Chapter 2
Comparative Analysis of Sustainable Urban Last-Mile Delivery Modes:
Environmental and Economic Impacts

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ABSTRACT

Sustainability has become more critical in logistics and transportation, especially in last-mile delivery (LMD). Electronic vehicles (EVs), electronic(E)-bicycles, cargo bikes, and drones are alternative solutions to the existing internal combustion engine (ICE) vehicles that enable low environmental and economic impact. However, they may require a higher investment and have constraints like battery autonomy, small loading capacity, and higher electricity production to meet the demand. This chapter aims to explore the environmental and economic impact of electronic vehicles, as well as the operational challenges and barriers to achieving sustainability. Hence, a thorough literature review is necessary to understand the scholarly work in the area. The study employs the systematic literature review (SLR) to extract data from the Scopus database from 2019-2023. Thirty-two articles were reviewed. The descriptive and thematic analyses have identified the environmental, economic, and social components related to the distribution methods, delivery methods, and perceived sustainability.

1. INTRODUCTION

The ultimate phase of the supply chain, often known as the "last mile," has grown more intricate due to the rapid growth of the e-commerce sector and the heightened expectations of consumers for prompt

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and frequent deliveries. A majority, exceeding 60% of individuals residing in rural areas, preferred the convenience of home delivery when making online purchases. Furthermore, it is noteworthy that there was minimal observable alteration in online purchasing patterns after the widespread impact of the COVID-19 pandemic (Markowska et al., 2023). In a business-to-consumer (B2C) context, the ultimate phase of the logistics chain is recognised as one of the most expensive, least efficient, and environmentally detrimental elements (Gevaers et al., 2014). Kiba-Janiak et al. (2022) posit that the utilisation of traditional last-mile delivery approaches leads to an escalation in the frequency of deliveries that results in traffic congestion, pollution, and accidents. Achieving sustainability in logistics necessitates a comprehensive assessment and juxtaposition of delivery strategies aimed at mitigating environmental harm and enhancing economic efficiency. Research by Klein and Popp (2022) found that the acceptance of delivery methods is influenced by perceived sustainability, which exhibits the combination of different parameters, including environment, economic, and social factors, and the specific delivery method itself. In addition, the Vehicle Routing Problem with Delivery Options (VRPDO) method incorporates shared location capacity, minimum service requirements, and route cost considerations to allocate routes among a fleet of vehicles. The objective is to ensure that each customer receives their order at one of their alternate locations within the specified time window (Markowska et al., 2023). Hence, various alternative delivery methods, including electric vehicles, cargo bikes, and drones, have emerged in response to these challenges. The utilisation of a heterogeneous array of vehicles possesses the capacity to mitigate urban air pollution, reduce fuel expenditures, and enhance operational efficiency (Fraselle et al., 2021).

In recent years, customers have tended to overlook the greenhouse gas (GHG) emissions associated with the final stage of product distribution (Nogueira et al., 2021). Kaushik et al. (2018) have identified that the transportation sector is responsible for 26% of the total annual GHG emissions. There will be a significant 64% surge in energy demand within the transportation sector between 2015 and 2040 (EIA, 2017). The reasons are heightened consumer demand, excessive noise pollution, and the intrusion of trucks into residential zones (Jaller & Pahwa, 2020). Hence, sustainable solutions for last-mile delivery (LMD) are needed immediately, particularly those that minimise waste, increase productivity, and promote the use of carbon-neutral vehicles and modes of transportation like EVs and cargo bikes (Ziókowski et al., 2022).

This chapter presents a cutting-edge study of sustainable urban last-mile delivery methods, explicitly emphasising their effects on the environment and the economy. Alternative delivery strategies, such as electric vehicles, cargo bikes, and internal combustion engine vehicles, are uniquely evaluated, together with energy consumption, greenhouse gas emissions, and their economic appeal. The study fills a significant research gap by examining operational efficiency, costs, potential return on investment, and customer adoption willingness. This comprehensive approach offers practical insights and essential guidance for practitioners and policymakers adopting eco-efficient delivery systems. It aims to reduce the environmental impact of last-mile deliveries, making a significant contribution to the discussion on urban sustainability.

To fill the gap, the following objectives are laid:

Objective 1. Assess and contrast GHG emissions, energy consumption, and air pollution indicators using alternative LMD methods.

Objective 2. Justify the financial implications of implementing sustainable delivery strategies, such as costs, operational efficiency, and return on investment.

Objective 3. Evaluate the merits and drawbacks of sustainable last-mile methods, such as the resources, frameworks, and customers' willingness to adopt them.