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22nd

INTERNATIONAL LOGISTICS AND SUPPLY CHAIN CONGRESS

Book of Abstracts and Full texts

Smart and Sustainable City Logstics and Transportation

October 17-18, 2024
09:00 - 17:00

Vadi Campus H
V-123 Conference Hall

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Book of Abstract and Full Texts

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Dilay Celebi, Istanbul Technical University, Türkiye, celebid@itu.edu.tr
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Eren Ozceylan, Gaziantep University, Türkiye, erenozceylan@gmail.com
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Esther Alvarez, University Of Deusto, Spain, esther.alvarez@deusto.es.
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Ezgi Uzel Aydınocak, Beykoz University, Türkiye, ezgiuzelbeykoz.edu.tr
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Fatiha Naoui-Outini, Excelia Business School, France, fatiha.naoui@unicaen.fr
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Frank Witlox, Ghent University, Belgium, frank.witlox@ugent.be
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Gulsen Serap Cekerol, Eskisehir Technical University, Türkiye, gscekerol@eskisehir.edu.tr
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Helena Vidova, Slovak University of Technology in Bratislava, Slovakia, helena.kvasnicova@stuba.sk
Ibrahim Akben, Hasan Kalyoncu University, Türkiye, ibrahim.akben@hku.edu.tr
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Ilhami Çolak, İstinye University, Türkiye, ilhami.colak@istinye.edu.tr, IEEE Senior Member
Ilker Murat Ar, Karadeniz Technical University, Türkiye, ilkermurat.ar@sanayi.gov.tr
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Joanna Nowakowska-Grunt, Czestochowa University of Technology, Poland j.nowakowska-grunt@pcz.pl
Joanna Zarebska, University of Zielona Gora, Poland, j.zarebska@wez.uz.zgora.pl
Jorgen Kristiansen, Aalborg University, Denmark
Kadir Ardıç, Kırgızistan-Türkiye Manas Üniversitesi, kadir.ardich@manas.edu.kg
Katarzyna Cheba, West Pomeranian University of Technology, Poland, katarzyna.cheba@zut.edu.pl
Koksal Hazır, Toros University, Türkiye, koksal.hazir@toros.edu.tr
Krzysztof Witkowski, University of Zielona Gora, Poland, k.witkowski@wez.uz.zgora.pl
Lenny Koh, University of Sheffield, UK, s.c.l.koh@sheffield.ac.uk
Maciej Szymczak, Poznan University of Economics and Business, Poland, maciej.szymczak@ue.poznan.pl
Maja Kiba-Janiak, Wroclaw University of Economics, Poland, maja.kiba-janiak@ue.wroc.pl
Maksim Grečkin,Panevezio Kolegija / State Higher Education Institution, info@aurida-logistics.eu
Mariusz Szuster, Poznan University of Economics, Poland, mariusz.szuster@ue.poznan.pl
Martin Straka, Technical University of Kosice, Slovakia, martin.straka@tuke.sk
Mathieu Van Vyve, Catholic University of Louvain, Belgium, mathieu.vanvyve@uclouvain.be
Mazlum Celik, Hasan Kalyoncu University, Türkiye, mazlum.celik@hku.edu.tr
Mehmet Tanyas, Maltepe University, Türkiye, mehmettanyas@maltepe.edu.tr
Mesut Yavuz, University of Alabama, USA, myavuz@cba.ua.edu
Michael Grabinski, Neu-Ulm University, Germany, michael.grabinski@hs-neu-ulm.de
Michal Balog, Technical University of Kosice, Slovakia, michal.balog@tuke.sk
Milos Cambal, Slovak University of Technology in Bratislava, Slovakia, milos.cambal@stuba.sk
Muhammed Bamyacı, Kocaeli University, muhammedbamyaci@gmail.com
Murat Baskak, Istanbul Technical University, Türkiye, baskam@itu.edu.tr
Mu-Yen Chen, National Cheng Kung University, Taiwan, mychen@ieee.org, IEEE Member
N. Elif Kongar, Fairfield University, USA, ekongar@fairfield.edu
Nahid Jafari, State University of New York, USA, jafarin@farmingdale.edu
Nelson Oly Ndubisi, Griffith University, Malaysia, nndubisi@qu.edu.qa
Nezih Altay, DePaul University, USA, naltay@depaul.edu
Nilgun Morali, Hasan Kalyoncu University, Türkiye, nilgun.morali@hku.edu.tr
Noyan Sebla Sezer, İstinye University, Türkiye, sebla.sezer@istinye.edu.tr
Okan Tuna, Dokuz Eylül University, Türkiye, otuna@deu.edu.tr
Omer Ozturkoglu, Yasar University, Türkiye, omer.ozturkoglu@bcu.ac.uk
Ozalp Vayvay, Marmara University, Türkiye, ozalp@marmara.edu.tr

Ozgur Ozpeynirci, Izmir Economy University, Türkiye, ozgur.ozpeynirci@gmail.com
Pawel Kuzdowicz, University of Zielona Gora, Poland, p.kuzdowicz@wez.uz.zgora.pl
Per Agrell, Catholic University of Louvain, Belgium, per.agrell@uclouvain.be
Radim Lenort, Skoda Auto University, Czech Republic radim.lenort@savs.cz
Rainer Leisten, University of Duisburg-Essen, Germany
Rasa Glinskienė,Panevezio Kolegija / State Higher Education Institution, rasa.glinskiene@panko.lt
Rene De Koster, Erasmus University, Netherland, rkoster@rsm.nl
Şafak Tercan, Hasan Kalyoncu Üniversitesi, safak.tercan@hku.edu.tr
Saliha Karadayı Usta, İstinye University, Türkiye, saliha.usta@istinye.edu.tr
Sebastian Saniuk, University of Zielona Gora, Poland s.saniuk@wez.uz.zgora.pl
Seyda SerdarAsan, Istanbul Technical University, Türkiye, serdars@itu.edu.tr
Seyil Nacimudinova Kırgızistan-Türkiye Manas Üniversitesi seyil.najimudinova@manas.edu.kg
Sezer Bozkuş Kayhaoğlu Kırgızistan-Türkiye Manas Üniversitesi sezer.kahyaoglu@manas.edu.kg
Soner Esmer, Kocaeli University, Türkiye, soneresmer@gmail.com
Stefan Seuring, Kassel University, Germany
Thomas Hanke, FOM University of Applied Sciences for Economics and Management, thomas.hanke@fom.de
Tolga Bektas, Southampton University, UK, T.Bektas@liverpool.ac.uk.
Umut R. Tuzkaya, Yildiz Technical University, Türkiye, umut tuzkaya@yildiz.edu.tr
Urszula Bąkowska-Morawska, Wroclaw University of Business, Poland, urszula.bakowska-morawska@ue.wroc.pl
Vedat Verter, Mcgill University, Canada, vedat.verter@queensu.ca
Yavuz Gunalay, Behcesehir University, Türkiye, yavuz.gunalay@eas.bau.edu.tr
Yigit Kazancioglu, Yasar Univeersity, Türkiye, yiğit.kazancioglu@yasar.edu.tr
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Zehra Vildan Serin, Hasan Kalyoncu University, Türkiye, zvildan.serin@hku.edu.tr

Organizing / Technical Committee

Saliha Karadayı Usta, İstinye University, Türkiye, saliha.usta@istinye.edu.tr
Emre Çakmak, İstinye University, Türkiye, emre.cakmak@istinye.edu.tr
Gulcin Buyukozkan, LODER, Türkiye, gulcin.buyukozkan@gmail.com
Mehmet Tanyas, LODER, Türkiye, mehmettanyas@maltepe.edu.tr
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Ömer Karakoç, İstinye University, Türkiye, omer.karakoc@istinye.edu.tr

Local Committee

Saliha Karadayı Usta, İstinye University, Türkiye, saliha.usta@istinye.edu.tr
Emre Çakmak, İstinye University, Türkiye, emre.cakmak@istinye.edu.tr
Erfan Babaee Tirkolaee, İstinye University, Türkiye, erfan.babaee@istinye.edu.tr
Noyan Sebla Sezer, İstinye University, Türkiye, sebla.sezer@istinye.edu.tr
Ömer Karakoç, İstinye University, Türkiye, omer.karakoc@istinye.edu.tr

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COLD CHAIN AS A RESILIENCE FEATURE OF THE SUPPLY CHAIN IN CHANGING CONDITIONS OF THE ENVIRONMENT

Zbigniew Bentyn, Sylwia Konecka

Poznań University of Economics and Business, zbigniew.bentyn@ue.poznan.pl
Poznań University of Economics and Business, sylwia.konecka@ue.poznan.pl

ABSTRACT:

Purpose:
This paper assesses the adequacy of existing Cold Chain technologies for use during increased temperature, increased demand, and required environmental protection. Adopting cold chain technologies due to observed environmental changes significantly improves the resilience of the supply chain.

Study design/methodology/approach:
The paper consists of an analysis of existing CC technologies conditions across industrial standards that relies on two stages: description of regulations regarding cold chain technologies and verification of the theoretical approach towards cold chain applications in the environmentally friendly supply chain.

Findings:
Energy usage restrictions and many regulatory requirements affect existing supply chains. Due to increased ambient temperatures, maintaining optimal temperatures in storage facilities becomes more difficult. This can lead to spoilage of perishable goods and require additional energy to maintain cool storage conditions. Product shortages and price fluctuations for various goods can also occur, creating uncertainty and instability within supply chains.

Originality/value:
Cold chain technologies improve the quality and efficiency of supply chain processes, yet changing environmental conditions make such systems more energy-hungry. Therefore, the demand for reliable and environmentally friendly cold chain solutions is increasing.

KEYWORDS

Supply chain management, cold chain, resilience, green supply chain, logistics

INTRODUCTION

Sustaining supply chain resilience may be one of the main goals in the world economy nowadays. Many events and disruptions create logistics barriers and significantly influence logistics operations. One of the disruptors is the changing climate. Observations and scientific research bring conclusions about factors and directions of changes awaiting the world economy. Adaptation of the supply chains is twofold. On the one hand, there is an observed effort to secure the flow in the global supply chain by employing, among others, cold chain technologies. On the other hand, curbing emissions in the logistics processes because of new regulations. Cold chain technologies may maintain safety for some reasons in logistics operations, but at the same time, they should deliver environmentally friendly solutions. These conditions pressure logistics operators and force them to assess existing cold chain technologies [1]. Overall, using cold chain technologies increases the supply chain's resilience by mitigating risks, enhancing product quality, improving visibility and traceability, reducing waste, ensuring regulatory compliance, and enabling flexible responses to disruptions. By investing in cold chain infrastructure and best practices, businesses can build a more resilient supply chain capable of withstanding unforeseen challenges and consistently delivering value to customers.

LITERATURE REVIEW AND THEORETICAL FRAMEWORK

Resilience of the supply chain is a prerequisite for sustaining international operations. Long and complex relations, natural in global logistics, increase risk and multiply the number of potential disruptions. Li et al.'s [22] conclusion definition of supply chain resilience (SCR) as responding to disruption and returning to its original state, stresses maintaining the previous level of operationality. In this context, Shishodia et al. [25] state that the supply chain resilience framework improves thanks to diversification, international partnerships, onshoring, and demand management, in addition to inventory building and preserving capacity. McKinsey report compares the level of preparedness of business players in the supply chain. Well prepared and unprepared to react to extreme weather events. The report concludes with a warning pointing out a significantly more significant loss in sales happening for those unprepared (-5% to: -35%) [32]. The proposed study supports actions towards preparedness of the supply chain; however, it limits the scope of potential threats to extreme weather conditions. Aguila and ElMaraghy [2] describe resilience in SC as balancing the desired performance and the costs of achieving resilience. One of the main disruptors is climate change, and Baskin observed that supply chain units need mitigation plans and strategies to bring back a previous normal state of operations in SC [5]. It is proven that preserving resilience stresses the identification of risks and decreases potential impact while securing the revenues of supply chain participants [3]. All that consideration is critical in the context of the real political situation in the year 2024. As shown in the graph Figure 1, the fluctuation of the GSCPI index in recent years become significantly bigger. The influence of Ukraine-Russia and Izrael-Palestine conflicts happening right after Covid pandemic crisis may have multiplied pressure on the global supply chain.

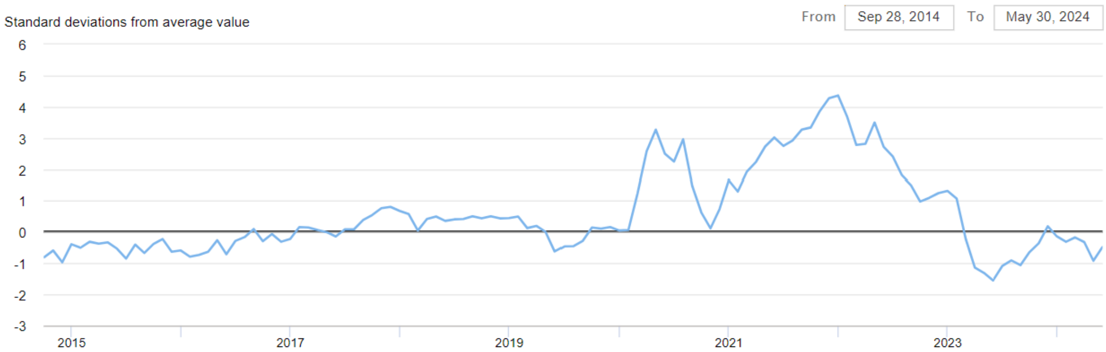

FIGURE 1. Ten-year period observation in the fluctuation of GSCPI index.
Source: Global Supply Chain Pressure Index (GSCPI), https://www.newyorkfed.org/research/policy/gscpi#/interactive.

Maintaining resilience is a crucial aspect of sustaining the logistics flow and, therefore, supporting the global economy. In conclusion, resilience is a central issue, and therefore, assessing ways of helping it is worth an effort, especially in a changing and demanding environment. Due to the increasing complexity and uncertainty in the global agri-food sector, stakeholders, including farmers, agribusinesses, and governments, must adapt their risk management strategies. The World Bank's Rapid Agricultural Supply Chain Risk Assessment provides a valuable framework for identifying and addressing potential risks within the entire agri-food system. This tool can help assess the vulnerability of supply chains, evaluate the severity of potential losses, and explore various risk mitigation options [10]. The tool provided by the World Bank helps to assess the threat of what is beneficial for the business participating in the supply chain. Unfortunately, to effectively secure the logistics flow, there are additional investments needed. That is why cold chain procedures encompass a set of practices and protocols designed to maintain optimal temperature conditions for temperature-sensitive products throughout the supply chain. Effective cold chain procedures are the backbone of maintaining product integrity in temperature-sensitive supply chains [30]. By implementing these procedures, companies can ensure the quality, safety, and regulatory compliance of their products.

CHANGING ENVIROMENTAL CONDITIONS

Years of industrialisation and development have positive and negative consequences. Leaving the obvious positive one it is certain that one of the negatives is global warming. Observed changes consisting of increased temperature accompanied by increased demand create a challenging mix for the global supply chain - Figure 2. Moreover, regulations created to withhold environmental change put pressure on logistics operations and require environmental protection enforced by restrictions.

Decreased use of energy, restrictions towards emissions and consequently, change of means of transportation are some of the factors modelling the modern supply chain. As noted by [28], change in climate adversely impacts human societies, business operations and the environment. Therefore, climate change-prone operations become an emanation of corporate strategic responses to sustainability issues [13]. Additionally, new customers require, as Christopher predicted, conscious strategies delivered by supply chains of corporations addressing climate change issues [12]. One of them is reducing emissions across the supply chain. Partnering with suppliers who prioritize sustainable practices, such as using renewable energy or adopting water-saving techniques. Utilizing more sustainable transportation options like electric vehicles, rail freight, or biofuels for long-haul journeys. Optimizing routes, utilizing larger capacity vehicles, and improving warehouse efficiency to reduce overall transportation emissions. Investing in energy-efficient equipment and appliances throughout the supply chain, particularly including cold chain technologies. Moreover, strategies of this kind also refer to resource efficiency. Embracing circular economy principles by incorporating recycled materials into packaging and products, extending product lifespans, and exploring opportunities for remanufacturing. Setting ambitious yet achievable emissions reduction targets across the supply chain and working towards transparent reporting on progress. Collaborating with suppliers to understand their environmental footprints and jointly develop strategies for emission reduction and resource efficiency. By implementing these strategies, they can reduce their environmental impact while improving resource efficiency. Participating in ongoing industry-wide initiatives and partnerships focused on developing and implementing sustainable supply chain practices. One example of such a strategic goal is Walmart's Project Gigaton, aiming to reduce a gigaton of greenhouse gas emissions from its global supply chain by 2030. Similarly, Maersk's Carbon Neutral Goal sets a target of achieving carbon neutrality across its entire operations by 2040. Unilever's Sustainable Living Plan outlines ambitious goals for reducing the environmental footprint of its products throughout its lifecycle, including supply chain practices.

Supply chains should adapt, remembering that vulnerability to climate change is expressed as a function of exposure, sensitivity, and adaptive capacity in the context of resilience [10]. In the case of the supply chain, precisely intrinsic sensitivity to the hazard and a lack of capacity to modify, absorb, and eventually recover from losses may threaten its functioning in the long term.

Due to innovations and gathered experience, there are particular ways to secure logistics operations. Some of the resistance strategies to cushion on the food supply chain may include climate-controlled storage facilities, improved crop cleaning and drying, better storage to avoid losses to pests, additional processing to reduce spoilage, and more robust packaging to withstand difficult transport conditions [29]. Naturally, the most vulnerable kind of merchandise is food. The fragility of cargo, the complexity of the supply chain, and the degree of inter-connectedness of and dependency on other industries make a dedicated supply chain prone to disruption [7].

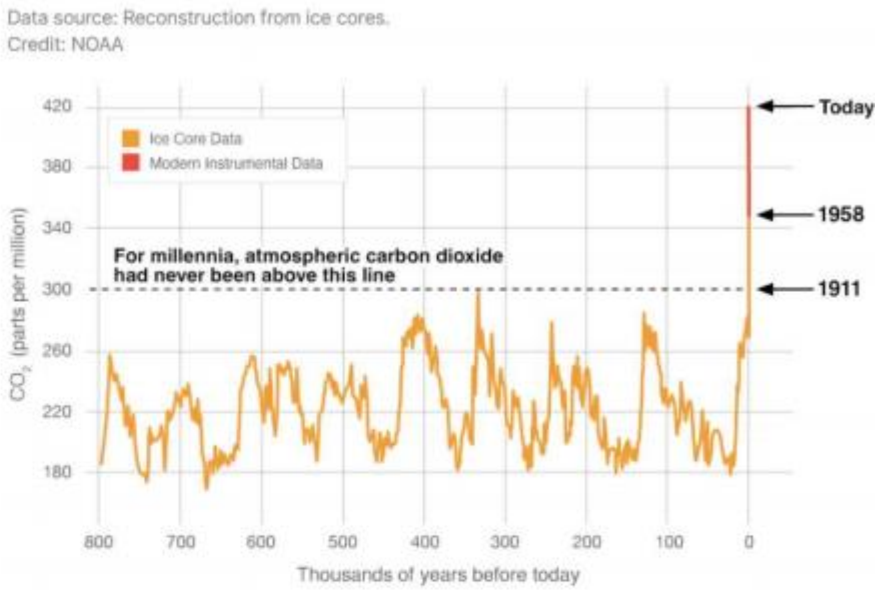

FIGURE 2. Reconstruction of carbon dioxide levels from ice cores in time. https://climate.nasa.gov/vital-signs/carbon-dioxide/?intent=121

Globally, the ramifications of severe weather phenomena like floods, droughts, and hailstorms are presently compromising the efficiency of supply chains. This is evident through decreased agricultural output, damage to processing and transportation facilities, and the decline in export revenue. This pattern is foreseen to persist and exacerbate, propelled by climate change-induced heightened occurrences of extreme events, alterations in precipitation trends, and escalating temperatures [21].

A global supply chain is intrinsically connected with strategies and business models of Multinational Enterprises (MNEs) The influence MNE's of on global greenhouse gas (GHG) emissions necessitates their inclusion in comprehensive climate change mitigation strategies. Proactive MNEs present a unique opportunity for substantial emissions reductions through the implementation of stringent sustainability standards and facilitation of green technology transfers throughout their extensive supply chains, potentially impacting millions of producers.
Understanding and employing various sustainability strategies in global supply chains is dependent on business decisions. Unfortunately, further analysis indicates a concerning trend, with the combined direct and indirect emissions from only 157 large MNEs potentially reaching 60% of global industrial emissions. Moreover, the data suggests insufficient commitment to decarbonization efforts within the majority of these MNEs. Only 25% have pledged to achieve net-zero GHG emissions by 2050, with even fewer outlining a concrete decarbonization strategy (long-term: 20%, medium-term: 13%, short-term: 5%) [27]. Due to the policy shift towards environmental protection, it is expected that also supply chain operations will face more regulations in

the form of monitoring emissions, direct laws and regulations, new taxes, incentives or fiscal support and pressure towards corporate commitments and obligatory information.

DESCRIPTION OF REGULATIONS REGARDING COLD CHAIN TECHGNOLOGIES

Due to the international reach and complexity of tasks undertaken in the global supply chain, there isn't a single, universal set of regulations regarding cold chain technologies. However, regulations from various bodies apply depending on the specific application and region. One differentiator is industry. Two main categories here are pharmaceuticals and food.
In the pharmaceutical group, the Food and Drug Administration (FDA) in the US has regulations (CFR 21 Part 211) for drug storage and handling, which include temperature control requirements. Similar regulations exist in other countries from their health agencies. Similarly, food category. In most of the countries, regulations for food storage and transportation often come from national or regional food safety agencies. They typically focus on maintaining safe temperatures for specific food types to prevent spoilage or growth of pathogens [29].
Another differentiator is the subject. Regulations describe limits in the areas of temperature, data monitoring, equipment, and packaging. In the case of temperature control, regulations may specify the required temperature ranges for different products during storage and transportation. Data monitoring in some country's regulations may require recording and maintaining temperature data throughout the cold chain to ensure compliance. Equipment and packaging: Regulations might exist for the qualification and validation of cold chain equipment (refrigerated trucks, freezers) and packaging materials (insulated containers) to ensure they meet performance standards. Despite some differences due to the location of specific logistics operations, the following bodies deliver rules for the industry. Among them are governmental health agencies like the FDA in the US, Industry associations related to pharmaceuticals, food, or cold chain logistics and international organizations like ISO (International Organization for Standardization) publish standards for good practices in cold chain management (e.g., ISO 22000 for food safety).

However, the ISO 22000 standard itself doesn't provide a specific set of rules for cold chain management. It focuses on establishing a Food Safety Management System (FSMS) that incorporates all aspects of food safety, including temperature control. Therefore ISO 22000 can be used to develop a cold chain management plan that aligns specific needs and complies with other relevant regulations.
Incorporating the following elements into FSMS, ISO 22000 helps ensure your cold chain processes are effectively managed to minimize the risk of food spoilage or contamination due to temperature fluctuations.
Hazard Analysis and Critical Control Points (HACCP) involve identifying potential hazards throughout the food chain, including temperature control failures. For cold

chain processes, this might involve identifying critical control points (CCPs) like receiving temperatures, storage temperatures, and transportation conditions.
Operational prerequisite programs (PRPs) are programs that establish the basic conditions for food safety and can be tailored to address cold chain management. Examples of PRPs related to a cold chain could include [17]:
Calibration and maintenance procedures for temperature monitoring equipment.
Training for personnel involved in cold chain activities on proper temperature control procedures.
Documentation for temperature control protocols and monitoring records.
Validation of cleaning and sanitation procedures for cold chain equipment.
Finally, while ISO 22000 doesn't dictate specific temperatures, it requires you to determine the appropriate temperature based on the food product and relevant regulations. Additionally, the FSMS should include procedures for monitoring temperatures at CCPs throughout the cold chain and maintaining records to demonstrate compliance. The system should define procedures for taking corrective actions if temperature deviations occur to minimise food safety risks. Overall, ISO 22000 provides a framework for managing food safety, including cold chain processes. By implementing an FSMS that incorporates these principles, you can ensure your cold chain operations are aligned with best practices and contribute to overall food safety. A practical example of the application of regulations is a set of the IATA Temperature Control Regulations (TCR), addressing temperature management issues identified by the industry [18]. Thanks to collaborations with leading authorities and organisations, IATA has improved preparedness for COVID-19 vaccine transportation, which, in the past, posed a high risk to the pharmaceutical supply chain.

COLD CHAIN APPLICATIONS IN THE ENVIRONMENTALLY FRIENDLY SUPPLY CHAIN

Climate changes and customer pressure influence supply chain strategies. A proper cold supply chain that takes sustainable suppliers into account is considered necessary in the demanding modern market. Cold product manufacturers and suppliers adopt sustainable procedures and try to comply with sustainable standards. It takes time and investment in the infrastructure, but in the long term, it may secure market attention to a product and service. The suppliers of frozen foods, often dispersed in remote locations, need to incorporate sustainable practices to ensure that their products are accepted globally [20]. Characteristics of cold chain technologies help to do just that. One of the main goal in application of cold chain is preserving product integrity. Cold chain technologies maintain optimal temperature conditions to safeguard the quality and efficacy of temperature-sensitive products. The outcome characterizes CCT as environmentally friendly, considering its role in maintaining optimal temperature conditions for temperature-sensitive products. Cold chain technologies significantly reduce food spoilage by maintaining proper temperatures during storage, transportation, and distribution [16]. Less food waste translates to less environmental impact associated with food production, such as water usage, land use, and greenhouse gas emissions. In the process, proper cold chain technologies deliver improved efficiency. Efficient cold chain systems optimize energy consumption by maintaining precise temperatures without excessive cooling [26] This can be achieved through advancements like insulated packaging, intelligent sensors, and route optimization software, leading to a lower carbon footprint.

Adjusting the temperature of transportation and storage allows CCT to minimize the use of preservatives. Cold chain technologies often significantly reduce the need for chemical preservatives in food products [6]. This is because optimal temperatures inhibit microbial growth, allowing for a more natural and potentially healthier product while minimizing the environmental impact of chemical production and disposal. Similarly to the food industry, temperature-sensitive pharmaceuticals and vaccines are very vulnerable. Cold chain technologies ensure their efficacy by preventing degradation. This reduces the need for overproduction and disposal of expired medication, minimizing resource use and potential environmental contamination from pharmaceuticals.

The development of cold chain technologies includes environmentally friendly practices. These consist of utilizing recyclable or biodegradable packaging materials, using natural refrigerants with lower environmental impact, and adopting renewable energy sources for powering cold storage facilities [15]. Thanks to CCT, logistic operators may mitigate economic risks and reduce the risk of spoilage, degradation, and supply chain disruptions.

Another critical goal of cold chain management is ensuring regulatory compliance. Cold chain practices preserve compliance with stringent regulatory requirements governing the storage and transportation of temperature-sensitive goods. There are three aspects of reaching this goal: temperature monitoring, documentation and traceability and standard operating procedures. Thanks to temperature monitoring, using validated temperature sensors delivers data accuracy and compliance with regulatory requirements. Continuous temperature monitoring throughout the cold chain is crucial for compliance. This involves deploying data loggers, thermometers, and other monitoring systems to track and record temperatures during storage, transportation, and handling [19]. In the area of documentation and traceability, electronic data management systems applied often in supply chain management facilitate efficient recordkeeping and traceability, enhancing compliance efforts. Maintaining detailed records of temperature data, including timestamps and product identification, is essential for demonstrating compliance during audits [9]. This allows for tracing product movements and identifying potential temperature deviations, effectively securing the risk of distributing spoiled goods. Another effort in creating standard operating procedures helps deliver regulatory compliance. Developing and implementing standardized procedures for all cold chain activities is critical. These procedures should outline protocols for temperature monitoring, handling practices, corrective actions in case of deviations, and equipment maintenance. Reliability in delivering operations is supported by the documentation created and secured throughout the whole supply chain [23]. This upholds consistency and compliance with regulatory requirements across the cold chain. By implementing robust cold chain practices and a focus on regulatory compliance, companies can ensure the integrity and safety of temperature-sensitive products throughout the supply chain. This not only safeguards public health but also fosters market trust and facilitates global trade supporting supply chain operations.

Cold chain infrastructure also plays a critical role in enhancing supply chain flexibility, particularly for products sensitive to temperature fluctuations. This allows businesses to adapt and thrive in dynamic environments with changing environmental conditions. Cold chain infrastructure enables agile responses to changing environmental conditions, allowing businesses to adapt and thrive in dynamic environments. Climate change is increasing the frequency and intensity of extreme weather events like droughts, floods, and heatwaves. These events can disrupt transportation routes, damage infrastructure, and disrupt power supplies, impacting cold chain operations. Cold chain infrastructure consisting of refrigerated storage facilities, insulated packaging, and controlled atmosphere transport allows for maintaining optimal temperatures regardless of external conditions [11]. This ensures product quality and safety even during environmental disruptions. Robust cold chain infrastructure supports the use of alternative transportation options like refrigerated trucks or air cargo even when traditional routes are disrupted due to weather events or infrastructure damage. The real-time monitoring and control deliver data, allowing adaptation of the supply chain operations. Advancements in sensor technology and data management systems facilitate real-time monitoring of temperature conditions throughout the cold chain [24]. This allows companies to proactively respond to any deviations caused by environmental changes and take corrective actions. Investing in resilient and flexible cold chain infrastructure is not just about maintaining product quality but also about building agility in the face of environmental uncertainty. This allows businesses to adapt their supply chains effectively, minimize disruptions, and thrive in a dynamic global marketplace.

An environmentally friendly supply chain goal is to minimize unnecessary waste. Cold chain technologies play a crucial role in minimizing waste within the supply chain by extending the shelf life of perishable products. This allows for efficient resource utilization throughout the food production cycle, from farm to fork. Here's a breakdown with scientific evidence: By extending the shelf life of perishable products, cold chain technologies contribute to reducing supply chain waste and optimizing resource utilization. The Food and Agriculture Organization (FAO) estimates that one-third of global food production is lost or wasted [16]. This translates to significant environmental impact, including wasted water resources, land use, and greenhouse gas emissions. Perishable products like fruits, vegetables, and meat are highly susceptible to spoilage due to microbial growth and biochemical degradation. Their shelf life, the period they remain safe and maintain quality, is limited by these factors. By extending shelf life and minimizing waste, cold chain technologies optimize resource utilization throughout the food supply chain.

Additionally, reduced water usage is another environmental goal of a green supply chain. Less food spoilage means less water is wasted during production, transportation, and storage.

Similarly, lower land use decreases environmental impact and may benefit producers, distributors, and consumers. Food production requires substantial land resources. With less food waste, the demand for agricultural land decreases. Reducing greenhouse gas emissions is a very important area of focus in the supply chain due to many transportation operations. However, wasting food contributes to greenhouse gas emissions, including methane from decomposition [4]. Minimizing waste, therefore, reduces this environmental burden often caused by worldwide distribution operations.

The environmental impact of cold chain technologies is a complex issue with both positive and negative aspects. Cold chain technologies significantly reduce spoilage of perishable goods, leading to less food waste. This translates to reduced environmental impact associated with food production, such as water usage, land use, and greenhouse gas emissions. Cold chain technologies often reduce the need for chemical preservatives in food products. This is because optimal temperature control inhibits microbial growth, allowing for a potentially healthier product and minimizing environmental impact from chemical production and disposal. Advancements in cold chain technologies include better insulation materials, energy-efficient refrigeration systems, and route optimization software. These advancements can lead to reduced energy consumption compared to older technologies. However refrigeration units used in storage facilities and transportation require significant energy consumption. This can contribute to greenhouse gas emissions depending on the source of electricity used. Traditional refrigerants used in some cold chain systems can be potent greenhouse gases. Strict regulations are phasing out some harmful refrigerants but leaks and improper disposal of older refrigerants can still contribute to climate change [14]. Disposable packaging materials used in cold chain logistics can generate waste. However, developments in reusable and recyclable packaging are offering more sustainable options. There is a possibility to point outs environmentally friendly CC technologies. Replacing traditional refrigerants with ammonia, carbon dioxide, or hydrocarbons offers a lower environmental impact. These natural refrigerants have lower global warming potential. Powering cold storage facilities with solar, wind, or hydroelectric energy significantly reduces reliance on fossil fuels and associated emissions. Utilizing thermal energy storage systems can optimize energy consumption by storing excess cooling capacity during off-peak hours for use during peak demand [11]. While existing cold chain technologies have drawbacks, advancements are constantly evolving towards a more sustainable future [8]. Focusing on energy efficiency, natural refrigerants, renewable energy sources, and waste reduction strategies will be crucial for minimizing the environmental impact of cold chain operations.

CONCLUSION

CCT will have to be sustained to continue operating despite demanding conditions. Environmental changes constantly pressure the global supply chain. Increased temperature due to emissions is one cause of extreme heat events like droughts and heat waves, which damage crops, reduce agricultural yields, and limit the availability of raw materials for various industries. Rising temperatures can lead to more frequent and intense storms, floods, and wildfires. This can damage transportation infrastructure like roads, bridges, railways, and ports, causing delays and disruptions to supply chains. Maintaining optimal temperatures in storage facilities also becomes more difficult due to increased ambient temperatures. This can lead to spoilage of perishable goods and require additional energy to sustain cool storage conditions.

Increased demand in some market segments may lead to another negative impact. Disruptions in production and transportation due to extreme weather events can lead to product shortages and price fluctuations for various goods, creating uncertainty and instability within supply chains. Moreover, unpredictable weather patterns make it difficult for businesses to forecast demand and maintain optimal inventory levels accurately.

Required environmental protection may lead to stricter regulations on energy consumption in various sectors, including cold chain operations. This may drive the development and adoption of energy-efficient refrigeration systems, better insulation materials, and optimisation software for storage and transportation. Regulations and economic incentives may encourage the integration of renewable energy sources like solar, wind, and hydropower to power cold storage facilities. Additionally, cold chain practices improve by increasingly embracing principles of a circular economy, minimising waste and maximising resource reuse and recycling.

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A GAMIFICATION FRAMEWORK FOR CROWDSOURCED COURIERS: TURKISH E-COMMERCE LOGISTIC COMPANY CASE STUDY

Eyüp Tolunay Küp, Ayşe Dilara Türkmen, Alaeddin Türkmen, Deniz Tosun

Kadir Has University/ HepsiJet, eyuptolunay.kup@stu.khas.edu.tr
HepsiJet, ayse.turkmen@hepsijet.com
HepsiJet, alaeddin.turkmen@hepsijet.com
HepsiJet, deniz.tosun@hepsijet.com

ABSTRACT:

Purpose:
This study investigates the potential of gamification to enhance the motivation and performance of crowdsourced transporters in last-mile delivery. It proposes a gamification framework integrated into a mobile application, aiming to increase courier participation, motivation and performance.

Study design:
The research involves integrating gamification elements, such as courier profiles and monthly leadership races, into a state-of-the-art mobile application used by couriers. A pilot case study was conducted in five different distribution branches of a logistics company to examine the effects of these factors on courier motivation and performance.

Findings:
The case study indicates that gamification is a practical approach for increasing courier participation and motivation through the mobile application. The integration of gamification elements positively influences the motivation and engagement of crowdsourced couriers.

Originality:
This study contributes to the understanding of how gamification can be effectively applied in the context of last-mile delivery and crowdsourced transportation. It offers insights into the development of mobile applications that incorporate gamification elements to enhance courier motivation and performance, ultimately improving the efficiency and sustainability of last-mile distribution.

KEYWORDS
Crowdsourcing, e-commerce logistics, employee motivation, gamification, mobile application

INTRODUCTION

Gamification has gained remarkable popularity in both learning and workplace environments for its capacity to enhance motivation and productivity by creating challenges and opportunities for users to internalize their experiences through gameplay. Gamification aids in developing a better understanding of information within personal or social contexts, as highlighted by [8]. Engagement in the tasks of users could be accomplished by game elements in gamification, as demonstrated in studies such as [10]. This powerful integration of game elements can help players and enterprises improve engagement and motivation levels by realigning existing processes and using gamified approaches, as discussed in [18]. While the allure of earning points and rewards is a compelling aspect for users, gamification offers more than mere entertainment. It has the potential to drive increased personal productivity and elevate organizational performance within the workplace, as emphasized by [24].

The COVID-19 pandemic ushered in a world of restricted movements, lockdowns, and remote/hybrid working scenarios in various countries, resulting in heightened time constraints and challenges in balancing professional and personal life. In this context, the significance of thinking smart in supply chain management and intelligent systems, as noted by [22], has become even more critical. The success and reliability of e-commerce companies are closely tied to the performance of logistics services and supply chain management. Customers' experience with the package delivery process is vital in influencing their decision to return to the same e-commerce platform. However, with rising demands and costs, such as gasoline and vehicle prices worldwide, maintaining the motivation of couriers at an optimal level has become a formidable task. Additionally, the nature of logistics tasks, being repetitive and intensive, can lead to declining interest and burnout, as mentioned by [19] and [13], respectively.

Gamification, as a trend across various industries, aims to incorporate game elements into non-game settings to excite and motivate users, as highlighted in [3]. In the context of e-commerce and logistics, gamification can make repetitive tasks more enjoyable, fostering a more positive attitude towards these activities and driving improvements in overall performance, as indicated by [21]. Furthermore, with the advent of Industry 4.0 and technology integration into industries, as discussed by [20], the advantages of gamification have become increasingly evident, making it a valuable asset in sectors like e-commerce and logistics.

The setup and design of the environment are to transform the boring into non-boring surroundings in Gamification. As a result, the user experiences a motivating, inspiring, and engaging state, which changes the user's attitude toward any activity. Identifying goals is essential for establishing the gamification framework with its design approach. The researchers in the literature referred to the gamification framework with its design approach. The researchers in the literature referred to the gamification approach as a dynamic mechanism to implement game elements such as points, progress, leaderboards, rewards, and feedback. Crowdsourcing is a distributed problem-solving approach that transforms problems and tasks into solutions by operating the potential of large groups via online applications rather than traditional employees. Crowdsourcing's success depends on a mass of motivated crowdsourced, crowdsourcing platforms that have increasingly been imbued with motivational design features borrowed from games, a practice often called gamification [15]. "Gamification" uses game design elements in non-game contexts [4]. When designing gamification factors, it is vital to accurately identify users' profiles and use appropriate elements for users. Otherwise, gamification factors can have negative consequences for users.

In this paper, we review and analyze the usage of gamification in crowdsourced courier systems based on Bartle's player typology for Multi-User Dungeons (MUDs) [23]. Bartle's player typology for Multi-User Dungeons (MUDs) is widespread in gamification. However, it was explicitly created for MUDs and should not be generalized to other game genres or gameful design. To address this problem, Marczewski developed the Gamification User Types Hexad [23] framework based on research on human motivation, player types, and practical design experience. Also, different game design elements that may support different user types are suggested. Figure 1 illustrates the six user types from the Hexad model.

Fig. 1. Six user types from the Hexad model [23].

The user types and the game design elements suggested by Marczewski to address the motivations of each type of below;

Philanthropists are motivated by purpose. They are altruis-tic and willing to give without expecting a reward

Socialisers are motivated by relatedness. They want to in-teract with others and create social connections

Free Spirits are motivated by autonomy, meaning freedom to express themselves and act without external control. They like to create and explore within a system

Achievers are motivated by competence. They seek to progress within a system by completing tasks, or prove themselves by tackling difficult challenges
Players are motivated by extrinsic rewards. They will do whatever to earn a reward within a system, independent-ly of the type of the activity

LITERATURE REVIEW

Although digital games were for entertainment purposes before, the idea of sharing your achievements with other people emerged in the late 1990s, with the spread of the internet and the ease of connecting between devices. The ability of the players to show their achievements to everyone not only made them addicted to the game but also made the game widespread [9]. Over time, gamification theory has been used for purposes such as motivating companies' employees, attracting their customers' attention, and creating an alternative to traditional advertisements. Gamification is frequently used in many applications such as business, education, exercise, and motivation [2]. Many companies invest in Gamification systems and frameworks to increase their users' participation and add fun elements for a better experience in monotonous tasks [16].

Gamification encompasses certain elements aimed at enhancing motivation to achieve specific goals. Among these elements are badges, leveling systems, and similar components, which emerge as significant tools to encourage user engagement, elevate interaction levels, and incentivize desired behaviors. Hamari [7] conducted a study investigating the impact of gamification, specifically a badge system, on user activity in a sharing economy service, such as a peer-to-peer marketplace. The research observed users earning badges through common actions and tasks on the platform, aiming to assess the positive effects of badge implementation on user engagement. The study, spanning 2 years with a pre-implementation group observed for 1 year and a post-implementation group monitored for an additional full year, revealed that users in the gamified condition exhibited significantly higher engagement, including increased trade proposals, transactions, comments, and overall usage of the service.
Landers et al. [11] conducted a study to investigate the impact of leaderboards on employee performance within the gamification context. In the experiment, participants engaged in a classic brainstorming task gamified with a leaderboard. Four traditional goal-setting levels were randomly assigned to participants alongside a leaderboard displaying initials and scores that mirrored the goal-setting conditions. The presence of the leaderboard effectively motivated participants to performance levels comparable to those set by difficult and impossible goals. This suggests that participants implicitly set goals aligned with or near the top of the leaderboard without explicit prompting. The study also assessed goal commitment, a common individual difference moderator in goal setting theory, and found that it behaved similarly in the presence of the leaderboard as it did when traditional goals were provided.

Meder et al. [14] experimented with 20.000 users in the mobile e-commerce application in order to investigate the effect of intangible and tangible rewards in gamification. In general, gamification has been seen to increase user interaction, but this increase varies according to the type of reward. The tangible reward group was 4.1 times more active than the intangible reward group, at the same time, the intangible reward group was 1.12 times more active than the non-gamified group. Liang et al. [12] researched the user impact of the Superhost badge on Airbnb. They concluded that those who have this badge receive more positive reviews and that guests spend more. In an article authored by Egger et al. [17], the logistics and transportation industry's significant challenge of coping with a global shortage of skilled workforce is addressed. The study explores the integration of gamification with augmented reality (AR) as a novel approach to attract interest in the logistics sector. The article aims to determine whether an AR-based application is a viable strategy for enhancing the attractiveness of logistics jobs. The assessment indicates that the combination of gamification and augmented reality holds promise as a tool to attract individuals to the logistics sector and reshape their perceptions of logistics professions. It can be concluded that the gamified AR approach has the potential to increase interest in jobs within a specific industry.

METHODOLOGY

The research project is structured with a series of sequential steps. Commencing with User Profile Analysis, the study delves into understanding the characteristics and preferences of the target audience. Subsequently, data analysis is used to analyze relevant data and extract meaningful insights. The project progresses to Implementation, where strategies and methodologies are implemented based on the insights gained. Finally, the study culminates in the Analysis of the Results, a critical phase where the outcomes are thoroughly examined and interpreted, providing a comprehensive understanding of the research findings. This systematic approach ensures a thorough and methodical exploration of the subject matter, fostering a rigorous and insightful research process.

User Profile Analysis

Quantitative and qualitative research were conducted to analyze courier profiles. Quantitative data are obtained from courier performance parameters such as number of daily packages, turnover rate, and surveys. Qualitative data are obtained from meetings with couriers, reasons for leaving the job, meetings with training departments, and investigations of distribution and cross-docks. Courier profile analysis studies started with analyzing operational data. Courier performance and operational factors affecting performance were examined.
Courier Turnover Status. To thoroughly investigate and comprehend the turnover among couriers, an in-depth analysis was conducted by engaging in interviews with couriers who resigned within a six-month timeframe. The focus was explicitly on

discerning the reasons behind their decision to leave. Upon reviewing the findings presented in Table 1, it is evident that a significant proportion, namely 47%, opted to leave their courier job in pursuit of alternative employment opportunities during the observed six-month period. This data sheds light on the primary cause of courier turnover and emphasizes the notable prevalence of couriers transitioning to other job opportunities within the specified timeframe. The comprehensive exploration of these departure motives contributes to a more nuanced understanding of courier turnover dynamics within the studied period.

Table 1. Reasons behind courier’s turnover

Reasons for Leaving	Rate
Found another job	47%
Left on trial	12%
Disciplinary behavior	10%
Not provided a vehicle	8%
Financial problems	6%
Family problems	5%
Not provided a vehicle after car accident	4%
Health problems	3%
Unable to start a company	3%
Unable to acquire necessary documents	2%
Moving to somewhere else	2%

Delivery Performance. Distribution performances of 311 couriers from different distribution areas over a two-month period were analyzed. Within this two-month period, the-longest term couriers delivered for 47 days and the shortest-term couriers delivered for 5 days. Number of the daily average deliveries was calculated to be 64, and the standard deviation was calculated to be 18.8. When we look at the number of days worked, couriers ran their operations on an average of 42 days with 9.2 standard deviation (see Table 2).

Table 2. Courier Performance Statistical Metrics

	Mean	Standard Deviation	N
Daily Package	64,3762	18,8487	311
Days Worked	42,0418	9,2161	311

Courier Survey. In order to determine courier profiles, "The Gamification User Types Hexad Scale" method [23] was used. Within this scope, in order to determine the user types, the Turkish Version of The Gamification User Type Hexad Scale [1] questionnaire with a total of 24 questions was sent to cross-docks, and the couriers were asked to fill this questionnaire anonymously. In addition to 24 questions, couriers were asked to evaluate their satisfaction with using the mobile application and working with the company on a scale from 1 to 10.

Data Analysis

A total of 215 questionnaires from 13 cross-docks were evaluated. Received questionnaires were fed into the system through the website in order to determine user types according to Hexad Gamification Technique [23]. Cross- Docks and their corresponding average mobile app and overall satisfaction can be seen at Table 3. The survey results were analyzed on a cross-dock basis (see Table 4). The most prominent user type for couriers found to be "Philanthropist" with a percentage of 18.9%, followed by "Socialiser" with 18.3%.

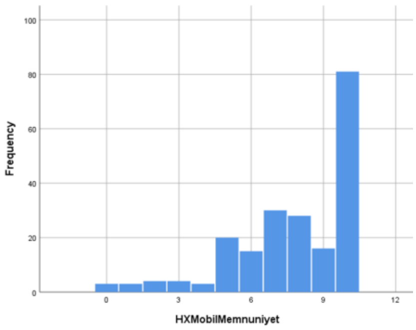
Table 3. Average mobile app and overall satisfaction survey statistics.

Cross-Dock	Survey Count	Mobile App Satisfaction	Overall Satisfaction
1	30	8,3	8,9
2	23	8,1	9,8
3	20	6,6	9,5
4	20	5,8	8,3
5	18	8,3	9,2
6	16	8,2	8,9
7	15	8,2	8,7
8	14	7,5	7,8
9	14	8,6	8,5
10	13	8,3	8,3
11	11	7,9	8,6
12	11	7,2	9,3
13	10	9,5	9,8
Total	215	7,8	8,9

Table 4. Couriers' Hexad Gamification survey result statistics.

Cross-Dock	Philanthropist	Socialiser	Achiever	Free Spirit	Player	Disruptor
1	5,8	5,5	5,3	5,5	5,0	2,9
2	4,3	4,4	4,0	4,0	3,9	2,5
3	3,8	3,7	3,4	3,3	3,3	2,5
4	3,8	3,6	3,4	3,5	3,2	2,4
5	3,4	3,2	3,2	3,1	3,2	2,0
6	3,3	3,1	2,9	2,5	2,6	1,6
7	2,8	2,8	2,6	2,6	2,4	1,8
8	2,7	2,6	2,5	2,3	2,3	1,7
9	2,7	2,5	2,6	2,4	2,3	1,6
10	2,2	2,1	2,3	2,2	2,2	2,2
11	2,1	2,2	2,0	1,9	1,8	1,1
12	2,2	2,1	2,0	1,8	1,7	1,2
13	1,8	1,8	1,7	1,8	1,8	1,2
Sum	40,6	39,4	37,9	36,7	35,7	24,6
Perc.	18,9%	18,3%	17,6%	17,1%	16,6%	11,5%

The satisfaction rate for Mobile App is 7.8 on a scale of 10 (see Figure 2). Average satisfaction rate of couriers working for the company is 8.9 on a scale of 10 (see Figure 3). Upon looking at the relationship between transporters' satisfaction with mobile applications and their satisfaction with working, the scatter graph comes out as follows. There is no linear relationship between the two (see Figure 4). Their satisfaction with the mobile application is lower than the overall satisfaction.



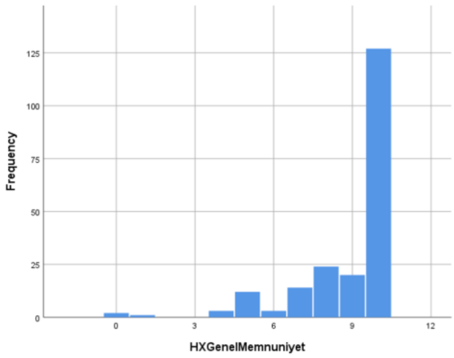


Fig. 2. Courier mobile app satisfaction.

Fig. 3. Overall company satisfaction of couriers.

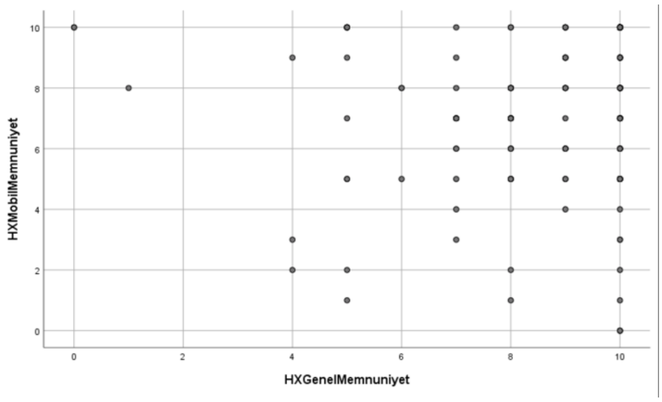


Fig. 4. The relationship between mobile application and overall satisfaction of couriers.

User motive combinations. Some of the underlying motivations of these types of users are related to each other. Achievers and Players are motivated by success, but their focus differs; while Players focus on external rewards Achievers focus on competence. Philanthropists and Socialisers are motivated by interacting with other people, but the interest of Socialisers lies in the interaction itself, while Philanthropists' interest lies in helping others. Both Free Spirits and Disruptors are motivated by creativity and autonomy. Having said that, Free Spirits stay within the boundaries of the system with no intention of altering it or interfering with it, whereas Disruptors try to break the limits and change the system. [23] 18.9% of couriers showed a tendency towards Philanthropist, while this rate is 18.3% for Socialisers, 17.6% for Achievers and 11.5% for Disruptors.

Implementation

Gamification system implementation layers are structured as follows: job success score calculation, level design, courier leadership race, and badges.

Job Success Score Calculation. The criteria used for calculating the Job Success Score were successful delivery, and number of days worked by courier. These criteria had different weights. While the weight of successful delivery was 80%, the weight of the number of days worked by the courier was 20%.

Level Up Rules. After calculating the job success score for each active courier, the current level of the courier is determined. Levels serve as a marker for players to know where they stand in a gaming experience over time. In game design, level difficulty is not linear. [25] A leveling algorithm was used to detect levels. A new courier started at level 1 and can go up to level 20. Rising to the next level is increasingly harder. The formula for this calculation was given in the following formula (1).

next_level = 500*(level^2) - (500 * level) (1)

By using the formula above, the job success score range to be reached for each level has been calculated and shown in the table below (see Table 5). The courier's current level is determined according to the corresponding range in this table.

Table 5. The courier's levels and required experiments.

Level	Required Exp.	Level	Required Exp.
1. Level	0	11. Level	55.000
2. Level	1.000	12. Level	66.000
3. Level	3.000	13. Level	78.000
4. Level	6.000	14. Level	91.000
5. Level	10.000	15. Level	105.000
6. Level	15.000	16. Level	120.000
7. Level	21.000	17. Level	136.000
8. Level	28.000	18. Level	153.000
9. Level	36.000	19. Level	171.000
10. Level	45.000	20. Level	190.000

Courier Leadership Race Design. The purpose of a leaderboard is to make simple comparisons. Unsurprisingly, most people don't need any explanation when they encounter a leaderboard [25]. Levels and leaderboards by themselves neither make nor break users' intrinsic motivation in non-game contexts. Instead, it is assumed that they act as progress indicators, guiding and enhancing user performance [5]. Regarding accomplishment elements, leaderboards are to be designed with care to avoid demotivating. The end users should be compared with meaningful people and they should not be placed at the bottom of a ranking, but instead between other users [6].

In this study, leaderboard design has been made considering user motive combinations (see Table 4). Since the positive effects of the user motive combinations, we focused on social competition and teamwork [26]. While making the leadership ranking, it is planned to create social competition by evaluating couriers from each region within itself. Couriers can see the 3 highest-performing couriers and their own rank in the region they work (see Figure 5). Couriers' scores are used as ranking criteria. Scores are calculated according to 3 performance criteria: Delivery performance, average evaluation points and route compliance rate. These performance criteria had different weights since their importance differed. While the weight of delivery performance was 70%, it was 25% for average evaluation scores and 5% for route compliance rate.

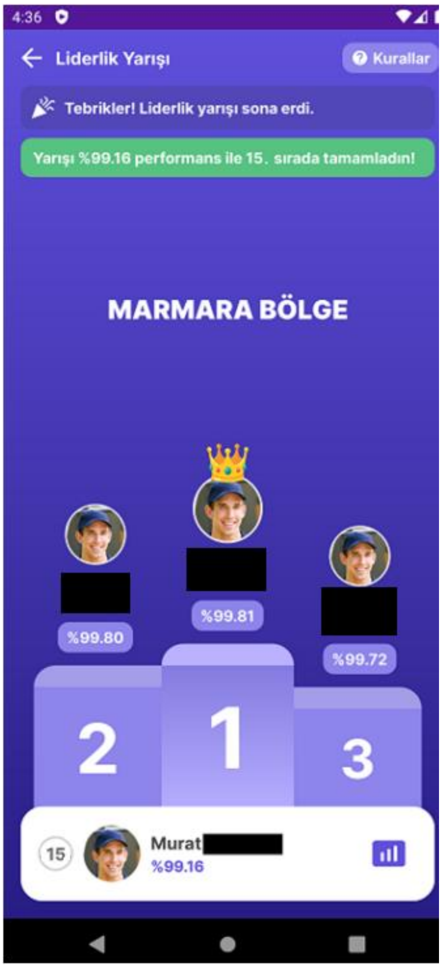


Fig. 5. Leadership race mobile application screenshot.

Another teamwork factor is "cross-docks wars" which is designed by qualifying the most successful cross-docks of the month. Each courier can see his/her individual contribution to the cross-dock performance he / she works.

Badges. For game designers, badges are an excellent way to encourage social promotion of their products and services. Badges also mark the completion of goals and the steady progress of play within the system [25]. The virtual car gallery has been designed as a reward system in the badge module due to its compliance with the courier profile. Badge level was determined based on the number of packages distributed by each courier. Couriers will be eligible to choose a new vehicle when they double the number of delivered packages. Mobile application badge pages' screenshots are given in Figure 6.

Table 6. The courier's badges and required number of transactions.

Coefficient	Number of Transactions	Car Category
2	10.000	A1
2	20.000	A2
2	40.000	A3
1,5	60.000	B1
1,5	90.000	B2
1,5	135.000	B3
1,2	162.000	C1
1,2	194.400	C2
1,2	233.280	C3
1,1	256.608	S

When the courier reaches each of the transaction numbers in the table above, it will be entitled to add one new vehicle to his/her virtual gallery. Vehicle selection is planned to start from at least 10,000 (2018 average) transactions.

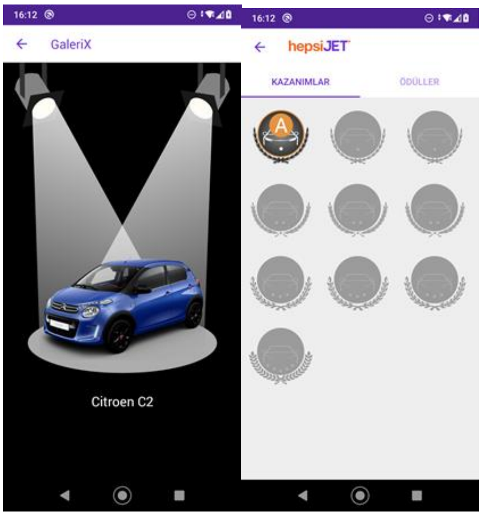


Fig. 6. Mobile application badge pages screenshots.

Hypothesis Testing for Performance Change

The study meticulously employed a one-sided t-test, a powerful statistical method chosen to rigorously evaluate the influence of gamification on last-mile delivery performance. This method allowed for a nuanced examination of the mean performance differences between the experimental and control groups. With a pre-established significance level (α) of 0.05, the analysis of p-values (p_cityid) became a critical component of the hypothesis testing process. The null hypothesis (H0) postulated that there would be no significant divergence in performance, while the alternative hypothesis (H1) anticipated a positive impact of gamification. The consistent attainment of p-values below the significance threshold bolstered the empirical evidence, providing compelling grounds for rejecting H0 and supporting the conclusion that gamification led to a statistically significant improvement in last-mile delivery performance.

In assessing the reliability of the statistical results, special attention was devoted to normality assumptions. Ensuring that the distribution of the data approximated a normal curve was crucial for the validity of the analysis. Furthermore, confidence intervals were systematically considered to provide a comprehensive range within which the true effect size of gamification on performance was likely to reside. This meticulous statistical methodology, which intricately combined a one-sided t-test, a predetermined significance level, rigorous adherence to normality assumptions, and careful consideration of confidence intervals, not only fortified the robustness of the findings but also contributed to the academic rigor of the study. Such a comprehensive approach facilitated a profound and insightful understanding of the sustained effects of gamification on the intricate dynamics of last-mile delivery performance.

EXPERIMENT

This study embarked on a comprehensive exploration of the influence exerted by gamification strategies on weekly courier performance across diverse urban environments. Using a statistical research design, two branches were meticulously chosen in each of the five cities, ensuring a harmonized alignment regarding geographical coverage, operational scale, and demographic characteristics of served neighborhoods. The overarching objective aimed to gauge the statistical significance of integrating gamification elements, with a focus on enhancing key performance indicators, including weekly delivery counts, courier numbers, and a composite metric comprising on-time delivery, customer ratings, and route compliance rates.

The validity of this experiment extends from its robust experimental design and methodological rigor. The careful selection of comparable branches within each city played a pivotal role in eliminating potential confounding variables, ensuring that any observed differences in courier performance could be confidently attributed to the introduction of gamification strategies. This meticulous branch selection process, which considers geographical, operational, and demographic aspects, enhances the internal validity of the study.

Table 7. City based performance change hypothesis testing results

City ID	p value	Performance Change
1	0.001*	+1.23567
2	0.003*	+0.87654
3	0.002*	+1.51234
4	0.004*	+0.92345
5	0.002*	+1.37456
*	signed rows are below the significance level of 0.05	

To further fortify the study's validity, a rigorous comparative analysis was conducted to ensure the baseline comparability of the selected branches. This comparative analysis, which employed statistical methods to validate the comparability of the experimental and control groups, helped establish a solid foundation for assessing the impact of gamification interventions on courier performance metrics. The experimental group, exposed to gamification elements such as performance-based incentives, recognition programs, and competitive challenges, was carefully delineated from the control group, which adhered strictly to conventional operational practices, providing a clear contrast for evaluation.

Statistical analysis was executed using a one-sided t-test framework with a predefined significance level (α) of 0.05. The consistent and statistically significant results across all cities, as evidenced by p-values (p_{cityid}) consistently falling below the significance threshold given in the Table 7, underscore the external validity of the findings. This uniformity in results across diverse urban landscapes reinforces the generalizability of the observed impact of gamification on courier performance, emphasizing the robustness of the statistical outcomes.

The experiment's validity is further strengthened by the duration of the study. The collection of data over 41 weeks provides a robust dataset for evaluating the sustained impact of gamification on courier services. This extended duration is especially valuable for hypothesis testing, aligning with normality assumptions and ensuring that the distribution of weekly courier performance data approximates normality over the course of the experiment. The prolonged observation period enhances the reliability of the statistical findings, allowing for a comprehensive and nuanced understanding of the sustained effects of gamification on courier performance.

CONCLUSION

To enhance the sustainability and success of crowdsourced transportation, this study proposes a gamification framework implemented through a mobile application. By integrating gamification elements such as courier profiles and monthly leadership races, the research demonstrates positive effects on courier motivation and participation.The structured research project, characterized by user profile analysis, data analysis, implementation, and analysis of results, ensures a comprehensive and methodical exploration of the subject matter. The gamification system's implementation layers, including job success score calculation and level design, contribute to a dynamic and engaging experience for couriers.The empirical findings, supported by a robust statistical research design and analysis, demonstrate a statistically significant improvement in key performance indicators across diverse urban environments. Employing a one-sided t-test framework with a predefined significance level (α) of 0.05, consistent p-values falling below the significance threshold underscore the external validity, highlighting the statistical outcomes' robustness. The careful selection of comparable branches and a rigorous comparative analysis, validating the comparability of experimental and control groups through statistical methods, enhance the study's internal validity. The 41-week duration strengthens the study's reliability, allowing for hypothesis testing alignment with normality assumptions and providing a nuanced understanding of gamification's sustained effects on courier performance. This research contributes valuable insights into gamification's role in addressing last-mile distribution challenges and motivating crowdsourced transporters, with statistical proof reinforcing the study's credibility.

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REAL-TIME PREDICTION OF DELIVERY DELAY IN SUPPLY CHAINS USING MACHINE LEARNING APPROACHES

Büşra Ülkü Küp, Eyüp Tolunay Küp, Ahmet Deniz Yücekaya, Mustafa Hekimoğlu, Gökçenur Koçak

Kadir Has University, busra.ulku@stu.khas.edu.tr
Kadir Has University/ HepsiJet, eyuptolunay.kup@stu.khas.edu.tr
Kadir Has University, ahmety@khas.edu.tr
Kadir Has University, mustafa.hekimoglu@khas.edu.tr
Kadir Has University, gokcenur.kocak@stu.khas.edu.tr

ABSTRACT:

Purpose:
The study aims to predict delivery delays in the e-commerce and logistics industries using machine learning models to optimize processes and enhance customer satisfaction. A real-world dataset from a Turkish e-commerce logistics company is used to validate and test the suggested approach.

Study methodology:
The suggested approach involves dividing the delivery process into two scenarios with 11 and 15 steps for different delivery types. Prediction models are applied to each step in both scenarios, and feature selection and parameter optimization are implemented to enhance model performance using four different classification algorithms.

Findings:
The study reveals that XGBoost and CatBoost achieved the highest ROC-AUC scores, ranging from 71.5% to 99.9%, indicating their predictive solid capabilities for early delivery delays incorporating the suggested approach. The research demonstrates the effectiveness of integrating real-time data analytics and machine learning in academic studies within the logistics industry.

Originality:
This research contributes to the field by providing valuable insights into predicting delivery delays using machine learning, utilizing real-world data for enhanced credibility. The study's methodology offers a unique approach to addressing delivery delay prediction for the logistics sector domain.

KEYWORDS
delay prediction, e-commerce, logistics, machine learning, real time prediction

INTRODUCTION

The internet is rapidly changing business around the world, hence promoting the growth of e-commerce. It is particularly seen in the increase of online activities and transactions occasioned by COVID-19. This has gained added charm since geographic constraints on product supply have, in most instances, been eliminated and, thus, are more irresistible than traditional retail. With the growth in e-commerce continuing to increase, so too will the need for logistics services be, thereby extending beyond currents existing storage and distribution networks around the world. Logistics organizations have been assisted by machine learning techniques in handling the demand for delivery, optimizing resources, and predicting shipment delays with its ability to handle volumes of big data and changing conditions.

The key focus of this study is shipment delay with resulting in the loss of consumer trust and a decrease in shipment volumes. It is against this background that the present study has come up with a machine learning-based framework for predictive modelling of delivery delays drawing upon insights emanating from historical transactional data. In this study, an attempt has been made to reduce delay and optimize logistic operations by applying high-performance classification algorithms like CatBoost, XGBoost, Logistic Regression, and Random Forest. The findings represent contributions both to practical logistics management and to the academic study of machine learning in logistics, using real-world data from an e-commerce logistics company

LITERATURE REVIEW

The suggestions are crucial for bringing improvements in efficiency, customer satisfaction, and profitability. It was proposed to conduct several models for delay time predictions. There has been a proposal of a machine learning framework which uses tree-based models and asymmetric loss functions to forecast order delivery time distributions and promised delivery times in cost-effective ways. With real-world testing, it improved the performance of the forecasts and increased sales by 6.1% [1]. The deep learning pipelines conducted the data about weather and parcel OD for last-mile delivery prediction demonstrated that CNN significantly outperformed all traditional models under consideration in the related study [2]. Another similar research work applied machine learning to predict the shipment arrival times considering holiday seasons and port congestion, where better accuracy was achieved with a longer lead time of 3.74 days MAE [3]. The integrated use of machine learning, constraint satisfaction, and QoS aggregation enhanced the monitoring of business processes by improving precision from 14% and recall from 23%, accordingly. Some limitations were mentioned about long-term predictions of delivery times concerning transportation and postal services. Boosting algorithms such as LGB and CatBoost proved to be very helpful for high delays. Delays in scheduled bus and plane transports have the potential to disrupt a logistics chain that might further cause delays in delivery. Research on container delay in shipping pointed out savings through improved scheduling [6]. Predictive models were developed using historical GPS and Bus route data, where the LSTM and Gradient Boosting showed very good performance, to predict journey and arrival times [7]. Causes of Flight Delay were analysed with the SVM models showing significant associations of pushback and tax-out delay as highly relevant for departure delay management [8]. ML will help in predicting delays in food delivery and e-commerce using information from the past to ensure that the elements of logistics result in customer satisfaction. In food delivery, models will consider the variances of distance, traffic flow, and order preparation to estimate times; similarly, models in machine learning are examining modes of transportation, courier performance, and order details in e-commerce for better predictions of delivery times. Both industries use machine learning to provide more accurate estimates, route optimization for delivery, and to minimize delays. A deep learning model was designed that could predict, in advance, drivers' delivery routes and time taken thereby optimizing the route generation process itself [12]. The innovative development of an intelligent system, which would use data mining techniques to predict food preparation times, hence an approximated pick-up time was another contribution to innovative urban solutions.

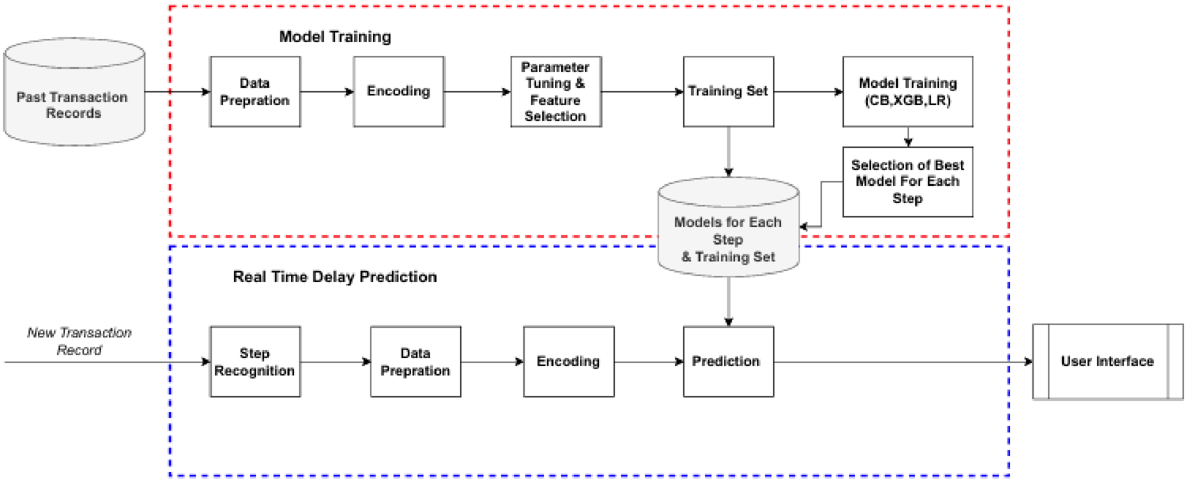

Figure 1: Proposed Approach Schema

METHODOLOGY

Problem Definition

Advanced technologies are used in real-time order processing, handling, and post-delivery to build a better experience for the customer and get more knowledge about the internal operation process. Machine learning models study shipment data to predict delays; they auto-update their predictions with time spent by a shipment in a stage of delivery, therefore increasing efficiency in delivery.

Proposed Approach

Predictive modelling for delivery delay begins with historical data collection, and preparation, including handling missing values and variable conversion, and selection of key features such as order date and customer location. Four machine learning algorithms; LR, XGBoost, CatBoost, and RF are each trained and evaluated using ROC-AUC for the best model. Real-time shipment data is used to predict the delay in each stage of the processing so that, where possible, it can be caught before it reaches its halfway point. Output is represented through a user interface or business tools. Models continuously update so that the results have accuracy always on.

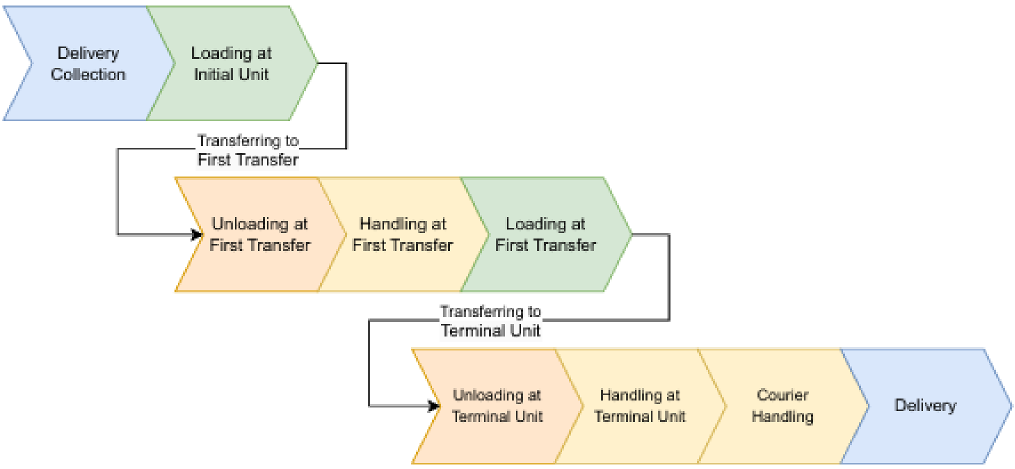

Figure 2: Step-Flow of 11-Step

Data Description

The raw features are collected from real-time delivery transactions. The variables unit_operation and duration have a pivot operation applied with a view to preparing them to enter the model, which gives rise, in its turn, to features based on 15-step and 11-step values in the unit_operation variable. The pivot operation then converts the transaction time of every unit and every transaction into values. Table 1 presents the features derived from cleaned and transformed 15-step and 11-step deliveries. Machine learning apply feature scaling, normalizes data; hence, the duration values are standardized into an average of zero, with a standard deviation of one to ensure all different features contribute equally.

Algorithms for Delivery Delay Prediction

In the paper, four algorithms have been used to predict delivery delays: LR is a traditional machine learning method that means Logistic Regression, while RF is a bagging algorithm representing Random Forest; XGBoost and CatBoost are Boosting algorithms. These algorithms are very common when performing a binary classification task in the field of logistics.

Logistic regression classifier

The Logistic Regression model is used for classification problems involving categorical and quantitative data. If-then rules of logical learning assess weights against inputs for making predictions of categorical or binary responses.

CatBoost classifier

CatBoost improves one-hot encoding and, through its decision trees, uses an objective function that combines log loss and L2 regularization to reduce prediction errors and avoid overfitting.

Features	
barcode	delivered_date
delivery_success	delivery_date_promised
teslimat_basarisi_time	receiver_xdock
sender_xdock	receiver_town
sender_town	receiver_district
sender_district	delivery_collection
loading_initial_unit	transferring_to_first_transfer
unloading_first_transfer	handling_first_transfer
loading_first_transfer	transferring_to_terminal_unit
unloading_terminal_unit	handling_terminal_unit
handling_courier	delivery
delivery_collection_hour	loading_initial_unit_hour
transferring_to_first_transfer_hour	unloading_first_transfer_hour
handling_first_transfer_hour	loading_first_transfer_hour
transferring_to_terminal_unit_hour	unloading_terminal_unit_hour
handling_terminal_unit_hour	handling_courier_hour
delivery_hour	delivery_collection_week
loading_initial_unit_week	transferring_to_first_transfer_week
unloading_first_transfer_week	handling-first_transfer_week
loading_first_transfer_week	transferring_to_terminal_unit_week
unloading_terminal_unit_week	handling_terminal_unit_week
handling_courier_week	delivery_week
year/month/week	dom/doy/woy
hour	total_time

Table 1: All Features

Step	Feature Description
delivery_collection	The duration required to collect the package from the sender's location and prepare it for transportation.
loading_initial_unit	The duration required to load the package onto the initial transportation vehicle.
transferring_to_ first_transfer	The time taken to transfer the package from the initial unit to the first transfer point.
unloading_first_transfer	The duration required to unload the package at the first transfer point.
handling_first_transfer	The time spent processing and organizing the package at the first transfer point.
loading_first_transfer	The duration required to load the package onto the transportation vehicle at the first transfer point.
transferring_to_ second_transfer*	The duration required to transfer the package from the first transfer point to the second transfer point.
unloading_ second_transfer*	The time taken to unload the package from the second transfer point.
handling_ second_transfer*	The duration spent processing and organizing the package at the second transfer point.
loading_ second_transfer*	The duration required to load the package onto the transportation vehicle at the second transfer point.
transferring_to_ terminal_unit	Time taken to move the shipment from the point of transfer number two to the destination terminal, which may include Local Distribution Center or Regional Warehouse.
unloading_terminal_unit	The time required to unload the package from the destination terminal.
handling_terminal_unit	The duration spent processing and organizing the package at the destination terminal.
handling_courier	The time taken for the courier to handle the package, including tasks like verification, signature collection, and any necessary paperwork.
delivery	The duration of the actual delivery process, starting from the departure of the courier from the destination terminal to the arrival of the package at the recipient's location.
	Note: 11-Step deliveries do not include operation steps marked with *.

Table 2: Descriptions of Step Features

XGBoost classifier

Extreme Gradient Boosting, or XGBoost for short, is a popular machine-learning algorithm mainly used for classification and regression. It is based on two major components:
1. Gradient Boosting: Decision trees are fit in stages with each subsequent tree minimizing the errors from all previous ones until some target accuracy is achieved.
2. Regularization: Techniques to avoid overfitting include penalizing complex models and choosing important features. These elements put together create an exact model.

Random forest classifier

The Random Forest diminishes variance in prediction, with "bagging" involving random subsets of data and features. The final prediction is based on the majority vote of the trees, hence more accurate and without overfitting.

Parameter Tuning and Feature Selection

The parameters required for binary classification, such as learning rate and regularization, must be tuned with the best balance to avoid reaching poor local minima or overfitting, which is very important to find optimal accuracy. Feature importance analysis in XGBoost, Random Forest, and CatBoost will be done based on SHAP values, supported by game theory. The literature proves the reliability of SHAP, where respective thresholds such as 0.01 are used for step-by-step feature selection for logistic regression. The method identifies a key variable that is necessary in the development of the prediction models, which in this context are operation durations and cross-dock details necessary for predicting delivery delays.

EXPERIMENTS

Real delivery data from a private logistics company is used, although experiments are carried out; several features are used to evaluate the real-time delivery delay prediction performance of binary classification models.

Experimental Setup

The StatModels package in Python was used to build the LR models. The scikit-learn library's GridSearchCV and StratifiedKFold methods were used to determine the optimal values for the parameters of XGBoost and CatBoost which are the hyper-parameters, including the learning rate, max-depth, and n-estimator parameters. Sender and receiver cross-dock, town, and district information are encoded using LabelEncoder from the scikit-learn preprocessing module. Using the StandardScaler method from scikit-learn, the duration values of each step column were standardized.

Experiment of Feature Selection and Parameter Tuning

For the experiments of feature selection, valuable insights were obtained through SHAP values regarding the individual contributions of features toward the model's predictions, allowing for the inclusion of the most significant variables. The initial models for both 11-step and 15-step XGBoost deliveries were constructed without hyper-parameter optimization or feature selection. A hyper-parameter optimization study was conducted to enhance the outcomes. In the first phase of the model, default parameters were used. A hyper-parameter optimization study was carried out as a second phase to improve the results.

Experiment of Delivery Delay Prediction

In these predictive analytics for delivery delay experiments, four algorithms are used to predict whether a delivery will be delayed Logistic Regression, Random Forest, XGBoost, and CatBoost-using some of the boosting algorithms. These diverse models integrate feature selection techniques with real data-based parameter optimization from a logistics company. Accordingly, comprehensive performance comparisons were carried out for every operational step regarding the logistic models, constructed through attribute selection involving 11 and 15-step shipments, the XGBoost, CatBoost, and RF models, which were developed by combining parameter optimization with the attribute selection method for 11 and 15-step deliveries. Comparisons will be done by using the Area Under the Receiver Operating Characteristic Curve (AUC) metric.

RESULTS

Results of Logistic Regression

The work used a logistic regression-based model to predict delays in delivery using several variables that included the duration their business has operated and geographic data of the locations of the sender and receiver. Initially, all the features were used to evaluate the overall performance of LR. Surprisingly, it yielded an AUC score of 0.844 for the 11-step delivery and 0.847 for the 15-step deliveries at step 4 itself, which is the unloading at the first transfer unit. Thus, well before the halfway point in the process, potential delays are already predicted with a very good degree of accuracy.
The model improved its predictive capability with each further delivery evidence by the higher AUC scores: 0.914 and 0.924 from the 11-step and 15-step deliveries, respectively, at the terminal unit, which helped to enhance its predictive capability of delays along the line of delivery.
Feature selection was a very significant point in the procedure that allowed us to increase the performance of the model. Using stepwise elimination with a p-value criterion of 0.01, the most relevant factors involve the time and duration of each operation, and sender and receiver info. As a result, four models were developed: two each for 11-step and 15-step deliveries, with feature selection and without it. The refined models yielded improved AUC scores of 0.849 and 0.858 after step 4 and 0.915 and 0.927 after the end of the final delivery stage. This illustrates that feature selection plays an important role in strengthening the capability of the LR model in predicting delivery delays.

Results of XGBoost

XGBoost was applied in the current study to develop an accurate forecast of delays with the support of delivery. Feature selection based on SHAP values and hyper-parameter optimization supported with grid search and k-fold cross-validation were the two performance enhancement approaches. This has optimized parameters such as learning rate, tree depth, and regularization seriously influencing model behaviour and complexity.

Initial models showed some promise, as AUC scores for 11-step deliveries ranged between 72.2% and 99.9%, and for 15-step deliveries, between 69.6% and 98.2%. Even though AUC scores showed some ups and downs throughout the graph, they generally went up as the deliveries continued through each step in the operations. The "unloading_first_transfer" step has noticeable improvements, with AUC scores reaching as high as 91.3% for 11-step deliveries and 88.4% for 15-step deliveries. The AUC scores jumped significantly during the "handling_terminal_unit" step, proving that the model got more and more accurate as deliveries were in more advanced stages. Following the tuning of hyper-parameters, several critical stages had much higher AUCs. For example, in the 11-step model, the stage "loading_initial_unit" went up from 71% to 73%. In the case of the 15-step model, the "handling_second_transfer" stage went up from 89.2% to 91.1%. The biggest jumps happened with the "unloading_first_transfer" stage, which in the 11-step model went up from 72.4% to 92%, and in the 15-step model from 70.3% to 89.9% AUCs. On a similar note, the "handling_terminal_unit" step increased AUCs from 93.2-96.7% for 11-step and from 90.9-93.6% for 15-step.
These final models received the best performance after feature selection and parameters tuning. In other words, AUC scores in the "unloading_first_transfer" step for the 11-step model went from 73.8% to 92.3%, and for the 15-step model, scores rose from 70.4% to 90%. Improvements in the next step, "handling_terminal_unit," continued as the AUC values moved upward from 93.2% to 96.8% and from 91.9% to 96% for the 11-step and 15-step models, respectively.
Overall, this time the combination of feature selection using SHAP values and hyper-parameter tuning really worked for XGBoost in the prediction of delivery delays. The models that would result given at the end were quite accurate and showcased the power of XGBoost in its application to predict logistics and supply chain delays.

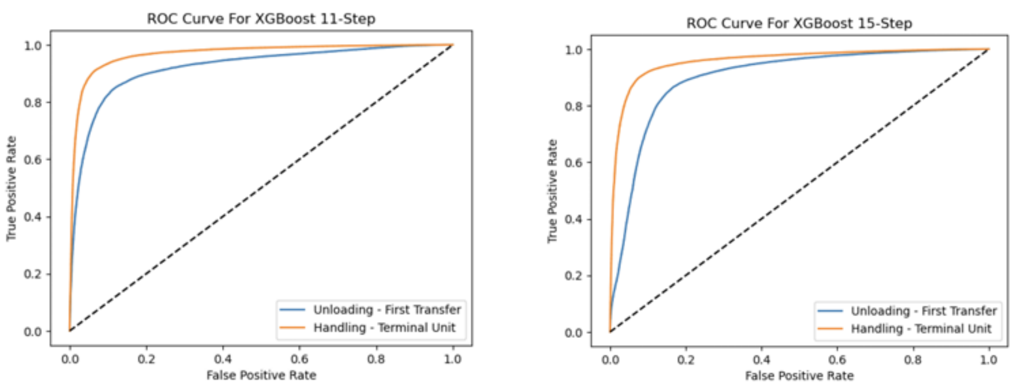

Figure 3. XGBoost 11-Step and 15-Step ROC Curves

Results of CatBoost

Historical delivery records were available in the dataset, along with the duration and timing of each operation step. For 11-step and 15-step deliveries, the first models were

trained on all the features with default CatBoost parameters. AUC, Recall, Precision, F1-score for each operation step is reported below in the table form: Whereas AUC values in the 11-step model went up throughout most of the process, there was only a single step down from 92.2% to 92.1%. The 15-step model has two decreases but is improved overall in other places. Then, during the unloading_first_transfer step, there was a big jump in AUC, going from 71.3% on to 90.2% in the 11-step sequence and 71.9% to 79.2% in the 15-step model. Because the performance metrics of the CatBoost model improved further fine-turning met an improved learning rate, depth, and n-estimators, hence improving the AUC scores across both models-the 11-step and 15-step models reached AUC values as high as 91.6% and 79.6%, respectively, while jumps went as high as 96.8% and 93.7% for the 11-step and 15-step models in handling_terminal_unit.
Feature selection using SHAP values and stepwise tuning improved performance in both models. AUC values went up remarkably, with unloading_first_transfer reaching 91.7% for the 11-step and 90.4% for the 15-step, and handling_terminal_unit rose to 97% and 96% for the respective models. These ROC curves confirm that SHAP-based feature selection gives a very significant boost to model accuracy. Each of these further improved in performance when the optimization of parameters was done, hence the model was able to effectively predict delivery delays.

Results of Random Forest

The RF algorithm used defaults to deliver the delay predictions for the 11-step and 15-step models. Initial models were presented that showed gradual but punctuated increases in AUC scores as the process progressed. As an example, the step "unload_first_transfer" increased the AUC score from 72.2% to 90.1% in the 11-step model, while in the 15-step model, it increased from 66.2% to 80.2%. Meanwhile, the "transferring_terminal_unit" stage increased the AUC from 92.8% to 96.1% in the 11-step model and from 85.6% to 86.9% in the 15-step model.
To improve these results, hyperparameter optimization was carried out using GridSearchCV by tuning parameters such as learning rate, max depth, and the number of estimators. This optimization led to a great improvement in AUC for both steps, especially the "unloading_first_transfer" step, whose AUC increased from 72.4% to 91.3% at 11-step and 67.3% to 81.1% at 15-step. These final models, tuned for hyper-parameters and with feature selection, outperformed both their counterparts and parameter-tuned models with further AUC gains. In the case of the "unloading_first_transfer" step, AUC rose to 91.7% in the case of the 11-step model and to 81.8% in the case of the 15-step model. From this, it is deduced that feature selection and parameter optimization played an important role in enhancing prediction accuracy, especially in logistics and supply chain aspects.
Our results show that the optimized models using Random Forest strongly improved the delivery delay predictions, confirming that feature selection and hyper-parameter tuning are crucial steps to improve accuracy.

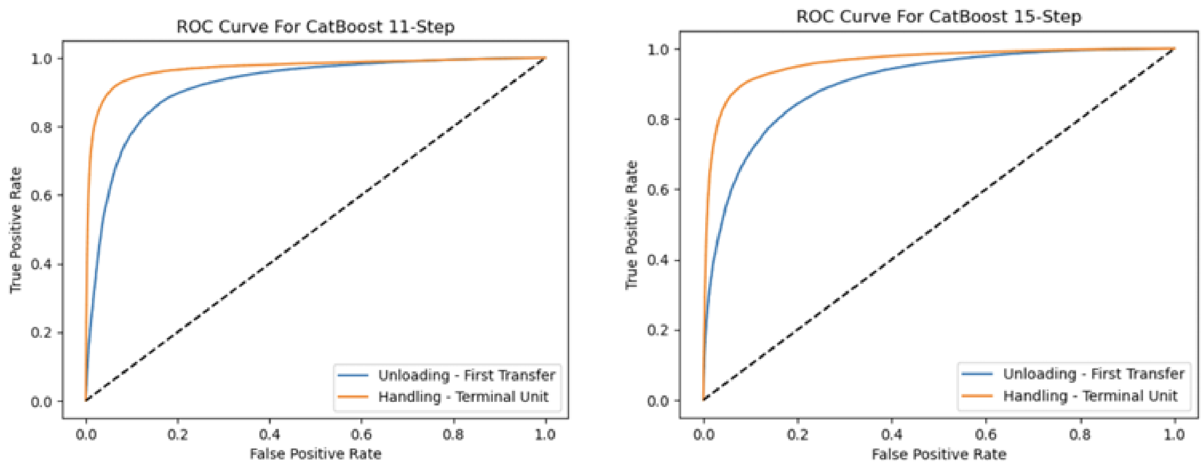

Figure 4. CatBoost 11-Step and 15-Step ROC Curves

DISCUSSION

Drawing from the current analysis, the performance of the different algorithms; LR, Random Forest, XGBoost, and CatBoost-are compared on an AUC score in predicting outcomes across the 11-step and 15-step delivery processes. For the 11-step models, LR indicated the poorest AUC scores, which ranged from 56.1% to 98.6%, although it did continuously improve throughout the process. RF outperformed LR, their scores ranged from 72.1% to 99.7%, but also remained behind the boosting algorithms. XGBoost and CatBoost showed quite similar performances where their AUC scores ranged between the same range from 72.7% to 99.9% and from 73.4% to 99.9% for XGBoost and CatBoost, respectively, though CatBoost performed better than XGBoost for the first three and last four steps. Once more, in all three 15-step models, LR and RF had lower AUC scores compared to the boosting algorithms. The scores taken by LR ranged from 59.6% to 98.8%, while those of RF ranged from 64.0% to 99.7%. LR tends to outperform RF slightly in several steps.

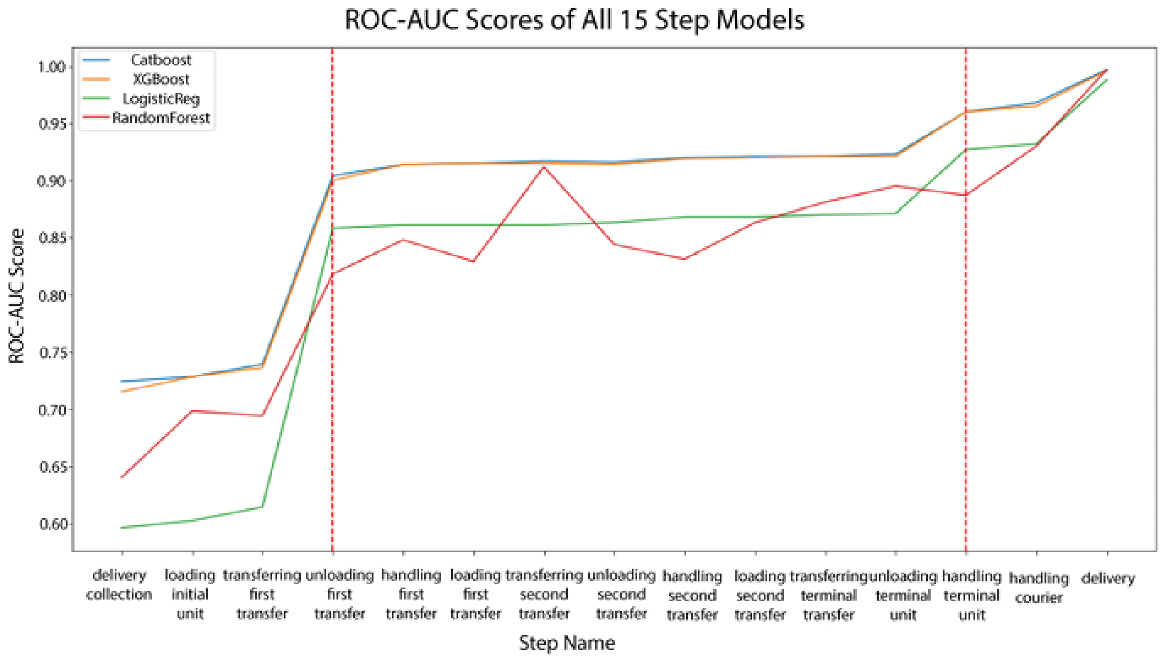

Figure 5. AUC Scores of All 15-Step Models

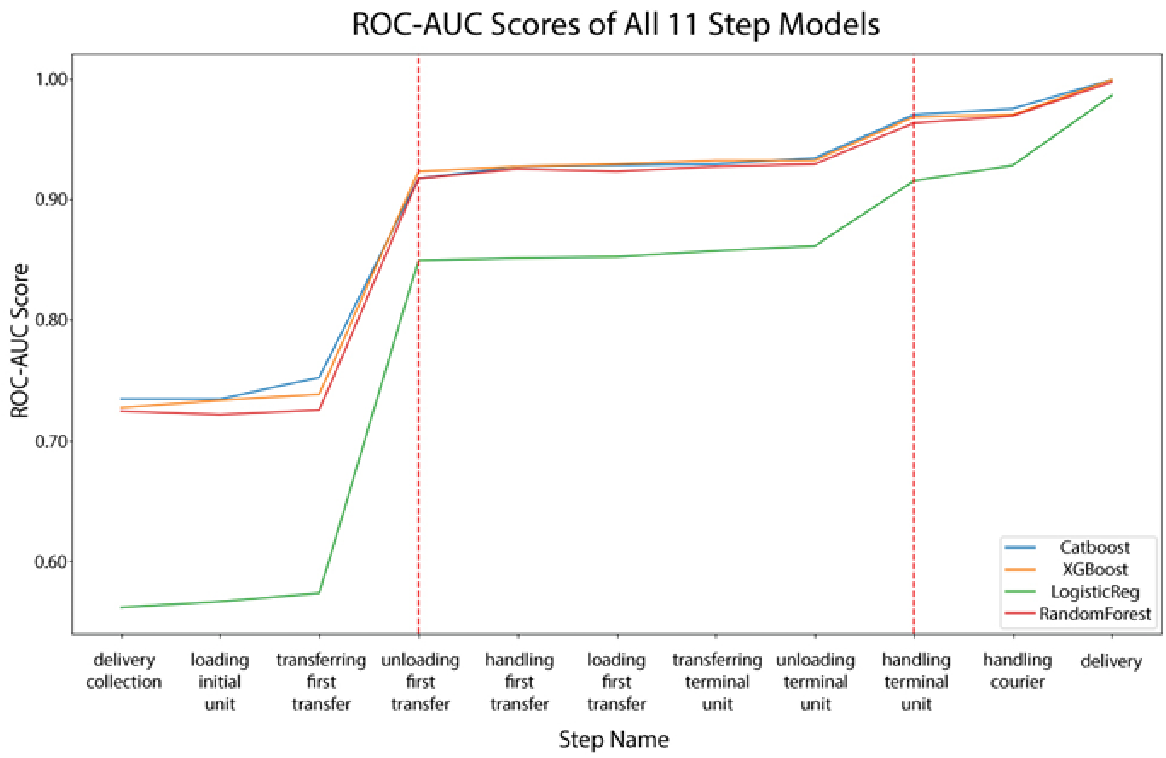

Figure 6. AUC Scores of All 11-Step Models

However, CatBoost outperformed XGBoost in this model system, especially in the shipment delay predictions where it showed higher accuracy. Mainly, two critical inflection points were observed in the improvement of AUC score-first, from "transferring_to_first_transfer" to "unloading_first_transfer" stage, and second, from "unloading_terminal_unit" to a "handling_terminal_unit" step. These jumps confirm the relevance of features and hyper-parameters used in the models. Generally speaking, the CatBoost algorithm proved to be better and ever outperformed other algorithms processed, especially in the 15-step models; hence, the best for making a prediction about shipment delays.

Step	LR	XGBoost	CatBoost	RF
delivery_collection	0.561	0.727	0.734	0.724
loading_initial_unit	0.566	0.733	0.734	0.721
transferring_to_first_transfer	0.573	0.738	0.752	0.725
unloading_first_transfer	0.849	0.923	0.917	0.917
handling_first_transfer	0.851	0.927	0.927	0.925
loading_first_transfer	0.852	0.929	0.928	0.923
transferring_to_terminal_unit	0.857	0.932	0.929	0.927
unloading_terminal_unit	0.861	0.932	0.934	0.929
handling_terminal_unit	0.915	0.968	0.970	0.963
handling_courier	0.928	0.970	0.975	0.969
delivery	0.986	0.999	0.999	0.997

Table 3. Table of AUC Scores for All 11-Step Models

Step	LR	XGBoost	CatBoost	RF
delivery_collection	0.596	0.715	0.724	0.640
loading_initial_unit	0.602	0.728	0.728	0.698
transferring_to_first_transfer	0.614	0.736	0.739	0.694
unloading_first_transfer	0.858	0.900	0.904	0.818
handling_first_transfer	0.861	0.914	0.914	0.848
loading_first_transfer	0.861	0.915	0.915	0.829
transferring_to_second_transfer	0.861	0.915	0.917	0.912
unloading_second_transfer	0.863	0.914	0.916	0.844
handling_second_transfer	0.868	0.919	0.920	0.831
loading_second_transfer	0.868	0.920	0.921	0.863
transferring_to_terminal_unit	0.870	0.921	0.921	0.881
unloading_terminal_unit	0.871	0.921	0.923	0.895
handling_terminal_unit	0.927	0.960	0.960	0.887
handling_courier	0.932	0.965	0.968	0.930
delivery	0.988	0.996	0.997	0.997

Table 4. Table of AUC Scores for All 15-Step Models

CONCLUSION AND FUTURE WORKS

This paper focuses on the problem of delivery delay prediction in the field of logistics as a binary classification problem and evaluates the performance of LR, XGBoost, CatBoost, and RF. Generally, CatBoost performed better, especially at the initial processing stage and later feature engineering steps. Feature selection and hyper-parameter tuning were done for optimization, and some of the selected features are sender and receiver cross-dock information, and time features. This research underlines the need for tailor-made features and hyper-parameter selections at each delivery step. That will be useful in logistics optimization. In the future, more algorithms will be explored, covering a bigger range; more features will be added to this work, and then deep learning models will be studied to enhance the accuracy and robustness of the results. Those are the model interpretability and computation requirements challenge for the next steps.

Abbreviations

The following abbreviations are used in this manuscript:

MDPI	Multidisciplinary Digital Publishing Institute
ANN	Artificial Neural Network
AUC	Area Under Curve
AVL	Automatic Vehicle Location
CatBoost	Categorical Boosting
CPU	Central Processing Unit
FN	False Negative
FP	False Positive
GBDT	Gradient Boosting Decision Tree
GPS	Global Positioning System
GPU	Graphics Processing Unit
LGB	Light-Gradient Boosting
LR	Logistic Regression
LSTM	Long Short-Term Memory Network
MAE	Mean Absolute Error
OD	Origin-Destination
OLR	Ordinary Logistic Regression
RF	Random Forest
ROC	Receiver Operating Characteristic
SVM	Support Vector Machine
SHAP	SHapley Additive exPlanations
TN	True Negative
TP	True Positive
XGBoost	Extreme Gradient Boosting

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Appendix A

Table A1:Performance Metrics of XGBoost Model for 11-Step

Step	AUC			Recall			F1-Score			Precision		
	Initial	P. Tuned	Final	Initial	P. Tuned	Final	Initial	P. Tuned	Final	Initial	P. Tuned	Final
Delivery Collection	0.696	0.699	0.706	0.748	0.762	0.766	0.313	0.316	0.320	0.194	0.198	0.202
Loading - Initial Unit	0.703	0.710	0.717	0.611	0.625	0.629	0.328	0.332	0.333	0.223	0.223	0.226
Transferring to First Transfer	0.695	0.703	0.704	0.694	0.704	0.710	0.330	0.337	0.341	0.220	0.222	0.225
Unloading - First Transfer	0.884	0.899	0.900	0.859	0.861	0.869	0.729	0.734	0.738	0.627	0.633	0.641
Handling - First Transfer	0.902	0.910	0.915	0.837	0.839	0.844	0.722	0.732	0.745	0.643	0.655	0.668
Loading - First Transfer	0.887	0.892	0.915	0.816	0.836	0.856	0.716	0.731	0.747	0.647	0.659	0.663
Transferring to Second Transfer	0.905	0.908	0.913	0.855	0.877	0.880	0.743	0.760	0.771	0.678	0.681	0.686
Unloading - Second Transfer	0.899	0.906	0.915	0.799	0.807	0.823	0.730	0.737	0.747	0.669	0.677	0.684
Handling - Second Transfer	0.892	0.911	0.919	0.799	0.815	0.830	0.744	0.750	0.755	0.660	0.676	0.692
Loading - Second Transfer	0.904	0.915	0.920	0.841	0.852	0.868	0.760	0.768	0.769	0.662	0.678	0.691
Transferring to Terminal Unit	0.908	0.911	0.918	0.824	0.826	0.841	0.743	0.748	0.758	0.676	0.681	0.690
Unloading - Terminal Unit	0.901	0.909	0.919	0.814	0.835	0.847	0.741	0.757	0.760	0.666	0.682	0.689
Handling - Terminal Unit	0.924	0.936	0.960	0.835	0.856	0.858	0.777	0.793	0.806	0.757	0.758	0.759
Handling - Courier	0.944	0.952	0.965	0.836	0.843	0.853	0.776	0.789	0.805	0.744	0.744	0.763
Delivery	0.982	0.995	0.997	0.767	0.780	0.797	0.814	0.830	0.831	0.853	0.855	0.867

Table A2: Performance Metrics of XGBoost Model For 15-Step

Step	AUC			Recall			F1-Score			Precision		
	Initial	P. Tuned	Final	Initial	P. Tuned	Final	Initial	P. Tuned	Final	Initial	P. Tuned	Final
Delivery Collection	0.701	0.730	0.734	0.235	0.234	0.238	0.371	0.369	0.375	0.875	0.873	0.879
Loading - Initial Unit	0.704	0.732	0.734	0.253	0.252	0.254	0.395	0.389	0.395	0.892	0.861	0.895
Transferring to First Transfer	0.713	0.726	0.752	0.253	0.254	0.253	0.399	0.394	0.393	0.871	0.868	0.903
Unloading - First Transfer	0.902	0.916	0.917	0.651	0.677	0.682	0.794	0.774	0.791	0.954	0.961	0.942
Handling - First Transfer	0.921	0.923	0.927	0.725	0.729	0.713	0.823	0.820	0.810	0.945	0.943	0.936
Loading - First Transfer	0.922	0.924	0.928	0.729	0.743	0.733	0.818	0.825	0.830	0.934	0.942	0.940
Transferring to Terminal Unit	0.921	0.926	0.929	0.722	0.733	0.731	0.815	0.822	0.813	0.936	0.935	0.916
Unloading - Terminal Unit	0.927	0.931	0.934	0.728	0.721	0.731	0.818	0.822	0.817	0.934	0.939	0.941
Handling - Terminal Unit	0.965	0.968	0.970	0.814	0.813	0.822	0.863	0.874	0.867	0.919	0.929	0.933
Handling - Courier	0.972	0.975	0.975	0.813	0.828	0.810	0.860	0.865	0.874	0.913	0.928	0.925
Delivery	0.997	0.999	0.999	0.884	0.906	0.922	0.860	0.889	0.872	0.911	0.913	0.915

Table A3: Performance Metrics of CatBoost Model for 11-Step

Step	AUC			Recall			F1-Score			Precision		
	Initial	P. Tuned	Final	Initial	P. Tuned	Final	Initial	P. Tuned	Final	Initial	P. Tuned	Final
delivery_collection	0.713	0.719	0.724	0.795	0.811	0.816	0.318	0.318	0.320	0.197	0.198	0.199
loading_initial_unit	0.721	0.726	0.728	0.813	0.834	0.835	0.336	0.338	0.347	0.216	0.219	0.219
transferring_to_first_transfer	0.719	0.725	0.739	0.812	0.832	0.841	0.338	0.344	0.346	0.213	0.218	0.218
unloading_first_transfer	0.792	0.796	0.904	0.885	0.902	0.924	0.694	0.711	0.719	0.569	0.574	0.589
handling_first_transfer	0.813	0.817	0.914	0.875	0.880	0.896	0.717	0.732	0.743	0.629	0.633	0.635
loading_first_transfer	0.816	0.817	0.915	0.873	0.877	0.894	0.735	0.740	0.754	0.628	0.643	0.652
transferring_to_second_transfer	0.806	0.814	0.917	0.879	0.901	0.903	0.747	0.749	0.754	0.639	0.645	0.647
unloading_second_transfer	0.813	0.819	0.916	0.866	0.888	0.904	0.738	0.745	0.762	0.647	0.650	0.659
handling_second_transfer	0.816	0.824	0.920	0.877	0.894	0.901	0.738	0.748	0.761	0.648	0.653	0.659
loading_second_transfer	0.821	0.826	0.921	0.895	0.903	0.904	0.756	0.758	0.764	0.649	0.661	0.661
transferring_to_terminal_unit	0.822	0.829	0.921	0.874	0.897	0.897	0.723	0.738	0.755	0.635	0.650	0.652
unloading_terminal_unit	0.825	0.833	0.923	0.868	0.886	0.894	0.751	0.765	0.767	0.649	0.659	0.672
handling_terminal_unit	0.927	0.937	0.960	0.855	0.870	0.891	0.804	0.810	0.821	0.748	0.752	0.760
handling_courier	0.944	0.945	0.968	0.866	0.874	0.885	0.807	0.815	0.817	0.744	0.754	0.759
delivery	0.983	0.991	0.997	0.801	0.805	0.809	0.819	0.824	0.830	0.834	0.834	0.853

Table A4: Performance Metrics of CatBoost Model for 15-Step

Step	AUC			Recall			F1-Score			Precision		
	Initial	P. Tuned	Final	Initial	P. Tuned	Final	Initial	P. Tuned	Final	Initial	P. Tuned	Final
delivery_collection	0.719	0.722	0.724	0.223	0.229	0.223	0.331	0.337	0.339	0.770	0.844	0.874
loading_initial_unit	0.720	0.721	0.721	0.242	0.235	0.236	0.358	0.381	0.384	0.830	0.873	0.846
transferring_to_first_transfer	0.722	0.724	0.725	0.243	0.239	0.230	0.357	0.356	0.355	0.768	0.835	0.793
unloading_first_transfer	0.91	0.913	0.917	0.640	0.591	0.600	0.757	0.750	0.735	0.851	0.934	0.887
handling_first_transfer	0.921	0.923	0.925	0.628	0.681	0.707	0.750	0.772	0.792	0.874	0.903	0.891
loading_first_transfer	0.92	0.921	0.923	0.668	0.674	0.697	0.814	0.762	0.821	0.899	0.894	0.883
transferring_to_terminal_unit	0.923	0.925	0.927	0.658	0.667	0.694	0.735	0.774	0.805	0.833	0.919	0.855
unloading_terminal_unit	0.928	0.928	0.929	0.669	0.654	0.676	0.777	0.730	0.771	0.850	0.861	0.895
handling_terminal_unit	0.961	0.962	0.963	0.760	0.763	0.745	0.799	0.852	0.800	0.826	0.905	0.926
handling_courier	0.966	0.967	0.969	0.730	0.797	0.765	0.795	0.842	0.836	0.872	0.904	0.896
delivery	0.997	0.997	0.997	0.847	0.877	0.819	0.804	0.796	0.869	0.818	0.822	0.838

SELECTION OF SUSTAINABLE SUPPLIERS IN THE FOOD INDUSTRY USING MULTI CRITERIA DECISION MAKING METHODS

Buşra Kesici, Havva Nur Mısır, Bilge Akbulut

Duzce University, Faculty of Engineering, Industrial Engineering,
busrakesici@duzce.edu.tr, misirhavvanur54@gmail.com,
akbulut.bilge02@gmail.com

ABSTRACT:

Purpose:
The purpose of this study is to examine supplier selection for a food manufacturer in Sakarya province with a sustainability approach.

Study design/methodology/approach:
The sustainable supplier selection criteria obtained through a detailed literature analysis were weighted by using AHP (Analytic Hierarchy Process), one of the multi criteria decision making methods, with the help of expert opinions. Then, the criterias were ranked with TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) and COPRAS (Complex Proportional Assessment) methods. In the study, the expert opinion of experienced purchasing managers of the company was used as decision makers. The validity and consistency of the results were tested with sensitivity analysis.

Findings:
Firstly, in the results of the pairwise comparison of the main criteria, the main criteria with the highest level of importance are quality > cost > delivery > supplier profile. In the sub-criteria comparisons, the most important sub-criteria for quality is customer satisfaction, for delivery it is quality delivery, for cost it is price and finally for supplier profile it is reliability. Supplier 1 was selected in the TOPSIS and COPRAS method calculations made after the weight determination.

Originality/value:
As environmental resources become increasingly valuable and limited, businesses need to identify indicators to address sustainability needs in their own operations as well as in the processes of their suppliers. Meeting these needs is vital to maintain competitive advantages and fulfill environmental and social responsibilities.

KEYWORDS
AHP, COPRAS, TOPSIS, Food Industry, Multi Criteria Decision Making, Sustainable Supplier Selection

EFFECTS OF THE HOUTHI CRISIS IN THE RED SEA ON GLOBAL TRADE

Aymine Bodur, Yurdagül Meral

www.dhl.com, aymine.bodur@dhl.com
Medipol University, ymeral@medipol.edu.tr

ABSTRACT:

Purpose:
The Yemen-based Houthis group is a group that operates both armed and unarmed and has been mentioned in constant conflicts and wars for years. The Red Sea is one of the most important routes used by countries as a commercial route, as it connects two large straits and its volume on trade is quite large. The purpose of this study is to describe the Houthis group based in the Yemen Market and then to examine the impact of Yemen-based Houthis group attacks on commercial cargo ships passing through the Red Sea with the Israel-Palestine war that started in October 2023.

Study design/methodology/approach:
Comparison of data before and after the attacks in Red Sea, like increase in prices, prolongation of transit times and the effects on global trade.

Findings:
In accordance with data were supported with tables, each data was explained with both percentage and numerical data, and the effects of the Houthis on the Red Sea were interpreted one by one.
As a result, the fact that the Houthis almost brought the trade on the Red Sea to a halt caused many variations in global trade, increased costs, extended transit times and caused production to be significantly delayed. In addition, climatically, the wars on the Cape of Good Hope and the Red Sea caused many problems and almost caused the closure of the Cape of Good Hope. The war is still ongoing and the crisis on global trade is expected to continue as a result of the effects of the war.

KEYWORDS
Suez Canal, Houthis, International Trade, Freight Rate, Ship Routes

AGILE APPROACHES IN SUPPLY CHAIN MANAGEMENT: AN APPLICATION

Buket Bolat Özkan
b.bolat@daikin.com.tr

ABSTRACT:

Purpose:
Technological advancements, socioeconomic, cultural, and political changes, and the rapid need to meet new demands highlight the necessity for companies to be agile. This research aims to (1) Examine agile supply management, (2) Assess company tendencies through literature review and surveys, (3) Raise awareness and outline actionable steps, (4) Identify and improve low-agility areas in supply management, (5) Propose a sample implementation draft. The study focuses on the agile supply management practices of small and medium-sized enterprises in Turkey, providing recommendations on how businesses can become more agile during crises, filling gaps in the literature, and redefining the relationship between agility and sustainability.

Study design/methodology/approach:
This study uses a mixed-methods research design to investigate the impact of agile supply chain management on sustainability. It begins with a literature review of existing theories and practices. A survey was conducted among small and medium-sized enterprises in Turkey to collect quantitative data on their agile supply chain management practices, sustainability strategies, and crisis management processes. The data were analyzed using quantitative methods and presented in tables and graphs. In-depth interviews with selected enterprises provided qualitative data, supporting and enriching the quantitative findings. This integrated approach offers a thorough analysis of the relationship between agile supply chain management and sustainability.

Findings:
The study demonstrates the positive effects of agile supply chain management on sustainability. Small and medium-sized enterprises adopting agile strategies can produce faster, more effective solutions during crises, become more resilient to disruptions, and improve overall performance. The impacts of alternative supplier selection and technology usage on agility are noteworthy. Qualitative data highlight that integrating agile practices with sustainability strategies is critical for long-term success. These findings underscore the role of agile approaches in enhancing competitiveness and achieving sustainability goals.

Originality/value:

This study significantly contributes to the literature by examining the agile supply chain management practices of small and medium-sized enterprises in Turkey and their impacts on sustainability. Analyzing the relationship from both theoretical and practical perspectives, the research shows how businesses can enhance agility to achieve sustainability goals during crises. Conducted in the context of developing countries like Turkey, it highlights the specific challenges and opportunities faced by local businesses, filling a gap in the literature. The study offers valuable insights for academic and sectoral practices.

KEYWORDS
Supply Chain Management, Agile Approaches, Sustainability, Business Performance, Procurement, Purchasing.

LASHING SERVICE PROVIDER SELECTION FOR CARGO SAFETY IN TRANSPORTATION

Merve Malgir, Pınar Gürol

Istanbul Ticaret University, Institute of Graduate Education, Department of Logistics Management, malgirmerve4@gmail.com

Istanbul Ticaret University, Faculty of Business, Department of Logistics Management, İstanbul, Turkey, pinargurol@gmail.com

ABSTRACT:

Purpose:
This study aims to develop a decision support system for selecting a lashing service provider for cargo safety in transportation.

Study design/methodology/approach:
This study employs multi-criteria decision-making (MCDM) methodology to select the most suitable lashing service provider for ensuring cargo safety in transportation. According to this, firstly comprehensive literature review was done to identify the criteria in the context of sustainability that influence lashing service provider selection. Subsequently, the Step-wise Weight Assessment Ratio (SWARA) is used to prioritize these criteria based on their relative importance. The final selection of the lashing service provider is achieved through the Multiple Attribute Utility Theory (MAUT). To collect data, a survey is conducted among industry experts. The survey responses are analyzed to derive the weightings for each criterion and select the most suitable alternative. This combined SWARA- MAUT approach ensures a robust and systematic evaluation, providing actionable insights for decision-makers.

Findings:
The analysis is still in progress; comprehensive findings will be included in the full manuscript submission.

Originality/value:
While existing literature extensively covers lashing methods, the specific evaluation and selection of lashing service providers remain inadequately studied.

KEYWORDS
Cargo Safety, Lashing Service Provider Selection, MAUT, SWARA

INVESTIGATION OF SUSTAINABLE TRADE PERFORMANCE USING HYBRID MCDM METHODS: A CASE OF CPTPP MEMBERS

Emre Kadir Özekenci

Cag University, ekadirozekenci@cag.edu.tr

ABSTRACT:

Purpose:

This paper analyzes the sustainable trade performance of Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP) members using the hybrid Multi-Criteria Decision-Making (MCDM) methods. In this study, eleven countries namely, New Zealand, Singapore, Australia, Canada, Japan, Chile, Vietnam, Malaysia, Mexico, Peru and Brunei are evaluated based on fourteen criteria. The criteria are as follows: tariff and non-tariff barriers, trade liberalization, exchange rate stability, foreign trade and payment risk, export concentration, political stability, goods produced by forced labor, trade in goods at risk of modern slavery, air pollution, ecological footprint, renewable energy, environmental standards in trade, share of natural resources in trade and carbon. The criteria are determined by literature review and expert opinions.

Study design/methodology/approach:

For this investigation, a hybrid model integrating the method based on the LOgarithmic Percentage Change-driven Objective Weighting (LOPCOW) and the Weighted Aggregated Sum Product Assessment (WASPAS) method is employed. The data is obtained from the 2023 Sustainable Trade Index report published by the IMD and Hinrich Foundation. The criteria weights are determined by the LOPCOW method, and the performance evaluation is carried out using the WASPAS method.

Findings:

The LOPCOW results showed that tariff and non-tariff barriers, foreign trade and payment risk and ecological footprint were the most important criteria, while goods produced by forced labor, share of natural resources in trade and trade in goods at risk of modern slavery were the least important criteria. The WASPAS results indicated that Japan, Canada and Australia achieved the highest sustainable trade performance, while Brunei, Malaysia and Vietnam experienced lowest sustainable trade performance.

Originality/value:
The results of this study are expected to offer valuable insights into the sustainable trade performance of CPTPP members. Consequently, it has the potential to provide guidance to countries or companies that aim to engage in trade with CPTPP members.

KEYWORDS
Sustainable trade, CPTPP, MCDM, LOPCOW, WASPAS

OPTIMAL STRATEGIC EQUILIBRIUM IN SUSTAINABLE TRANSPORT CORRIDORS

Bruno G. Kamdem, Nahid Jafari

School of Business, SUNY Farmingdale, New York, kamdemb@farmingdale.edu
School of Business, SUNY Farmingdale, New York, Jafarin@farmingdale.edu

ABSTRACT:

Purpose:
We tackle the challenge of optimizing sustainable transport corridors by balancing economic and environmental factors, particularly in geopolitically sensitive regions (such as the Zangezur Corridor) with fluctuating commodity prices and significant environmental impacts. There is a crucial need for strategies that ensure both profitability and ecological sustainability. Traditional models often fail to integrate these aspects comprehensively, especially in volatile areas like the Zangezur corridor.

Study design/methodology/approach:
Our model incorporates an environmental cost function in a stochastic different game setting, including emissions penalties and pollution reduction technology costs, providing a more accurate prediction of commodity prices and a deeper understanding of transport activities' environmental impacts. Key drivers include the integration of multiple variables, such as tax and emission rates, influenced by various stakeholders.

Findings:
The model yields robust transportation strategies capable of withstanding geopolitical and economic fluctuations while promoting sustainability. We offer a valuable framework for policymakers to align economic growth with environmental stewardship, supporting the development of transport corridors like the Zangezur Corridor, that are both economically viable and environmentally responsible, crucial for sustainable global trade routes.

Originality/value:
We introduce a log-normal mean-reverting process for commodity prices, uniquely accounting for geopolitical and environmental uncertainties.

KEYWORDS
Game Theory, CO2 emissions, Optimal Control, Supply Chain.

THE ECONOMIC EFFECT OF ADVANCED DELIVERY LOCATIONS FOR THE LAST MILE ROUTING PROBLEM

Ece Yağmur

Konya Technical University, ecyagmur@ktun.edu.tr

ABSTRACT:

Purpose:
The last-mile logistics phase is considered the most costly phase in the supply chain. So, some innovative delivery options have been proposed for last-mile activities in recent years. In real life, some customers may prefer to self-pick up their orders for a certain amount of discount from advanced delivery locations that are accessible 24/7. This paper analyzes a novel last-mile routing problem by not only utilizing the self-pickup option but also the crowd-shipping approach. The problem addressed can be applied to many applications in real life, especially large retail stores where online ordering is available.

Study design/methodology/approach:
For optimal distribution decisions with the objective of minimizing the weighted sum of total travel and tardiness costs, a novel Mixed Integer Programming formulation is developed. The proposed model is applied to newly generated test instances, and some sensitivity analyses of selected parameters are investigated.

Findings:
According to the computational results, it is observed that the CPLEX is quite sensitive to the number of customers and advanced delivery locations. Due to the simultaneous use of resources for distribution services, there is a general decrease in the objective function value when the total cost is evaluated as the number of delivery locations increases.

Originality/value:
The paper demonstrates that the proposed approach, which takes advantage of both advanced delivery locations and crowd shipping, can significantly outperform the conventional vehicle routing approach. To the best of our knowledge, this is the first study in which both delivery options are examined simultaneously in a single-echelon structure.

KEYWORDS
Advanced delivery locations, home delivery, last mile logistics, mixed integer programming, vehicle routing.

RISK FACTORS IN SMART CITY LOGISTICS SYSTEMS: STRATEGIC ANALYSIS WITH CAUSAL LOOP DIAGRAM

Zeynep Nur Köstepen

Izmir Bakircay University, Department of Industrial Engineering, Izmir, Turkey, zeynepkostepen@gmail.com

ABSTRACT:

Purpose:
The use of smart solutions, which is increasing in today's technological age, is also increasing in applications in cities. One such area is the management of logistics in smart cities. The main purpose of this study is to identify the risks caused by uncertainties in logistics and supply chain processes in smart cities and to devise strategies for the mitigation of their adverse effects.

Study design/methodology/approach:
This study employs causal loop diagrams to analyze logistics and supply chain management in smart cities. Causal loop diagrams identify positive and negative feedback loops in a process and evaluate the interactions within that process through these loops. This methodology allows for the clear identification of risks encountered in smart city logistics management and the interaction between these risks, thereby facilitating the development of proactive solutions.

Findings:
This study shows how the risks and uncertainties encountered in smart city logistics management are determined and analyzed with causal loop diagrams. The dynamic structure of logistics processes and the interactions between the factors affecting these processes are determined with causal loop diagrams. It has been revealed that the risks in the process can be minimized by correctly analyzing these interactions and developing new solution methods.

Originality/value:
This study presents an original approach to analyze uncertainties and risks using causal loop diagrams in smart city logistics management. This study, which deeply examines the dynamic structure of logistics and supply chain processes in smart cities and the interactions of risks encountered in these processes, provides a new perspective for developing proactive solutions.

KEYWORDS
Causal Loop Diagram, Logistics, Risk Management, Smart Cities

PORT SAFETY FROM THE CAPTAINS' PERSPECTIVE

Mehmet Gürtürk, Erkan Çelik

Student/Res. Assist., mehmetgurturk@comu.edu.tr
Assoc. Prof., erkancelik@istanbul.edu.tr

ABSTRACT:

Purpose:
Accidents in ports result in significant losses. With the number and size of ships increasing at an alarming rate, the urgency to address port safety is more pronounced than ever. Numerous factors influence the provision of port security. One of the most crucial is the captains. Captains are responsible for safely docking the ship by ensuring port safety. This study aims to use the best-worst method (BWM) to identify factors affecting port safety from the perspective of captains.

Study design/methodology/approach:
This study's methodology is based on the best-worst method (BWM), a multi-criteria decision-making approach.

Findings:
As a result, we have uncovered the factors that impact port security from the perspective of captains.

Originality/value:
This study is more recent, comprehensive, and in-depth than similar studies and uses different methods.

KEYWORDS
Port, Captain, Port Safety.

DEVELOPING AN OPTIMIZATION ALGORITHM FOR ORDER PICKING AND STORAGE ASSIGNMENT IN AN AUTOMOTIVE SUB-INDUSTRY WAREHOUSE

Derya Alp Balbay, Eray Aksoy, Ozan Aksu, Ömer Faruk Eskici, Süha Turgut Ufuk, Zehra Düzgit

İstanbul Bilgi University, Department of Industrial Engineering,
alp.balbay@bilgiedu.net, eray.aksoy@bilgiedu.net, ozan.aksu@bilgiedu.net, faruk.eskici@bilgiedu.net, zehra.duzgit@bilgi.edu.tr

ABSTRACT:

Purpose:
The purpose of this study is to design a joint order picking and storage assignment policy for an automotive sub-industry warehouse. The order picking system of this manual warehouse is low-level picker-to-parts. Order picking is the most labor-intensive, time-consuming and costly operation in such warehouses. Since travelling constitutes the major time of order picking, the objective is to minimize the total travelled distance of order pickers.

Study design/methodology/approach:
Three routing heuristics (S-Shape, Largest Gap, Midpoint) are implemented to find the best route for order pickers. Moreover, genetic algorithm is adapted for order picking problem where the effect of different population sizes, crossover and mutation probabilities and operators, and termination criteria are examined. The best parameter set is determined for three picklist sizes. For the storage assignment problem, a frequency-focused class-based policy, called Fast, Slow and Non-moving (FSN)+Brand, is developed.

Findings:
According to the computational tests, the combination, where genetic algorithm is adopted for order picking and FSN+Brand is implemented for storage assignment problem, is superior to all combinations in terms of minimizing total travelled distance of order pickers.

Originality/value:

The proposed solution approach is applicable to any multi-block warehouse layout. For the storage assignment, F, S and N classes were combined with brand groups and a novel policy is achieved. A user interface is designed by using Flutter. For any selected picklist, the interface visually displays the best route and the corresponding total travelled distance for an order picker regarding any combination of four order picking routing policies and two storage assignment policies.

KEYWORDS
Genetic algorithm, Order picking, Picker routing, Storage assignment, Warehouse

GREEN LOGISTICS AND SUSTAINABILITY: VISIBILITY AND IMPACT IN SCIENTIFIC PUBLICATIONS

Nida Oruç, Batuhan Kocaoğlu

Istanbul Topkapi University, nidaoruc@topkapi.edu.tr
Istanbul Topkapi University, batuhankocaoglu@topkapi.edu.tr

ABSTRACT:

Purpose:
This study aims to present a bibliometric analysis of scientific publications using the keywords "Sustainability" and "Green Logistics." The analysis seeks to determine the growth rate of the field, contributions of authors, international collaborations, and the impact of publications. By providing an overview of research conducted on sustainability and green logistics, this study aims to offer valuable insights that will guide future research in these areas.

Study design/methodology/approach:
The study conducted a search in the Web of Science (WoS) database using the keywords "Sustainability" and "Green Logistics," covering the years 2005-2024. Initially, 1327 documents were retrieved. When filtering for articles as the document type, English as the language, and Science Citation Index (SCI) and Social Sciences Citation Index (SSCI) as the indices, the number of analyzed articles decreased to 839. These articles were analyzed using metrics such as annual growth rate, number of authors, rate of international co-authorship, number of references, average publication age of articles, and average citations per article.

Findings:
According to the analysis results, the annual growth rate was determined to be 22.11%. A total of 2486 authors contributed, with an average of 3.69 co-authors per author. The number of single-authored articles was 51. A total of 2757 different keywords were used. Furthermore, observations reveal that the number of publications in the field of green logistics and sustainability has significantly increased, especially since 2012. In 2023, there were 130 publications, and in the first six months of 2024, there were 89 publications. The countries with the highest number of publications are China, the USA, India, the United Kingdom, and Italy. In terms of authors, the most prolific are Sarkis J., Kumar A., Govindan K., Khan Sar., and Mangla SK., respectively.

Originality/value:
This study provides a comprehensive bibliometric analysis of scientific publications on sustainability and green logistics, revealing the general dynamics and trends in the field.

It examines topics such as author productivity, contributions of countries, journals in which articles are published, and the most frequently used keywords. The data indicate significant growth in research on sustainability and green logistics, with widespread international collaborations. This rapid entry into the academic literature highlights the increasing importance of these fields. Consequently, this study offers significant contributions to better understanding the existing literature and guiding future research in this area.

KEYWORDS
Bibliometric analysis, green logistics, sustainability

THE IMPACT OF AIR LOGISTICS AND TRANSPORTATION ON THE OPERATIONAL EFFICIENCY OF 10 EUROPEAN INTERNATIONAL AIRPORTS BY USING DATA ENVELOPMENT ANALYSIS

Ahmet Ilbaş, Hakan Kaya

İstanbul Arel Üniversitesi, Lojistik Yönetimi, ahmetilbas@arel.edu.tr.
İstanbul Arel Üniversitesi, Havacılık Yönetimi, hakankaya@arel.edu.tr.

ABSTRACT:

Purpose:
This paper studies the impact of air logistics and transportation on the operational efficiency of 10 major European international airports over the 2021–2023 period by using Data Envelopment Analysis (DEA) method.

Study design/methodology/approach:
Literature review has been done and then input and output variables used in the logistics operational efficiency analysis of airports are determined. In this study, as input variables; surface of the airport, cargo terminal area, number of passenger terminals, number of runways and as output variables; number of flights, number of passengers and amount of cargo are used.

Findings:
As a result of this study, it was revealed that the operational performance of 8 of 10 major international airports (Amsterdam Schiphol, Barcelona, Leonardo da Vinci-Fiumicino, Frankfurt Main, Istanbul, London Gatwick, London Heathrow and Munich) in the 2021-2023 period was effective, and only 2 of them (Paris Charles de Gaulle, Madrid) were ineffective. While two inefficient airports could have produced more output by better utilizing their potential with the same input amounts, they produced less output where they were located.

Originality/value:
Many studies have been conducted on measuring and improving the efficiency performance of airports, but no study has been found on measuring the efficiency of airports in Europe, including Istanbul Airport. This study is expected to contribute to the literature on understanding the impact of air logistics and transportation on the

operational efficiency of airports in 10 major international airports in Europe, including Istanbul Airport.

KEYWORDS
Logistics, Air Transportation, Data Envelopment Analysis (DEA), Logistics Operational Efficiency

SUPPLIER SELECTION FOR HOSPITALITY INDUSTRY WITH EXTENDED INTUITIONISTIC FUZZY EDAS METHOD

Eren Kamber, Murat Baskak

Department of Industrial Engineering, Alanya Alaaddin Keykubat University, Antalya, Alanya, Turkey, e-mail: eren.kamber@alanya.edu.tr
Department of Industrial Engineering, Istanbul Technical University, İstanbul, Beşiktaş, Turkey, e-mail: baskakm@itu.edu.tr

ABSTRACT:

Purpose:
This study aims integration of intuitionistic fuzzy sets and EDAS (Evaluation Based on Distance from Average Solution) method from a different perspective and to present as a new solution model of intuitionistic fuzzy EDAS (IF-EDAS) method for multi criteria decision making models in literature with supplier selection problem in tourism sector.
Study design/methodology/approach:

Before solving supplier selection problem, related criteria will be determined considering literature and will be weighted by decision makers. To validate presented IF-EDAS decision-making model, a numerical example will be proposed in tourism sector. After, the results will be compared with intuitionistic fuzzy CODAS method.

Findings:
Considering the comparative analyses, the purpose will be to obtain consistent results and the validity of the IF-EDAS method will be thus proven. Finally, the results of the study will be evaluated in terms of tourism sector.

Originality/value:
The importance of supplier selection for tourism will be emphasized in this study. In addition, the proposed method has various advantages. Firstly, intuitionistic fuzzy sets develop the membership function by assigning membership and non-membership degrees. Also, the main idea of EDAS method is to benefit from the positive distance and negative distance concerning the average solution derived from the decision matrix.

KEYWORDS
Intuitionistic fuzzy sets, EDAS, hospitality, supplier selection

ELECTRIC VEHICLE CHARGING STATIONS

Seda Yanik, Osman Oguncl u

Industrial Engineering Department, Istanbul Technical University, Istanbul, Turkey, sedayanik@itu.edu.tr, ogunclu20@itu.edu.tr

ABSTRACT:

Purpose:
Addressing climate change necessitates the acceleration of global decarbonization, with the development of the electric vehicle (EV) ecosystem and its supply chain playing a crucial role. Charging stations and their infrastructure are the critical factors for the widespread adoption of electric vehicles. In a study conducted to identify the factors important to customers in Turkey's transition to electric vehicles, charging infrastructure and charging duration, along with vehicle price and range, were identified as the four most important ecosystem factors.

Study design/methodology/approach:
Considering the significance attributed to charging infrastructure, this study aims to define electric vehicle charging stations and infrastructure from a system perspective, and to examine the role of charging stations in the proliferation of electric vehicle usage as well as the challenges and opportunities arising from their interaction with the electric grid.

Findings:
Initially, the study provides a detailed examination of the components, lifecycle, various classifications, manufacturers within the supply chain, installation process, and the operational and management processes of charging stations. Subsequently, it investigates the current status and future requirements of the charging infrastructure in Turkey and globally, considering both quantitative aspects such as quantitative volume and capacity with qualitative dimensions including station reliability, user experience, and efficiency. Additionally, the study summarizes the dimensions of the interaction between electric vehicles, charging infrastructure, and the electric grid, and explores the types of approaches that can be utilized for their economic design.

Originality/value:
Finally, this study offers recommendations for the development and management of charging stations and infrastructure to meet current needs and future advancements effectively.

KEYWORDS
Electric Vehicle, Charging Stations, Charging Infrastructure, EV and Charging Standards

A PRACTICAL APPROACH TO IDENTIFYING DENSE DELIVERY LOCATIONS

Salih Cebeci, Ayşe Dilara Türkmen, Zehra Hafızoğlu Gökdağ, Ali Çıltık

HepsiJET, salih.cebeci@hepsijet.com
HepsiJET, ayse.turkmen@hepsijet.com
HepsiJET, zehra.gokdag@hepsijet.com
HepsiJET, ali.ciltik@hepsijet.com

ABSTRACT:

Purpose:
In recent years, the rapid expansion of e-commerce has significantly increased the package volume handled by business-to-consumer logistics companies. Customers exhibit varying order demands, with some regions experiencing higher density while others have more sparse demand. The purpose of this study is to develop a practical approach for detecting dense delivery points in business-to-consumer logistics. By identifying high-density delivery locations, it is possible to optimize last mile operations for more cost-effective delivery.

Study Design/Methodology/Approach:
The process begins by identifying delivery points that are within a specified distance-based proximity to each point, thereby forming a proximity cluster for each point. These clusters will be utilized as intermediate steps to form final clusters that are planned to be obtained. The cluster with the maximum number of points is selected as one of the final clusters. Then the points in this cluster are removed from every other cluster they were in. This process was repeated until there were no clusters left that are over the predefined minimum number of elements. The obtained clusters were the final clusters that refer to dense delivery locations. The algorithm is designed to handle large datasets efficiently through various innovative methods proposed in the study.

Findings:
The proposed approach successfully identifies dense delivery locations, thereby facilitating the planning of various operational scenarios for regions with varying delivery densities. Methods that are used to solve such large-scale problems, might require an excessive amount of time. Thus, our algorithm was enhanced with innovative techniques, significantly improves efficiency and is capable of handling larger datasets, covering wider areas and longer time periods.

Originality/Value:

This study offers a method for identifying dense delivery points in last-mile logistics, addressing the challenges posed by varying delivery volumes across different regions. The improvements that enhance the algorithm's performance provide practical solutions for large-scale problems, contributing valuable insights for optimizing delivery operations in the logistics industry.

KEYWORDS
algorithm processing time, clustering, last mile logistics, operational optimization

UTILIZING ACORNS AS A SUSTAINABLE RAW MATERIAL: SUPPLY CHAIN NETWORK DESIGN

Irem Nur Ilbaş, Şeyda Serdarasan

İstanbul Technical University, ilbas22@itu.edu.tr, serdars@itu.edu.tr

ABSTRACT:

Purpose:
Non-wood forest products (NWFPs), such as acorns, represent valuable natural resources with diverse economic potential across various industries. This study aims to explore the economic value of acorns as a NWFP and design a sustainable supply chain network for their utilization. This research addresses the integration of logistics and supply chain management approach to improve the efficiency and sustainability of acorn processing and distribution.

Study design/methodology/approach:
A multi-objective supply chain network design model is presented, aimed at optimizing transportation and processing of acorns into flour, tannin, and biomass. The model incorporates logistics costs, production capacities, and environmental impacts such as carbon emissions. A set of Pareto solutions is obtained using the augmented ε-constraint (AUGMECON) method. The study evaluates different market demands and strategically places processing facilities to achieve optimal economic and environmental outcomes.

Findings:
The optimized model identifies cost-effective and sustainable logistics and processing routes for oak acorns, improving resource utilization and reducing environmental impact. It enhances supply chain efficiency for tannin, biomass, and flour production, achieving significant cost savings and carbon emission reductions while promoting economic feasibility and environmental sustainability through scenario analysis.

Originality/value: This study contributes to the emerging field of non-wood forest products by focusing on acorns as a sustainable raw material. The supply chain design offers insights into maximizing the value of NWFPs while minimizing environmental impact. The research provides practical implications for industries seeking sustainable sourcing strategies and underscores the value of acorns in diversified industrial applications.

KEYWORDS

Acorn (quercus sp.), sustainable supply chain, augmented ε-constraint, supply chain network design, non-wood forest products

EVOLUTION OF SCOR MODEL APPLICATIONS: A COMPREHENSIVE LITERATURE ANALYSIS BY SECTORS AND TECHNIQUES

Elif Tekin, Nagihan Kartal, Batuhan Kocaoğlu

Research Assistant, İstanbul Topkapı University, Department of Management Information Systems, eliftekin@topkapi.edu.tr
Research Assistant, İstanbul Topkapı University, Department of Management Information Systems, nagihankartal@topkapi.edu.tr
Prof. Dr., İstanbul Topkapı University, Department of Management Information Systems, batuhankocaoglu@topkapi.edu.tr

ABSTRACT:

Purpose:
This literature review aims to comprehensively analyze the application and development of the Supply Chain Operations Reference (SCOR) model in various industries from its inception to the present day. In this way this study provides valuable information to academics and practitioners by highlighting the SCOR model's versatility, adaptability, methodological advances, and impact on supply chain performance.

Study design/methodology/approach:
In the research, databases and academic publications were systematically scanned and articles published between 2005 and 2024 were classified according to basic criteria. How the SCOR model is applied in different sectors, which methodological approaches are preferred and the impact of these approaches on supply chain performance were investigated.

Findings:
This literature review reveals that the SCOR model has been successfully applied across a wide range of industries thanks to its versatility and adaptability. The model is widely used in manufacturing, transportation, service and other industries. Various methodological approaches have been adopted in the application of the SCOR model. This diversity shows that researchers approach the SCOR model from different perspectives. It also appears that the SCOR model has evolved with continuous updates and improvements in response to new challenges encountered.

Originality/value:

This study reveals how the use of the SCOR model adds value not only in academic theory but also in practical applications. Additionally, this study shows that the SCOR model has broad potential for future research, encouraging further innovative work, especially in areas such as digital transformation, sustainability and risk management.

KEYWORDS
Methodological Approaches, Supply Chain Management, Supply Chain Operations Reference (SCOR) Model.

A NOVEL FUZZY MULTI-CRITERIA DECISION MAKING METHOD FOR THE SUPPLIER SELECTION PROBLEM IN UNCERTAIN HEALTHCARE ENVIRONMENTS

Fateh Seghir

Intelligent Systems Laboratory, Faculty of Technology, Ferhat Abbas University - Setif 1-, seghir.fateh@gmail.com

ABSTRACT:

Purpose:
The supplier selection problem in healthcare supply chain management is a complex Multi-Criteria Decision Making (MCDM) issue, involving various dynamic factors such as quality, cost-effectiveness, reliability, and sustainability in the acquisition of medical supplies, equipment, and healthcare services. Due to the uncertain environments in which these supplies are acquired, criteria such as price fluctuations and supply chain disruptions are often ambiguous and unpredictable. Therefore, it is inappropriate to represent these factors using fixed and exact values.

Study design/methodology/approach:
Given that generalized trapezoidal fuzzy numbers are robust, versatile, and general models for expressing uncertain values and linguistic terms, the supplier selection problem in uncertain healthcare environments is formulated as a fuzzy MCDM problem. To address this issue, a novel Fuzzy Multi-Criteria Decision Making (FMCDM) approach has been developed. In fact, new fuzzy ranking operators and fuzzy distance computation method are integrated into the developed FMCDM approach to handle the fuzzy ambiguity of various conflicting criteria that characterize the healthcare supplier selection problem under fuzziness.

Findings:
To demonstrate the effectiveness and applicability of the proposed approach, a case study of healthcare supplier selection under uncertainty is conducted and analyzed. Moreover, the rationality and feasibility of the proposed FMCDM are verified by comparing it with some recent state-of-the-art fuzzy MCDM methods.

Originality/value:

The original contribution of this study lies in the simplicity, efficiency, and applicability of the developed FMCDM method in addressing the complexities of the healthcare supplier selection problem in uncertain and dynamic environments.

KEYWORDS
Supplier selection problem, uncertain healthcare environments, Multi-criteria decision making, generalized trapezoidal fuzzy numbers.

LOGISTICS AND SUPPLY CHAIN USING ARTIFICIAL INTELLIGENCE: NAVIGATION THE FUTURE WITH INNOVATION AND EFFICIENCY

Farid Ayeche

Faculty of Technology, Ferhat Abbas University - Setif 1-, ayeche_farid@yahoo.fr

ABSTRACT:

Purpose:
The integration of Artificial Intelligence (AI) in logistics and supply chain management has revolutionized business operations by enhancing efficiency, reducing costs, and optimizing various processes. This article aims to delve into the pivotal role of AI within this sector, focusing on its significant benefits, diverse techniques employed, and the potential future landscape. The primary goal is to highlight how AI-driven innovations are reshaping logistics and supply chain management to meet the demands of a dynamic global marketplace.

Study design/methodology/approach:
This study undertakes a comprehensive review of existing literature and industry case studies to analyze the impact of AI on logistics and supply chain management. The methodology includes an examination of various AI applications, such as process automation, predictive analytics, route optimization, and demand forecasting. By synthesizing findings from multiple sources, the study provides a holistic view of the current state of AI integration in the logistics sector and explores potential future developments. Additionally, specific AI techniques, including machine learning, natural language processing, computer vision, and robotics, are investigated for their practical applications and contributions to the industry.

Findings:
The findings demonstrate that AI significantly contributes to reducing operational costs, enhancing visibility and transparency, improving customer experience, and mitigating risks within the supply chain. AI-driven techniques such as machine learning algorithms, natural language processing, computer vision, and robotics play crucial roles in achieving these benefits. The future of AI in logistics and supply chain management is projected to include advancements in autonomous vehicles, blockchain integration, edge computing, and sustainability efforts, further driving efficiency and innovation.

Originality/value:

The original contribution of this study lies in the simplicity, efficiency, and applicability of the developed FMCDM method in addressing the complexities of the healthcare supplier selection problem in uncertain and dynamic environments.

KEYWORDS
Artificial Intelligence, Automation, Logistics, Predictive Analytics, Route Optimization, Supply Chain Management.

DIGITALIZATION OF INDIRECT PROCUREMENT PROCESS

Mehmet Emir Dürgeci, Sena Çökerim, Yasen Yaşar, Seval Ene Yalçın, Emine Eş Yürek

Bursa Uludağ University, Department of Industrial Engineering, Bursa, Türkiye,
emirdurgeci@gmail.com, senacokerim@gmail.com, 031940029@ogr.uludag.edu.tr, sevalene@uludag.edu.tr, esyurek@uludag.edu.tr

ABSTRACT:

Purpose:
The high number of manual transactions in indirect procurement processes leads to difficulties in responding to irregular and urgent product demands, resulting in inefficient and non-value-added workloads, and causing disruptions in operations. To reduce the number of manual transactions and facilitate decision-making, a system that supports supplier selection, price, and demand forecasting was designed.

Study design/methodology/approach:
For the supplier selection problem, Fuzzy DEMATEL and TOPSIS, multi-criteria decision-making methods, were utilized. Five algorithms were employed for price and demand forecasting problems: ARIMA, KNN, Linear Regression, SVM, and Holt-Winters.

Findings:
A user interface was developed using Python, allowing the supplier selection, price, and demand forecasting results to be monitored together. After reading the data provided by the user through the interface, the application performs data preprocessing, runs the algorithms, and applies hyperparameter optimization. The results with the smallest error among five forecasting algorithms are displayed on the screen to the user. Besides, the user is given several suppliers ranked from the most suitable based on quality, lead time, price, etc.

Originality/value:
As a result of this study, the number of manual transactions has been reduced. The primary benefits of this study include reducing the risk of production downtime, strengthening the purchasing officer's position during negotiations, and eliminating the experience-based system in supplier selection.

KEYWORDS
Demand forecast, Machine learning, Multi-criteria decision making, Price forecast, Supplier selection

A MAXIMAL CAPTURE LOCATION MODEL FOR CHARGING STATIONS: AN APPLICATION ON A CORRIDOR IN TURKEY

Gökhan Sarıkaya, Yunus Emre Öztürk, Seda Yanık

Industrial Engineering Department, Istanbul Technical University,
sarikayago18@itu.edu.tr, ozturky18@itu.edu.tr, sedayanik@itu.edu.tr

ABSTRACT:

Purpose:
In the rapidly evolving landscape of electric vehicles (EVs), the strategic placement of charging stations plays a pivotal role in shaping the efficiency and accessibility of the charging infrastructure. This article delves into the realm of location optimization for electric vehicle charging stations.

Study design/methodology/approach:
In the first part of our study, the number of electric vehicles in Turkey are projected in the future. Double exponential smoothing is employed for forecasting the number of electric vehicles and number of total automobiles in Turkey. In the second part, we aim to optimize the locations of electric charging stations along an intercity highway road network. The aim is to maximize potential capture of EV traffic flow by the located EV charging stations. To achieve this, we use a mixed integer programming for the charging station location problem in a transportation network to cover intercity travels.

Findings:
A real life case is presented using a high-way road network from Edirne to Ankara in Turkey. The predicted number of total EVs will be approximately 23 million and the proportion of EVs to total automobiles are found to be almost 40%. It consists of 33 links and 263 internodes where EV charging stations can be installed. As a result of the model, 43 optimal locations for EV charging stations are selected out of 263 potential locations.

Originality/value:
This study integrates mathematical optimization, data analysis, and visualization techniques to devise an efficient and effective strategy for the placement of electric vehicle charging stations, addressing both current and future demand. An interface is designed that facilitates ease of use for charging station manufacturers, empowering them to make informed decisions based on the optimized solution.

KEYWORDS
Electric vehicle charging stations, demand forecasting, double exponential smoothing, maximal capture location problem, mixed integer programming

INTRODUCTION

In the rapidly evolving landscape of electric vehicles (EVs), the strategic placement of charging stations plays a pivotal role in shaping the efficiency and accessibility of the charging infrastructure. This article delves into the realm of location optimization for electric vehicle charging stations, presenting a research endeavor dedicated to designing a decision support system tailored for manufacturers and operators of these vital facilities. The application phase focuses on the Turkish highway network, specifically D100, D200, D300, D550, D650, and the European highway, serving as a real-world testing ground for our proposed optimization framework. This research aspires to contribute valuable insights and practical solutions to enhance the deployment of electric vehicle charging infrastructure, aligning it with the evolving needs of the electric mobility ecosystem.
The optimization of site selection for electric vehicle charging stations is the system that we are investigating in this study. The aim is to create an algorithm that makes the choice of locations and station types for electric vehicle charging stations as efficient as possible. The model takes into account a number of variables, including the adoption of electric vehicles, the availability of infrastructure, and user accessibility. The system's boundaries is set as the highways and state roads of Turkey. The owners of electric vehicles who will use the charging stations, operators of the charging stations who will install and maintain the charging stations, and the governmental organizations in charge of regulating and promoting the usage of electric vehicles are the stakeholders who influence and are influenced by the output of this study. Increasing the use of electric vehicles, cutting carbon emissions, and providing convenient and accessible charging stations are some of the potential contributions to the society and the stakeholders' of this ecosystem.
The paper is organized as follow: in the next section our forecasting approach for predicting the electric vehicle inventory in Turkey and the mathematical model is presented, then an application section is devoted for the case study and the results obtained, then the conclusion section gives the findings and future studies.

METHODOLOGY

First part of this study is forecasting the number of electric vehicles in Turkey. Predicting the total amount of electric vehicles in the determined future is a crucial input for optimizing locations of electric vehicle stations which will be the second part of the study.

Initially, attention is directed towards forecasting the traffic volumes of electric vehicles at potential charging station locations. Secondly, total number of automobiles in traffic in Turkey will be forecasted in order to predict proportion of EVs to the total number of automobiles. To this aim, monthly EV sales data from 2021 to 2023 is collected from Automotive Distributors' and Mobility Association. Our model for forecasting EV sales is based on Double exponential smoothing (Holt linear) method. The same approach is also used to forecast total number of automobiles in traffic in Turkey. With this two forecasted value, proportion of EVs to the total number of automobiles in Turkey can be predicted for any year in the future. The projected proportion of EVs within Turkey will serve as an input data for optimizing the placement of EV charging stations along the road network of Turkey.
The forecast for each period in double exponential smoothing is determined by the sum of the preceding period's level and trend components. The level component is calculated using the Equation 1:

$$L_t = \alpha \times y_t + (1 - \alpha) \times (L_{t-1} + T_{t-1}). \quad (1)$$

The trend component is calculated using Equation 2:

$$T_t = \beta \times (L_t - L_{t-1}) + (1 - \beta) \times T_{t-1} \quad (2)$$

In our problem, we aim to optimize the locations of electric charging stations along an intercity highway and road network. The aim is to maximize potential capture of EV traffic flow by EV charging stations installed using the model. To achieve this, we adopted a mathematical model from Ref [1] based on an mixed integer programming (MIP) and modified some components according to our problem definition. The notation used in our model can be found in Table 1.

TABLE 1
Model Notation

Notations	Parameters
I	Budget
m_i	Number of alternative locations on link i
r	Maximum distance between two consecutive CSs
l_i	Distance of link i (km)
d_{ij}	Distance from the start point of link i to the location j (km)
h_{ij}	The traffic volume of the alternative location j on link i
c_{ij}	Cost of installing charging station at the internode j on link i
o_i	Number of competitor charging stations on link i
	Binary Variables
x_{ij}	1 if there is a CS at the internode j on link i; 0 otherwise
z_{ijk}	1 if there is a CS in location j and k on link i; 0 otherwise

b_{ijk}	1 if there is at least one CS between the CSs at locations j and k on link i; 0 otherwise

W $i, g = the\ set\ of\ links\ (1, \dots, \dots, n)$
$j, k, e = the\ set\ of\ possible\ locations\ of\ stations\ (1, \dots, \dots, M_i)$

The MIP model is formulated using Equations (3)-(12).
Max z = $\sum_{i=1}^{n}\sum_{j=1}^{m_i}\frac{1}{o_{ij}+1} h_{ij}\, x_{ij}$ (3)
s.t.
$\sum_{j=1}^{m_i} x_{ij}$ >= 1 $\forall i,\ d_{ij}$ <= r (4)
$\sum_{j=1}^{m_i} x_{ij}$ >= 1 $\forall i,\ l_i$ - d_{ij} <= r (5)
$x_{ij} + x_{ik} - 1 <= z_{ijk}$ $\forall i$,j,k, j>k (6)
$x_{ij} + x_{ik} >= 2 * z_{ijk}$ $\forall i$,j,k, j>k (7)
$\sum_{k}^{m_i} z_{ijk} \leq m_i * b_{ije}$ $\forall i$,j,e, j>k>e (8)
$\sum_{k}^{m_i} z_{ijk} \geq b_{ije}$ $\forall i$,j,e, j>k>e (9)
$(z_{ijk} - b_{ijk}) * (d_{ij} - d_{ik}) < r$ $\forall i$,j,k, $m_i > 1$, j > k (10)
$x_{ij}c_{ij}$ <= I $\forall i$, j (11)
x_{ij}, z_{ijk}, b_{ijk} BIN $\forall i$,j,k (12)
In Eq. (3) the goal is to maximize capture of traffic flow but if there is competitor stations on the link, traffic flow is shared. Eq (4) and (5) ensure that there must be at least one CS within the r from the start of each link and there must be at least one CS within the r from the end of each link respectively. Eq (6) and (7) are constraints states that there is a CS in location j and k on link “i”. Eq (8) and (9) are constraints for ensuring that there is at least one CS between the CSs at locations j and k. Eq (10) guarantees that the distance between two consecutive CSs satisfies r. Eq (11) ensures total cost of charging stations does not exceed I. Eq (12) is the constraint for binary variables. This Mixed Integer Programming is solved using Python Gurobi.

APPLICATION

In the application section, two components of the design will be implemented as outlined in the methodology. The first part involves forecasting the traffic volumes of electric vehicles at potential charging station locations. The results of this forecast will serve as input for optimizing the locations of electric vehicle stations, which constitutes the second part of the project. In the optimization section, our model will be initially applied to an illustrative example featuring three cities and two connecting links. Subsequently, the proposed optimization model will be applied to a real-world case study based on busiest highways and roads within the road network that goes through Turkey's largest cities.

Forecasting EV Inventory in Turkey

As outlined in the methodology, Double exponential smoothing (Holt linear) is employed for forecasting the number of electric vehicles and number of total automobiles in Turkey. Firstly, EV sales will be forecasted using monthly EV sales data from 2021 to 2023 depicted in Figure 1.

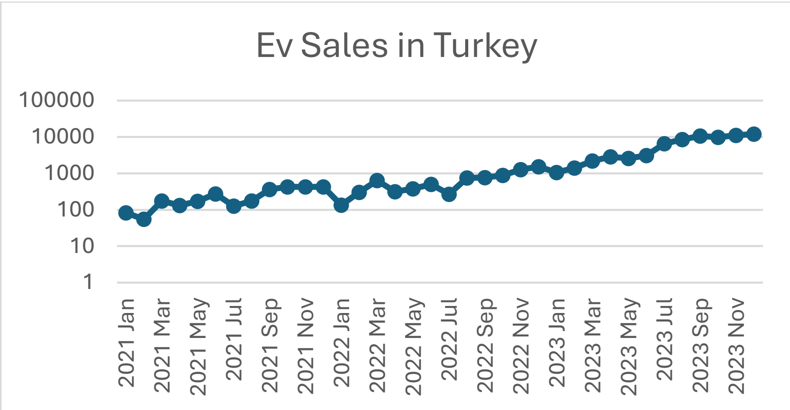

FIGURE. 1
EV Sales in Turkey.

Before forecasting into the future, the values for α and β in Eq (1) and (Eq. (2) need to be optimized. Initially, the EV sales data is divided into two sets: the first 30 months of data are allocated for training, while the last 6 months are reserved for testing. Through the utilization of training data, the optimal values for alpha and beta are derived by minimizing the Mean Absolute Percentage Error (MAPE) of the forecasted values. The minimum MAPE is achieved at 39.5%, corresponding to optimized values of alpha at 0.517 and beta at 0.204. The MAPE for the test data has been calculated to be 20.1%. The results can be seen in Figure 2.

alpha	0.517
beta	0.204
Training MAP	39.5%
Test MAPE	20.1%

Period	Actual EV Sales	Level	Trend	Forecasted EV Sales	Error	ABS Error	Error^2	APE
2021 Jan	83							
2021 Feb	55	55.0	-28.0					
2021 Mar	174	103.0	-12.5	27	147.0	147.0	21609.0	0.845
2021 Apr	132	112.0	-8.1	91	41.4	41.4	1718.0	0.314
2021 May	173	139.6	-0.8	104	69.1	69.1	4776.8	0.400
2021 Jun	274	208.7	13.5	139	135.2	135.2	18272.0	0.493
2021 Jul	128	173.5	3.5	222	-94.2	94.2	8874.7	0.736
2021 Aug	177	177.0	3.5	177	0.0	0.0	0.0	0.000
2021 Sep	364	275.4	22.9	181	183.5	183.5	33665.6	0.504
2021 Oct	427	364.9	36.5	298	128.7	128.7	16561.4	0.301
2021 Nov	428	415.1	39.3	401	26.7	26.7	710.3	0.062
2021 Dec	431	442.3	36.8	454	-23.4	23.4	548.7	0.054
2022 Jan	134	300.6	0.4	479	-345.1	345.1	119112.7	2.576
2022 Feb	301	301.0	0.4	301	0.0	0.0	0.0	0.000
2022 Mar	638	475.5	35.9	301	336.6	336.6	113312.7	0.528
2022 Apr	315	409.8	15.2	511	-196.4	196.4	38575.6	0.624
2022 May	376	399.7	10.0	425	-49.0	49.0	2401.5	0.130
2022 Jun	499	455.9	19.4	410	89.3	89.3	7980.2	0.179
2022 Jul	269	368.6	-2.3	475	-206.3	206.3	42565.3	0.767
2022 Aug	751	565.3	38.3	366	384.7	384.7	148022.5	0.512
2022 Sep	773	691.2	56.2	604	169.5	169.5	28718.2	0.219
2022 Oct	883	817.5	70.5	747	135.6	135.6	18399.1	0.154
2022 Nov	1275	1088.2	111.4	888	387.0	387.0	149764.4	0.304
2022 Dec	1519	1364.8	145.1	1200	319.5	319.5	102069.3	0.210
2023 Jan	1071	1282.9	98.7	1510	-438.8	438.8	192581.2	0.410
2023 Feb	1406	1394.2	101.3	1382	24.4	24.4	594.8	0.017
2023 Mar	2193	1856.3	175.0	1496	697.5	697.5	486437.3	0.318
2023 Apr	2857	2458.3	262.1	2031	825.8	825.8	681873.0	0.289
2023 May	2592	2654.0	248.6	2720	-128.5	128.5	16507.9	0.050
2023 Jun	3128	3019.2	272.4	2903	225.4	225.4	50802.6	0.072
2023 Jul	6560	4982.1	617.5	3292	3268.4	3268.4	10682716.4	0.498
2023 Aug	8584	7143.1	932.6	5600	2984.5	2984.5	8907169.1	0.348
2023 Sep	10660	9412.3	1205.4	8076	2584.3	2584.3	6678616.2	0.242
2023 Oct	9832	10211.3	1122.4	10618	-785.7	785.7	617399.2	0.080
2023 Nov	11218	11273.9	1110.2	11334	-115.8	115.8	13405.7	0.010
2023 Dec	12078	12225.8	1077.9	12384	-306.1	306.1	93705.1	0.025

FIGURE. 2
Double Exponential Smoothing on EV Sales.

Now equipped with optimized alpha and beta values, the model can be employed to forecast future. Forecasts of 2024 can be seen in Figure 3.

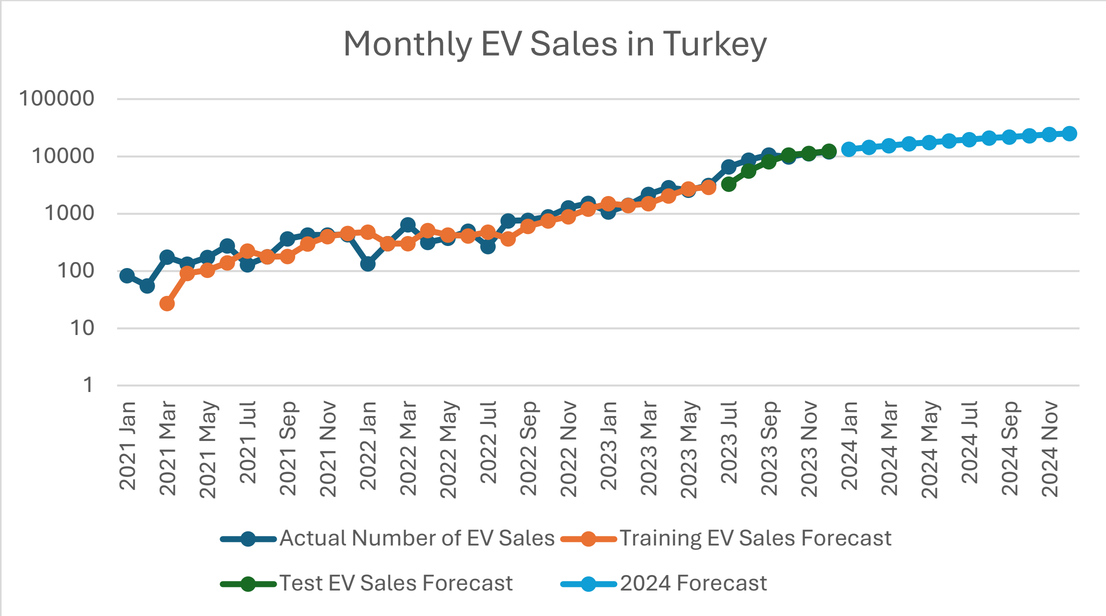

FIGURE. 3
Monthly EV Sales Forecast in 2024.

In the second step, double exponential smoothing is also be applied to predict the future total number of automobiles in Turkey. The dataset has been divided into two sets: the years 2009 to 2020 are designated for training, while the years 2021 to 2023 are set aside for testing. The same approach is applied, utilizing the training dataset from 2009 to 2020, resulting in the determination of alpha as 1 and beta as 0.723, which minimized the MAPE to 1.33%. The MAPE for the test data has been calculated to be 0.97%. The results can be seen in Figure 4.

alpha	**1**
beta	**0.723**
Training MAPE	**1.33%**
Test MAPE	**0.97%**

Year	Actual Number of Automobiles in Traffic	Level	Trend	Forecasted Cars in Traffic	Error	ABS Error	Error^2	APE
2009	**7,093,964**							
2010	**7,544,862**	7544862	450898					
2011	**8,113,111**	8113111	535764	**7,995,760**	117351	117351	13771257201	1.45%
2012	**8,648,875**	8648875	535764	**8,648,875**	0	0	0	0.00%
2013	**9,283,923**	9283923	607564	**9,184,639**	99284	99284	9857314062	1.07%
2014	**9,857,915**	9857915	583285	**9,891,487**	-33572	33572	1127097135	0.34%
2015	**10,589,337**	10589337	690415	**10,441,200**	148137	148137	21944436656	1.40%
2016	**11,317,998**	11317998	718074	**11,279,752**	38246	38246	1462761126	0.34%
2017	**12,035,978**	12035978	718006	**12,036,072**	-94	94	8789	0.00%
2018	**12,398,190**	12398190	460703	**12,753,984**	-355794	355794	126589336362	2.87%
2019	**12,503,049**	12503049	203363	**12,858,893**	-355844	355844	126624699415	2.85%
2020	**13,099,041**	13099041	487305	**12,706,412**	392629	392629	154157217174	3.00%
2021	**13,706,065**	13706065	573883	**13,586,346**	119719	119719	14332683774	0.87%
2022	**14,269,352**	14269352	566220	**14,279,948**	-10596	10596	112283999	0.07%
2023	**15,131,392**	15131392	780151	**14,835,572**	295820	295820	87509299418	1.96%

FIGURE. 4
Double Exponential Smoothing on Number of Automobiles in Traffic

Now equipped with fine-tuned alpha and beta values, the model is ready to project into the future. The forecasted values for the period 2024 to 2028 are depicted in Figure 5.

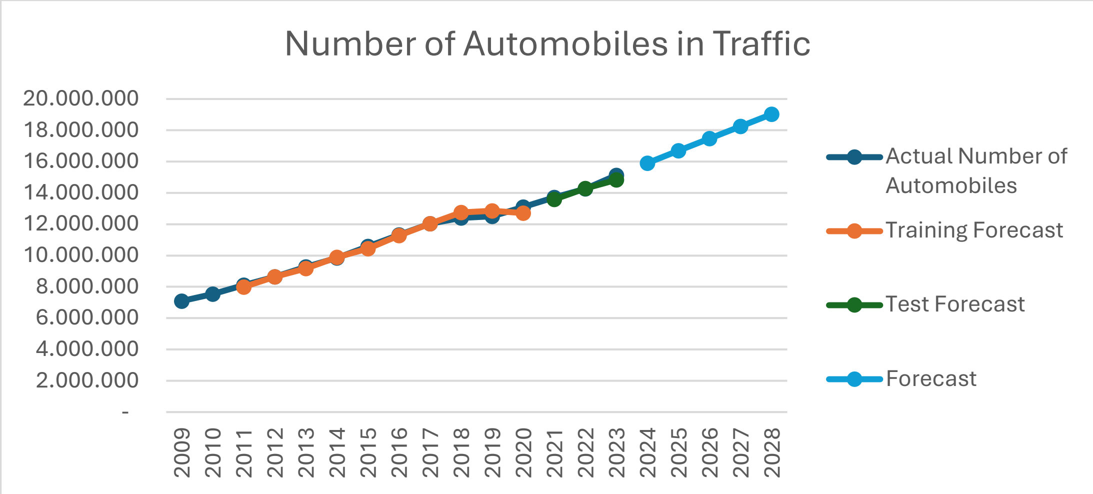

FIGURE. 5
Forecast of Total Number of Automobiles in Traffic

With these calculations, the raw numbers of electric vehicles and total automobiles are forecasted. However, it is essential for our model to predict the proportion of electric vehicles to total automobiles in order to anticipate the flow of EVs on each highway and road segment. The predicted proportions can be seen in Table 2.

TABLE 2
Forecast of the Proportion of Electric Vehicles to the Total Number Automobiles

2021	2022	2023	2024	2025	2026
0.03%	0.08%	0.57%	1.98%	4.20%	3.10%
2028	2029	2030	2031	2032	2033
10.98%	15.63%	20.68%	26.09%	31.82%	37.83%

Location Optimization of Charging Stations

In this section, the optimization model presented in the methodology will be applied to both a hypothetical example and a real-world case problem. The optimization model is formulated and solved using Python with Gurobi in both applications.
In this example, there are three cities: City A, City B, and City C. Two links connect these cities one from City A to City B and another from City B to City C. Each link has six potential charging station locations. This scenario is illustrated in Figure 6.

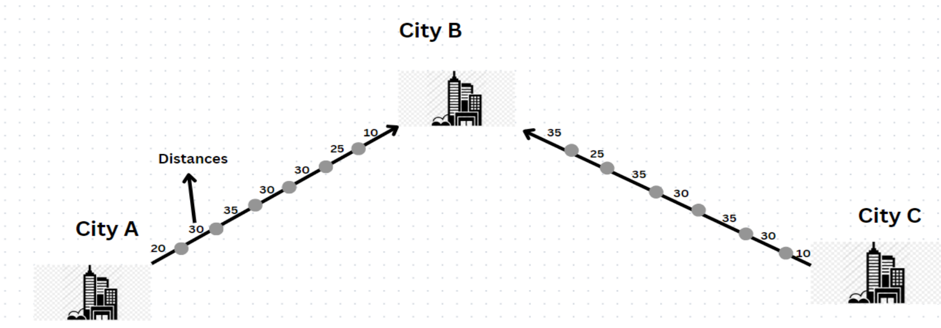

FIGURE. 6
Illustration of Sample Case

In this sample case there are 12 potential charging station locations. There are three main constraints. Firstly, distances between two consecutive charging stations can not be bigger than r = 80 km. Secondly there must be at least one charging stations within the r = 80 km from the start and end of each link. This distance constraints are added to prevent EV users to be stranded. Thirdly cost of installing charging stations can not exceed I = 200 in this sample. Fomulation of the model with all parameters, variables and data using Gurobi is shown in the python code in below. Figure 7 shows the indices, parameters and variables. Figure 8 presents the objective function and constraints.

```
import gurobipy as gp
from gurobipy import GRB
```

+ Code + Markdown

```
# Indices
ind_i = range(2)
ind_j = range(6)
ind_k = range(6)
ind_e = range(6)

# Parameters
p = 5
r = 80
I = 200
m = pd.DataFrame(data={'i': [6, 6]})
l = pd.DataFrame(data={'i': [180, 200]})
d = pd.DataFrame(data=[[20, 50, 85, 115, 145, 170], [10, 40, 75, 105, 140, 165]])
h = pd.DataFrame(data=[[100, 160, 150, 130, 80, 85], [80, 180, 130, 110, 80, 100]])
c = pd.DataFrame(data=[[20, 35, 40, 25, 30, 30], [45, 30, 35, 25, 35, 30]])
o = pd.DataFrame(data={'i': [1, 2]})

model = gp.Model("Charging Station Location")

x = model.addVars(pd.MultiIndex.from_product([ind_i, ind_j]), vtype=GRB.BINARY, name='x')
z = model.addVars(pd.MultiIndex.from_product([ind_i, ind_j, ind_k]), vtype=GRB.BINARY, name='z')
b = model.addVars(pd.MultiIndex.from_product([ind_i, ind_j, ind_k]), vtype=GRB.BINARY, name='b')
```

FIGURE. 7
Formulation of Optimization Model Using Python Gurobi

```python
# Objective Function
model.setObjective(gp.quicksum(h.iloc[i, j] * x[i, j] / (o.iloc[i, j] + 1) for i in ind_i for j in ind_j), sense=GRB.MAXIMIZE)

# Constraints
model.addConstrs((gp.quicksum(x[i, j] for j in ind_j if d.iloc[i, j] <= r) >= 1 for i in ind_i), name='constraint1')
model.addConstrs((gp.quicksum(x[i, j] for j in ind_j if l.iloc[i, 0] - d.iloc[i, j] <= r) >= 1 for i in ind_i), name='constraint2')
model.addConstrs((x[i, j] + x[i, k] - 1 <= z[i, j, k] for i in ind_i for j in ind_j for k in ind_k if j > k), name='constraint3')
model.addConstrs((x[i, j] + x[i, k] >= 2 * z[i, j, k] for i in ind_i for j in ind_j for k in ind_k if j > k), name='constraint4')
model.addConstrs((gp.quicksum(z[i, j, k] for k in ind_e if j > k > e) <= m.iloc[i, 0] * b[i, j, e] for i in ind_i for j in ind_j for e in ind_e), name='constraint5')
model.addConstrs((gp.quicksum(z[i, j, k] for k in ind_e if j > k > e) >= b[i, j, e] for i in ind_i for j in ind_j for e in ind_e), name='constraint6')
model.addConstrs(((z[i, j, k] - b[i, j, k]) * (d.iloc[i, j] - d.iloc[i, k]) <= r for i in ind_i for j in ind_j for k in ind_k if m.iloc[i, 0] > 1 and j > k), name='constraint8')
model.addConstr(gp.quicksum(x[i, j] * c.iloc[i, j] for i in ind_i for j in ind_j) <= I, name='constraint10')

model.optimize()
```

FIGURE. 8
Formulation of optimization model using Python Gurobi

The results show that in first link, first, second and fourth internodes, in the second link second, third and fourth and sixth internodes should be used to locate stations. The optimal value of the objective function is determined to be 678 indicating that optimally placing the 7 stations along the route at locations where the total traffic flow is 368 cars per day.

The real life case is a road network in Turkey. It consists of 33 links and 263 internodes where EV charging stations can be installed. Internodes are located on route where cars that use these road links can easily access. Necessary data such as distances, traffic flows collected from General Directorate of Highways in Turkey [2]. Installment costs are assumed to be correlated with average rent prices in each province and those values are used for installing costs [3]. Number of current competitor charging stations are determined using data from Google Maps. For this real case scenario, budget is determined to be 4000, and maximum distance between two consecutive CSs is determined to be 150. After all data is. The model in Figure 7 and Figure 8 is used in this case as well.
It took 1.12 seconds to solve this model. A total of 43 optimal locations to place EV charging stations are selected out of 263 potential locations. The optimal objective function value has been determined to be 71125. This results show that on average 71125 EV cars can be captured by these selected charging stations by the year 2033. The results show the specific internodes within each link where stations are to be optimally placed. Selected internodes are presented in the figure below (Figure 9).

CONCLUSION

In summary, this comprehensive process integrates mathematical optimization, data analysis, and visualization techniques to devise an efficient and effective strategy for the placement of electric vehicle charging stations, addressing both current and future demand. The designed interface facilitates ease of use for charging station manufacturers, empowering them to make informed decisions based on the optimized solution.

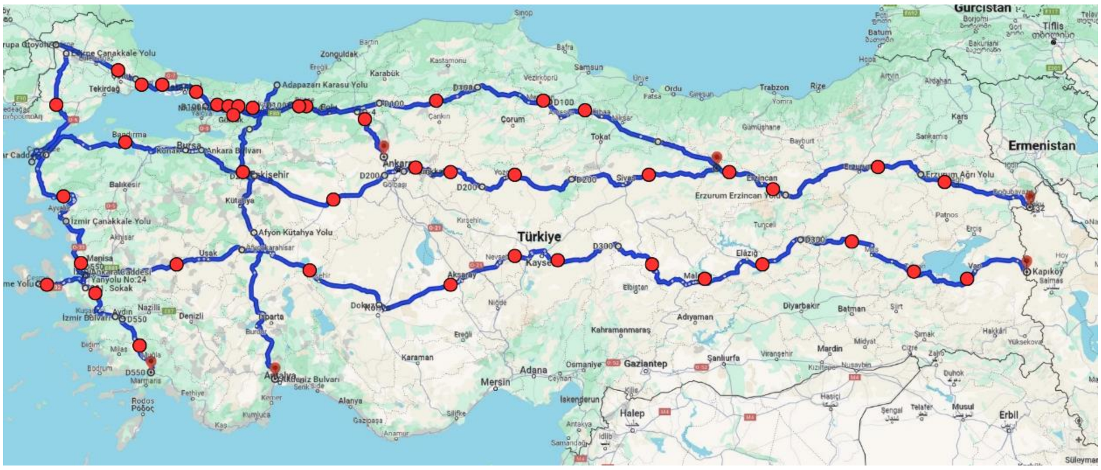

FIGURE. 9
Optimal Locations of EV Charging Stations on Map

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USE OF NEW TECHNOLOGIES IN TRANSPORTATION CORRIDORS AND GLOBAL SUPPLY CHAINS

Hulya Yilmaz, Seda Yanik

Quality Coordination Office, Kirklareli University, 39100 Kirklareli, Turkey, hulyayilmaz@klu.edu.tr

Department of Industrial Engineering, Istanbul Technical University, 34367 Istanbul, Turkey, sedayanik@itu.edu.tr

ABSTRACT:

Purpose:
The planning, management, and operation of complex transportation systems are important for their efficiency and sustainability. This study aims to examine the role of new technologies in improving the efficiency of complex transportation systems.

Study design/methodology/approach:
Complex transportation systems are defined as systems that integrate different countries or regions, serve global supply chains, or involve the combined use or interchange of various modes of transportation. This study investigates how new technologies emerging with the advance of information systems increase the efficiency of these systems. A bibliometric analysis is conducted by identifying keywords related to modern technologies such as Industry 4.0, intelligent systems, blockchain, machine learning, optimization, and multi-criteria decision-making (MCDM). Moreover, the methods used in the studies are identified through content analysis and finally, recommendations are made for future research.

Findings:
The results show that the most widely used modern technology is optimization, followed by the Internet of Things and blockchain technologies. The most studied topic is found to be supply chain, followed by transportation and logistics. Moreover, quantitative studies are the majority of the analyzed studies.

Originality/value:
The study investigates the relationship between complex transportation systems and modern technologies using bibliometric and content analysis. In this way, the gaps in the literature at the intersection of these two fields and areas for further research are identified. The study provides valuable recommendations for further research and applications, making important contributions to how complex transportation systems can be improved in terms of efficiency and sustainability.

KEYWORDS
Bibliometric analysis, content analysis, global supply chain, modern technology, transportation corridors

TRANSPORTATION CORRIDORS AND GLOBAL SUPPLY CHAINS

Transportation corridors are routes that connect two points using one or many modes of transportation to transport freight and passengers. There have been major transport corridors historically affecting the development of the geographical areas and shaping the globe. One major example of such a transport corridor is the Silk Road, connecting many countries along the European and Asian continents. Since then, many technological advancements have occurred and many of them play important roles in the success of these corridors. Therefore, understanding the technological factors affecting the sustainability and efficiency of a transport corridor is of the utmost importance.

There are various transportation corridors to carry out international trade effectively and efficiently. These types of corridors are referred to by different terminologies in the literature: development corridors, economic corridors, transportation corridors, multimodal transportation corridors, transit corridors, trade corridors, logistics corridors, main (core) corridors, and auxiliary networks [1]. Developing transportation corridors requires a complex planning process. This process transcends management layers and takes place within administrative and national borders, necessitating cooperation between different disciplines. Some basic elements for effective international corridor management are: Modeling the corridor governance and institutional framework, facilitating trade and transportation, ensuring appropriate transportation, operating transportation logistics effectively, operating coordination between openings, determining the necessary budget for the corridor, working through bottlenecks, and creating capacities. The integrated division of these elements ensures efficient and sustainable processing of corridors and external barriers to international trade, and hosted, and economic groups are restricted. The main challenges in international corridor management are operations at border crossing points, operational gaps, technical compatibility issues, road transport permits, harmonization of standards, language and communication barriers, visa procedures, traffic regulations, vehicle and driver legislation, regulations on cargo use, and process monitoring. necessary mechanisms for follow-up. These challenges are significant obstacles that must be overcome to operate corridors effectively and efficiently.

The transport corridors mostly serve global supply chains which cover all processes from the production stage of products until they reach consumers. And the fact is that these processes occur in more than one country. The elements required to create an effective global supply chain are parallel to an effective transport operation. These include cross-border and inter-regional infrastructures, operational processes, technical compatibility and interoperability, integration of different transport modes, and economic, social, and environmental sustainability. Additionally, risk management is an important part of this process. The operations of global supply chains encounter various obstacles. These obstacles begin when competition among logistics service providers makes collaboration and information sharing difficult. In addition, there are problems such as the lack of visible and accessible load flow information due to the inadequacy of information and communication technologies, and the provision of official regulations through individual agreements instead of multilateral agreements. While complex supply chain structures make it difficult to manage multiple parties, deficiencies in infrastructure and storage services also create problems. Geographic dispersion around the terminal may result in high road transportation costs and transfer and storage costs. Other barriers, such as port costs and the lack of traffic forecasts or real-time traffic information in multimodal transportation networks, negatively impact the effectiveness of this process. In this context, it is of great importance to overcome these obstacles and provide the necessary elements to increase the efficiency of the global supply chain [1].

In this study, we aim to review the literature and present a bibliometric analysis within the framework of transport corridors and global supply chains and the use of technological advancements for their operations. Through this review, we enlighten the relationships among the stages of transport corridor operations and the new technologies. Moreover, we also bring light to open areas for further studies.

USE OF NEW TECHNOLOGIES

In today's world, the increase in customer demands and requirements due to globalization necessitates continuous improvements in efficiency, load capacity, planning, and similar processes. In this regard, existing solutions may be inadequate in some cases and the integration of new technologies plays a critical role in overcoming these disadvantages. Supply chain and logistics operations in particular benefit greatly from the advantages offered by new technologies. Industry 4.0, the Internet of Things (IoT), blockchain, cloud technology, intelligent systems, and other new technologies are making significant contributions to solving challenges and problems in this area.

The general literature review conducted within the scope of this study identified the following new technologies as effective in the field of logistics and supply chain: Industry 4.0, IoT, blockchain, machine learning, intelligent systems, optimization, and multi-criteria decision-making (MCDM). Industry 4.0 refers to an approach that makes production and logistics processes smarter and more flexible, while the IoT supports real-time information flow by enabling physical objects to exchange data over the internet. Blockchain technology can prevent fraud and mistakes by providing secure and transparent data management in supply chain processes. Cloud technology provides operational flexibility by enabling data and applications to be managed and shared through a centralized system. Intelligent systems and technologies supported by artificial intelligence and automation increase operational efficiency, enabling faster and more accurate execution of processes. Optimization techniques ensure the most efficient use of resources and improve decision-making processes, while MCDM methods help to evaluate various criteria in complex decision processes.

These new technologies each offer a variety of solutions to address the challenges faced in logistics and supply chain processes and improve the efficiency of the processes. The integration of these emerging technologies will contribute to making supply chain and logistics operations more efficient, reliable, and sustainable.

METHODOLOGY

The methodological approach applied in this study is presented in Figure 1. The initial stage of the process involved a comprehensive search of the Web of Science (WoS) database, conducted using specific keywords in the title and abstract sections. The search is limited to publications written in English and indexed in the Social Sciences Citation Index (SSCI), the Arts & Humanities Citation Index (AHCI), the Science Citation Index Expanded (SCIE), or the Emerging Sources Citation Index (ESCI), thus ensuring a focus on high-quality and relevant sources. Subsequently, a bibliometric analysis is conducted on the identified publications. This entailed a comprehensive examination of the abstracts of the selected papers to determine their relevance and alignment with the study's focus.

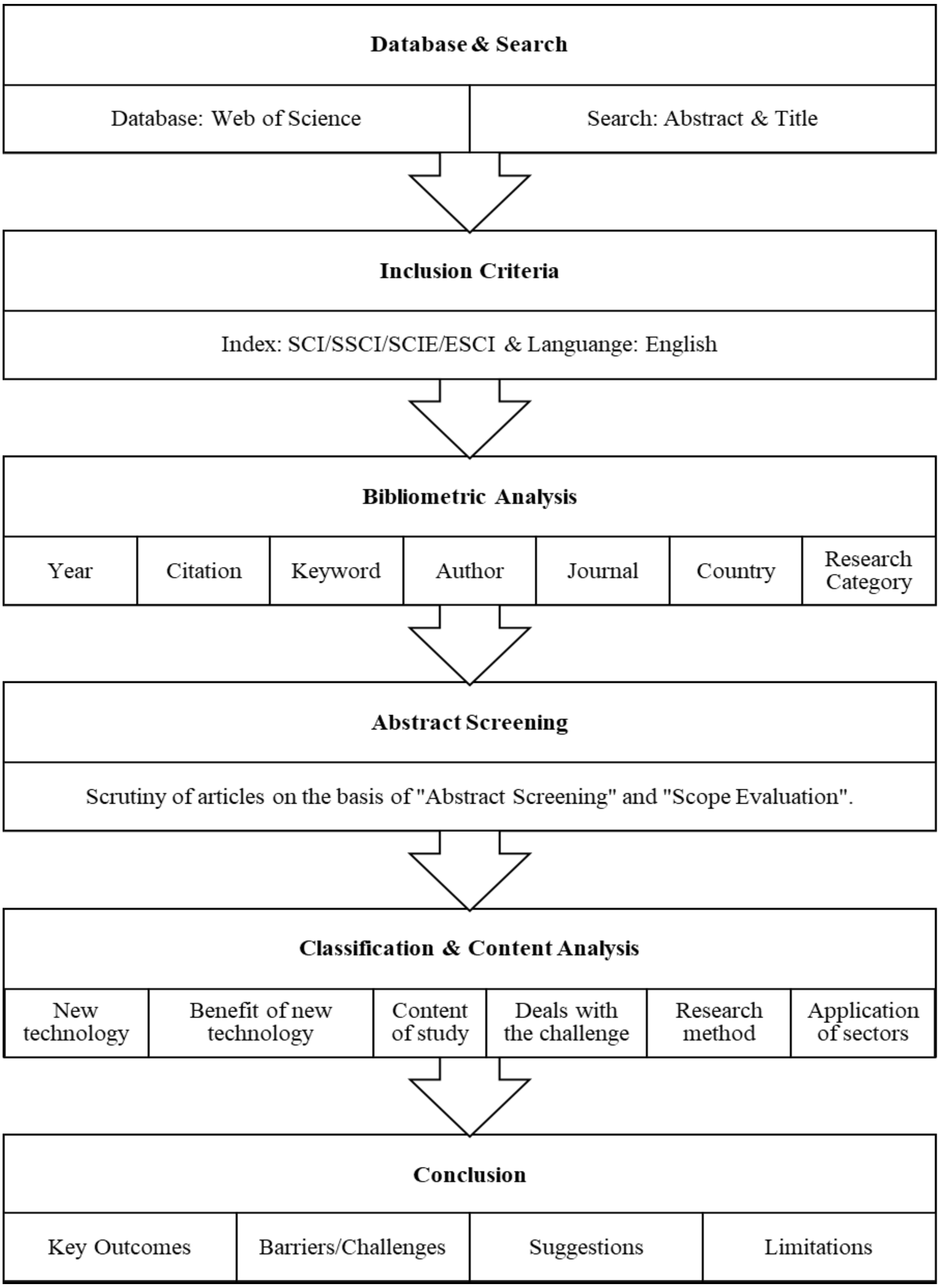

FIGURE 1
The flowchart of the study

Subsequently, the selected publications are subjected to a comprehensive classification and content analysis process. In the classification phase, the selected papers are organized based on their use of new technology, their approach to addressing challenges, their research method, and their application to the sector. This process enables a structured evaluation of the literature. The content analysis further involves an in-depth review of the papers to identify key outcomes, barriers/challenges, research gaps, and suggestions in the field. This systematic approach is designed to enhance the understanding of the research landscape and contribute valuable insights to the study.

APPLICATION AND RESULTS

This section presents the detailed findings on the results of the bibliometric and content analyses, which are the two methods employed in the study. Firstly, the numerical and relational characteristics of the publications will be revealed through bibliometric analysis. Subsequently, the findings of the content analysis will be presented in a subsequent section, with a detailed account of the evaluations conducted on the content and thematic scope of the publications. The findings obtained from both methods of analysis will be presented in detail, to provide a comprehensive understanding of the main issues addressed in the research and the trends identified in the literature.
Figure 2 shows the search flowchart in the WoS database. A total of 512 documents are obtained from the WoS database using the keywords shown in Figure 2. Of the total number of publications, 278 are selected for analysis, having been published in the English language and included in one of the following indexes: SCI, SSCI, SCIE, or ESCI. Following the removal of duplicate studies, 257 publications are evaluated through a bibliometric analysis. During this analysis, publications with 10 or more citations and abstracts of publications published in 2023 and earlier are examined. Subsequently, the 85 publications identified as relevant in terms of subject matter undergo a content analysis.

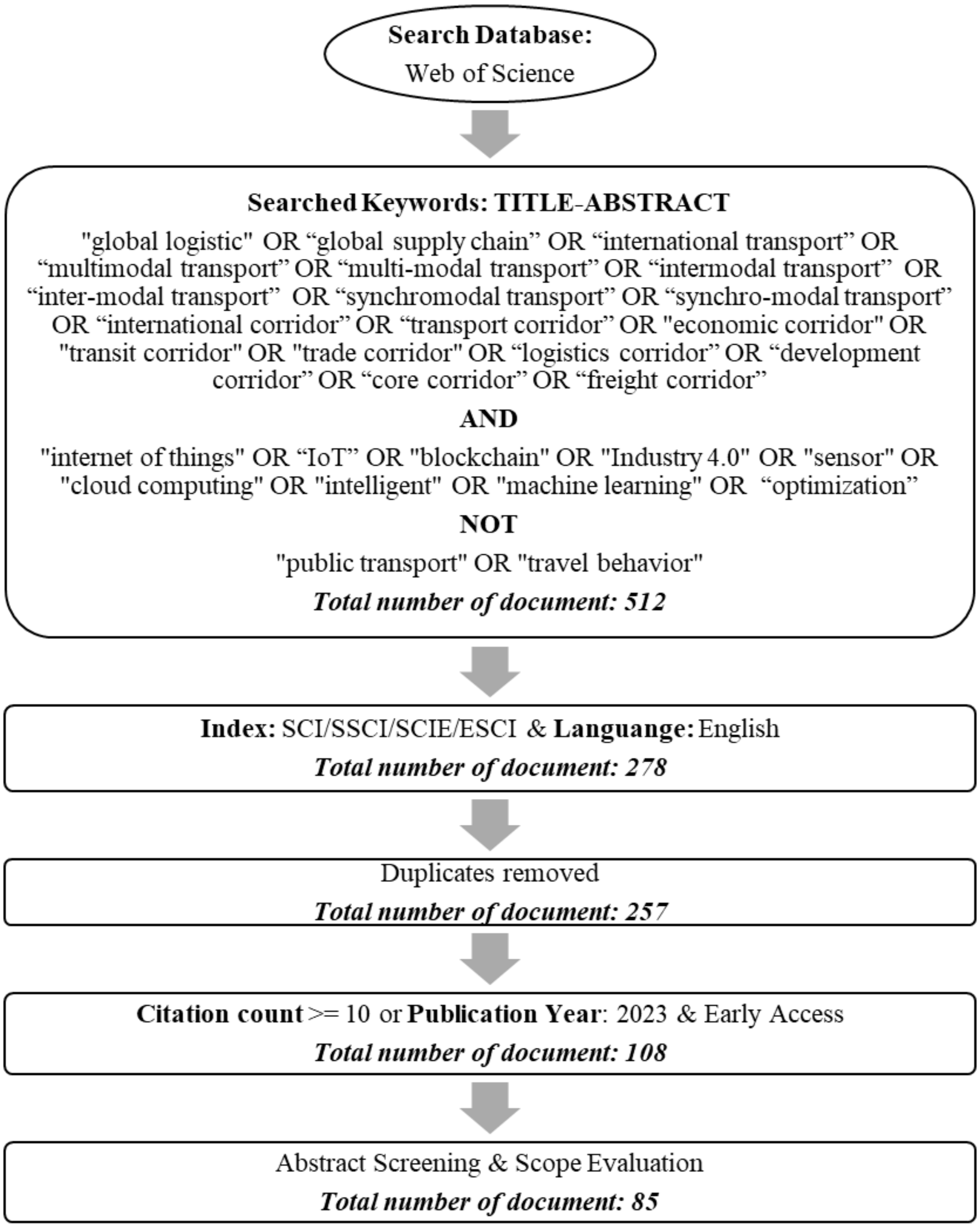

FIGURE 2
Flowchart of a search in the Wos database

Bibliometric Analysis

Bibliometric analysis is an effective technique widely used to observe the field of study as a whole and to have a general idea about the subject. It is used as an important tool in various studies to evaluate and analyze academic research outputs [2, 3]. In this study, bibliometric analysis is employed to obtain a range of data, including the number of publications and number of citations by year, a journal analysis, a publication citation map, a keyword cloud, a co-occurrence map of keywords, and a country collaboration map. The VOSviewer software is used to obtain the journal citation analysis map, publication citation map, keyword co-occurrence map, and country collaboration map [4]. Figure 3 illustrates the number of publications and citations by year.

As illustrated in Figure 3, the majority of publications have been published in 2018 or later. Especially in 2018, there has been a significant increase in research outputs. As of 2023, the reason for the decrease in the number of publications and citations is that only the data until May 2023 are used in this study. Therefore, it is expected that the number of publications and citations will increase. In addition, in terms of the number of citations, 2019 reached a remarkable level with 1710 citations.

A detailed analysis of the journals in which the studies are published reveals that a total of 257 publications emerged from 163 different journals. Of the journals in question, 34 have published two articles each, while 24 have published three articles each. The journal with the highest ranking according to the number of publications is Sustainability, with 14 publications. The second-ranked journal is Computers & Industrial Engineering, which has published 11 articles. The third-ranked journal is IEEE Access, which has published ten articles.

The only publication to exceed 1000 citations is "Blockchain Technology and Its Relationships to Sustainable Supply Chain Management" [5]. This publication is the most notable in terms of the number of citations it has received. The publications in the second, third, and fourth positions each received more than 200 citations, as indicated in references [6-8]. These publications are situated in the regions where the yellow color is observed with particular intensity in Figure 7. Other significant publications with over 100 citations are identified as follows: [9-14]. The presented data serve to illustrate the extent and significance of the academic interest in the subject matter.

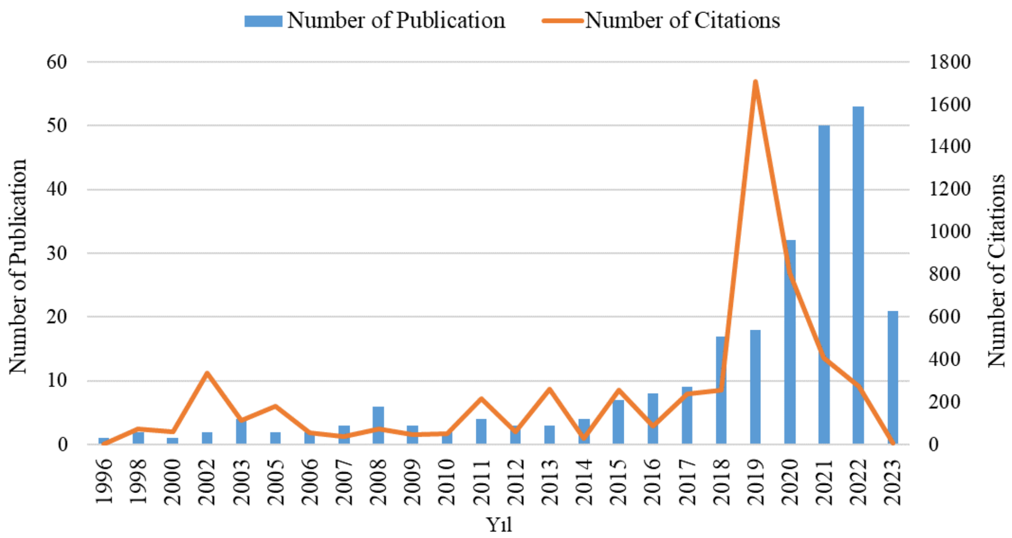

FIGURE 3
Number of publications and citations by years

The keyword cloud, created using the keywords from the analyzed studies, is presented in Figure 4. The results indicate that the most frequently used keywords are "global supply chain," "multimodal transport," "supply chain management," "optimization," "Industry 4.0," and "blockchain." It is apparent that the terms "global supply chain" and "supply chain management" cover a broad range of concepts and that there is a substantial body of literature on the subject of supply chain management. Similarly, the terms "optimization", "Industry 4.0" and "blockchain" indicate that technological and innovative approaches play an important role in this field. These findings provide valuable insights for future research, reflecting emerging trends and areas of intense interest within the field.

To obtain the co-occurrence map of keywords, the frequency of the co-occurrence of keywords is set as a minimum of three, and the co-occurrence of keywords is determined by using the VOSviewer. The keywords are classified into distinct clusters, which represent disparate research areas. Each cluster is represented by a different color. The findings indicate that the most frequently used keywords are "supply chain," "blockchain," and "optimization".

FIGURE 4
The keyword cloud

For the co-authorship collaboration map, the minimum number of documents and the minimum number of citations in each country are set as three, and Figure 5 is obtained using the VOSviewer for the 28 countries that meet these criteria. Figure 5 illustrates the extent and distribution of co-authorship collaboration between countries. China is identified as the country with the highest number of publications in terms of co-authorship. The United States of America is in second place, while the Netherlands has been placed in third.

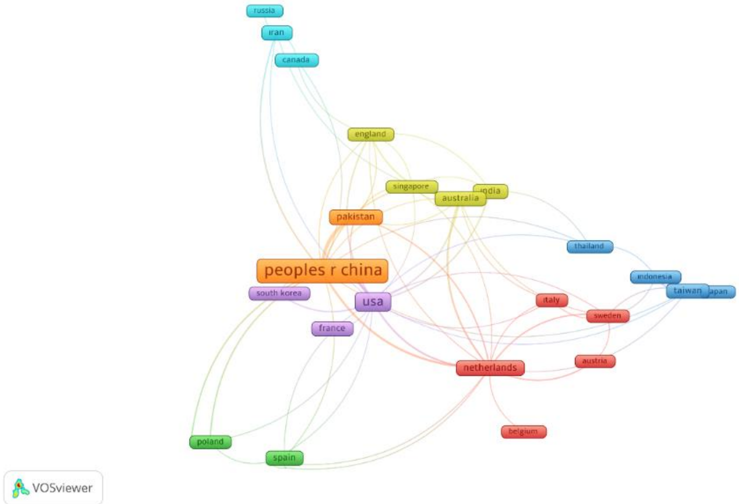

FIGURE 5
Map of country collaborations

Content Analysis

The new technologies and methods used in 85 publications analyzed within the scope of content analysis are discussed in detail. Optimization is used in 47 of these studies, IoT in 15, blockchain in 12, machine learning in 4, MCDM in 5, and other new technologies in 7 in Figure 6. In some studies, it is observed that more than one new technology is used together. The analysis also varies according to the application types. The studies can be broadly classified into two categories: quantitative and qualitative. Of the studies, 75.29% employed quantitative methods, while 24.71% focused on qualitative methods. These rates indicate that quantitative methods are more frequently employed, particularly in domains such as data analysis and modelling. While qualitative methods are employed less frequently, it is apparent that they play a significant role in facilitating in-depth analysis and interpretation. The application of methods is employed in 31 studies, numerical examples in 23 studies, literature reviews in 16 studies, and theoretical approaches in 12 studies. This distribution demonstrates that applied and numerical examples are more frequently utilized than literature reviews and theoretical approaches. Additionally, the methodological diversity of the analyzed studies is significant. Overall, the content analysis provides a comprehensive assessment of the use of different approaches and tools, reflecting the diversity of technologies and methods in the research field.

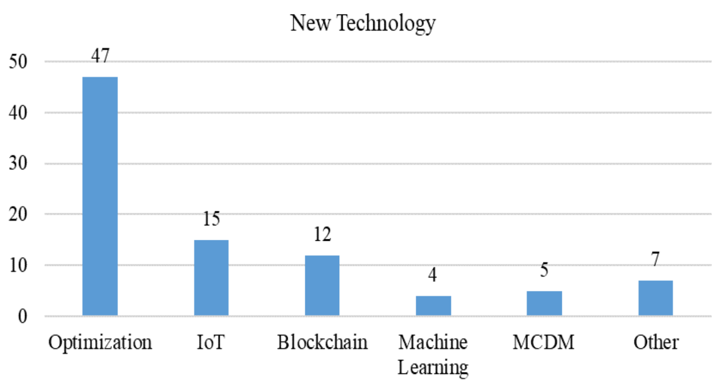

FIGURE 6
Distribution of new technologies employed in the studies

The distribution of study subjects is shown in detail in Figure 7. As illustrated in the figure, studies on supply chains represent the largest category, accounting for 57.65% of the total. The second most prevalent category, following that of supply chains, is that of transportation studies. The distribution of new technologies used in supply chain studies, which is the most focused topic, is also examined. In this context, optimization is employed in 25 studies, blockchain in 11 studies, IoT in 5 studies, machine learning in 2 studies, and analytics in 1 study. This distribution of technologies indicates that optimization and blockchain are the most prevalent tools employed in the field of supply chain management. In particular, optimization techniques are extensively employed to enhance the efficiency of supply chain processes. Blockchain technology has also been identified as a significant area of application, although it is not yet as widely adopted. The application of the IoT and machine learning in supply chain management is less prevalent.

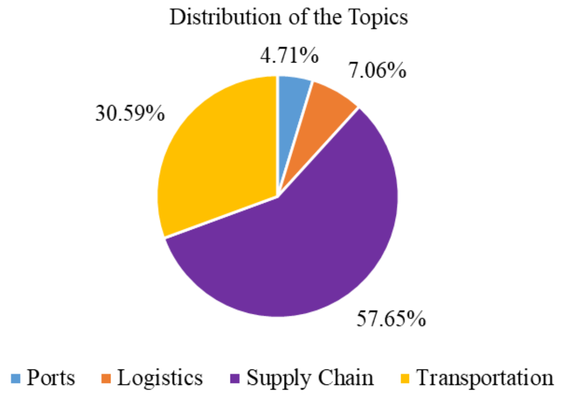

FIGURE 7
Distribution of topics in the reviewed studies

CONCLUSION AND RECOMMENDATIONS

The results of the study indicate that the most frequently utilized new technology is optimization, followed by the IoT and blockchain technologies. In the analysis of the new technologies, application examples are the most prevalent, followed by numerical examples. The research topics showed that the area of supply chain management represents the most studied area, with 58% of the total number of studies, followed by transport and logistics. The majority of studies (75%) employ quantitative methods. In addition, it is found that literature studies on optimization are less than IoT and blockchain.

The recommendations are presented below in line with the findings obtained:

Mathematical models, heuristics, machine learning methods, and simulation methods can be used in blockchain studies.

MCDM, heuristics, and simulation methods can be used in studies dealing with the IoT.

Fuzzy mathematical or fuzzy heuristic models in optimization studies can be used.

Efficiency analysis, economic modelling, scheduling, and consolidation problems can be given greater emphasis in optimization studies.

Literature review methods can be used more in optimization studies.

In conclusion, these studies can provide information and recommendations to researchers and practitioners by demonstrating the applicability and benefits of new technologies in various fields. The effective use of new technologies and the application of different research methods can contribute to solving problems in the supply chain and other fields.

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INDUSTRY 4.0 ORIENTED SUPPLIER SELECTION

Gizem Gul Koc, Mensure Zuhal Barak

ggkoc@atu.edu.tr
mzbarak@atu.edu.tr

ABSTRACT:

Purpose:
In this study, it is aimed to determine the improvements provided in the supply chain with Industry 4.0 to examine the relationship density between them. DEMATEL technique, which is one of the multi-criteria decision making methods, was used as an evaluation method. Factors were determined as evaluation criteria. As a result of the analysis of these factors, the factors that affect the others are determined.

Study design/methodology/approach:
It is inevitable for a company that wants to be successful and continuously develop in global competition to work in harmony with its suppliers. Especially the increase in competition and customer expectations has made this situation even more important. Industry 4.0, which we have been using in almost every field for the last years. In this transformation, processes are made smarter and more efficient by using technologies.

Findings:
The Multi-Criteria Decision Making (MCDM) method is an effective tool used in choosing the right supplier and contributes to determining the weights and importance levels of various criterias. This method enables the selection of the most suitable Industry 4.0-focused suppliers in a transparent and systematic way, the ranking of suppliers, and the ability to make different decisions under changing conditions. Thanks to this method, it has been revealed which criteria affect supplier performance more and which criteria companies should give more importance to.

Originality/value:
There are studies in the literature on green supply chain and industry 4.0 criteria, but there is no direct examination of supplier selection in industry 4.0.

KEYWORDS
Dematel, MCDM, Dametel, Supply Chain, Industry 4.0., Supplier Selection

DRIVER-RELATED ISSUES IN LOGISTICS: A STUDY ON FACTORS AFFECTING TRUCK DRIVERS' JOB SATISFACTION AND PERFORMANCE

Aylin Çalışkan, Cansu Akçiçek, Yücel Öztürkoğlu

Yasar University, Department of Business Administration,
aylin.caliskan@yasar.edu.tr
Yasar University, Graduate School, cansu.akcicek@yasar.edu.tr
Yasar University, Department of Logistics Management,
yucel.ozturkoglu@yasar.edu.tr

ABSTRACT:

Purpose:
Logistics service providers are crucial in the service sector, aiming to survive under high costs while increasing performance and profitability by minimizing human errors. This study has two purposes; to identify driver-related problems in logistics sector and to determine the factors affecting job satisfaction and job performance of truck drivers.

Methodology:
An extensive literature study was conducted to determine the factors affecting job performance of truck drivers. In order to test these factors, a focus group study was conducted with managers of three different leading companies in the sector. Based on these discussions, survey questions were developed and distributed to truck drivers. Finally, factor analysis was conducted with the collected data and followed by regression analysis to measure the effect of each variable on job satisfaction and performance.

Findings:
In the light of the analysis, six main factors were identified: health, operations, senior management, compensation, job satisfaction, and performance. The results of the regression analysis showed that operation, top management, health and payment factors directly and significantly affect job satisfaction of truck drivers, explaining 58% of its variance. Operation and health factors have been found to have a significant impact on business performance, explaining 32% of its variance.

Originality:
While a lot of studies have focused on truck drivers from logistics service providers, few have examined job satisfaction related to long commutes and heavy working conditions. This study is the first to include both white-collar and blue-collar

employees, providing a roadmap for company managers based on its comprehensive findings.

KEYWORDS
Truck drivers, job satisfaction, job performance, factor analysis, regression analysis

SERVICE NETWORK DESIGN PROBLEM FOR A MAJOR EXPRESS PACKAGE CARRIER

Yusuf Seçerdin

Department of Industrial Engineering, Ankara Bilim University, Ankara, Türkiye
yusuf.secerdin@ankarabilim.edu.tr

ABSTRACT:

Purpose:
This study considers the aircraft routing and scheduling problem of a large express cargo (parcel) carrier operating in Central and South America. The company's business problem involving air network design and express package flow is formulated as a service network design problem over a hub-and-spoke network.

Study design/methodology/approach:
We propose a multi-step solution procedure that includes data processing, feasible route generation and elimination, modelling and post-processing. The proposed procedure first executes data processing and pickup/delivery route generation modules. Then it proceeds to route elimination for the purpose of reducing the size of the solution space in the mathematical model. Two alternative routing policies are considered, dedicated runs and milk-runs. These policies are incorporated into the mathematical model, which results obtaining alternative problem settings. In the last step of the procedure, time conflicts between routes are resolved.

Findings:
A comprehensive experiment based on alternative scenarios, including routing policies, network configurations, demand node-hub assignments, and fleet changes, has been performed. According to the experimental results, the proposed procedure can generate solutions with savings on the total daily operating cost ranging from a minimum of 0.91% to a maximum of 13%.

Originality/value:
This paper is one of the first to address location and demand assignment decisions in the context of service network design for an express package (parcel) carrier. The proposed solution procedure can generate daily schedules that can be easily and repeatedly applied in the transportation network without any additional processing.

KEYWORDS
Express carrier, mathematical modelling, network design, network optimization

COBOTS IN WAREHOUSE MANAGEMENT

Menşure Zühal Barak, Esra Karakaş

Adana Alparslan Türkes Bilim ve Teknoloji University, Business Faculty, Business Administration Department, mzbarak@atu.edu.tr

Adana Alparslan Türkes Bilim ve Teknoloji University, Business Faculty, Business Administration Department, ekarakas@atu.edu.tr

ABSTRACT:

Purpose:
This study aims to provide information on where cobots, which have become popular in industry 4.0, are used in warehouse management. In this paper, studies between 2010 and 2024 were scanned in the literature and current warehouse transactions were discussed. The automated areas used in warehouse management have been determined and how useful cobots can be in these areas has been revealed.

Findings:
With the latest developments in technologies, the number of areas where human workers and robots work together in warehouse management is increasing. The importance of automation is increasing in Industry 4.0 and it will provide great benefits to companies through specialization in the field Thus, the importance of cobots in warehouse management is increasing. In this study, the benefits of cobots, which enable humans and robots to work together, in warehouse management are revealed by reviewing the literature.

Originality/value:
Cobots are becoming increasingly important in the industry. But there are very few studies in the literature about Cobots. This study reveals detailed information about cobots and by revealing the importance of cobots for warehouse management, it offers a different perspective on the performance of humans and automation in warehouses.

KEYWORDS
Cobots, Industry 4,0, Supply Chain Management, Warehouse Management.

LOGISTICS PROBLEMS ENCOUNTERED BETWEEN MAIN CONTRACTORS AND SUBCONTRACTORS IN MEGA PROJECTS

Nurullah Cabir Kahraman, Pınar Gürol, Yahya Fidan

Istanbul Ticaret University, Institute of Graduate Education, Department of Logistics Management, ncabirkahraman@gmail.com

İstanbul Ticaret University, Faculty of Business, Department of Logistics Management, İstanbul, Turkey, pinargurol@gmail.com

İstanbul Ticaret University, Faculty of Business, Department of Logistics Management, İstanbul, Turkey, yfidan@ticaret.edu.tr

ABSTRACT:

Purpose:
This study focuses on logistics management and supply chain issues in mega projects and addresses the importance of co-operation between the main contractor and subcontractors. The research aims to identify gaps in the sector and develop better solutions.

Study design/methodology/approach:
A qualitative methodology employed to explore logistics problems between main contractors and subcontractors in mega projects through face-to-face interviews. Semi-structured interviews, will be conducted to gather in-depth insights into the specific logistics challenges.

Findings:
According to the results of the study, it is stated that the lack of cooperation between center management and construction site management and the selection of low-priced suppliers/subcontractors negatively affect project performance and cause financial losses. It is also emphasized that material deliveries are not scheduled and real-time data updates are critical in logistics management.

Originality/value:
This study focused examination of the logistics problems specifically encountered between main contractors and subcontractors in the context of mega projects, an area that has received limited attention in existing literature.

KEYWORDS
Construction Industry, Logistics Management, Supply Chain Management, Collaboration

INTRODUCTION

Project management is a practical way to organize, plan, and oversee project activities, aiming to make things run smoothly and achieve the best results efficiently and effectively [1, 2]. Quickly changing world, with new opportunities and challenges to manage projects on [3], successful completion of projects depends heavily upon the usage of time limits, handling the project capabilities, and realistic budgeting [4].

Mega Projects are those which are otherwise of very high complexity in nature compared to normal scale, involve many sectors and industries, and are performed through the coordination of a large number of people involved—mostly involving a huge workforce and social network in order to achieve the project. Effective management of logistics is the most important aspect of keeping everything on track within large-scale construction, especially mega projects. These are immense exercises with too many moving parts, and the interrelationship between main contractors and subcontractors is absolutely key to success in these types of projects [5]. When things go wrong, like missed deliveries or miscommunications, the whole project can face delays and cost overruns [6].

This study aims to identify gaps in the sector and develop better solutions. According to this aim a qualitative methodology employed to explore logistics problems between main contractors and subcontractors in mega projects through semi-structured interviews.

In this context, this study is organized as fallows; methodology sections detail the research methodology, giving an overview of the qualitative approach and data collection through interviews. The findings section report major logistics challenges identified as poor coordination between management and construction sites, selection of subcontractors based entirely on cost, and deliveries without scheduling. In the conclusion section, the results are analyzed, encapsulates the key takeaways and recommended points for the future of mega projects.

METHODOLOGY

Research Approach

This was a qualitative study, where the interviews were semi-structured and conducted on industry experts in this field. Opinions have been received from 5 individuals, including project managers, logistics coordinators, and subcontractors, out of this league of professionals. Rich detailed answers are allowed through the fact that it is conducted in a semi-structured manner with direct questions regarding the specific problems that they face.

Data Collection and Analysis

The interviews were conducted for a period of three months in which investigations had mainly been centered around the collaboration between contractors and subcontractors, how materials are programmed to be delivered on-site, and the effect of selecting subcontractors solely based on the grounds of cost. Thematic analysis of issues and patterns running through the data was conducted after transcribing the interviews as per the instruction by Braun and Clarke [7].

FINDINGS

Poor Coordination Between Management and the Construction Sites

One of the issues that arose through the interview process relates to the poor relationship of the center's management and the on-ground construction staff. Such misconception would, in most cases, result in late delivery of the materials, which often leads to a slow-moving project. As stated in the literature [8], most of the respondents gave a more in-depth explanation that the management is not conversant with what transpires in the ground that makes them always experience poor scheduling and, thus, late submissions.

Low-Cost Subcontractors Selection

Another issue that emerged strongly was regarding the engagement of very cheap subcontractors, as the interviewees often said. While choosing among proposals, it may be quite tempting to go with the lowest bid, but in most cases, such chosen subcontractors will not have the resources or experienced personnel needed for keeping up with the demands of a project, thus leading to delays and increased costs. This finding does support what other studies have discovered [9], that is the selection of the lowest-priced subcontractor may not be the most productive choice.

Unscheduled Deliveries and Lack of Real-Time Data

Many respondents complained that material deliveries were not properly scheduled in a timely manner. Materials usually arrive late or early, in turn becoming an onsite problem. Interviewees also reflected on not having in place real-time data systems for monitoring deliveries and ensuring logistics are well coordinated. The use of these technologies allows project teams to make on-the-fly adjustments, hence raising the level of efficiency [10].

CONCLUSION

The obtained results of the research point to the critical urgency for developed cooperation between prime contractors and subcontractors. For example, there is no clear communication and coordination and so this causes project delays and cost overrun. Moreover, avoiding poor choices of subcontractors to do the work based on quality rather than price is a mechanism related to preventing performance problems caused by poor choices of subcontractors. Finally, systems of real-time data should be in place and material deliveries should be planned and scheduled properly.

This paper has described the logistics problems that usually arise in mega projects, specifically in cooperation among contractors and subcontractors. It highlights improved communications, real-time data tracking, and prudent selection of subcontractors. These problems will eventually make the huge projects more efficient, and as a consequence, bring a reduction of delays and financial losses.

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PRODUCT ALLOCATION PROBLEM FOR SPLIT ORDERS AND SOLUTIONS

Nihal Erginel, Doğa Dönmez, Büşra Özel, Gülperi Duygu Caner

Industrial Engineering Department, Eskisehir Technical University

The product allocation problem for split orders occurs whenever an order is fellfield in more than one depot. This causes additional costs handling and picking up cost, shipping cost that are not charged to the customer. So, we need product allocation to the depots according to the orders. This is the main challenging area for logistic firms if they have more than one warehouses and carry out the picking process from several warehouses for each order.

This study is related to determine which product should be located to the which warehouse to minimize the number of visited warehouses under warehouse capacity. Firstly, the mathematical problem is constructed and solved with GAMS 38.3.0. Secondly, due to the product allocation problem is a clustering problem in which products can be clustered with respect to the number of warehouses, k-means algorithm is used for clustering the products to the four warehouses. Results are compared.

KEYWORDS

Product allocation problem, split orders, clustering, k-means algorithm, logistics

TRANSFORMING URBAN FREIGHT TRANSPORTATION: SMART CITY TECHNOLOGIES AND SUSTAINABLE LOGISTICS APPROACHES

Ilknur Yardimci Coşkun, Umut Kazanci, Mehmet Tanyaş

Maltepe University, ilknuryardimci@maltepe.edu.tr
Maltepe University, umutkazanci@maltepe.edu.tr
Maltepe University, mehmettanyas@maltepe.edu.tr

ABSTRACT:

Purpose:
In today's rapidly expanding urban environments and accelerating urbanization processes, the efficient and sustainable management of urban logistics activities has become imperative. Urban freight transportation plays a critical role in maintaining the economic vitality of cities and meeting societal needs. However, these activities often lead to various problems such as traffic congestion, environmental pollution, and energy consumption. Therefore, smart and sustainable urban logistics solutions have the potential to enhance the efficiency of urban freight transportation and minimize its negative impacts. This study examines 70 approaches related to smart city technologies and sustainable logistics in the context of urban freight transportation. The aim of this study is to examine the approaches and technologies of smart and sustainable urban freight transportation.

Study design/methodology/approach:
A qualitative research design was employed, and within this framework, a literature review was conducted to examine urban freight transportation and applications in smart sustainable cities.

Findings:
Smart and sustainable logistics solutions for urban freight transportation will be listed, followed by a classification of these solutions and approaches based on the type of logistics activity they address.

Originality/value:
In this study, sustainable and smart freight transportation efforts are categorized based on logistics activities. While there are many literature reviews available, no classification of this kind exists.

KEYWORDS
City Logistics, Freight Transportation, Smart Cities, Urban Logistics.

INTRODUCTION

Logistics is the service of effectively and efficiently planning, implementing, transporting, storing, and controlling the movement of all kinds of products, service activities, and information flow within the supply chain from the point of origin (source) to the point of consumption (end consumer) to meet customer needs. Logistics management activities typically include inbound and outbound transportation management, fleet management, warehousing, materials handling, order fulfillment, logistics network design, inventory management, supply/demand planning, and management of third party logistics services providers. To varying degrees, the logistics function also includes sourcing and procurement, production planning and scheduling, packaging and assembly, and customer service [1].
The rapid urbanization and continuous growth of cities have intensified the need for efficient and sustainable urban logistics. Urban freight transportation is a critical component in maintaining the economic vitality and livability of cities, yet it often contributes to significant challenges such as traffic congestion, air pollution, and increased energy consumption. Addressing these issues is crucial for the development of smart and sustainable urban environments. According to [2], optimizing urban freight systems can significantly reduce the negative impacts associated with logistics activities in cities.
In the context of smart city initiatives, the integration of advanced technologies and innovative logistics solutions offers promising avenues for enhancing urban freight transportation. Smart distribution systems, leveraging real-time data and analytics, can improve route efficiency and reduce emissions [3]. Furthermore, sustainable logistics practices, such as the use of electric vehicles and green delivery methods, are gaining traction as cities strive to minimize their carbon footprint [4].
This paper aims to explore the intersection of smart technologies and sustainable practices in urban freight transportation. Through a comprehensive literature review, it’s examined current challenges, technological advancements that contribute to the development of smart and sustainable urban logistics. The ultimate goal is to identify strategies that can improve the efficiency and sustainability of urban freight systems, thereby enhancing the quality of urban life and fostering environmentally responsible urban development.

MATERIALS and METHODS

The subject of this research is to determine the studies that have been done in this field in order to find solutions on how urban freight transportation should be handled with a smart and sustainable city approach. Based on the study objectives, it’s followed a specific methodology for material collection, tool choice for the analysis, and answering the research questions. For this purpose, it's performed a systematic literature review (SLR). In the material collection phase, publications were reviewed using the keywords "logistics", "city freight transportation", "urban freight transportation" and "sustainable cities" "smart cities" across the following databases: DergiPark Akademik (TUBİTAK), Ebsco, Elsevier eBooks, Emerald Insight (Journals), Google Scholar, IEEE Taylor & Francis Online and Web of Science.

LITERATURE REVIEW

In smart and sustainable cities, freight transportation plays a critical role in enhancing the environmental, economic, and social sustainability of urban areas. To achieve this, freight transportation systems need to be designed efficiently and effectively. Approaches and strategies based on academic research are concentrated different problems.

Green logistics practices should be adopted to reduce the environmental impact of freight transportation. This includes measures such as using fuel-efficient vehicles, transitioning to electric and hybrid vehicles, and optimizing delivery routes. Studies have shown that the use of electric vehicles in urban delivery significantly contributes to reducing the carbon footprint [5] [6] [7] [8].

Advanced data analytics and Internet of Things (IoT) technologies should be utilized in freight transportation for smart cities. These technologies provide real-time data to optimize traffic flow, improve route planning, and shorten delivery times. For instance, IoT sensors can provide real-time information about traffic congestion and road conditions, enabling the selection of more efficient routes [9] [10] [11].

Optimizing storage and distribution infrastructure is crucial for freight transportation in smart cities. Smart warehouses can speed up freight handling and reduce error rates by using robotic systems and automation technologies. Additionally, micro distribution centers located close to city centers can improve efficiency by shortening delivery times [12] [13] [14] [15] [16].

Collaborative delivery and load consolidation strategies should be adopted in freight transportation. This involves combining deliveries to the same area in a single vehicle, thereby reducing traffic congestion and fuel consumption. Studies have shown that collaborative delivery strategies are effective in reducing costs and environmental impacts in freight transportation [17] [18] [19] [20] [21].

Urban traffic management systems should use smart algorithms and sensor technologies to optimize the movements of transportation vehicles. Traffic lights synchronized with systems that analyze traffic congestion can minimize stop-and-go movements of transportation vehicles, thereby reducing fuel consumption and emissions [11] [22] [23] [24] [25].

These strategies present important steps toward reducing the environmental impact and increasing the efficiency of urban freight transportation in smart and sustainable cities. Academic research highlights that such approaches are beneficial for both economic and environmental sustainability.

FINDINGS

Demand and Inventory Management, Warehousing, Value-Added Services, Insurance, Transportation, Terminal Services, and Customs are the core logistics activities in supply chain management. Logistics activities are grouped under 7 headings with their sub-fields (Table 1). The literature review will determine which of these are related to sustainable and smart city studies and solutions.

TABLE 1.
Core Logistics Activities (Developed from [26])

Logistics Activity	Logistics Activity Sub-fields
1. Demand and Inventory Management	Demand Planning Inventory Management Order Management Customer Services
2. Warehousing	Free Warehouse Bonded Warehouse Temporary Storage Area
3. Value-Added Services	Packaging Labeling Kit Preparation, etc.
4. Insurance	Risk Assessment Appraisal Insurance Services, etc.
5. Transportation	Rail Transportation Sea Transportation Road Transportation Air Transportation Multimodal Transportation
6. Terminal Services	Inspection and Supervision Securing Fumigation, etc.
7. Customs	Import Export Transit, etc.

According to the literature review, the approaches of 76 articles were analyzed, and it was observed that they were distributed as shown in Table 2. Smart and Sustainable City Freight Logistics Approaches are listed in Table 2 and it is found that each of them focuses on very different areas.

TABLE 2.
Smart and Sustainable City Freight Logistics Approaches

Approaches	Study
Adoption of Eco-Friendly Vehicles Electric, Hybrid Vehicles and and Alternative Fuel Vehicles, Autonomous Vehicles Cargo Bikes Drones Scooter etc.	[5], [27], [28], [29], [30], [31], [32]
CO2 Free Zones	[33]
Collaborative Transportation Systems Shared Vehicle Use in Urban Freight Transportation Crowdsourcing	[30], [31], [34]
Cooperation Among Delivery Services	[30], [35], [36], [37]
High First-Attempt Delivery Rates Time Window Dynamic Pricing	[30], [38], [39], [40], [41], [42], [43], [44]
Integrated Technological Solutions Mapping Customer Behavior	[34], [45], [46]
Micro-Depots and Centralized Hubs and Urban Freight Consolidation Parcel Lockers and Points, Use of Multi-Label Shops and Packstations	[27], [30], [31], [32], [47]
Public and Private Sector Initiatives Sustainable Urban Logistics Plans	[30], [32], [48], [49], [50], [51]
Internet of Things (IoT) and Big Data Analytics	[52], [53], [54], [55], [56]
Intelligent Traffic Management Systems Dynamic Traffic Management Systems Smart Traffic Lights	[27], [30], [42], [57], [58], [59], [60]
Transfer Between Modes in Urban Logistics	[27], [30], [61], [62], [63], [64]
Renewable Energy / Material Sources	[31], [65], [66], [67], [73], [74], [75], [76]
Smart Warehousing Solutions	[68], [69], [70], [71], [72]

As a result of these findings, it has been observed that the approaches are concentrated around four logistical activities; Transportation Based Solutions, Warehouse Based Solutions, Packaging Solutions and Demand and Stock Management Based Solutions (Table 3).

TABLE 3.
Smart and Sustainable City Freight Logistics Solutions Based on Logistics Activity

Logistics Solutions Area	Solutions	Study
Transportation Based Solutions	Eco-Friendly Vehicles Collaborative Transportation Systems Cooperation Among Delivery Services High First-Attempt Delivery Rates (Time Window, Dynamic Pricing) Internet of Things (IoT) and Big Data Analytics Intelligent Traffic Management Systems Transfer Between Modes in Urban Logistics	[5], [27], [28], [29], [30], [31], [32], [34], [35], [36], [37], [38], [39], [40], [41], [42], [43], [44], [52], [53], [54], [55], [56], [57], [58], [59], [60], [61], [62], [63], [64]
Warehouse Based Solutions	Micro-Depots and Centralized Hubs and Urban Freight Consolidation (Parcel Lockers and Points, Use of Multi-Label Shops and Packstations) Internet of Things (IoT) and Big Data Analytics Renewable Energy Sources Smart Warehousing Solutions	[27], [30], [31], [32], [47], [52], [53], [54], [55], [56] [65], [66], [67] [68], [69], [70], [71], [72]
Packaging Solutions	Reusable Packages Packaging fully compatible with product size Packaging made from recyclable materials	[5],[73],[74],[75],[76]
Demand and Stock Management Based Solutions	Mapping Customer Behavior Internet of Things (IoT) and Big Data Analytics	[34], [45], [46]

CONCLUSION AND RECOMMENDATIONS

In the context of today's rapidly growing urban environments and accelerating urbanization processes, the efficient and sustainable management of urban logistics activities is essential. This paper has examined the effects of smart city technologies and sustainable logistics approaches on urban freight transportation through a qualitative research design and literature review.

The literature review revealed that while some studies in urban logistics and freight transportation focus on a single area or specific problem, others address multiple problems and develop various approaches. The findings show that the approaches are concentrated around four logistical activities: transportation-based solutions, warehouse-based solutions, packaging solutions, and demand and stock management-based solutions. Each of these areas presents specific strategies for improving efficiency and sustainability. Findings comprehensively summarizes the different approaches for smart and sustainable city logistics by logistics area. While transportation-based solutions stand out as the most studied area, other areas such as warehouse-based solutions and packaging solutions are also important but relatively less researched. This suggests the need to develop a holistic sustainability strategy in city logistics.

Further research should focus on exploring the long-term impacts of smart and sustainable logistics solutions on urban freight transportation. Additionally, examining the economic implications and cost-benefit analysis of implementing these technologies and practices will provide valuable insights for policymakers and stakeholders. By adopting these smart and sustainable logistics solutions, urban freight transportation can be transformed to improve the quality of life in cities, reduce environmental impacts, and create more livable urban environments for future generations.

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SUSTAINABLE PACKAGING SOLUTIONS IN THE TURKISH FOOD AND BEVERAGE INDUSTRY: A CONTENT ANALYSIS APPROACH

Fatmanur Avar Çalişkan
Izmir Kavram Vocational School, fatmanur.avar@kavram.edu.tr

ABSTRACT:

Purpose:
This study investigates sustainable packaging solutions in the Turkish food and beverage industry by adopting a content analysis approach. It aims to identify and evaluate sustainable packaging practices, trends and innovations adopted by leading companies in the industry. The analysis aims to provide insights into the scope of sustainability integration and its impact on industry practices.

Study Design/Methodology/Approach:
The research examines publicly available reports, sustainability disclosures and packaging materials of major Turkish food and beverage companies using content analysis methodology. The study evaluates the adoption of sustainable packaging practices, such as recycling initiatives, use of biodegradable materials, and reductions in plastic use. A systematic review of industry documents and company reports was conducted to find out relevant data and trends.

Findings:
The study's findings expose varying levels of commitment to sustainable packaging among Turkish food and beverage companies. While some companies are adopting innovative solutions such as compostable packaging and reduced plastic use, others are in the early stages of integrating sustainable practices. The study emphasizes the importance of the role of consumer demand, regulatory pressures and corporate strategies in shaping packaging practices.

Originality/Value:
By focusing on the Turkish context, which is often underrepresented in global sustainability research, this study contributes to the sustainable packaging literature. It provides valuable insights for industry stakeholders, policy makers and researchers interested in understanding and improving sustainable packaging practices in emerging markets.

KEYWORDS

Content Analysis, Emerging Markets, Food and Beverage Industry, Sustainable Packaging

INTRODUCTION

Sustainability is becoming an increasingly important issue in contemporary business practices, especially in sectors with significant environmental impacts [1]. The food and beverage industry is increasingly notable for its environmental footprint due to packaging practices that often rely on plastics and non-biodegradable materials, causing to pollution and resource depletion [2]. In this context, sustainable packaging solutions offer significant environmental and economic benefits [3].

As a major player in the food and beverage industry, Turkey represents a growing market for sustainability practices [4]. However, current researches on sustainable packaging practices in the Turkish context have not yet reached a sufficient level of maturity [4]-[5]. This study aims to examine and evaluate sustainable packaging solutions in the Turkish food and beverage industry, focusing on practices, trends and innovations adopted by leading companies in the industry.

Despite the growing global interest in sustainable packaging, there is a significant gap in the literature regarding the specific challenges and opportunities in emerging markets, particularly in Turkey. Existing studies mainly focus on more developed economies, leaving a significant gap in understanding how companies in emerging markets deal with the complexities of implementing sustainable practices. This research aims to fill this gap by providing an in-depth analysis of sustainable packaging efforts in the Turkish food and beverage industry. By doing so, it aims to contribute to the limited body of knowledge and provide a foundation for further studies examining sustainable practices in similar contexts.

The main objective of this research is to identify and assess the extent to which major Turkish food and beverage companies adhere to sustainable packaging practices. Using content analysis methodology, the study will examine the public reports, sustainability statements, and packaging materials of firms in the sector in question to reveal the adoption of practices such as recycling initiatives, use of biodegradable materials, and reduction in plastic use. Additionally, the research will analyze the impact of consumer demands, regulatory pressures, and corporate strategies on firms' packaging practices [5].

Ultimately, this study aims to provide valuable insights into the existing literature on sustainable packaging in the Turkish context and to provide practical recommendations for industry stakeholders, policy makers and researchers interested in advancing sustainable packaging practices in emerging markets.

LITERATURE REVIEW

Sustainable packaging solutions are vital to reducing the environmental impact of the food and beverage industry, a sector known for its reliance on non-biodegradable materials [6]. This review synthesizes the existing literature on sustainable packaging, focusing on advances, regional practices and challenges, particularly in the Turkish context.

The detrimental environmental impacts of traditional packaging materials highlight the importance of sustainable packaging [7]. Reference [3] presents a holistic methodology for sustainable packaging design, emphasizing the importance of integrating environmental considerations throughout the design process. The authors' approach addresses issues such as waste reduction and resource conservation. Similarly, Reference [2] investigates the evolution of sustainable packaging within a circular economy framework, maintaining innovations that support recycling and reuse. This review has highlighted the need for new materials and practices that align with sustainability goals.

The environmental impact of traditional plastics is a major concern, leading to a shift towards sustainable alternatives [8]. Reference [9] examines recent developments in food packaging, highlighting the benefits of materials such as polylactic acid (PLA). PLA and similar eco-friendly materials offer significant improvements over traditional plastics by reducing pollution and promoting sustainability. The review also considers the challenges associated with these materials, their production and end-of-life disposal, providing a balanced view of their environmental advantages and limitations.

The adoption of sustainable packaging practices in Turkey is a rising trend with significant implications for the food and beverage industry. Reference [5] sheds light on regional challenges and opportunities by examining how Turkish retailers integrate sustainability into their packaging practices. The study specifies key drivers for adopting sustainable packaging, such as consumer demand and regulatory pressures, and provides examples of companies that are pioneers in sustainable practices. This regional perspective is important for understanding the unique dynamics affecting sustainability in Turkey.

According to the 2022 report on Environmental Sustainability Efforts in the Turkish Packaging Sector by the European Union, inadequate or insufficient packaging can be particularly hazardous, especially concerning food products. Therefore, it emphasizes that packaging design must be properly executed to ensure the most appropriate packaging [10]. Also, The Plastics Europe Market Research Group (PEMRG) states that there is no single effective solution to significantly reduce waste disposal and greenhouse gas emissions. It emphasizes that solutions implemented both upstream and downstream in the supply chain are complementary and most effective when deployed together [11].

Significant steps are being taken in Turkey regarding sustainable packaging. Numerous food and beverage producers in Turkey are working to reduce packaging waste and use recyclable packaging materials, while also developing biodegradable packaging materials and reusable packaging systems [10]. Organizations such as Packworld Türkiye, Sustainable Packaging are promoting the adoption of environmental standards in the packaging sector and providing guidance in this area [12]. Digital technologies are being utilized in packaging processes to develop systems for monitoring and

managing sustainability, with the Turkish Packaging Manufacturers Association (ASD) leading projects that support the adoption of such technologies [13]. Additionally, the Turkish Standards Institute (TSE) provides training on packaging standards and sustainability issues [14].
Innovations in sustainable packaging are evolving rapidly, triggered by the need to address environmental concerns. Reference [8] examines recent developments in sustainable and bio-based food packaging, highlighting the latest materials and design strategies. The review indicates innovations such as compostable packaging and materials derived from renewable resources. By focusing on these developments, the study offers insights into how new technologies and design approaches are shaping the future of sustainable packaging and potential solutions to current environmental challenges.
The literature shows significant progress in sustainable packaging, but also reveals challenges, particularly in the Turkish context. To address these challenges and promote widespread adoption of sustainable practices, research and innovation will be essential.

METHODOLOGY

The methodology section summarizes the research design, data collection methods, and data analysis techniques used to investigate sustainable packaging solutions in the Turkish food and beverage industry. This study uses a content analysis approach to systematically analyze and evaluate the packaging practices of leading companies in this industry.

Research Design

The research design for this study is a qualitative content analysis that aims to identify and evaluate sustainable packaging practices among major Turkish food and beverage companies. Content analysis stands out in qualitative studies due to its ability to systematically analyze written, verbal or visual communication messages [15] and is the technique chosen for this study. This method is particularly suitable for examining companies' sustainability reports, corporate disclosures and packaging material information, providing a comprehensive understanding of current practices and trends.
The study focuses on publicly available reports and documents from leading companies in the Turkish food and beverage sector. Selection criteria for companies include market share, industry impact and availability of detailed sustainability reports. The analysis period covers the last five years, ensuring the inclusion of the latest data and practices.

Data Collection

Data collection includes collecting publicly available reports, sustainability disclosures, and packaging material information from websites and publications of major Turkish food and beverage companies. Primary data sources include:

Annual Reports provide comprehensive information on companies’ overall performance, including sustainability initiatives.
Sustainability Reports provide detailed insights into companies’ environmental, social and economic practices, focusing on packaging solutions.
Corporate Websites often include specific sections on sustainability and highlight recent initiatives, goals, and accomplishments.
Industry Publications such as industry journals, magazines, and news articles provide additional context and updates on the latest trends and innovations in sustainable packaging.
Purposive sampling is used to identify companies that are leaders in the industry and have made significant strides in sustainability practices. This approach ensures that the data collected is relevant and that the selected companies are representative of the industry's efforts towards sustainable packaging.

Company Selection Criteria

The companies selected for this study were based on the following criteria:
Companies with significant market share in the Turkish food and beverage sector were identified to ensure that the findings were representative of industry leaders.
Companies recognized for their industry impact and leadership were selected. This includes companies that are pioneers in adopting innovative practices and setting industry standards.
Companies that publish comprehensive sustainability reports that provide detailed information on their packaging practices were included. This ensures that sufficient data is available for comprehensive analysis.
Companies representing a diversity of products in the food and beverage sector were selected to capture a broad spectrum of packaging practices.
Companies that have received awards or recognition for sustainability efforts, including packaging, were considered. This helps identify companies at the forefront of sustainable practices.
Based on the five criteria outlined in italics above, the following companies were selected for the study:
Ülker: Founded in 1944, Turkey's leading, deep-rooted, strong, domestic and national brand known for its wide product range and significant market share. This food brand is known for its commitment to sustainability and publishes detailed sustainability reports.
Coca-Cola İçecek: The Turkish subsidiary of Coca-Cola since 1964, which is influential in the beverage sector and has extensive sustainability initiatives, including sustainable packaging practices.
Eti: Founded in 1961, another major player in the Turkish food sector, stands out with its innovative packaging solutions and commitment to reducing environmental impact.
Tat Gıda: Founded in 1967, leading company in the Turkish food industry known for its diverse product offerings and active sustainability programs.

Pınar: Pınar, Turkey's leading dairy and beverage company since 1973, known for its sustainability efforts and innovative packaging solutions.

Data Analysis

Data analysis involves systematically examining collected reports and documents using content analysis techniques. The steps in the data analysis process are:
Coding: Data collected through content analysis was coded using a predefined coding scheme. The coding scheme was developed based on existing literature and includes categories such as recycling initiatives, biodegradable materials, reduction in plastic use, and innovative packaging solutions.
Thematic Analysis: The coded data was analyzed to reveal recurring themes and patterns. Thematic analysis helps to understand common practices, challenges and innovations in sustainable packaging among selected companies.
Comparative Analysis: The practices and perspectives of different companies are compared to identify differences in the adoption and implementation of sustainable packaging solutions. This comparison highlights industry leaders and laggards.
Impact Assessment: The impact of consumer demand, regulatory pressures and corporate strategies on packaging practices has been assessed. This includes analyzing statements and actions related to these factors and their impact on companies' sustainability efforts.
For data analysis, Microsoft Excel was used to organize, manage, and analyze data. Excel facilitated the processes of coding, thematic analysis, and comparative analysis, and provided tools to sort, filter, and visualize data.
The analysis aims to provide a comprehensive overview of the current status of sustainable packaging in the Turkish food and beverage industry, identifying best practices, challenges and areas for improvement. Findings from the data analysis are used to draw conclusions and provide recommendations to stakeholders, policy makers and researchers seeking to advance sustainable packaging practices in emerging markets.

FINDINGS

Overview of Sustainable Practices of Selected Companies

The analysis of selected companies, namely Ülker, Coca-Cola Icecek, Eti, Tat Gida and Pınar, reveals different levels of commitment and different approaches to sustainable packaging. This section discusses the findings from the content analysis and highlights common practices, innovations and challenges.
Ülker takes a comprehensive approach to sustainable packaging, focusing on reducing plastic use and increasing recyclability [16]. The company has stated its goals to reduce paper usage in cardboard boxes by 20%, plastic usage in flexible packaging by 20%, and packaging waste generation by 50% by the year 2024. The company has

implemented several initiatives, including using recycled materials in packaging and developing biodegradable packaging options. Ülker’s sustainability reports demonstrate a strong commitment to reducing its environmental footprint through continuous innovation and consumer engagement.
Coca-Cola İçecek has made significant strides in sustainable packaging by launching initiatives such as the “World Without Waste” program, which aims to make all packaging recyclable by 2025 [17]. The company has focused on using recycled PET (rPET) in its bottles and has sought to reduce the overall amount of plastic used. The company has outlined its goals to make 100% of its packaging globally recyclable by 2025 and to use at least 50% recycled materials in its packaging by 2030. The company's efforts are guided by global sustainability goals and local regulatory pressures, reflecting a proactive approach to environmental responsibility.
Eti has adopted innovative packaging solutions such as the use of compostable materials and reduced plastic content in its products [18]. The company’s sustainability strategy is built on the importance of aligning packaging practices with environmental goals and focuses on minimizing waste and promoting recycling. The company's initiatives are documented in its annual report and sustainability reports, demonstrating its leadership in sustainable packaging in the Turkish market.
Tat Gıda’s sustainable packaging approach includes initiatives to reduce packaging waste and improve recyclability [19]. The company prioritizes waste management and packaging. In line with its policy, Tat Gıda aims to reduce waste at its facilities and factories by preventing it at the source and is implementing effective projects to minimize waste through recycling. The company has introduced environmentally friendly packaging materials and collaborates with suppliers to develop sustainable solutions. Tat Gıda's adherence to sustainability is evident in its detailed sustainability reports, which highlight the company's efforts to integrate sustainable practices across its operations.
Pinar is known for its innovative packaging solutions, like the use of bio-based materials and efforts to reduce the environmental impact of its packaging [20]. The company’s sustainability initiatives focus on reducing plastic use and increasing recyclability, driven by consumer demand and regulatory entailments. The company, driven by its commitment to environmental sustainability, highly prioritizes the use of eco-friendly materials and technologies. As a result, 98% of its product packaging is made from recyclable materials. Pınar's sustainability reports provide insights into its ongoing projects and future goals in sustainable packaging.

Common Trends and Innovations

The content analysis for the study reveals some common trends and innovations across the selected companies. The first common trend is to reduce plastic use, and all companies are implementing measures to reduce the amount of plastic used in their packaging. Examples include using lighter materials, optimizing packaging design, and

adding recycled content. Another common trend is the use of biodegradable and compostable materials, a growing tendency especially in food packaging.
Recycling initiatives are a key focus for all companies, and there are initiatives that aim to increase the use of recycled materials and improve recyclability. Coca-Cola Icecek's use of rPET and Ülker's recycling programs are valuable examples [17] - [16]. For the consumer engagement trend, companies are increasingly making efforts to engage with consumers to promote sustainable packaging practices, including educational campaigns, clear labeling, and encouraging recycling.

Challenges and Barriers

While there are many trends and innovations, the analysis also highlights several challenges and barriers to widespread adoption of sustainable packaging. Cost implications may the most significant one, and since sustainable packaging solutions are often costlier, the initial investment in new materials and technologies can be a barrier, especially for smaller companies. Also, regulatory compliance could be challenging for companies, as complying with changing regulations at the local and international levels requires significant resources and adaptability. Consumer behavior is another major challenge. Consumer awareness and demand for sustainable packaging is increasing, but changing consumer behavior remains a challenge. It is essential that companies invest in education and communication to drive this behavioral change. Supply chain constraints can be a limiting factor in the availability and reliability of sustainable materials. Creating a sustainable supply chain requires collaboration with suppliers and investment in research and development.
SDG Map Turkey notes that adoption of sustainable packaging faces challenges and obstacles such as industrial plastic dependence, technical barriers to finding suitable materials, high cost constraints, inertia in the supply chain and insufficient regulatory support [21].

DISCUSSION

The findings of this study contribute to the theoretical understanding of sustainable packaging in emerging markets and offer some theoretical implications. The study highlights the importance of integrating sustainability into business practices, particularly in sectors with significant environmental impacts, such as the food and beverage industry. The results emphasize the need for a holistic approach to sustainability that includes environmental, economic and social dimensions. The analysis also underlines the critical role of innovation in developing sustainable packaging solutions. Companies that invest in and care about research and development are in a more advantageous position to adopt and implement environmentally friendly packaging practices. SDG Map Turkey emphasizes that breaking the industry's dependence on plastic requires the adoption of sustainable materials that may not always match the functionality of plastic and the development of alternatives. It stresses that innovation and long-term investment must support compostable packaging options and the development of new materials. Additionally, it is suggested that governments and regulatory bodies promote this transition by offering credits or tax incentives for sustainable materials. Furthermore, the inertia of established supply chains should be overcome through long-term impact innovation and support from Environmental, Social, Governance (ESG)-focused investors [21].

For executives and industry leaders, the study offers several practical insights and recommendations. Primarily, strategic investment in sustainability is crucial. Executives should prioritize investing in sustainable packaging solutions, considering the long-term perspective of environmental and economic benefits. This perspective requires investing resources in research and development and collaborating with suppliers to develop new materials and technologies. Secondly, consumer engagement and education constitutes another managerial implication. It is essential to engage consumers and educate them about the benefits of sustainable packaging. Companies should implement clear labeling, education campaigns, and initiatives to encourage responsible disposal and recycling. Regulatory compliance and advocacy is the third key recommendation. Companies must stay on top of regulatory changes and ensure compliance with environmental standards. In addition, it would also be beneficial if companies could play a proactive role in advocating for positive policies that support sustainable practices.

CONCLUSION AND RECOMMENDATIONS

The analysis of sustainable packaging practices in the Turkish food and beverage sector reveals a significant shift towards more environmentally friendly solutions. Companies are increasingly embracing strategies such as material reduction, use of recyclable and renewable materials, and engaging consumers in sustainability efforts. Eti's initiative to reduce plastic content by 20% and Ülker's commitment to using 100% recyclable materials are examples of this trend These efforts align with global movements toward sustainability, as emphasized in recent research that highlights the importance of sustainable packaging in reducing environmental impact and enhancing brand reputation [9]- [22].

In spite of these developments, challenges remain, including higher costs, supply chain integration, consumer acceptance, and regulatory compliance. As noted by companies, the higher cost of sustainable materials and the complexity of aligning supply chains are significant barriers. These challenges are not unique to Turkey, but resonate globally as noted in studies on sustainable packaging practices in other regions [5]- [6].

There are several limitations to this study that should be noted. Initially, the focus of the study is limited to a select number of leading companies in the Turkish food and beverage industry, which may not be representative of the practices and challenges of smaller or emerging companies. Secondly, Data was collected primarily through company reports and public statements, which may not cover all aspects of their packaging strategy or potential proprietary innovations.

Future research should aim to address these limitations by expanding the scope to include more diverse companies in the industry and at different scales. In addition, conducting interviews or surveys with key stakeholders can provide deeper insights into the motivations, challenges and future directions of sustainable packaging. Comparative studies across different regions or industries may also be valuable to understand broader impacts and identify best practices that can be adopted in Turkey.

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OPTIMIZING ROBOTIC COMPACT STORAGE AND RETRIEVAL SYSTEMS WITH DUAL-COMMAND OPERATIONS

Mahmut Tutam

Department of Industrial Engineering, Erzurum Technical University, Erzurum, Türkiye, mahmut.tutam@erzurum.edu.tr

ABSTRACT:

Purpose:
E-commerce growth has increased storage demand, especially in space-constrained cities. Robotic compact storage and retrieval systems offer a solution by eliminating the traditional aisle structure and using robots for efficient storage and retrieval operations within a stacked grid. This study optimizes robotic compact storage and retrieval system designs with dual-command operations.

Study design/methodology/approach:
A discrete formulation is developed to estimate the expected dual-command operation time, which is then solved using enumeration to determine the best configuration for a given storage capacity.

Findings:
We present the optimal dimensions for robotic compact storage and retrieval systems with varying storage capacities. Our findings show that dual-command operations result in an increased stacking height of one additional bin compared to single-command operations.

Originality/value:
This study is the first to use dual-command operations to determine the optimal dimensions for the robotic compact storage and retrieval system.

KEYWORDS
Compact storage, dual-command, optimal design, travel-between, warehouse.

INTRODUCTION

With the rapid growth of e-commerce, the increase in the number of individual orders with small sizes has driven the rise in the volume of stored products, leading to an increased demand for storage space. This has become a major issue, particularly in metropolitan areas where space is either limited, expensive, or both. To address this challenge, alternative warehouse designs, such as robotic compact storage and retrieval

(RCS/R) systems, have been proposed in recent years. These systems enhance space utilization by eliminating the need for traditional picking and cross aisles.

This study explores the optimal design of the RCS/R system using dual-command operations. A discrete formulation for the expected dual-command operation time is developed, and the derived formulation is solved through enumeration to determine the optimal number of bins stacked on top of each other for three different storage capacities. Additionally, the resulting optimal system designs are compared with those obtained for single-command operations as reported in the literature. The following section describes the problem, followed by a review of the literature. We then detail the methodology and present the research results. The final section summarizes our findings and discusses future research directions.

PROBLEM DESCRIPTION

In a typical RCS/R system setup, robots operate on a cuboid grid structure to retrieve, transport, and store bins stacked vertically (see Figure 1). When a stock-keeping unit (SKU) is requested, the robot is instructed to bring the bin containing the SKU to a port on the side of the grid structure. If the requested bin is at the top of a stack, the robot directly retrieves it and deposits it at the port. If the bin is not at the top, the robot first removes all blocking bins above the targeted bin, retrieves the desired bin, then replaces the blocking bins before transporting the retrieved bin to the port. After being deposited at the port, the bin is conveyed down to a workstation. Once the order picking process is complete, the bin is lifted back up to the port and transported to the top of a stack. The robot then waits for the next retrieval request.

In a single-command operation, the robot performs either a retrieval or a storage operation. Depending on the instruction type (retrieve or store), the robot travels from a port to a storage or retrieval location and then returns to the port. As a result, the robot travels empty for half of the operation time. By combining storage and retrieval operations (dual-command operation), the robot's travel path can be optimized. In a dualcommand operation, the robot first travels from the port to a storage location. Instead of returning to the port immediately after the storage operation, the robot proceeds to a retrieval location before making the return trip.

We focus on developing formulations for the expected operation time to estimate the performance of the RCS/RS system with dual-command operations for a given storage capacity. We investigated various designs to identify the optimal configuration that minimizes the expected dual-command operation time for different storage capacities.

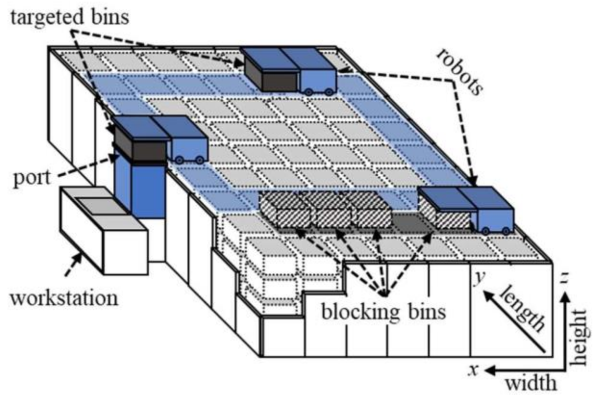

FIGURE 1
An RCS/RS System with 4 Levels, including 252 Bins (7x9 Bins per Level).

LITERATURE REVIEW

Research on RCS/R systems is limited. Beckschafer et al. [1] used discrete event simulation (DES) to explore SKU placement strategies. Zou et al. [2] analyzed optimal system dimensions for various storage policies using semi-open queueing network (SOQN) models. Trost et al. [3] used DES to explore the impact of the number of bins per stack and the filling degree on throughput performance in an RCS/R system with multiple robots.

Cai et al. [4] optimized robot task assignments using dual-command operations. Kartnig et al. [5] explored the effects of stack height, filling degree, and grid size on an RCS/R system with a single robot. Trost et al. [6] determined the optimal number of robots based on various system factors. Tutam et al. [7] optimized bin assignments in RCS/R systems for different storage policies under single-command operations. Wang et al. [8] applied a nested SOQN model and reinforcement learning for bin placement. Yener and Yazgan [9] investigated the impact of rearrangement strategies on throughput.

Trost and Eder [10] used an analytical approach, validated with DES, to assess the efficiency of an RCS/R system with a single robot. Trost and Eder [11] developed an operation time expression for performance evaluation using an open queueing model. Trost and Eder [12] estimated multi-robot system throughput with a multi-queue model and validated the results against DES. Tutam et al. [13] developed closed-form expressions to optimize system configuration and operation time for various bin activity levels.

From the literature, we conclude that our research is unique because only one study, Cai et al. [4], has considered dual-command operations, focusing on optimizing robot task assignments rather than our objective of finding the optimal configuration of the RCS/R system.

METHODOLOGY

In this section, we develop a discrete formulation to determine the expected dual-command operation time and an algorithm to find the best design for a three-dimensional RCS/RS system with a given storage capacity. We first calculate the single-command operation time for each storage/retrieval location. Then, we compute the travel time between every pair of storage/retrieval locations. By taking the average of the singlecommand and travel-between operation times, and summing them, we obtain the expected dual-command operation time.

Notation

We employ the following notation to develop expressions and the algorithm.
nx (ny, nz) = number of bins in the x-direction (y-direction, z-direction)

N = total number of storage bins (N = nx ny nz) nzmax = maximum number of bins stacked in the z-direction bx (by, bz) = dimensions of a bin in the x-direction (y-direction, z-direction) vx (vy) = travel velocity of a robot in the x-direction (y-direction) vz = lifting or lowering velocity of a robot in the z-direction SCijk = travel time from a port to <ijk> location, representing x-, y-, z-coordinates, respectively TBijlm = travel time between locations ij and lm, where i and l represent x-coordinates and j and m represent y-coordinates, respectively

E [SC] = expected single-command operation time
E [TB] = expected travel-between operation time
E [SC] = expected dual-command operation time

Operation Time Calculations

We adapted the formula derived by Tutam et al. [7] to compute the single-command operation time between the port and the location <ijk>.

$$SC_{ijk} = 2\,(i - 0.5)\,b_x / v_x + 2\,|\,j - 0.5(1 + n_y)\,|\,b_y / v_y + k2\,b_z / v_z + (k2 - k)\,b_x / v_x \qquad (1)$$

Note that we assume the port (and workstation) is centrally located along the y-direction border, and any blocking bins above the targeted bin are removed and placed on top of stacks aligned in the x-direction. Moreover, we developed the travel-between time formula as follows:

$$TB_{ijlm} = |\,i - l\,|\,b_x / v_x + |\,j - m\,|\,b_y / v_y \qquad (2)$$

We provide an example calculation for the RCS/R system with dimensions of 252 bins (7x9x4 bins in x, y- and z- directions). We use the following parameter values to generate Tables 1 and 2: nx = 0.6m, ny = 0.8m, nz = 0.33m, vx = vy = 3m/s and vz = 1.6m/s.

Table 1 depicts roundtrip travel time calculations from/to the port to/from any storage/retrieval location. Note that the leftmost subfigures correspond to the highest level, with the vertical level decreasing from left to right.

TABLE 1
Roundtrip Travel Time Calculations from/to the Port to/from Any Storage/Retrieval Location.

	1	2	3	4	5	6	7		1	2	3	4	5	6	7		1	2	3	4	5	6	7		1	2	3	4	5	6	7	
	2.5	2.9	3.3	3.7	4.1	4.5	4.9	1	3.6	4.0	4.4	4.8	5.2	5.6	6.0	1	5.4	5.8	6.2	6.6	7.0	7.4	7.8	1	8.0	8.4	8.8	9.2	9.6	10.0	10.4	1
	2.0	2.4	2.8	3.2	3.6	4.0	4.4	2	3.0	3.4	3.8	4.2	4.6	5.0	5.4	2	4.9	5.3	5.7	6.1	6.5	6.9	7.3	2	7.5	7.9	8.3	8.7	9.1	9.5	9.9	2
	1.5	1.9	2.3	2.7	3.1	3.5	3.9	3	2.5	2.9	3.3	3.7	4.1	4.5	4.9	3	4.3	4.7	5.1	5.5	5.9	6.3	6.7	3	7.0	7.4	7.8	8.2	8.6	9.0	9.4	3
	0.9	1.3	1.7	2.1	2.5	2.9	3.3	4	2.0	2.4	2.8	3.2	3.6	4.0	4.4	4	3.8	4.2	4.6	5.0	5.4	5.8	6.2	4	6.4	6.8	7.2	7.6	8.0	8.4	8.8	4
I/O Point	0.4	0.8	1.2	1.6	2.0	2.4	2.8	5	1.4	1.8	2.2	2.6	3.0	3.4	3.8	5	3.3	3.7	4.1	4.5	4.9	5.3	5.7	5	5.9	6.3	6.7	7.1	7.5	7.9	8.3	5
	0.9	1.3	1.7	2.1	2.5	2.9	3.3	6	2.0	2.4	2.8	3.2	3.6	4.0	4.4	6	3.8	4.2	4.6	5.0	5.4	5.8	6.2	6	6.4	6.8	7.2	7.6	8.0	8.4	8.8	6
	1.5	1.9	2.3	2.7	3.1	3.5	3.9	7	2.5	2.9	3.3	3.7	4.1	4.5	4.9	7	4.3	4.7	5.1	5.5	5.9	6.3	6.7	7	7.0	7.4	7.8	8.2	8.6	9.0	9.4	7
	2.0	2.4	2.8	3.2	3.6	4.0	4.4	8	3.0	3.4	3.8	4.2	4.6	5.0	5.4	8	4.9	5.3	5.7	6.1	6.5	6.9	7.3	8	7.5	7.9	8.3	8.7	9.1	9.5	9.9	8
	2.5	2.9	3.3	3.7	4.1	4.5	4.9	9	3.6	4.0	4.4	4.8	5.2	5.6	6.0	9	5.4	5.8	6.2	6.6	7.0	7.4	7.8	9	8.0	8.4	8.8	9.2	9.6	10.0	10.4	9

Table 2 depicts travel-between time calculations for each pair of locations in the example RCS/RS system. The matrix represents travel times between all possible pairs of the 7x9 locations at each level. The full matrix is sized 63x63 and displaying it at its full size is not feasible. Due to the repetitive nature of some parts of the matrix, we divided it into smaller sections.

TABLE 2
Travel-between Time Calculations for Each Pair of Locations.

A

x	1	2	3	4	5	6	7
1	A	B	C	D	E	F	G
2	B	A	B	C	D	E	F
3	C	B	A	B	C	D	E
4	D	C	B	A	B	C	D
5	E	D	C	B	A	B	C
6	F	E	D	C	B	A	B
7	G	F	E	D	C	B	A

B

y	1	2	3	4	5	6	7	8	9
1	0.0	0.3	0.5	0.8	1.1	1.3	1.6	1.9	2.1
2	0.3	0.0	0.3	0.5	0.8	1.1	1.3	1.6	1.9
3	0.5	0.3	0.0	0.3	0.5	0.8	1.1	1.3	1.6
4	0.8	0.5	0.3	0.0	0.3	0.5	0.8	1.1	1.3
5	1.1	0.8	0.5	0.3	0.0	0.3	0.5	0.8	1.1
6	1.3	1.1	0.8	0.5	0.3	0.0	0.3	0.5	0.8
7	1.6	1.3	1.1	0.8	0.5	0.3	0.0	0.3	0.5
8	1.9	1.6	1.3	1.1	0.8	0.5	0.3	0.0	0.3
9	2.1	1.9	1.6	1.3	1.1	0.8	0.5	0.3	0.0

y	1	2	3	4	5	6	7	8	9
1	0.2	0.5	0.7	1.0	1.3	1.5	1.8	2.1	2.3
2	0.5	0.2	0.5	0.7	1.0	1.3	1.5	1.8	2.1
3	0.7	0.5	0.2	0.5	0.7	1.0	1.3	1.5	1.8
4	1.0	0.7	0.5	0.2	0.5	0.7	1.0	1.3	1.5
5	1.3	1.0	0.7	0.5	0.2	0.5	0.7	1.0	1.3
6	1.5	1.3	1.0	0.7	0.5	0.2	0.5	0.7	1.0
7	1.8	1.5	1.3	1.0	0.7	0.5	0.2	0.5	0.7
8	2.1	1.8	1.5	1.3	1.0	0.7	0.5	0.2	0.5
9	2.3	2.1	1.8	1.5	1.3	1.0	0.7	0.5	0.2

C

y	1	2	3	4	5	6	7	8	9
1	0.4	0.7	0.9	1.2	1.5	1.7	2.0	2.3	2.5
2	0.7	0.4	0.7	0.9	1.2	1.5	1.7	2.0	2.3
3	0.9	0.7	0.4	0.7	0.9	1.2	1.5	1.7	2.0
4	1.2	0.9	0.7	0.4	0.7	0.9	1.2	1.5	1.7
5	1.5	1.2	0.9	0.7	0.4	0.7	0.9	1.2	1.5
6	1.7	1.5	1.2	0.9	0.7	0.4	0.7	0.9	1.2
7	2.0	1.7	1.5	1.2	0.9	0.7	0.4	0.7	0.9
8	2.3	2.0	1.7	1.5	1.2	0.9	0.7	0.4	0.7
9	2.5	2.3	2.0	1.7	1.5	1.2	0.9	0.7	0.4

D

y	1	2	3	4	5	6	7	8	9
1	0.6	0.9	1.1	1.4	1.7	1.9	2.2	2.5	2.7
2	0.9	0.6	0.9	1.1	1.4	1.7	1.9	2.2	2.5
3	1.1	0.9	0.6	0.9	1.1	1.4	1.7	1.9	2.2
4	1.4	1.1	0.9	0.6	0.9	1.1	1.4	1.7	1.9
5	1.7	1.4	1.1	0.9	0.6	0.9	1.1	1.4	1.7
6	1.9	1.7	1.4	1.1	0.9	0.6	0.9	1.1	1.4
7	2.2	1.9	1.7	1.4	1.1	0.9	0.6	0.9	1.1
8	2.5	2.2	1.9	1.7	1.4	1.1	0.9	0.6	0.9
9	2.7	2.5	2.2	1.9	1.7	1.4	1.1	0.9	0.6

E

y	1	2	3	4	5	6	7
1	0.8	1.1	1.3	1.6	1.9	2.1	2.4
2	1.1	0.8	1.1	1.3	1.6	1.9	2.1
3	1.3	1.1	0.8	1.1	1.3	1.6	1.9
4	1.6	1.3	1.1	0.8	1.1	1.3	1.6
5	1.9	1.6	1.3	1.1	0.8	1.1	1.3
6	2.1	1.9	1.6	1.3	1.1	0.8	1.1
7	2.4	2.1	1.9	1.6	1.3	1.1	0.8
8	2.7	2.4	2.1	1.9	1.6	1.3	1.1
9	2.9	2.7	2.4	2.1	1.9	1.6	1.3

F

y	1	2	3	4	5	6	7	8	9
1	1.0	1.3	1.5	1.8	2.1	2.3	2.6	2.9	3.1
2	1.3	1.0	1.3	1.5	1.8	2.1	2.3	2.6	2.9
3	1.5	1.3	1.0	1.3	1.5	1.8	2.1	2.3	2.6
4	1.8	1.5	1.3	1.0	1.3	1.5	1.8	2.1	2.3
5	2.1	1.8	1.5	1.3	1.0	1.3	1.5	1.8	2.1
6	2.3	2.1	1.8	1.5	1.3	1.0	1.3	1.5	1.8
7	2.6	2.3	2.1	1.8	1.5	1.3	1.0	1.3	1.5
8	2.9	2.6	2.3	2.1	1.8	1.5	1.3	1.0	1.3

G

y	1	2	3	4	5	6	7	8	9
1	1.2	1.5	1.7	2.0	2.3	2.5	2.8	3.1	3.3
2	1.5	1.2	1.5	1.7	2.0	2.3	2.5	2.8	3.1
3	1.7	1.5	1.2	1.5	1.7	2.0	2.3	2.5	2.8
4	2.0	1.7	1.5	1.2	1.5	1.7	2.0	2.3	2.5
5	2.3	2.0	1.7	1.5	1.2	1.5	1.7	2.0	2.3
6	2.5	2.3	2.0	1.7	1.5	1.2	1.5	1.7	2.0
7	2.8	2.5	2.3	2.0	1.7	1.5	1.2	1.5	1.7
8	3.1	2.8	2.5	2.3	2.0	1.7	1.5	1.2	1.5

9	3.1 2.9 2.6 2.3 2.1 1.8 1.5 1.3 1.0	9	3.3 3.1 2.8 2.5 2.3 2.0 1.7 1.5 1.2

Solution Algorithm

The pseudo-code for the algorithm used to calculate dual-command operation time is presented in Algorithm 1. To simplify the three-dimensional problem, we converted it into a one-dimensional problem by fixing the total number of storage locations and limiting the number of bins in the z-direction to 20 bins. We enumerate the number of bin locations in the z-direction up to 20, the number of bin locations in the x-direction up to ⌈ N / nz ⌉, and calculate the number of bin locations in the y-direction as ⌈ N / (nz nx) ⌉. This approach helps in determining the optimal design by selecting the configuration with the minimum dual-command operation time from the values obtained through the loop iterations.

ALGORITHM 1
Enumeration to determine the Optimal Design.

max
Input: N, bx, by, bz, vx, vy, vz, nx
for nz = 1 to nxmax

```
for k = 1 to                                                         nz
        for nx = 1 to ⌈ N / nz ⌉
            ny = ⌈ N / (nz nx) ⌉
            Nupdated = nx ny nz
            for i = 1 to nx
                for j = 1 to ny

for l = 1 to                    calculate SCijk                      nx
end                             SumSC = SumSC + SCijk
                            end
                        end
                    end
2                   E [SC] = SumSC / Nupdated
                    for i = 1 to nx
                        for j = 1 to ny
         27
end                             for m = 1 to ny
                                    calculate TBijlm
                                    SumTB = SumTB + TBijlm

                                end
                            end
                        end
                    E [TB] = SumTB / (nx   ny )
                    E [DC] = E [SC] + E [TB]
        end
```

Output: find nx, ny , nz for min (E [DC])

RESULTS

In this section, we present the results for different storage capacities (N ≈ 10000, 20000, and 30000 bins). Table 3 illustrates the expected dual-command operation time results. For a total of 10,000 bins, the optimal system dimensions are 38, 44, and 6 in the x-, y-, and z-directions, respectively. With an increase to 20,000 or 30,000 bins, the number of bins in the z-direction rises to 7. Compared to the single-command operations described by Tutam et al. [7], there is an increase of one bin in the stacking height.

TABLE 3
Expected Dual-Command Operation Time Results for Different Storage Capacities.

nx	ny	nz	N	E[DC]
91	110	1	10010	48.9
65	77	2	10010	35.2
53	63	3	10017	29.6
44	57	4	10032	26.9
40	50	5	10000	25.6
38	44	6	10032	25.4
35	41	7	10045	25.8
33	38	8	10032	26.7
31	36	9	10044	28.1
28	36	10	10080	30.0
26	35	11	10010	32.2
27	31	12	10044	34.8
25	31	13	10075	37.7
24	30	14	10080	41.0
23	29	15	10005	44.6
25	25	16	10000	48.5
22	27	17	10098	52.7
20	28	18	10080	57.2
22	24	19	10032	62.0
20	25	20	10000	67.1

nx	ny	nz	N	E[DC]
130	154	1	20020	69.1
91	110	2	20020	49.4
75	89	3	20025	41.3
65	77	4	20020	37.0
58	69	5	20010	34.7
53	63	6	20034	33.6
52	55	7	20020	33.4
44	57	8	20064	33.9
42	53	9	20034	34.8
40	50	10	20000	36.3
38	48	11	20064	38.3
38	44	12	20064	40.6
35	44	13	20020	43.3
35	41	14	20090	46.4
32	42	15	20160	49.8
33	38	16	20064	53.5
31	38	17	20026	57.6
31	36	18	20088	62.0
31	34	19	20026	66.6
28	36	20	20160	71.7

nx	ny	nz	N	E[DC]
158	190	1	30020	84.6
112	134	2	30016	60.4
91	110	3	30030	50.2
79	95	4	30020	44.7
69	87	5	30015	41.6
65	77	6	30030	39.9
58	74	7	30044	39.2
56	67	8	30016	39.3
53	63	9	30051	40.0
50	60	10	30000	41.2
48	57	11	30096	42.9
44	57	12	30096	45.1
42	55	13	30030	47.6
43	50	14	30100	50.5
40	50	15	30000	53.8
40	47	16	30080	57.4
37	48	17	30192	61.4
38	44	18	30096	65.6
36	44	19	30096	70.2
35	43	20	30100	75.1

CONCLUSIONS

We formulate a discrete model to calculate the expected dual-command operation time and design an algorithm to find the best configuration for a three-dimensional RCS/RS system given a certain storage capacity. Based on RCS/RS systems with varying storage capacities, we present the optimal dimensions for each design. We found that dual-command operations lead to an increase of one bin in the stacking height compared to singlecommand operations.

Future research on RCS/R systems should focus on optimizing bin allocation within the context of a classbased storage policy. Developing a more efficient algorithm, as an alternative to enumeration, is also advisable. Furthermore, investigating configurations with multiple ports situated at various points around the perimeter of the system could yield significant insights.

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DIGITAL TWINS IN THE SUPPLY CHAIN; LITERATURE REVIEW AND BEST PRACTICES

Gülnihal Akan Özkök

Maltepe University, gulnihalakan@maltepe.edu.tr

ABSTRACT:

Purpose:
The aim of this study is to examine how digital twins in the supply chain are reflected in scientific research and how and in which business processes these technologies are implemented by companies, with the goal of contributing to future research. To this end, publications on the topic of "digital twins in the supply chain" and companies that apply digital twins technology in their business processes have been investigated.

Study design/methodology/approach:
The research questions of this study are: What are the reflection of the application of digital twins technology in the supply chain in the literature, in which areas and how has it created an impact, which are the most cited studies on this topic, which companies best implement digital twins technology? To answer these questions, a literature review was conducted in the Web of Science database using the keywords "digital twins" and "supply chain". The reports from the Web of Science database were used for data analysis and visualization. To investigate the companies that best implement digital twins technology in the industry, reports published on the relevant industry and digitalization were reviewed, and the companies' websites were utilized.

Findings:
A total of 182 studies published between 2016 and 2024 were identified in the literature (Web of Science). This study examines the distribution of these publications by year and highlights the most cited works, as well as featuring the 15 companies that best implement digital twins technology. Data regarding the identified studies were analyzed and visualized using the Web of Science database..

Originality/value:
While there are publications that include literature reviews on digital twins technologies in the supply chain, this study not only reviews the literature but also encompasses companies that implement these technologies. Thus, this study provides researchers and practitioners with a comprehensive perspective on the current state and future trends of digital twins technology in the supply chain.

KEYWORDS
Supply chain, digital twins, literature review, best pratices.

INTRODUCTION

With Industry 4.0, businesses have undergone a major transformation and interest in new technologies such as big data, artificial intelligence, blockchain, internet of things and digital twins has increased. Businesses are trying to achieve transformation by adopting Industry 4.0 technologies and support strategic decisions such as real-time monitoring, forecasting, decision-making and adaptation with the data obtained through these technologies. Thus, businesses gain benefits such as short product development time, product customization according to demand, increased flexibility of the production line, decentralization and resource efficiency. The changing understanding of production directs businesses to be both lean and agile rather than just lean. As the critical importance of data and information increases today, it also reveals the necessity of obtaining meaningful information from data and making this process fast and efficient. Transforming data into meaningful information and benefiting from this information in decision-making and production processes provides a significant competitive advantage for businesses. In this respect, digital twins stand out as an important technology that will play an important role in the future and make valuable contributions to product design, information-driven production, on-demand services and business applications in smart manufacturing [1]. In fact, the digital twins is seen as an inevitable part of digital transformation.

Businesses trying to adapt to changing business models with the impact of Industry 4.0 are trying to develop continuous and rapid response strategies to changes in the nature of demands or supply and supply problems. For this reason, digital twin technology is used to solve crises and needs that arise in the supply chain, directly affecting efficiency. Businesses that use digital twins enable improvement throughout the supply chain by identifying supply chain problems in advance. Digital twins developed with high-level technical equipment such as artificial intelligence and machine learning; It is used to optimize various operational processes in the supply chain through simulations. By using a digital twins, businesses can manage complex and interconnected operational processes such as capacity, service, inventory and total cost.

Businesses that can manage their supply chains effectively and efficiently can gain competitive advantage and adapt to changing business models. Digital twins technology is also an effective technology tool in managing supply chains. For this reason, this study was conducted to determine the usage areas of the digital twins in the supply chain and its place in the literature, and literature analysis was preferred as the method. Studies on digital twins in the supply chain were examined in the Web of Science (WOS) database [2]. This research, which provides theoretical evidence that businesses can increase their efficiency by using digital twins technology in their supply chains, is a literature research on the classification of contributions with digital twins. This study has also investigated how digital twin applications have increased in companies and highlighted the best practices.

The aim of this study is to reveal the importance of the concept in the literature (Web of Science), in the context of the extent of interest in digital twins in the supply chain, which countries and authors they have discussed, and the cited works. Additionally, it is aimed to contribute to future research by examining how digital twins in the supply chain are reflected in scientific research. For this purpose, a literature analysis of publications related to "digital twins in the supply chain" was conducted. Accordingly, in the study, the concepts of supply chain and digital twins were explained, the relationship between the two concepts was examined, and articles written about these two concepts were compiled. Additionally, the best practices of companies were also highlighted.

This study aimed to answer the following questions:
What are the reflection of the application of digital twins technology in the supply chain in the literature?
In which areas and how has it created an impact?
Which are the most cited studies on this topic?
Which companies best implement digital twins technology?

LITERATURE REVIEW

Supply chain management is a set of approaches aimed at efficiently integrating suppliers, manufacturers, warehouses and stores. Supply chain management is the integrated management of the flow of materials, money, and information to ensure that the right product reaches the customer at the right time, at the right place, at the right price, and with the minimum cost for the entire supply chain [3]. This integration can be achieved much more effectively today with digital twins, enabling better management of supply chain processes.

The Global Supply Chain Forum members have eight processes defined. These processes; customer management relations, supplier relations management, customer service management, demand management, order processing, manufacturing flow management, product development and commercialization, returns management [4]. Supply chain management is a strategic and systematic method that includes the business functions, processes and plans of the companies in question, covering all companies in the chain, in order to increase the long-term performance of all companies in the supply chain, especially suppliers, manufacturers and customers.

Due to the number of businesses in the chain and the different strategies and goals that businesses have, the complexity of the supply chain increases and becomes difficult to manage. The performance of supply chain management processes affects the holistic performance of the supply chain. The structure of the supply chain is complex, requiring the use of different tools, methodologies and systems to improve the supply chain. There are many techniques and tools used for analysis, evaluation and decision-making in supply chain management, and one of them is simulation. Simulation is an effective tool in manufacturing operations and logistics systems that provides the advantage, compared to mathematical programming methods or stochastic models, of allowing the user to observe, analyze and learn the dynamic system of behavior [5]. However, simulation to optimize the supply chain has begun to be replaced by digital twin technology in recent years. The digital twin is the next phase of simulation. In the context of simulation applications, digital twins are seen as the future of simulation, modeling, and optimization technology.

Digital twins technology is a virtual copy of the behavior of an object, system, product or living thing existing in the physical world, created in a digital environment. Digital twins is a technology that helps detect problems that may occur in the real world, create scenarios by testing these problems, analyze the problems that may occur and apply the problems that may occur in the real world on a virtual structure [6]. The most significant advantage of digital twins is their ability to generate and learn from real-time data, enabling understanding and assessment of system operations. This allows users to comprehend and optimize the performance of a physical entity throughout its lifecycle [7].

Other advantages of the digital twin are the availability of in-depth analysis of the physical twin, the design and validation of new or existing product/process, the ability to predict the performance of the physical twin, and the ability to provide real-time control over the physical twin [8]. Additionally, the formation of digital twins using virtual resources enables businesses to achieve traceability and control through remote access in situations where the actual product does not exist, thus offering cost-effectiveness suitable for enterprises. Furthermore, leveraging digital twins allows for predicting the future state of the physical twin and enables rapid prototyping and product redesign by facilitating a series of scenario explorations [8]. Digital twins also helps in performing process controls, making strategic decisions and making real-time decisions by feeding decision support systems [9].

Specifically, digital twins have many applications in the supply chain; product tracking and monitoring, supplier relationship management, production optimization, risk management. Each application can be customized and integrated depending on the needs and goals of the business.

The concept of a digital twins involves creating a digital copy of a physical object and using this copy to collect data, analyze and perform simulations about the state of the object in the real world. In this context, digital twins applications in the supply chain have significant advantages and disadvantages. Its advantages include real-time monitoring, forecasting and planning, and process optimization. However, the creation, maintenance, and continuous updating of digital twins can be costly, posing a barrier, particularly for small-scale enterprises. Moreover, since digital twins gather significant amounts of data, they entail security risks, necessitating the management of risks such as data or system breaches. Specifically, integration and compatibility of digital twins with existing systems can sometimes be complex. Developing a standardized approach to facilitate data transfer from existing systems to digital twins is crucial. Lastly, the outcomes provided by digital twins depend on the quality and accuracy of the data utilized. If the data quality is low or incorrect data is inputted, the value of digital twins diminishes, or they may yield misleading results.

The use of digital twins in the supply chain provides great advantages for businesses in general, but with these advantages it also brings some challenges. By taking good planning, appropriate investment and security measures, it is possible to make the most of the potential of digital twins.

Although digital twins applications are popular in many sectors, digital twins applications are not common in supply chain management or design. In the literature, digital twins studies in the supply chain have begun to increase in recent years.

When the concept of digital twin in the supply chain is researched through the Web of Science (WOS) database, 173 studies are found. The years in which the studies were concentrated are shown in the Figure 1.

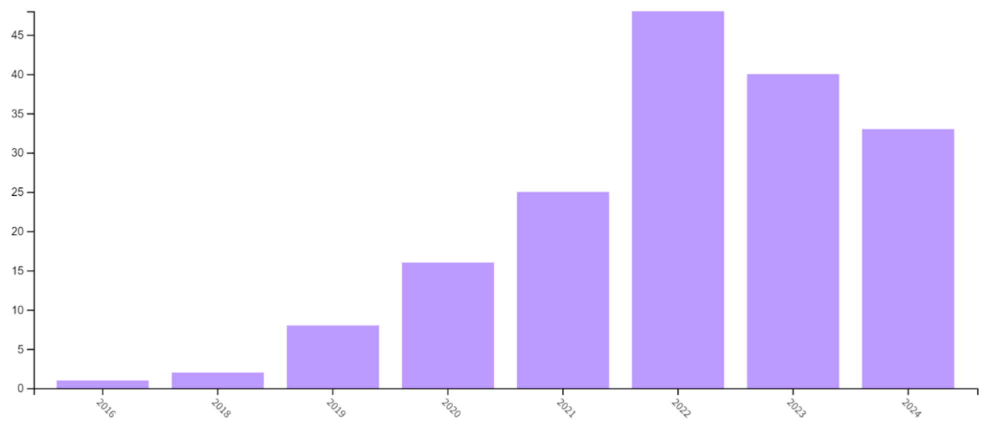

FIGURE. 1
Distribution of Publications by Year
(Source: Web of Science Database – Access Date: 28.08.2024)

Out of the 173 studies found, 106 are articles, 1 is a book chapter, 7 are early access, 1 is editorial material, 38 are proceeding papers, and 30 are review articles. The distribution can be seen in the chart below.

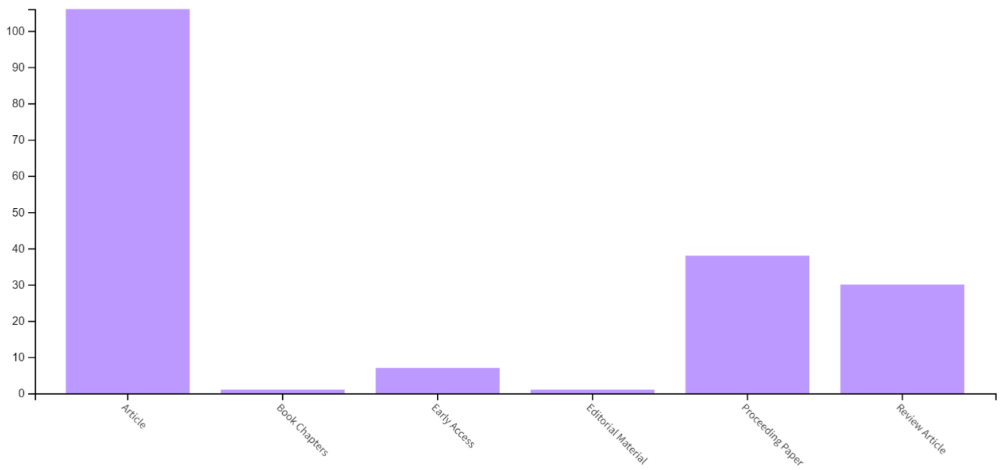

FIGURE. 2
Document Types
(Source: Web of Science Database – Access Date: 28.08.2024)

It is seen that digital twins studies in the supply chain are mostly carried out in the field of engineering. It is seen that there are studies in the fields of management and sustainability, mainly in computer and software engineering, industrial engineering, production engineering. Figure 3 shows the areas in which digital twins studies are being carried out in the supply chain.

There are 173 studies on the subject in the WOS database, 124 are conceptual studies and 49 are case studies.

The first study on the concept of digital twins in the supply chain in the WOS database was conducted in 2016 by Ameri, F; Sabbagh, R [10]. They developed the concept of a digital factory that could represent the technological capabilities of manufacturing facilities. With the digital factory, they replicated the facility, installed machines, material handling equipment, and layout plan as the digital twin of the physical facility, thus developing a mathematical model to measure operational capabilities.

FIGURE. 3
Distribution of Studies by Fields
(Source: Web of Science Database – Access Date: 28.08.2024)

The top 10 most cited articles and summaries of the articles in the WOS database are as follows;

Ivanov, D and Dolgui, A, (2021); "A digital supply chain twin for managing the disruption risks and resilience in the era of Industry 4.0". Digital twins have been used for mapping and ensuring visibility of supply networks. In this study, risk management in the supply chain was conducted by developing predictive and reactive decisions to leverage the advantages of supply chain visualization, historical disruption data analysis, and real-time disruption data, thus providing end-to-end visibility [11]. (528 citations)

Maddikunta, PKR; Pham, QV; Liyanage, M, (2022); "Industry 5.0: A survey on enabling technologies and potential applications". This research focuses on Industry 5.0, emphasizing the digitalization of all business models. They proposed the creation of digital twins to improve supply chain processes [12]. (443 citations)

Burgos, D and Ivanov, D, (2021); "Food retail supply chain resilience and the COVID-19 pandemic: A digital twin-based impact analysis and improvement directions". This study examines the impact of the COVID-19 pandemic on food retail supply chains and the resilience of these chains. Various aspects and practical applications have been proposed to enhance the resilience of the food retail chain. The importance of the supply chain has been emphasized, and visibility in flexible demand, inventory, and capacity management has been provided through digital twin technology. The study aims to

increase the resilience of food retail outlets in preparation for future pandemics and pandemic-like crises through digital twin technology [13]. (177 citations)

Jamwal, A; Agrawal, R; Giallanza, A, (2021); "Industry 4.0 Technologies for Manufacturing Sustainability: A Systematic Review and Future Research Directions". In this study, a systematic literature review was conducted to uncover the current research progress and future research potential of Industry 4.0 technologies. Potential use cases of digital twins in the supply chain have been outlined [14]. (117 citations)

Adel, A, (2022); "Future of industry 5.0 in society: human-centric solutions, challenges and prospective research areas". The aim of the article is to analyze the potential applications of Industry 5.0. Firstly, the definitions of Industry 5.0 and the advanced technologies required by this industrial revolution have been discussed. Applications enabled by Industry 5.0, such as healthcare services, have been addressed, and recommendations have been made on how these technologies can be utilized in the supply chain and manufacturing [15]. (95 citations)

Smith, MJ, (2020); "Getting value from artificial intelligence in agriculture". In this article, the applications of artificial intelligence in the agriculture sector have been investigated, and the digital twin technology has been elucidated to improve supply chain structures [16]. (90 citations)

Defraeye, T; Tagliavini, G; Bühlmann, A, (2019); "Digital twins probe into food cooling and biochemical quality changes for reducing losses in refrigerated supply chains". In this article, a digital twin of the mango fruit has been created for its transportation and storage in refrigerators, preservation of its quality, prevention of food waste, and consequent reduction of energy losses. This digital twin simulated the thermal behavior of the mango fruit along the cold chain based on measured environmental temperature conditions, i.e., the ambient temperature near the fruit. Thus, digital twins have assisted in improving cooling processes and logistics to reduce food losses [17]. (81 citations)

Greif, T; Stein, N and Flath, CM, (2020); "Peeking into the void: Digital twins for construction site logistics". This article suggests that construction is one of the least digitized sectors in the economy and proposes digital transformation to curb the increasing costs of construction activities. Thus, the aim is to make logistics processes more efficient with digital twin technology [18]. (77 citations)

Huo, R; Zeng, SQ; Liu, YJ, (2022); "A Comprehensive Survey on Blockchain in Industrial Internet of Things: Motivations, Research Progresses, and Future Challenges". This article focuses on Industry 4.0 technologies, explaining the Internet of Things, digital twins, and robotics technologies, and providing insights into their applications [19]. (70 citations)

Defraeye, T; Shrivastava, C; Rossi, RM, (2021); "Digital twins are coming: Will we need them in supply chains of fresh horticultural produce?". In this article, a digital twin of fresh garden produce has been created. Thus, digital twins have provided exporters, retailers, and consumers with actionable data, such as remaining shelf life for each shipment, upon which logistics decisions and marketing strategies can be based. Additionally, it has been demonstrated that digital twins assist in diagnosing and predicting potential issues that could compromise food quality and lead to food loss in supply chains [20]. (73 citations)

BEST PRACTICES

The application of digital twin technology in supply chain and logistics helps make processes more efficient, flexible, and transparent. Examples of digital twins applications in this field are as follows [21]:

Inventory and Warehouse Management

Real-Time Inventory Tracking: Digital twins are used in warehouse and inventory management to enable real-time tracking of stock levels. This ensures inventory optimization and prevents overstocking or stockouts.

Simulation of Warehouse Operations: By creating a digital twin of all operations within the warehouse, it is possible to simulate and optimize processes. This allows for the most efficient arrangement of warehouse layout and material flow.

Transportation and Logistics Management

Route Optimization: Digital twins of transportation vehicles are used for the simulation and optimization of transportation processes. This helps minimize fuel consumption, transportation time, and costs.

Real-Time Vehicle Tracking: Digital twins of transportation vehicles allow for real-time tracking of the vehicles' location, speed, and status, ensuring transparency and traceability in transportation processes.

Production and Supply Management

Production Line Simulation: Digital twins of production processes are used to analyze the performance of the production line, identify bottlenecks, and make process improvements. This helps increase production efficiency and reduce costs.

Supply Chain Visualization: By creating digital twins of all components in the supply chain, end-to-end visualization of the supply chain is achieved. This helps anticipate potential disruptions throughout the supply chain and minimize risks.

Forecasting and Planning

Demand Forecasting: Digital twins collect and analyze data for demand forecasting, enabling more accurate predictions. This helps make more effective decisions in production planning and inventory management.

Production Planning and Simulation: Digital twins of production processes assist in determining the most efficient production planning by simulating different scenarios.

Quality Control and Maintenance

Preventive Maintenance: Digital twins of production equipment continuously monitor equipment performance to predict potential failures and enable preventive maintenance. This reduces downtime and lowers maintenance costs.

Quality Monitoring: Digital twins of production processes are used to automate and improve quality control processes. This enhances product quality and reduces defect rates.

Customer Experience and Service Quality

Order Tracking: Customers are provided with the ability to track the status of their orders in real time during production and transportation processes. This increases customer satisfaction and improves service quality.

Personalized Services: Digital twins help respond to customer demands quickly and accurately, allowing for more personalized services.

Examples of companies in the supply chain and logistics sector that successfully implement digital twins technology and their applications are listed below.

Amazon: Application Area: Logistics and Warehouse Management

Example: Amazon uses digital twin technology in warehouse and inventory management to enable real-time tracking of stock levels and optimize warehouse operations. This helps reduce errors in inventory management and speeds up order processing [22].

DHL: Application Area: Transportation and Logistics

Example: DHL uses digital twins in transportation processes to monitor the location, speed, and status of vehicles in real time. This enables route optimization and makes transportation processes more efficient [23].

Unilever: Application Area: Consumer Goods Manufacturing

Example: Unilever uses digital twin technology in its production facilities to simulate and optimize production processes. Digital twins are utilized to reduce energy consumption and increase production efficiency [24].

Mearsk: Application Area: Maritime Transport

Example: Maersk creates digital twins of container ships and cargo to optimize maritime transport processes. Digital twins allow for real-time monitoring of ship performance, route planning, and cargo status, enhancing operational efficiency and improving the management of logistics processes [25].

UPS: Application Area: Cargo and Distribution

Example: UPS uses digital twin technology to optimize distribution networks and cargo processes. Digital twins monitor the status of distribution vehicles and packages in real time, enabling more efficient route planning and improvement of transportation processes [26].

P&G (Procter & Gamble): Application Area: Consumer Goods Manufacturing and Distribution

Example: P&G uses digital twins of its production facilities and supply chain processes to enhance production efficiency and optimize supply chain management. Digital twins simulate production processes to identify potential issues in advance and provide operational improvements [27].

Bosch: Application Area: Industrial Manufacturing and Logistics

Example: Bosch uses digital twins in its production facilities and logistics processes to optimize operations. Digital twins monitor the performance of production equipment and logistics processes, enabling better maintenance planning and process improvements [28].

FedEx: Application Area: Cargo and Distribution

Example: FedEx uses digital twin technology in its cargo and distribution processes to enhance performance. Digital twins simulate cargo processes and distribution networks to optimize delivery times and costs. This application shortens delivery times by 15% [29].

DB Schenker: Application Area: Transportation and Logistics

Example: DB Schenker improves logistics processes and warehouse management with digital twins. Digital twins simulate processes in the supply chain, enhancing operational efficiency and reducing costs by 12% [30].

Ceva Logistics: Application Area: Logistics and Supply Chain Management

Case Study: CEVA Logistics uses digital twin technology to optimize supply chain processes. Digital twins simulate logistics operations, increasing process efficiency and reducing costs by 10% [31].

CONCLUSION

In this study, publications in the field of digital twins in the supply chain were examined using literature analysis, focusing on document and source. Only the Web of Science (WOS) database was utilized, and the data were analyzed using the WOS results. With this study, the literature on digital twins in the supply chain was classified, visualized, and interpreted to guide further research, exclusively using the Web of Science (WOS) data source.

The study has demonstrated that digital twins in the supply chain studies represent a contemporary and emerging research field. The first article on the subject was written by Ameri, F; Sabbagh, R in 2016, and since then, 173 studies have been produced on this topic.

It has been observed that digital twins in the supply chain studies are most closely associated with the topics of Industry 4.0, simulation, Internet of Things, and blockchain. Additionally, in recent years, concepts such as sustainability, machine learning, and artificial intelligence have also been included.

It has been determined that digital twins in the supply chain studies are predominantly conducted in the field of engineering, including computer and software engineering, industrial engineering, and production engineering. Additionally, research in management and sustainability areas has also been observed. In this context, it is noted that journals such as the International Journal of Production, Sustainability, and Computers in Industry are current and relevant.

The digital twins technology has been academically advancing, while its applications in the industry have also begun to increase. Companies use digital twins technology to enhance their efficiency and lean business processes, and they have also started to adopt it as an optimization tool. Digital twins technology has found its place in the industry in the field of inventory and warehouse management, transportation and logistics Management, production and supply management, forecasting and planning, quality control and maintenance, customer experience and service quality. In this study, companies that are best at applying digital twins technology in the logistics sector and aim to develop it further through investment have been included. These companies include Amazon, DHL, Unilever, Mearsk, UPS, P&G (Procter & Gamble), Bosh, FedEx, DB Schenker, Ceva Logistics.

This study has highlighted the extent of interest in digital twins in the supply chain within the literature (Web of Science) and the industry, identifying which studies and authors have addressed the topic and the significance of the concept in terms of cited works and best practices in the industry. Additionally, by examining how digital twins in the supply chain are reflected in scientific research, this study aims to contribute to future research endeavors.

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REAL-TIME OPTIMIZATION OF INTRA-HOSPITAL TRANSPORTATION WITH SIMULTANEOUS REQUEST HANDLING USING THE DIAL-A-RIDE PROBLEM FRAMEWORK

Hossein Torkinezhadirani, Sibel Salman

Koç University, htorkinezhadirani23@ku.edu.tr
Koç University, ssalman@ku.edu.tr

ABSTRACT:

Purpose:
The goal of this research is to improve the efficiency of intra-hospital transportation system, with a special emphasis on the management of transportation requests handled by hospital's porters. The objectives are to optimize task distribution, reduce operating expenses, and improve service quality by minimizing requests wait times. The study aims to improve patient care and resource usage by incorporating real-time tracking technology such as RFID to respond to changing hospital logistics demands.

Study design/methodology/approach:
In this study, we enhance intra-hospital transportation by initially assuming a static version of the Dial-a-Ride Problem, for which we propose a mathematical model to optimize porter scheduling and routing. Following the static phase, we transition to a dynamic approach, adapting our strategies to accommodate real-time transportation requests. This shift to dynamic methodologies is aimed at significantly boosting the adaptability and operational effectiveness of hospital logistics. The exploration of this dynamic phase is still in progress.

Findings:
Our findings indicate that our approach offers substantial improvements by integrating strategies that consider not only total travel time but also porters' workload and delay reduction. This comprehensive model ensures a more balanced and efficient handling of transportation requests within the hospital, enhancing overall operational workflows. As for the dynamic version of our study, the results are still forthcoming as this phase is actively ongoing.

Originality/value:
The originality of the study lies in its comprehensive approach using the Dial-a-Ride Problem framework, supporting simultaneous request handling for patients and other

critical hospital items like medical supplies and documents. By not only minimizing total travel time but also balancing workloads, minimizing delays, and maintaining ride time limits, the study offers a valuable contribution to optimizing hospital logistics, prioritizing efficiency, fairness, and responsiveness.

KEYWORDS
Intra-hospital transportation, Real-time scheduling, Dial-a-Ride Problem, and Healthcare logistics.

THE MEDIATING ROLE OF DIGITAL TRANSFORMATION TECHNOLOGIES IN THE IMPACT OF REVERSE LOGISTICS APPLICATIONS ON LOGISTICS SERVICE QUALITY AND REPURCHASE BEHAVIOR FROM THE PERSPECTIVE OF CONSUMERS IN E-COMMERCE BUSINESSESS

Nazlıcan Dindarik, Ayşe Atabey Bölük

0000-0003-4313-6576, ndindarik@bartin.edu.tr
0000-0003-3469-5835, ayse.atabey@ostimteknik.edu.tr

ABSTRACT:

Purpose:
The purpose of this research is to investigate the mediating role of digital transformation technologies in the impact of reverse logistics practices on logistics service quality and repurchase behavior from the perspective of consumers in e-commerce businesses.

Study design/methodology/approach:
In the research, an online survey was administered to 400 participants using the convenience sampling method. The obtained data were analyzed using SPSS 23.0 and SPSS 23.0 Process Macro 4.3 software packages. In the data analysis, mediation analysis was conducted to measure the impact of digital transformation technologies on reverse logistics processes. These analyses were performed using the bootstrap technique and calculated with the help of the SPSS PROCESS add-on (Model 4).

Findings:
As a result of the data analyses, it was determined how digital transformation technologies affect service quality and consumer behavior in reverse logistics processes and to what extent this effect plays a mediating role. It was found that digital transformation technologies enhance the efficiency of reverse logistics practices and contribute to the optimization of these processes. Furthermore, it was demonstrated that digital transformation technologies are a significant tool in improving logistics service quality and positively influencing consumers' repurchase behavior.

Originality/value:

Focusing on how reverse logistics processes can be optimized with digital transformation technologies and the impact of this optimization on logistics service quality and consumer behavior makes the study unique. Additionally, the detailed analysis of the mediating role of digital transformation technologies on logistics service quality and repurchase behavior fills a gap in the existing knowledge in this area.

KEYWORDS
Digital Transformation, E-commerce, Logistics Service Quality, Repurchase, Reverse Logistics

BIBLIOMETRIC ANALYSIS OF RESEARCH ON FOOD SUPPLY CHAIN OPTIMIZATION

Nesrin Kolukırık, Şule Önsel Ekici

Istanbul University-Cerrahpasa,Engineering Faculty,Industrial Engineering Department, nesrinkolukirik@gmail.com

Istanbul University- Cerrahpasa,Engineering Faculty,Industrial Engineering Department, sule.ekici@iuc.edu.tr

ABSTRACT:

Purpose:
The food supply chain consists of many processes from the production of food to its delivery to the end consumer. Due to the numerous interconnected processes, managing the food supply chain has become increasingly complex, prompting more in-depth research on optimization. This study aims to conduct a bibliometric analysis to enhance understanding of the academic research landscape within the realm of food supply chain optimization.

Study design/methodology/approach:
A bibliometric analysis was conducted using the Biblioshiny program, a significant tool for bibliometric analysis leveraging an R package designed for research activities Within the scope of this study, the study was carried out using articles in the Scopus and Web of Science databases. In this context, 575 articles were compiled by selecting "Food Supply Chain" and "Optimization" as keywords for the study.

Findings:
The study presents the most prevalent research themes and identifies potential contributions to the field's literature. Notably, key topics include multi-objective mathematical models, sustainability, and waste management. Newer topics such as climate change and modern retail suppliers are emerging, with limited research conducted on them.

Originality/value:
This study offers current insights into food supply chain optimization up to the year 2024. It provides a concise overview of existing research efforts and highlights gaps in the literature, offering valuable guidance for researchers planning future studies in this area.

KEYWORDS
Bibliometric Analysis, Food Supply Chain, Optimization, Sustainability

COMPARING LOGISTICS PERFORMANCE OF AIRLINE COMPANIES USING DATA ENVELOPMENT ANALYSIS (DEA) AND MULTICRITERIA DECISION MAKING ANALYSIS (MCDA)

Aliye Gizem Doğan, Metehan Atay

Hasan Kalyoncu University, agizem.dogan@std.hku.edu.tr
Hasan Kalyoncu University, metehan.atay@hku.edu.tr

ABSTRACT:

Airline logistics is a logistics discipline that provides coordination between air transportation and other types of transportation and covers all operational activities required for the transportation of goods by air. As an integral component of international trade, airline logistics enables the efficient transportation of billions of dollars of goods worldwide. Optimum logistics performance increases passenger satisfaction and strengthens the competitive advantage of companies. In this study, Data Envelopment Analysis (DEA) and Multi-Criteria Decision Making Analysis (MCDA) methods are used to comprehensively compare the logistics performance of airlines. First, data on airline logistics performance is collected in detail and an efficiency analysis is conducted using DEA method. The DEA method enables performance to be measured in terms of efficiency. Then, performance criteria were evaluated in detail and ranked using MCDA. The comparison between the two methods provided strategic insights to improve the logistics performance of the companies. The findings revealed that DEA and MCDA are powerful and comprehensive tools for evaluating airline logistics performance. This study aims to contribute to the development of more effective strategies in airline logistics to improve passenger satisfaction and gain competitive advantage.

KEYWORDS
Airline Logistics, Data Envelopment Analysis (DEA), International Trade, Logistics Performance, Multi-Criteria Decision Making Analysis (MCDA)

SUSTAINABILITY IN SUPPLY CHAINS: A CASE IN ACTION

Mustafa Altuntaş, Zehra Deniz Turhan

Schindler Türkeli Asansör San. A.Ş., mustafa.altuntas@gmail.com
Industrial Engineering, Istanbul University of Health and Technology,
deniz.turhan@istun.edu.tr

ABSTRACT:

Purpose:
Sustainability in supply chains has increasingly become a central issue to c-level management suites in regional and global companies alike. Players in various industries are employing methods to bring sustainability into practice, rather than another management fad soon to be passe. This case study investigates the implementation of sustainable practices within the supply chain of a leading multinational corporation in urban mobility sector.

Study design/methodology/approach:
A qualitative case study approach was adopted to gain in-depth insights into the company’s sustainable supply chain practices. Data collection involved multiple methods to ensure comprehensive coverage and triangulation, including Semi-Structured Interviews and Document Analysis. Interviews were conducted with key stakeholders across various levels of the supply chain, including executives, supply chain managers, and sustainability officers to capture the perspectives and experiences of those directly involved in sustainability initiatives. In unison, internal company documents, sustainability reports, and supply chain policies were reviewed to understand the strategic frameworks and operational procedures related to sustainability. External documents, such as industry reports and regulatory guidelines, were also examined to contextualize the company’s practices within broader industry trends and requirements.

Findings:
This case study reveals several key insights into the implementation and outcomes of sustainability practices within the supply chain of a leading multinational corporation in the urban mobility industry. Aspects for different stakeholders including the sector at large are captured.

Originality/value:
With an industry-based outlook, the findings of this study contribute to the broader discourse on supply chain sustainability, offering practical insights for practitioners and policymakers aiming to enhance sustainability in supply chain operations.

KEYWORDS
Supply chain sustainability in practice

A LITERATURE REVIEW: SUPPLY CHAIN RISKS ON E-COMMERCE

İdil Şahin, Mehmet Tanyaş

İdil Şahin, Maltepe University, idilsahin91@hotmail.com
Mehmet Tanyaş, Maltepe University, mehmettanyas@gmail.com

ABSTRACT:

Purpose:
This study is a summary review about supply chain risks in e-commerce. Study will contain a literature review about risk management on supply chain especially on e-commerce, and it also aimed to examine the differences with the traditional channel.

Study design/methodology/approach:
General literature study with Web of Science platform and a bibliometric study if available. The aim of this study is to examine bibliometric the studies published in the Web of Service database beginning with early 2000's.

Findings:
The existing sources are being examined in detail.

Originality/value:
The originality and value of this study lie in the fact that there is not enough research study on this topic and area. This study is aims to be a useful resource for those who want to work in this field.

KEYWORDS
E-commerce, Logistics, Risk Management, Supply Chain, Supply Chain Risk Management

EMERGENCIES AND CRISIS LOGISTICS IN THE RED SEA CRISIS

Mert Hazar

Kocaeli University, e-mail: mert.hazar@kocaeli.edu.tr

ABSTRACT:

Purpose:

This study examines how supply chain management and logistics were affected by geopolitical tensions during the Red Sea crisis. It seeks to pinpoint the crucial elements generating delays and interruptions and offers a framework for boosting logistics resilience during emergencies of a similar nature.

Study design/methodology/approach:

This study combines both qualitative data sources in a multifaceted manner. It entails a thorough analysis of the body of research on crisis logistics and geopolitical consequences as well as a review of relevant historical facts pertaining to the Red Sea region. To provide a thorough picture of the crisis's effects on logistical operations, secondary data from government reports, international trade groups, and maritime authorities are also used. The study analyzes big datasets from news stories, trade reports, and social media using machine learning algorithms. This approach captures a variety of viewpoints and new challenges in real-time using sentiment analysis and trend analysis.

Findings:

The study lists a number of significant barriers, such as constrained delivery channels, increased security threats, and erratic demand trends. These elements severely impede logistics processes, which raises expenses and causes delays. The results emphasize the need for strong backup plans and dependable logistics techniques. The study also emphasizes how crucial it is to use cutting-edge forecasting methods and real-time data analytics to anticipate and mitigate the effects of such catastrophes.

Originality/value:

This study provides important light on the logistical difficulties that arise from geopolitical crises, particularly as they relate to the Red Sea. It gives useful suggestions for improving crisis preparedness and response systems for legislators and logistics managers. The study guarantees a thorough and dependable analysis by concentrating on internet-based data collection and modern data analytics.

KEYWORDS

Crisis logistics, Emergencies, Geopolitical Tensions, Red Sea, Supply Chain Management, Resilience

INTRODUCTION

Geopolitical tensions have always faced substantial challenges to global supply chains, the Red Sea crisis is an example of the serious disruptions that these conflicts can bring about [1]. The Red Sea is an essential sea route for international trade, acting as a link between Europe, Asia, and Africa [2]. Any disruption in this area can have a significant impact on the effectiveness and dependability of supply chains all around the world [3]. The weaknesses in global logistics networks, especially those that depend on geopolitical stability for the efficient transportation of products, have thus been brought to light by the Red Sea crisis [4]. In today's globalized economy, the complexity and interconnectedness of supply chains mean that a disruption in one region can easily spread to the entire world [5]. An example of how regional wars and security threats have caused major delays and increased operational costs across numerous businesses is the Red Sea crisis [6]. The necessity of creating robust supply chains that can endure and adjust to these kinds of geopolitical shocks is highlighted by this crisis [1]. Supply networks must be resilient, according to research, especially when dealing with geopolitical threats [3]. In this sense, supply networks' resilience is defined as their capacity to withstand shocks, bounce back swiftly, and continue operating [5]. The Red Sea crisis has brought to light a number of significant obstacles that must be overcome in order to achieve this resilience, such as limited distribution options, increased security threats, and variable demand patterns [2]. These difficulties not only raise expenses but also highlight the flaws in the logistical frameworks that are in place now. [6] In order to examine the particular effects of the Red Sea crisis, this study expands on the research of eminent experts in supply chain management and crisis logistics. [4] It examines massive datasets from news articles, trade reports, and social media using advanced data analytics and machine learning techniques, offering a real-time study of the crisis's effects on logistical operations [5]. This method provides useful insights for improving supply chain resilience by gathering a variety of viewpoints and recognizing new issues [6].

SUPPLY CHAIN RESILIENCE IN THE FACE OF GEOPOLITICAL TENSIONS

Global supply networks can be severely disrupted by geopolitical concerns, which have been repeatedly recognized as important determinants. These dangers, which include wars, unstable political environments, and territorial disputes, have the capacity to seriously damage logistical networks [5]. One well-known example of how political tension and crucial commerce routes can collide to create serious supply chain problems is the Red Sea issue. Supply networks that significantly depend on geopolitical stability [3]. The interdependence of global supply chains makes this vulnerability worse since interruptions in one area can have an immediate effect on operations throughout the world [1].
Additionally, in order to create plans to lessen the risks brought on by geopolitical conflicts, it is crucial to comprehend the factors that contribute to supply chain

vulnerability [7]. The significance of recognizing and mitigating vulnerabilities, particularly in areas that are vital to global trade, is emphasized by the Red Sea crisis. Comprehensive supply chain risk management techniques are essential, especially in the event of geopolitical disruptions [8].

Resilience in supply chains has gained momentum, especially as geopolitical conflicts have become more frequent [6]. A supply chain's resilience is its capacity to withstand shocks, bounce back quickly, and continue operating. The Red Sea crisis exposed a number of important obstacles to reaching this resilience, such as restricted supply linnes and fluctiating demand trends [4]. A framework for global supply chain resiliency was created to highlight the necessity for supply chains to successfully react to disruptions [9].

In addition, the body of literature has been enchanced by other researchers by creating instruments for supply chain resilience assessments [10]. According to their findings, taking proactive steps to improve security and diversify supply routes can help a country become more resilient to geopolitical conflicts. These recommendations are supported by the Red Sea crisis findings, which emphasize the need for strong supply chain policies to control and reduce risks.

THE RED SEA CRISIS AND ITS IMPACT ON SUPPLY CHAINS

The Red Sea region, which is an essential maritime route between Europe, Asia, and Africa, experienced a period of extreme geopolitical stress known as the "Red Sea Crisis." Control over important international commerce routes, especially through the Suez Canal, accounts for the region's importance. Among the most important canals in the world, this canal makes it easier for products to move between Europe and Asia as well as between the Mediterranean and the Red Sea [3]. Any disturbance in this sector can have significant effects on global supply networks due to its strategic relevance.

Because of its advantageous location, the Red Sea has served as a focal point for a number of geopolitical confrontations. Confrontations in the region have involved nations including Yemen, Saudi Arabia, Egypt, and Iran; these conflicts have frequently revolved around control over shipping routes, territorial seas, and wider political influence [10]. As a result of these tensions, there have been several instances of piracy, military blockades, and even attacks on commercial ships, severely disrupting marine activity[11].

(1)Disruption of Shipping Routes

One of the Red Sea crisis's most immediate repercussions was the disruption of shipping routes, especially those that went via the Suez Canal. Due to the situation, a lot of shipping companies had to postpone trips or divert ships around the Cape of Good Hope, which resulted in much longer transit times. Due to the longer trips and increased fuel consumption, this rerouting not only resulted in longer shipping times but also significant cost increases [1]. Global supply chains were negatively impacted by the commodities' transportation delays, especially in sectors where just-in-time inventory systems are crucial [3].

(2)Increased Operational Costs

Insurance rates for ships traveling through the Red Sea increased significantly due to the increased danger of piracy and military conflicts in the area. Furthermore; raising operating expenses, maritime businesses were compelled to adopt more stringent security measures, such hiring armed guards or operating in convoys [4]. Consumer prices climbed and corporate margins shrank as a result of these higher costs being frequently transmitted down the supply chain [9].

(3)Delays in Trade Flows

The interruption of trade flows was one of the crisis's other major effects. Trade around the world was slowed by threats to important marine routes like the Suez Canal. Trade volumes decreased as a result of this interruption, particularly for commodities traveling between Europe and Asia, and bottlenecks were created at several points in the supply chain [3].

(4)Increased Security Risks

The region's increasing military actions and piracy created serious security threats to commercial vessels. To secure the safe passage of products over the Red Sea, this circumstance required the implementation of tighter security procedures, such as convoy systems and advanced tracking technologies [4].

(5)Increased Uncertainty in Global Trade

The interruption of trade was one of the crisis's most significant effects. The Red Sea crisis increased commercial uncertainty worldwide. Businesses found it challenging to plan for long-term trade since important trade routes were constantly under threat. Due to the ongoing uncertainty around the stability of important supply routes, investor confidence was also severely impacted by this uncertainty [9].

(6)Need for Enhanced Supply Chain Resilience:

The crisis brought attention to the weakness of international supply systems and the requirement for increased resilience. Companies realized how critical it was to create supply networks that were more adaptable and durable so they could withstand these kinds of geopolitical shocks. Numerous businesses have strengthened and reevaluated their supply chain strategy in response to this awareness [10].

STRATEGIES TO MITIGATE THE IMPACT OF THE RED SEA CRISIS ON SUPPLY CHAINS

The Red Sea crisis's impacts highlight how crucial it is to have effective plans to lessen how geopolitical tensions affect international supply chains. Several strategies can be used to increase resilience and decrease vulnerabilities;

(1)Diversification of Supply Routes and Sources

Diversifying supply chains and sourcing areas is one of the best ways to lessen the effects of geopolitical disruptions. Businesses can lessen the chance of complete supply chain failures during a crisis by minimizing reliance on a single trading channel, like the Suez Canal. Diversity plays a crucial role in the resilience of supply chains by offering other pathways for commodities to reach their intended destinations. To spread risk, businesses can look at alternate shipping routes, create a variety of sourcing strategies, and set up regional hubs [10].

(2)Investing in Monitoring and Real-Time Data Analytics

Systems for real-time monitoring and advanced data analytics can greatly improve an organization's capacity to react to interruptions. Businesses can swiftly see new risks and modify their plans by investing in technologies that give them real-time visibility into supply chain processes. Real-time data analytics are essential for anticipating possible interruptions and facilitating proactive decision-making [4]. Businesses that used predictive analytics and real-time tracking, for example, were better able to reroute goods and minimize delays during the Red Sea crisis.

(3)Building Strategic Partnerships

Creating strategic alliances with governments, logistics companies, and other interested parties can also lessen the effects of geopolitical tensions. In times of crisis, cooperative partnerships can give businesses access to crucial information and resources. Partnerships can improve supply chain resilience by enabling coordinated responses to shocks [9]. For instance, businesses may cooperate with local government agencies to obtain alternate routes for transportation or with logistics companies to exchange up-to-date information on shipping circumstances.

(4)Enhancing Security Measures

Improving security protocols for maritime activities is crucial, considering the heightened dangers of piracy and armed conflicts in areas such as the Red Sea. This entails putting strong security measures in place, like convoy travel, using armed escorts, and making use of cutting-edge tracking tools. Supply chain resilience depends heavily on security, especially in high-risk sectors. Companies who want to safeguard their assets and guarantee the safe transportation of commodities should make investments in both physical and cyber-security measures [5].

(5)Developing Contingency Plans and Stress Testing

Another essential tactic for controlling the dangers brought on by geopolitical tensions is contingency planning. Businesses should create thorough emergency plans that specify what should be done in case of an emergency. These plans should include backup suppliers, emergency contacts, and alternate routes for supplies. The significance of stress testing is important to these strategies to make sure they function well in a variety of situations [6]. Companies can find gaps in their plans and strengthen overall readiness by regularly conducting exercises and simulations.

(6)Cooperation between the Government and Industry

Lastly, cooperation between the government and business community is essential to building a safe and stable climate for international trade. By guaranteeing safe passage via vital marine routes, mediating disputes, and supporting impacted industries, governments can significantly reduce geopolitical risks. Public-private collaborations can improve supply chain resilience by coordinating the activities of both industries to counter shared vulnerabilities [8].

CONCLUSION

In summary, the Red Sea crisis provides a potent reminder of the weaknesses present in international supply systems, particularly those that rely on stable geopolitical conditions. This theoritical research has demonstrated that whereas short-term tactics can lessen some of the immediate effects, more thorough methods are desperately needed to develop long-term resilience[1]. Subsequent investigations should concentrate on creating increasingly complex models for forecasting and controlling the effects of geopolitical conflicts on supply chains. Furthermore, more research is required to determine how supply chain resilience can be improved by utilizing cutting-edge technologies like machine learning and real-time data analytics [6].

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ASSESMENT OF SUSTAINABILITY RISKS IN DIGITAL SUPPLY CHAINS

Melisa Ozbiltekin-Pala

Research Assistant, Logistics Management, Yaşar University, İzmir, Türkiye,
melisa.ozbiltekin@yasar.edu.tr

ABSTRACT:

Purpose:
Recently, digital supply chain management has become a critical element for the success of organizations. However, the transition to digital systems brings with it various risks in terms of sustainability. These risks include factors such as ethical concerns, natural resource management, customer stakeholder engagement etc., which affect the efficiency and resilience of supply chains. In order to manage these risks effectively, risks must be prioritized and evaluated quantitatively with a systematic approach. Therefore, the aim of this study is to identify, prioritize and evaluate sustainability risks in digital supply chains.

Study design/methodology/approach:
After the sustainability risks that may be encountered in digital supply chains are determined by literature review, the SWARA method is applied based on expert opinions to determine and rank the weights of the identified risks.

Findings:
The study is expected to provide a ranked list of sustainability risks in digital supply chains. The findings aim to offer insights into how companies can improve their supply chain resilience and sustainability by addressing the highest-priority risks.

Originality/value:
The originality of the study lies in the application of the SWARA method to assess sustainability risks in digital supply chains. While most studies address the issues of sustainability or digital supply chains separately, this research combines both areas with a quantitative risk assessment approach. It provides an innovative framework to help organizations proactively manage sustainability risks by systematically assessing and ranking risks.

KEYWORDS
List about four (maximum of six), key words or phrases in alphabetical order, separated by commas.

THE VEHICLE ROUTING PROBLEM WITH TIME WINDOWS FOR A GROCERY MARKET

Sonya Javadi, Muhammet Murat Uzun

Işık University 1, sonya.javadi@isikun.edu.tr
Işık University 2, 21INDE1009@isik.edu.tr

ABSTRACT:

Purpose:
The purpose of this study is to develop and evaluate optimization methods for solving the Vehicle Routing Problem with Time Windows (VRPTW) for FreshCart's online grocery delivery operations. The goal is to create an efficient routing plan that minimizes total operational costs, including travel distance and vehicle usage, while satisfying the capacity constraints and delivery time windows. This study aims to enhance delivery efficiency and customer satisfaction, providing recommendations to improve FreshCart's logistical performance for cost-effective delivery.

Study design/methodology/approach:
To solve the VRPTW problem for FreshCart's grocery market, a hybrid optimization approach was considered. This approach balances exploration and precision, addressing the VRPTW's complexity to ensure timely deliveries and minimize operational costs, thereby optimizing FreshCart's delivery operations.

Findings:
For the analysis, we used a benchmark dataset with customer locations, demands, and time windows. The proposed hybrid optimization approach was evaluated based on total travel cost, number of vehicles used, and computational time. The results showed significant improvements in cost and vehicle usage compared to baseline heuristic methods, validating the solution's effectiveness.

Originality/value:
This study's approach significantly improves operational costs and vehicle usage, providing valuable insights and a scalable model for optimizing delivery operations in the grocery market.

KEYWORDS
Online Grocery Market, Optimization, Transportation, VRPTW.

CIRCULAR SUPPLY CHAIN AND FAST FASHION: A REVIEW OF OPPORTUNITIES AND CHALLENGES

Abdelmounaim Aggour, Raja Elboq

EST, Ibn Zohr University, Morocco, a.aggour@uiz.ac.ma
ÉSITH, Morocco, elboq@esith.ac.ma

ABSTRACT:

Purpose:
This paper aims to critically analyze and synthesize existing literature on circular supply chain (CSC) in the fast fashion industry to identify the opportunities and challenges associated with implementing a circular supply chain model. This study aims to provide the potential benefits of CSC for fast fashion companies, as well as the challenges that must be overcome to successfully implement CSC practices.

Study design/methodology/approach:
A systematic literature review was adopted, which involved establishing a keyword search to identify and filter relevant papers. The content of these papers was then analyzed, with a focus on identifying key contributions related to circular supply chains and fast fashion.

Findings:
The review reveals that existing research on CSC in the fast fashion industry is predominantly descriptive and empirical studies are lacking, which highlights the need for more empirical research to understand the effectiveness and impact of CSC practices.

Originality/value:
The originality of this review lies in its comprehensive analysis of the literature on CSC in the fast fashion industry, and its identification of the need for more empirical studies to advance the understanding of CSC implementation in fast fashion companies.

KEYWORDS
Circular economy, Circular supply chain, Closed-loop supply chain, Fast fashion

SUPPLY CHAIN RISK MANAGEMENT: A LITERATURE REVIEW AND FUTURE RESEARCH DIRECTION

Pelin Kemaloglu, A. Serdar Tasan

Dokuz Eylul University, kemaloglu.pelin@ogr.deu.edu.tr, serdar.tasan@deu.edu.tr

ABSTRACT:

Purpose:
The purpose of this study is to review the existing literature on Supply Chain Risk Management (SCRM) to identify supply chain risk factors and highlight future research directions, with a focus on the increasing use of artificial intelligence (AI) techniques.

Study design/methodology/approach:
This study employs a comprehensive literature review to analyze current methodologies in SCRM. It focuses on the transition from traditional qualitative methods, such as operational modeling and case studies, to advanced data-driven approaches. Special emphasis is placed on the role of AI and machine learning (ML) in identifying supply chain risk factors and enhancing risk management strategies.

Findings:
The review reveals that traditional qualitative methods face limitations due to their sample sizes, whereas data-driven techniques are gaining prominence. The increasing availability of data and computational power has facilitated the adoption of AI and ML in SCRM, leading to more accurate identification of supply chain risk factors. This shift has enabled the development of proactive and predictive risk management strategies, highlighting the transformative potential of AI in providing enhanced visibility and decision-making capabilities.

Originality/value:
This study provides a comprehensive overview of the current state of SCRM literature and underscores the transformative impact of AI and ML. By identifying the limitations of traditional methods and showcasing the benefits of data-driven approaches, it offers valuable insights for both academics and practitioners in the field of supply chain management. The study also emphasizes the crucial role of AI techniques in the identification of supply chain risk factors.

KEYWORDS
Data-driven decision making, Risk management, Supply chain risk management

ENVIRONMENTAL AND SOCIAL SUSTAINABILITY PERFORMANCE OF GREEN SUPPLY CHAINS

Funda Sinem Konuk
fskocak@atu.edu.tr

ABSTRACT:

Purpose:
Businesses are under pressure to adopt sustainability practices to reduce their negative effects on the environment and operations from society, customers, and governments. Companies that are seen as the source of environmental problems have had to review their supply chains, and the field of environmental issues in supply chain management has also grown significantly. The concept of green supply chain management (GSCM) is integrating environmental thinking into supply chain management. As such, GSCM plays a significant role in determining sustainability performance. This study aims to investigate the role of GSCM activities on environmental and social sustainability performance in transportation and warehouse companies.

Study design/methodology/approach:
The main motivation behind the research is the assessment of sustainability performance using multi-criteria decision-making methods (MCDM). For this purpose, data of Turkish transportation and warehouse companies with green supply chains was drawn from the ESG (environmental, social and government) database of the Thomson Reuters Eikon which the world's largest environmental, social and governance rating database. The data were analyzed via the MAIRCA method.

Findings:
The data were analyzed via the MAIRCA method. Based on the findings, THY (0,98) has the best performance in terms of environmental and social sustainability. Setair (1,00) was the second-best performing transportation company.

Originality/value:
This study extends the practical application of the relationship between sustainability and green supply chain management, substantially contributing to existing knowledge.

KEYWORDS
Green supply chain management, MCDM, sustainability

A DECISION-MAKING APPROACH TO ESTABLISH A SUSTAINABLE-CIRCULAR WASTE MANAGEMENT SYSTEM: A CASE STUDY OF ISTINYE UNIVERSITY

Erfan Babaee Tirkolaee, Alper Bora Koçak

Istinye University, erfan.babaee@istinye.edu.tr, alperkocak0@outlook.com

ABSTRACT:

Purpose:
The purpose of this study is to develop a decision-making approach for designing a sustainable and circular waste management system at Istinye University. This approach aims to integrate sustainability and circular economy principles to minimize waste generation and enhance resource efficiency.

Study design/methodology/approach:
The study adopts a mixed-methods approach, combining both qualitative and quantitative methods. Data was collected through a comprehensive review of existing waste management practices at Istinye University, interviews with stakeholders, and analysis of waste streams. The decision-making process was supported by multi-criteria decision analysis (MCDA) to evaluate various sustainable waste management strategies.

Findings:
The findings reveal that the proposed waste management system significantly reduces waste generation and increases recycling rates. Key performance indicators show improvements in environmental impact, cost efficiency, and stakeholder engagement. The system also highlights the importance of integrating advanced technologies for monitoring and optimization.

Originality/value:
This research provides a novel approach by integrating decision-making techniques with circular economy principles specifically tailored for waste management in a university setting. The study's value lies in its practical application to Istinye University, offering a replicable framework for other institutions seeking to enhance their sustainability efforts through a comprehensive waste management system that aligns with both environmental and economic objectives.

KEYWORDS
Decision-making, sustainable-circular, waste management

INTRODUCTION

1.1.Objectives and Questions

A sustainable, circular waste management system is one that is designed to minimize waste and maximize resource recovery. This type of system typically includes a waste reduction hierarchy that prioritizes waste prevention, followed by reuse, recycling, and finally, disposal. Waste prevention strategies seek to avoid the generation of waste in the first place. This can be accomplished through source reduction, which involves reducing the amount of materials used or purchased, or through product redesign, which involves making products that are easier to reuse, repair, or recycle. Reuse strategies aim to extend the life of products and materials by finding new ways to use them. This can be done by repairing or refurbishing products, or by using them for a different purpose than they were originally intended. Recycling strategies aim to turn waste into new products or materials. This can be done by breaking down materials into their component parts and then using those parts to create new products, or by using waste as a fuel source to generate energy. Disposal strategies aim to safely and responsibly get rid of waste that cannot be prevented, reused, or recycled. This can be done by incinerating waste to generate energy, or by sending it to a landfill. A well-designed waste management system will take into account the unique needs and resources of the community it serves. It will also be flexible, so that it can adapt as the community's needs change over time. This paper will utilize a Decision-Making Approach to Design a Sustainable- Circular Waste Management System using the Case Study of Istinye University.

The term "circular economy" (abbreviated "CE") was coined in 2010 as a "overall idea" with the goal of developing a more resource-efficient economic structure. It aims to close material and energy loops in production processes, making them more sustainable. As per Sauvé et al., a number of scholars envisioned the CE as a key instrument in achieving sustainable development. This is why governments, investors, businesses, and the public all show increasing enthusiasm for its advocacy. There is little to no impact on the economy or the environment from this passion. Systems that adopt circular ideas, promote circularity, or are themselves part of the circular economy may not always be the most environmentally friendly option. There are financial and ecological costs associated with the procedures needed to reintroduce previously used and/or recyclable materials in accordance with the CE principle. Others see the direct connection between CE and sustainable development and see it as an important part of CE's mission. Some writers go farther, arguing that CE is a precondition notion for sustainability that necessitates a shift in value creation, conceptualization, and model creation in business and management. As an alternative to the necessary transition to a new development model, related to strategies for developing sustainable business models, the suggestion of circular integration of the activities of smart manufacturing may be the best option.

However, the interaction between CE and the economy, society, and the natural environment is still complicated, and the impact of CE on environmental sustainability is not yet thoroughly demonstrated (despite Moraga et alargument's to the contrary). However, the circularity of materials, components, and finished goods is defined and identified by the CE via the waste management procedures of waste avoidance, reuse readiness, recycling, other recovery, and disposal/landfill. Even though one of CE's weaknesses is that it fails to take into account non-material flows, Elia et al. and Geng et al. argue that the usage of renewable energy, water, and land should be included into any evaluation of CE. Indicators that can track the CE's development are needed for its implementation. To efficiently manage waste created, it is necessary to implement new systems that categorize, divert, or experiment in the reduction of waste, even if the CE is mainly concerned with the architecture and circularization processes of open or conventional production lines.

Since CE is expected to herald in a new age of economic initiatives and programmers, it will stimulate the regeneration of current development networks by forcing changes in the way they approach design and manufacturing, it is imperative that all industrial processes be evaluated with a long-term perspective and incorporated with CE. More than €600 million in cost savings may be realized by European businesses via eco-design, prevention, and reuse. In light of this, it has been recommended to conduct research on the ecological effects of the waste-management procedures used by the enterprises that make up the Collective System of Extended Producer Responsibility System (hereinafter, CPR).

As means to this end, we have settled on the carbon footprint (hereafter, CF) as a sustainability indicator due to its close association with life cycle thinking, widespread adoption by businesses, availability of standardized methods for measurement, and presence in public records for recording results. The regulatory board also wants them to be minimally vetted. GHG emissions from these operations may be calculated using this indicator, but so can the source, nature, biodegradable nature (if relevant), and utilization of the energy supplies employed in these procedures, all of which are crucial to the notion of CE for environmental sustainability. By calculating CF, an environmental sustainability measure that take into account non-material flows of waste circularization, we may learn how sustainable the EC's waste management operations are.

The overarching goal of this effort is to demonstrate the interdependence and importance of eco-design and waste management. The former reduces trash production, whereas the latter promotes economic recirculation. To demonstrate the necessity for further in-depth study, we use the carbon footprint as a sustainability indicator to critically analyze the structure and results of an existing CPR. The subject of "how much emissions a CPR creates to complete the loop of existing Extended Producer Responsibility Systems (EPR) from present goals of CE?" is investigated on this basis.

The following are the necessary measures to achieve the aforementioned goals: First, a consideration of how the CE framework may be applied to waste management systems for extended product producers; second, a decision of whether or not these systems can be maintained in the long run-in terms of carbon footprint (CF). To do so, we shall use the SBA model, an activity-based sustainability management framework. For the purpose of investigating the ecological consequences generated by CPRs in their own tire waste management process, CPRs of particular interest are those that have estimated their environmental impact in a transparent way by implementing the ISO 14064-1 and ISO 14069 benchmarks for the establishment of current assets and categorization of GHG emissions.

1.2.Questions

What kind of MCDM method can be the most applicable one in our case?
How can we validate the efficiency of MCDM method?
How can we gather the required information?
Who are the experts in our case?
Are the adverse effects of improper waste management very detrimental to human health?
What is the extent of improper waste pollution in the university without the intervention of sustainable circular waste management system?
What are the available interventions to improve waste management within the university?
Is sustainable circular waste management system the answer to improper waste management in the university?

1.3.Contributions

The difference of our paper from other papers is that this paper is focused on a specific environment and population that is the ISU. Consequently, it proposes a particular solution to the improper waste management menace within the university which is expected to be implemented on approval of the research.
Next, we perform a literature review of CE models, waste disposal, and cooperation systems of product stewardship (CPR), focusing on ELT and its impact on climate change and environmental sustainability via the lens of carbon footprint. The third section elaborates on the SBA paradigm, often known as activity-based sustainable management and how it is used to assess the climate-change-related viability of a CPR's approach to dealing with used tires. The study paper's findings and suggestions for the future are revealed towards the end.
Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) came in the 1980s as a multi-criteria-based decision-making method. TOPSIS chooses the alternative of shortest the Euclidean distance from the ideal solution and greatest distance from the negative ideal solution. In our paper, we will be discussing by analyzing İstinye University on basis of sustainability, circularity, and some other factors. We will define the weights and impacts with this method.

AHP is a method for organizing and analyzing complex decisions, using math and psychology. The popularity of AHP stems from its simplicity, flexibility, intuitive appeal, and ability to mix quantitative and qualitative criteria in the same decision framework. Based on our criterias we assign weights with respect to our objectives which we mentioned previously. For the further steps, we assess the relative value or priority of each decision criterion, calculate the weights of the criteria and priorities and analyze consistency.

1.4.Structure of the Research

This report will be organized into small sections with the intention of making it well presented and understandable. Section 2 represents the literature in order to find the works that have done in waste management with the help of sustainability and circularity. Section 3 describes the propose methodology of research which includes AHP and TOPSIS. Section 4 reviews the progress report to examine what we did search for and what we achieved so far.

LITERATURE REVIEW

Korhonen et al. (2015) propose the CE within this framework, defining it as "a sustainable development effort with the objective of reducing the social systems of production-consumption of materials and energy of linear performance through the deployment of circular, renewable materials and cascading energy flows." Together with traditional recycling and the development of innovative systems aimed at fostering cooperation among manufacturers, shoppers, and other social players in the name of sustainable development, the circular economy promotes the use of high-value circular materials.

Circular integration (CI), a concept introduced by Walmsley et al. (2019) for the development of eco-friendly systems, fits in this vein. The goal of CI is to optimize overall sustainability via a systemic approach to creating circular systems in which designs, operations, and maintenance of each subsystem span numerous scales and dimensions. The ability to consider the impact of a product or service on the environment from its initial creation to its final disposal is an example of life cycle thinking.

Despite the promise of CE, Korhonen et al. (2015) found six barriers to its widespread use. There are six types of limits: (1) those imposed by thermodynamics; (2) those imposed by the system's space and time; constraints imposed by management and administration, those enforced by cultural and societal conceptions, and those imposed by the physical size of the economy. Resource cycle, sustainable sources, and downstream energy flow-based manufacturing and consumption systems are impacted by the aforementioned elements. It's possible that similar expenses would arise if additional linear characteristics were converted to circular ones. CE should serve as a model for sustainable development, it has the same limitations and challenges as conventional economic theory, including issues with growth and equity.

Charisios et al. (2013) referred to the use of Multi-Criteria Decision Analysis (MCDA) to tackle waste management problems. In their paper, they showed that there are many factors and influences – often mutually conflicting – criteria for finding solutions in real-life applications by presenting a review of the literature on multi-criteria decision aiding in waste management problems for all reported waste streams. They used MCDA and Analytic Hierarchy Process (AHP) techniques and documented them in graphs. The registration of applied methods provides the ability for a decision-maker to check the consistency and increase the reliability of each waste management alternative's result. I am thankful for how they conduct their tools effectively.

Soltani et al. (2015) presented a few previous studies on the use of MCDA for solving MSWM problems with more consideration of the studies that presented multiple stakeholders that get involved in the process of finding suitable waste management or strategies. The outcomes that they reached were that AHP was the most used method regarding multiple stakeholders, experts, and governments being the most common participant in these studies.

Jovanovic et al. (2016) used MCDM for the selection of the best strategy for municipal solid waste management: This paper presents the procedure for selecting the most suitable Municipal Solid Waste Management System (MSW) for the region of Kragujevac city (Republic of Serbia) based on the MCDM method. Compare proposed Waste Management Strategies (WMS) using his two methods of Multi-Attribute Decision-Making (MADM): SAW (simple additive weighting) and TOPSIS (sequence priority by similarity to ideal solution). Each strategy created was simulated with the software package IWM2. The proposed strategies were then laid out in the form of tables and charts obtained based on both MCDM methods.

Goulart et al. (2017) MCDM to support waste management: A critical review of current practices and methods Waste management is a complex area with several dimensions interacting to assist researchers and decision-makers, the purpose of this article is to present a literature review on MCDM applications used in waste management, supply a critical assessment of current practices, and it is to offer suggestions for future work. First, they briefly outlined the basic concepts on this topic, followed by an analysis of 260 articles related to the application of MCDM in waste management According to the articles analyzed, research using MCDM in solid waste management targets municipal solid waste-related issues related to facility location or management strategies.

Coban et al. (2018) showed 8 solid waste dumping alternatives rated by 7 criteria with the implementation of TOPSIS, Preference Ranking Organization Method for Enrichment Evaluations (PROMETHEE) I and PROMETHEE II. The findings highlight the importance of recycling and landfill technologies for developing countries. Aung et al. (2019) showed that the application of multi-criteria decision-making method to analyze the medical management system Mynamar Healthcare services inevitably generate medical waste that can become hazardous to public health and the environment. Their study developed a new framework for evaluating the management of medical waste based on the world health organization (WHO) guidelines on the safe management of waste from medical activities. MCDM was used to model the endpoint framework for hospital waste management.

Garcia-Bernabeu et al. (2020) developed a Circular Economy Composite indicator to benchmark EU countries' performance because the monitoring framework in the Circular Economy Action Plan lacked it. They used a multi-criteria approach to create a composite circular economy index based on the TOPSIS methodology. In addition, they demonstrated a new aggregation method to construct a composite metric, considering different levels of compensability of the distances to the ideal and anti-ideal (or negative ideal) values of each metric.

Pamučar et al. (2021) talked about the importance of HCW management and offered a novel integrated multicriteria decision-making model based on D numbers for processing fuzzy linguistic information. The purpose of the model was to aid the management in the public project 'Zdravstvo Brčko.' The outcome of this study was that the A1 alternative provided the most optimal outcome, and A5 provided the worst outcome. Aminsharei et al. (2022) showed an implementation of two different MCDM methods, AHP and TOPSIS, to rank three basins, and it resulted in sub-basin 3 being the best.

Garcia (2022) referred to the topic of Using MCDM to perfect solid waste management. MCDM is surrounded by several types of methods that support the multiple criteria of decision-making. It is one of the most sustainable solutions to manage solid waste and the most relevant MCDM methodologies. Alao et al. (2022) chose the best waste-to-energy (WTE) technology with respect to a subjective view of a decision maker and objective rating of the real-life result of each option. By using a new hybrid MCDM model that is applied to 4 alternatives with 14 sub-factors, they produced a result for the most sustainable WTE technologies as the order below: digestion $\succ$ gasification $\succ$ pyrolysis $\succ$ incineration.

Zhao et al. (2022) worked on measuring zero waste city performance of a coal resource with the MCDM approach. Their study proposed a practical integrated MCDM approach to assess the performance of the ZW city and applied the approach to a typical coal resource-based province in China. The performance levels increased during the study period. As a result, the study uses the natural breakpoint method to classify the evaluation results, which are divided into four levels: high, medium, low, and extremely low. In conclusion, they reduce solid waste production at source and improve the utilization rate of industrial solid waste resources.

Thanh (2022) presented a fuzzy MCDM model for a solid-waste-to-energy plant location in Vietnam. By using the AHP model they identified potential landfill sites as the main finding. The Fuzzy Analytic Hierarchy Process (FAHP) technique is also utilized to analyze the relative weight of the primary and secondary evaluation elements. As a result, Hai Phongwas found to be the optimal location to build a solid-waste-to-energy plant. The work might be expanded to the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) model though.

Recently, Seker (2022) talked about IoT-based sustainable smart waste management system evaluation using the MCDM model under interval-valued q-rung ortho pair fuzzy environment waste management technologies, Information and Communication Technology (ICT), and Internet of Things (IoT) play a key role in the field of municipal waste management in terms of sustainability aspects such as business, economic, social, and environmental.

Considering future development and environmental sustainability, choosing the most proper smart technology to manage waste collection can have a lasting impact. This paper aims to evaluate IoT-based smart waste collection systems based on uncertain parameters by applying modified entropy measurement and MCDM. Table 1 represents the summary of the available literature on waste management, circular economy and sustainable waste management systems.

Methodology

This study tried to establish a circular waste management system in the university campus using different waste management interventions. Date from the staff members will be collected using online survey form. 4 different aspects/ criteria for the proposed or included interventions were considered in this study, namely environmental, social, economic, and technical aspects. The gather data will be analyzed using Multi Criteria Decision Method (MCDM), particularly through Analytical Hierarchy Process (AHP) and Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS).

3.1.Selection Criteria for Proposed Alternatives

3.1.1.Environmental aspects

These aspects incorporated the extent upto which different proposed interventions will be affected by the anthropogenic activities. These aspects are highly important to be included in the analysis as they have a direct relationship with public health protection, reduce natural resources depletion, and ensure sustainable development. The important criteria considered for accounting the environmental impacts include:

- Resources-energy requirements /abiotic depletion
- Land use
- Water pollution
- Air pollution

3.1.2.Economic aspects

Similarly, the economic impacts are associated closely with the costs and benefits required for adopting any proposed or considered waste management intervention. 4 major criteria considered for evaluating the economic impacts of the proposed/ considered interventions include:

- CAPEX
- OPEX
- Revenues

- Resource recovery

3.1.3.Social aspects

The socio-cultural impacts are also important for improvisation of working environments, profits and access to social resources. 5 main criteria considered for assessing the socio cultural impacts include:

- Public health
- Job creation/employment
- Acceptance
- Implementation
- Adoptability

3.1.4.Technical aspects

Technical impacts are related to the level and ability of technology applied during the process of treatment. 5 main criteria considered in technical impacts include the following:

- Adaptability to existing systems
- Machine/equipment
- Time to complete the process
- Local labor
- Handling capacity

3.2.Circular Waste Management Interventions

The possible solid waste management interventions include any of the following:

- Composting of Organic and Paper Waste
- Crushing of Plastic Waste and Selling it to Recyclers
- Landfilling the Plastic Waste (Single Use)
- Selling the Glass

3.3.Analysis Techniques

AHP and TOPSIS methods will be used for the assessment of collected data and recommend the most suitable option for circular waste management at the campus.

3.3.1.AHP Method

Brief detail of the steps carried out under AHP process are explained below:

Step-I: Define the Problem and Criteria.

Step-II: Develop a hierarchy of criteria. The criteria are broken down into smaller, more manageable parts and organized into a hierarchy. The top-level of the hierarchy represents the overall while the lower-level criteria represent the factors that contribute to achieving that objective.

Step-III: Define pairwise comparison matrices for each level of the hierarchy. Pairwise comparison matrices are used to determine the relative importance of each criterion in relation to the other criteria at the same level. The comparison matrix entries are made on a scale ranging from 1 to 7, where 1 represents equal importance, and 7 represents extremely important.
Step-IV: The criteria weights are calculated using the AHP approach. This involves calculating the geometric mean of each row in the matrix and normalizing the results to obtain the weight vector for each level of the hierarchy.

3.3.2.TOPSIS Method

TOPSIS stands for the Technique for order preference by Similarity to ideal solution, a decision maker has two select the best option out of various attributes ad options, following are the steps involves in the TOPSIS method:
Step-I: Convert the linguistic terms in numeral values scale. Make sure that all the attributes are either monotonically increasing or decreasing.
Step-II: Do vector normalization (Euclidean) is used for all criteria. (i.e., for benefit and cost same formula used), it can be represented as:

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} \quad (x_{ij})^2}}$$

Step-III: A scale of relative importance, according to Saaty (1990), was established for the intensity importance.

Intensity of Importance	Definition
1	Equal Importance
3	Moderate Importance
5	Strong Import
7	Very strong Importance
9	Extreme Importance
2,4,6,8	Intermediate values
1/3, 1/5, 1/7,…..	Values for inverse comparison

Step-IV: After assigning the numeric values we plot the matrix of all the criteria across the criteria that we called it as Pairwise Comparative Matrix to obtain a Normalized Pairwise Comparison Matrix.
Step-V: The average of each row calculated is considered as the weight.
Step-VI: Check the consistency of the weight obtained or not without normalization and take the weighted sum of each criteria.
Step-VII: Calculate the Lambda which is the weighted sum of value/ respective weight.
Step-IX: Calculate the average of lambda.
Step-X: Check the consistency-by-consistency index= (Lambda max – n)/ n-1
Where n is number of criteria.

Step-XI: Calculate the Random Index (Standard Values)

N	1	2	3	4	5	6	7	8	9
RI	0	0	.58	.90	1.12	1.24	1.32	1.41	1.45

Consistency Ratio = CI/ RI
If the CR value is less than 0.10 then weights are acceptable else re-evaluated the pairwise comparison
Step-XII: Now Determined the weighted normalized decision matrix (V)
Vij = wj rij
Step-XIII: Calculation for the Ideal best and Ideal worst from matrices. Ideal best means the lowest in terms of cost attribute while Ideal worst will be the scenario that cost high most value.
Step-XIV: Calculate the Separation measure for each row:
Ideal Separation: $Si = \sqrt{\sum_{j=1}^{n} \quad (v_{ij} - v_j)^2}$
Step-XV: Calculate the relative closeness to the ideal solution.

$$c_i = \frac{\underline{s_i}}{s_i + \underline{s_i}}$$

Step-XVI: Rank the options.
3.4.Model implementation
For off all, AHP method will be implemented to ensure the weightage of any of the selected decision criteria, i.e., environmental, social, technical, or economical. Based on its outcomes, TOPSIS method will be applied for determining the preference order among various technologies being considered under this study.

RESULTS

4.1.Participants' Details

The data was collected through online questionnaire. The participants were university members, staff individuals and students. Responses received from them revealed that the questionnaire was primarily answered by the students from different departments in the university, sharing an overall percentage of 89.5%. Most of them Contrary to it 10.5% of the responses were received from the academic members (mainly from lecturers). However, none of the response was received from staff members. This information is briefly described in the form of pie chart in Figure 3.

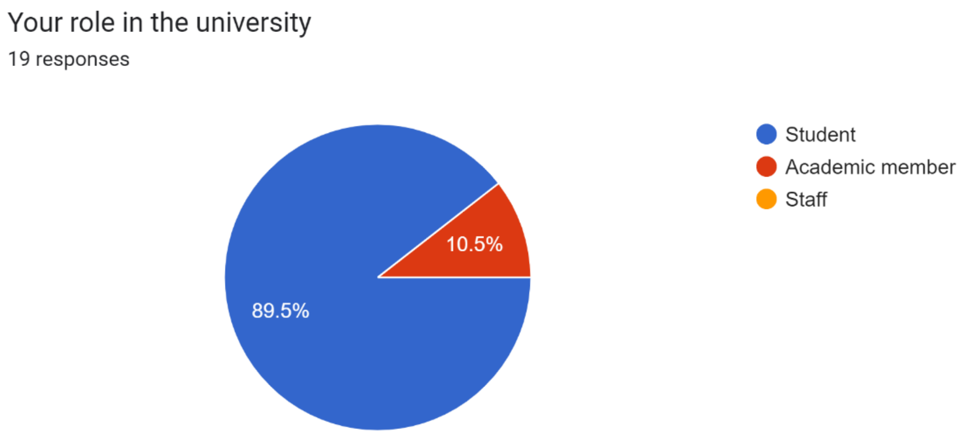


Figure 3. Statistics of Survey Participants.

4.1.1.Participants' Gender

Considering the gender variation among the participants who answered the survey, 68.4% of the respondents were male while 31.6% were females. Figure 4 represents this information in
the form of pie chart. Among all of the respondents, 52.6% reported that they had been visiting or working in the campus for 2 to 4 years, 5.3% for over 4 years, and 42.1% respondents are
working or visiting the campus for less than 2 years.

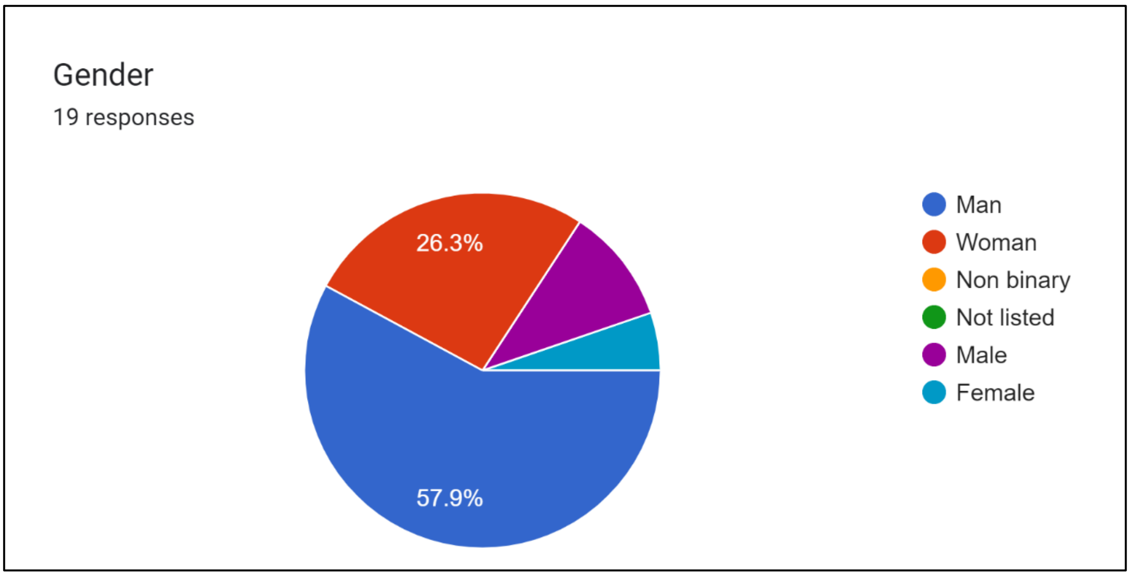


Figure 4. Gender Representation of Respondents.

When the respondents were asked about the extent of circularity of the waste management system existing inside the campus, 73.7% of them reported that it is circular whereas 26.3% of the participants did not think that the existing waste management system in the university campus is circular. Although 3 bins system is available and practiced upto some extent but most of the times, generated solid waste is collected and disposed off in the dumpsite.

4.2.Waste Management Options

Different options were provided in the questionnaire and responses were requested. As a result, highest percentage of respondents (47.4%) supported that all the provided options must be considered for bringing the circularity in the existing waste management system in the university. 42.1% respondents were of the view that selling of reusable wastes such as glass can address this issue. 26.3% respondents preferred composting for bringing circularity in the existing waste management system in the university whereas only 5.3% of them supported the concept of collecting and disposing off the waste in the landfill site as shown in Figure 5.

4.3.Important Criteria
Four important decision criteria considered include environmental, technical, social, and economical criteria. 73.7% of the respondents said that environmental criteria is most important, whereas 10.5% preferred technical, 10.5% preferred social, and 5.3% preferred economical criteria. Figure 6 explains this information briefly.

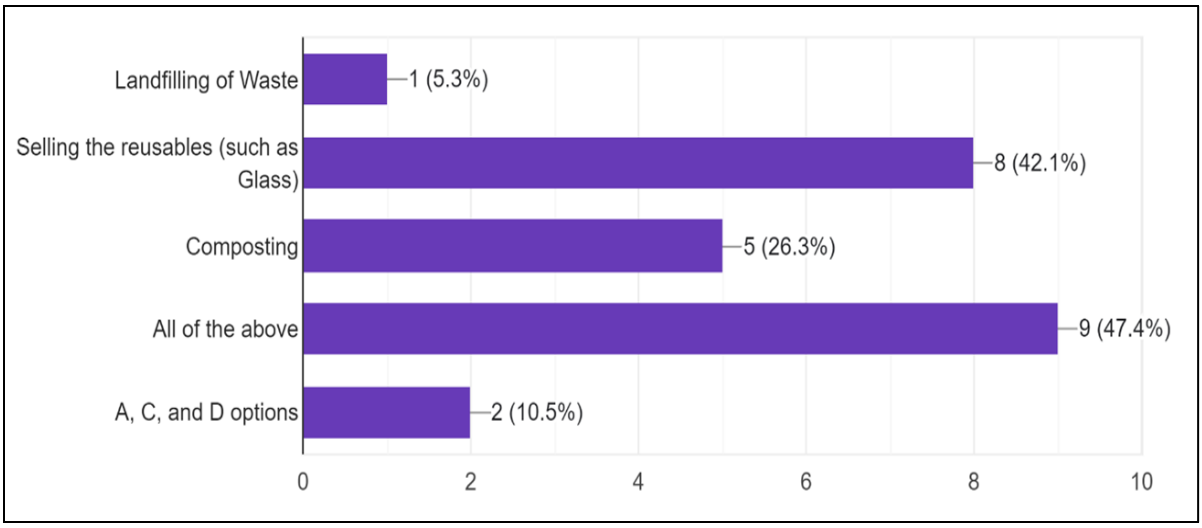
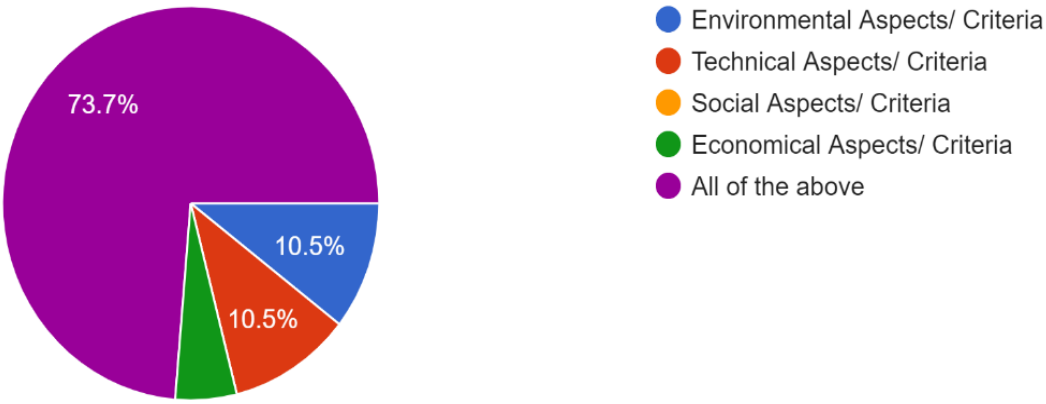


Figure 5. Alternatives for Bringing Circularity in Waste Management System in Campus.



4.4.AHP Analysis

According to the data collected from the participants, AHP analysis was carried out for estimating the weightage of 4 considered criteria (Environmental, Economical, Technological, and Social) was identified. the pairwise matrix prepared using the collected data is shown in the Table 2.

Table 2. Pairwise Matrix.

Pairwise Comparison Matrix				
	Economic	Environment	Technology	Social
Economic	1	0.14	1	7
Environment	7	1	5	9
Technology	1.00	0.20	1	5
Social	0.14	0.11	0.20	1
Sum	9.1	1.45	7.2	22

Based on this pairwise matrix, a normalized matric was developed as shown in Table 3.

Table 3. Normalized Pairwise Comparison Matrix.

Normalized Pairwise Comparison Matrix					
	Economic	Environment	Technology	Social	Criteria Weights
Economic	0.1	0.10	0.139	0.32	0.17
Environment	0.8	0.69	0.69	0.41	0.64
Technology	0.109	0.14	0.14	0.23	0.15
Social	0.016	0.08	0.03	0.045	0.04
Sum	1	1	1	1	

Based on the normalized pairwise matrix prepared, consistency of the collected information and compiled results were assessed as provided in Table 4.

Table 4. Consistency Estimation Table.

Estimating the Consistency							
	Econ.	Environ.	Tech.	Social	Weighted Sum	Criteria Weights	Ratio
Weight	0.17	0.64	0.15	0.04			
Econ.	0.2	0.09	0.15	0.29	0.70	0.17	4.2
Environ.	1.2	0.64	0.77	0.37	2.94	0.64	4.6
Techn.	0.17	0.13	0.15	0.21	0.65	0.15	4.3
Social	0.02	0.07	0.03	0.04	0.17	0.04	4.0
Sum	1.5	0.93	1.10	0.91			

Since the consistency index of this data came out to be equal to 10% therefore, these results are acceptable and can be used for running the TOPSIS. Hence, the calculated percentage weightage of each of these criteria is given in the form of Table 5.

Table 5. Criteria Weight Identification.

Sr. #	Criteria	Estimated Weightage
1	Economic	22%
2	Environment	60%
3	Technology	13%
4	Social	5%

Table 6. Ranks of Considered Alternatives.

Alternative	Relative Closeness to Ideal Solution
Composting	0.956685942
Landfilling	0.168177577
Selling recyclables	0.043314058

DISCUSSION

Sustainable development is one of the hot topics being discussed all acrosss the globe. Countries are striving hard to limit the negative environmental impacts posed by the industrial production. Waste generation and management is also associated closely with the achievement of sustainable development. Waste generated by the industries and residencial areas is properly managed and treated in developed countries. The concept of circular economy through waste management is becoming more and more important for them. Significant financial resources are being spent on redesigning the linear business models in these countries so that the negative environmental impacts could be minimized.

Particularly in the field of solid waste management and treatment, several treatment technologies have been developed such as pyrolysis (wet and dry), hydrothermal carbonization, incineration, composting (conventional, vermicompoting), RDF manufacturing and reycling and reusing the waste items. İn this study, several waste management alternatives have been considered against different criteria. According to the results obtained, participants highly preferred environmental criteria over other types, i.e., social, technological, and economical. After applying the AHP process, it was found that the composting is best technology for treating the waste on-campus. This finding is also in accordance with the outcomes received after applying AHP-TOPSIS together. In addition to the applied methods, this finding is also in-line with the findings published in the literature.

Conclusion

This study evaluated 3 alternatives for managing the solid waste generated inside the university campus. AHP method (alone) and AHP-TOPSIS approaches were used for obtaining the results. The total number of survey participants provided their feedbacks were 19. The results have clearly depicted that the best method to be adopted is the composting of waste. This will enable the administration to tackle 50 to 55% of the waste produced. The second most preferred option is of selling the recyclable materials found in the waste stream. Landfilling of waste was least preferred option according to the participants. It is due to the associated environmental impacts with this type of waste disposal method.

Adoption of first or second alternative will result in decreasing the waste quantities and will simultaneously assist in improving the recycling rate in the city. Better results could be achieved if both the alternatives will be adopted at the same time. In addition to these advantages, the campus can set an excellent example for the citizens to practice the same techniques for tackling waste related problems in their homes or in their communities where they live.

However, the number of participants were very limited in this study. Better results could be obtained if the number of participants can be increased further in future. In addition, this study only emphasized on finding the best practice for managing the waste or ranking the best alternative among the three considered. Future studies could be carried out on developing the implementation plan or designing a comprehensive solid waste management plan for the university campus. Another avenue for future research is to carry out the techno-economic comparison study which could also cover the financial aspects associated with these waste management techniques. Use of other MCDM techniques is also another aspect available for conducting the future research.

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RELIABILITY ANALYSIS OF NEEDLE LIFE IN TEXTILE MACHINES

Sümeyra Gülbahar, Selda Kapan Ulusoy, Mithat Zeydan

Department of Industrial Engineering, Erciyes University, Kayseri, Turkey, sumeyra-kay1616@hotmail.com

Department of Industrial Engineering, Erciyes University, Kayseri, Turkey, skapan@erciyes.edu.tr

Department of Industrial Engineering, Istanbul Medeniyet University, Istanbul, Turkey, mithat.zeydan@medeniyet.edu.tr

ABSTRACT:

Purpose:
In the textile industry, the effective and sustainable operation of machinery directly impacts production quality and efficiency. In this context, the life values of critical components such as needles are of great importance, especially in circular knitting machines. Needles are sensitive parts that directly affect the performance of machines and have a certain lifespan. Accurately estimating and effectively managing this life optimizes machine performance, ensuring uninterrupted and efficient continuation of production processes. The aim of this study is to minimize logistics holding costs by estimating the life of needles used in circular knitting machines.

Study design/methodology/approach:
Different reliability measures of needle life such as the cumulative distribution function, reliability function and failure rate function were calculated. Lifetime analysis is performed by using MINITAB 17. Mean residual life is an estimate of the average remaining life of a working component. Estimating the mean residual life of needles based on their current condition helps optimizing maintenance and replacement strategies.

Findings:
The study was carried out in a factory producing bed fabric in Kayseri and the life of the needles used in circular knitting machines was analyzed. Results showed that the lifetime of the needles followed a lognormal distribution. As a result, this study improves maintenance processes by providing more accurate and reliable predictions of needle lifespan. This supports the efficient operation of machines by minimizing interruptions in the production line. Additionally, by creating accurate life estimates and effective maintenance strategies, logistics holding costs will be minimized and operational efficiency will increase.

Originality/value:
The study provides a previously uncontested assessment of the mean residual life of needles used in circular knitting machines in the textile industry. In addition, a strategy was developed to reduce logistics inventory costs and increase operational efficiency through needle life predictions. This represents an innovative approach that integrates maintenance and logistics management.

KEYWORDS
Lognormal Distribution, Mean Residual Life (MRL), Cumulative Distribution Function, Reliability Function, Failure Rate Function.

INTRODUCTION

Needles are components that cannot be repaired when they fail. Such parts become unusable in the event of failure. Therefore, reliability analysis is critical to assessing the performance, reliability, and failure of non-repairable components such as needles. Reliability analysis determines the appropriate probability distributions for the life of these components and helps developing strategies to ensure long-term and reliable system life.
Mean Residual Life (MRL) is an important metric in reliability analysis of non-repairable systems. This concept helps to estimate how long a needle can continue to function in its current state, i.e. after operating for a certain period. The MRL determines the future lifetime of the system based on the current age of the system, and this information is critical for planning maintenance strategies and optimizing the performance of the system. For a random lifetime X, the MRL is the conditional expectation E[X-t | X>t], where t ≥ 0. The MRL function can be simply represented with the reliability function R(t) = P(X > t) = 1-F(t) as:

$$MRL(t) = E[X - t \mid X > t] = \frac{\int_t^{\infty} R(x)dx}{R(t)} \quad (1)$$

Where R(t) > 0 for MRL(t) to be well defined. When R(0) = 1 and t = 0, the MRL equals the average lifetime. When R(t) = 0, then MRL(t) is defined to be 0 [1].
F(x) is the cumulative distribution function (CDF) It provides the probability that a random variable X takes a value less than or equal to t. Mathematically, this is expressed as:

$$F(x) = P(X \leq t) = \int_0^t f(t)dt \quad (2)$$

where f(x) is the probability density function (pdf) of the lifetime X. The mean lifetime (or expected lifetime) of the random variable X can be calculated using the probability density function f(x) as follows:

$$E[X] = \int_0^{\infty} x f(x) dx \tag{3}$$

The hazard function h(x) provides an alternative perspective by describing the instantaneous rate of failure at time t. It can be related to the reliability function and is given by:

$$h(t) = \frac{f(t)}{R(t)} \tag{4}$$

The hazard function is particularly useful in survival analysis and reliability engineering to understand how the risk of failure evolves over time [2].

Reliability analysis of non-repairable components requires the use of various probability distributions to estimate their lifetimes and failure rates. Lognormal distribution is important as lifetime distribution for instrument engineers and product reliability experts [3]. It is widely used in reliability analysis of metals when the failure is due to fracture from fatigue crack growth [4]. The lognormal pdf is skewed to the right, and the hazard function initially increases and then decreases, which makes the lognormal distribution a suitable model for such lifetimes [5]. Additionally it has been observed that many characteristics from various fields are also well modeled by the lognormal distribution [6]-[7]-[8].
In this study reliability analysis of circular knitting machine needles is performed. It is determined that the needle lifetime is distributed by lognormal distribution. MRL of needles are estimated to assist maintenance and logistic planning.

THE ESTIMATION MODEL OF MRL

The lognormal distribution is a probability distribution of a random variable whose logarithm is normally distributed. The lognormal distribution is suitable for data that can only take positive values, such as lifetime data, because it does not include negative values and has a long right tail. These properties allow for effective modeling of the life time of a component or product.

The time-to-failure T of an item is said to be lognormally distributed with parameters μ and σ, T ~ lognorm(μ, σ), if Y=logT is normally (Gaussian) distributed with mean μ and standart deviation σ [i.e. Y~N(μ, σ^2)]. The probability density function (pdf) of T is

$$f(t) = \{ \frac{1}{\sqrt{2\pi}\,\sigma t} e^{-\frac{1}{2\sigma^2}(logt-\mu)^2} \; 0 \quad \frac{for \;\; t > 0}{otherwise} \tag{5}$$

The mean and variance of T are given by $E(T) = e^{\mu+\sigma^2/2}$ and $Var(T) = e^{2\mu}(e^{2\sigma^2} - e^{\sigma^2})$. The median is e^{μ} and the mode $e^{\mu-\sigma^2}$. The survivor function of T~lognorm (μ, σ) is

$$R(t) = Pr\,Pr\,(T > t) = Pr\,Pr\,(logT > logt) = Pr\,Pr\left(\frac{logT-\mu}{\sigma} > \frac{logt-\mu}{\sigma}\right) = 1 - \Phi\left(\frac{logt-\mu}{\sigma}\right) \quad (6)$$

where Φ(.) is the cumulative distribution function of the standard normal distibution. The failure rate function of T~ lognorm (μ, σ) is

$$h(t) = \frac{\frac{1}{\sqrt{2\pi}\,\sigma t}\, e^{-\frac{1}{2\sigma^2}(logt-\mu)^2}}{1-\Phi\left(\frac{logt-\mu}{\sigma}\right)} \quad (7)$$

The MRL for a lognormal distribution is typically computed as follows:

MRL(t) = E (T − t | T > t) (8)

The MRL represents the expected remaining life given that the current age is t. For a lognormal distribution, the expected remaining life given that T > t is:

The MRL is then calculated as [9]:

$$MRL(t) = e^{\mu+\frac{\sigma^2}{2}} \frac{[1-\Phi((lnt-\mu-\sigma^2)/\sigma)]}{1-\Phi((lnt-\mu)/\sigma)} - t \quad (9)$$

This calculation is usually performed with a statistical software or calculation tool, as it requires calculating the cumulative distribution function of the normal distribution and logarithm transformations.

MRL provides valuable insights for reliability engineering and maintenance planning. It helps estimate how much longer a component or product is expected to function based on its current age, enabling more effective maintenance and replacement strategies.

ANALYSIS OF NEEDLE LIFETIME DATA

3.1. Description of the Problem

In the fabric production process of circular knitting machines, needles are small but crucial components of these machines. The durability of needles affects the efficiency and the quality of the fabric production process. Failure of a needle causes production stoppage and quality defects in the fabric therefore reduces the overall performance of a machine.

The needle durability can vary due to abrasion. Long lifetime needles ensure continuous and uninterrupted machine operation, improve production quality, and reduce maintenance costs. Therefore, accurately predicting and managing the lifetime of needles plays a critical role in optimizing machine performance and ensuring the smooth continuation of production processes.

The aim of this study is to do the reliability analysis of needles. Results of the analysis will help to optimize machine performance and to minimize logistics holding costs by planning timely and effective maintenance procedures.

The study was conducted in a company operating in the bed fabric sector in Turkey and the lifetime of the needles used in the circular knitting machine was analyzed. The factory works 24 hours a day in 3 shifts. Weekly maintenance and repairs of the machine and equipment parts are carried out periodically on Sundays. From past data, it was determined that the usage times of the needles varied between 50 minutes and 1000 minutes. The data on the lifetime of 162 needles collected in the last 2 months are given in Table 1.

TABLE 1

Needle Lifetime Data

SN	LT	SN	LT	SN	LT	SN	LT	SN	LT	SN	LT	SN	LT	SN	LT
1	104	22	248	43	482	64	63	85	93	106	412	127	571	148	225
2	173	23	210	44	209	65	64	86	253	107	273	128	193	149	586
3	557	24	346	45	951	66	186	87	325	108	222	129	110	150	997
4	433	25	347	46	395	67	276	88	807	109	348	130	165	151	83
5	143	26	364	47	145	68	270	89	160	110	309	131	683	152	257
6	103	27	151	48	123	69	144	90	530	111	281	132	200	153	97
7	415	28	193	49	739	70	140	91	901	112	133	133	165	154	204
8	80	29	91	50	171	71	86	92	340	113	143	134	76	155	124
9	220	30	434	51	358	72	861	93	369	114	782	135	229	156	204
10	294	31	924	52	141	73	223	94	117	115	746	136	245	157	197
11	289	32	53	53	355	74	700	95	292	116	327	137	414	158	342
12	256	33	605	54	202	75	122	96	415	117	960	138	173	159	122
13	63	34	214	55	133	76	448	97	517	118	801	139	257	160	57
14	282	35	557	56	259	77	266	98	217	119	197	140	305	161	176

15	635	36	190	57	236	78	160	99	201	120	345	141	413	162	98
16	87	37	183	58	407	79	68	100	232	121	657	142	197		
17	886	38	149	59	271	80	74	101	702	122	366	143	204		
18	229	39	215	60	869	81	518	102	222	123	752	144	545		
19	248	40	450	61	114	82	974	103	453	124	355	145	264		
20	149	41	336	62	86	83	65	104	106	125	138	146	998		
21	666	42	164	63	976	84	285	105	997	126	89	147	137		

SN: Sample Number LT: Lifetime (Minutes)

Determining the Life Time Distribution of the Needles

The Individual Distribution Identification tool in Minitab was used to evaluate the fit of the data to a log-normal distribution. This tool analyzes the data based on probability plots and goodness-of-fit tests to determine which distribution best fits the data. The Anderson-Darling test is one of the goodness-of-fit tests used in Minitab to assess whether the data conforms to a specific distribution.
To determine the distribution of needle lifetimes, various distribution types were tested and compared. The Anderson-Darling test and probability plot were used to evaluate which distribution was the most appropriate. The results obtained with Minitab 17 program are shown in Figure 1. Based on the comparison of distribution types, the data was found to fit a log-normal distribution better, as the p-value of 0.209 is greater than the significance level of α=0.05. When probably plots for the different distributions compared again the best fit was seen for lognormal distribution. These findings indicate that the log-normal distribution provides a better explanation of the data compared to other distributions.

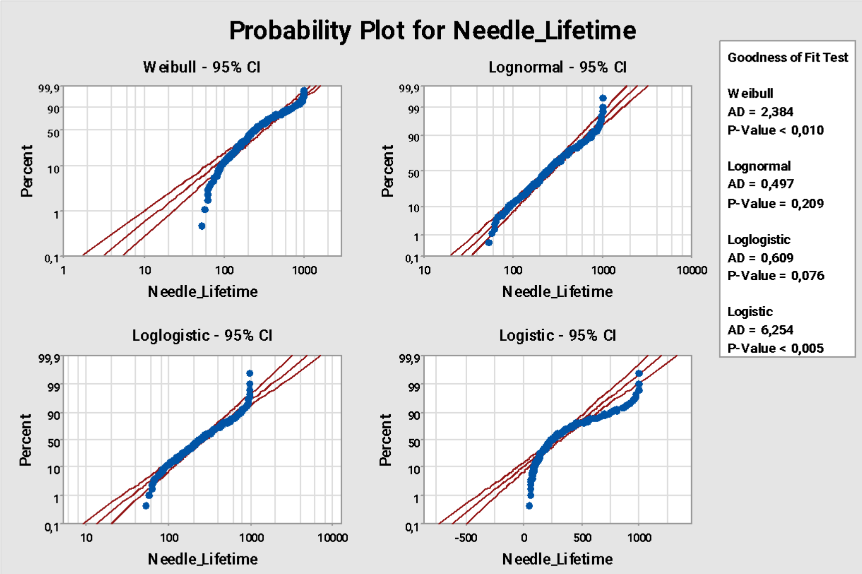


FIGURE 1
Examination of Data Distributions and Model Selection

Estimation of Lognormal Distribution Parameters

Estimation of the parameters of the log-normal distribution is a critical step in understanding and accurately modeling data that follows this distribution. This process involves estimating the two main parameters that define the pdf of the log-normal distribution: the scale (μ) and shape (σ) parameters. These parameters are essential for accurately modeling the data, making reliable predictions, and conducting effective statistical analyses.
Since the sample size is big enough, maximum likelihood estimation method is used for estimation of distribution parameters. Table 2 presents the parameter estimates and confidence intervals for the log-normal distribution. The shape parameter was found to be 0.729533, and the scale parameter was found to be 5.54026. The parameter values were determined using Minitab 17 program.

TABLE 2
Parameter Estimates

		Standard	95,0% Normal CI	
Parameter	Estimate	Error	Lower	Upper
Location	5,54026	0,0573175	5,42792	5,65260

Scale	0,729533	0,0405296	0,654268	0,813456

The location parameter represents the mean of the normal distribution when taking the logarithm of the log-normal distribution. The estimated value here is 5.54026. The error value indicates the accuracy of the estimate, which in this case is 0.0573175. The 95% confidence interval indicates that there is a 95% probability that the true location parameter lies within this range. This interval is between 5.42792 and 5.65260.
The scale parameter represents the standard deviation of the normal distribution when taking the logarithm of the log-normal distribution. The estimated value here is 0.729533. The error value indicates the accuracy of the estimate, which in this case is 0.0405296. The 95% confidence interval indicates that there is a 95% probability that the true scale parameter lies within this range. This interval is between 0.654268 and 0.813456.
Table 3 provides comprehensive information on various statistical measures of the data and their confidence intervals. Measures such as the mean, median, standard deviation, and interquartile range are used to understand the central tendencies and spread of the data. Confidence intervals indicate the reliability of these estimates and the level of uncertainty.
TABLE 3
Characteristics of Distribution

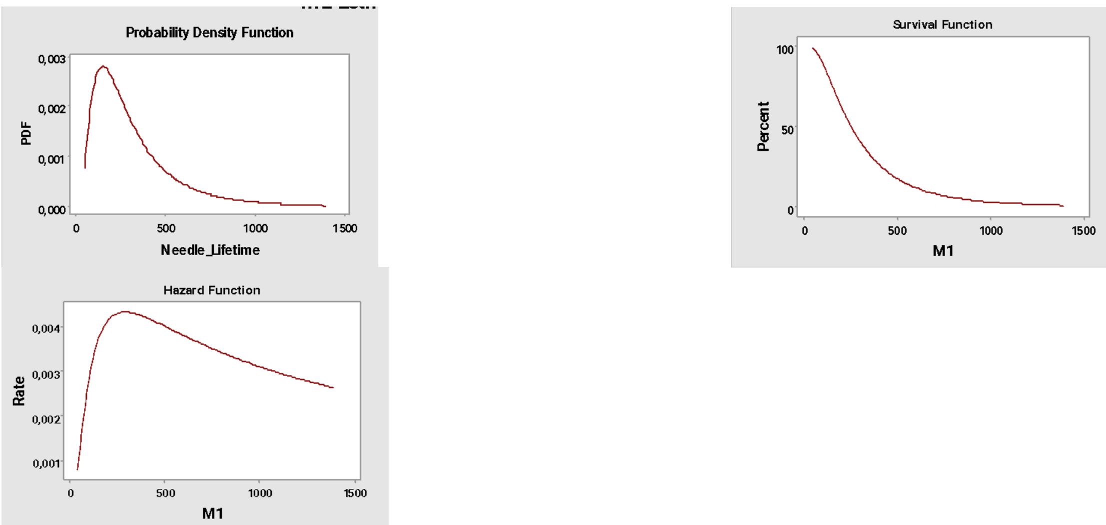
		Standard	95,0% Normal CI	
	Estimate	Error	Lower	Upper
Mean Time to Failure(MTTF)	332,411	21,4387	292,939	377,202
Standard Deviation	278,652	32,4115	221,848	350,002
Median	254,745	14,6014	227,676	285,033
First Quartile (Q1)	155,742	9,89005	137,516	176,384
Third Quartile (Q3)	416,683	26,4605	367,919	471,910
Interquartile Range (IQR)	260,941	21,6464	221,784	307,011

The characteristics of the log-normal distribution are presented in Table 3. The mean represents the central tendency of the data. The estimated mean lifetime of the needles is 332.411 minutes, with a 95% confidence interval ranging from 292.939 to 377.202 minutes. The standard deviation measures the spread of the data. The estimated standard deviation is 278.652 minutes, with a 95% confidence interval between 221.848

and 350.002 minutes. This indicates the extent of variability in the data. The median represents the middle value of the data. The estimated median lifetime is 254.745 minutes, with a 95% confidence interval ranging from 227.676 to 285.033 minutes. The median shows the central tendency of the data while reducing sensitivity to outliers.
The first quartile (Q1) indicates that 25% of the needle lifetime data is shorter than 155.742 minutes, with a confidence interval between 137.516 and 176.384 minutes. The third quartile (Q3) indicates that 75% of the needle lifetime data is shorter than 416.683 minutes, with a confidence interval between 367.919 and 471.910 minutes. The interquartile range (IQR), which measures the difference between Q3 and Q1, reflects the degree of spread in the data. The estimated IQR is 260.941 minutes, with a 95% confidence interval between 221.784 and 307.011 minutes.

3.4. Calculation and Analysis of Mean Residual Life (MRL)

MRL is a statistical measure that determines how long a system or equipment can continue to function on average, given that it has survived for a certain period of time [10]. The MRL calculation method typically uses various statistical models and techniques to understand the behavior of failures over time. The goal of these methods is to gain insight into the life of a component and determine when it needs to be maintained or replaced.



a b c

FIGURE 2
a) pdf, b) cdf , c) Failure Rate Function of Lognormal Distribution

Figure 2 includes various parametric graphs based on the lognormal distribution values. First, the probability density function (pdf) shows the density of the data at a given lifetime according to the lognormal distribution; this graph allows us to clearly see in which intervals the data is more dense and the shape of the distribution right-skewed. The long right tail of the pdf indicates that the needle life may be very long, but most will fail in a shorter time. The survival plot shows the probability of survival over so as expected it is a decreasing of survival over time. Finally, the failure rate plot increases to a point then decreases. These plots provide important information in the process of analyzing and interpreting various aspects of the lognormal distribution.

In the calculation of MRL for the lognormal distribution, the survival probability at a certain time must first be found. In this study, the parameters of the lognormal distribution were found as μ=5.54026 and σ=0.729533 and a certain time t=50 minutes was chosen. First, the log t value was found for the calculation; where log 50 ≈ 3.912 Then, a normalized Z score was calculated using the lognormal distribution parameters:

$$Z = \frac{logt - \mu}{\sigma} = \frac{3.912 - 5.54026}{0.729533} \approx -2{,}233 \tag{10}$$

This Z-score is compared to the cumulative distribution function (cdf) value from a standard normal distribution table or calculation tool. In this case, the probability of survival is calculated as follows:

$$\Pr(T > t) = 1 - \Phi(-2.233) \approx 1 - 0{,}0129 = 0.9871 \tag{11}$$

MRL Calculation:

$$MRL(t) = e^{5.54026+\frac{0.729533^2}{2}} . \frac{[1 - \Phi((log50 - 5.54026 - 0.729533^2)/0.729533)]}{1 - \Phi((log50 - 5.54026)/0.729533)} - 50 \tag{12}$$

From the standard normal distribution table, the cumulative distribution function (CDF) value for Φ(−2.965) ≈ 0.0015.

$$MRL(t) = e^{5.54026+\frac{0.729533^2}{2}} . \frac{[1 - 0.0015]}{0.9871} - 50 \approx 284.2 \tag{13}$$

In this study, the Mean Residual Life (MRL) for a given time t =50 minutes was calculated to be approximately 284.2 minutes. This indicates that after the needle has been working until time t =50 minutes, it can continue to function for an average of 284.2 minutes.

TABLE 4
Mean Residual Life (MRL) Values for Different Time Points

t	MRL
50	284.2
100	259.6
200	249.8
300	232.2

Table 4 shows the MRL values for different time points. You can see that as the needle working time t increases, the MRL decreases. This indicates that as the needle works for longer periods, its remaining life will decrease.

CONCLUSIONS

In the applied study, a suitable distribution for the needle lifetime data was selected. The analyses revealed that these lifetimes followed a log-normal distribution. The choice of distribution was based on the data and its characteristics. The parameters of the chosen log-normal distribution were estimated through statistical analysis of historical data. Using these parameters, the mean residual life (MRL) after a certain time t was calculated.
The MRL calculation enables the creation of a lifetime prediction model. These calculations are performed using a specific distribution and parameter estimates, and the model helps predict the future lifetime of a component or product. Such predictive models play a critical role in assessing and improving the reliability of products and systems.
The study found that the needle usage time varied significantly between 50 and 1000 minutes. Predicting needle lifetime accurately in such a broad range is quite challenging. However, the model employed has overcome this challenge, providing more accurate and reliable predictions of needle lifetime. These precise predictions help optimize maintenance and replacement strategies, enhancing production efficiency and supporting uninterrupted operations. Moreover, accurate lifetime predictions allow for more effective planning of inventory management and logistical processes. Better management of stock levels and spare parts needs aids in controlling inventory holding costs and increasing operational efficiency. Consequently, the use of the model improves overall efficiency and minimizes logistics cost by enhancing in maintenance process.

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A MATHEMATICAL MODEL USING AHP-BASED PARAMETERS FOR SOLVING LOCATION-ALLOCATION PROBLEM

Begüm Yanıkoğlu, Damla Kizilay

Industrial Engineering Department, Izmir Democracy University, Izmir, Turkey, 2317110004@std.idu.edu.tr

Industrial Engineering Department, Izmir Democracy University, Izmir, Turkey, damla.kizilay@idu.edu.tr

ABSTRACT:

Purpose:
This study includes the strategic placement of emergency supply centers that serve as temporary warehouses within a region, ensuring quick access to affected individuals in disaster scenarios. In this context, the aim is to decide which warehouses will be opened and assigned to the disaster area(s) in case of an emergency, by minimizing the weighted distance.

Methodology:
This study utilizes one of the multi-criteria decision-making methods, the Analytical Hierarchy Process (AHP), to determine the ranking scores of several possible warehouse locations. To obtain these ranking scores, surveys were conducted considering various features of the warehouses, such as cost, capacity, ease of transportation, and more. The obtained scores from AHP were converted into weights for each potential warehouse. Subsequently, a mixed-integer linear mathematical model was developed, focusing on minimizing weighted distances while solving the location-allocation problem.

Findings:
Various scenarios were investigated to identify potential disaster area locations and the number of warehouses to be opened. The developed mathematical model was solved using IBM ILOG CPLEX Optimization Studio 22.1, and the results obtained for all scenarios were analyzed to ensure that the warehouse location and assignment decisions are made quickly and efficiently in emergencies.

Originality:
This study evaluates several possible warehouses after a disaster according to various criteria and produces fast and useful location-allocation solutions by taking into account not only the proximity of the storage area to the disaster points but also its characteristics, such as capacity, cost and etc., which differentiates this paper from the existing literature.

KEYWORDS
AHP, Humanitarian logistics, Location-allocation, Mixed integer linear programming model.

INTRODUCTION

Today, the frequency and impact of natural disasters are increasing. Therefore, the planning and management of emergency relief operations is becoming more complex. In this context, in the event of a potential disaster, it is critical to effectively emergency supply centers in a given region and quickly reach those in need [1]. At this point, it is important to choose the right location for these centers to be used in an emergency. This study was carried out to collect aid coming from various regions, provinces, or city centers in these centers after any disaster and to deliver it from only these centers to the disaster points. The selection of these certain supply centers (warehouses) is crucial to prevent possible chaos after the disaster and clarify the aid points. Thus, the determined warehouses will be known by the people, and organizations who want to send aid, in this way the supplies will be prevented from being lost, stolen, or looted. Therefore, in this study, within the scope of the location allocation problem; it is planned to select the most suitable warehouse with the facility location problem and to assign the selected warehouses to the disaster areas with the allocation problem.
Facility location problems involve the selection of the most suitable location for the targeted objective under certain constraints such as ease of access to demand points and cost-effectiveness [2]. Facility location problems are very important for businesses and disaster management in terms of selecting the location of the facility, warehouses, and transshipment points [3]. In this study, the selection among alternative warehouses was planned within the framework of the weighed distance minimization objective function. Since the weights of alternative warehouses were determined according to a wide variety of criteria, the analytical hierarchical process (AHP) method, one of the multi-criteria decision-making methods (MCDM), was used at this stage. MCDM methods used in decision analysis involve the evaluation of alternative options by considering more than one criterion [4, 5]. The MCDM methods were highly used in the literature including location-allocation problems [6]. In this study, first, the alternative warehouses (facilities) in Izmir, which was selected as a pilot province that could serve as emergency supply centers were listed. These warehouses consist of universities, sports halls, and stadiums. Then, the AHP method was applied to rank these warehouses by considering six different criteria such as their distance to the city center, usage cost, total number of public transportation types around them, population of the district where they are located, their capacity, and their distance to main roads. After obtaining the ranking scores, a mathematical model was developed by turning these scores into the weights for all alternative warehouses.
A similar study in literature considers the location-allocation problem to determine the location of the emergency shelters and make suitable assignments between these shelters and the residents [7]. The emergency is experienced as a cluster coverage

problem and MILP is used to model the problem. It is very similar to our study but the authors consider shelters for the residents so they try to cover a certain area considering the shelter capacities In this study, the facility locations to be determined will ensure that emergency supply materials are stored and delivered to the residence. We also differ from this study and the literature in terms of objective function and decision-making methods.
The remaining parts of the paper are as follows. The following section includes the problem definition and mathematical model where the purpose of the problem and the developed MILP model under certain assumptions are explained. Then the Analytic Hierarchy Process section explains the steps of the AHP method, which was utilized in this study as one of the MCDM methods. The Computational Results section is divided into three parts; data generation, visual representation of a solution, and the summary of all results obtained by the MILP model. Finally, in the Conclusion section, the concluding remarks and future research are proposed.

PROBLEM DEFINITION AND MATHEMATICAL MODEL

This study includes a location-allocation problem that aims to determine the optimal warehouse selection for humanitarian aid logistics in the event of a possible disaster. For this purpose, AHP (Analytic Hierarchy Process) is used to determine the weights of temporary warehouses considering several criteria and a mathematical model based on the P-median problem to minimize the weighted distances of the warehouses to the disaster areas where they will be assigned. Izmir province was selected as the plot area and alternative buildings in Izmir were listed. This list is composed by considering possible alternative buildings that could be used as temporary warehouse areas after the disaster. The assumptions of the problem are as follows:
The number of warehouses to be selected is determined in advance.
The total capacity of the warehouses to be selected is sufficient for the aid materials to be collected.
All needs of the aid points assigned to any warehouse are met from this warehouse.
Aid materials can be transmitted between warehouses.
All alternative warehouses have the authority to be opened.
Warehouses are not homogeneous, they all have different weights according to their characteristics. These weights are calculated with AHP.
The properties of the warehouse with more weight are better.
A mixed integer mathematical model (MILP) based on the p-median facility location problem was developed. All the indices, parameters, and decision variables are given in this section. The objective function of the model and the constraints were explained after the equations.
Indices
i: Index of potential disaster areas (i=1,2,3…N)
k: Indeks of warehouses (k=1,2,3…M)
Parameters

N: Total number of potential disaster areas
M: Total number of temporary warehouses
P: Total number of emergency supply centers (warehouses) requested to be opened
$d_{i,k}$: Distance of potential disaster area i from temporary warehouse k.
w_k: Weight of temporary warehouse k.

Decision Variables

$$x_{i,k} = \begin{cases} 1, \text{ if potential disaster area i is assigned to warehouse k} \\ 0, \text{otherwise} \end{cases}$$

$$y_k = \begin{cases} 1, \text{ if the temporary warehouse k is opened} \\ 0, \text{otherwise} \end{cases}$$

Objective Function

$$\text{Min} \quad \sum_i^N \sum_k^M (1/w_k) \times d_{i,k} \times x_{i,k} \qquad (1)$$

Constraints

$$\sum_{k=1}^{M} x_{i,k} = 1, \ \forall i = 1,2,3 \dots N \qquad (2)$$

$$\sum_{i=1}^{N} x_{i,k} \geq y_k, \ \forall k = 1,2,3 \dots M \qquad (3)$$

$$x_{i,k} \leq y_k, \ \forall i = 1,2,3 \dots N \text{ ve } \forall k = 1,2,3 \dots M \qquad (4)$$

$$\sum_{k=1}^{M} y_k = P \qquad (5)$$

$$x_{i,k}, \ y_k \in [0,1] \text{ and } \forall i = 1,2,3 \dots N, \forall k = 1,2,3 \dots M \qquad (6)$$

The objective function (1) expresses the weighted distance minimization of warehouse locations to the possible disaster areas. In this calculation, the weights of the temporary warehouses were taken inversely and made suitable for the minimization purpose. Since the properties of the warehouses with the higher weight are better than the other, the distances in the minimization objective function are divided into these weights. Constraint (2) ensures that each potential disaster area is assigned to a single warehouse. By providing all the needs of every disaster area from a single warehouse, both complexity and chaos will be prevented and there will be no disaster area left without a supply center. Constraint (3) ensures that if any warehouse is opened, it must serve at least one disaster area. This constraint indirectly makes capacity planning. The number of warehouses that need to be opened is a number that the decision maker gives as input to the problem (P). This number is determined according to the magnitude of the disaster, the disaster areas, and the amount of needs. In other words, meeting all the needs of the disaster areas will only be possible by using all the opened warehouses. Constraint (4) indicates that a disaster area can only receive help from an open warehouse. If the warehouse is not open, it is out of service and cannot send help to any disaster area from there. Constraint (5) ensures that a specified number of warehouses are opened. Constraint (6) provides the sign restrictions of the variables.

ANALYTICAL HIERARCHY PROCESS

AHP uses a hierarchical structure leveled as criteria, sub-criteria, and alternatives under a goal determined by the decision maker. Weights of the criteria are created and the most appropriate alternative is tried to be determined [4].
A hierarchical structure is created in AHP to determine the weights of the alternative warehouses. The decision hierarchy of our problem is shown in Figure 1. This study determines six criteria for the alternative warehouses, such as capacity, cost, transportation options, distance to the city center, proximity to main roads, and district population. There may be many alternative warehouses in the problem, however, since this study is considered within the scope of Izmir province, it was conducted for 22 alternative warehouses located in Izmir. While determining these alternative warehouses, areas that can be quickly converted into warehouses and used after a disaster were considered. Therefore, universities, sports halls, and stadiums located in Izmir province were determined as emergency supply centers.

FIGURE.1. Decision Hierarchy of the AHP Method.
After the hierarchical structure is created, pairwise comparison matrices are created between the alternatives according to each criterion. The scores of the alternative warehouses for each criterion were obtained as a result of the survey. Within the scope of the survey, pairwise comparisons were made between the alternatives for each criterion. The geometric averages of the coefficients obtained as a result of these pairwise comparisons were taken and the score of each alternative for each criterion was calculated. Similarly, the pairwise comparison was executed for these six criteria and the weight of each criterion was determined. Due to the unit differences in the values used for different criteria, the normalization is conducted and the relative

importance weights of the warehouses are calculated. Then, the matrix consistency is calculated to determine the accuracy and consistency of the values determined by the respondents of the survey. The holistic priorities of the alternatives are calculated by multiplying their values for each criterion by the weight of the criteria. Finally, the alternative warehouses are given a score and ranked according to these scores.

According to the figure, the capacity criterion considers the size of the warehouse. The larger the warehouse, the more aid will be stored, thus serving more than one disaster area. In addition, as the capacity expands, the classification of the aid materials brought to this warehouse will also become easier. The transportation options criterion is the number of alternative transportation options such as buses, metro, ferries, and trams close to the warehouse location. Since it is not known what type of natural disaster will occur, it is assumed that the more different types of transportation around the warehouses to be assisted, the easier it will be to access the disaster areas from the warehouse. Distance to city center criterion takes into account the distance of the warehouse location to the city center. It was determined by considering that the people and organizations that will provide aid will be located mostly in the city center. The proximity to main roads criterion was determined to understand the accessibility of each warehouse. Considering that aid/supply from different regions would come via these main roads, it was thought that it would be advantageous for the warehouse to be located close to these roads. If the population of the region where the warehouse is located is high, the number of possible aid coming to the warehouse from the people of that region will increase. Therefore, the district population criterion was also considered. In the calculation of the cost criterion, the normalized values of the other criteria were used. Because it is thought that the cost of a facility increases as its capacity increases, as it gets closer to the city center, and as the number of people living in that area increases. In addition to these criteria, additional costs are also included in the calculation if the facility is not a government institution and is affiliated with a private institution. The following calculation (7) for the cost criterion was used.

$$\text{Cost} = (2 \times \text{Capacity}) + \text{Distance to City Center} + \text{District population} + (4 \times \text{Normalized Private Institution Fee}) \quad (7)$$

COMPUTATIONAL RESULTS

The MILP model developed in this study was solved using OPL CPLEX Studio IDE 22.1.1 and optimal results were obtained within seconds. The weights of the warehouses used in the objective function of the MILP model were obtained using Microsoft Excel with the AHP method.

Parameter Generation

In this study, different scenarios were considered having three different numbers for potential disaster zones (5, 10, 20) and three different numbers for the required number of open warehouses (2, 3, 4). Furthermore, the potential disaster areas are divided into two groups. The first one includes scattered locations around the city center. The second one consists of clustered locations in nearby regions. All the locations are generated within a 50 km radius of the city center. For the clustered potential disaster areas, the locations inside the same cluster were generated within a 5 km radius of a location that is also generated within the borders of Izmir province. For both groups, 15 data sets were prepared by creating 5 different combinations from each scenario, composing a total of 30 data sets. The generation of potential disaster areas was done with a C++ language that generates random coordinates within the coordinate boundaries of Izmir province. The distances from the disaster areas to alternative warehouse locations were calculated by Manhattan distance. Calculations were made according to the latitude and longitude of the locations.

Results of the AHP Model

The AHP model is applied to determine the weights of the alternative warehouses based on six different criteria. There are 22 alternative warehouses in the plot area of İzmir, and their values for each criterion are collected from open-source data on the websites of the warehouses or the search engine. Then these values of the alternative warehouses were normalized since there are different units for each criterion. Also, the profit or cost criteria are checked whether the criteria are directly or inversely proportional to the objective of the problem, and a normalized matrix was formed in Table 1. When the criteria are examined, we can see that three of the criteria are profit-based: Capacity, transportation options, and district population; and the other three criteria are cost-based: Proximity to main roads, distance to city center, and cost. All criteria are calculated to be profit-based during this normalization, so reverse normalization is applied to some criteria. Also, the weights of the criteria are determined as a result of a survey and normalized.

After obtaining the normalized values for all alternative warehouses, the resulting scores are calculated by obtaining the weighted sum of all rows. Then these scores are used as the weights of the warehouses in the developed MILP model.

Visual Representation of the Solution

In order to show a visual representation of the optimal solution, a sample dataset that consists of 22 temporary warehouses and 5 potential disaster areas was chosen from all instances. The number of temporary warehouses to be opened has been accepted as 2. The problem is solved for both scattered and clustered disaster areas optimally. Figures 2 and 3 show the locations of the temporary warehouses with the scattered and clustered disaster areas, respectively. In the figures, locations indicated by crosses represent disaster areas, and locations indicated by houses represent alternative warehouses. All locations are located within the province of Izmir, and the geographical locations of all locations are depicted approximately in a way that they are consistent with each other. Opened warehouses are depicted as larger than others. The assignment between the opened warehouses and disaster areas is shown with arrows.

TABLE 1
Normalized Decision Matrix for Each Alternative and Criterion

Criteria	Proximity to main roads (m)	Capacity (m²)	Distance to the city center (km)	Cost	Transportation options	District population	Weights of the Warehouses
Weights	0.241	0.147	0.130	0.169	0.176	0.135	
W1	0.126	0.226	0.025	0.007	0.043	0.063	0.08
W2	0.045	0.367	0.021	0.005	0.021	0.073	0.08
W3	0.049	0.000	0.033	0.040	0.064	0.067	0.04
W4	0.002	0.229	0.005	0.008	0.021	0.011	0.04
W5	0.141	0.140	0.011	0.012	0.021	0.030	0.07
W6	0.008	0.012	0.008	0.066	0.021	0.029	0.02
W7	0.032	0.001	0.023	0.004	0.043	0.011	0.02
W8	0.253	0.000	0.181	0.003	0.064	0.046	0.10
W9	0.070	0.005	0.030	0.004	0.043	0.063	0.04
W10	0.012	0.007	0.027	0.004	0.021	0.073	0.02
W11	0.045	0.000	0.212	0.015	0.085	0.046	0.06
W12	0.002	0.001	0.004	0.197	0.021	0.015	0.04
W13	0.023	0.001	0.110	0.025	0.064	0.046	0.04
W14	0.027	0.001	0.049	0.041	0.085	0.046	0.04
W15	0.026	0.001	0.014	0.063	0.043	0.048	0.03
W16	0.024	0.001	0.106	0.026	0.085	0.046	0.05
W17	0.010	0.002	0.018	0.047	0.021	0.063	0.03
W18	0.014	0.001	0.029	0.038	0.021	0.073	0.03
W19	0.049	0.002	0.033	0.039	0.064	0.067	0.04
W20	0.030	0.004	0.048	0.040	0.085	0.046	0.04
W21	0.010	0.001	0.008	0.103	0.043	0.029	0.03
W22	0.001	0.002	0.003	0.213	0.021	0.012	0.04

As seen in Figure 2, when there are scattered disaster areas, opened warehouses are also scattered and positioned in a way that they are close to disaster areas. At this point, the effect of the minimize distance objective function is seen. However, although there are closer warehouses to disaster areas 1 and 4, the warehouse that is farther away is selected. At this point, the effect of the warehouse weights obtained from AHP is seen.

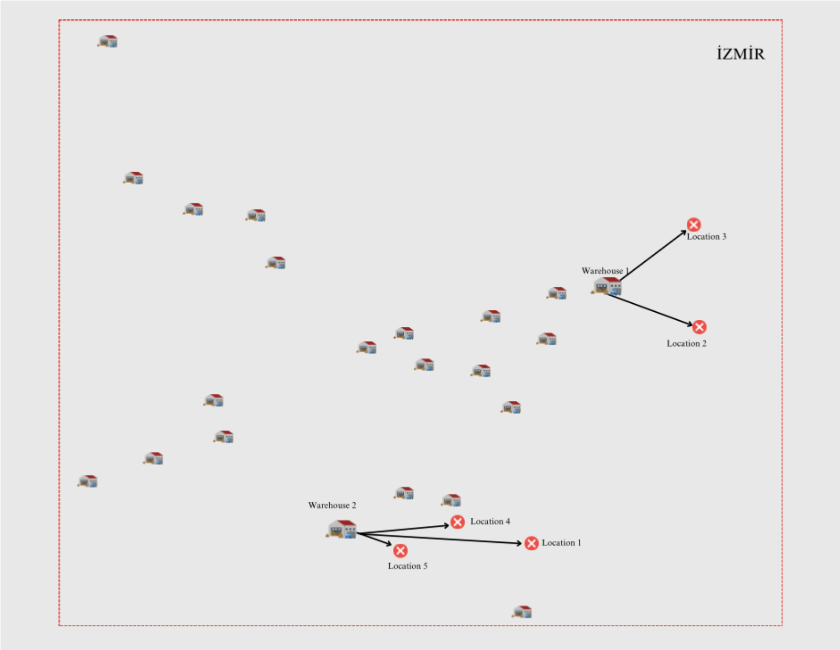

FIGURE. 2 Visual Representation of Location-Allocation Problem for Scattered Disaster Areas.

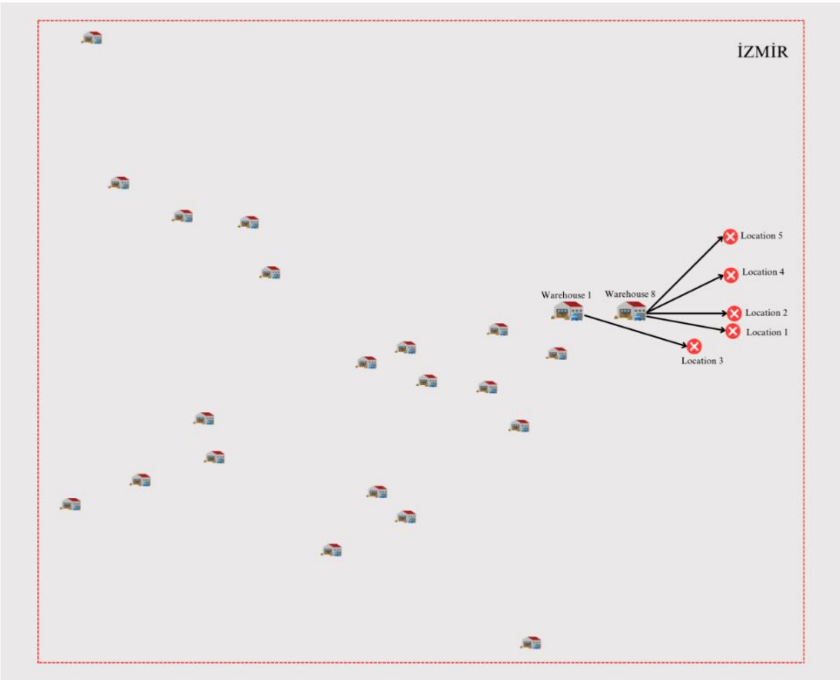

FIGURE. 3 Visual Representation of Location-Allocation Problem for Clustered Disaster Areas.

In Figure 3, which is an example with clustered disaster areas, the warehouses closest to these clusters were opened and the problem tended to assign all disaster areas to the same warehouse. Since each opened warehouse must be assigned to at least one disaster area, an assignment was made for warehouse number 1 as well. These examples prove that the problem works correctly and logically.

Results of the MILP Model

The results were obtained for six different combinations each having five instances, so a total of 30 datasets. Table 5 summarizes the results for each combination (Number of Disaster Areas, Number of Warehouses to be Opened, Customer Distribution Types) including the obtained objective function value and the CPU time in seconds. All the results are obtained less than one-hundredth of a second of CPU time.
As can be seen from Table 5, all optimal results were obtained very quickly. As the number of disaster areas increases, it was decided that the number of warehouses that should be opened should be higher. As these numbers increase, the objective function value also increases. This increase is expected since more distance affects the objective function. The increase in the number of disaster areas did not cause a significant change in the CPU time. With preliminary research for the post-disaster period, possible warehouse areas were determined for Izmir province and weighted with the AHP method. After this time, a solution can be obtained very quickly after a disaster that will occur in Izmir province at any time and which facilities should be converted into warehouses can be determined.

CONCLUSION

In this study, it was decided which of the possible facilities would be selected as temporary warehouses after any disaster and which disaster areas these selected warehouses would serve. This study was conducted to prevent chaos in the city after any disaster, to ensure that aid reaches its destination, and to determine where the people and organizations should send their aid.
Within the scope of the study, weights were determined for the possible warehouses with the AHP method, considering many features such as capacity, cost, proximity to main roads, etc. Later, with the help of the developed MILP model, it was decided which warehouses would be opened and which disaster areas they would be assigned to, in line with the weighted distance minimization objective function.
Izmir was selected as a pilot province for the study and the possible warehouse locations here were used with their real coordinates and features. A total of 30 data sets with different combinations of disaster area number/location and the number of warehouses to be opened were produced. Optimal results were obtained within seconds for all data sets. Thus, Izmir became able to easily and quickly select aid warehouses after any disaster.

TABLE. 5 The Results of the MILP Model for all Datasets

Data	Number of potential disaster areas	Number of warehouses to be opened	Scattered or Clustered Customers	Objective Function	CPU (s.)
1	5	2	Clustered	7.637	0.004
2	5	2	Clustered	22.608	0.004
3	5	2	Clustered	28.496	0.006
4	5	2	Clustered	24.818	0.004
5	5	2	Clustered	23.013	0.004
6	10	3	Clustered	15.655	0.005
7	10	3	Clustered	49.05	0.006
8	10	3	Clustered	56.965	0.006
9	10	3	Clustered	50.882	0.005
10	10	3	Clustered	44.655	0.006
11	20	4	Clustered	33.51	0.008
12	20	4	Clustered	96.691	0.010
13	20	4	Clustered	110.334	0.010
14	20	4	Clustered	100.836	0.010
15	20	4	Clustered	88.468	0.010
16	5	2	Scattered	15.2	0.004
17	5	2	Scattered	18.083	0.004
18	5	2	Scattered	10.104	0.004
19	5	2	Scattered	17.405	0.005
20	5	2	Scattered	9.454	0.004
21	10	3	Scattered	22.08	0.006
22	10	3	Scattered	33.343	0.005
23	10	3	Scattered	30.067	0.006
24	10	3	Scattered	36.236	0.005
25	10	3	Scattered	28.72	0.005
26	20	4	Scattered	52.613	0.009
27	20	4	Scattered	56.574	0.009
28	20	4	Scattered	58.698	0.010
29	20	4	Scattered	59.137	0.009
30	20	4	Scattered	61.156	0.009

In the future, this study can be applied to other regions and provinces, thus providing widespread impact. In addition to the study, adding the vehicle routing problem to facilitate and accelerate the transportation of aid to disaster areas will contribute more. At this point, it can be considered to collect and distribute aid between aid warehouses

and disaster areas. Finally, loading the aid trucks properly is another issue that can be integrated into the problem.

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VEHICLE ROUTING OPTIMIZATION FOR A LIQUID WASTE COLLECTION COMPANY

Demet Özgür-Ünlüakın, Alim Ateş, Ulaş Sütlü, Yiğit Hanefi Yıldız, Doruk Emre Aydın

Industrial Engineering Department, Işık University, demet.unluakin@isikun.edu.tr
Industrial Engineering Department, Işık University, 19inde1004@isik.edu.tr
Industrial Engineering Department, Işık University, 19inde1005@isik.edu.tr
Industrial Engineering Department, Işık University, 19inde1017@isik.edu.tr
Industrial Engineering Department, Işık University, 19inde1028@isik.edu.tr

ABSTRACT:

Purpose:
Within the aim of achieving sustainable cities, it is crucial to recycle waste oil properly to protect clean water resources. Some business models have been developed for this purpose. In such a model, restaurants agree to store their liquid waste in containers provided by a waste collection company. When these containers are full, the company collects the liquid waste and reprocesses it or disposes of it. This approach protects the environment and contributes to the economy. In this study, we address the optimization of the waste collection operations of a liquid waste collection company that collects waste oil using capacitated vehicles from restaurants across various regions of a city. Our goal is to enable the company to serve new customers by optimizing its operations.

Study design/methodology/approach:
We propose a two-step hierarchical procedure where, in the initial step, we determine the daily visit lists based on the weekly customer requests. In the second step of the hierarchy, we determine the optimal routes of the waste collection vehicles on each weekday based on the daily visit lists. The first step problem is solved using a k-means algorithm, whereas a mathematical model is developed for the second step routing problems, which are then solved with an exact solver.

Findings:
With the help of the proposed approach both the total time and the total distance covered by the vehicles on weekly routes decrease significantly. We achieved a reduction of 18% in time spent and a reduction of 43% in distance traveled in a week.

Originality/value:
The proposed approach contributes to the vehicle route optimization of a waste collection company and increases its operational efficiency. It also allows for more

customers to be served by the company. Hence, it enables to protect clean water resources and achieve sustainable cities.

KEYWORDS
Liquid waste collection, sustainable cities, two-step hierarchical approach, vehicle routing optimization.

A BIBLIOMETRIC LITERATURE REVIEW ON ORDER PICKING METHODS

Ayşen Öztoprak, Atiye Tümenbatur

Maltepe University, aysen.oztoprak@sick.com.tr
Maltepe University, atiyetumenbatur@maltepe.edu.tr

ABSTRACT:

Purpose:
The importance of industrial automation products is increasing with the rising trend of digitalization and industry 4.0, and since the use of industrial automation products reduces the need for manpower, its impact on production costs is also becoming more prominent. The majority of industrial automation products are manufactured in Europe and the Far East, with very limited production in Turkey. The fact that production is carried out abroad highlights the importance of logistics activities in the accessibility of products. For these products, which are used at critical points in production, stock management, ordering processes, storage processes and shipment processes must be managed correctly. Especially after the supply problems experienced during the pandemic period, both manufacturers and users of industrial automation products have experienced great difficulties in stock planning and have become unable to manage their stocks. Excess demand products given during periods when products could not be reached caused both cost and storage space shortages in stocks. It is seen that industrial automation representative companies in our country generally focus on sales processes and allocate limited space for storage processes. The fact that fast delivery is an important factor in competition requires logistics activities to be carried out with maximum efficiency in a limited area. This study focuses on order picking processes, which are the most critical in terms of labor and cost in warehousing.

Study design/methodology/approach:
Within the scope of this study, a bibliometric and content analysis based literature review on order picking operations was conducted. For this, Scopus database was utilized. In the Scopus database, “order picking or order picking operation”, “warehouse”, “optimization or efficiency” keywords and query structure were used to identify relevant studies.

Findings:
As a result of the query, 3,192 studies were obtained. However, since our study focuses on order picking, 477 studies were obtained by restricting the search criteria to search the order picking query only in the main titles and bibliometric analysis was performed according to these studies. In the analysis, it was seen that the studies on order picking started to increase as of 2008, especially in 2020-2021-2022, the pandemic period when

the importance of the supply chain issue came to the fore, and it was determined that the top three countries that published the most studies were China with 94 studies, Germany with 79 studies and the United States with 69 studies. When we look at the results of the analysis of keywords, it can be said that the majority of the studies are clustered in warehousing and order picking.

Originality/value:
It is thought that this study will give direction to researchers conducting research on order picking methods in warehouses.

KEYWORDS
Order picking, order picking operation, warehouse, optimization or efficiency.

BIBLIOMETRIC ANALYSIS OF STUDIES IN INTERNATIONAL TRADE: 2000-2023

Cüneyt Çatuk
Sirnak University

ABSTRACT:

In this study, a total of 20,659 studies published in the Web of Science (WOS) database between 2000-2023 in the field of international trade, including articles, conference papers, books, book chapters, and similar types, were examined from a bibliometric perspective. The aim was to reveal the trends and tendencies in the field over time. As a result of this study covering a 23-year period, it was determined that China is the country with the most publications in the field, the USA is the country with the most citations, the National Bureau of Economic Research (NBER) is the institution with the most citations, the Centre for Economic Policy Research is the institution with the most publications, Andrzej Cieslik is the researcher with the most publications, and Muhammad Shahbaz is the researcher with the most citations.

KEYWORDS
International trade, bibliometry, Web of Science

DESIGNING A FRAMEWORK FOR INTEGRATED SUPPLY PLANNING OF A RETAIL COMPANY

Demet Özgür-Ünlüakın, Buse Hacıbeyoğlu, Hakkı Anıl Aksoy, Uğur Bilgin

Industrial Engineering Department, Işık University, demet.unluakin@işikun.edu.tr

ABSTRACT:

Purpose:
Supply planning of a retail company is a difficult task when there are several products with seasonal sales which can be purchased from several suppliers with varying capacities. In this study, we address the optimization of the demand and production planning of a home textile retail company working with multiple suppliers so that the total cost, including production, setup, holding, shortage, capacity exceeding, is minimized.

Study design/methodology/approach:
We propose a two-step hierarchical procedure where, in the initial step, we determine the monthly demand for product families using different forecasting techniques based on the monthly sales data of the previous two years. In the second step, we construct an integrated mixed integer linear programming model to determine the optimal decisions of production, inventory and shortage amounts of each product family which is solved optimally with an exact solver. Sensitivity analyses on the cost and capacity parameters are also performed to see how their change affects the solution.

Findings:
With the help of the proposed approach, a methodological framework is enabled in the company to perform its integrated supply planning. Optimal production plans for the suppliers are achieved which is previously planned manually. Sensitivity analyses enable the company to understand the most critical model parameters so that they pay more attention to those during their supply planning operations.

Originality/value:
The proposed approach contributes to the demand and production planning of a home textile retail company and increases its operational efficiency in the supply chain. Cost minimization is achieved while ensuring a balanced supply chain operation.

KEYWORDS
Forecasting, mixed integer linear programming, supply planning, two-step hierarchical approach.

A SYSTEMATIC REVIEW OF CUSTOMER CHURN PREDICTION AND CUSTOMER SEGMENTATION PROBLEMS IN THE LOGISTICS INDUSTRY

Helin Öykü Demircioğlu, Burak Koç, Berna Şimşek, Tuncay Özcan

DHL Worldwide Express Transport and Trade Inc., helinoyku.demircioglu@dhl.com, burak.koc@dhl.com, berna.simsek@dhl.com

Istanbul Technical University, tozcan@itu.edu.tr

ABSTRACT:

Purpose:

Accurate analysis of customer behavior, dynamic detection of loyal customers and prediction of churn and non-churn customers are critical for businesses. At this point, customer segmentation and customer churn prediction can be defined as two important problems in customer analytics. This study aims to present a systematic review of literature studies on customer segmentation and churn prediction problems in the logistics industry.

Study design/methodology/approach:

A systematic and structured literature review was conducted on the problems of customer segmentation and churn analysis in the logistics industry. Literature studies from 2000 to 2024 were explored from databases using the keywords "Logistics", "Customer Churn" and "Customer Segmentation". Literature studies were analyzed using dimensions such as methodology used, data size, variables used, performance measure, country and sub-sector.

Findings:

When literature studies are examined, classification algorithms such as logistic regression, decision trees, k-nearest neighbor, random forest and XG-Boost for customer churn prediction and clustering algorithms such as k-means and fuzzy c-means for customer segmentation are widely used in the logistics sector. Literature studies on generative artificial intelligence and large language models for solving problems related to customer analytics are limited.

Originality/value:

This paper provides a systematic insight into customer segmentation and churn prediction problems in the logistics industry.

KEYWORDS

Customer analytics, Customer churn prediction, Customer segmentation, Generative AI, Logistics Industry.

OVERALL EQUIPMENT EFFECTIVENESS FOR PORT SERVICES IN LOGISTICS

Okan Aksu, Mehmet Yörükoğlu

Industrial Engineer, aksuokan@hotmail.com, mehmet.yorukoglu@toros.edu.tr

ABSTRACT:

Purpose:
This study investigates the Overall Equipment Effectiveness (OEE) for port services at PORT ABC, focusing on three critical equipment types: Ship-to-Shore (STS) Cranes, Rubber-Tired Gantry (RTG) Cranes, and Mobile Harbour Cranes (MHC).

Study design/methodology/approach:
By integrating descriptive and analytical research methods, the project evaluates the current state of OEE and identifies areas for improvement. The analysis covers the three main components of OEE: availability, performance, and quality, with detailed metrics and real-world aligned data to support findings.

Findings:
Key recommendations include the adoption of standardization, digitalization, joint training programs, and predictive maintenance strategies to enhance operational efficiency.

Originality/value:
Future directions highlight the potential of IoT, AI, ML, and advanced analytics in revolutionizing OEE monitoring and analysis, along with integrating OEE metrics into ERP, TOS, and MMS systems. The study also emphasizes the importance of automation, digitalization, and the use of autonomous equipment to maintain competitiveness in the evolving port logistics industry.

KEYWORDS
Overall Equipment Effectiveness (OEE), Port Services, Container Handling Equipment

EVALUATING THE GREEN PERFORMANCE OF THIRD PARTY LOGISTICS COMPANIES IN A SPHERICAL FUZZY ENVIRONMENT UTILIZING AN INTEGRATED AHP-ARTASI MODEL

Veysel Tatar, Berk Ayvaz

Artvin Çoruh University, Department of Maritime and Port Management, Artvin, Türkiye vtatar@artvin.edu.tr
Istanbul Ticaret University, Faculty of Engineering, Industrial Engineering, Istanbul, Türkiye bayvaz@ticaret.edu.tr

ABSTRACT:

The logistics and transportation sector exerts considerable pressure on the environment, particularly in the context of mounting environmental concerns such as global warming and air pollution attributable to greenhouse gas emissions. In view of the growing global awareness of the need for environmental protection, green supply chain management (GSCM) has recently emerged as a significant area of interest for both academic researchers and industry practitioners. In the context of global trade and increasing competition, environmental sustainability has emerged as a primary concern for logistics companies. Third-party logistics (3PL) companies must not only fulfil their responsibilities under existing environmental policies, but also develop their capabilities in green performance activities in response to their customers' proactive environmental policies. The identification of the most suitable third-party logistics (3PL) partner entails a complex and meticulous process of evaluation, whereby a multitude of criteria and potential alternatives must be taken into account. The objective of this study is to evaluate the green performance of third-party logistics (3PL) providers utilizing a multi-criteria decision-making framework. This framework integrates the Analytic Hierarchy process (AHP) and the Alternative Ranking Technique based on Adaptive Standardized Intervals (ARTASI) method within a spherical fuzzy environment. In conclusion, this study will provide managerial and theoretical implications for policymakers and executives working in this field in effectively evaluating the green performance of third-party logistics (3PL) providers.

KEYWORDS
Third-party logistics company, Green performance, Spherical fuzzy set, AHP

A REVIEW OF THE USE OF BIG DATA IN LOGISTICS PROCESSES

Uğur Erdoğan

Selçuk University, Faculty of Economics and Administrative Sciences, Department of International Trade and Finance, Konya, Türkiye, uerdogan@selcuk.edu.tr

ABSTRACT:

Purpose:
The logistics sector has been growing rapidly both in the world and in Turkey in recent years and its importance for all businesses is increasing day by day. The logistics sector is quite open to development, innovation and new technologies, especially in today's world where the volume of international trade and e-commerce is constantly increasing. Businesses that manage logistics processes are trying to stand out in competition by incorporating new technologies into their business processes. Industry 4.0 and digital transformation have particularly affected sectors such as logistics, where competition and speed are extremely important. It is seen that big data technologies that emerged with the digital transformation process are frequently used in logistics activities as in every field. Big data is seen as one of the most important technological developments in recent times, which facilitates the analysis and storage of data in many areas.

Study design/methodology/approach:
In the study, the concepts of big data and logistics are discussed and big data applications used in logistics are included.

Findings:
The fact that logistics processes generally have a complex structure and that many variables directly and significantly affect the efficiency of logistics operations has made the need for data extremely important for optimizing logistics processes. It is expected that Big Data will play a very important role in logistics processes in the future. It is seen that the importance of big data in the field of international logistics is constantly increasing and that it makes logistics processes more efficient.

Originality/value:
In this study, big data applications applied in logistics processes and research conducted in this field are examined and ideas for future studies are given.

KEYWORDS
Logistics, Big Data, Industry 4.0, International Logistics

INVESTIGATION OF THE CRITERIA AFFECTING THE SUSTAINABLE DISASTER LOGISTICS MATURITY MODEL BY DEMATEL METHOD

Ayca Özceylan, Mehmet Tanyaş

Gaziantep University, Oğuzeli Vocational School, Gaziantep 27100, Türkiye,
ozceylan@gantep.edu.tr
Maltepe University, Department of International Trade and Logistics,
Istanbul 34858, Türkiye, mehmettanyas@maltepe.edu.tr

ABSTRACT:

Purpose:
The aim of this study is to determine which criteria should be included in a maturity model developed for sustainable humanitarian logistics and to analyze the interaction between these criteria.

Study design/methodology/approach:
The criteria required for a sustainable humanitarian logistics maturity model were found both from the literature and with the help of experts in the field. The interactions between the criteria were calculated with the DEMATEL approach.

Findings:
According to the findings, a pool of nearly eighty criteria in five main dimensions was obtained. In addition to economic indicators, social and environmental factors were also found to be important for sustainable humanitarian logistics. According to the DEMATEL results, it is observed that environmental factors directly affect economic factors.

Originality/value:
The number of studies on sustainable humanitarian aid logistics and maturity models specific to this field is quite low. Accordingly, there is no scientific study that looks at the interactions of the criteria to be evaluated within the scope of the maturity model with the DEMATEL approach.

KEYWORDS
Criteria evaluation, DEMATEL, maturity model, sustainable humanitarian logistics.

A REVIEW OF 3D / 4D / 5D PRINTING APPLICATIONS FOR BIOMEDICAL SUPPLY CHAIN

Ibrahim Akben

Hasan Kalyoncu University, Faculty of Economics, Administrative and Social Sciences, Department of International Trade and Logistics,
e-mail: ibrahim.akben@hku.edu.tr

ABSTRACT:

Purpose:
The purpose of this study is to draw attention to the key roles and paradigm shift of 3D, 4D and 5D printers used in the additive manufacturing sector in the supply chain in the biomedical sector.

Study design/methodology/approach:
This study was designed as a theoretical study that includes a broad literature review on the developments and studies on the areas of use of 3D, 4D and 5D printers in the biomedical sector.

Findings:
In this field, 3D, 4D and 5D printers have the ability to produce materials such as tissues, organs, bones, prostheses and additionally medical devices and intelligent surgical robots produced in the biomedical field in a shorter time and at a lower cost. In these aspects, they will have a disruptive role on the traditional supply chains of the biomedical field.

Originality/value:
The study is considered valuable in terms of drawing attention to the changes that will occur in the supply chain and the use of 3D, 4D and 5D printers in the biomedical sector and shedding light on the theoretical and practical studies in this field.

KEYWORDS
3D Printing, 4D Printing, 5D Printing, Biomedical Applications, Supply Chain

EXPLORING THE ROLE OF ARTIFICIAL INTELLIGENCE IN SUSTAINABLE SUPPLY CHAINS: A BIBLIOMETRIC ANALYSIS

Burcu Devrim-İçtenbaş
Ankara Science University, bdevrim22@hotmail.com

ABSTRACT:

Purpose:
AI's potential contribution to sustainable SCM includes optimizing resource use, reducing waste, improving energy efficiency, and enhancing transparency in the supply chain. However, despite the growing interest, the specific ways in which AI can effectively contribute to these sustainability goals are still underexplored. This creates a need for further research to understand and harness AI's full potential in driving sustainability within supply chains. This study aims to assist researchers, industry practitioners, and academics in understanding the trends, developments, and focal points of artificial intelligence (AI) in sustainable supply chains.

Study design/methodology/approach:
A bibliometric analysis was conducted using relevant keywords to collect articles from the Web of Science (WoS) database. A total of 502 articles were obtained, but only journal articles were included, resulting in a systematic review of 330 journal articles. In the study, the VOSviewer software—which was created for bibliometric analysis—was employed.
After the articles that will be used are chosen, details are given regarding the number of papers published each year, how they are distributed, and general perspectives on the articles related to sustainable supply chain along with descriptive statistics pertaining to the research.

Findings:
The findings reveal that AI applications have become crucial in transforming supply chains into more agile and resilient systems. Key players in the area were recognized and their main contributions to the field were disclosed. Among the research findings are the evolution and interactions of the concepts throughout time, as well as a content analysis of the terms used in related studies.

Originality/value:
This study offers insights into the evolving landscape of AI applications in sustainable supply chains. It proposes a conceptual framework for adopting AI techniques in

sustainable supply chain management, aiming to balance economic, environmental, and social factors for long-term success.

KEYWORDS
Artificial Intelligence, Bibliometric Analysis, Sustainable Supply Chain, Machine Learning

ANCE OF AIRLINE COMPANIES USING DATA ENVELOPMENT ANALYSIS (DEA) AND MULTICRCOMPARING LOGISTICS PERFORMITERIA DECISION MAKING ANALYSIS (MCDA)

Aliye Gizem Doğan, Metehan Atay

Hasan Kalyoncu University , agizem.dogan@std.hku.edu.tr
Hasan Kalyoncu University, metehan.atay@hku.edu.tr

ABSTRACT:

Purpose:
This study aims to increase passenger satisfaction in airline logistics, strengthen the competitive advantage of companies and contribute to the development of more effective strategies. By employing Data Envelopment Analysis (DEA) and Multi-Criteria Decision Making Analysis (MCDA), the research seeks to comprehensively compare the logistics performance of airlines, offering insights that can be used to optimize operational efficiency.

Study design/methodology/approach:
The research begins by collecting data on airline logistics performance, covering all operational activities related to air freight. DEA is used to conduct an efficiency analysis, measuring performance in terms of operational efficiency. Subsequently, performance criteria are evaluated and ranked using MCDA. This dual approach—combining DEA's efficiency measurement with MCDA's multi-criteria evaluation—enables a thorough comparison of airline logistics performance.

Findings:
The study's findings demonstrate that both DEA and MCDA are robust and comprehensive tools for assessing airline logistics performance. DEA effectively measures efficiency, identifying areas where airlines can enhance their operational processes. MCDA complements this by ranking performance across various criteria, providing a more holistic view of the factors influencing logistics success. The insights gained from comparing the two methods offer strategic guidance for improving airline logistics performance.

Originality/value:
This study is unique in its application of both DEA and MCDA methods to evaluate airline logistics performance. By integrating these two methodologies, the research

offers a comprehensive evaluation framework that can guide airlines in refining their logistics strategies. The value of this study has the potential to increase passenger satisfaction and provide airlines with a competitive advantage in the global market.

KEYWORDS
Airline Logistics, Data Envelopment Analysis (DEA), International Trade, Logistics Performance, Multi-Criteria Decision Making Analysis (MCDA)

DEVELOPING A DIGITAL MATURITY MODEL FOR HEALTHCARE SUPPLY CHAINS

Elif Tekin, Gülçin Büyüközkan

Research Assistant, İstanbul Topkapı University, Department of Management Information Systems, eliftekin@topkapi.edu.tr
Galatasaray University, Department of Industrial Engineering, gbuyukozkan@gsu.edu.tr

ABSTRACT:

Purpose:
The objective of this study is to develop and propose a comprehensive digital maturity model specifically designed for healthcare supply chains. This model seeks to evaluate the current levels of digital maturity, identify areas requiring enhancement, and offer actionable recommendations to improve overall efficiency and effectiveness.

Study design/methodology/approach:
The study adopts a qualitative research approach to assess digital maturity. In the first stage, a comprehensive literature review was conducted on existing digital maturity models and strategies related to healthcare supply chains. This review included insights from industrial reports and existing academic literature. After the data collection, the analysis process was carried out and based on the findings, an innovative digital maturity model specifically designed for healthcare supply chains was developed.

Findings:
The developed model addresses digital maturity in healthcare supply chains within a multidimensional framework. The model details the current status in critical areas such as adoption of digital technologies, automation of processes, data management and organizational culture, and provides concrete and applicable suggestions for improvement in these areas. Thus, the challenges encountered in the digital transformation processes of healthcare supply chains are more clearly understood and strategies are developed to overcome these challenges.

Originality/value:
This study introduces a unique model for assessing digital maturity and enhancing healthcare supply chains, filling a gap in existing literature. Drawing insights from various sectors, this model offers a strategic framework to effectively manage digital transformation in healthcare, maximizing benefits and addressing challenges.

KEYWORDS
Digital Maturity Model, Healthcare Supply Chain, Digital Transformation, Technology Adoption.

AN MCDM APPROACH TO PRIORITIZE ERGONOMIC CRITERIA FOR OPTIMAL EXOSKELETON SELECTION IN WAREHOUSE LOGISTICS

Şura Toptancı

Eskişehir Technical University, Faculty of Engineering, Department of Industrial Engineering, 26555, Eskişehir, Türkiye, sani@eskisehir.edu.tr

ABSTRACT:

Purpose:
In warehouse logistics, manual material handling tasks pose serious ergonomic challenges and injury risks for workers. One way to mitigate these risks and alleviate strain on the musculoskeletal system is to utilize exoskeleton technology. Exoskeletons are considered to have the potential to increase the physical capacity of workers, reducing fatigue and absenteeism during long-term work. However, it is also accepted that they can increase existing ergonomic problems or cause new ones. For these reasons, the exoskeletons must be designed according to the requirements of the work and ergonomic criteria. In this process, each criterion addressed may not have the same importance. Accordingly, this study aims to define ergonomic criteria to evaluate the potential of exoskeletons to alleviate the difficulties experienced in warehouse logistics tasks and to determine the importance of these criteria.

Study design/methodology/approach:
In the study, the ergonomic criteria were determined by utilizing the guidelines published within the Exo@work project and the literature. These criteria were prioritized by taking the opinions of two occupational safety experts and an industrial designer and using a new Multi-Criteria Decision-Making (MCDM) method, the Criteria Importance Assessment (CIMAS) method.

Findings:
The results of this study revealed the importance ranking of the criteria affecting the ergonomic performance of exoskeletons for warehouse logistics. This ranking can guide the decisions to be taken in the design and evaluation process of exoskeletons for warehouse logistics under scarce resources.

Originality/value:
This study contributes to designers and manufacturers to meet ergonomic expectations in the design of exoskeleton technology for warehouse logistics, adopt a more analytical approach to evaluation, select the optimal exoskeleton by optimizing the experience of

workers, and increase productivity and worker health and safety by considering the requirements and challenges specific to warehouse logistics. This study also introduces the CIMAS method to the logistics and ergonomics literature.

KEYWORDS
Ergonomics, Exoskeletons, Logistics, Manual material handling, Multi-criteria decision-making.

DIGITALIZATION AND SUSTAINABILITY: LOGISTICS STRATEGIES IN SMART CITIES

Emre Türkmen, Ayberk Soyer

Istanbul Technical University, Department of Industrial Engineering,
turkmenemr@itu.edu.tr, ayberk@itu.edu.tr

ABSTRACT:

Purpose:
This article explores the link between digitalization and environmental sustainability in smart city logistics strategies. It aims to demonstrate how advanced digital technologies enhance sustainability, efficiency, and urban resilience in logistics processes. Emphasizing smart cities, it examines the use of information and communication technology (ICT) and the Internet of Things (IoT) to optimize logistics systems, lower carbon emissions, and tackle issues from rapid urbanization.

Study design/methodology/approach:
This study investigates the impact of key technologies like the Internet of Things (IoT), big data analytics, and blockchain on sustainable logistics development. Through a thorough literature review and analysis, it examines current trends and techniques in digital logistics and environmental sustainability, offering an in-depth perspective on innovative methods in smart city logistics.

Findings:
The study reveals that incorporating digital technologies like real-time tracking, predictive analytics, and autonomous vehicles into logistics significantly boosts efficiency and reduces environmental impact. Additionally, it underscores the necessity of eco-friendly logistics practices, such as green and reverse logistics, to mitigate urban logistics' environmental effects. Overcoming technological, legal, and regulatory obstacles is crucial for the successful adoption of these sustainable methods.

Originality/value:
This article aims to broaden the discussion on intelligent city logistics by incorporating digitalization and sustainability. It offers insights on using advanced technologies to create eco-friendly logistics solutions in urban settings. Its distinctiveness lies in examining the intersection of sustainability and digital innovation within smart cities, providing practical applications for policymakers and industry experts seeking to improve urban logistics' environmental impact.

KEYWORDS
Autonomous Vehicles, Digitalization, IoT, Logistics Strategies, Sustainability, Smart Cities.

ANALYSIS OF USER EXPERIENCE IN E-COMMERCE PLATFORMS USING TEXT MINING TECHNIQUES: THE CASE OF HEPSIBURADA

Aycan Pekpazar

Samsun University, Faculty of Engineering and Natural Sciences, Department of Industrial Engineering, Samsun, Türkiye, aycan.pekpazar@samsun.edu.tr

ABSTRACT:

Purpose:
This study aims to analyze user reviews of the Hepsiburada platform on Google Play Store to gain insights into customer experience and satisfaction using Natural Language Processing (NLP) techniques.

Study design/methodology/approach:
The research examines 21,301 user reviews posted between January 2023 and August 2024. Various NLP techniques implemented in Python were applied to the dataset, including text cleaning, tokenization, sentiment analysis, word frequency analysis, and bigram analysis. Additionally, topic modeling and feature extraction techniques were employed to determine the main themes in the reviews.

Findings:
Sentiment analysis classified reviews as positive, negative, or neutral. Word frequency and bigram analyses revealed the most frequently mentioned topics and phrase patterns. Negative review bigrams helped identify key customer complaint areas. Topic modeling and feature extraction techniques determined main themes in the reviews and assessed the impact of the Hepsiburada mobile application on user experience. Results indicate that users experience significant issues with app updates, slow performance, complex user interface, excessive notifications, payment difficulties, and inadequate customer service. Technical problems, including app crashes and high ad density, were prominent. However, users praised Hepsiburada's wide product range, timely deliveries, quality customer service, and user-friendly interface features.

Originality/value:
This study provides valuable insights into how large-scale e-commerce platforms can improve user experience. It demonstrates the potential of NLP techniques in analyzing user feedback, highlighting areas where Hepsiburada needs to improve, such as customer service, payment processes, and app performance.

KEYWORDS
E-Commerce, Google Play Store, Hepsiburada, Natural Language Processing, Sentiment Analysis, User Review

SELECTION OF SUSTAINABLE SUPPLIERS IN THE FOOD INDUSTRY USING MULTI CRITERIA DECISION-MAKING METHODS

Buşra Kesici, Havva Nur Mısır, Bilge Akbulut

Duzce University, Faculty of Engineering, Industrial Engineering,
busrakesici@duzce.edu.tr, misirhavvanur54@gmail.com,
akbulut.bilge02@gmail.com

ABSTRACT:

Purpose:
The purpose of this study is to examine supplier selection for a food manufacturer in Sakarya province with a sustainability approach.

Study design/methodology/approach:
The sustainable supplier selection criteria obtained through a detailed literature analysis were weighted by using AHP (Analytic Hierarchy Process), one of the multi-criteria decision-making methods, with the help of expert opinions. Then, the criteria were ranked with TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) and COPRAS (Complex Proportional Assessment) methods. In the study, the expert opinion of experienced purchasing managers of the company was used as decision-makers. The validity and consistency of the results were tested with sensitivity analysis.

Findings:
Firstly, in the results of the pairwise comparison of the main criteria, the main criteria with the highest level of importance are quality > cost > delivery > supplier profile. In the sub-criteria comparisons, the most important sub-criteria for quality is customer satisfaction, for delivery, it is quality delivery, for cost it is price and finally for supplier profile, it is reliability. Supplier 1 was selected in the TOPSIS and COPRAS method calculations made after the weight determination.

Originality/value:
As environmental resources become increasingly valuable and limited, businesses need to identify indicators to address sustainability needs in their own operations as well as in the processes of their suppliers. Meeting these needs is vital to maintaining competitive advantages and fulfilling environmental and social responsibilities.

KEYWORDS
AHP, COPRAS, TOPSIS, Food Industry, Multi-Criteria Decision-Making, Sustainable Supplier Selection

THE TRENDS OF BLOCKCHAIN IN GREEN SUPPLY CHAIN RESEARCH: A BIBLIOMETRIC ANALYSIS

Kevser Yılmaz

ABSTRACT:

Purpose:
This paper aims to analyze and assess blockchain technology-green supply chain related literature from 2008 to 2024 using bibliometric techniques.

Study design/methodology/approach:
This article analyses 238 papers from the Web of Science and Scopus databases. In addition, bibliographic information is mapped using Bibliometrix R-Package software.

Findings:
The study revealed that the number of publications steadily increased after 2020, peaking in 2023. The country with the highest productivity is China. In addition, China has an international partnership with the United States, England, and Saudi Arabia. Additionally, "Sustainability" is the most productive journal in terms of total publications. In addition, "Blockchain technology and its relationships to sustainable supply chain management" is the most cited paper on blockchain and green supply chains. "Management", "performance" and "impact" are the most frequently used keywords.

Originality/value:
By providing a secure and transparent platform, blockchain technology offers an effective solution to track and measure the success of sustainability initiatives. Recently, however, a limited number of studies have explored blockchain and green supply chain themes. This is an area of research that needs to be further investigated in order to better understand the potential applications of blockchain technology in green supply chain management. The study explores current trends and patterns in the blockchain-related green supply chain research.Through evaluation of the journals and articles, this study aims to uncover the current state of blockchain-related green supply chain research. Ultimately, this study provides insights for researchers to understand the dynamics between blockchain and green supply chains, and offer valuable suggestions for further research.

KEYWORDS
blockchain, bibliometric analysis, green supply chain, sustainability, review

INTRODUCTION

Consumers are becoming increasingly aware of the importance of making sustainable choices, and they want to ensure that the products they buy are sustainable [1],[2]. Therefore, it is important for manufacturers to ensure that their sustainability efforts are effectively communicated throughout the supply chain, from raw material sourcing to production, packaging and distribution. Businesses must ensure that their sustainability message is accurately and effectively communicated throughout their entire supply chain [3], [4],[5].

Blockchain technology is characterized by decentralization, non-tampering, and traceability. This technology provides an effective platform for implementing sustainable practices and tracking their progress [6]. Blockchain can greatly enhance green supply chain sustainability by providing transparent and immutable records of every transaction and process [5], [7]. This ensures that all stakeholders have access to verified data, reducing the risk of fraud and increasing accountability. Furthermore, blockchain's traceability feature allows companies to track the environmental impact of their products at each stage, promoting more responsible sourcing and production practices. As a result, blockchain technology provides an effective platform for implementing sustainable practices and tracking their progress through supply chain [8], [9]. However, not many studies have explored the research about blockchain and green supply chain themes in recent years. To gain a better understanding of the impact of blockchain technology on green supply chains, more research is needed.

As a systematic approach to analyzing scientific publications, bibliometric techniques employ statistical methods of bibliography to evaluate developments in literature on a specific topic and evaluate the quality and influence of publications [10]-[13].Thus, the purpose of this study is to shed light on the following aspects of blockchain-related green supply chain research: 1) demonstrating how the number of publications has changed over time 2) evaluating the countribition of countries/territories blockchain fields related to green supply chains, 3) evaluating the performance of journals and articles, 4) to gain a deeper understanding of global hot topics through keyword and cooperative keywords relationship analysis, which contributes to the future development of blockchain and green supply chain literature and influences future research directions. As a result, the remainder of the paper can be categorized as follows. In Section 2, the author discusses the methodology of the study, while in Section 3, the author analyzes the research and discusses the findings. The final section of the paper summarizes the papers by presenting some concluding remarks pertaining to the blockchain-related research pertaining to green supply chains.

METHODOLOGY

A bibliometric approach is a method for analyzing scientific publications using statistical methods [10]. By taking into account the number of publications, citations, and impact of these publications, bibliometric techniques can provide a comprehensive analysis of a particular topic [11]. As bibliometrics analysis relies heavily on quantitative and reliable data, it is also accompanied by mathematical and statistical techniques that are used in the research process [12],[13]. It can provide insights into the structure of a given research field and can help to identify the most influential authors. Moreover, Bibliometric techniques can be used to assess the productivity of researchers. The bibliometric analysis allows researchers to better understand the current state of research in a particular field and to identify gaps. It also allows researchers to identify the most influential authors and publications in the field [14], [15].

Researchers predominantly use the Bibliometrix R-Package program that provides a comprehensive analysis of the cooperative behaviour and structure of any network, making it an invaluable tool for researchers [16]-[18]. WoS and Scopus databases are widely used by researchers as a reliable source of data for bibliometric analysis [19]-[21].

As a result, in this study, bibliometric techniques are applied to systematically assess blockchain technology on green supply chain research in order to generate a thorough and objective assessment of the field. To this end, this study explores the effects of blockchain technology on green supply chain management research, providing a scientific and unbiased overview of the field.

TABLE 1
Methodology of the Research

Type of analysis	Qualitative and quantitative
Period of analysis	01.01.2008-10.08.2024
Search engines	Web of Science and Scopus
Query string	“blockchain” and "green supply chain"
First Result	463 Papers (225 papers from WoS and 238 papers from Scopus)
Elimination of Duplicate Study	123 papers were eliminated.
Exclusion criteria	Elimination of papers which title, keywords and abstracts, did not indicate the concentration on the blockchain technology on green supply chain research (102 papers eliminated)
Final Result	238 papers were picked for further analysis.

The summary of the methodology is given in the Table 1. Data collection is the first stage of this analysis. All data of this study was collected on 10 August 2024 from the Web of Science and Scopus databases, which are two highly respected and widely used databases [22]-[24].

Later, a query string was created (see Table 1) by using the “blockchain” and "green supply chain" keywords and entered the search area. The initial result was 463 papers.

After, duplicated studies were eliminated (N:123). Then, the title, keywords, and abstracts of the remaining studies were appraised to find the correct publications concentrating on the topic and 102 papers were removed from sample. After the all elimination process, The remaining 266 studies were picked for further analysis and the Bibliometrix R-Package program was used as analyze tool.

ANALYSIS AND DISCUSSIONS

Characteristics of Publications

Table 2 displays some characteristics of the assess blockchain technology-green supply chain related articles between 2018 to 2024. Additionally, Figure 1 clearly illustrates the total number of articles published during 2018-2024. These results indicate a few studies about the topic between 2018 and 2019. After 2019, the number of publications on blockchain technology-green supply chain increased incrementally between 2020-2022 and peaked in 2023.

TABLE 2
Characteristics of publications between 2018-2024

Year	Publication Number	Total Citation	Total Citation per Paper
2018	13	576	44,31
2019	14	2637	188,36
2020	25	1724	68,96
2021	35	918	26,23
2022	63	1637	25,98
2023	108	845	7,82
2024	82	81	0,99

Moreover, papers published in 2019 have the highest total citation and per paper value. The result indicates that these studies are essential for new researchers and create the backbone of the literature. By examining the total number of citations per paper in 2020, it is clear that citations gradually decreased with the increase in publications.

Contribution of Countries/Territories

Figure 2 shows the world map of collaboration. This Figure shows the geographical distribution of blockchain technology-green supply chain articles using the R-package tool based on authors' addresses. The higher the intensity of blue, the higher the total publication, and grey indicates no publication at all. The lines indicate a strong correlation between the number of publications and the number of collaborations between countries. Therefore, the map shows that China is the most productive country. Following China, U.S.A., Australia, Brazil, India, Saudi Arabia and Egypt. When the colloabaration between countries are examined, China has the collobaration between U.S.A., England and Saudi Arabia.

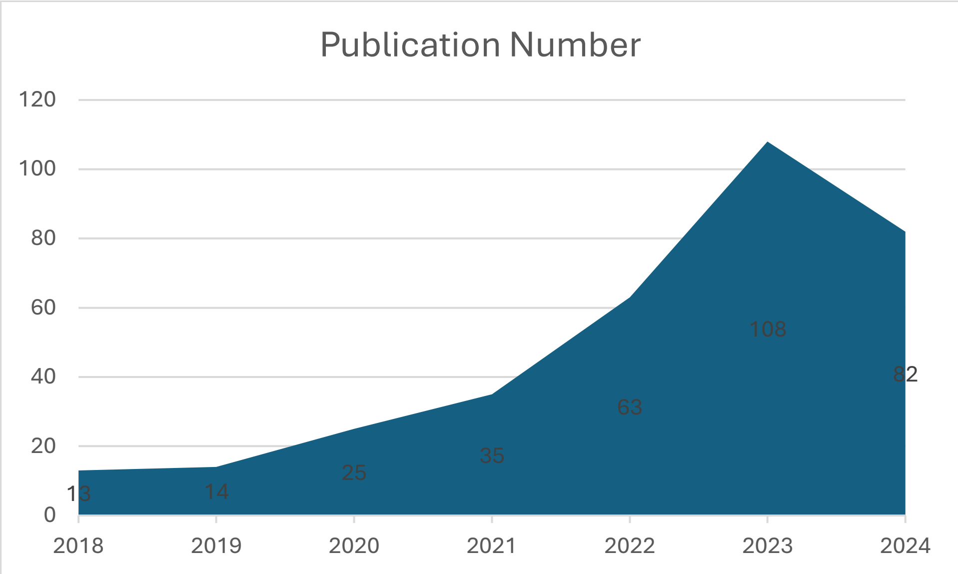

FIGURE 1
The annual number of publications during 2018-2024

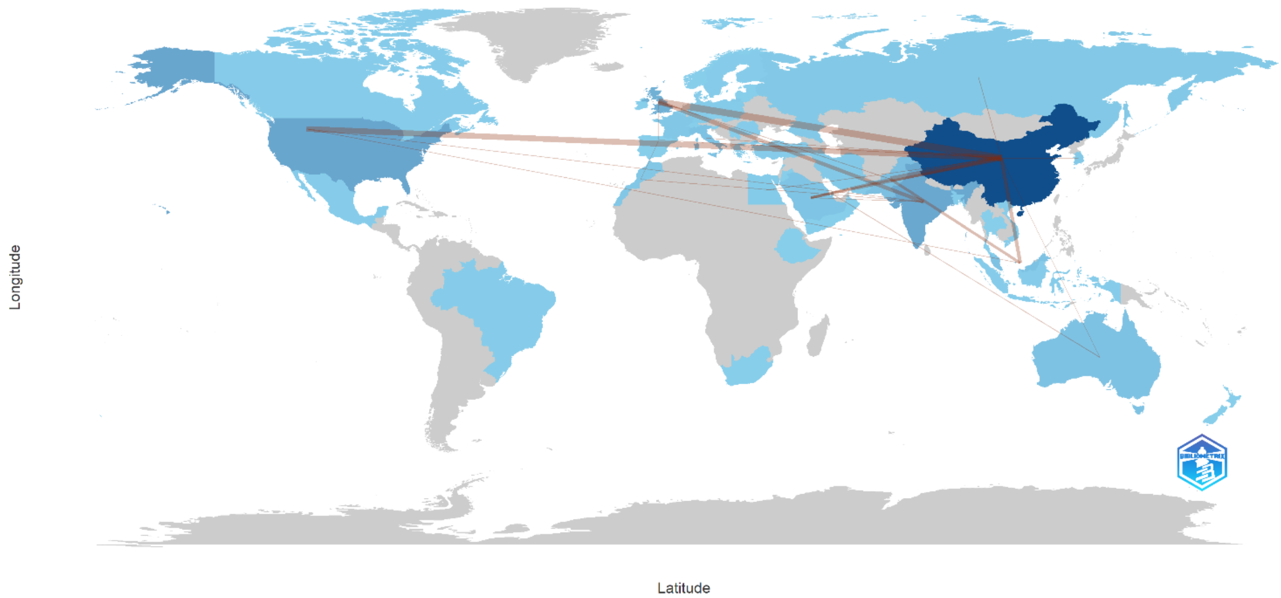

FIGURE 2
Country Collaboration Map

Journal Distribution

Table 3 shows the top 10 productive journals and conference from 2018 to 2024 in the blockchain technology and green supply chain related studies. Approximately 29% of the this topic is published in the top 10 journals and conference. Sustainability is the most productive journal with 19 articles, followed by Journal of Cleaner Production (8). Annals of Operations Research (7), Computers \& Industrial Engineering (7) and IEEE 2018 International Congress on Cybermatics (7) are ranks 3rd in the number of publications.

Table 3
The Top 10 most productive journals

Journal Name	Number of Published Articles
Sustainability	19
Journal of Cleaner Production	8
Annals of Operations Research	7
Computers \& Industrial Engineering	7
IEEE 2018 International Congress on Cybermatics / 2018 IEEE Conferences on Internet of Things, Green Computing and Communications, Cyber, Physical and Social Computing, Smart Data, Blockchain, Computer and Information Technology	7
Transportation Research Part E-Logistics and Transportation Review	5
IEEE Access	4
International Journal of Production Research	4
Management of Environmental Quality	4
Product Lifecycle Management: Green and Blue Technologies to Support Smart and Sustainable Organizations	4

Moreover, Figure 3 is indicates journals’ productivity based on the year. According to this figure, The number of publications of the Sustainability journal has been significantly increased since 2019 and it can be most productive journal in 2024. Following the Sustainability, publication number of the Journal of Cleaner Production has been significantly increased since 2019.

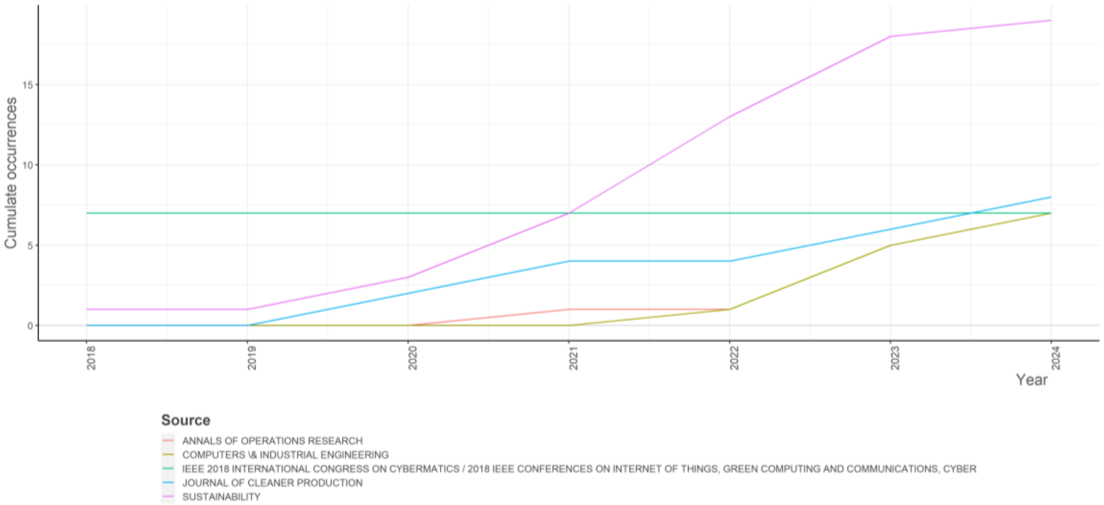

FIGURE 3
Top 5 Journals’ Production over Time

The most frequently cited articles

Table 4 indicates the top 10 highly cited articles in blockchain technology related green supply chain with the total citations for 2018-2024. Reading these articles will give researchers a more comprehensive understanding of the blockchain and green supply chain field, allowing them to make better decisions and further research.
Among the all publications, article whose name is "Blockchain technology and its relationships to sustainable supply chain management" is the most cited paper about blockchain and green supply chain field. The article "Blockchain technology for enhancing supply chain resilience" is rank as second and "Blockchain for the future of sustainable supply chain management in Industry 4.0" is rank as third based on the total citation. When the analyze the total citation per year, first rank is the same, however, "Blockchain for the future of sustainable supply chain management in Industry 4.0" article is rank as second and "Applying blockchain technology to improve agri-food traceability: A review of development methods, benefits and challenges" is rank as third.
Table 4
Most Frequently Cited Articles

Author	Publication Year	Paper Name	Journal Name	Total Citations	TC per Year
Saberi, S., Kouhizadeh, M., Sarkis,	2019	Blockchain technology and its relationships to sustainable	International journal of production research	1519	253,17

J., & Shen, L. [25]		supply chain management			
Min, H. [26]	2019	Blockchain technology for enhancing supply chain resilience	Business Horizons	402	67,00
Esmaeilian, B., Sarkis, J., Lewis, K., & Behdad, S. [5]	2020	Blockchain for the future of sustainable supply chain management in Industry 4.0	Resources, conservation and recycling	354	70,80
Feng, H., Wang, X., Duan, Y., Zhang, J., & Zhang, X. [8]	2020	Applying blockchain technology to improve agri-food traceability: A review of development methods, benefits and challenges	Journal of cleaner production	340	68,00
Kouhizadeh, M., & Sarkis, J. [27]	2018	Blockchain practices, potentials, and perspectives in greening supply chains	Sustainability	302	43,14
Gurtu, A., & Johny, J. [28]	2019	Potential of blockchain technology in supply chain management: a literature review	International Journal of Physical Distribution & Logistics Management	141	23,50
Rehman Khan, S. A., Yu, Z., Sarwat, S., Godil, D. I., Amin, S., &	2022	The role of block chain technology in circular economy practices to	International Journal of Logistics Research and Applications	137	45,67

Shujaat, S. [29]		improve organisational performance			
Tang, Y. M., Chau, K. Y., Fatima, A., & Waqas, M. (2022) [30]	2022	Industry 4.0 technology and circular economy practices: business management strategies for environmental sustainability	Environmental Science and Pollution Research	135	45,00
Khan, S. A. R., Godil, D. I., Jabbour, C. J. C., Shujaat, S., Razzaq, A., & Yu, Z. [7]	2021	Green data analytics, blockchain technology for sustainable development, and sustainable supply chain practices: evidence from small and medium enterprises	Annals of Operations Research	133	33,25
Kouhizadeh, M., Sarkis, J., & Zhu, Q [31]	2019	At the nexus of blockchain technology, the circular economy, and product deletion	Applied Sciences	125	20,83

Research Hotspots

By analyzing authors' keywords, researchers can find out what research priorities and interests they have, as well as what's trending [19],[20]. This figure 4 provides readers with a comprehensive overview of the most frequently mentioned keywords, allowing readers to quickly identify the most important topics. Consequently, Figure 4 represents the dominant topics and subtopics of articles related to blockchain technology and green supply chains. More frequently used keywords have bigger font sizes. Based on the keyword analysis, management tops the list with 42 keywords, followed by performance (32 keywords), impact (29 keywords), technology (26 keywords), and challenges (22).

FIGURE 4
Most Frequently Used Keywords

Thematic maps are enable identification of different themes within a domain using keywords. This thematic map (Figure 5) provides a visual representation of the research areas, highlighting the most important trends in the field. Clusters of keywords are represented by bubbles. On the basis of their co-occurrence, their names are the most relevant keywords. In the thematic map, centrality is represented by the position of the bubble along the horizontal axis, with themes placed towards the right being more central and important. Density, on the other hand, is depicted by the vertical position of the bubble, with higher placement indicating more advanced and well-developed themes.

This thematic map allows for a quick assessment of the significance and maturity of various research themes. Thus, emerging topics of significance in the area be placed within the motor themes area. This is provide a comprehensive overview of the domain, allowing researchers to identify potential areas of research. In addition, it enabled them to see how the themes were connected and which of them were the most important. In this study, four different motor themes are found: (1) performance, impact, sustainability, (2) investment, online, manufacturing, (3) empirical evidence of the art,

(4) management, technology, challenges. The other themes on the map are indicates unmature topics or gaps in the study area.

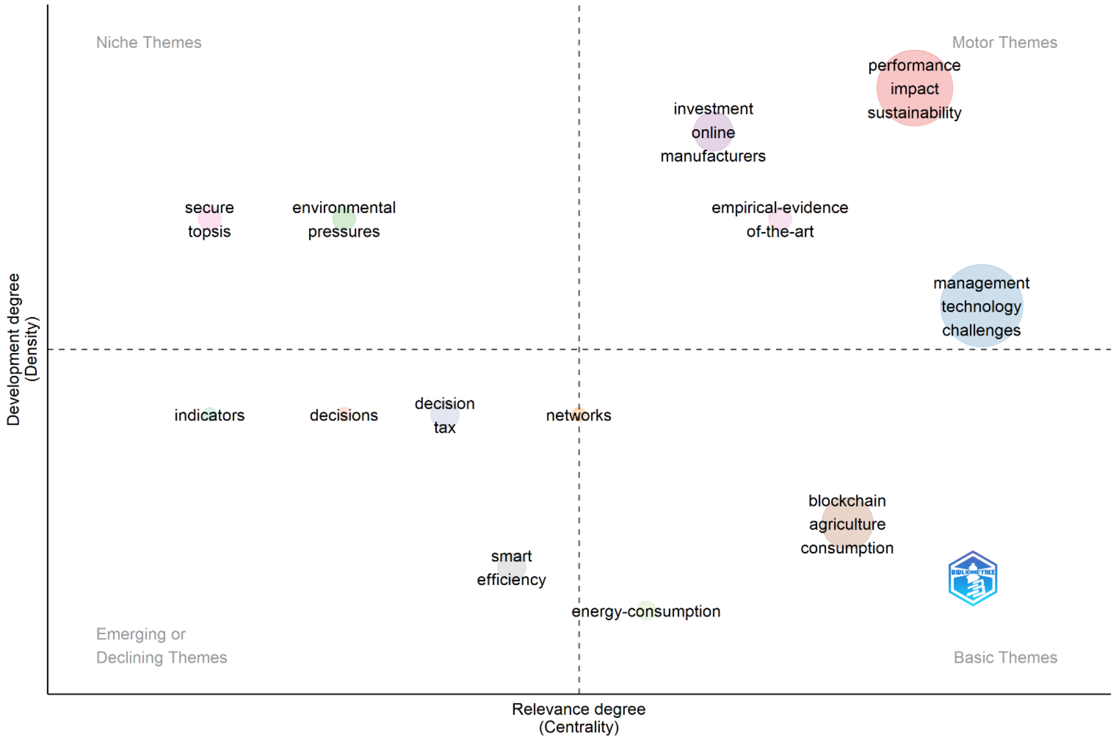

FIGURE 5
Thematic map of the degrees of relevance (centrality) and development (density).

CONCLUSIONS

Bibliometric techniques provide an invaluable tool for assessing the impact of publications, helping researchers make informed decisions about their work. Furthermore, this type of analysis can provide insights into the current trends in the research field and can help to identify potential areas for further research. This technique can also identify influential authors and researchers in the field, providing a resource for researchers to identify potential collaborators and mentors. By providing a comprehensive literature review and in-depth analysis of relevant research topics, this study aims to fill the gaps in our understanding of blockchain technology and green supply chains.

Based on bibliometric techniques, the purpose of this study is to analyze and assess the literature related to blockchain technology and green supply chains from 2008 to 2024. Based on the Web of Science and Scopus databases, this article analyzes 238 publications. Furthermore, bibliographic data is mapped using the R-Package software. Based on the results of the study, the number of publications increased steadily after 2020, peaking in 2023. China is the country with the highest productivity. Further, China has partnerships with the United States, England, and Saudi Arabia. Also, in terms of total publications, "Sustainability" is the most productive journal. Furthermore, the paper "Blockchain technology and its relationships to sustainable supply chain management" has been cited most frequently. "The most frequent keywords are "management", "performance", and "impact".

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THE IMPACT OF THE U.S. TECHNOLOGY DECOUPLING FROM CHINA ON INTRA-INDUSTRY TRADE BETWEEN THE U.S., CHINA AND NAFTA

Ayfer Ustabaş, Gülçin Elif Yücel

İstinye University, ayfer.ustabas@istinye.edu.tr
Beykent University, elifyucel@beykent.edu.tr

ABSTRACT:

Purpose:
The United States has pursued a range of policies aimed at loosening its economic ties with China, including restructuring supply chains, imposing export controls, and incentivizing domestic producers. Despite the U.S. efforts to diversify its supply chains by engaging Southeast Asia and other alternative regions, the trade volume between the two countries remains robust and China's central role in global production networks persists. This paper examines the impact of the U.S. decoupling strategy from China on intra-industry trade among the U.S., China, Mexico and Canada for the period of 2007-2023.

Study design/methodology/approach:
In the study, the U.S. manufactured trade with China, Mexico and Canada has been examined. The Grubel-Lloyd index (GLI) and harmonized system 6-digit trade statistics of World Bank supported software have been utilized to calculate the intra-industry trade.

Findings:
The findings of this study assess the limited effects of decoupling on intra-industry trade between the U.S. and China, despite the United States' attempts to reduce its strategic dependence on China. Another result of the study indicates the rising ratio of intra-industry trade between the U.S. and Mexico.

Originality/value:
The study analyzes the evolution of the U.S. trade relationships with China and NAFTA from the perspective of intra-industry trade with a special focus on manufacturing industry. Our findings may have various implications for policy makers to build new and more resilient growth patterns of foreign trade amidst increasing uncertainty.

KEYWORDS

China, Decoupling, Geopolitical competition, Supply chains, Trade war, Technology competition, United States

APPLICATION OF DISCRETE-EVENT SIMULATION ON A CIVIL REGISTRY OFFICE

Elif Doğru, Şura Canik, Sena Solak, Ezgi Güven, Nadi Serhan Aydın

Elif Doğru Istinye University, Industrial Engineering Student, elif.dogru@stu.istinye.edu.tr
Şura Canik Istinye University, Industrial Engineering Student, sura.canik@stu.istinye.edu.tr
Sena Solak Istinye University, Industrial Engineering Student, sena.solak@stu.istinye.edu.tr
Ezgi Güven Istinye University, Industrial Engineering Student, ezgi.guven@stu.istinye.edu.tr
Asst. Prof. Nadi Serhan Aydın, Istinye University, serhan.aydin@istinye.edu.tr

ABSTRACT:

Purpose:
This paper aims to reduce congestion and long waiting times at a civil registry office in Istanbul, enhancing system efficiency by analyzing factors influencing queue length and waiting times. By employing discrete-event simulation, the study seeks to identify and address system constraints, improve service quality and maximize customer satisfaction. Alternative scenarios are tested using simulation modeling techniques such as control variables to facilitate daily operations and ensure service sustainability.

Study design/methodology/approach:
A pre-assessment table was first prepared to evaluate the system components and confirm its suitability for simulation modeling. Process flow diagrams and layout charts were constructed to provide detailed system insights. Performance metrics were defined, forming the basis for the system design. A conceptual model was then created, focusing on factors influencing the system's output. Using Simio software, a 3D simulation model of the office was developed to test scenarios and assess performance. Verification and validation processes ensured the model's accuracy and consistency with real-world data. SMORE plots and the Bonferroni approach were applied to evaluate multiple confidence intervals for scenario comparison.

Findings:
The analysis indicates that enhancing the capacity of the receipt vending machine or incorporating additional servers could effectively diminish queue length and waiting periods, thereby optimizing process flow and customer satisfaction.

Originality/value:

This study is distinctive in that it applies discrete-event simulation to a civil registry office system, thereby offering original insights into the potential for enhancing public service efficiency.

KEYWORDS
Civil Registry Office, Discrete-Event Simulation, Optimization, Public Services, Queueing System, Simulation Modeling

EVALUATION OF THE EXPECTED COMPETENCIES OF VOLUNTEERS WORKING IN HUMANITARIAN LOGISTICS WITHIN THE FRAMEWORK OF LITERATURE

Salih Doğru, Iskender Peker

Gümüşhane University, salihdogruakademi@gmail.com
Gümüşhane University, iskenderpeker@gumushane.edu.tr

ABSTRACT:

Purpose:
The purpose of this study is to determine the competencies and criteria expected to be possessed by volunteers working in humanitarian logistics in disaster situations in order to increase their effectiveness and efficiency within the framework of the literature.

Study design/methodology/approach:
This study, based on a general literature review, aims to provide standards or criteria related to humanitarian logistics and disaster volunteering by conducting a descriptive research on the concept of humanitarian volunteer/disaster volunteer. In this context, research was conducted on the Web of Science (WOS) and Scopus databases.

Findings:
As a result of the literature review, certain characteristics are expected for volunteers to be effective and productive in times of disaster. It is especially recommended that they have knowledge, skills, teamwork, leadership, motivation, psychological resilience and empathy. In general, individuals who can take responsibility and are experienced are expected to volunteer.

Originality/value:
Unplanned and inexperienced volunteer participation in disaster situations leads to complications such as health and safety problems. It is also known that they lose their lives due to the lack of equipment. Despite everything, it is inevitable to minimize the loss of life and property with a planned, educated and effective volunteer source. With our study, it is suggested that standards related to volunteering be formed in the field of disaster volunteering, which is not yet included in the literature. In this way, it is expected to form a basis for new studies to be conducted on volunteer criteria.

KEYWORDS

Disaster Volunteer, Volunteer Criteria, Humanitarian Logistics, Disaster Volunteer Competencies.

MCDM METHOD EVALUATION OF DISASTER PARK POTENTIAL IN GÜMÜŞHANE

Nurcan Şimşek, Iskender Peker

Gumushane University, nurcansimsek@gumushane.edu.tr
Gumushane University, iskenderpeker@gumushane.edu.tr

ABSTRACT:

Purpose:
Public open spaces act as second cities during the post-disaster intervention and recovery phases, playing an important role in meeting the basic needs of disaster victims such as nutrition, shelter and medical assistance. Disaster parks are being built in public open spaces in order to minimize the negative effects of disasters in the world and in our country. While disaster parks are used for recreational purposes before a disaster, they are multifunctional public open spaces where life resumes after a disaster, where functions such as temporary shelter, logistics base, coordination and center are maintained. This study was carried out to evaluate the possibility of transforming parks in Gümüşhane province into disaster parks.

Study design/methodology/approach:
Our study consists of two stages. In the first stage disaster park location selection criteria were determined by a comprehensive literature research and the importance level of the criteria and the interaction network between them were determined by the DEMATEL method. In the second stage parks in Gümüşhane were observed on-site and examined in terms of interior architecture and equipment and Atatürk Park, Sema Doğan Park and Mimar Sinan Park, which were determined as alternatives, were evaluated using the ARAS method.

Findings:
As a result of this evaluation, water source, sanitation and security were determined as the most important criteria and Sema Doğan Park was determined as the most suitable area in terms of area and equipment. In relation to the study, it was concluded that the parks in Gümüşhane had deficiencies in terms of area, security and equipment and that disaster parks should be established in safer areas.

Originality/value:
Gümüşhane province is a region that has the potential to be affected by major earthquakes that may occur on the North Anatolian Fault Zone (NAFZ) due to its

proximity to this zone. There are a limited number of parks that can be used as gathering and shelter areas after a disaster in the mountainous region. When the studies on disaster parks in the literature are examined, it is seen that parks have not been evaluated in terms of disaster management in Gümüşhane province and their potential to be transformed into disaster parks has not been addressed. With this study, the deficiencies of the parks in the city will be determined and urban resilience will be increased.

KEYWORDS
Disaster Park, Disaster Logistics, Public Open Space

DRIVER-RELATED ISSUES IN LOGISTICS: A STUDY ON FACTORS AFFECTING TRUCK DRIVERS' JOB SATISFACTION AND PERFORMANCE

Aylin Çalışkan, Cansu Akçiçek, Yücel Öztürkoğlu

Yasar University, Department of Business Administration,
aylin.caliskan@yasar.edu.tr
Yasar University, Graduate School, cansu.akcicek@yasar.edu.tr
Yasar University, Department of Logistics Management,
yucel.ozturkoglu@yasar.edu.tr

ABSTRACT:

Purpose:
Logistics service providers are crucial in the service sector, aiming to survive under high costs while increasing performance and profitability by minimizing human errors. This study has two purposes; to identify driver-related problems in logistics sector and to determine the factors affecting job satisfaction and job performance of truck drivers.

Methodology:
An extensive literature study was conducted to determine the factors affecting job performance of truck drivers. In order to test these factors, a focus group study was conducted with managers of three different leading companies in the sector. Based on these discussions, survey questions were developed and distributed to truck drivers. Finally, factor analysis was conducted with the collected data and followed by regression analysis to measure the effect of each variable on job satisfaction and performance.

Findings:
In the light of the analysis, six main factors were identified: health, operations, senior management, compensation, job satisfaction, and performance. The results of the regression analysis showed that operation, top management, health and payment factors directly and significantly affect job satisfaction of truck drivers, explaining 58% of its variance. Operation and health factors have been found to have a significant impact on business performance, explaining 32% of its variance.

Originality:
While a lot of studies have focused on truck drivers from logistics service providers, few have examined job satisfaction related to long commutes and heavy working conditions. This study is the first to include both white-collar and blue-collar

employees, providing a roadmap for company managers based on its comprehensive findings.

KEYWORDS
Truck drivers, job satisfaction, job performance, factor analysis, regression analysis

A RESEARCH ON DETERMINING NEED SCORES THAT CAN BE USED IN SOCIAL ASSISTANCE PROCESSES: APPLICATION OF NOMINAL GROUP TECHNIQUE

Iskender Peker, Gokhan Çaybaşi, Birdoğan Baki, Ismail Erol, Mehmet Tanyas, Mustafa Bilgehan Imamoglu, Gulsah Ayvazoglu, Suleyman Ertemoğlu

Gumushane University, iskenderpeker@gumushane.edu.tr
Erzincan Binali Yildirim University, gokhan.caybasi@erzincan.edu.tr,
Karadeniz Teknik University, bbaki@ktu.edu.tr
Baskent University, ierol@baskent.edu.tr
Maltepe University, mehmettanyas@maltepe.edu.tr
Karadeniz Teknik University, bilgehan@ktu.edu.tr
Hatay Mustafa Kemal University, gulsahayvazoglu@mku.edu.tr
Gumushane University, suleyman.ertemoglu@gumushane.edu.tr

ABSTRACT:

Purpose:
In this study, a research was conducted to determine the requirement score that can provide a more transparent structure in social assistance processes. In this direction, the main purpose of the study is to determine and prioritize the criteria that can be effective in the formation of the requirement score by Nominal Group Technique (NGT).

Study design/methodology/approach:
NGT is a systematic, guided approach to group decision-making that produces and ranks ideas in a group setting. By allowing everyone to participate and rank ideas, it makes to contributions organizations to investigate an issue fairly. For this purpose, two different NGT sessions were held. In the first session, fourteen criteria were determined by taking into account the preliminary assessment form used by the Social Assistance and Solidarity Foundations to determine people in requirement. In the second session, the weighting of these criteria was carried out. NGT sessions were held with an expert group consisting of academics working in the relevant field and an expert working in the Social Assistance and Solidarity Foundation.

Findings:
The results show that the following factors should be taken into account when calculating the requirement score: monthly income, total amount of aid received, number of in-kind aid, number of household members the person is required to care for,

disability status, and chronic diseases. Furthermore, it was found that the two most crucial factors were the overall amount of aid received and the quantity of in-kind aid.

Originality/value:
One could argue that it is difficult to determine who exactly qualifies of the poverty in in the nations. Different factors are taken into consideration when evaluating in requirement by organizations such as the Red Cross, the Social Assistance and Solidarity Foundation, municipalities, and others. This hinders the development of a comprehensive strategy. The study in question adds to the pertinent literature by starting the process of coming to an agreement on the criteria and offering a comprehensive method for figuring out the requirement score

KEYWORDS
Social relief, Requirement assessment, Donation distribution, Vulnerability scoring

EVALUATION OF HUMANITARIAN AID ACTIVITIES DURING THE FEBRUARY 6, 2023 KAHRAMANMARAŞ EARTHQUAKES USING THE SIX THINKING HATS TECHNIQUE

Gülşah Ayvazoğlu, Gülçin Büyüközkan

Hatay Mustafa Kemal University, gulsahayvazoglu@mku.edu.tr
Galatasaray University, gbuyukozkan@gsu.edu.tr

ABSTRACT:

Purpose:
This study aims to assess the effectiveness and areas for improvement in humanitarian aid activities following the February 6, 2023 earthquakes centered in Kahramanmaraş, using the Six Thinking Hats technique. The goal is to identify the strengths and weaknesses of the aid processes, particularly in areas such as planning, logistics, and organization, through analysis from multiple perspectives.

Study design/methodology/approach:
Humanitarian aid processes were evaluated using the Six Thinking Hats technique. This included analyzing the processes from the viewpoints of the blue, green, yellow, black, red, and white hats. The blue hat focused on general planning and organizational shortcomings, while the green hat proposed creative solutions and technological innovations. The yellow hat emphasized the positive aspects and opportunities, and the black hat highlighted risks and problems. The red hat explored emotional responses and insights, and the white hat provided concrete data and facts.

Findings:
As a result of the evaluations, it was emphasised that the most important problem was the lack of coordination and that technology should be used effectively in disaster management and humanitarian aid processes. Planning and logistics challenges were identified, while the contribution of volunteers was recognized as a significant advantage. However, inequalities in aid distribution and logistical processes were observed. The importance of accurate information sharing and the need for psychological support for those in the affected areas were also emphasized.

Originality/value:

This study, as the first study to evaluate humanitarian aid activities after the 6 February 2023 Kahramanmaraş earthquakes from six different perspectives, reveals the aspects of the process that can be improved. The insights provided by the various thinking hats will contribute to the development of new approaches to humanitarian aid processes and help produce more effective solutions in disaster management.

KEYWORDS
Humanitarian logistics, Six Thinking Hats technique, 6 February earthquakes

DETERMINATION OF THE IMPACT OF THE ASSOCIATE DEGREE PROGRAM IN TRANSPORTATION SERVICES ON BUSINESS LIFE

Ramazan Eyüp Gergin, Aslı Inci
gergin@gumushane.edu.tr, asliinci1999@icloud.com

ABSTRACT:

Purpose:
Considering the place of the transportation services sector in daily life and the role it plays in extraordinary situations, the expectations of personnel in the transportation services sector become a strategic issue for the institutions of transportation services. Due to this importance, the main purpose of this study is to determine the impact of the transportation services associate degree program on business life.

Study design/methodology/approach:
For the purpose of the study, integrated Analytic Hierarchy Process (AHP)-Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) method were used with integrated to determine the impact of the transportation services associate degree program on business life. For this purpose, firstly, the main and sub-expectations of the transportation services department associate degree program graduates were determined via the literature research and the opinions of the expert group in the study. After, the importance weights of the expectations that affecting the transportation services associate degree program on business life were calculated with the AHP method. Finally, the workplaces determined as alternatives were evaluated via utilizing TOPSIS method.

Findings:
The results of the performed application showed that the "Motivational Expectations" are the most important main expectation for the transportation services department associate degree graduates. In addition, the Alternative workplace of the 13th. has been identified as the best workplace in the way of meeting the expectations of transportation services department associate degree graduates within the alternative workplaces in the study.

Originality/value:
This study, which was conducted for determine the impact of the transportation services associate degree program on business life, uses quantitative methods for the first time in terms of methodology. Also, the first study to evaluate the business lives of students

who graduated from the transportation services program after graduation, which constitutes the another original value of the study.

KEYWORDS
AHP, Business Life, TOPSIS, Transportation Services.

SERVICE QUALITY AND ASSIGNMENT RELATIONSHIP AT MARITIME TRANSPORTATION

Hakan Görgün

Maltepe University, h.gorgun@yasashipping.com

ABSTRACT:

Purpose:
The seafarers are being hired via fixed term employment contracts in maritime industry. So, they are being replaced with others frequently. This situation creates a problem for the companies to provide a good service for transportation at a consistent base. Because, and especially the management level crew combination plays a crucial role for each vessel in terms of service quality on the sea transportation process.

My purpose here is to find best option(s) of management crew assignments for the vessels on a ship management company having group of vessels working on tramp base international trade.

Study design/methodology/approach:
The study uses linear programming through Microsoft Excel / Solver to define the best option in accordance with the restrictions and resources to have a desired level of management at every vessel by proper crew assignments.

Findings:
The outcome of the study brought a solution to make best assignments to a fleet to provide a constant and similar quality level of transportation service to the customers at each vessel, and prevent significant fluctuations at the service quality levels.

Originality/value:
The study is applicable to the different combinations of logistic installations. But requires numeric values of each person, manager, truck or other source to make assignments.

KEYWORDS
Assignment, Management, Maritime Transportation, Service Quality.

SCREENING OF CRITERIA USED IN SELECTING THE LOCATION OF TEMPORARY SHELTER AREAS

Yasemin Deniz Öztürk, Iskender Peker

Artvin Coruh University, yasemindeniz17@gmail.com
Gumushane University, iskenderpeker@gumushane.edu.tr

ABSTRACT:

Purpose:
After disasters, the primary need of disaster victims is shelter and the search for safe spaces. Both during the critical moments of the disaster and throughout the recovery process, it is essential to provide tents to the victims, and later, containers or prefabricated structures. To ensure that this logistical process is carried out comprehensively, promptly, and equitably for everyone, planning must be done before the disaster occurs. Thus, the aim of this study is to conduct a literature review on studies related to the site selection of temporary shelters.

Study design/methodology/approach:
This study has conducted an in-depth examination of research on the site selection for temporary shelters that can be used after disasters, focusing on the criteria used and the methods employed.

Findings:
Based on the results obtained, it can be stated that criteria such as land slope, proximity to main roads, suitability of land use, closeness to health centers, distance from residential areas, and security are frequently used. It can also be said that these criteria align with the recommended standards for the construction of relevant areas. Furthermore, in terms of methods, multi-criteria decision-making techniques are identified as the most commonly used approaches in the selection of temporary shelter sites.

Originality/value:
Properly locating temporary shelters is vital for disaster victims. In this regard, accurately identifying the criteria and methods that can be effective in the establishment of these areas is crucial. The study aims to contribute to the literature by providing a comprehensive guide on the criteria and methods that can be effective in the selection of temporary shelter sites, potentially serving as a valuable reference.

KEYWORDS
Disaster, MCDM, Temporary shelter, Literature review, Site selection

EVALUATION OF THE POTENTIAL OF BECOMING A SAFE HOSPITAL WITH THE MCDM APPROACH

Dilber Coşkun, Iskender Peker

Munzur University, Department of Emergency Aid and Disaster Management, dilberbagdatli@munzur.edu.tr
Gumushane University, Faculty of Economics and Administrative Sciences, iskenderpeker@gumushane.edu.tr

ABSTRACT:

Purpose:
Safe hospitals are needed to improve the general health of society with emergency response and treatment in disasters and emergencies, to create a safe area in case of disaster with structural durability, to contribute to the continuity of critical resources with effective supply chain management, and to ensure that the society is more resilient to disasters by providing service continuity and emergency management. This study aims to evaluate safe hospital standards with multi-criteria decision-making methods and determine potential safe hospitals.

Study design/methodology/approach:
A two-stage model was adopted in this study. First, safe hospital criteria were created based on the literature review and the guide published by the World Health Organization, and the importance levels of the criteria and their effects on each other were determined by DEMATEL (The Decision Making Trial and Evaluation Laboratory) technique. In the second stage, three hospitals with similar scales were selected and these hospitals were ranked in terms of their potential to be safe hospitals using the TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) method.

Findings:
The findings showed "Disaster and Emergency Management" as the most important criterion, while "Non-Structural Safety" was the least. The safest hospital had low risk, high structural integrity, and strong disaster management.

Originality/value:
This study is expected to contribute to the creation of safe hospitals against emergencies, that resource investments can be made in appropriate areas, that an effective supply chain can be established, and that community resilience will be increased.

KEYWORDS
Safe Hospital, Disasters, MCDM, DEMATEL, TOPSIS

EVALUATION OF BARRIERS TO IMPLEMENTING DRONE IN THE LAST-MILE DELIVERY

Esra Boz

KTO Karatay University, esrayasaarr@gmail.com

ABSTRACT:

Purpose:
Since their initial development for use in aerial vehicles, drones have found applications in a variety of fields. They are becoming more widespread, particularly in the logistics industry, and this tendency is accelerating daily. Several businesses are using drones to deliver goods to customers, especially for last-mile deliveries. This study aims to analyze the barriers to using drones in last-mile delivery.

Study design/methodology/approach:
By conducting a relevant literature review, the barriers to the use of drones have been identified. During the literature review, the keywords "barrier," "drone," and "logistics" were used together.

Findings:
These barriers fall into the following categories: technological, societal, environmental, and economic. The use of drones may be impeded if these barriers are not overcome. As a result, 34 barriers have been identified and given thorough definitions.

Originality/value:
This study contributes to the literature by adding some barriers related to the use of drones in logistics, while also revealing certain research gaps identified during the literature review.

KEYWORDS
Barrier, drone, last-mile delivery, logistics

EUROPEAN UNION IMPORT CONTROL SYSTEM (ICS): CHANGES IN EXPORT CUSTOMS PROCESS FOR TURKISH EXPORTERS AND TRANSPORT COMPANIES

Yurdagül Meral
Istanbul Medipol University, ymeral@medipol.edu.tr

ABSTRACT:

Purpose:
European Union will implement Import Control System ICS for road and rail transport on 1st of April, 2025. Turkey's export volume to EU is exceeding 100billion dollars and which is transported with more than 1 million trucks through customs Kapıkule Customs gate in 2023. This study will explore what is ICS and what changes will come into force with ICS especially with exporters and logistics companies.

Study design/methodology/approach:
Method used in this system will be literature and legislation of review of the European Union Import Control System.

Findings: European Union's new legislation of Import Control System which will come in affect as of 1st April, 2025, will affect customs process of Turkish exporters exporting to EU and transport companies carrying goods to EU must take necessary precautions and be ready as of 1st April, 2025, to avoid risks and recommendations will be given how to avoid such risks.

Originality/value:
The subject itself is novel/a new legislation/application which affects Turkish Exporters, exporting to EU which is very important with nearly half of our export volume and transport companies carrying said goods to EU.

KEYWORDS
Export Import Management, International Logistics, European Union, International Risk Management, Import Control System (ICS),

EVALUATION OF SUPPLY CHAIN 5.0 REQUIREMENTS USING INTUITIONISTIC FUZZY COGNITIVE MAP METHODOLOGY

Celal Alpay Havle

Özyeğin University, Faculty of Aviation and Aeronautical Sciences, Professional Flight Program, celal.havle@ozyegin.edu.tr, celal.alpay.havle@gmail.com

ABSTRACT:

Purpose:
Rising cutting edge technologies have transformed the business world and triggered Industry 5.0 revolution. This latest revolution has revealed the significance of human centricity, resilience and sustainability. Following this, supply chains in today`s business world has undergone radical change and supply chain 5.0 concept has become popular. From this point of view, the purpose of the study is to evaluate supply chain 5.0 requirements from industry 5.0 perspective.

Study design/methodology/approach:
In this study, the requirements for human centricity, resilience and sustainability within the scope of supply chain 5.0 have been identified based on literature survey and the opinions of decision makers (DMs) who are industrial experts. Human centricity, resilience and sustainability are interrelated within the scope of industry 5.0. Therefore, the cognitive map (CM) approach has been adopted in the study. To eliminate uncertainty, human perception, complexity, intuition, and hesitation in decision-making processes, the CM approach has been expanded to the intuitionistic fuzzy (IF) environment and applied as IFCM on a real case in Turkey.

Findings:
The study revealed an interrelated IFCM model of supply chain 5.0 requirements. The values of the requirements have computed using iterative IFCM equation of the methodology and weights of the links that represents causal relationships are obtained.

Originality/value:
The study models and analyzes the requirements to be considered for supply chain 5.0 using IFCM in a case study and shows the causal relationship between the criteria.

KEYWORDS
Fuzzy Cognitive Map, Industry 5.0, Success Factors, Supply Chain 5.0

PRIORITIZING CRITICAL SUCCESS FACTORS FOR DIGITALIZATION OF FRUIT AND VEGETABLE WHOLESALE MARKETS USING FUZZY SWARA

Noyan Sebla Gunay-Sezer
sebla.sezer@istinye.edu.tr

ABSTRACT:

Purpose:
This study explores the digitalization process of fruit and vegetable wholesale markets aiming to identify critical success factors and prioritize them using a robust multi-criteria decision-making approach. By focusing on integrating automation systems for activities such as storage, transport, and packaging, this study aims to enhance operational efficiency and minimize errors in the supply chain.

Study design/methodology/approach:
A comprehensive literature review was undertaken to identify key criteria influencing the digital transformation of fruit and vegetable wholesale markets. A total of 26 criteria were identified and categorized into five groups: sustainability, digitalization, data security, security and safety, and market security. To prioritize these criteria affecting the digitalization process, the study employs the Fuzzy Stepwise Weight Assessment Ratio Analysis (Fuzzy SWARA) method. A survey was conducted with experts, and fuzzy numbers were used to analyze the responses and calculate each criterion weight.

Findings:
The study revealed the relative importance of each criterion and ranked the most critical factors influencing the digital transformation of fruit and vegetable wholesale markets. The study identified digitalization and market security criteria groups as the most critical factors. Digitalization emphasizing the importance of process optimization, effectiveness, and efficiency in transitioning to digital systems emerged as the top priority. Market security which includes wholesaler-retailer integration and marketplace strategies also receives high importance. Additionally, sustainability plays a vital role, focusing on sustainable agricultural practices and minimizing environmental impacts. These findings highlight the importance of implementing robust digital technologies, safeguarding market operations, integrating sustainable practices, and ensuring data security to achieve a successful digital transformation.

Originality/value:

This research provides a comprehensive framework for understanding the critical success factors for digitalizing fruit and vegetable wholesale markets. The study contributes to the field by offering a scientific and practical approach that can guide stakeholders in developing effective digital transformation strategies for the fruit and vegetable sector.

KEYWORDS
Fruit and vegetable markets, Digitalization, Sustainability, MCDM, Fuzzy-SWARA