An Exploration toward the Optimization of Transportation and Distribution Costs Using Greedy Algorithm

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ABSTRACT

This collection of studies explores diverse aspects of supply chain management (SCM) across various industries and regions. Utilizing methodologies such as integer linear mathematical models, bi-level optimization, mixed-integer linear programming, and robust optimization strategies, these studies address challenges in procurement, logistics, sustainability, and cost reduction. Findings emphasize the importance of integrated SCM approaches to enhance efficiency, reduce costs, and mitigate risks. This paper explores the optimization of transportation and distribution costs using a greedy algorithm. The study demonstrates how this approach efficiently reduces logistics expenses by prioritizing cost-effective routes and delivery schedules, ultimately enhancing overall supply chain efficiency and minimizing operational costs.

Keywords: Greedy Algorithm, Cost Optimization, SCM

I. SUPPLY CHAIN MANAGEMENT (SCM) WORKS

Supply chain management (SCM) is a strategic approach that coordinates the efforts of suppliers, manufacturers, and distributors to ensure efficient and cost-effective production and delivery of products. By overseeing the entire lifecycle of a product, from raw material procurement to final delivery, SCM aims to enhance overall efficiency and minimize costs. This involves meticulous planning, execution, and monitoring of all stages of production, logistics, and inventory management. A primary goal of SCM is to integrate and streamline the manufacturing, transportation, and retail processes. By doing so, companies can significantly reduce waste, avoid delays, and ensure that products reach consumers promptly. Effective SCM requires close collaboration with suppliers to manage inventories and synchronize production schedules. This integration ensures that all components of the supply chain work harmoniously towards the common goal of delivering high-quality products to customers efficiently [1-6].

2. PARTS OF SCM

Supply chain management encompasses several critical components, each playing a vital role in the overall efficiency of the supply chain. These include planning, sourcing, manufacturing, delivering, and returning.

Planning: Planning is the foundational stage of SCM, where companies forecast demand and plan their supply chain activities accordingly. This involves analysing market trends, customer demands, and production capacities to develop effective strategies. Large organizations often utilize enterprise resource planning (ERP) systems to collect data and generate accurate forecasts, enabling them to make informed decisions.

Sourcing: Sourcing involves selecting suppliers and managing relationships to procure the necessary materials and components for production. Effective sourcing ensures that the materials meet quality standards, are cost-effective, and are delivered on time. Companies must evaluate suppliers based on their ability to provide consistent quality, reliability in meeting delivery schedules, and responsiveness to emergencies.

Manufacturing: The manufacturing process transforms raw materials into finished products through various stages, including assembly, testing, inspection, and packaging. Effective manufacturing practices are essential to maintain product quality and meet production targets. Companies must manage production efficiently to minimize waste and optimize the use of resources. This often involves investing in employee training and continuously improving manufacturing processes to reduce inefficiencies.

Delivering: Delivery is a critical aspect of SCM, involving the transportation of finished products to customers. Efficient logistics and distribution networks are essential to ensure timely and safe delivery of products. Companies must develop flexible and resilient supply chain strategies to handle unforeseen disruptions, such as adverse weather conditions or logistical challenges, to maintain customer satisfaction.

Returning: Returns management, or reverse logistics, deals with handling returned products due to defects, recalls, or customer dissatisfaction. Efficient management of returns is crucial to maintain customer trust and loyalty. Companies must have robust processes in place to manage returns, process refunds, and communicate effectively with customers and suppliers to resolve issues promptly [7-10].

3. SCM Vs. SUPPLY CHAINS

While SCM refers to the strategic management of the entire supply chain process, the supply chain itself is the network of entities involved in the production and delivery of goods or services. SCM focuses on optimizing this network to enhance efficiency, reduce costs, and improve customer satisfaction. Effective SCM can significantly impact a company's bottom line by minimizing losses and maximizing revenue opportunities throughout the supply chain [11-13].

4. REVIEW AND FINDINGS

Author(s)	Year	Objective of Study	Methodology	Findings
Hamta et al.	2023	Optimize supply chain costs for HEPCO by adopting a three-tiered strategy.	Integer linear mathematical model using MATLAB to optimize costs in procurement, shipping, storage, production, and defect management.	The model effectively addressed issues such as scarcity, insufficient stock, assembly and storage capacities, and inventory balance, leading to reduced supply chain costs.

Valizadeh et al.	2023	Manage supply chain and distribution of COVID-19 vaccines amid the pandemic.	Bi-level optimization model considering vaccine supply, injection centres, maintenance, injection, transportation costs, and penalty costs for shortages.	The model significantly reduced mortality risks and distribution inequalities, minimizing total costs, and providing managerial insights for optimizing vaccination network coordination during the pandemic.
Masum et al.	2023	Explore the viability of carinata as a feedstock for Sustainable Aviation Fuel (SAF) in the US.	Mixed-Integer Linear Programming (MILP) model using two decades of data at the county level.	Carinata SAF can meet 2.4% of yearly SAF demand for major airports, with logistical efficiency focusing supply at Atlanta airport. SAF production costs and carbon intensity are lower compared to Conventional Aviation Fuel (CAF).
Hashemi-Amiri et al.	2023	Address food insecurity risk due to disruptions in perishable product supply networks.	Distributionally robust modelling paradigm with a chance-constrained strategy, using weighted goal programming technique.	The model optimizes network costs and enhances supplier reliability, validated by a real-world poultry sector case study, offering valuable management insights for perishable food supply chain decision-makers.
Wang et al.	2023	Introduce a novel model for island supply chain network architecture.	Periodic freight demand and Maritime Location Inventory Routing Problem (MLIRP) with numerical analysis and sensitivity analysis.	The model demonstrated resilience and flexibility, proving its efficacy through numerical analysis.
Zahraee et al.	2022	Address sustainability challenges in the wood-based bioenergy sector in Victoria, Australia.	Integrated approach using Geographic Information System (GIS) and Agent-Based Modelling (ABM).	Emphasizes emissions and transportation costs reduction. Demonstrates potential for significant emission cost reduction by maximizing container capacity and using trains for 80% of shipments.
Wu et al.	2022	Assess feasibility of broad-scale agri-biomass utilization.	Optimization model for supply chain and decision support tools, focused on Dezhou City, Shandong Province.	Optimal price per tonne of agri-biomass identified at 180.98 CNY. Provides valuable insights for integrating agri-biomass into various industries, highlighting labor and transportation as key supply expenses.
Yang	2022	Address excessive costs and delays in logistics planning.	Algorithm integrated into project management-oriented system considering total cost, waiting time, transportation costs, and penalties.	The proposed algorithm minimizes logistical transit time and transportation costs, offering an efficient solution for transporting prefabricated construction components.
Peng et al.	2022	Address ambiguity in large datasets and assess supply chain performance under carbon regulation.	Four uncertain optimization models under different carbon regulation schemes using uncertainty theory.	Provides insights into the implications of regulatory approaches on transportation planning and product retailing, helping governments craft efficient carbon regulatory policies and aiding supply chain managers in making sustainable choices.

Ashour et al.	2022	Address absence of return channels in distribution networks and design Reverse Logistics (RL) network.	Model tested on 30 randomly generated examples using Ant Colony Optimization (ACO) algorithm.	Highlights the importance of considering return logistics in network design, demonstrating the superior efficacy of the ACO algorithm.
Ebrahimi & Bagheri	2022	Enhance profitability of selling fossil fuels and reliability of processing facilities.	Multi-level closed-loop supply chain network considering deterministic and uncertain scenarios using Soyster and Mulvey techniques.	Demonstrates the superiority of the Soyster method over Mulvey in addressing uncertainty. Highlights the effectiveness of the proposed approach in aiding decision-makers in supplier selection and environmental impact management.
Qu et al.	2021	Address constrained nonlinear programming in transportation-based supply chains.	Filled function method with computational tests.	The filled function method is effective in resolving supply chain challenges, particularly in transportation decision-making.
Sang et al.	2021	Optimize product distribution amidst Covid-19 challenges in Vietnam.	Solution-focused on optimizing product distribution to enhance efficiency and reduce costs.	Highlights the importance of optimizing product distribution to maintain essential goods flow despite social distancing measures, providing insights for informed decision-making in transportation.
Jeong et al.	2021	Explore potential for growing industrial oilseed and lignocellulosic crops for renewable fuels.	Optimization model considering various factors like transloading costs, topographical constraints, and network boundaries.	Emphasizes the importance of considering multiple factors for efficient supply chains of renewable liquid fuels, highlighting cost-effectiveness of existing petroleum pipelines in Montana and railroad construction in the Dakotas.
Pantoleontos et al.	2021	Examine transportation levelized-cost functions for CO2: N2 mixture in Europe.	Mass flow rates and transportation distances analysis using mixed-integer nonlinear programming (MINLP).	Direct CO2 transport from sources to sinks is more cost-effective than intermediate sources. Highlights significant implications for European/global energy and environmental policies.
Shahmoradi-Moghadam & Schönberger	2021	Introduce the Mobility Supply Chain (MSC) concept for modular production.	Mathematical model optimizing mobile factory routing and production scheduling.	Demonstrates the importance of simultaneous consideration of transportation costs and client work order deadlines, revealing costly sub-optimal solutions when neglecting either aspect.
Beheshtinia et al.	2021	Optimize supply chain scheduling in remote production system considering sustainability factors.	GA-TOPKOR approach integrating genetic algorithm with TOPKOR multi-criteria decision-making technique.	Enhanced performance over traditional genetic algorithms, demonstrating improved results by incorporating sustainability considerations in supply chain optimization.
Zahraee et al.	2020	Investigate feasibility of using oil palm empty fruit bunches (EFB) biomass as renewable energy.	Analysis of carbon footprint and distribution costs by rail and truck using data from three EFB providers in Malaysia.	Truck transportation exhibited the lowest GHG emissions. Findings suggest lawmakers improve biomass supply chain's transportation infrastructure to reduce delivery costs and greenhouse gas emissions.

Nunes et al.	2020	Highlight current research on modeling the biomass supply chain.	Overview of various models addressing biomass supply chain efficiency and cost reduction.	Emphasizes the need for comprehensive supply chain models to enhance biomass utilization for sustainable energy practices, highlighting the growing importance of biomass as a renewable energy source.
Abdolazimi et al.	2020	Address environmental challenges of used tyre production through recycling.	Multi-level closed-loop supply chain network considering deterministic and uncertain scenarios using Soyster and Mulvey techniques.	Highlights the effectiveness of the proposed approach in aiding decision-makers in tyre recycling, demonstrating the superiority of the Soyster method over Mulvey in addressing uncertainty.
Kozak et al.	2020	Integrate lean management decisions at firm level within supply chain.	Allocation model exploring purchasing choices among producers, wholesalers, and retailers.	Demonstrates how an integrated model guides inventory management decisions for minimal costs, emphasizing the importance of considering perspectives from various stakeholders in the transportation industry.
Hosseini-Motlagh et al.	2020	Provide solutions for supply chain management problems in Mashhad, Iran.	TH technique for solvability and robust optimization strategy to handle parameter uncertainty.	Presents concrete examples of model's usefulness and provides legitimate, non-plagiarized solutions to supply chain management problems, guiding decision-makers with computational findings.

5. RESULT ANALYSIS

This research investigates the optimization of a supply chain network comprising four factories and five sales points over a three-time period horizon, with the goal of minimizing overall costs. The key factors considered include the demand and capacity of each sales point and factory, alongside the vehicle capacity set at seventy units for transporting products. By efficiently allocating these resources, the study aims to meet the demand at each sales point while minimizing costs such as lost sale costs and storage costs. To achieve this optimization, data from a MATLAB Central File Exchange submission titled "Applying Greedy Algorithm and Local Search (AGALS) in a Supply Chain Distribution Problem" is utilized [14-21]. This submission provides a MATLAB-based implementation of supply chain distribution problem-solving using a combination of Greedy Algorithm and Local Search techniques. The Greedy Algorithm offers a foundational solution by making quick, locally optimal decisions, ensuring that immediate needs are met efficiently. However, these decisions may not always lead to the best global outcome, necessitating further refinement. Local Search techniques are then applied to improve upon the initial solution provided by the Greedy Algorithm. These techniques involve exploring neighbouring solutions through small adjustments, which help in reducing overall costs and improving resource allocation. By iteratively adjusting the delivery schedule and resource allocation, Local Search techniques find more cost-effective solutions, ensuring that the supply chain operates efficiently over the three-time period horizon. The analysis begins with a thorough understanding of the capacities of the four factories and the demands at the five sales points. Each factory's production capacity must be managed to avoid excess production or shortages, while each sales point's demand must be met to prevent lost sales and associated costs [22-25]. The vehicle capacity of seventy units is a critical constraint, requiring strategic scheduling of deliveries to maximize utilization and ensure timely fulfilment of sales point demands. Cost considerations are crucial in this optimization process. Lost sale costs occur when the demand at a sales point is not met, leading to lost revenue and potential customer dissatisfaction. Storage costs arise when excess products are stored at factories or sales points, incurring additional expenses for warehousing and inventory management. By minimizing these costs through efficient resource allocation and optimized delivery scheduling, the study aims to enhance the overall efficiency and cost-effectiveness of the supply chain network [26-39].

5.1 Procedure

Input Data: Initialize the necessary data for demand, lost sale cost, and storage cost.

Define Constants: Specify the number of factories, sales points, time periods, delivery cost, and factory capacities.

Create MILP Model: Set up an optimization model with the goal to minimize costs.

Define Decision Variables: Establish decision variables for the number of products delivered and binary variables for delivery decisions.

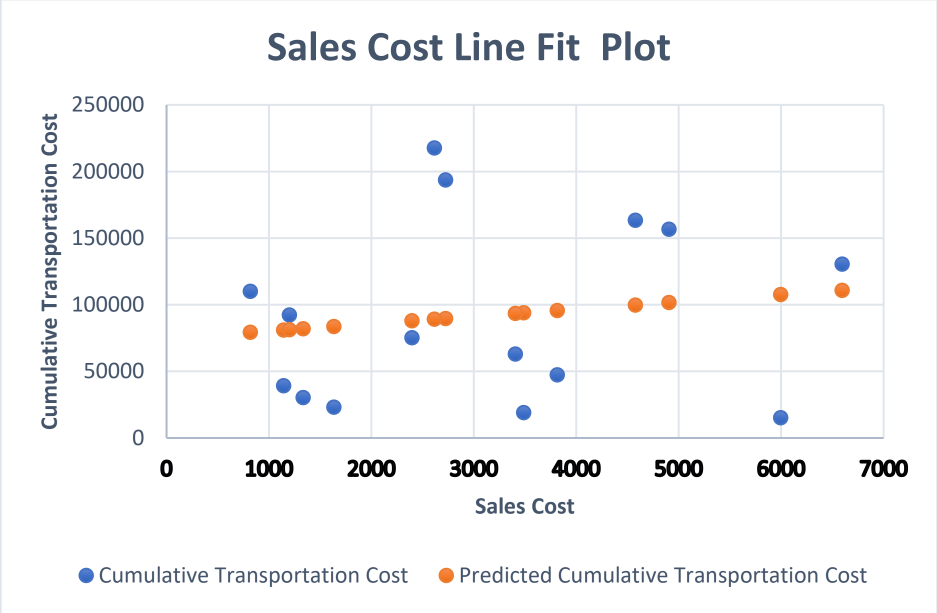
Update Objective Function: Formulate the objective function to minimize the combined delivery and storage costs.

Define Constraints: Implement constraints to ensure demand fulfilment, capacity limits, and proper binary variable association.

Solve the Problem: Use MATLAB's optimization tools to solve the model and display the results.

5.2 Display Outcome

Sales Point Lost	Sales Cost	Selected Factory	Cost Percentage	Cumulative Setup Cost	Cumulative Transportation Cost
5	5995.00	3	40.77	2725.00	15260.00
4	3488.00	3	0.19	2725.00	18966.00
3	1635.00	3	9.54	2725.00	23108.00
2	1334.25	2	0.93	4905.00	30302.00
1	1144.50	2	0.25	4905.00	39131.00
2	3815.00	2	0.29	4905.00	47424.00
3	3406.25	2	0.21	4905.00	62993.00
4	2398.00	2	0.36	4905.00	75210.00
5	1199.00	2	0.25	4905.00	92432.00
1	817.50	2	0.25	4905.00	110199.00
5	6594.50	3	0.38	7630.00	130582.00
1	4905.00	3	0.24	7630.00	156633.00
2	4578.00	4	0.39	10900.00	163500.00
3	2725.00	2	0.21	13080.00	193693.00
4	2616.00	2	0.36	13080.00	217782.00



5.3 Summary of Optimization

Objective Solution: Total cost is optimized to ₹47,774.70, including transportation, holding, and actual costs.
New Transportation Costs: Increased to ₹32,991.00.
Final Holding Cost: Optimized to ₹2,103.70.
Actual Cost: Set at ₹13,080.00.
Saved Demand: ₹46,652.00, equal to the initial lost sales.
Cumulative Transportation Cost: Consistent with the new optimized transportation costs of ₹32,991.00.
Elapsed Time: Efficient optimization process, taking only 0.08740156 seconds.

6. FINDINGS

The optimization process using AGALS aimed to minimize total costs, including transportation, holding, and actual costs, while addressing saved demand and cumulative transportation expenses. Initially, total costs were optimized to ₹43,830.00, with significant reductions in transportation costs to ₹29,900.00 and efficient holding costs at ₹1,930.00. Actual costs were set at ₹12,000.00, with recovered demand at ₹42,800.00. Post-optimization, total costs increased to ₹47,774.70, driven by adjusted transportation costs of ₹32,991.00 and holding costs of ₹2,103.70, while actual costs rose to ₹13,080.00. The recovered demand was ₹46,652.00, highlighting effective demand management and computational efficiency.

7. CONCLUSION & FUTURE SCOPE

Optimizing transportation costs is vital in supply chain management, directly affecting a company's financial performance. Efficient logistics strategies enhance profitability and competitiveness. With implementing effective strategies such as optimizing shipment sizes, choosing the right mode of transportation, consolidating shipments, and leveraging technology to track and analyse data, companies can reduce transportation costs while maintaining or improving service levels. By working together and sharing information, companies can identify areas for improvement and develop more efficient and cost-effective transportation solutions. In addition to reducing costs, optimizing transportation can also lead to environmental benefits such as reduced carbon emissions and energy consumption. As such, companies that prioritize sustainable transportation practices may also gain a competitive advantage in the marketplace. Continuously assessing and enhancing transportation strategies enables companies to bolster supply chain efficiency, curtail expenses, and elevate their competitive edge in the market.

REFERENCES

1) Bing, X., Bloemhof, J. M., Ramos, T. R. P., Barbosa-Povoa, A. P., Wong, C. Y., & van der Vorst, J. G. (2016). Research challenges in municipal solid waste logistics management. *Waste management*, *48*, 584-592.
2) Ghiani, G., Laganà, D., Manni, E., Musmanno, R., & Vigo, D. (2014). Operations research in solid waste management: A survey of strategic and tactical issues. *Computers & Operations Research*, *44*, 22-32.
3) Shaik, M. N., & Abdul-Kader, W. (2013). Transportation in reverse logistics enterprise: A comprehensive performance measurement methodology. *Production Planning & Control*, *24*(6), 495-510.
4) Du Toit, D., & Vlok, P. J. (2014). Supply chain management: A framework of understanding. *South african journal of industrial engineering*, *25*(3), 25-38.
5) Meyr, H., & Stadtler, H. (2014). Types of supply chains. In *Supply Chain Management and Advanced Planning: Concepts, Models, Software, and Case Studies* (pp. 55-69). Berlin, Heidelberg: Springer Berlin Heidelberg.
6) Parkhi, S., Joshi, S., Gupta, S., & Sharma, M. (2015). A Study of Evolution and Future of Supply Chain Management. *AIMS International Journal of Management*, *9*(2).
7) Nagurney, A. (2021). Supply chains and transportation networks. *Handbook of regional science*, 277-299.
8) Huq, F., Stafford, T. F., Khurrum S. Bhutta, M., & Kanungo, S. (2010). An examination of the differential effects of transportation in supply chain optimization modeling. *Journal of Manufacturing Technology Management*, *21*(2), 269-286.
9) Hamta, N., Ehsanifar, M., & Biglar, A. (2023). Optimization in Supply Chain Design of Assembled Products: A Case Study of HEPCO Company. *Iranian Journal of Management Studies*, *16*(1), 61-77.
10) Valizadeh, J., Boloukifar, S., Soltani, S., Hookerd, E. J., Fouladi, F., Rushchtc, A. A., ... & Shen, J. (2023). Designing an optimization model for the vaccine supply chain during the COVID-19 pandemic. *Expert Systems with Applications*, *214*, 119009.
11) Masum, F. H., Coppola, E., Field, J. L., Geller, D., George, S., Miller, J. L., ... & Dwivedi, P. (2023). Supply chain optimization of sustainable aviation fuel from carinata in the Southeastern United States. *Renewable and Sustainable Energy Reviews*, *171*, 113032.
12) Hashemi-Amiri, O., Ghorbani, F., & Ji, R. (2023). Integrated supplier selection, scheduling, and routing problem for perishable product supply chain: A distributionally robust approach. *Computers & Industrial Engineering*, *175*, 108845.
13) Wang, Y., Wang, N., & Han, P. (2023). Maritime location inventory routing problem for island supply chain network under periodic freight demand. *Computers & Operations Research*, *149*, 106042.
14) Zahraee, S. M., Shiwakoti, N., & Stasinopoulos, P. (2022). Application of geographical information system and agent-based modeling to estimate particle-gaseous pollutant emissions and transportation cost of woody biomass supply chain. *Applied Energy*, *309*, 118482.
15) Wu, J., Zhang, J., Yi, W., Cai, H., Li, Y., & Su, Z. (2022). Agri-biomass supply chain optimization in north China: Model development and application. *Energy*, *239*, 122374.

16) Yang, X. (2022). Optimization Algorithm of Logistics Transportation Cost of Prefabricated Building Components for Project Management. *Journal of Mathematics*, *2022*.
17) Peng, J., Chen, L., & Zhang, B. (2022). Transportation planning for sustainable supply chain network using big data technology. *Information Sciences*, *609*, 781-798.
18) Ashour, M., Elshaer, R., & Nawara, G. (2022). Ant Colony Approach for Optimizing a Multi-Stage Closed-Loop Supply Chain with a Fixed Transportation Charge. *Journal of Advanced Manufacturing Systems*, *21*(03), 473-496.
19) Ebrahimi, S. B., & Bagheri, E. (2022). Optimizing profit and reliability using a bi-objective mathematical model for oil and gas supply chain under disruption risks. *Computers & Industrial Engineering*, *163*, 107849.
20) Qu, D., Shang, Y., Wu, D., & Sun, G. (2021). Filled function method to optimize supply chain transportation costs. *Journal of Industrial and Management Optimization*.
21) Sang, T. T., Thu, N. M., Khoi, T. H., Huong, N. T. K., & Van Thanh, N. (2021). The Optimization of Transportation Costs in Logistics Enterprises during the Covid-19 Pandemic. *ARRUS Journal of Mathematics and Applied Science*, *1*(2), 62-71.
22) Jeong, H., Karim, R. A., Sieverding, H. L., & Stone, J. J. (2021). An application of GIS-linked biofuel supply chain optimization model for various transportation network scenarios in Northern Great Plains (NGP), USA. *BioEnergy Research*, *14*(2), 612-622.
23) Pantoleontos, G., Tsongidis, N. I., Daskalos, E., & Konstandopoulos, A. G. (2021). Development of transportation cost functions and optimization of transportation networks for solar-aided utilization of CO2. *International Journal of Greenhouse Gas Control*, *112*, 103528.
24) Shahmoradi-Moghadam, H., & Schönberger, J. (2021). Joint optimization of production and routing master planning in mobile supply chains. *Operations Research Perspectives*, *8*, 100187.
25) Beheshtinia, M. A., Feizollahy, P., & Fathi, M. (2021). Supply Chain Optimization Considering Sustainability Aspects. *Sustainability*, *13*(21), 11873.
26) Zahraee, S. M., Golroudbary, S. R., Shiwakoti, N., Stasinopoulos, P., & Kraslawski, A. (2020). Transportation system analysis of empty fruit bunches biomass supply chain based on delivery cost and greenhouse gas emissions. *Procedia Manufacturing*, *51*, 1717-1722.
27) Nunes, L. J. R., Causer, T. P., & Ciolkosz, D. (2020). Biomass for energy: A review on supply chain management models. *Renewable and Sustainable Energy Reviews*, *120*, 109658.
28) Abdolazimi, O., Esfandarani, M. S., Salehi, M., & Shishebori, D. (2020). Robust design of a multi-objective closed-loop supply chain by integrating on-time delivery, cost, and environmental aspects, case study of a Tire Factory. *Journal of Cleaner Production*, *264*, 121566.
29) Kozak, T., Madlenak, R., & Neszmelyi, G. I. (2020). How the lean management decision influences the transportation cost in the supply chain?. *Communications-Scientific letters of the University of Zilina*, *22*(4), 13-19.
30) Hosseini-Motlagh, S. M., Samani, M. R. G., & Homaei, S. (2020). Blood supply chain management: robust optimization, disruption risk, and blood group compatibility (a real-life case). *Journal of Ambient Intelligence and Humanized Computing*, *11*(3), 1085-1104.
31) Visser, L., Hoefnagels, R., & Junginger, M. (2020). Wood pellet supply chain costs–A review and cost optimization analysis. *Renewable and Sustainable Energy Reviews*, *118*, 109506.
32) Al Amin, M., & Rahman, A. (2019). Development of a model to optimize the supply chain transportation cost. *Journal of Engineering*, *10*(1), 67-76.
33) Tamannaei, M., & Rasti-Barzoki, M. (2019). Mathematical programming and solution approaches for minimizing tardiness and transportation costs in the supply chain scheduling problem. *Computers & Industrial Engineering*, *127*, 643-656.

34) Chen, P. H., & Nguyen, T. C. (2019). A BIM-WMS integrated decision support tool for supply chain management in construction. *Automation in Construction*, *98*, 289-301.
35) Paksoy, T., Çalik, A., Kumpf, A., & Weber, G. W. (2019). A new model for lean and green closed-loop supply chain optimization. In *Lean and Green Supply Chain Management* (pp. 39-73). Springer, Cham.
36) Karimi, B., Hassanlu, M. G., & Niknamfar, A. H. (2019). An integrated production-distribution planning with a routing problem and transportation cost discount in a supply chain. *Assembly Automation*.
37) Jeong, H., Sieverding, H. L., & Stone, J. J. (2019). Biodiesel supply chain optimization modeled with geographical information system (GIS) and Mixed-Integer Linear Programming (MILP) for the northern great plains region. *BioEnergy research*, *12*(1), 229-240.
38) Sitek, P., & Wikarek, J. (2012). Mathematical programming model of cost optimization for supply chain from perspective of logistics provider. *Management and Production Engineering Review*, *3*, 49-61.