A lean and cleaner production benchmarking method for sustainability assessment: A study of manufacturing companies in Brazil

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ABSTRACT

A constant evolution in the efficiency of production systems and government policies has enabled the control of the environmental impact of production activities and encouraged companies to develop strategies to achieve more sustainable operations. Despite this, more needs to be done to reduce the risks of globalised production activities. In this context, evidence suggests that Lean Manufacturing (LM) and Cleaner Production (CP) make a positive contribution to the environmental performance of organizations. However, very little has been reported in the scholarly literature regarding the convergence and divergence of these two approaches. This work therefore attempts to take advantage of the synergies of LM and CP by proposing a Lean Cleaner Production Benchmarking (LCPB) method to assess the practices and culture regarding the application of CP in companies. The method considers the management aspects of people, information, products, suppliers and customers, management and processes, as well as the LM practices that contribute to a more eco-efficient production. LCPB uses a methodology based on benchmarking that was applied to 16 Brazilian manufacturing companies in order to assess their practices and performances regarding CP. The method seeks to provide a diagnosis to verify whether CP is effectively carried out by the companies, and what their performances are regarding actions beneficial to the environment. The application of LM practices that contribute to CP was also evaluated through the proposed LCPB method. The paper contributes to the theory by proving further evidence of the compatibility and synergies of LM and CP. In addition, it proposes a novel method that enables the analysis of companies' practices and performances related to CP, assesses their actions associated with sustainability, and contributes to identifying points where there is a lack and difficulty regarding CP. The proposed method helps to relate LM and CP activities, indicating that companies that seek to apply LM concepts are those that present high CP practices and performance.

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1. Introduction

Over the years, rapid industrialization around the globe has, on one hand, improved quality of life, whereas on the other hand, it has had a significant negative effect on our environment (Georgiadis et al., 2006). Considering the perception of the negative impacts generated, many organizations have started to invest in re-designing processes and products to make them more sustainable. Currently, companies are considering, within the scope of their operations, the establishment of goals which consider and address environmental concerns. This has been mainly influenced by customers' behavior, changing environmental regulations, and the need to seek alternatives to reduce costs and improve quality (Garza-Reyes, 2015a; Nishitani et al., 2011). Customers are increasingly demanding with regard to the cost and quality of

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products, and more recently, the environmental impact generated by such products and their production processes. This has represented a significant change in the production business models seen over the last decades, which have now been enhanced through the adoption of various environmentally friendly practices to make products and processes more sustainable (Mont, 2002; Simpson et al., 2004). Among the most significant sustainability practices that have been integrated into the value chain of companies is Cleaner Production (CP) (UNEP, 2012). CP refers to the continuous application of an integrated economic, environmental, and technological strategy to products and processes in order to increase efficiency in the use of raw materials, water, and energy through the non-generation, minimization or recycling of waste in all production sectors (Mantovani et al., 2017; UNEP, 2012). Therefore, CP seeks to provide preventive actions aiming to minimize the impact to the environment, and avoid actions carried out only at the exit of the production system.

On the other hand, another set of practices that have contributed to sustainability are those of Lean Manufacturing (LM) (Garza-Reyes, 2015a). In this line, recent studies have demonstrated that LM can be a significant contributor to address current sustainability issues (Cherrafi et al., 2016, 2017a; Nadeem et al., 2017; Garza-Reyes et al., 2016; Chiarini, 2014; Jabbour et al., 2013). Consequently, Lean and Green initiatives have been merged to deploy operational strategies that aim at not only helping organizations to achieve their economic objectives but also improve their sustainability performance (Garza-Reyes, 2015b). The resulting merged approach, i.e. Green Lean, has recently taken relevance in the scholarly literature (e.g. Verrier et al., 2016; Cherrafi et al., 2016, 2017a; Garza-Reyes, 2015a; Garza-Reyes, 2015b) due to the synergetic characteristics of Lean and Green and the positive results associated to their integration.

In the same way, both LM and CP contribute to improving productivity, quality and enable the optimization of materials and other resources (Verrier et al., 2016; Yüksel, 2008), indicating also some synergetic characteristics between the two (Bergmiller and McCright, 2009). CP and LM have similar points for deployment in an organization, and together they can complement each other as they link systemic elements to waste reduction goals. LM deals with aspects of waste (Chiarini, 2014; Dües et al., 2013) whereas CP focuses on the inputs and outputs of raw material, resources, energy, water, among other resources (Silva et al., 2017). Dües et al. (2013) listed some differences between lean and green (which is related to CP) practices and they are: (a) the lean customer is driven and satisfied by achieving cost and lead time reduction, whereas the green customers are satisfied when the products help them being more environmentally friendly; (b) lean practices focus on performance and cost maximization, while green practices apply methods such as life-cycle assessment (LCA) to design the products so that every step in the product life-cycle is optimized from an environmental point of view; (c) in a lean environment the replenishment frequency of raw material or semi-finished product output is high since very little inventory is maintained. However, frequent replenishment results in an increase of transportation, which increases CO_2 emissions, contradicting the CO_2 reduction principles of green practices.

According to EPA (2007), both CP and LM seek to foster an organizational strategy that emphasizes employee involvement in problem solving and the search for improvement. Based on these similar characteristics, King and Lenox (2001) suggest that LM can be considered green, or rather, it leads to CP. Furthermore, Bergmiller (2006) identified that the infrastructure destined for LM serves as a catalyst to obtain improved CP results. Bergmiller and McCright (2009) conducted a study to explore the correlation between LM and CP. The results suggested that when CP is deployed in

conjunction with LM, CP boosts LM, mainly in relation to production costs. Thus, their study generally concluded that there is a synergetic effect between the two when applied together. Silva et al. (2017) deployed a CP initiative under the umbrella of the LM's PDCA approach in a Brazilian beverage organization. Put together, this evidence suggests that similarly to Lean and Green, LM and CP can also synergize their philosophies, practices, methods and tools to obtain improved sustainability results in a company's operations. However, very little about this synergy has been reported in the scholarly literature (Silva et al., 2017; Bergmiller and McCright, 2009), especially compared to the now relatively extensive literature on Green Lean (e.g. Abreu et al., 2017; Verrier et al., 2016; Cherrafi et al., 2016, 2017a; Garza-Reyes, 2015a; Garza-Reyes, 2015b).

To address this research gap, this paper proposes a Lean Cleaner Production Benchmarking (LCPB) method to assess the practices and culture of the application of CP in organizations. According to Kuriger et al. (2011), to succeed in the combination of LM and CP, it is important to work with appropriate assessments/indicators that combine production and sustainability metrics (Abreu et al., 2017; Campos et al., 2015). Therefore, the proposed LCPB method is based on evaluating the management aspects of people, information, products, suppliers and customers, management and process, as well as the LM practices that contribute to a more eco-efficient production. The method centres on the benchmarking methodology, and it was applied in some organizations to assess their practices and performances regarding CP. Often companies do not have a structure focused on CP, but because of actions in the context of LM, they may indirectly contribute to achieve CP. For this reason, the proposed method also evaluates the application of LM practices that contribute to CP.

The rest of the paper is divided as follows: in Section 2 the literature review is presented; Section 3 contains a description of the proposed Lean Cleaner Production Benchmarking method; the results and analysis are presented in Section 4; and in Section 5 the conclusions are presented.

2. Literature review

In this section we delve into the factors that underpin the proposed Lean Cleaner Production Benchmarking (LCPB) method. Therefore, in this review we focus on discussing the background, main characteristics and benefits of CP, the relationship of LM and the environment, and lean benchmarking.

2.1. Cleaner Production (CP)

Historically, CP dates back to the 1980s, when programs based on this concept and aimed at transforming the unsustainable patterns of production prevailing in various locations were initiated from Greenpeace campaigns of the United Nations Industrial Development Organization (UNIDO) (Santos et al., 2015). CP seeks the conservation of raw materials and energy in production processes, eliminating toxic materials and aiming at reducing the toxicity of all wastes before they are generated by a process (UNEP/UNIDO, 2017). Regarding products, CP focuses on their life cycle and seeks to reduce the environmental impact from the extraction of raw materials to its final disposal. CP acts comprehensively and directly at the source, seeking to evaluate the: (1) processes of extraction and quality of raw materials; (2) energy used (i.e. generation, distribution, and consumption); (3) type of transport used to supply the process, until the distribution of the products; (4) characteristics and volume of the packages adopted, checking their destination after their use and the possibility of recycling; and (5) use and final destination of the product after the end of its useful