Submitted on: 22 / 10/ 2023
Revised form accepted on: 03/11/ 2023
Coresponding author:fatiha.djelid@univ-usto.dz

Revue
Nature et Technologie
http://www.univ-chlef.dz/revuenatec
ISSN : 1112-9778 – EISSN : 2437-0312

Specialty: Computer Science **Option: Network and Distributed System**

Supply Models in Logistic Transport Networks

DJELID Fatiha, KHELIFA Said and MEKKAKIA MAAZA Zoulikha
SIMPA Laboratory, Department of Computer Science, Faculty of Mathematics and Computer Science, University of Science and Technology of Oran Mohamed Boudiaf, USTO-MB, BP 1505, El Mnaouer, 31000, Oran, Algeria

Abstract

Supply management within the transport supply chain and logistics plays a pivotal role in shaping overall business performance and enhancing customer satisfaction. This article delves into a comprehensive examination of the supply models applied in this domain, giving due consideration to the diverse transport networks, which encompass road transport, rail, maritime, aerial, and multimodal transport. The objective is to review and synthesize various approaches and methodologies used in the existing scientific literature to address the diverse challenges of supply management in the transportation industry.

Keywords: Transport Networks, Logistics, Supply chain, Supply Management, Supply Model

1. Introduction

Effective supply management in the transport logistics chain is essential to overall business performance and customer satisfaction. Over the last few decades, this discipline has evolved considerably, mainly due to the globalisation of markets. The integration of supply models as part of logistic transport networks enhances the overall effectiveness of the supply process. Supply models help optimize the allocation of resources, inventory management, and demand forecasting, enabling efficient decision-making and coordination across the transport network. By aligning the supply process with the capabilities and constraints of the transport network, supply models contribute to improved operational efficiency, reduced costs, and enhanced customer satisfaction. This area of research focuses on analysing the different facets of supply management, from optimising the flow of goods to reducing costs, via risk management and innovation in logistics practices. In this article, the various transport networks are presented, including road, rail, sea, air and multimodal transport, as well as supply models. With the main objective of examining the different methods and approaches used in the scientific literature to address these complex challenges.

Supply Models in Logistic Transport Networks

2. Transport Networks

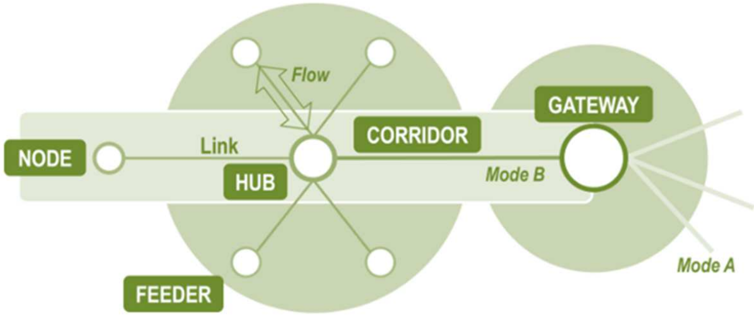

Figure 1: Structural components of transport networks

A transport network is a system of nodes and connections that enables people and goods to move between locations using transport infrastructure such as roads, railways, airports and seaports. These networks are often represented as graphs with basic elements, with connections representing infrastructure segments or service routes. Nodes such as gateways, hubs, feeders, corridors and transport nodes represent the locations where goods are transported, such as ports, airports and truck terminals. These points are essential for safe long-distance transport (1). However, it is necessary for goods to be transferred from one mode of transport to another. According to (2) these processes are referred to as transhipments. They are crucial in supply chain process management, requiring changes in the transport or location of goods. They are particularly important when goods are already in transit and need to be redirected due to the route changes, carrier changes or alternative transport methods. The aim is to deliver products efficiently and cost-efficiently, while respecting demand constraints and minimizing costs. Transhipments can occur at various points in the supply chain, including warehouses, distribution centres and ports.

Transport networks can be classified into different types depending on their characteristics and use. The main types of transport networks are as follows:

a. **Road transport networks** are a sub-system within the overall transport system and encompass both supply and demand elements. The supply side includes physical components such as infrastructure, traffic management and transport support facilities, road vehicles, fuel/energy sources and operating personnel (3).

b. **Rail transport networks** Rail transport networks are an essential mode of transport that offers safety and economic viability for people and goods. Its significant capacity in terms of passenger trains and charges helps to reduce road congestion and carbon dioxide emissions (4).

c. **Air transport networks** Air transport plays an essential role in the context of globalisation by reducing the geographical distances between nations. Researchers have shown an interest in analysing the structure, dynamics and resilience of air transport networks. According to (5) civil aviation is a complex system that requires a global approach to develop as a whole.

d. **Maritime transport networks** Encompass the movement of goods and people by the sea. The authors of (6) have developed a network architecture combining distributed computing, edge computing and block chain technology within maritime networks. This innovative approach aims to optimise task planning and energy use.

e. **Multimodal transport networks** It is efficient and environmentally friendly, offering benefits such as increased resource utilisation, reduced environmental pollution and reduced congestion. Multimodal transport can be classified into five categories: motorway-railway, motorway-inland waterway, railway-inland waterway, inland waterway-inland waterway and train-air-truck (TAC). It can be national or international. The operational framework for multimodal transport involves the creation of multimodal transport hubs, which fall into three main categories: rail-oriented hubs, aviation-oriented hubs and inland waterway-oriented hubs (7).

3. Supply Process

According to Dr. Hau L.Lee from Stanford University "A supply chain is a dynamic network of organisations, people, activities, information and resources involved in the creation and delivery of products or services, from suppliers to customers. It encompasses the planning, procurement, production, transportation, distribution and return of goods and services, while optimising efficiency, cost, quality, flexibility and customer satisfaction".

From design and procurement of raw materials to final delivery to customers. This includes production, stock management, transport, distribution and returns management. Effective logistics management involves implementing strategies to optimise operational performance, foster collaboration between stakeholders and adapt in real time to market trends and environmental changes. This involves optimising operational performance, coordinating with other stakeholders and adapting to market trends and environmental changes (8).

Supply management is an essential element of supply chain management and plays a major role in an organization's performance and competitiveness. In this part, a variety of scientific works dedicated to this process are presented.

The study of (9) presented an integrated three-stage method for supplier selection and order allocation (SSOA), comprising demand forecasting, SWOT analysis and an optimisation model. The hybrid learning technique based on LSTM improved the accuracy of demand forecasting over traditional techniques such as Seasonal Auto-Regressive Integrated Moving Average (SARIMA), and a deep learning model named Multilayer Perceptron (MLP). A complex supplier evaluation model was developed using SWOT analysis, and a multi-objective programming model was developed to identify the most suitable suppliers and optimise orders, the findings of the performance comparison among the forecasting models evaluated reveal that the proposed LSTM model could lead to lower predicting errors than the SARIMA and MLP models. As well as the authors of (10) that proposed an hybrid strategy for supplier selection and order allocation to accommodate both favourable developments such as Industry 4.0 and negative events such as natural disasters. The strategy uses fuzzy Fuzzy Analytical Hierarchical Process (fuzzy-AHP) criteria, derived from existing literature and expert evaluations. Key criteria included disaster detection, implementation of RFID/bar code technology, public-private partnerships and improving manufacturing flexibility. Analytical techniques such as Data Envelopment Analysis (DEA) and Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) were used to identify and include efficient suppliers, reducing the risk of supply chain disruption. They also examined the correlation between supplier selection criteria and supply chain risk, and introduced a mixed-methods programme for supplier selection and order allocation.

Other researches focused on hybrid artificial intelligence (AI) models for solving the supplier selection problem, as (11) who proposed an evaluation model for supplier selection based on a BP network optimised using genetic algorithms. The model used data from 36 suppliers tested against nine indicators, including system quality certification, rush order capability, production flexibility, technological resilience, company reputation, standardisation, service improvement and corporate culture. The model aimed to overcome BP network dependency and local convergence issues, providing a practical and effective method for supplier evaluation.

In addition to that, (12) proposed a supplier selection models using Group Decision Making (GDM). The research methodology included data acquisition, identification of relevant criteria and alternatives, construction of a group decision matrix, (GDM), using the Analytic Hierarchy Process (AHP) to assign weights to these criteria, and using the Jaya algorithm for optimisation. Five different automotive parts suppliers were evaluated on factors such as product quality, technology level, flexibility, delivery times and pricing. The GDM process was divided into two phases: consensus and normalisation, favouring dynamic and interactive decision-making. The proposed methodology showed superior performance, particularly in complex decision-making scenarios, and offers advantages such as reduced computational complexity and optimal solutions. The authors of (13) also presented a research methodology in fuzzy multi-criteria decision making (MCDM) framework adapted to supplier selection in the context of digital supply chains. This framework was characterised by the integration of various fuzzy logic technique, including the fuzzy best-worst method (BWM), multi-objective fuzzy optimization based on radio analysis and full multiplier from (MUL-TIMOORA), complex proportional fuzzy evaluation of alternatives (CO-PRAS) and the fuzzy ideal solution similarity preference technique (TOPSIS), the final results demonstrated the efficacy of the suggested approach. On the other hand (14) developed a decision-making model for the approval of spare parts from different supplier using the Analytic Hierarchy Process (AHP) and of a Analytic Network Process (ANP) methodologies. The study examined specifically the automotive industry, focusing on a small and medium-sized enterprise faced with the decision of choosing one of three potential suppliers for critical parts replacement. The evaluation included six key supplier attributes: delivery time, product availability, and price, vendor elections using AHP and ANP techniques, allowing a complete evaluation of their results.

The work in (15) aimed to improve the effectiveness of DEA in negative data contexts by introducing a new non-radial model for UPD evaluation and by proposing a hybrid Multi-Attribute Decision Management (MADM)-DEA approach using the fuzzy version of the VIKOR method. This innovative approach was demonstrated in the selection of suppliers in a manufacturing company, a crucial marginal concern. Also explored was the evaluation of production decision units (PDUs) in the presence of negative data, focusing on supplier selection within a manufacturing firm. The special model called "Model 25" was used to effectively manage negative data. The results show that 23 out of 28 suppliers received a maximum score. The study recommended one supplier as the preferred choice for supplier selection, taking into account factors such as cost, efficiency, customer satisfaction and product quality. Modern information technology was also essential to improve and increase the efficiency of customer service structure (CSS) management. Furthermore, to manage the services provided to customers, expressing the interaction between suppliers and consumers. the graph-based solution was presented by (16), that causal graph model was introduced for the efficient management of production capacity, to resource supply and transport, and to ensure efficient service to customers. Similar approaches were developed for combinatorial optimisation problems. The model was organised into three levels: suppliers, intermediate customers and final customers of the supplier, the transport medium and the customer's needs. A matrix representation was introduced to express the causal dependency between states. The proposed control system for a transport network, including the case study, guarantees a 47% improvement in transport efficiency. The authors highlighted the importance of modern information resources and the importance of effective decision-making in the management of customer service structures.

Further study, such as a multi-objective optimisation model for the integrated supplier selection, manufacturing scheduling, and remanufactured product distribution was presented by (17). The model takes into account cost, profit, carbon emissions, resource usage, and other economic and environmental goals. And lastly, the distribution of orders and selection of green suppliers a thorough quantity discount model for dynamic green supplier selection and order allocation was developed by (18). The model takes into account both static and dynamic aspects, including manufacturing capacity, pricing, quality, delivery performance, and environmental performance. The authors provided a heuristic approach to solve the problem, and they included numerical tests to show how successful it was.

The supply process is a crucial aspect of an organization's supply chain, affecting costs, quality, and customer satisfaction. Effective supply process management is essential, addressing supplier selection, order allocation, and performance evaluation. The research cites studies in this section on this topic, highlighting trends and challenges in the field, such as the increasing use of AI and the need for agility in response to disruptions. The Supply Process section offers insights for developing and implementing more effective supply process management practices.

Table 1 comprises the comparison between the different related works in section 3, and the methods used in recent research articles.

Table 1 Comparative Table

Ref	Approach / Technique	Metrics	Dataset	Actor concerned	Desaventage and Limits
(9)	Hybrid deep learning technique based on a long and short term memory network (LSTM)	Qualitative criteria: reputation of suppliers, flexibility and innovation. Quantitative criteria : delivery time, cost and quality.	Canadian Juice Industry Real Dataset.	Supplier Selection, Order Allocation	The framework can be tested using various datasets from different business settings.
(10)	-DEA - FAHP-TOPSIS. -Mixed Integer Program (MIP).	Disaster detection using BDA, RFID/bar codes, public-private partnership, manufacturing flexibility and cyber security.	Real industry data Use cases	Supplier selection and management	The model can be expanded to include lead-time constraints, delays, and late orders, and integrate other supply chain functions with supplier selection as production.
(11)	Neural Networks based on a Genetic Algorithm	Qualitative criteria: Product eligibility rate ,Quality system certification Product price ,Order cost ,Transport and warehousing cost , Order turnaround time ability to accept urgent requests, R&D capacity and speed, Qualitative criteria: Production flexibility , Resilience and Company reputation.	Real industry data	Supplier Evaluation	The study does not compare the performance of the proposed model to other supplier evaluation models. This makes it difficult to assess the relative effectiveness of the proposed model.
(12)	Metaheuristic,Group Descision Making (GDM)	Heterogeneous information using weighted power average (WPA)	Supplier selection dataset	Supplier selection and order allocation	The authors should explore dynamic GDM methods with heterogeneous information and connect them to domains like Education, Health Care, and Election Predictor Systems.
(13)	FuzzyMulticriteria Model	Input flow demand Congestion avoidance control quantities	Real data	Supplier and customer services	The application to different selection problems such a site selection and partner selection and developing and testing other integrated models and combing them with MAH method
(14)	Multi-Criteria Decision Analysis	Quantitative criteria : delivery cycle time, supplier availability, price part quality, Qualitative criteria : customer service, supplier response rate, sustainability,	Real industry data	Supplier selection	Combining methods with Machine Learning tools like ANN or AHP-Fuzzy. Comparing results sections and assigning importance weights based on criteria like company hierarchy, time experience.

(15)	Data EnvelopmentAnalysis (DEA)	operating cost, staff training schedule, sales, system agility, customer satisfaction,	Real industry data	Supplier Ranking	The design of hybrid approaches to address the shortcomings of the DEA cross efficiency method and applying to other industry and community issues.
(16)	Causal graphical Configuration	input flow, Congestion prevention	Real industry data	Supplier selection and management	Focusing on the transport problem associated with the configuration graph, expressed in terms of distance, pollution and fuel consumption.

4. Conclusion

Supply models in the transport logistics chain are a crucial area of research for improving the operational efficiency of companies and their ability to respond to changing market demands. The different approaches and methodologies studied, as well as their application to various transport networks, revealed the extent of the contribution of these models to strategic and operational decision-making.
The studies analysed demonstrated the importance of integrating advanced analytical methods to improve supplier selection and order allocation. Highlighting the effectiveness of genetic algorithms and metaheuristic approaches to address these complex issues. They also enable a more global evaluation of suppliers. We must also take into account the importance of DEA methods and concerted decisions aimed at optimising supplier-customer services.

This research has contributed significantly to the advancement of knowledge in the field of supply management, particularly in the context of transport supply chains. However, Supply management in the transport industry faces numerous challenges, including the increasing complexity of global supply chains, the need for greater visibility and traceability of goods, the growing demand for sustainable transportation solutions, and the impact of new technologies. Future research should focus on developing new models and methods for managing complex supply chains, integrating new technologies like blockchain, AI, and IoT, developing sustainable transportation solutions, and studying the impact of new technologies like autonomous vehicles and drones. Addressing these challenges can improve the efficiency and effectiveness of supply management in the transport industry.

Acknowledgements

This research was supported by the Algerian Ministry of Higher Education and Scientific Research, General Direction of Scientific Research and Technological Development [grant number C00L07UN310220230007].

References

1. Sarkar DD, Kar S, Basu K, Sharma S. Solution of a transshipment problem with uncertain parameters under impaired and enhanced flow. J Anal. (2023) . https://doi.org/10.1007/s41478-023-00649-5

2. Xie F, Levinson DM. Modeling the Growth of Transportation Networks: A Comprehensive Review. Rochester, NY; (2007) . https://doi.org/10.1007/s11067-007-9037-4

3. Janić M. Road Transport System. In: Janić M, éditeur. Resilience, Robustness, and Vulnerability of Transport Systems: Analysis, Modelling, and Practice. Cham: Springer International Publishing; (2022). p. 45-144. https://doi.org/10.1007/978-3-031-13040-3

4. Maskeliūnaitė L, Sivilevičius H. The Model for Evaluating Criteria Describing the Internal Safety of a Railway Trip by International Train. In: Gopalakrishnan K, Prentkovskis O, Jackiva I, Junevičius R, éditeurs. TRANSBALTICA XI: Transportation Science and Technology. Cham: Springer International Publishing; 2020. p. 610□21. (Lecture Notes in Intelligent Transportation and Infrastructure). https://doi.org/10.1007/978-3-030-38666-5_64

5. Hirst M. 1 - More than one answer? In: Hirst M, éditeur. The Air Transport System. Woodhead Publishing; (2008). p. 3□24. ISBN : 9781845693251.

6. Sinesi S, Altieri MG, Marinelli M, Dell'Orco M. A multivariate logic decision support system for optimization of the maritime routes. In: 2017 5th IEEE International Conference on Models and Technologies for Intelligent Transportation Systems (MT-ITS). Naples, Italy: IEEE; 2017. p. 75□9. doi: 10.1109/MTITS.2017.8005614.

7. Xiao J hua, Liu X. Development of Multimodal Transport in China. In: Xiao J hua, Lee S ju, Liu B lian, Liu J, éditeurs. Contemporary Logistics in China: Collaboration and Reciprocation [Internet]. Singapore: Springer Singapore; 2018. p. 137□60. Disponible sur: https://doi.org/10.1007/978-981-13-0071-4_7

8. Hugos MH. Essentials of supply chain management. Fourth Edition. Hoboken, New Jersey: Wiley; 2018. 355 p. (Essentials series). SBN : 978-1-119-46110-4

9. Islam S, Amin SH, Wardley LJ. Supplier selection and order allocation planning using predictive analytics and multi-objective programming. Computers & Industrial Engineering. déc 2022;174:108825. https://doi.org/10.1016/j.cie.2022.108825

10. Kaur H, Prakash Singh S. Multi-stage hybrid model for supplier selection and order allocation considering disruption risks and disruptive technologies. International Journal of Production Economics. 1 janv 2021;231:107830. https://doi.org/10.1016/j.ijpe.2020.107830

11. Meng L. Research on Supplier Evaluation Model of BP Neutral Network Based on Genetic Algorithm. In: 2022 4th International Conference on Artificial Intelligence and Advanced Manufacturing (AIAM). Hamburg, Germany: IEEE; (2022) . p. 437-40.

doi: 10.1109/AIAM57466.2022.00089.

12. Kannan ASK, Balamurugan SAA, Sasikala S. A Customized Metaheuristic Approaches for Improving Supplier Selection in Intelligent Decision Making. IEEE Access. (2021);9:56228-39. doi: 10.1109/ACCESS.2021.3071454.

13. Tavana M, Shaabani A, Caprio DD, Amiri M. An integrated and comprehensive fuzzy multicriteria model for supplier selection in digital supply chains. Sustainable Operations and Computers. 2021;2:149□69. https://doi.org/10.1016/j.susoc.2021.07.008

14. Rodrigues M, Šírová E, Mugurusi G. A supplier selection decision model using multi-criteria decision analysis in a small manufacturing company. IFAC-PapersOnLine. 2022;55(10):2773□8. https://doi.org/10.1016/j.ifacol.2022.10.149

15. Soltanifar M, Sharafi H. A modified DEA cross efficiency method with negative data and its application in supplier selection. J Comb Optim. janv 2022;43(1):265□96. https://doi.org/10.1007/s10878-021-00765-7

16. Dimon C, Popescu D, Bîlbîie R. Efficient and Collaborative Decisions for Supplier-Customer Services Management. Procedia Computer Science. 2022;214:1144□51.https://doi.org/10.1016/j.procs.2022.11.289.

17. Muneeb SM, Asim Z, Hajiaghaei-Keshteli M, Abbas H. A multi-objective integrated supplier selection-production-distribution model for re-furbished products: Towards a circular economy. Renewable and Sustainable Energy Reviews. avr 2023;175:113156. https://doi.org/10.1016/j.rser.2023.113156

18. Hamdan S, Cheaitou A, Shikhli A, Alsyouf I. Comprehensive quantity discount model for dynamic green supplier selection and order allocation. Computers & Operations Research. déc 2023;160:106372. https://doi.org/10.1016/j.cor.2023.106372