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Analyses of Logistics Network Design With the Consideration of Carbon Emission Reduction Preference

ZhongMing Tang, Hubei University of Education, China
Xingxing Liu, Wuhan University of Technology, China
Yuanrong Hu, Hubei University of Education, China

ABSTRACT

As a major cause of global warming, carbon emissions have become a considerable concern in society. In this paper, the authors examine logistics network design considering the carbon emission reduction preferences of decision-makers. To investigate the effects of carbon reduction preferences on carbon emissions, the authors first develop two optimization models with the objectives of optimizing carbon emissions and operation costs, respectively. Subsequently, the authors analyze the effects of the emission reduction preferences of decision-makers on logistics network design at both the strategic and tactical levels. Moreover, the authors propose coordination mechanisms for carbon emissions and operation costs in logistics network design. The results indicate that emission reduction preferences significantly affect carbon emissions and operation costs in logistics network design, especially at the strategic level.

KEYWORDS

Carbon Emission, Coordination, Emission Reduction Preference, Logistics Network Design, Operations Cost, Simulation, Strategic Level, Tactical Level

INTRODUCTION

In the last couple of decades, environmental pollution and climate change have become concerns globally. Because of the logistics industry's high energy consumption and carbon emissions, this industry has attracted much attention from society and scholars (Khan et al., 2019; Khan et al., 2018). Although increased logistics activities may promote economic growth, they can also cause numerous environmental problems such as air pollution and global warming (Khan et al., 2018). To address with the ecological crisis, various carbon policies and legislations have been implemented in many countries (Tang et al., 2018). Under these policies, leading manufacturers have begun to implement green supply chain practices to reduce carbon emissions (Zhu et al., 2017). A recent study evaluating 415 Chinese manufacturing firms and 218 Pakistani manufacturing firms indicated that the implementation of green supply chain practices can positively affect an organization's economic and environmental performance (Khan and Dong, 2017b). By contrast, non-green logistics service and poor transport infrastructure can generate a large amount of CO2, which is harmful to environmental sustainability and reduces economic growth (Khan et al., 2019; Khan et al., 2018). These findings indicate that it is of great importance for both companies and countries to adopt green supply chain practices.

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As one of the world's largest economies, China is committed to environmental improvement and has been highly active in managing air pollution and climate change (Wu et al., 2019). However, the rapid growth of Chinese e-commerce businesses has led to the marked growth of the country's logistics activities, posing a great challenge to the reduction of energy consumption and carbon emissions. According to Zheng and Ru (2011), logistics companies account for almost 10% of China's total energy consumption. Thus, Chinese logistics and e-commerce enterprises must control their total carbon emissions in production and operation activities. In addition to the adoption of renewable energy and green transport infrastructure, reasonable logistics network design is a crucial factor for developing a low-carbon logistics system, which involves determining the optimal configuration of logistics infrastructure (Zhang et al., 2018). In the context of sustainable development, decision-makers of logistics network design should not only focus on carbon emissions but also on operating costs during production. Such decision-makers must usually maintain a delicate balance between an enterprise's social responsibility (e.g., environmental protection) and the goal of maximizing its economic profit (Xu et al., 2019). In this situation, the designer's personal low-carbon preference may play a crucial role in the firm's amount of carbon emissions and operating costs. However, this factor has seldom been considered in prior research. Studies have usually assumed that managers make decisions based only on costs when designing a logistics network (Simic, 2015; Zhou and Zhou, 2015). Specifically, their main goal is to reduce the total cost of the logistics system during the operation process. In recent years, scholars have started to introduce the factor of carbon emissions in logistics system optimization, and they have studied logistics network design against a low-carbon-economy background (Govindan et al., 2015; Yu and Solvang, 2017) and under different carbon emission policies (Hoen et al., 2014; Micheli and Mantella, 2018); however, the effect of the low-carbon preference of decision-makers has seldom been considered in research. To fill this gap, this study investigates the low-carbon preferences of decision-makers who are fanatical environmentalists for the logistics network problem. Specifically, this study addresses the following research questions:

Research Question 1: Considering carbon emission reduction preferences, how do decision-makers design the logistics network and optimize the logistics plan to minimize carbon emissions in the logistics system?

Research Question 2: How do decision-makers' low-carbon preferences affect logistics costs and carbon emissions?

Research Question 3: According to decision-makers' low-carbon preferences, how do they decide the logistics network and operation scheme under various carbon emission reduction policies?

Based on the aforementioned research questions, the objective of this study is achieved through three specific means: (i) the construction of logistics network design models under the two cases of carbon emission minimization and cost minimization; (ii) the comparison of the results of logistics network optimization under the two cases of carbon emission reduction preference and cost minimization preference as well as the identification of the influence of decision-makers' carbon emission reduction preferences on logistics network design; and (iii) the provision of collaborative strategies to balance carbon emission targets and cost targets in logistics network optimization under different emission regulations.

The remainder of this paper is organized as follows. The second section presents a literature review. The third section describes how two logistics network design models are constructed in this study under carbon emission reduction and cost minimization preferences, and the section presents an analysis of the computational complexity and solution strategies of the model. The fourth section presents the numerical calculation and analysis of the model. In the fifth section, the operating results of the two aforementioned models are compared and analyzed using simulation analysis. In the sixth section, collaborative strategies are proposed for the minimization of carbon emissions and costs in logistics network optimization, and finally, the seventh section provides the conclusions to the paper.