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A Cost-Effective Approach for Inventory- Transportation to Address Carbon Tax Policy

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Abstract

The growing concern regarding global warming has resulted in the implementation of regulations aimed at progressively diminishing the volume of greenhouse gases released by industrial sectors and their associated supply chains. This research study concentrates on quantifying the carbon emissions within a two-tiered supply chain, in which a single supplier distributes a single product to different retailers, while also coordinating the many elements of the chain including transportation and inventory. A mixed integer programming (MIP) approach has been developed to attain this goal. This model considers decisions such as the time and quantity of replenishment for each retailer, the types of transportation vehicles employed, and the number of products transported by each vehicle. The goal of this optimization model is not only a reduction in transportation expenses and inventory management costs but also carbon emissions across the supply chain which can be reduced by regarding tax as a leverage.

Keywords
Supply chain, transportation, inventory, carbon emission tax

1. Introduction
Supply chain has attracted significant attention in academia and industry. The primary focus lies on the carbon emissions stemming from supply chain operations, prompting numerous governments to enforce carbon taxes as a means to encourage emission reduction and energy preservation. Against this failure, the effects of carbon taxes on the supply chain and its associated operational choices have become highly debated subjects.

*-+The supply chain is a network of interconnected business activities designed to maximise customer satisfaction. The first step in this process is the extraction of raw materials, which is followed by the fabrication of items and their subsequent delivery to the client. To produce a service or good that customers are prepared to pay for, all links in the supply chain must work together, but this is what happens when the network is efficient. A number of elements collaborate (sometimes independently of the other elements) to function as an expanded organisation and make optimal use of company resources (human resources, processes, and technology) in order to provide the highest quality, most cost-effective, and most timely delivery of the product to the ultimate customers (Deshpande and Swaminathan, 2020).

The term "green supply chain management" refers to the process of incorporating environmental considerations into every step of the supply chain, from product selection to manufacturer and material selection to production methods to packaging to delivery methods (Mardani et al., 2020).

Environmental issues, along with other economic variables, have been incorporated into supply chain modelling in recent years (Frommer and Day, 2017). (Bray, Serpa and Colak, 2019) stated that the environmental compatibility of the various phases of the supply chain may result in more competitive trade and operational performance. Green supply chain management has been classified based on the relative importance of green supply chain elements, green design, and green operations (Gopalakrishnan, Granot and Granot, 2021).

Scientists have been concerned for decades about a one-degree Celsius increase in average air temperature over the last century. As the average temperature of the Earth rises, sea level rises and weather becomes more unpredictable. These include the catastrophic hurricane that struck Europe in 2021, Hurricane Katrina, which struck the United States in 2005, and Australia's drought, fires, and unprecedented snowfall in 2020 (Michaelowa, Shishlov and Brescia, 2019; Ertimur et al., 2020; Fan, Chen and Chen, 2022).

These events have strengthened widespread agreement that greenhouse gases are hazardous to the ecosystem. Carbon dioxide and other pollutants are collectively referred to as "greenhouse gases." Carbon dioxide emissions have been shown to account for 71% of all greenhouse gas emissions. (Drakea, 2018; Gao and Souza, 2022).

Carbon emissions can be caused by the use of fossil fuels (emission scope 1), electricity (emission scope 2), or both. The reporting of emission data that are unrelated to operational decisions is discouraged by standard practise (emission scope 3). Furthermore, the supply chain's emissions may not be reported.

The impacts of industries' carbon monoxide emission targets are being studied quickly. Some reporting standards have been established as a first step towards quantifying the effects of carbon emissions. Unlike emissions from scopes 1 and 2, which are often connected with direct firm participation at the time of launch and indirect emissions through electricity use, emissions from the supply chain are classified as scope 3 (Huang, Fang and Lin, 2020; Gao and Souza, 2022).

A "carbon tax" is a type of pollution tax charged on the extraction, transportation, and use of fossil fuels. The carbon footprint serves as the foundation for this. Finland was the first country to impose a carbon price in 1990. This regulation is presently in effect in several Nordic nations. The law was implemented throughout Europe, following the lead of Finland, Sweden, Denmark, and the United Kingdom. Implementing such a tax has helped some US states and Canadian provinces (Quebec and British Columbia) cut carbon emissions. According to Rosenthal's New York Times piece, Ireland is currently 15% greener than it was in 2008. This country's greenhouse gas emissions were comparable to those of the United States. In 2011, Ireland's greenhouse gas emissions declined 7.6 percent to 34.57 million metric tonnes (Anand and Giraud-Carrier, 2020; Gore, Rigot-Müller and Coughlan, 2022).

The novelty of the mixed integer model presented in this model lies in its consideration of:
1. Incorporating carbon emission costs alongside vehicle costs, transportation costs, and inventory holding costs at retailers.
2. Utilizing different types of vehicles with varying emission levels due to factors such as manufacturing technologies, fuel types, and vehicle age.
3. Allowing for splitting retailers' demand over multiple vehicles in each time period, resulting in reduced vehicle usage and shorter total travel distances.

2. Literature Review

Along with the green design of the supply chain, research has been done on optimising operational decisions with a focus on carbon emissions in the supply chain, and researchers considered the reduction of costs related to greenhouse gases at the operational level of the supply chain. (Qi et al., 2022) looked into the transportation scheduling problem using the time-space network and developed a model using mixed integer programming to cut down on transportation expenses and carbon emissions during the distribution process. (Ganesh Kumar and Uthayakumar, 2019) used mixed integer programming and a genetic algorithm to solve the transportation problem posed by the carbon emission exchange programme, and their findings supported the use of the genetic algorithm in the design of a transportation network with a minimum carbon footprint. A two-tier supply chain replenishment model was studied (Modak and Kelle, 2021). The results of this research demonstrate that carbon emissions can be lowered without significant financial outlay by employing control policies. A straightforward lot-sizing model in the supply chain was studied by taking into account various policies to regulate carbon emissions (As'ad, Hariga and Shamayleh, 2020). According to the findings of their study, the price of carbon emissions can be drastically cut simply by making the right choices in how the business is run.

As was previously mentioned, research into the effect of carbon emissions on operations management is currently underway. Carbon emissions can be reduced without increasing supply chain costs if different levels of the chain work together to achieve this goal. How much carbon dioxide an automobile releases is calculated in a number of ways, the most common of which are distance-based and fuel-based (Quan et al., 2020).

A vehicle's carbon footprint is affected by many variables, including the technology used in its production, the fuel used, the vehicle's age, the vehicle's average speed, the type of road, traffic, the weight of the vehicle and its load, the distance driven, and the weather (Wong, Tai and Zhou, 2018; Li, Soleimani and Zohal, 2019). This study was conducted due to the interest in the topic and the application of mathematical modelling to the problem.

Vehicle routing is one example of a problem that can be modelled using greenhouse gas considerations. Both a case study in the field of distribution and a solution to a vehicle routing problem that takes carbon emissions into account using an objective function based on mixed integer programming have been presented by (Göncü and Çetin, 2022). As a case study, the flour industry under vendor inventory management policy was used to present a model for the inventory routing problem that analyses the ecological and financial effects of different routing options (Mahjoob et al., 2021). Their research, conducted with similar vehicles, demonstrated the feasibility of simultaneously lowering transportation costs and carbon emissions. To cut down on fuel consumption, a model expanded the routing problem into a routing problem with multiple routes, and then chose a route based on its carbon emissions (Li, Soleimani and Zohal, 2019). Naturally, in their model, it is assumed that customer requests will never exceed the carrying capacity of the vehicles and will instead have to be fulfilled by a single, larger vehicle. (Rahbari, Naderi and Mohammadi, 2018), with the assumption of the possibility of transportation between nodes and carbon emissions, examined the problem of routing and inventory for multiple goods over multiple time periods, including a factory and several suppliers, and demonstrated that the distance a vehicle must travel can be minimised under these conditions. According to a recent in-depth study on the topic of green vehicle routing, the majority of studies in this area focus on uniform fleets of vehicles, leaving a research void in the area of utilising vehicles with different characteristics (Asghari and Mirzapour Al-e-hashem, 2021). The vehicle routing problem with a fixed fleet and carbon emissions consideration was modelled as a mixed integer programme by (Ganji et al., 2020). Using time intervals, they found a solution and came to the conclusion that carbon emissions can be drastically cut without sacrificing the advantages of carbon exchange.

(Yakavenka et al., 2020) applied epsilon constraint method to the solution of a multi-objective linear programming model in an international fruit supply chain, yielding compromises between total logistics cost and carbon emissions. They emphasised the significance of fuel quality, distances between supply chain members, and the effect that these factors have on environmental performance across the supply chain. As a result, they came to the conclusion that green tax incentives improve both the economy and the environment.

The majority of studies in this area considered carbon emissions when addressing supply chain design and vehicle routing. Most studies have focused on the strategic level of supply chain planning, with only a small amount of study devoted to the tactical and operational levels and the improvement of the current situation in terms of supply chain environmental performance.

Table (1) evaluates and analyses the strengths and shortcomings of the models given in previous research in the field of green supply chain management.

3. Modelling Mixed integer model

This article addresses the problem of coordinating distribution and inventory management in a two-level, multi-product, multi-period supply chain consisting of a supplier and multiple retailers. The supply chain takes into account environmental factors through carbon tax policy in addition to traditional performance metrics. The supplier is located at a far distance from the retailers, with consistent distances between each retailer. The demand from retailers is dynamic, but the supplier has advanced knowledge through their inventory management system and is responsible for making decisions within the supply chain. This includes determining shipment size, type and quantity of goods to be sent, and timing of deliveries to each retailer based on demand information. Additionally, the supplier must consider their available fleet when selecting appropriate vehicles based on carrying capacity and carbon emissions for each time period. The objective is to minimize distribution costs, which encompass fixed vehicle costs, transportation expenses, inventory holding at retail stores, and fleet management.

Table 1. Review of related sources and gap analysis

Reference:	Novelty of model	Limitation of model	Relevancy to this research
(Singh, Chandra Misra and Kumar, 2020)	Using ANP method, a model has been presented for deciding the operational issues of the sustainable supply chain. A small example about the sensitivity analysis of the proposed model is provided.	Th considered factors are not complete and are general.	A method to solve MCDM problem has been proposed in SSCM
(Wen et al., 2022)	Solved VRP problem by considering the amount of carbon emissions in the objective function with a case study.	Only routing problem considering carbon emission has been considered and three heuristic algorithms have been used to solve the model which is NP-hard and no exact or meta-heuristic solution has been used.	It can be useful because it includes carbon emissions in the modeling.
(Jazinaninejad et al., 2022)	They have done a comprehensive study in line with the green supply chain. It has also provided a classification and framework.	There is no mention of carbon emission costs in the supply chain.	It is useful because all the green supply chain articles have been reviewed.
This research	Considering economic and environmental dimensions in the supply chain Presenting bi-objective model in which decisions related to tactical and operational levels are taken into account Presenting a bi-objective decision-making model considering indirect carbon emissions Providing accurate solution method for small and medium sized problems	Not considering the assumption of uncertainty in parameters and model Not considering large size issues	

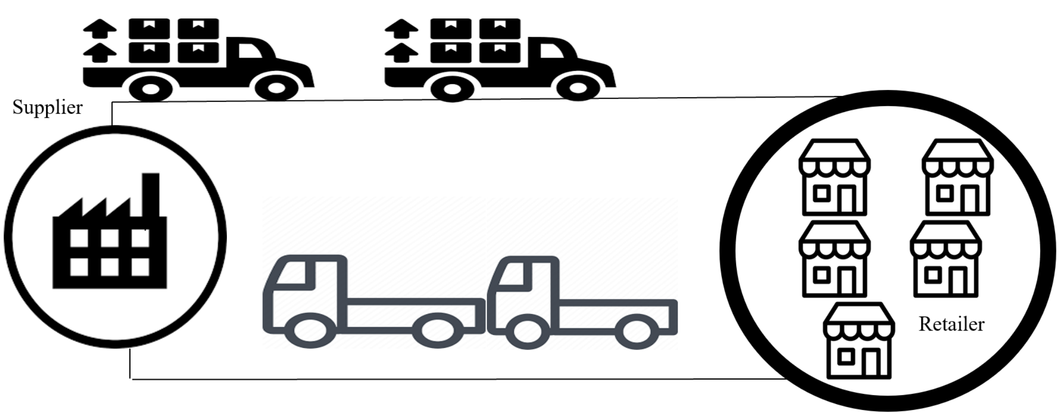

Figure 1. The structure of model

Figure (1) depicts the simplified structure of the supply chain of the problem, in which the is responsible for delivering goods to five retailers within a specified timeframe using two distinct types of vehicles, based on their demand.
The following model has been established by with respect to carbon emission to integrate inventory transportation planning with different products and time-periods in a two-layer network:

Sets
$\boldsymbol{i}$: $\boldsymbol{Index\ for\ products}$ $(\boldsymbol{i} = \boldsymbol{1}, \boldsymbol{2}, \ldots, \boldsymbol{I})$;
$\boldsymbol{j}$: $\boldsymbol{Index\ for\ retailers}$ $(\boldsymbol{j} = \boldsymbol{1}, \boldsymbol{2}, \ldots, \boldsymbol{J})$;
$\boldsymbol{p}$: $\boldsymbol{Index\ for\ vehicle\ types}$ $(\boldsymbol{p} = \boldsymbol{1}, \boldsymbol{2}, \ldots, \boldsymbol{P})$;
$\boldsymbol{k}$: $\boldsymbol{Index\ for\ vehicles}$ $(\boldsymbol{k} = \boldsymbol{1}, \boldsymbol{2}, \ldots, \boldsymbol{K})$;
$\boldsymbol{t}$: $\boldsymbol{Index\ for\ time\ periods}$ $(\boldsymbol{t} = \boldsymbol{1}, \boldsymbol{2}, \ldots, \boldsymbol{T})$;

Parameters
$\boldsymbol{d_{ijt}}$: Demand for product $\boldsymbol{i}$ and retailer $\boldsymbol{j}$ in time $\boldsymbol{t}$
$\boldsymbol{h_{ijt}}$: The holding inventory cost of every unit of product $\boldsymbol{i}$ and retailer $\boldsymbol{j}$ in period $\boldsymbol{t}$
$\boldsymbol{A_p}$: The costs (including driver salaries, fuel expenses, and maintenance costs)
for vehicle type $\boldsymbol{p}$
$\boldsymbol{L_{jp}}$: The transportation cost for retailer $\boldsymbol{j}$ by vehicle type $\boldsymbol{p}$
$\boldsymbol{W_p}$: Weigh for vehicle type $\boldsymbol{p}$
$\boldsymbol{V_p}$: Volume for vehicle type $\boldsymbol{p}$
$\boldsymbol{w_i}$: Weight for product type $\boldsymbol{i}$
$\boldsymbol{v_i}$: Volume for product type $\boldsymbol{i}$
$\boldsymbol{dsr}$: Mean distance between retailers and supplier
$\boldsymbol{drr}$: Mean distance between retailers
$\boldsymbol{TX}$: Carbon emission tax

Variables
$\boldsymbol{x_{ijpkt}}$: The amount of delivered goods group $\boldsymbol{i}$ to retailer $\boldsymbol{j}$ via vehicle $\boldsymbol{k}$ and vehicle group $\boldsymbol{p}$ in time $\boldsymbol{t}$
$\boldsymbol{y_{pkt}}$: The amount of transported goods via vehicle $\boldsymbol{k}$ and vehicle type $\boldsymbol{p}$ in time $\boldsymbol{t}$
$\boldsymbol{I_{ijt}}$: The level of inventory for products group $\boldsymbol{i}$ to retailer $\boldsymbol{j}$ by vehicle $\boldsymbol{k}$ in time $\boldsymbol{t}$
$\boldsymbol{X_{jpkt}}$: Binary variable that will be equal to 1 if $\boldsymbol{x_{jpkt}} = \sum_{\boldsymbol{i}} \boldsymbol{x_{ijpkt}} > \boldsymbol{0}$; otherwise, 0
$\boldsymbol{Y_{pkt}}$: Binary variable that will be equal to 1 if $\boldsymbol{y_{jpkt}} = \sum_{\boldsymbol{i}} \sum_{\boldsymbol{j}} \boldsymbol{x_{ijpkt}} > \boldsymbol{0}$; otherwise, 0
$\boldsymbol{n_{pkt}}$: Number of visited retailers by vehicle $\boldsymbol{k}$ type $\boldsymbol{p}$ in time $\boldsymbol{t}$
$\boldsymbol{E_{pkt}}$: Emission by vehicle $\boldsymbol{k}$ type $\boldsymbol{p}$ in time $\boldsymbol{t}$
$\boldsymbol{C_{srt}}$: Emission in the route connecting supplier and retailers in time $\boldsymbol{t}$
$\boldsymbol{C_{rrt}}$: Emission in the path between retailers in time $\boldsymbol{t}$
$\boldsymbol{Ce_t}$: Emission throughout chain in time $\boldsymbol{t}$

$$Min_z = \sum_p \sum_k \sum_t A_p Y_{pkt} + \sum_j \sum_p \sum_k \sum_t L_{jp} X_{jpkt} + \sum_i \sum_j \sum_t h_{ijt} I_{ijt} + TX \sum_t Ce_t$$	(1)

St:

$$\sum_p \sum_k x_{ijpkt} + I_{ij,t-1} - d_{ijt} = I_{ijt} \quad \forall i, j, t$$	(2)
$$\sum_i \sum_j w_i x_{ijpkt} \le W_p \qquad \forall p, k, t$$	(3)

$$\sum_i \sum_j v_i x_{ijpkt} \le V_p \qquad \forall p, k, t$$	(4)
$$Csr_t = 2dsr \sum_p \sum_k E_{pkt} Y_{pkt} \quad \forall t$$	(5)
$$Crr_t = drr \sum_p \sum_k E_{pkt}(n_{pkt} - Y_{pkt}) \quad \forall t$$	(6)
$$Ce_t = Csr_t + Crr_t \;\; \forall t$$	(7)
$$x_{ijpkt}, I_{ijt}, y_{pkt}, x_{jpkt}, n_{pkt}, E_{pkt}, Csr_t, Crr_t Ce_t \ge 0 \;\; \forall i, j, p, k, t$$	(8)
$$X_{jpkt}, Y_{pkt} \in \{0, 1\} \;\; \forall j, p, k, t$$	(9)

The objective function of the model comprises of four distinct parts. The first component represents the total costs associated with vehicles (including driver salaries, fuel expenses, and maintenance costs), while the second component denotes the total cost incurred in transporting products between retailers. The third component reflects the total inventory maintenance costs, and the fourth section displays the total costs attributed to carbon emissions. Constraint (2) is for determining the inventory balance for each retailer. This guarantees that the remaining stock of a retailer for the upcoming period is equivalent to the sum of products received, their remaining inventory from the previous period, minus the current demand for each individual product. Constraints (3) and (4) ensure that the carrying capacity of a vehicle does not exceed its loading capacity within a specific time period. Equations (5) through (7) define variables utilized in the objective function to measure the costs for carbon emission. Constraints (8,9) denote non-negative and binary variables, respectively.

6. Conclusion

In this article, we delved into the intricacies of transportation and inventory planning within a 2-layer, multi-product, multi-time network, with a specific emphasis on mitigating carbon emissions. Specifically, we consider the definite and dynamic demand of retailers and the decision-making responsibility of the supplier regarding the quantity and timing of goods sent. This decision-making is facilitated by an inventory management system implemented by the seller. This model introduces several innovations, including taking into account different modes of transportation, utilizing different modes of transportation, accounting for fluctuating carbon emissions, and integrating the dimensions and mass of goods into the modeling process. To achieve this, we have developed a non-linear mixed integer programming model that has been linearized using linear methods. The objective of this study is to obtain precise solutions for small and medium-sized examples to demonstrate the practical application of our model under different scenarios.

References

Anand, K. S. and Giraud-Carrier, F. C., ‘Pollution regulation of competitive markets’, Management Science, 66(9), 2020. doi: 10.1287/mnsc.2019.3413.

As’ad, R., Hariga, M. and Shamayleh, A., ‘Sustainable dynamic lot sizing models for cold products under carbon cap policy’, Computers and Industrial Engineering, 149m, 2020. doi: 10.1016/j.cie.2020.106800.

Asghari, M. and Mirzapour Al-e-hashem, S. M. J., ‘Green vehicle routing problem: A state-of-the-art review’, International Journal of Production Economics, 2021. doi: 10.1016/j.ijpe.2020.107899.

Bhattacharya, K. and De, S. K., ‘A robust two layer green supply chain modelling under performance based fuzzy game theoretic approach’, Computers and Industrial Engineering, 152, 2021. doi: 10.1016/j.cie.2020.107005.

Bray, R. L., Serpa, J. C. and Colak, A., ‘Supply chain proximity and product quality’, Management Science, 65(9), 2019. doi: 10.1287/mnsc.2018.3161.

Deshpande, V. and Swaminathan, J. M., 'Introduction to the special issue on responsible operations and supply chain management', Manufacturing and Service Operations Management, 2020. doi: 10.1287/MSOM.2020.0944.
Drakea, D. F., 'Carbon tariffs: Effects in settings with technology choice and foreign production cost advantage', Manufacturing and Service Operations Management, 20(4), 2018. doi: 10.1287/msom.2017.0674.
Ertimur, Y. et al., 'Financial reporting for pollution reduction programs', Management Science, 66(12), 2020. doi: 10.1287/mnsc.2019.3416.
Fan, X., Chen, K. and Chen, Y.-J., 'Is Price Commitment a Better Solution to Control Carbon Emissions and Promote Technology Investment?', Management Science, 2022. doi: 10.1287/mnsc.2022.4365.
Frommer, I. D. and Day, R. W., 'Game—A Carbon Emissions Game', INFORMS Transactions on Education, 18(1), 2017. doi: 10.1287/ited.2017.0171.
Ganesh Kumar, M. and Uthayakumar, R., 'Modelling on vendor-managed inventory policies with equal and unequal shipments under GHG emission-trading scheme', International Journal of Production Research, 57(11), 2019. doi: 10.1080/00207543.2018.1530471.
Ganji, M. et al., 'A green multi-objective integrated scheduling of production and distribution with heterogeneous fleet vehicle routing and time windows', Journal of Cleaner Production, 259, 2020. doi: 10.1016/j.jclepro.2020.120824.
Gao, F. and Souza, G. C., 'Carbon Offsetting with Eco-Conscious Consumers', Management Science, 2022. doi: 10.1287/mnsc.2021.4293.
Göncü, K. K. and Çetin, O., 'A Decision Model for Supplier Selection Criteria in Healthcare Enterprises with Dematel ANP Method', Sustainability, 14(21), p. 13912, 2022. doi: 10.3390/su142113912.
Gopalakrishnan, S., Granot, D. and Granot, F., 'Consistent Allocation of Emission Responsibility in Fossil Fuel Supply Chains', Management Science, 67(12), 2031. doi: 10.1287/mnsc.2020.3874.
Gore, K., Rigot-Müller, P. and Coughlan, J., 'Cost assessment of alternative fuels for maritime transportation in Ireland', Transportation Research Part D: Transport and Environment, 110(May), p. 103416, 2022. doi: 10.1016/j.trd.2022.103416.
Han, D., Qiao, R. and Ma, X., 'Optimization of land-use structure based on the trade-off between carbon emission targets and economic development in Shenzhen, China', Sustainability (Switzerland), 11(1), 2019. doi: 10.3390/su11010011.
Huang, Y. S., Fang, C. C. and Lin, Y. A., 'Inventory management in supply chains with consideration of Logistics, green investment and different carbon emissions policies', Computers and Industrial Engineering, 139, 2020. doi: 10.1016/j.cie.2019.106207.
Islam, A. and Lownes, N., 'When to go electric? A parallel bus fleet replacement study', Transportation Research Part D: Transport and Environment, 72, 2019. doi: 10.1016/j.trd.2019.05.007.
Jabbarzadeh, A., Fahimnia, B. and Sabouhi, F., 'Resilient and sustainable supply chain design: sustainability analysis under disruption risks', International Journal of Production Research, 56(17), 2018. doi: 10.1080/00207543.2018.1461950.
Jazinaninejad, M. et al., 'Sustainable operations, managerial decisions, and quantitative analytics of biomass supply chains: A systematic literature review', Journal of Cleaner Production, 374(September), p. 133889, 2022. doi: 10.1016/j.jclepro.2022.133889.
Khan, S. A. R. et al., 'A state-of-the-art review and meta-analysis on sustainable supply chain management: Future research directions', Journal of Cleaner Production, 2021. doi: 10.1016/j.jclepro.2020.123357.
Li, Y., Soleimani, H. and Zohal, M., 'An improved ant colony optimization algorithm for the multi-depot green vehicle routing problem with multiple objectives', Journal of Cleaner Production, 227, 2019. doi: 10.1016/j.jclepro.2019.03.185.
Li, Z. and Hai, J., 'Inventory management for one warehouse multi-retailer systems with carbon emission costs', Computers and Industrial Engineering, 130, 2019. doi: 10.1016/j.cie.2019.03.015.
Mahjoob, M. et al., 'A green multi-period inventory routing problem with pickup and split delivery: A case study in flour industry', Sustainable Operations and Computers, 2, 2021. doi: 10.1016/j.susoc.2021.04.002.
Mardani, A. et al., 'Evaluation of green and sustainable supply chain management using structural equation modelling: A systematic review of the state of the art literature and recommendations for future research', Journal of Cleaner Production, 249, 2020. doi: 10.1016/j.jclepro.2019.119383.
Meherishi, L., Narayana, S. A. and Ranjani, K. S., 'Sustainable packaging for supply chain management in the circular economy: A review', Journal of Cleaner Production, 237, 2019. doi: 10.1016/j.jclepro.2019.07.057.
Michaelowa, A., Shishlov, I. and Brescia, D., 'Evolution of international carbon markets: lessons for the Paris Agreement', Wiley Interdisciplinary Reviews: Climate Change, 2019. doi: 10.1002/wcc.613.

Modak, N. M. and Kelle, P., 'Using social work donation as a tool of corporate social responsibility in a closed-loop supply chain considering carbon emissions tax and demand uncertainty', Journal of the Operational Research Society, 72(1), 2021. doi: 10.1080/01605682.2019.1654413.

Mohammed, A., 'Towards a sustainable assessment of suppliers: an integrated fuzzy TOPSIS-possibilistic multi-objective approach', Annals of Operations Research, 293(2), 2020. doi: 10.1007/s10479-019-03167-5.

Mohebalizadehgashti, F., Zolfagharinia, H. and Amin, S. H., 'Designing a green meat supply chain network: A multi-objective approach', International Journal of Production Economics, 219, 2020. doi: 10.1016/j.ijpe.2019.07.007.

Qi, Y. et al., 'Transport service selection and routing with carbon emissions and inventory costs consideration in the context of the Belt and Road Initiative', Transportation Research Part E: Logistics and Transportation Review, 159, 2022. doi: 10.1016/j.tre.2022.102630.

Quan, C. et al., 'Analysis on the influencing factors of carbon emission in China's logistics industry based on LMDI method', Science of the Total Environment, 734, 2020. doi: 10.1016/j.scitotenv.2020.138473.

Rahbari, M., Naderi, B. and Mohammadi, M., 'Modelling and Solving the Inventory Routing Problem with CO2 Emissions Consideration and Transshipment Option', Environmental Processes, 5(3), 2018. doi: 10.1007/s40710-018-0302-y.

Rentizelas, A. and Trivyza, N. L., 'Enhancing circularity in the car sharing industry: Reverse supply chain network design optimisation for reusable car frames', Sustainable Production and Consumption, 32, pp. 863–879, 2022. doi: 10.1016/j.spc.2022.06.009.

Rissman, J. et al., 'Technologies and policies to decarbonize global industry: Review and assessment of mitigation drivers through 2070', Applied Energy, 2020. doi: 10.1016/j.apenergy.2020.114848.

Singh, S., Chandra Misra, S. and Kumar, S., 'Identification and ranking of the risk factors involved in PLM implementation', International Journal of Production Economics, 222, 2020. doi: 10.1016/j.ijpe.2019.09.017.

Sun, Y. et al., 'A fuzzy programming method for modeling demand uncertainty in the capacitated road-rail multimodal routing problem with time windows', Symmetry, 11(1), 2019. doi: 10.3390/sym11010091.

Wen, M. et al., 'An adaptive large neighborhood search for the larger-scale multi depot green vehicle routing problem with time windows', Journal of Cleaner Production, 374(March), p. 133916, 2022. doi: 10.1016/j.jclepro.2022.133916.

Wong, E. Y. C., Tai, A. H. and Zhou, E., 'Optimising truckload operations in third-party logistics: A carbon footprint perspective in volatile supply chain', Transportation Research Part D: Transport and Environment, 63, 2018. doi: 10.1016/j.trd.2018.06.009.

Yadav, V. S. et al., 'Design of multi-objective sustainable food distribution network in the Indian context with multiple delivery channels', Computers and Industrial Engineering, 160, 2021. doi: 10.1016/j.cie.2021.107549.

Yakavenka, V. et al., 'Development of a multi-objective model for the design of sustainable supply chains: the case of perishable food products', Annals of Operations Research, 294(1–2), 2020. doi: 10.1007/s10479-019-03434-5.

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