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Efficiency & sustainability model to design and manage two-stage logistic networks

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Abstract

The distribution and storage efficiency together with the environmental sustainability are mandatory targets to consider when designing and managing modern supply chain (SC) networks. The current literature continuously looks for quantitative multi-perspective strategies and models, including and best balancing such issues that often diverge.

This paper presents and applies a bi-objective optimization model to best design and manage two-stage logistic networks looking for the best trade-off between the SC stock level and the building and distribution environmental impact. The existence of good balance confirms the possibility to reduce the average SC stock level without a relevant increase of the emissions due to frequent replenishments.

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1. Introduction

Lean Management (LM) is an industrial philosophy aiming to increase productivity and to reduce costs and no-value added activities in the form of overproduction, transporting, inventory and defects. The main goal of LM is waste elimination. Green Management (GM) integrates the environmental thinking in Supply Chain Management (SCM), including sustainable product design, low-carbon material sourcing and selection, green manufacturing processes, end-of-life management and reverse logistics of the products at the end of their lifespan [1]. LM and GM share the common goal of waste elimination even if their focus is on different types of waste. A large number of researchers investigates the benefits of implementing such two practices separately. Few contributions exist in the literature examining the integration between LM and GM in the field of SCM, especially from a quantitative, i.e. modelling, point of view. The combination of LM and GM can lead to great results, higher than the sum of the performance from their separate application.

Starting from this framework, this paper shortly revises the literature about recent studies on the topic before presenting and applying a bi-objective optimization model to design and manage modern logistic networks investigating possible balance between the storage efficiency, the building and distribution sustainability. In the analysis, LM is modeled in terms of storage efficiency while GM in terms of building and distribution emissions.

According to these goals, the reminder of this paper is organized as follows: the next Section 2 presents a short literature review of the topic. Section 3 introduces the bi-objective model for logistic networks design, while Section 4 applies the model to a case study about a mid-scale Italian network located in the Emilia-Romagna region. Finally, Section 5 concludes this paper with some remarks and future research opportunities.

2. Literature review

Few contributions exist in the literature examining the relationship between LM and GM in the field of SCM, especially from a quantitative, i.e. modelling, point of view. First considered as “parallel universes”, increasing authors recognize more than just a simply co-existence [2]. In particular, studies and research works carried out in this field find that the concurrent implementation of LM and GM produces synergic effects and great results [3-5]. Despite such synergic win-win effects, the replenishment frequency rises as the main point of collision. In product manufacturing and distribution processes, LM calls for a replenishment frequency of small product batches, according to the Just-in-Time (JIT) principle, to decrease the warehouse stock level [6-7]. Conversely, GM calls for a sparse shipments of larger batches to reduce the environmental impact of trucks and the other carrier vehicles. Furthermore, the distance between the logistic actors plays a critical role. LM calls for distances to be as short as possible. This means that a short lean supply chain (SC), e.g. regional networks, is also green, but as distances increase lean and green are in conflict. In the age of global trade, few SC are local with short transportation links. In addition, the low cost of labor in the developing countries is an important factor in choosing where to locate production sites [6].

Kainuma and Tawara [8] face these questions from a quantitative approach. In their study, using the multi-attribute utility theory, they evaluate the performances of the SC not only from a managerial perspective but also from an environmental performance viewpoint. Through computational experiments, the authors quantify the benefit of information sharing to decrease the average stock level in the SC and the out-of-stock ratio at the retailer level. Bergmiller and McCright [9] propose a statistical analysis concluding that including elements of Green Operations Systems to Lean firms leads to stronger Lean results. Their analysis compares measure of elements of Green Management System and Green Waste Reduction Technique with scores of Lean results. Evidences show that GM drives Lean results and improves the cost performance. Similarly, King and Lenox [10] analytically prove that the adoption of ISO 9001 quality management standard increases the probability that managers adopt the ISO 14001 environmental management standard. Finally, Miller et al., by using discrete event simulation modeling, state that LM and GM can have a more significant, positive impact on multiple aspects when implemented concurrently rather than separately [11].

Table 1 shows a preliminarily classification of the relevant literature from 2006 to 2016.

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