the literature. For this aim, the list of measures proposed by the EPA was used [45]. For each indicator Figure 5 shows the number of studies attesting that the adoption of Lean practices has improved its value (green color), worsened its value (red color), in some cases improved and in others worsened its value (yellow color). In addition, the gray color indicates the number of studies that claim that indicator among those that should benefit from the implementation of Lean practices but do not provide a measure of this improvement.

Within the sample of 64 papers analysed the EPA indicators most used to measure the environmental performance of companies and processes are air emissions, energy use, solid waste, money saved, water pollution, toxic/hazardous chemicals use, water use and materials use (see Figure 5, the indicators are listed in descending order of quotations).

As shown in Figure 5, air emissions [5], [12], [13], [15], [22], [25], [26], [27], [31], [43], [44], [45], [50], [56], [61]; energy use [5], [11], [12], [15], [22], [26], [27], [36], [37], [44], [45], [50], [53], [58], [60]; solid waste [11], [13], [15], [22], [26], [27], [31], [35], [36], [37], [44], [45], [50], [53], [61]; and money saved [5], [11], [12], [15], [25], [26], [33], [35], [36], [43], [44], [45], [50], [53]; are the indicators which are more benefited from the implementation of Lean practices. However, it is interesting to note that for the air emissions indicator there are four papers in which the relationship is not positive [58], [59], [62], [63]; money saved [59] and product impacts [62] both have one manuscript sustaining negative results.

Additionally, but to a lesser extent water pollution [11], [12], [15], [26], [27], [35], [36], [44], [45], [46], [53], [61]; materials use [11], [15], [22], [26], [35], [37], [43], [44], [45], [46], [53], [60]; toxic/hazardous chemicals use [11], [22], [25], [27], [35], [36], [43], [44], [45], [53], [61]; and water use [11], [12], [22], [26], [35], [36], [44], [45], [46], [53]; are also strongly related with Lean practices. Land use [5], [22], [43], [45]; and product impacts [22], [45]; are the indicators that have less positive evidence in the literature.

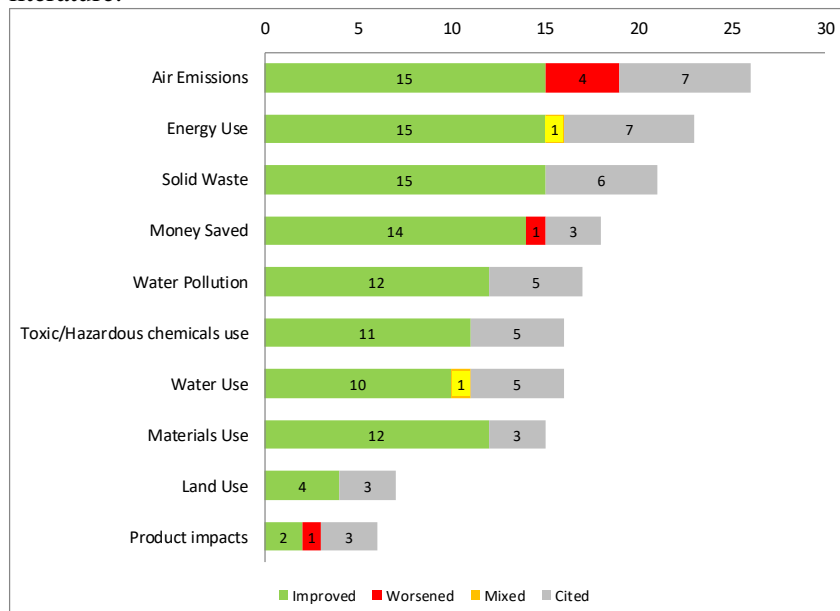


Figure 5. Distribution of the results of the environmental measures.

4. Conclusions and Future Research

In both academic and industrial-managerial fields it is increasing the interest in knowing the effects of Lean practices implementation on environmental performance. The analysis of the scientific literature showed that most scholars acknowledge that there is a positive correlation between adopting Lean production practices and improving environmental performance. Moreover, Lean facilitates a cultural background in the company that leads to green objectives, waste elimination and pollution prevention, which are mandatory for environmental performance [43]. There are now many empirical evidences that those businesses that are following a Lean transformation process will improve resource efficiency and therefore will increment their ecological outcomes [31].

The literature review conducted in this paper was also aimed at understanding which indicators are most cited in the literature and benefit most from the implementation of Lean practices. Using a model developed by USA Environmental Protection Agency the main environmental indicators were identified such as: air emissions, energy use, solid waste, money saved, water pollution, toxic/hazardous chemicals use, water use, materials use, land use and product impacts. For each

indicator, we counted the number of studies that found an improvement or a deterioration or both an improvement and a deterioration of its initial value in companies that have started a Lean transformation path.

The results are of interest because highlight which are the environmental indicators that are more benefited with the implementation of Lean practices. For example, the following indicators are the ones that perform best: air emissions, energy use and solid waste.

However, it should be emphasized that, regarding to air emissions, the results are controversial as there are several studies that state that the adoption of Lean practices does not improve this indicator. Companies have to manage well JIT activities since are a cause of air emissions increments [58], [59]. An important point emerging from the literature analysis concerns the need to involve customers and suppliers in the process of implementing Lean practices. As stated by Dhingra *et al.*, manufacturers should encourage suppliers and customers to collaborate in waste reduction activities in order to facilitate extra environmental performance and arrive to maximum sustainability levels [16].

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