

Digitalisation and waste management in cold chains: A sustainable corporate perspective

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Abstract

The increasing use of digitalization in the cold chain industry has brought about significant changes in waste management practices. The incorporation of technological innovations associated with Industry 5.0, including the Internet of Things (IoT), big data, cloud technologies, cyber-physical systems, artificial intelligence, and blockchain, has transformed various industries, including waste management in the cold chain. Despite the increasing digitalisation of cold chain supply systems, there is still a gap of knowledge surrounding its impact on enabling end-to-end waste management. This paper examines the impact of these technologies in various processes of the cold chain, including sourcing, production, packaging, logistics, distribution, and retail.

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1. Introduction and gap in the knowledge

In recent years, there has been a growing interest in the topic of sustainable supply chain management (SSCM) (Rizwan et al., 2021; Pagell et al., 2021; Dukkardt et al., 2020; Gupta et al., 2021). This trend is driven by concerns over the environmental impact of supply networks, including issues such as waste, overuse of non-renewable resources, pollution, and greenhouse gas emissions (Ahi et al., 2021; Pagell et al., 2021; Modak et al., 2020; Pereira et al., 2020).

The cold chain industry is an essential component of the global food supply chain. The industry is responsible for the transportation, storage, and distribution of perishable goods, such as food, pharmaceuticals, and vaccines. However, the industry also generates a significant amount of waste, which has negative environmental and economic impacts. Waste in the cold chain industry is primarily caused by improper temperature management, supply chain inefficiencies, and packaging and labeling errors (Kim et al., 2020; Nwachukwu et al., 2021; Rosado-Serrano et al., 2021; Yadav and Tiwari, 2017).

The issue of food waste is a significant environmental concern within the food supply chain, with varying estimates suggesting that between 20 to 30% of all food produced is wasted during the supply process (FAO, 2019; Parfitt et al., 2010; Stenmarck et al., 2016). It is crucial to consider the context of the waste, with developing countries experiencing waste mainly during post-harvesting and processing, while developed countries face waste downstream in the supply chain (Gustavsson et al., 2011; Kummu et al., 2012).

Digitalisation has been increasingly adopted in the cold chain industry to address waste challenge and to improve efficiency, quality, and safety (Ghiani et al., 2019; Kim et al., 2020; Rosado-Serrano et al., 2021). Despite the increasing digitalisation of cold chain supply systems, there is still a gap of knowledge surrounding its impact on enabling end-to-end waste management. As such, further research is needed to establish the impact of digitalisation on various processes in cold chain waste management (Bianchini et al., 2020; Lu et al., 2021; Zhang et al., 2021).

According to a study by the International Institute of Refrigeration (IIR), there is a current gap in knowledge regarding digitalisation and waste management in cold chains. The study found that there is a lack of research and understanding of how digitalisation can be used to improve waste management processes, as well as a lack of understanding of how digitalisation can be used to improve the traceability of waste, improve the safety and security of cold chain operations, and provide better data for decision-making (International Institute of Refrigeration, 2020). This is a critical area of research, as cold chain waste management is an important factor for ensuring the safety and quality of food products, and digitalisation can lead to development of new techniques for waste monitoring and management, with the potential to reduce wastage and improve the efficiency of cold chains (Kumar et al., 2020; Rosado-Serrano et al., 2021; Zhao et al., 2021).

Industry 5.0, which is the fifth industrial revolution, is expected to bring significant changes in the cold chain industry through enabling comprehensive digitalisation and end-to-end supply chain level. According to Li et al. (2020), Industry 5.0 will lead to the development of smart and intelligent cold chain systems that can effectively manage waste and improve the overall efficiency of the supply chain. In their study, Li et al. (2020) identified that Industry 5.0 will enable the integration of emerging technologies such as the Internet of Things (IoT), Artificial Intelligence (AI), and blockchain to enhance waste management in the cold chain. Similarly, Kuo et al. (2020) noted that Industry 5.0 will provide the cold chain industry with innovative solutions that can minimize waste, reduce costs, and enhance sustainability. The

researchers emphasized the importance of Industry 5.0 in promoting circular economy principles in cold chain management. Overall, the impact of Industry 5.0 on waste management in the cold chain is significant, and further research in this area is necessary to fully understand the potential benefits of this emerging technology in various supply chain processes (Zheng et al., 2021; Cheng et al., 2021; Zhu et al., 2021).

As discussed, the literature on cold chain has reviewed various dimensions, such as food waste, sustainable supply chain performance, and digitalization. However, there is a lack of decision-making and application frameworks to achieve sustainable performance in a data-driven environment. The critical components of Industry 5.0-enabled waste management and its impact on sustainable performance in the cold chains are not well understood. More information is needed on the application of technological innovations, sustainable objectives attained, supply chain processes, and waste types/sources (Ghasemi et al., 2021; Karimzadeh et al., 2021; Sarkar et al., 2021; Verhulst et al., 2020).

The aim of this study is to provide an overview of digital interventions associated with Industry 5.0 for preventing and managing waste in food/cold chains and to evaluate their effectiveness for waste management at end-to-end supply chain level.

The study examines the UK food supply network, from the point of entry to purchase by the consumer, including storage, grading, processing, distribution, and retailing, while excluding consumption. The aim is to explore the following questions:

- What are the key sources and types of waste in cold chains, and currently what practises are used to address them?
- How can technological innovations associated with Industry 5.0 lead to improved waste management in cold chains?

2. Sustainable corporate theory

Sustainable corporate theory suggests that companies must operate in an environmentally and socially responsible manner to achieve long-term success. This theory emphasizes the need for companies to be responsible and accountable to a broad range of stakeholders, including employees, customers, suppliers, local communities, and the environment (Kantabutra and Ketprapakorn, 2020). Digitalisation and waste management are two critical areas where companies can make significant sustainability gains (Smith, 2021). Waste management is a key aspect of sustainability, particularly in the context of cold chains, which involve the transport and storage of temperature-sensitive products such as food and pharmaceuticals (Yu et al., 2020; Govindan et al., 2021; United Nations Environment Programme, 2018).

In the context of sustainable corporate theory, waste management involves minimizing the amount of waste generated, reducing the environmental impact of waste, and increasing the efficiency of waste disposal and treatment (Ahi and Searcy, 2019; Epstein, 2018; Zhu et al., 2018).

Overall, sustainable corporate theory recognizes that waste management is a critical component of corporate sustainability and emphasizes the importance of reducing waste and minimizing negative environmental impacts in order to create long-term value for all stakeholders (Jamali & Mirshak, 2020).

Several academic studies have explored the relationship between sustainable corporate theory and waste management in cold chains. For example a study by Wu et al. (2020) investigated the impact of sustainable supply chain management on waste reduction in the pharmaceutical

cold chain, highlighting the importance of collaboration and transparency among stakeholders in achieving sustainability goals. Moreover, Filieri and Arreola-Risa (2019) explore the ways in which digital transformation can support sustainable business practices. The authors argue that digitization can enable companies to optimize processes and reduce waste, leading to improved sustainability. Similarly, Schmid and Preuss (2020) review the literature on the relationship between corporate sustainability and digitalization. They argue that digital technologies can enable companies to improve sustainability by reducing waste and enhancing transparency.

3. Research strategy

Many studies suggest that sustainable corporate theory can play a significant role in promoting effective waste management in cold chains, through the implementation of green logistics practices and other sustainable supply chain management strategies. As such, given the significant impact of Industry 5.0 and its associated technologies on promoting sustainability initiatives, the study aims to apply this theory as a theoretical basis to carry out an exploratory literature review and conduct interviews with key players in cold chains to further investigate the impact of digitalization on addressing waste challenges in cold chain processes.

It is hoped that the comprehensive and explorative literature review will lead to the identification of key concepts related to digitalization and waste efficiency. Then, through analysing the key variables and indicators corresponding to both key categories of concepts, we will investigate the interplays between various technological innovations, corporate sustainability, and waste efficiency. The developed conceptual framework will be further validated and elaborated through interviews with key cold chain players, which will allow for exploring experts' experiences or predictions on the potential challenges and opportunities.

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