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Editorial: Supply chain transformation for pursuing carbon-neutrality

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Editorial on the Research Topic
Supply chain transformation for pursuing carbon-neutrality

The progress toward using renewables and increasing energy efficiency is deemed insufficient as global warming is outpacing the positive developments. Taking energy consumption as an example, the overall share of fossil fuels in global primary energy demand has remained constant over the past 25 years. Current initiatives often focus narrowly on specific supply chain activities and may rely on traditional technologies, resulting in suboptimal outcomes. A comprehensive examination of whole supply chains and understanding the trade-offs between different activities is required for a positive overall impact, achieving carbon neutrality, and, eventually, ecological restoration.

Acknowledging the role of manufacturing and construction activities in environmental issues, many studies focused on the supply chain's transformation to establish carbon neutrality in these sectors. Our primary investigations of the supply chain literature showed a growing interest in carbon-related issues. These studies are multidisciplinary with the research methodologies ranging from conceptual and qualitative to quantitative. While *carbon neutrality* has been used since late 2021, *carbon footprint*, *carbon tax*, *carbon trading*, and *low-carbon economy* are among the related concepts that have long been discussed in the academic literature. Adopting disruptive new technologies that support the green transformation of supply chains, like *blockchain*, is one of the recent topics that attracted academic attention. The keyword *"carbon neutrality"* has most frequently co-occurred with *green supply chain*, *sustainability*, *life cycle assessment*, *game theory*, *optimization*, and *blockchain*.

Hierarchical clustering of the most frequently used keywords in the literature is considered to identify the major research themes using a three-step procedure. Considering keywords as vertices and co-occurrences as edges, the shortest steps between all vertices are determined first. The steps required to reach from the source vertex to every other vertex are then calculated. As the final step, the edge(s) with the highest crossings are removed with distinct node clusters being the results. Results are shown in Figure 1. In this figure, the size of the vertices and edges represent their importance with respect to the keyword's occurrence and the keywords' co-occurrences, respectively. Closeness between vertices shows greater correlations.

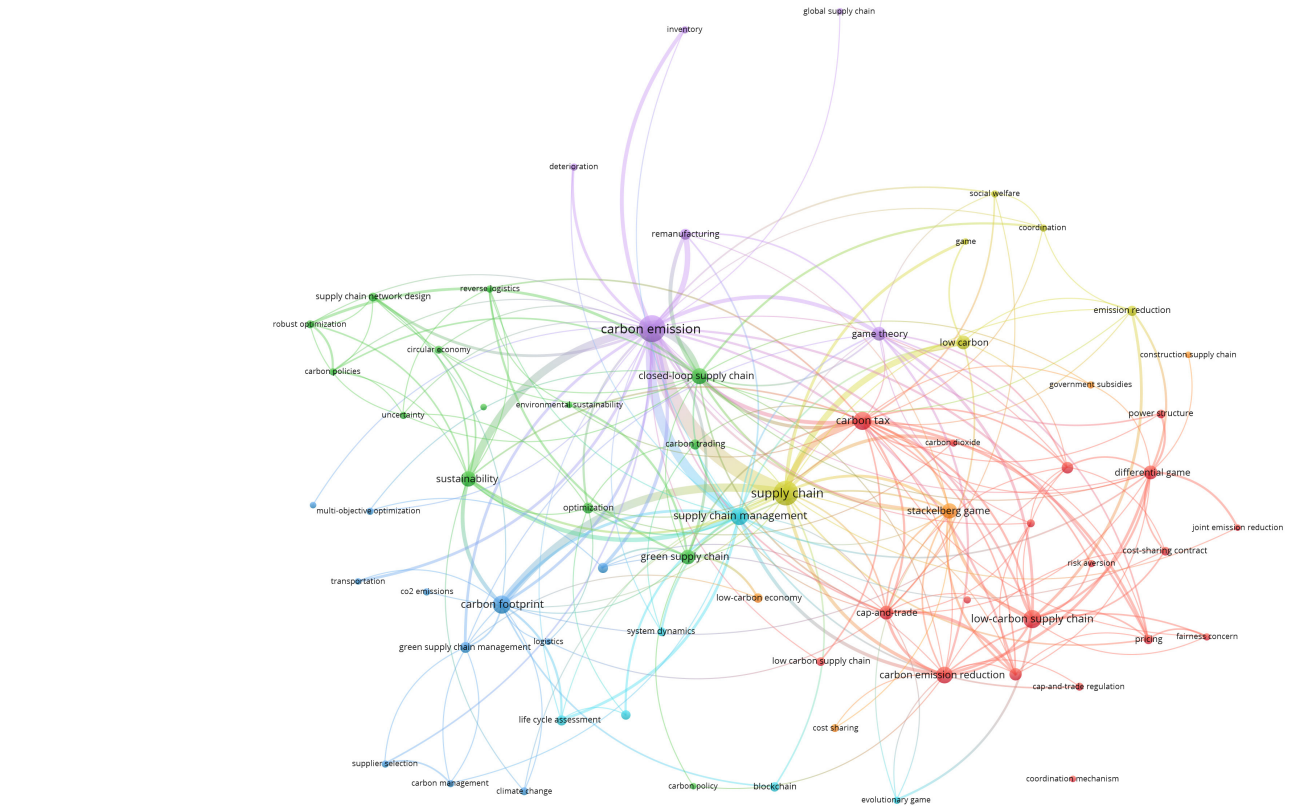

FIGURE 1
Network visualization of the frequently used keywords and their interactions (the figure is generated using *VOSviewer* considering the articles published until the end of 2024).

This investigation revealed that *low carbon supply chain*, *cap-and-trade*, *carbon emission reduction*, and *pricing* formed the most prevalent research theme (represented by red nodes) where Differential and Stackelberg games are among the major applied methodologies. *Closed-loop supply chain*, *circular economy*, *reverse logistics*, and *remanufacturing* are central to the second biggest research cluster (represented by green nodes) with optimization and supply chain network design being the major research methods. The third largest research cluster (represented by blue nodes) has formed around *carbon footprint*, *life cycle assessment*, and *green supply chain management*, which mostly concerns decision-making, like *supplier selection*.

Overall, the main objective of the studies on supply chain transformation has been to reduce the negative impacts of industrial activities on the environment. In addition, net-zero practices have implications for improving social welfare and fostering a low-carbon economy. Exploring the opportunities and challenges of supply chain transformation with a focus on carbon peak and neutrality concepts, both in theory and practice plays an important role in the sustainable development of industries. This exploration inspired our Research Topic. We invited contributions focusing on technological transformation, energy transition, and modernization of manufacturing supply chains to bring together researchers from different backgrounds to contribute to the supply chain transformation for pursuing carbon neutrality. A summary of these contributions is presented below.

"Supply chain control tower and the adoption of intelligent dock booking for improving efficiency" explored the implementation of Intelligent Dock Booking within a Supply Chain Control Tower framework. The proposed system decreases truck waiting times and idle periods, optimizes dock usage, and improves overall transportation efficiency, contributing to reduced fuel consumption and lower carbon emissions (Wyciślak and Pourhejazy).

"The impact of global value chain embedding on the upgrading of China's manufacturing industry" examined the impact of global value chain embedding on the green transformation of China's manufacturing industry. The study highlights the importance of technological upgrading and innovation in the manufacturing sector, which could be extended to clean technologies for carbon neutrality (Fu).

"Coordination contracts and numerical analysis of low-carbon competitive supply chains under the influence of low-carbon goodwill" introduced a novel low-carbon goodwill model that incorporates advertising competition; they highlighted the role of balancing competition and cooperation in low-carbon initiatives (Xie et al.).

"A sustainable NEV manufacturer-retailer system under the Nash bargaining framework considering the impact of the COVID-19 epidemic under the CVaR criterion" developed a novel negotiation mechanism incorporating risk aversion and the Conditional Value-at-Risk (CVaR) criteria. The article provided insights into promoting sustainability in vehicle production and sales (Han and Cheng).

"Extended reality implementation possibilities in direct energy deposition-arc" integrated extended reality (XR) technologies into additive manufacturing as another disruptive new technology. The authors showed that implementing XR in the manufacturing process can potentially reduce material wastage and energy consumption by enabling more accurate design, planning, and execution of manufacturing tasks (Lund et al.).

"Implementing concepts from green logistics in the turkey production supply chain" contributed an optimization model for brooder-finisher assignments in a turkey production network, aiming to minimize transportation distances and associated greenhouse gas emissions. They showed a 50 percent reduction in greenhouse gas emissions associated with turkey transportation (Wilson et al.).

"Power plant units for CO2 neutral energy security in Switzerland" introduced the concept of Power Plant Units (PPUs) for the on-demand delivery of renewable energy and addressing the intermittency issues associated with renewable energy sources. The authors evaluated various renewable energy production and storage technologies, and provided a roadmap for technology adoption in the transition to a carbon-neutral economy (Züttel et al.).

"Closed-loop supply chain decision making and coordination considering channel power structure and information symmetry" explored Corporate Social Responsibility (CSR) and the possibility of manufacturers mis-reporting information about their recycling efforts. Their analysis of recycling rates and CSR levels indirectly addressed emissions reduction strategies by promoting the recycling and remanufacturing of used products (Huo et al.).

"Towards the design of a smart warehouse management system for spare parts management in the oil and gas sector" contributed a framework for implementing digital technologies in spare parts warehousing; their supply chain framework can reduce waste, improve efficiency in spare parts management, and is aligned with circular economy principles by optimizing inventory levels and reducing avoidable material waste (Khan et al.).

Supply chain transformation is a prerequisite for pursuing the Sustainable Development Goals (SDGs). The editors sincerely hope that this Research Topic will attract more researchers to the sustainability discussion and inspire more innovations in pursuing carbon neutrality.

Author contributions

PP: Writing – original draft. SW: Writing – original draft. WS: Writing – review & editing. ÅE: Writing – review & editing.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

The author(s) declared that they were an editorial board member of Frontiers, at the time of submission. This had no impact on the peer review process and the final decision.

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