Engineering Applications of Artificial Intelligence 126 (2023) 106839

Contents lists available at ScienceDirect

Engineering Applications of Artificial Intelligence

journal homepage: www.elsevier.com/locate/engappai

Revolutionizing sustainable supply chain management: A review of metaheuristics

Laith Abualigah [a,b,*], Essam Said Hanandeh [c], Raed Abu Zitar [d], Cuong-Le Thanh [b], Samir Khatir [b,e], Amir H. Gandomi [f,g,**]

[a] Computer Science Department, Prince Hussein Bin Abdullah Faculty for Information Technology, Al al-Bayt University, Mafraq 25113, Jordan
[b] Center for Engineering Application and Technology Solutions, Ho Chi Minh City Open University, Ho Chi Minh, 700000, Viet Nam
[c] Department of Computer Information System, Zarqa University, P.O. Box 13132, Zarqa, Jordan
[d] Sorbonne Center of Artificial Intelligence, Sorbonne University-Abu Dhabi, Abu Dhabi, United Arab Emirates
[e] Laboratory Soete, Department of Electrical Energy, Metals, Mechanical Constructions, and Systems, Faculty of Engineering and Architecture, Ghent University, Gent 9000, Belgium
[f] Faculty of Engineering and Information Technology, University of Technology Sydney, Ultimo NSW 2007, Australia
[g] University Research and Innovation Center (EKIK), Óbuda University, 1034 Budapest, Hungary

ARTICLE INFO

Keywords:
Meta-heuristics
Optimization algorithms
Sustainable
Supply chain management

ABSTRACT

This paper reviews the application of metaheuristics for optimized sustainable supply chain management (SSCM). This paper explores the potential of metaheuristics to improve the supply chain's sustainability while enhancing its efficiency and competitiveness. The paper provides an overview of the principles of SSCM and the challenges businesses face in achieving sustainable supply chain management. It then introduces the concept of metaheuristics and describes their use in solving complex optimization problems. The paper reviews various metaheuristics algorithms applied to sustainable supply chain management and analyzes their effectiveness in addressing the challenges of SSCM. The paper also identifies the key factors that influence the success of using metaheuristics for SSCM, such as the choice of algorithm, problem complexity, and data quality. Finally, the paper provides recommendations for future research in this area and highlights the potential of metaheuristics to promote sustainable supply chain management. The review suggests that metaheuristics can be a valuable tool for optimizing sustainable supply chain management and improving supply chain operations' sustainability, efficiency, and competitiveness.

1. Introduction

Metaheuristics are optimization algorithms that can solve a wide range of problems, including those that are difficult or impossible to solve using traditional methods (Tzanetos and Dounias, 2021; He et al., 2022; Sharma et al., 2021). These algorithms are based on exploring a problem's search space intelligently and efficiently to find a high-quality solution (Chawla and Duhan, 2018; Halim et al., 2021).

One key characteristic of metaheuristics is their ability to handle complex and nonlinear functions (Mazaheri and Khodadadi, 2020; De León-Aldaco et al., 2015), which makes them particularly useful for optimization problems that involve a large number of variables or constraints (Cuong-Le et al., 2021; Sang-To et al., 2023). Another advantage of metaheuristics is their flexibility, as they can be adapted to different problem domains and tailored to specific objectives (Nama et al., 2023, 2017).

There are many different types of metaheuristics, each with its strengths and weaknesses (Abualigah et al., 2021a,b, 2022). Some examples are Genetic algorithms: These are inspired by natural selection and use principles of genetics and evolution to optimize a population of solutions over multiple generations. Particle swarm optimization: This algorithm is based on the movement of particles in a search space, which moves toward the best solutions found so far while exploring new regions of the search space (Kennedy and Eberhart, 1995). Simulated annealing: This algorithm is based on the annealing process used in metallurgy, where a metal is heated and then slowly cooled to reduce defects. Similarly, simulated annealing involves starting with a high temperature and gradually decreasing it to find a good solution. Ant colony optimization: This algorithm is inspired by the behavior of ants, which use pheromones to communicate and find the shortest path between their nest and a food source (Bertsimas and Tsitsiklis, 1993). Ant colony optimization uses a similar approach to find the best path

* Corresponding author at: Center for Engineering Application and Technology Solutions, Ho Chi Minh City Open University, Ho Chi Minh, 700000, Viet Nam
** Corresponding author at: Faculty of Engineering and Information Technology, University of Technology Sydney, Ultimo NSW 2007, Australia.
E-mail addresses: Aligah.2020@gmail.com (L. Abualigah), hanandeh@zu.edu.jo (E.S. Hanandeh), raed.zitar@sorbonne.ae (R.A. Zitar), cuong.lt@ou.edu.vn (C.-L. Thanh), samir.Khatir@ugent.be (S. Khatir), gandomi@uts.edu.au (A.H. Gandomi).

https://doi.org/10.1016/j.engappai.2023.106839
Received 27 February 2023; Received in revised form 26 June 2023; Accepted 18 July 2023
Available online 2 August 2023

between a start and end point in a graph (Dorigo et al., 2006). Tabu search: This algorithm uses a memory-based approach to prevent the algorithm from revisiting previous solutions that have already been explored (Glover, 1989; Chakraborty et al., 2021). This can help the algorithm explore new regions of the search space more efficiently.

While these algorithms differ in their underlying principles and mechanics, they all aim to find high-quality solutions to optimization problems (Agushaka et al., 2022a; Oyelade et al., 2022; Ezugwu et al., 2022). Using intelligent exploration and optimization techniques, metaheuristics can help solve complex problems across a wide range of domains (Agushaka et al., 2022b).

Sustainable supply chain management (SSCM) manages the entire supply chain to reduce negative environmental, social, and economic impacts while increasing positive impacts (Carter and Liane Easton, 2011). The objective of SSCM is to ensure that the supply chain is operated in a manner that is sustainable and does not harm the environment or society. The concept of SSCM is based on the recognition that the supply chain is a complex system that significantly impacts the environment and society. The supply chain includes all the activities involved in producing and delivering a product or service, from extracting raw materials to disposing the end product (Carter and Rogers, 2008; Seuring and Müller, 2008).

The main principles of SSCM include the integration of sustainability considerations into all aspects of the supply chain, the reduction of waste and emissions, the development of sustainable products and services, and the promotion of ethical and socially responsible business practices (Mosteanu et al., 2020). SSCM also involves the collaboration and communication between all parties involved in the supply chain, including suppliers, manufacturers, retailers, and customers. SSCM can bring numerous benefits to businesses, such as increased efficiency, reduced costs, improved reputation, and reduced environmental and social risks. It can also contribute to achieving sustainable development goals and mitigating climate change (Beske and Seuring, 2014; Ashby et al., 2012).

Some of the key practices of SSCM include the use of eco-friendly materials, reduction of energy consumption and emissions, adoption of sustainable transportation and logistics, the implementation of responsible sourcing policies, and the development of sustainable product design and packaging (Kafa et al., 2013). These practices can be supported by using sustainability metrics and tools to measure and monitor the environmental and social impact of the supply chain. SSCM is an important approach to managing the supply chain sustainably and responsibly. It can help businesses to reduce their environmental and social footprint while improving their competitiveness and meeting the growing demands of consumers for sustainable products and services (Singhry, 2015; Khan et al., 2022).

The problem of metaheuristics for optimized, sustainable supply chain management involves designing and managing a supply chain network that achieves the best possible balance between economic, environmental, and social performance while considering the complexity and combinatorial nature of the problem. To model the problem, various decision variables need to be considered, such as the selection of suppliers, production facilities, transportation modes, inventory levels, and distribution channels. These decision variables are subject to constraints, such as capacity, demand, and environmental constraints, among others.

The model's objective is to minimize the total cost of the supply chain while maximizing the social and environmental benefits. The total cost includes direct costs such as procurement, transportation, and inventory holding costs, as well as indirect costs such as the cost of carbon emissions, waste management, and social responsibility (Arampantzi and Minis, 2017; You et al., 2012). Metaheuristic algorithms can be used to solve the optimization problem, such as genetic algorithms, simulated annealing, ant colony optimization, and particle swarm optimization. These algorithms are used to explore the solution space and find the optimal set of decision variables that minimize the total cost of the supply chain while satisfying the set of constraints. The problem can also be formulated as a multi-objective optimization problem, where multiple conflicting objectives are optimized simultaneously, such as minimizing cost and environmental impact while maximizing social benefits. In this case, metaheuristic algorithms can be used to find a set of Pareto optimal solutions that represent the trade-off between the conflicting objectives.

To integrate sustainability metrics into the model's objective function, novel approaches can be used, such as carbon emissions, water usage, and social responsibility metrics. These sustainability metrics can be incorporated into the objective function to represent the sustainability performance of the supply chain network. Overall, metaheuristics' problem definition and modeling for optimized, sustainable supply chain management require careful consideration of the decision variables, constraints, and objective function to ensure that the supply chain network balances economic, environmental, and social performance.

This paper provides a comprehensive review of metaheuristics in sustainable supply chain management. Metaheuristics are optimization techniques that can be used to solve complex problems in supply chain management, to improve sustainability. The paper discusses various metaheuristics used in the literature, including genetic algorithms, ant colony optimization, and simulated annealing. The advantages and limitations of each technique are examined, as well as their potential applications in sustainable supply chain management. The paper also discusses future research directions in the field, highlighting opportunities for further development and improvement of metaheuristic approaches for sustainable supply chain management. Overall, this paper is a valuable resource for researchers and practitioners interested in understanding and applying metaheuristics in the context of sustainable supply chain management.

2. Supply chain management problem: Formulation, definition, and modeling

Optimized sustainable supply chain management is a complex problem that involves designing and managing a supply chain network that achieves the best possible balance between economic, environmental, and social performance. The problem involves making decisions regarding the selection of suppliers, production facilities, transportation modes, inventory levels, and distribution channels, among others (Zhang, 2006; Chandra and Tumanyan, 2007).

The objective of optimized sustainable supply chain management is to minimize the total cost of the supply chain while maximizing the social and environmental benefits. The costs include direct costs such as procurement, transportation, and inventory holding costs, as well as indirect costs such as the cost of carbon emissions, waste management, and social responsibility (Costantino et al., 2012; Angerhofer and Angelides, 2000).

The optimization problem in optimized sustainable supply chain management is typically formulated as a mathematical model that includes an objective function and a set of constraints (Talaei et al., 2016). The objective function represents the total cost of the supply chain, which includes the economic, environmental, and social costs. The constraints represent the limitations on the decision variables, which are the choices that the supply chain manager can make (Amin and Zhang, 2013).

To solve the optimization problem in optimized sustainable supply chain management, various techniques can be used, such as linear programming, metaheuristics, and multi-objective optimization. The solution obtained from the optimization problem can provide insights to supply chain managers for making decisions that can lead to a more sustainable and efficient supply chain network.

Here are some examples of mathematical notations and equations used in optimized sustainable supply chain management:

- Objective function:
  The objective function represents the goal of the optimization problem. The objective function of sustainable supply chain management may include economic, environmental, and social factors. A generic form of the objective function is:

$$\min \sum_{i=1}^{n} f_i(x) \tag{1}$$

  where n is the number of decision variables, $f_i(x)$ is the cost function associated with the ith variable, and x is the vector of decision variables.
- Constraints:
  Constraints represent the limitations on the decision variables that must be satisfied in the optimization problem. In sustainable supply chain management, constraints may include resource availability, emissions limits, and social responsibility requirements. A generic form of the constraint is:

$$g_i(x) \leq b_i, \quad i = 1, 2, \ldots, m \tag{2}$$

  where m is the number of constraints, $g_i(x)$ is the ith constraint function, and b_i is the upper bound of the ith constraint.
- Linear programming:
  Linear programming is a widely used optimization technique that can be applied to sustainable supply chain management problems. In linear programming, the objective function and constraints are linear functions. A generic form of the linear programming problem is:

$$\min \mathbf{c}^T \mathbf{x} \tag{3}$$

  subject to:

$$\mathbf{A}\mathbf{x} \leq \mathbf{b} \tag{4}$$

  where $\mathbf{x}$ is the vector of decision variables, $\mathbf{c}$ is the cost coefficient vector, $\mathbf{A}$ is the matrix of constraint coefficients, and $\mathbf{b}$ is the vector of constraint bounds.
- Metaheuristics:
  Metaheuristics are techniques used to solve complex optimization problems that are difficult to solve using traditional optimization techniques. A generic form of a metaheuristic algorithm is:

$$\mathbf{x}^{(t+1)} = \mathrm{H}(\mathbf{x}^{(t)}) \tag{5}$$

  Where $\mathbf{x}^{(t)}$ is the solution at the tth iteration, $\mathbf{x}^{(t+1)}$ is the solution at the $(t+1)$-th iteration, and H is the heuristic function that generates the new solution based on the current solution. Metaheuristic algorithms include genetic algorithms, particle swarm optimization, and ant colony optimization.
  These are just a few examples of the mathematical notations and equations used in optimized, sustainable supply chain management. The specific notations and equations will depend on the problem being addressed and the optimization technique being applied.

3. Literature review with related works

3.1. Optimization methods

In recent years, the number of suppliers, manufacturers, and customers in the global supply chain has increased, creating a more complex and linked network. Due to the growing significance of environmental challenges, there has been a trend toward attaining sustainability in supply chain management. A sustainable network or green supply chain tries to lessen a product's negative environmental impact. However, the difficulties in monitoring the effects within the intricate network architecture and the higher operational expenses frequently prevent the deployment of green supply chain management. Furthermore, it might be not easy to adopt green techniques in practical applications since stakeholders are not always aware of their importance. Cost and carbon emissions are only two examples of the many elements that go into green supply chain management. The multiobjective optimization approach is frequently used to assess supply chain performance. An in-depth analysis of the most recent state-of-the-art literature on the application of multiobjective optimization techniques in green supply chain management is provided in this review article. The study focuses on various green supply chain topologies, model formulation strategies considering many objectives, and approaches for solving multiobjective optimization issues (Asha et al., 2022). The review study outlines future research directions for incorporating economic and environmental factors into sustainable supply chain management.

By introducing a novel way to model network redundancy optimization, the current study provides a novel methodological approach to fill the gap in the literature (Pavlov et al., 2019). This approach enables the simultaneous determination of the best network redundancy and proactive contingency planning while considering the risks of structural disruption and supply dynamics. This study's distinctive features are integrating sustainable resource usage and supply chain resilience based on the synchronization of structure- and flow-oriented optimization. By changing the processing intensity of resource consumption in the network in response to supply and structure dynamics, the suggested model offers a useful technique to examine and optimize supply chain redundancy. This makes it possible to consider resource usage dynamics explicitly when creating contingency plans for interruption scenarios.

The project attempts to reduce the external cost of global warming caused by transportation, given the considerable contribution of the transportation industry to global warming and the environmental effects of material delivery. In addition to the storage facility on the project site, this research suggests a supply chain network architecture for inventory management that uses an auxiliary warehouse (Mohammadnazari and Ghannadpour, 2021). The research uses multi-criteria decision-making methodologies to choose the best site for the warehouse. In order to order the right amount for the project site while taking the auxiliary warehouse into account, the research develops a mathematical model. A numerical example is given to demonstrate the model's usefulness. The findings show that incorporating uncertainty into decision-making enhances it and can raise confidence levels.

This study proposes a two-tiered multi-programming problem-based paradigm for two-tier supply chain firms working in an unpredictable environment (Jin et al., 2018). Interval numbers and anticipated values based on Me manage undetermined coefficients in the objective function and constraints. A stochastic-based robust optimization approach is devised to produce a solution resistant to uncertainty. An interactive fuzzy programming methodology paired with the NSGA-II multi-objective algorithm is suggested as the solution approach for the challenging and nonlinear bi-level multi-follower model. An application to the Urban Construction Group contractor and its subcontractors illustrates the suggested model's viability and effectiveness. Furthermore included is the sensitivity analysis to changes in key parameters. More realistic than earlier research, the model accounts for uncertainties in green construction options' price, length, and carbon emissions.

A sustainable supply chain management (SCM) model for phosphorus (P) fertilizer, a crucial component of inorganic fertilizers used in agriculture, is presented in this paper (Shokouhifar et al., 2023). The multi-product and multi-objective model considers issues with the economy and the environment. An ensemble heuristic-metaheuristic method called H-WOA-VNS, which combines the benefits of a problem-dependent heuristic, the whale optimization algorithm, and a variable neighborhood search, is presented to manage the complexity of the model. The algorithm maximizes agricultural output and P usage efficiency while minimizing overall economic costs. The experimental study's findings on a genuine case study of the P-fertilizers supply chain attest to the suggested strategy's usefulness for raising crop yields.

Companies now understand that establishing and preserving a sustainable competitive edge is essential for surviving today's dynamic environment. The paper suggests a multi-level, multi-commodity, multi-period, and multi-objective mathematical model to achieve this goal (Mehri Charvadeh et al., 2022). The model, which focuses on closed-loop supply chains for cellulosic-based goods at all levels, contains three levels in the reverse direction and five in the forward route, including corrugated board and paper. The quality of returned goods in the reverse supply chain is also considered with its effect on product collection and recycling. The study finds that transportation expenses significantly influence the number of distribution centers built. The number of centers specifically rises directly to an increase in transportation costs, up to a threshold at which the number of centers stabilizes. On the other hand, at a certain point, lowering transportation costs does not significantly reduce the number of developed centers.

The energy sector is facing difficulties due to environmental issues with coal use and resource depletion. The management of the coal supply chain must be made more effective in order to lower the cost of coal mining and maximize the long-term use of mined coal. In order to increase the sustainability of the coal supply chain, this research suggests a mathematical model that accounts for the price of energy destruction, commonly known as entropy. The model is created using exergy analysis in the suggested technique, and it is then successfully solved using a genetic algorithm (Naderi et al., 2021). Numerical examples of coal supply chains are shown and examined to show the suggested technique's effectiveness and highlight the advantages of the proposed energetic coal supply chain model over other models. According to the findings, the suggested strategy can reduce the energy utilized by 17.6% while only causing an expense increase of 2.7%. This methodology may be applied to new projects and ongoing operations to increase the sustainability of coal supply chains.

This thesis offers a two-stage strategy combining debris management operations with a sustainability framework to control catastrophe debris (Habib et al., 2018). The first step, which comprises debris quantification, interim disaster debris management site selection, and debris allocation, addresses the immediate environmental and health hazards provided by disaster debris in impacted areas. A debris allocation optimization model that uses fuzzy probabilistic programming to allocate debris is used. The United States Army Corps of Engineers (USACE) debris estimation model is used for debris estimate. In contrast, the analytical network process (ANP) and fuzzy methodology for order of preference by similarity to the ideal solution are used for site selection (TOPSIS). The framework's second stage discusses the long-term effects of trash processing methods on the neighborhood from social, environmental, and economic sustainability viewpoints. A supply chain optimization model for processing trash is put out that considers social, environmental, and economic factors. Given the ambiguous catastrophe scenario, a robust possibilistic programming (RPP) based approach provides optimal compromise solutions for the suggested optimization model. A modified version of the weighted Werners technique is also included in the thesis to transform the multi-objective model into a single-objective model. For both stages, numerical examples show how the suggested structure works. The numerical outcomes show that the suggested structure can result in a long-lasting catastrophe debris management system.

The study described in this paper aims to develop a five-level supply chain network, which consists of donors, hospitals, mobile and stationary blood collection sites, regional blood centers, and blood centers, to optimize the sustainable humanitarian supply chain of blood products in Tehran (Khodaverdi et al., 2022). Connecting blood donors with individuals who need blood, reducing waste and corruption of blood products, and keeping prices down are all goals of managing the blood supply chain. The suggested model is a mixed integer linear programming optimization model considering social, environmental, and economic goals. The model is built into a robust optimization model since blood supply, demand, and cost factors are variable and random. The multi-objective issue is reduced to a single-objective problem using the-constraint approach. The model is GAMS-coded, and the CPLEX solver resolves it. The findings demonstrate that the robust model reduces supply, demand, and cost uncertainties. At = 100, the supply network costs 51,746, and the supply chain is reliable in all earthquake scenarios with zero unmet blood demand. The paper closes with recommendations for additional research and practical ramifications.

Supply chain design must consider the effects of manufacturing processes on the environment and employ ways to improve sustainability to comply with environmental standards. Yet, striking a balance between operational effectiveness and environmental sustainability may be challenging, including strategic and operational factors. The difficulty is in allocating the production budget in a way that assures both operational effectiveness and sustainability. A brand-new mathematical model with a quadratic goal function and primarily linear restrictions is suggested to solve the issue. This study offers a thorough analysis of this problem, emphasizing lowering CO_2 emissions from supply chain manufacturing and transportation (Caramia and Stecca, 2022). The budget designated for green investments is represented by a quadratic constraint in the model, which is influenced by the complexity brought about by huge production flows. A multi-start technique based on sequential linear approximations is developed to solve this problem. The computational outcomes demonstrate the viability of our suggestion.

An important area of the current study on green supply chain management systems is how to encourage cooperative development between businesses and the environment in resource limitations and environmental constraints (He, 2021). Performance evaluation is crucial to comprehend how the green supply chain functions, identify its flaws and pinpoint areas that need development. The theory of sustainable supply chain management and its performance evaluation system are discussed, along with the relative weights of each index using a sustainability calculation approach. This study also analyzes the research state of sustainable supply chain management in various nations. The performance of the sustainable supply chain is evaluated using a fuzzy comprehensive assessment approach and a decentralization degree of the index. The report also analyzes a case study and assesses the economic, social, and environmental performance of the green supply chain component. The assessment algorithm is examined based on the sustainable calculation approach, and good businesses are chosen as examples. The findings show that a thorough analysis of the enterprise performance of green supply chain management and sustainable algorithm research may spot possible issues with a business's operations and enhance them overall.

It is necessary to solve the problem of electric grid power consumption burden if smart cities are to have a sustainable and ecologically friendly ecology. Consumption load, supply, and the availability of electricity to providers and customers must all be considered while designing a smart city power grid infrastructure. To achieve this equilibrium, a well-designed supply chain management system is suggested for deployment in the Smart City of Athens, Greece (Anagnostopoulos et al.). The technique is based on information about the amount of electricity consumed each week for a year. This study focuses on the Independent Power Transmission Operator (ITPO) of Greece's electric load forecast as part of an Energy Management System (EMS). Based on stochastic data of electric energy consumption load, the research suggests employing a machine learning second-order exponential smoothing technique to forecast future electric power demand or supply. The algorithm's ability to estimate future power consumption load offers a potential parameter for projecting the demand for electric power in future smart cities. The system is assessed using the Normalized Root Mean Square Error (NRMSE) assessment measure, ensuring it can forecast future electric power consumption demand in smart cities.

The basic objective of a supply chain is to choose the best suppliers for consumers while considering variables like cost, time, and risk. Supply chain management (SCM), which many businesses rely on to deliver their goods, is made more effective via optimization techniques (Alkahtani, 2022b). In order to improve the effectiveness of SCM analysis, the projected stochastic gradient (PSG) approach is suggested in this work. The PSG technique provides several benefits, including strong sequence convergence to the singular optimum with probability one and a weakly convergent sequence of iterates to a minimizer in the convex case. The profit, stock, and demand of various items were examined using the SCM dataset in order to gauge the success of the technique. The PSG technique also considers holding expenses when determining the company's profit. The PSG technique also has the benefit of being able to estimate demand, which may boost profitability even further.

The supply chain and logistics management (SCLM) of a business called ITE is the subject of this essay. By examining the possibilities of IoT technology and ITE's current SCLM expertise, the article suggests an economic analysis methodology for IoT-based SCLM. The suggested model is verified using detailed data from ITE, and process analysis is used to carry out additional optimization. The findings show that by including information groups, the suggested economic analysis model may efficiently optimize the interests of businesses and reduce the supply chain process. Also, the newly developed IoT-based technique decreases average waiting times (AWT) and vehicle AQT by roughly 7 and 4 times, respectively. This study optimizes the interaction between customers and suppliers, improves the core competitiveness of ITE, and considerably increases the collaboration efficiency of multiple departments by implementing IoT technology in SCLM (Xie and Chen, 2022). The research presented in this study has significant implications for encouraging China's small and micro equipment businesses to grow.

Supply chain management (SCM) is becoming increasingly crucial in many economic contexts. Blockchain technology offers a viable secure information sharing (IS) option in SCM. Private and public-key cryptography are frequently selected because maintaining security at all levels of the blockchain is essential. This research intends to include "Modified Data Sanitization and Data Restoration" with an ideal key generation approach to secure sensitive data in each block, enhancing the security and privacy of "blockchain-assisted supply chain management (SCM)". The most difficult part of maintaining data transfer security is choosing the best key. The best key is produced in both phases using the proposed hybridized algorithm, Whale Updated Butterfly Optimization (WU-BO). The Butterfly Optimization Algorithm (BOA) and Whale Optimization Algorithm are conceptually combined in the WU-BO model (WOA). Lastly, a test is run to confirm the viability of the suggested model (Kalyani et al., 2022).

The management of the supply chain for fresh products must include partner selection. While important, environmental protection is frequently disregarded in conventional supplier selection techniques. This study aims to create the best mathematical model possible for choosing green business partners based on four factors: price, product quality, green assessment score, and timing. A multi-objective evolutionary algorithm utilizing the weighted sum approach is suggested to find the ideal solutions (Chen and Chen, 2022). The model also includes a supply chain network topology to examine the typical Pareto-optimal solutions with the evolutionary algorithm for the four issues. The findings reveal a discernible variance between the second and third criteria and the first and fourth criteria, demonstrating that the second and third criteria have a major impact on the performance of the new product supply chain network.

Artificial intelligence (AI) and nature-inspired optimization (NIO) techniques can be applied to lessen the effects of supply chain interruptions. These days, AI is a highly sought-after tool that may be used to improve inventory management and the robustness of the supply chain. The purpose of this study is to give an overview of several key areas of the supply chain where AI can be used, among other things, to improve the adaptability of optimization techniques inspired by nature, guarantee prompt delivery to the destination, and provide customized solutions to the stakeholders involved in both upstream and downstream supply chains (Jain et al., 2022). The core AI-based supply chain and inventory management models have been defined to show the subject's present state. It has also been underlined that AI and NIO may help with just-in-time product availability, delivery process optimization, and future possibilities.

Big data has become a significant asset for many firms due to its increasing demand as data technologies grow. Large amounts of organized and unstructured data that are too difficult to manage using conventional database and scheduling techniques are called "big data" (Nath et al., 2022). Due to its increasing complexity, the supply chain (SC) is crucial to big data. Meta-heuristic techniques and Big Data Analytics must be used to produce dynamic supply chain risk forecasts. The notion of big data and its different sources are introduced in this chapter, along with background research. Also, it covers data processing and analytics, supply chain management concerning agriculture, and the several difficulties that might be encountered in this area.

3.2. Multi-objective optimization

To satisfy consumer demands, the industry is increasingly moving toward automation to increase production rates and guarantee product quality quickly. Nonetheless, this pattern has led to a rise in energy demand, stressing the need for sustainable development regulations to stop developed nations from using more energy. Also, the substantial problem of global warming brought on by greenhouse gas emissions has prompted a growth in the usage of renewable energies, such as solar energy, in recent years to offset energy consumption and lessen the industrial sector's carbon imprint. This essay focuses on the supply chain management of the auto component manufacturing sector, where quantity production optimization with numerous goals is considered. The main goals are to use renewable energy sources to reduce energy expenses, reduce carbon footprint, and lower total production costs. The research analyzes the issue in which providers manage and control operations to outsource goods of subpar quality (Sarkar et al., 2018). The suggested mathematical model, which incorporates sustainable suppliers, is solved using a weighted goal programming approach. Sensitivity analysis is carried out for various energy use scenarios. The findings demonstrate that the suggested approach may reduce carbon emissions while lowering production costs, offering the automotive sector a workable answer. The results also imply that the model may be used to achieve sustainability in the context of a supply chain, taking into account both producers and suppliers.

The innovative method for managing many items with multiple objectives that this study suggests integrates green investments to support environmental sustainability (Ahmadini et al., 2021). The suggested model is written as a multi-objective fractional programming problem with four goals: maximization of profit as a percentage of total back-ordered quantity, minimization of holding costs, reduction of total waste produced by the inventory system per cycle, and minimization of total penalty costs associated with the green investment. Budget constraints, space restrictions, ordering costs for each item, environmental waste disposal restrictions, pollution control expenses, power consumption costs during manufacturing, and greenhouse gas emissions are all factors that must be considered. The numerical study shows how successful the suggested model is and offers helpful recommendations for manufacturing industry decision-makers.

The optimization approach for municipal solid waste treatment that this study suggests makes sustainability a top priority. The model integrates pretreatment drying technologies to increase calorific waste value and considers the capacity selection of MSW technologies across various locations. Binary and continuous variables are used in the optimization problem to specify the options for MSW technologies and network operations (Saif et al., 2022). The MSW network's economic goal is to maximize net present value (NPV) while reducing the environmental effects of using MSW technologies and transportation. Maximizing employment creation is the societal goal. The research discovers conflicts between the many sustainability objectives, and therefore it offers a compromise utilizing Pareto, optimum solutions from the multi-objective optimization model.

Optimization-based inventory and supply chain management under uncertainty may give organizations a major competitive edge. This can be done by utilizing stochastic or resilient formulations, which need precise definitions of unknown parameters, or by employing deterministic online optimization, which recalculates SCM choices regularly based on new system information. This paper undertakes a thorough numerical examination of several formulations for inventory production and distribution planning under unknown customer demand in the setting of multi-echelon, multiperiod supply chains to compare these methods' performance (Lejarza et al., 2022). The findings suggest that when compared to stochastic and robust optimization formulations, deterministic online optimization based on feedback control delivers superior computational and economic performance.

Manufacturers must optimize a product's life cycle to fulfill circular economy standards and earn a competitive edge. Production, distribution, and field service operations must be coordinated to accomplish sustainability objectives. There are not many PSS solutions available for optimizing supply chain management, even though the product-service system (PSS) approach is one of the most promising business models for effectively addressing the demands of producers and customers. This paper suggests a solution to fill this gap by combining the PSS Functional Matrix, the Screening Life Cycle Modeling (SLCM) technique, and stock management theory to improve aftermarket services based on customer demand (Fargnoli et al., 2022). A case analysis in the study's section on the medical equipment industry shows the advantages of the suggested technique in terms of costs and environmental effects. In particular, the PSS strategy enabled the firm to modify the manufacturer's business model and provide aftermarket services to accommodate changing client demands throughout the contract. The findings point to more studies on PSS and supply chain management.

Municipal Solid Waste's (MSW) negative environmental consequences, such as sludge waste, acid compounds, and carbon dioxide, have received much attention lately. This study suggests a supply chain model that uses two kinds of power plants: biogas, incineration, and a trash collecting center and a separation center spread over several metropolitan areas. Transportation planning is used to collect the MSW, which is then transported to the collection/separation center and processed according to humidity levels, with dry trash going to the incinerator facility and wet garbage going to the biogas center. Eventually, the trash is turned into power and distributed for sale (Abbasi et al., 2022). A case study of 11 Tehran, Iran, districts determined the best economic and environmental advantages. A hybrid technique (GAs + Gams) can be employed for bigger scenarios. A sensitivity analysis was conducted to reduce the negative environmental consequences and increase the beneficial economic effects. The findings revealed that sewage sludge and carbon dioxide had much lower positive effects than acid chemicals. However, the power plants' running expenses did not affect the supply chain's economic goals.

3.3. Fuzzy multi-objective and linear programming

A rising area of study is the use of the internet to alter supply chain interactions, sometimes referred to as e-supply chain management or e-business-enabled supply chain. The study on the environmental lifetime impact of e-commerce is expanded upon in this work and applied to the sustainable management of e-supply chains for electronic devices (Luo et al., 2001). Developing an integrated network structure considers information and material movement across the supply chain, product demanufacturing, and material and component reuse. Several criteria that describe economic, technical, and environmental challenges are represented and optimized using fuzzy logic to manage data ambiguity and information shortages. A fuzzy multi-objective optimization approach is presented to balance supply chain factors, e-business strategies, and environmental performance. Discrete event system simulation approaches are used to examine the stochastic behavior of the ideal network and supply chain performance. A case study is presented to model and improve the e-supply chain management for desktop personal computers.

The paper proposes a mathematical model incorporating cost and environmental variables in the battle between four supply chain echelons and several goods (Ehtesham Rasi, 2022). The goal is to develop a bi-objective model that employs metaheuristic methods to optimize the SSC network's architecture. In order to broaden the scope of the rivalry amongst supply chains, discrete choice modeling is utilized to account for the diverse customer choices regarding cost and environmental effects. The suggested model is solved using two metaheuristic algorithms, NSGAII and MOPSO. A real-world case study is utilized to demonstrate the proposed model's applicability to the supply chain network of the American corporation. The research concludes that, despite NSGA-II having a faster calculation time, the MOPSO method is typically more effective than NSGAII in performance measures like MID, SM, QM, and DM.

This essay thoroughly examines the use of formulas from linear programming to optimize transportation issues. The suggested approach aims to swiftly and effectively arrive at the best solutions for transportation issues. This optimization method can obtain the optimal solution without requiring iterative techniques like chain reactions or simplex transportation algorithms by appropriately modifying the original basic viable solution (Putcha et al., 2021). This optimization approach has the potential to be extremely helpful in tackling large-scale optimization problems in a variety of domains, including supply chain management, green engineering, and smart manufacturing, even if the current implementation is restricted to small-scale issues. Certain transportation-related examples are provided to show the usefulness of the suggested method. Several fields, including but not limited to Industrial and Mechanical Engineering, can benefit greatly from these ideas.

Currently, discarded plastics and municipal solid trash are considered environmental hazards. The two main disposal techniques are the revalorization and recycling (Amorim Leandro De Castro Amoedo et al., 2021). However, it needs to be clarified which is superior. Yet, it has been established that waste logistics are economically significant. This project aims to assess if using electric rubbish-collecting vehicles for the collection and transportation of waste is feasible. Linear programming using mixed integers is used to formulate the issue. Based on economic and environmental factors, the outcomes are evaluated and rated, offering guidance for decision-making. The system is improved by using an electric fleet, with logistics costing between 37% and 80% of the entire cost. Integrating an electric fleet results in a payback period of fewer than five years and considerably lower operational expenses—also, a 30% reduction in logistics impact on environmental indices. Solutions with less environmental impact are more reliable, according to a sensitivity analysis of the power price.

Due to a lack of highly trained people and technological resources, particularly regarding outsourcing, production companies need help managing their supply chains. The right degree, quantity, quality, and pricing must be chosen, among other strategic considerations, while outsourcing. While outsourcing might reduce the need for capital expenditure, it can also raise serious issues with production management and inventory control, resulting in more inventories. Semi-finished goods are frequently outsourced for specific processes to solve these problems before being returned to the manufacturer for finishing operations. This article suggests a mathematical model for supply chain management process outsourcing optimization to reduce overall costs while considering variable quantities and defective manufacturing (Alkahtani, 2022a). Using data from the industry, the suggested model was evaluated, and the findings were significant in determining the ideal production and outsourcing volumes. A sensitivity analysis was also conducted to ascertain how input factors affect overall expenses. The study significantly contributes to developing a mathematical model for process outsourcing in supply chain management. It can assist managers in determining whether outsourcing inventory management and supply chain management between manufacturers and outsourcing vendors is economically feasible.

Supply chain management is essential in reducing the strain of competition. The competitive landscape and customer image have recently changed, with an increased emphasis on environmental issues. As a result, choosing green suppliers is now a pressing concern. The difficulty of choosing green suppliers based on flexibility, robustness, environmental sensitivity, leanness, and sustainability is discussed in this study. Green and traditional supplier selection have different criteria for evaluating environmental factors, such as recycling applications, environmental applications, carbon footprint, and water usage (Alshammari et al., 2022). A method based on the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) approach, incorporated in the spherical linear Diophantine fuzzy sets (SLDFSs) technique, is offered as a solution to this issue—background information on SLDF sets and a clear explanation of the various operations on SLDFSs. Based on the multicriteria decision-making (MCDM) strategy, which has applications in many different sectors, the suggested hybrid TOPSIS approach was developed. The SLDFS and TOPSIS methods are combined to lessen the effects of instability and ambiguity since the fuzzy methodology must be utilized to handle linguistic criteria and the incapacity to evaluate all criteria. Using the spherical linear Diophantine fuzzy TOPSIS technique is made possible by the ease with which decision-makers and criteria may be evaluated. This hybrid approach, which may be used for related problems, is very effective in identifying the best provider among the alternatives based on the standards established by order of significance.

3.4. Machine learning methods

Supply Chain Management (SCM) researchers, managers, and CEOs notice how important sustainable cooperation in SCM has become too corporate performance. However, making choices on SCM sustainable collaboration has proven difficult for SCM managers and CEOs due to the need for a control model and rules. In this work, decision tree algorithms (DTA) were utilized to create a control model for SCM sustainable cooperation, including benchmarks such as logistic regression analysis (LRA) and multivariate determinate analysis (MDA) (Lim, 2006). The three models examined the performance of predicting SCM sustainable cooperation, and DTA was the most successful. The study offered insightful data on the determinants of sustainable SCM collaboration in manufacturing and distribution businesses.

Artificial neural networks (ANN) are frequently used by businesses to enhance forecasting. Several methods have been devised to improve results, including using various algorithms, selecting and evaluating input attributes, and modifying the input case through instance selection. In order to overcome forecasting difficulties in Supply Chain Management (SCM) sustainable collaboration, this study uses ANN. In the study (Lim and Hahn, 2005), the effectiveness of four distinct ANN models – COANN (Conventional ANN), FWANN (ANN with Feature Weighting), FSANN (ANN with Feature Selection), and HYANN – in forecasting SCM sustainable cooperation is compared (Hybrid ANN with Feature Weighting and Feature Selection). According to the study, HYANN produces the best precise forecasts for SCM sustainable collaboration.

This research suggests a novel method for optimizing deep learning neural networks using the particle swarm optimization (PSO) algorithm to increase business decision assessment models' precision and convergence rate (Chen and Du, 2022). The current conventional neural network-based approach has drawbacks regarding convergence and matching the best solutions. Combining normal distribution attenuation with the inertia weight strategy to create the normal distribution decay inertial weight particle swarm optimization (NDPSO) technique, the suggested method comprises adjustments to the model parameter settings. The experimental investigation using two test functions confirmed that the NDPSO algorithm maintains a big step size in the early stages and a small one in the latter stages. The experimental findings demonstrated that the NDPSO algorithm outperformed other algorithms optimized on the Sphere function regarding the minimal value, average value, and standard deviation. This suggests quicker convergence and precise solutions may be achieved by enhancing global search and local development capabilities with the normal distribution decay inertia weight.

Lending effect analysis must consider a client's financial situation and risk-evaluation methods, especially in today's complicated and dynamic world. The ability of the borrower to pay interest and the principal amount is considered by the conventional lender when evaluating the threat. Nevertheless, issues with data storage and retrieval, delays brought on by a lack of timely access to pertinent data, shipment delays, and customer demands for faster delivery present difficulties in lenders' threat assessments. With credit risk frameworks that mainly rely on modeling machine learning, this study suggests a machine learning-based linear regression method (ML-LRA) for supplier credit risk (SCR) assessment based on supply chain management (SCM) (Wei et al., 2022). A distribution forecasting tool may evaluate certain judgments based on assumptions in variability, and logistic constraints in regression models can mimic the effects of numerous factors on a customer's creditworthiness. The study concludes that the ML-LR technique is crucial for selecting suppliers, predicting risks, and estimating demand and sales. The report also identifies the biggest limitations and challenges to improving the supply chain management system and guaranteeing the entire system's sustainability.

3.5. Applications

Long-term agreements between the participants in the supply chain are used in energy supply chain management (ESCM) to guarantee a consistent energy supply and lower prices. Environmental laws and uncertainty are two significant societal challenges that this complicated topic must address. Eco-friendly management has become more important as environmental restrictions become more stringent globally. As a result, energy purchasers today must consider operational costs and carbon emissions. Emergency procurement has become a standard technique due to the ESCM process being disturbed by unforeseen events like pandemics and conflicts. The authors created an optimization model utilizing mixed-integer linear programming for ESCM with supplier selection challenges during emergency procurement to address these problems (Noh and Hwang, 2023). The model considers a single thermal power plant and several sources of fossil fuels. To control uncertainty, they utilized the rolling horizon method (RHM), a well-known technique for resolving deterministic issues in mathematical programming models. To evaluate the model and RHM, they ran three numerical experiments. Initially, they looked at replenishment plans and timetables for an unknown demand. Second, they ran a supplier selection experiment while working under a tight budget and carbon emission guidelines. Our examination of the sensitivity of carbon emission restrictions was the last step. Our findings demonstrate how our RHM manages ESCM under ambiguous conditions.

Through reducing resource waste and boosting service quality, this research seeks to enhance supply chain inventory management and assist green supply chain management. The research starts by looking at the important green and intelligent supply chain technologies from the standpoint of the ecological environment. For the prediction of inventory management, a novel model known as IPSO-BPNN that combines a backpropagation neural network (BPNN) with an enhanced particle swarm optimization (IPSO) method is developed (Guan et al., 2022). Finally, the performance of the particle swarm optimization (PSO) method is enhanced, making it more efficient for BPNN learning and training. The performance of the combination model is simulated, and the simulation results are examined to determine the model's future applications. Findings show that training with a single BPNN model leads to significant errors. The IPSO-BPNN model, on the other hand, performs better and has a reduced error rate. The training and test set classification error rates for the improved model are 1.51 and 2.16, respectively. Furthermore, when the number of concealed nodes is 11, the daily and monthly measurement model errors are minimal. The 6-11-1 suggested network topology for the combination model is found. The prediction module created in this study offers ideas for buy volume and inventory volume, which can help with the environmentally friendly growth of inventory management.

The growing interest in low-carbon economies prioritizing sustainable growth, low energy consumption, and low pollution is a result of worldwide attention to environmental challenges. As a result, supply chain management faces new difficulties and possibilities. Each node firm should work toward a balance between profits and environmental benefits through green supply chain management to maintain economic and environmental compatibility in the supply chain. This research examines three green supply chain models using the conversion of businesses to green practices as a starting point (Li and Zhou, 2022). A green supply chain model is suggested for manufacturers and retailers by considering several eco-friendly objectives. The research examines the effects of manufacturers' and retailers' environmental choices on the supply chain system. The bi-objective model demonstrates that when the manufacturer's environmental preference is 1, a supply chain profit of up to 1901 may be realized, suggesting the potential for simultaneous optimization of the profit and environmental aims. The findings of this research imply that green supply chain optimization is feasible.

This study aims to identify the ideal electric power mix for an electric power market network while considering the environment (Sun et al., 2022). Increasing the Green Energy Coefficient (GEC), which measures the proportion of renewable energy generation, is the current emphasis of the electric power market. Many studies have examined various aspects of the power market, such as the growth of power generating systems, consumer distribution of electric power purchases, and pricing configuration. In integrating renewable energy, this study suggests stochastic programming optimization models for the electrical supply chain. In order to fulfill the total demand for each period, a multistage stochastic supply balance model is created and solved. This accounts for the intermittent nature of renewable energy sources. A case study is undertaken to show how the model may be used to support an electrical supply chain management strategy.

In order to get around the drawbacks of conventional energy supply systems, this study aims to optimize management techniques for energy supply chains in oil and gas firms (Sun and He, 2022). Backpropagation neural networks are used in oil and gas firms to estimate energy supply and provide early warning of energy security in order to achieve this. An auxiliary cognitive system, which forecasts the peak value of the oil and gas supply, is created to support the security early warning system. Neural networks create a thorough evaluation model for the security management of the oil and gas supply chains. Several models' performance in terms of detection and data security transfer is examined and compared. The accuracy of the upgraded BPNN model method is determined to be 5.4% higher than that of the CNN.

The symmetric encryption (SM)-254 method enhances the cloud system's security capabilities and solves concerns about data loss and privacy violations by hackers while computing occurs. The management system of a supply chain firm is automated using a backpropagation neural network (BPNN) algorithm based on the organizational structure of each department. An accurate people identification system is produced by this automation, with text and picture recognition accuracy reaching roughly 92%. This automated approach has advantages for businesses, such as time, money, staff savings, flexibility, and simplified personnel management (Junhui, 2022). Moreover, it helps businesses create a thorough HR database, increase operational effectiveness, and use their talent pool best. The danger of information leaking in the HR database is further decreased by the cloud system's improved security algorithm. An overview of the most recent and comment-published papers is presented in Table 1.

4. Insights from previous literature reviews

Insights from previous literature reviews of "metaheuristics for optimized, sustainable supply chain management" can include:

- Metaheuristics have been widely applied to solve the optimization problem in sustainable supply chain management due to the complexity and combinatorial nature of the problem. Metaheuristics algorithms such as genetic algorithms, simulated annealing, ant colony optimization, and particle swarm optimization have been used to optimize various aspects of the supply chain, including supplier selection, inventory management, and transportation routing.
- Multi-objective optimization is an important area of research in sustainable supply chain management, where the objective is to optimize multiple conflicting objectives simultaneously, such as minimizing cost and environmental impact, while maximizing social benefits. Metaheuristics algorithms have been used to solve multi-objective optimization problems in sustainable supply chain management.
- The integration of sustainability metrics into the supply chain optimization problem has been challenging, as there is often a trade-off between economic, environmental, and social objectives. However, several studies have proposed novel approaches to integrate sustainability metrics into the objective function of the optimization problem, such as carbon emissions, water usage, and social responsibility.
- The use of big data analytics and machine learning algorithms has the potential to improve the sustainability and efficiency of the supply chain by providing real-time data and predictive analytics to support decision-making. Metaheuristics algorithms can be combined with big data analytics and machine learning to optimize the supply chain and improve sustainability performance.
- Collaboration and cooperation between supply chain partners are critical for achieving sustainability objectives. Metaheuristics algorithms can model and optimize collaborative supply chain networks that achieve joint economic, environmental, and social performance objectives.

5. Future insights and potential solutions in metaheuristics for sustainable supply chain management

Revolutionizing sustainable supply chain management using metaheuristics is a research paper that provides insights into the application of metaheuristics in sustainable supply chain management. Metaheuristics are optimization techniques that can solve complex problems in various domains, including supply chain management. The paper highlights the potential of metaheuristics to enhance sustainability and efficiency in supply chain management.

- Future Insights
    1. Integration with Emerging Technologies: With the advent of emerging technologies like IoT, blockchain, and AI, there is a significant potential for the integration of these technologies with metaheuristics. This integration can further enhance the capabilities of metaheuristics in solving complex supply chain problems.
    2. Optimization of Complex Supply Chains: Metaheuristics can optimize complex supply chains involving multiple tiers and stakeholders. In the future, metaheuristics can be extended to solve supply chain problems across different industries, including food, healthcare, and manufacturing.

Table 1
An overview of the most recent and comment published papers.

Year	Reference	Method	Application
2018	Sarkar et al. (2018)	A multi-objective optimization	Energy, economic, and carbon emission
2018	Jin et al. (2018)	Longitudinal cooperative optimization	sustainable supply chain management
2019	Pavlov et al. (2019)	Optimization of network redundancy	Sustainable and resilient supply chain resource management
2021	Ahmadini et al. (2021)	Multi-objective optimization	Inventory and production management
2021	Mohammadnazari and Ghannadpour (2021)	Optimization methods under uncertainty	Sustainable construction with the spotlight of inventory
2022	Guan et al. (2022)	Artificial Intelligence based PSO optimization	Inventory Management Optimization of Green Supply Chain
2022	Wei et al. (2022)	A machine learning algorithm	Supplier Credit Risk Assessment
2022	Nath et al. (2022)	Big Data and metaheuristic strategies	Supply Chain Management
2022	Jain et al. (2022)	Artificial Intelligence based nature-inspired optimization	Inventory and Supply Chain Management
2022	Chen and Chen (2022)	Genetic algorithm	Analysis and modeling of fresh products
2022	Alshammari et al. (2022)	Spherical linear Diophantine fuzzy algorithm	Green supply chain management system
2022	Abbasi et al. (2022)	A multi-objective optimization approach	Incineration and biogas waste-to-energy supply chain
2022	Kalyani et al. (2022)	A hybrid optimization algorithm	Secured information sharing in supply chain management
2022	Chen and Du (2022)	Particle swarm optimization algorithm integrated with deep learning	Dynamic relationship network and international management of enterprise
2022	Fargnoli et al. (2022)	The product–service system	Foster the optimization of supply chain management
2022	Xie and Chen (2022)	IoT-based economic logistics model	Supply chain and logistics management for international enterprises
2022	Alkahtani (2022a)	Mathematical Modeling of Inventory and Process Outsourcing	Optimization of Supply Chain Management
2022	Asha et al. (2022)	Optimization approaches	Sustainable green supply chain management
2023	Noh and Hwang (2023)	Optimization Model	Energy Supply Chain Management in Emergency Procurement

3. Big Data Analytics: With the increasing amount of data being generated in supply chains, the use of big data analytics can help provide valuable insights into supply chain operations. Using metaheuristics in conjunction with big data analytics can enhance the efficiency and sustainability of supply chain operations.

- Potential Solutions

1. Development of Customized Metaheuristic Solutions: To achieve sustainable and efficient supply chain operations, it is essential to develop customized metaheuristic solutions to address specific supply chain problems. Developing customized metaheuristic solutions requires a deep understanding of the supply chain domain and the ability to adapt metaheuristic algorithms to specific problems.
2. Collaboration and Co-creation: Collaboration and co-creation between supply chain stakeholders, researchers, and metaheuristic experts can facilitate the development of sustainable supply chain solutions. This collaboration can help identify supply chain problems and design customized metaheuristic solutions to address them.
3. In conclusion, the future of sustainable supply chain management lies in the integration of emerging technologies, optimization of complex supply chains, and big data analytics. Customized metaheuristic solutions, collaboration and co-creation, and adoption of sustainability metrics can be potential solutions for achieving sustainable and efficient supply chain operations.

Adoption of Sustainability Metrics: The adoption of sustainability metrics can help measure supply chain sustainability performance. Metaheuristics can be used to optimize these sustainability metrics, thereby enhancing the sustainability of supply chain operations.

6. Trends in metaheuristics for sustainable supply chain management

The application of metaheuristics for optimized sustainable supply chain management (SSCM) is a rapidly evolving field, and several trends can be identified:

- Integration with emerging technologies: Integrating metaheuristics with emerging technologies, such as blockchain and the Internet of Things (IoT), is a growing trend. These technologies can enhance the ability to track and monitor the sustainability of the supply chain, and new algorithms are being developed to leverage their strengths.
- The use of hybrid algorithms, which combine the strengths of multiple metaheuristics algorithms, is becoming more common. By leveraging the strengths of different algorithms, hybrid algorithms can provide more effective solutions to complex SSCM problems.
- Consideration of multiple objectives: The consideration of multiple objectives, such as economic, environmental, and social factors, is an emerging trend in metaheuristics for SSCM. Multi-objective optimization can enable businesses to find solutions that balance sustainability and profitability.
- Incorporation of uncertainty: The incorporation of uncertainty, such as demand and supply fluctuations, is an important trend in metaheuristics for SSCM. New algorithms are being developed to handle uncertain conditions, providing more robust and flexible solutions.
- Collaboration between stakeholders: Collaboration between stakeholders, such as suppliers, manufacturers, and retailers, is becoming increasingly important in SSCM. New algorithms are being developed that support stakeholder collaboration and communication, enabling more effective supply chain management.

Recent years have seen a substantial increase in interest in sustainable supply chain management (SSCM) as environmental, social, and economic sustainability issues have grown. Researchers and practitioners have used metaheuristics as potent optimization tools to manage supply chains with sustainability objectives. Metaheuristics provide adaptable approaches to addressing problems that can handle challenging and dynamic supply chain problems. We talk about the problems with sustainable supply chain management and look at real-world applications of metaheuristics to solve them.

Problems in Sustainable Supply Chain Management:

- Greenhouse Gas Emissions: Sustainable supply chains require reducing carbon emissions and promoting ecologically friendly

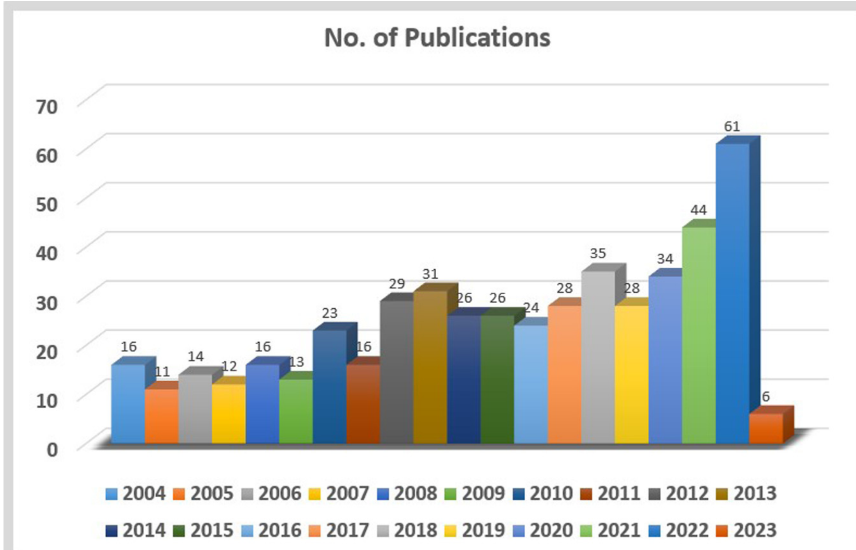

Fig. 1. Number of publications per year.

activities. A challenging issue, however, is how to reduce greenhouse gas emissions while improving supply chain operations. Some of these elements include transportation modes, routing, and inventory management.

- Finding and choosing suppliers who follow sustainable practices is essential for developing sustainable supply chains. Traditional supplier selection techniques frequently ignore critical sustainability variables, including ethical sourcing, labor practices, and environmental impact in favor of focusing only on cost and quality.
- Reverse Logistics and Garbage Management: For supply chains to be sustainable, it is essential to manage product returns, recycling, and garbage disposal effectively. To reduce costs and environmental effects, reverse logistics optimization covers issues such as choosing the best collecting places, routing, and disposal/recycling facilities.
- Energy Consumption Optimization: It is important to balance energy consumption across the supply chain for sustainability. To minimize the total environmental impact, the best choices for production scheduling, transportation routes, and inventory management must consider energy consumption and efficiency.

Overall, the trends in metaheuristics for optimized, sustainable supply chain management suggest a growing focus on the integration of emerging technologies, the use of hybrid algorithms, the consideration of multiple objectives, the incorporation of uncertainty, and the promotion of collaboration between stakeholders. These trends are expected to continue in the coming years as the field of SSCM and metaheuristics evolve and advance.

7. Numbers and facts

This section aims to present quantitative data and statistical information relevant to the paper's topic. This section provides a detailed analysis of the trends, patterns, and dynamics of the sustainable supply chain management field from a quantitative perspective.

In this section, the paper presents data on the current state of sustainability practices in supply chain management, including adopting green supply chain practices, using sustainable technologies, and implementing environmental and social standards. The section may also provide information on sustainable supply chain practices' economic and environmental impact and the potential benefits of optimization in this context.

Moreover, this section may include a comparative analysis of the performance of different supply chain optimization models, highlighting their strengths and limitations in supporting sustainable supply chain management. It may also include statistical analyses of the effectiveness of optimization strategies in improving supply chain performance and reducing environmental impact.

The data shows the number of publications per year from 2004 to 2023, as shown in Fig. 1. The data shows that the number of publications has increased, with a few fluctuations.

In the early years, from 2004 to 2009, the number of publications ranged from 11 to 16, with no clear trend in the data. However, from 2010 to 2021, there is a clear increasing trend, with the number of publications almost doubling from 2010 to 2021. The most significant increase occurred between 2012 and 2013 when publications jumped from 29 to 31.

The trend has continued in recent years, with 35 publications in 2018, 28 in 2019, and 34 in 2020. The number of publications for 2021 was 44, which is a new high, and the trend has continued in 2022 with 61 publications. However, the data for 2023 is incomplete, with only six publications recorded so far.

There are many possible reasons for the increasing trend in the number of publications. It could be due to the growth of the field or the increased availability of research funding. The increasing popularity of open-access publishing and preprint servers may have also contributed to the growth. Furthermore, the availability of new technologies, tools, and resources may have facilitated research and increased the number of publications. Overall, this data shows a positive trend in the number of publications, indicating growth and development in the field.

Fig. 2 shows the number of publications per publisher for a certain period; the selected papers are the most important and recently published papers in this domain. The data shows that Elsevier has the highest number of publications 9, followed closely by Springer and MDPI, with eight publications each. Hindawi and IEEE have 7 and 4 publications, respectively, and Wiley has the lowest number of publications, with 3.

It is important to note that the number of publications does not necessarily indicate the quality of the work published by the respective publishers. However, it can be inferred that Elsevier, Springer, and MDPI are leading publishers in the field, as they have published the highest number of papers in the given period.

Moreover, the data shows that the number of publications is relatively evenly distributed among the publishers, with no one publisher

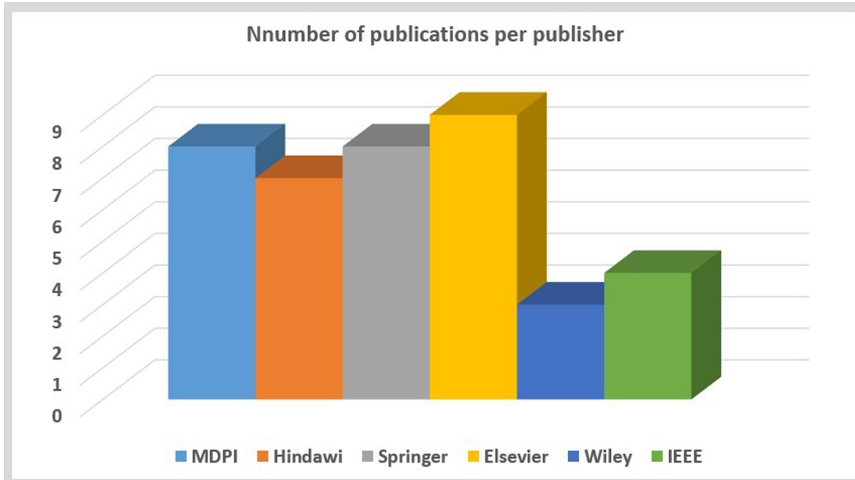

Fig. 2. Number of publications per publisher.

dominating the field. This suggests a healthy level of competition and a diverse range of research being published across various platforms.

It is also worth noting that different publishers may have different focuses, areas of expertise, and target audiences. Researchers may choose to submit their work to a specific publisher based on these factors and other factors such as journal reputation, impact factor, publication speed, and open-access policies.

In summary, the data indicates that Elsevier, Springer, and MDPI are the leading publishers in the number of publications in the given period, with no one publisher dominating the field. However, the number of publications alone does not necessarily reflect the quality or impact of the research, and researchers may choose to submit their work to a specific publisher based on various factors.

In summary, the "Numbers and Facts" section provides a quantitative perspective on sustainable supply chain management, presenting data and statistics to support the arguments and conclusions of the review paper. This section helps readers better understand the impact of optimization in sustainable supply chain management and provides evidence to support the proposed optimization strategies.

8. Vosviewer visualization

This section visualizes the respective Scopus data using the common tool called VOSviewer. Which can be accessed through www.vosviewer.com.

This software program called VOSviewer is used to visualize and analyze bibliometric networks, including co-citation and co-authorship networks. Nees Jan van Eck and Ludo Waltman from Leiden University in the Netherlands created it.

With the tool, you can build network visualizations based on bibliographic information that you may get in places like Scopus and Web of Science. When the data has been put into VOSviewer, you may use a variety of clustering and mapping algorithms to find groups of connected documents or authors and to see the connections between them. Overall, VOSviewer is a powerful tool for visualizing and analyzing bibliometric networks, and it has been widely used in research fields such as science mapping, scientometrics, and bibliometrics.

Fig. 3 shows the map between the Supply Chain Management and other keywords. This domain is connected with other keywords like water, food, sustainability, engineering, etc. Fig. 4 shows the between Supply Chain Management and other domains. This figure clarifies the connection between Supply Chain Management and other domains. Some commonly shared domains are planning, design, carbon emission, biomass, environmental objective, and investments.

Fig. 5 displays the bibliographic among the top 20 authors. Notably, a green-colored cluster consisting of Sarkar, B., Lam, H.L., Guillén-Gosálbez, G., and Pishvaee, M.S. is observed, although other authors may also be involved. This cluster suggests a higher degree of overlap in the reference lists of publications among these authors. Additionally, a red-colored cluster composed of You, F., Kaihara, T., How, B.S., and Shah, N. is apparent, indicating that these authors are likely working on a similar topic (specifically, "sustainable AND supply AND chain AND management AND optimization") and citing the same source in their reference lists.

Fig. 6 illustrates the bibliographic connection between the top 20 most prolific nations. This connection implies that these nations frequently cite the same sources in their published papers. The image shows two separate clusters, one of which is orange (China, Belgium, Taiwan, Poland, Turkey, and others) and the other of which is green (US, Portugal, Spain, Austria, Colombia, and others). Notably, China, Canada, and Farce have thicker links than other nations, indicating that their literary output is more likely to overlap and interact.

9. Conclusion and future works

In conclusion, this review highlights the potential of metaheuristics for optimizing sustainable supply chain management. Integrating sustainable practices into the supply chain is a complex and challenging task that requires the consideration of multiple factors and trade-offs. Metaheuristics offers a promising approach for addressing these challenges, as they provide a means of exploring the solution space intelligently and efficiently. By leveraging the strengths of different metaheuristics algorithms, businesses can improve their supply chain's sustainability while enhancing its efficiency and competitiveness.

The review identifies several key factors that influence the success of using metaheuristics for SSCM, including problem complexity, data quality, and the choice of algorithm. The choice of metaheuristics algorithm should be based on the specific requirements and characteristics of the supply chain problem being addressed, and a thorough analysis of the problem and available data is necessary to ensure the algorithm is appropriately applied.

While using metaheuristics for SSCM is a relatively new area of research, the review suggests significant potential for further development and exploration. Future research should focus on developing more effective and specialized metaheuristics algorithms for SSCM and applying these algorithms to real-world supply chain problems. Integrating sustainability metrics and tools into metaheuristics algorithms could also enhance the ability to measure and monitor the environmental and social impact of the supply chain.

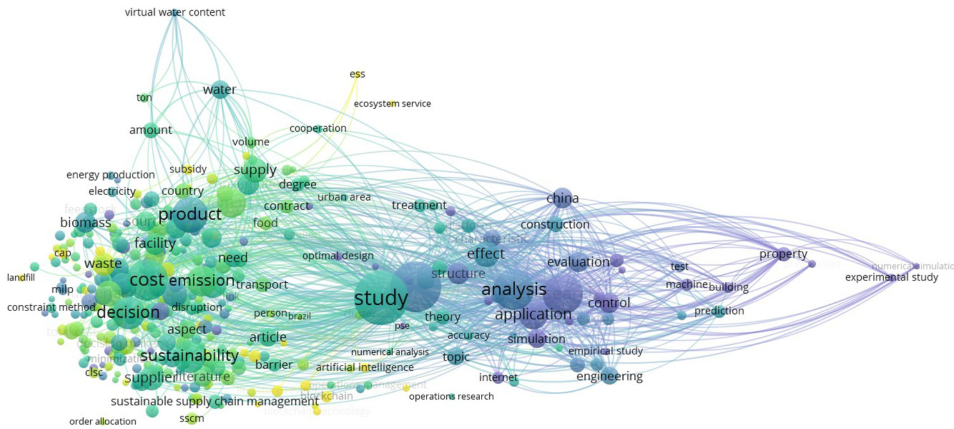

Fig. 3. The map between the Supply Chain Management and other keywords.

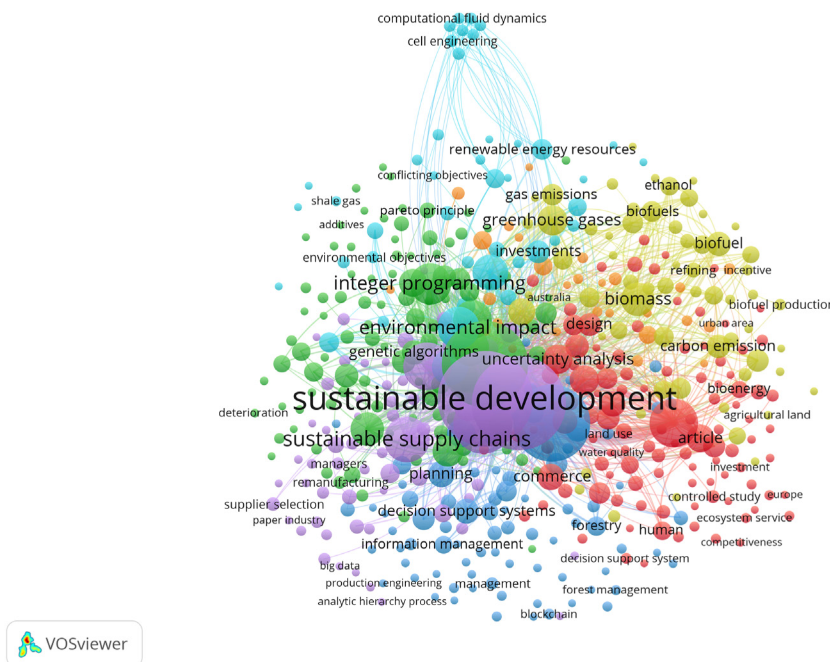

Fig. 4. The map between the Supply Chain Management and other domains.

Overall, the review suggests that using metaheuristics for optimized, sustainable supply chain management can contribute to achieving sustainable development goals and improving supply chain operations' overall sustainability, efficiency, and competitiveness. Based on the review of the application of metaheuristics for optimized sustainable supply chain management (SSCM), several future research directions can be identified:

- Development of more specialized metaheuristics algorithms: While many algorithms can be applied to SSCM, their effectiveness can be limited by the specific characteristics of the supply chain problem being addressed. Future research should focus on developing more specialized algorithms tailored to the specific requirements and constraints of SSCM.
- Integration of sustainability metrics and tools: Integrating sustainability metrics and tools into metaheuristics algorithms can enhance the ability to measure and monitor the environmental and social impact of the supply chain. Future research should focus on developing sustainability metrics and tools that can be integrated into metaheuristics algorithms and their validation and application in real-world SSCM problems.
- Collaboration between stakeholders: The success of SSCM depends on the collaboration and communication between all parties involved in the supply chain, including suppliers, manufacturers, retailers, and customers. Future research should focus on developing metaheuristics algorithms that support stakeholder collaboration and communication and identify best practices for effective collaboration.
- Application to real-world SSCM problems: While using metaheuristics for SSCM shows great promise, there is still limited empirical evidence on their effectiveness in addressing real-world SSCM problems. Future research should focus on applying metaheuristics to real-world SSCM problems and evaluating their effectiveness and impact.
- Integration with emerging technologies: The integration of metaheuristics with emerging technologies, such as blockchain and the Internet of Things (IoT), can enhance the ability to track and monitor the sustainability of the supply chain. Future research should focus on integrating metaheuristics with these emerging technologies and developing new algorithms that can leverage their strengths.

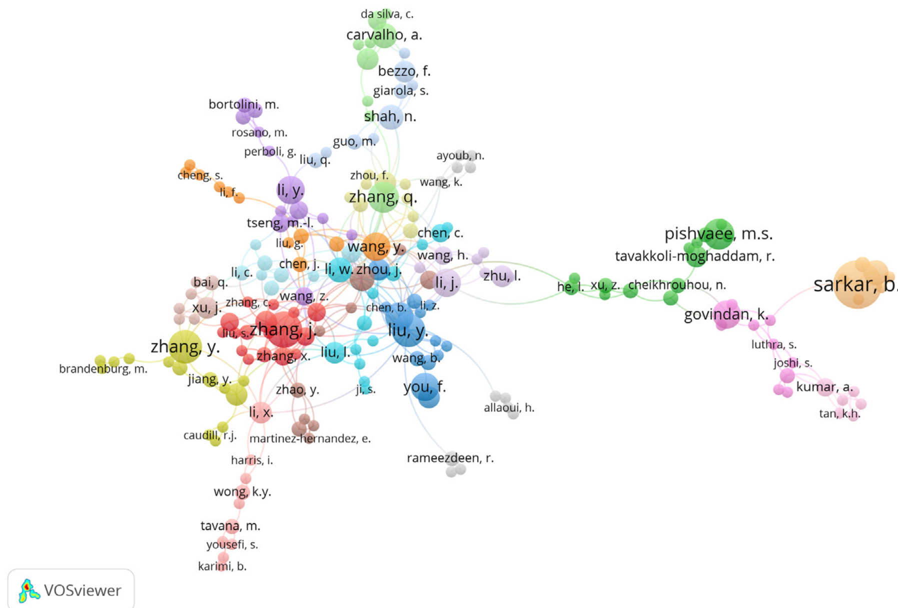

Fig. 5. The relations between the most reputed authors in the Supply Chain Management domain.

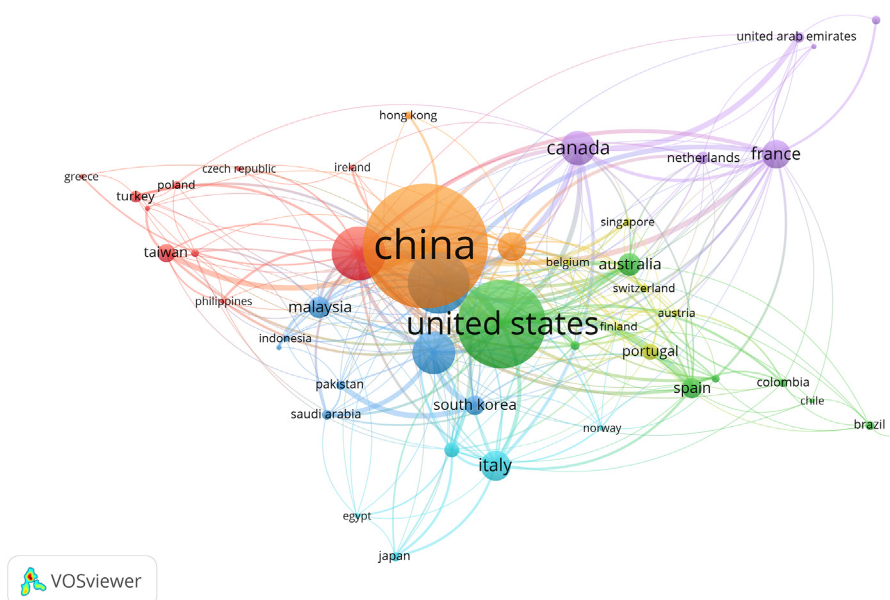

Fig. 6. The map between the institutions/organizations that interested in this domain.

Overall, future research should focus on developing more specialized algorithms, integrating sustainability metrics and tools, promoting collaboration between stakeholders, evaluating effectiveness and impact, and integrating with emerging technologies to enhance the effectiveness of metaheuristics for optimized, sustainable supply chain management.

Ethical approval

This article does not contain any studies with human participants or animals performed by any of the authors.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

References

Abbasi, G., Khoshalhan, F., Hosseininezhad, S.J., 2022. Municipal solid waste management and energy production: A multi-objective optimization approach to incineration and biogas waste-to-energy supply chain. Sustain. Energy Technol. Assess. 54, 102809.

Abualigah, L., Abd Elaziz, M., Sumari, P., Geem, Z.W., Gandomi, A.H., 2022. Reptile search algorithm (RSA): A nature-inspired meta-heuristic optimizer. Expert Syst. Appl. 191, 116158.

Abualigah, L., Diabat, A., Mirjalili, S., Abd Elaziz, M., Gandomi, A.H., 2021a. The arithmetic optimization algorithm. Comput. Methods Appl. Mech. Engrg. 376, 113609.

Abualigah, L., Yousri, D., Abd Elaziz, M., Ewees, A.A., Al-Qaness, M.A., Gandomi, A.H., 2021b. Aquila optimizer: a novel meta-heuristic optimization algorithm. Comput. Ind. Eng. 157, 107250.

Agushaka, J.O., Ezugwu, A.E., Abualigah, L., 2022a. Dwarf mongoose optimization algorithm. Comput. Methods Appl. Mech. Engrg. 391, 114570.
Agushaka, J.O., Ezugwu, A.E., Abualigah, L., 2022b. Gazelle Optimization Algorithm: A novel nature-inspired metaheuristic optimizer. Neural Comput. Appl. 1–33.
Ahmadini, A.A.H., Modibbo, U.M., Shaikh, A.A., Ali, I., 2021. Multi-objective optimization modelling of sustainable green supply chain in inventory and production management. Alex. Eng. J. 60 (6), 5129–5146.
Alkahtani, M., 2022a. Mathematical modelling of inventory and process outsourcing for optimization of supply chain management. Mathematics 10 (7), 1142.
Alkahtani, M., 2022b. Supply chain management optimization and prediction model based on projected stochastic gradient. Sustainability 14 (6), 3486.
Alshammari, I., Parimala, M., Ozel, C., Riaz, M., 2022. Spherical linear diophantine fuzzy TOPSIS algorithm for green supply chain management system. J. Funct. Spaces 2022, 1–12.
Amin, S.H., Zhang, G., 2013. A multi-objective facility location model for closed-loop supply chain network under uncertain demand and return. Appl. Math. Model. 37 (6), 4165–4176.
Amorim Leandro De Castro Amoedo, R., Achi, D., Kantor, I.D., Maréchal, F., 2021. Towards a sustainable supply chain on plastic waste management: a multi-criteria optimization approach. In: Proceedings of the 34th International Conference on Efficiency, Cost, Optimization, Simulation and Environmental Impact of Energy Systems, No. CONF.
Anagnostopoulos, T., Komisopoulos, F., Vlachos, A., Psarras, A., Salmon, I., Ntalianis, K., Sustainable supply chain management of electric grid power consumption load for smart cities based on second-order exponential smoothing algorithm.
Angerhofer, B.J., Angelides, M.C., 2000. System dynamics modelling in supply chain management: research review. In: 2000 Winter Simulation Conference Proceedings (Cat. No. 00CH37165), Vol. 1. IEEE, pp. 342–351.
Arampantzi, C., Minis, I., 2017. A new model for designing sustainable supply chain networks and its application to a global manufacturer. J. Clean. Prod. 156, 276–292.
Asha, L.N., Dey, A., Yodo, N., Aragon, L.G., 2022. Optimization approaches for multiple conflicting objectives in sustainable green supply chain management. Sustainability 14 (19), 12790.
Ashby, A., Leat, M., Hudson-Smith, M., 2012. Making connections: a review of supply chain management and sustainability literature. Supply Chain Manag. Int. J. 17 (5), 497–516.
Bertsimas, D., Tsitsiklis, J., 1993. Simulated annealing. Stat. Sci. 8 (1), 10–15.
Beske, P., Seuring, S., 2014. Putting sustainability into supply chain management. Supply Chain Manag. Int. J.
Caramia, M., Stecca, G., 2022. Sustainable two stage supply chain management: A quadratic optimization approach with a quadratic constraint. EURO J. Comput. Optim. 10, 100040.
Carter, C.R., Liane Easton, P., 2011. Sustainable supply chain management: evolution and future directions. Int. J. Phys. Distrib. Logist. Manage. 41 (1), 46–62.
Carter, C.R., Rogers, D.S., 2008. A framework of sustainable supply chain management: moving toward new theory. Int. J. Phys. Distrib. Logist. Manage.
Chakraborty, S., Saha, A.K., Nama, S., Debnath, S., 2021. COVID-19 X-ray image segmentation by modified whale optimization algorithm with population reduction. Comput. Biol. Med. 139, 104984.
Chandra, C., Tumanyan, A., 2007. Organization and problem ontology for supply chain information support system. Data Knowl. Eng. 61 (2), 263–280.
Chawla, M., Duhan, M., 2018. Levy flights in metaheuristics optimization algorithms–a review. Appl. Artif. Intell. 32 (9–10), 802–821.
Chen, Y., Chen, H., 2022. Analysis and modeling of supply chain management of fresh products based on genetic algorithm. Int. J. Syst. Assur. Eng. Manag. 1–10.
Chen, M., Du, W., 2022. Dynamic relationship network and international management of enterprise supply chain by particle swarm optimization algorithm under deep learning. Expert Syst. e13081.
Costantino, N., Dotoli, M., Falagario, M., Fanti, M.P., Mangini, A.M., 2012. A model for supply management of agile manufacturing supply chains. Int. J. Prod. Econ. 135 (1), 451–457.
Cuong-Le, T., Minh, H.-L., Khatir, S., Wahab, M.A., Tran, M.T., Mirjalili, S., 2021. A novel version of Cuckoo search algorithm for solving optimization problems. Expert Syst. Appl. 186, 115669.
De León-Aldaco, S.E., Calleja, H., Alquicira, J.A., 2015. Metaheuristic optimization methods applied to power converters: A review. IEEE Trans. Power Electron. 30 (12), 6791–6803.
Dorigo, M., Birattari, M., Stutzle, T., 2006. Ant colony optimization. IEEE Comput. Intell. Mag. 1 (4), 28–39.
Ehtesham Rasi, R., 2022. Optimization bi objective for designing sustainable supply chain network economic based competition by cost management approach. Adv. Math. Finance Appl. 7 (2), 293–312.
Ezugwu, A.E., Agushaka, J.O., Abualigah, L., Mirjalili, S., Gandomi, A.H., 2022. Prairie dog optimization algorithm. Neural Comput. Appl. 34 (22), 20017–20065.
Fargnoli, M., Haber, N., Tronci, M., 2022. Case study research to foster the optimization of supply chain management through the PSS approach. Sustainability 14 (4), 2235.
Glover, F., 1989. Tabu search—part I. ORSA J. Comput. 1 (3), 190–206.
Guan, Y., Huang, Y., Qin, H., 2022. Inventory management optimization of green supply chain using IPSO-BPNN algorithm under the artificial intelligence. Wirel. Commun. Mob. Comput. 2022.
Habib, M.S., et al., 2018. Robust Optimization for Post-Disaster Debris Management in Humanitarian Supply Chain: A Sustainable Recovery Approach (Ph.D. thesis).
Halim, A.H., Ismail, I., Das, S., 2021. Performance assessment of the metaheuristic optimization algorithms: an exhaustive review. Artif. Intell. Rev. 54, 2323–2409.
He, C., 2021. Performance evaluation model and algorithm of green supply chain management based on sustainable computing. Ecol. Chem. Eng. S 28 (4), 499–512.
He, F., Kalantrai, K.R., Ebrahimnejad, A., Motameni, H., 2022. An effective fault-tolerance technique in web services: an approach based on hybrid optimization algorithm of PSO and Cuckoo search. Int. Arab. J. Inf. Technol. 19 (2), 230–236.
Jain, M., Sharma, D.K., Sharma, N., 2022. Artificial intelligence computing and nature-inspired optimization techniques for effective supply chain management. In: Data Analytics and Artificial Intelligence for Inventory and Supply Chain Management. Springer, pp. 63–80.
Jin, M., Song, L., Wang, Y., Zeng, Y., 2018. Longitudinal cooperative robust optimization model for sustainable supply chain management. Chaos Solitons Fractals 116, 95–105.
Junhui, L., 2022. Security enhancement algorithm of SM-254 cloud system and automated personnel identification of the management in the supply chain enterprise. Math. Probl. Eng. 2022.
Kafa, N., Hani, Y., El Mhamedi, A., 2013. Sustainability performance measurement for green supply chain management. IFAC Proc. Vol. 46 (24), 71–78.
Kalyani, D., Srivani, P., Pradeep, S., 2022. Secured information sharing in supply chain management: Modified data sanitization with optimal key generation via hybrid algorithm. Adv. Eng. Softw. 173, 103194.
Kennedy, J., Eberhart, R., 1995. Particle swarm optimization. In: Proceedings of ICNN'95-International Conference on Neural Networks, Vol. 4. IEEE, pp. 1942–1948.
Khan, S.A.R., Godil, D.I., Yu, Z., Abbas, F., Shamim, M.A., 2022. Adoption of renewable energy sources, low-carbon initiatives, and advanced logistical infrastructure—an step toward integrated global progress. Sustain. Dev. 30 (1), 275–288.
Khodaverdi, R., Shahbazi, M., Azar, A., Fathi, M.R., 2022. A robust optimization approach for sustainable humanitarian supply chain management of blood products. Int. J. Hosp. Res. 11 (1).
Lejarza, F., Kelley, M.T., Baldea, M., 2022. Feedback-based deterministic optimization is a robust approach for supply chain management under demand uncertainty. Ind. Eng. Chem. Res. 61 (33), 12153–12168.
Li, M., Zhou, Y., 2022. Analysis of supply chain optimization method and management intelligent decision under green economy. Wirel. Commun. Mob. Comput. 2022.
Lim, S.H., 2006. The design of controls in supply chain management sustainable collaboration using decision tree algorithm. IJCSNS 6 (5A), 159.
Lim, S., Hahn, J., 2005. Optimization of forecasting supply chain management sustainable collaboration using hybrid artificial neural network. In: Advances in Neural Networks–ISNN 2005: Second International Symposium on Neural Networks, Chongqing, China, May 30-June 1, 2005, Proceedings, Part III 2. Springer, pp. 1052–1057.
Luo, Y., Wirojanagud, P., Caudill, R.J., 2001. Network-based optimization and simulation of sustainable e-supply chain management. In: Proceedings of the 2001 IEEE International Symposium on Electronics and the Environment. 2001 IEEE ISEE (Cat. No. 01CH37190). IEEE, pp. 185–190.
Mazaheri, V., Khodadadi, H., 2020. Heart Arrhythmia diagnosis based on the combination of morphological, frequency and nonlinear features of ECG signals and metaheuristic feature selection algorithm. Expert Syst. Appl. 161, 113697.
Mehri Charvadeh, M., Pourmousa, S., Tajdini, A., Tamjidi, A., Safdari, V., 2022. Presenting a management model for a multiobjective sustainable supply chain in the cellulosic industry and its implementation by the NSGA-II meta-heuristic algorithm. Discrete Dyn. Nat. Soc. 2022.
Mohammadnazari, Z., Ghannadpour, S.F., 2021. Sustainable construction supply chain management with the spotlight of inventory optimization under uncertainty. Environ. Dev. Sustain. 23, 10937–10972.
Mosteanu, N.R., Faccia, A., Ansari, A., Shamout, M.D., Capitanio, F., 2020. Sustainability integration in supply chain management through systematic literature review. Calitatea 21 (176), 117–123.
Naderi, R., Nikabadi, M.S., Alem-Tabriz, A., Pishvaee, M.S., 2021. Sustainable coal supply chain management using exergy analysis and genetic algorithm. Manag. Syst. Prod. Eng. 29 (1), 44–53.
Nama, S., Saha, A.K., Chakraborty, S., Gandomi, A.H., Abualigah, L., 2023. Boosting particle swarm optimization by backtracking search algorithm for optimization problems. Swarm Evol. Comput. 79, 101304.
Nama, S., Saha, A.K., Ghosh, S., 2017. Improved backtracking search algorithm for pseudo dynamic active earth pressure on retaining wall supporting backfill. Appl. Soft Comput. 52, 885–897.
Nath, M.P., Priyadarshini, S.B.B., Mishra, D., 2022. Supply chain management (SCM): Employing various big data and metaheuristic strategies. In: Advances in Machine Learning for Big Data Analysis. Springer, pp. 145–165.
Noh, J., Hwang, S.-J., 2023. Optimization model for the energy supply chain management problem of supplier selection in emergency procurement. Systems 11 (1), 48.
Oyelade, O.N., Ezugwu, A.E.-S., Mohamed, T.I., Abualigah, L., 2022. Ebola optimization search algorithm: A new nature-inspired metaheuristic optimization algorithm. IEEE Access 10, 16150–16177.

Pavlov, A., Ivanov, D., Pavlov, D., Slinko, A., 2019. Optimization of network redundancy and contingency planning in sustainable and resilient supply chain resource management under conditions of structural dynamics. Ann. Oper. Res. 1–30.

Putcha, C., Banerjee, A., Rana, B.S., 2021. A fast convergence method for optimal solution of transportation optimization problems in sustainable supply chain management. J. Green Eng. 11, 195–205.

Saif, Y., Griffiths, S., Almansoori, A., 2022. Municipal solid waste supply chain management under an integrated optimization of sustainability targets. Comput. Chem. Eng. 160, 107725.

Sang-To, T., Le-Minh, H., Wahab, M.A., Thanh, C.-L., 2023. A new metaheuristic algorithm: Shrimp and goby association search algorithm and its application for damage identification in large-scale and complex structures. Adv. Eng. Softw. 176, 103363.

Sarkar, B., Omair, M., Choi, S.-B., 2018. A multi-objective optimization of energy, economic, and carbon emission in a production model under sustainable supply chain management. Appl. Sci. 8 (10), 1744.

Seuring, S., Müller, M., 2008. From a literature review to a conceptual framework for sustainable supply chain management. J. Clean. Prod. 16 (15), 1699–1710.

Sharma, S., Saha, A.K., Lohar, G., 2021. Optimization of weight and cost of cantilever retaining wall by a hybrid metaheuristic algorithm. Eng. Comput. 1–27.

Shokouhifar, M., Sohrabi, M., Rabbani, M., Molana, S.M.H., Werner, F., 2023. Sustainable phosphorus fertilizer supply chain management to improve crop yield and P use efficiency using an ensemble Heuristic–Metaheuristic optimization algorithm. Agronomy 13 (2), 565.

Singhry, H.B., 2015. An extended model of sustainable development from sustainable sourcing to sustainable reverse logistics: A supply chain perspective. Int. J. Supply Chain Manag. 4 (4), 115–125.

Sun, Q., He, S., 2022. Auxiliary cognition system-based management strategy optimization of supply chain of new energy in oil–gas enterprises. Expert Syst. e12974.

Sun, J., Ozawa, M., Zhang, W., Takahashi, K., 2022. Electricity supply chain management considering environmental evaluation: A multi-period optimization stochastic programming model. Clean. Responsib. Consum. 7, 100086.

Talaei, M., Moghaddam, B.F., Pishvaee, M.S., Bozorgi-Amiri, A., Gholamnejad, S., 2016. A robust fuzzy optimization model for carbon-efficient closed-loop supply chain network design problem: a numerical illustration in electronics industry. J. Clean. Prod. 113, 662–673.

Tzanetos, A., Dounias, G., 2021. Nature inspired optimization algorithms or simply variations of metaheuristics? Artif. Intell. Rev. 54, 1841–1862.

Wei, Y., et al., 2022. A machine learning algorithm for supplier credit risk assessment based on supply chain management. Int. Trans. Electr. Energy Syst. 2022.

Xie, J., Chen, C., 2022. Supply chain and logistics optimization management for international trading enterprises using IoT-based economic logistics model. Oper. Manag. Res. 15 (3–4), 711–724.

You, F., Tao, L., Graziano, D.J., Snyder, S.W., 2012. Optimal design of sustainable cellulosic biofuel supply chains: multiobjective optimization coupled with life cycle assessment and input–output analysis. AIChE J. 58 (4), 1157–1180.

Zhang, D., 2006. A network economic model for supply chain versus supply chain competition. Omega 34 (3), 283–295.