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Multimodal Logistics for Resilient and Sustainable Global Supply Chains: Strategic Insights from Integrated Transport Systems

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ABSTRACT : Multimodal transportation has emerged as a critical solution for enhancing the efficiency and resilience of integrated logistics networks. This narrative review aims to synthesize current research on the effectiveness of multimodal logistics in addressing global supply chain challenges. Using a structured keyword-based search across Scopus, Web of Science, and Google Scholar, this study selected peer-reviewed literature published between 2010 and 2024. Emphasis was placed on studies focusing on cost optimization, environmental impact, digital integration, and strategic network planning. The review identifies five key dimensions—logistics cost-efficiency, crisis resilience, environmental sustainability, technological integration, and network design—as central to the performance of multimodal systems. Optimization models significantly reduce logistics costs and emissions, while real-time data and IoT systems enhance operational coordination. In crisis contexts, multimodal approaches offer adaptable responses, particularly when supported by digital infrastructure. However, challenges such as regulatory fragmentation and infrastructure disparity limit broader implementation, especially in developing regions. Synchromodal strategies and policy alignment are highlighted as critical enablers of system responsiveness and sustainability. This review concludes that strategic technological and institutional reforms are essential to unlock the full potential of multimodal logistics. Future research should explore adaptive AI-driven models and conduct cross-regional analyses to inform context-specific solutions. Strengthening digital infrastructure and fostering stakeholder collaboration will be key in developing resilient and future-ready logistics systems.

Keywords: Multimodal Transportation; Integrated Logistics Networks; Synchromodal Logistics; Supply Chain Resilience; Iot In Logistics; Green Logistics; Transportation Optimization

INTRODUCTION

In recent decades, the increasing complexity of global logistics networks has intensified the demand for innovative transportation solutions that are both efficient and sustainable. Among these, multimodal transportation systems have emerged as a vital strategy to improve the flexibility and responsiveness of freight logistics. Multimodal transportation refers to the use of two or more

modes of transport—such as road, rail, air, and sea—within a single integrated system, enabling the seamless movement of goods across long distances and various terrains. The growing emphasis on environmental sustainability, coupled with the need for resilient supply chains in the face of global disruptions, has further elevated the strategic significance of multimodal systems. Current research underscores the importance of digital integration, stakeholder coordination, and real-time data usage in operationalizing multimodal logistics effectively (Brochado et al., 2024; Rentschler et al., 2022).

While the potential of multimodal transportation is widely acknowledged, the implementation process remains fraught with numerous challenges, particularly when aligning disparate transport modes within a cohesive framework. Literature has increasingly explored the influence of synchromodal logistics, which builds upon multimodal systems by allowing for flexible, real-time switching between transport modes based on operational conditions. Despite technological advances, persistent issues such as incompatible information systems, uneven adoption of ICT solutions, and policy fragmentation continue to impede optimal integration (Brochado et al., 2024; Rentschler et al., 2022). For instance, the study by Heddebaut and Ciommo (2017) on the Lille urban logistics hub ("EuraFlandres") illustrates the strategic complexities associated with intermodal planning and hub location in urban areas, revealing the institutional and infrastructural barriers that hinder efficient intermodality.

The disparity in technological adoption between developed and developing regions further highlights the uneven landscape of multimodal logistics. In highly industrialized economies, the integration of Internet of Things (IoT), advanced scheduling platforms, and digital infrastructure has optimized logistics performance, enabling real-time visibility and agile operations (Brochado et al., 2024; Ghiara & Ne'Tori, 2013). Conversely, developing nations often struggle with underdeveloped infrastructure, limited funding, and institutional fragmentation, which inhibit the widespread deployment of multimodal systems. Studies focusing on economic corridors in such contexts reveal that these limitations directly affect the speed and consistency of implementation, widening the performance gap between regions (Fernando & Jha, 2021; Okyere et al., 2019).

A growing body of empirical evidence demonstrates the tangible benefits of multimodal systems in achieving cost efficiency and environmental sustainability. For instance, optimization models for multimodal routing have been shown to significantly reduce operational costs and CO2 emissions (Dérpich et al., 2024). The use of real-time data and digital technologies in synchromodal systems contributes to improved logistics efficiency and reduced environmental footprints (Rentschler et al., 2022). Furthermore, research by Makarova et al. (2023) links multimodal integration with regional development, highlighting its role in boosting operational resilience and promoting sustainable growth. These findings substantiate the strategic importance of investing in technological innovations within the logistics sector.

In emergency contexts, such as post-disaster or global crises, multimodal transportation becomes indispensable. The ability to dynamically integrate different transport modes—road, rail, sea, and air—enables rapid and flexible deployment of relief supplies, thereby minimizing delays and

maximizing resource utilization. Xu et al. (2024) proposed a route optimization model for emergency logistics that accounts for uncertainty, while Liu et al. (2022) emphasized the necessity of integrated multimodal planning in enhancing crisis response capabilities. Complementing these findings, Ri-Qing et al. (2023) demonstrated that strengthening multimodal logistics networks can significantly improve systemic resilience in post-pandemic recovery efforts. Collectively, these studies affirm that multimodal strategies serve as a critical framework for adaptive and responsive emergency logistics.

Despite these advancements, several gaps persist in the academic literature. Notably, existing research often focuses on cost minimization and emission reduction, but lacks comprehensive methodologies for route planning and hub location under real-time operational uncertainty. For example, while Zhang et al. (2021) and Dérpich et al. (2024) provide models for low-carbon route optimization and cost efficiency, there remains limited integration of real-time dynamic modeling in these approaches. Sun et al. (2015) also noted deficiencies in adaptive decision-making frameworks that can manage uncertainty. Moreover, the optimization of hub-and-spoke networks under fluctuating demand conditions, as discussed by Zhang et al. (2024), continues to pose a significant research challenge. These gaps highlight the need for further investigation into dynamic planning tools, cross-modal coordination mechanisms, and risk evaluation frameworks to enhance multimodal logistics planning.

To address these issues, this review aims to synthesize recent findings and identify core themes that influence the performance of multimodal logistics networks. Specifically, it analyzes key factors such as cost efficiency, delivery time, and environmental impact, which consistently appear as priorities across various studies (Dérpich et al., 2024; Zhang et al., 2021; Xu et al., 2024). Additionally, this review seeks to explore how real-time data and digital technologies contribute to improved decision-making and adaptive planning. By integrating these dimensions, the review intends to provide a comprehensive understanding of the current state of multimodal logistics and offer evidence-based recommendations for future development.

The scope of this study encompasses a global perspective, with a particular emphasis on comparative analyses between developed and developing regions. This approach enables a nuanced understanding of how technological, institutional, and infrastructural differences shape the adoption and effectiveness of multimodal transportation. Special attention is given to case studies from emerging economies, where logistical challenges are more pronounced, and where strategic investments in multimodal systems could yield significant developmental benefits. Furthermore, the review includes recent empirical models and optimization approaches that account for operational uncertainty, crisis response, and environmental sustainability, thus ensuring the analysis remains relevant to contemporary logistics challenges.

METHOD

This study adopted a narrative review methodology to synthesize and contextualize current research on multimodal transportation within integrated logistics networks. The narrative review

approach was selected for its flexibility in capturing a wide range of empirical, theoretical, and conceptual studies, while allowing for a critical interpretation of themes, frameworks, and evolving trends in the field. Unlike systematic reviews that adhere strictly to predefined protocols, the narrative review enables a broader exploration of relevant literature and a more comprehensive understanding of the conceptual development and practical challenges of multimodal systems.

The literature collection process began with the formulation of search strategies based on carefully selected keywords. Keywords were determined through preliminary scoping of existing literature and expert consultation, ensuring that they were both representative of the domain and inclusive of recent terminological developments. The primary keywords employed included "multimodal transport," "integrated logistics networks," "synchromodality," and "hub-and-spoke." The term "synchromodality" has gained prominence in recent years, reflecting the evolution of multimodal systems into highly flexible and responsive logistics frameworks supported by real-time data integration (Brochado et al., 2024). "Hub-and-spoke," on the other hand, refers to a strategic network model in which goods are consolidated and distributed through central hubs, a concept that plays a vital role in structuring multimodal operations (Zhang et al., 2024). Additional search terms such as "multimodal freight transportation," "logistics service network," and "integrated transport system" were also incorporated to capture the diverse perspectives and dimensions embedded within the multimodal logistics discourse.

To retrieve relevant academic literature, searches were conducted across multiple high-quality databases, including Scopus, Web of Science, and Google Scholar. These platforms were selected due to their extensive indexing of peer-reviewed articles, conference proceedings, and other scholarly publications pertinent to the transportation and logistics fields. Boolean operators were used in combination with the aforementioned keywords to refine search results and ensure a high degree of relevance. The search period was restricted to literature published between 2010 and 2024 to reflect contemporary developments in multimodal transportation technologies and policies.

Titles and abstracts of the retrieved records were assessed to eliminate duplicates and exclude studies that were clearly outside the scope of multimodal logistics. Only articles written in English and published in peer-reviewed journals or conference proceedings were considered. At this stage, articles that focused solely on monomodal transportation, or that lacked methodological clarity, were excluded. Full-text screening was then conducted on the remaining articles to evaluate their suitability based on relevance to the review's objectives.

The inclusion criteria were formulated to ensure the analytical value of the studies selected. Studies were included if they addressed issues related to multimodal transportation or synchromodal systems, examined integration mechanisms within logistics networks, presented empirical findings or theoretical models relevant to system performance, efficiency, or sustainability, and were situated within either developed or developing country contexts to allow for comparative insights. Studies were excluded if they provided only a generic overview without empirical or theoretical

contribution, lacked relevance to integrated logistics systems, or focused on unrelated sectors such as personal mobility or urban commuting without a freight or logistics dimension.

The types of studies incorporated into the review were diverse and included a mix of empirical investigations, simulation-based modeling studies, case studies, and conceptual papers. Empirical studies included randomized field evaluations and observational research focusing on the performance and adoption of multimodal systems. Simulation and optimization studies contributed quantitative insights into routing algorithms, cost minimization, and carbon footprint reduction strategies. Conceptual and theoretical papers were also included for their value in framing the evolution of multimodal transport paradigms, such as the transition from traditional intermodality to advanced synchromodal logistics.

To complement the database searches and enhance the comprehensiveness of the review, the snowballing method was employed. This involved examining the reference lists of all selected articles to identify additional relevant sources that might not have been captured in the initial search. Snowballing proved particularly useful in uncovering foundational studies and landmark models frequently cited in recent literature. This iterative process of backward and forward citation tracking ensured that the literature base for this review was both wide-ranging and historically grounded.

In evaluating the selected articles, particular attention was given to methodological rigor, relevance to the research questions, and contribution to existing knowledge. Studies were assessed based on the clarity of their research design, the robustness of their data collection and analysis procedures, and the transparency of their findings. Articles that employed mixed-methods approaches or integrated qualitative and quantitative data were particularly valued for their ability to provide nuanced insights into the complex dynamics of multimodal logistics systems. A matrix synthesis approach was used to map key findings against thematic categories such as cost efficiency, delivery performance, environmental impact, policy alignment, and technological integration.

Although this review did not employ the PRISMA protocol, it maintained a structured and coherent strategy to ensure the academic credibility and interpretive depth of the findings. The narrative review methodology allowed for the synthesis of broader patterns, relationships, and research gaps, moving beyond mere aggregation to offer meaningful interpretations that support the evolution of multimodal logistics theory and practice.

Overall, this methodological approach aimed to balance interpretive richness with academic rigor. Through a combination of structured keyword-based searches, iterative citation tracking, and thematic synthesis, this narrative review offers a comprehensive and insightful portrayal of the current state of research on multimodal transportation within integrated logistics networks. It supports the formulation of nuanced conclusions and actionable recommendations for future research, policy, and practice in an increasingly interconnected and dynamic logistics environment.

RESULT AND DISCUSSION

The review of current literature on multimodal transportation systems within integrated logistics networks reveals five major thematic domains: cost efficiency and logistics performance, resilience in crisis scenarios, environmental sustainability, technological integration, and network planning and design. These themes consistently appear across a range of empirical and theoretical studies, reflecting the multidimensional challenges and opportunities embedded in multimodal logistics.

In terms of logistics cost efficiency, various models and algorithms have been developed to evaluate and optimize operational expenditures within multimodal systems. These include heuristic optimization, mathematical modeling, and data envelopment analysis (DEA). Pongsayaporn and Chinda (2022) introduced a dynamic systems model integrating truck-ship and truck-rail combinations to lower end-to-end logistics costs. Their findings underscore that strategic selection and coordination of transport modes can reduce final logistics expenses through improved scalability and resource allocation. Similarly, Dérpich et al. (2024) applied an optimization strategy that not only decreased distribution costs but also accounted for environmental externalities such as carbon emissions. Their model demonstrated how synchronizing route planning and vehicle selection across modes can deliver dual benefits of cost reduction and environmental performance. Empirical outcomes from these studies suggest that multimodal networks tend to yield higher cost efficiencies than single-mode systems due to their operational flexibility and scale economies (Pongsayaporn & Chinda, 2022; Dérpich et al., 2024).

The theme of resilience during crises further highlights the strategic value of multimodal transportation. In the face of systemic disruptions—such as pandemics, natural disasters, or geopolitical conflicts—multimodal systems provide critical adaptive capacity. Liu et al. (2022) presented a multimodal emergency logistics framework that significantly enhanced response time and resource redistribution in crisis conditions. Their model emphasized the importance of cross-modal flexibility in absorbing supply chain shocks. Complementarily, Ri-Qing et al. (2023) conducted a simulation study showing that mode-switching between maritime and land transport improved the resilience of supply chains under stress. Their results highlighted how multimodal integration can buffer against the cumulative effects of disruptions, enhancing the robustness and agility of logistics systems. These findings reinforce that resilience should be considered alongside cost and speed as a core performance metric in designing future logistics systems (Liu et al., 2022; Ri-Qing et al., 2023).

Environmental sustainability represents a central pillar in the ongoing transformation of logistics networks. Studies show that multimodal transportation can offer more sustainable logistics solutions than conventional single-mode systems. Alves et al. (2021) developed a two-stage evaluation framework that combined a Network Equilibrium Model (NEM) and DEA to assess Green Transport Corridors (GTCs). Their research found substantial reductions in carbon emissions and air pollutants through optimized modal combinations and corridor planning. Likewise, Dérpich et al. (2024) embedded environmental costs into their multimodal optimization model, explicitly targeting reductions in logistical carbon footprints. Technological enablers such as containerization and the Internet of Things (IoT) also play a crucial role. Brochado et al. (2024) demonstrated how real-time operational monitoring via IoT devices enabled more efficient load

management and resource deployment, contributing to lower emissions. These findings collectively support the argument that multimodal transportation, when combined with technological innovations, can significantly advance the environmental objectives of the logistics sector (Alves et al., 2021; Dérpich et al., 2024; Brochado et al., 2024).

The integration of technology emerges as both a facilitator and a prerequisite for multimodal logistics optimization. Real-time data and IoT infrastructure are foundational in enabling responsive scheduling and predictive analytics within complex logistics systems. Brochado et al. (2024) proposed an IoT-based architecture that supports adaptive operations through dynamic scheduling algorithms. This system was capable of reacting swiftly to real-time changes in cargo flow and transport availability. In parallel, Ghiara and Ne'Tori (2013) examined how information and communication technologies (ICT) contribute to greater interoperability between modes. Their analysis emphasized that ICT-driven integration supports not only operational coordination but also strategic planning by enabling advanced analytics and system-wide visibility. Together, these studies confirm that without advanced digital infrastructure, the full potential of multimodal logistics—especially in terms of flexibility and scalability—cannot be realized (Brochado et al., 2024; Ghiara & Ne'Tori, 2013).

Finally, network planning and design remain fundamental to the performance of multimodal logistics systems. Mathematical modeling and simulation are widely used to identify optimal hub locations, design efficient routing structures, and test interoperability scenarios. Chen et al. (2010) introduced a mathematical model aimed at optimizing the location of hubs in multimodal networks. Their model considered both spatial and operational factors, such as cargo volume, route accessibility, and transshipment costs. Building on this, Steenbergen et al. (2021) employed network simulation techniques to explore intermodal interoperability patterns. Their simulation studies revealed how synchronized schedules and shared infrastructure improve throughput and reduce operational bottlenecks. Heddebaut and Ciommo (2017) provided a case-based analysis of hub-and-spoke implementation in a developing urban context. Their research on the EuraFlandres logistics hub highlighted the strategic challenges in aligning city-level transport policies with regional interconnectivity goals. These studies collectively point to the importance of adaptive planning tools that can accommodate uncertainty in demand, infrastructure constraints, and modal availability (Chen et al., 2010; Steenbergen et al., 2021; Heddebaut & Ciommo, 2017).

Across all five thematic areas, the reviewed literature consistently emphasizes the multidimensional benefits of multimodal transportation within integrated logistics networks. The empirical evidence affirms that well-designed multimodal systems not only optimize costs and enhance environmental sustainability but also improve adaptability in volatile conditions. The strategic integration of digital technologies emerges as a recurring factor across all domains, further underlining the necessity of investments in ICT infrastructure and data analytics capabilities. From a global perspective, disparities persist between developed and developing regions, particularly in infrastructure readiness and policy coordination. Nevertheless, the converging evidence underscores a clear trajectory: multimodal transportation is central to the evolution of sustainable, resilient, and efficient global supply chains.

The discussion of this narrative review synthesizes key findings across five thematic areas, examining their broader implications, systemic influences, and potential solutions. The integration of multimodal transportation systems into global logistics networks is undeniably promising, yet its realization is contingent upon addressing underlying systemic challenges and enhancing technological capabilities. Central to this discussion is the role of public policy, infrastructure maturity, and regulatory coherence in shaping the success of multimodal logistics.

Public policy emerges as a pivotal determinant in the effectiveness of multimodal integration. Şahan and Tuna (2021) assert that policy interventions such as fiscal incentives, operational standardization, and institutional coordination significantly facilitate collaboration among stakeholders. These interventions not only reduce friction between different transport operators but also create a conducive environment for data sharing and system harmonization. Moreover, consistent and well-aligned regulatory frameworks are essential for enabling seamless interoperability across logistics infrastructure. The real-time responsiveness that synchromodal logistics promises can only be achieved through integrated regulations that support data exchange, operational transparency, and system scalability. These factors collectively create an ecosystem where both public and private entities can contribute to the development of flexible, resilient, and sustainable logistics.

Infrastructure readiness further determines the viability of multimodal strategies. In regions where technological infrastructure is well-developed, systems such as IoT-based monitoring, integrated information systems, and automated terminals have enabled high levels of cross-modal coordination (Brochado et al., 2024). However, in developing regions, infrastructure gaps persist, limiting the scalability of such systems. These disparities underscore the necessity for region-specific infrastructure investment policies that consider existing capacity and future scalability. Harmonizing investment with context-specific logistics needs—whether urban, peri-urban, or rural—can ensure more equitable and effective deployment of multimodal systems. The disparity between developed and developing countries, as highlighted by Okyere et al. (2019), reveals an urgent need for targeted research and funding strategies that address contextual barriers to infrastructure development.

The synchromodal approach, widely cited in the literature as a best practice for multimodal integration, provides valuable insights into adaptive logistics management. According to Brochado et al. (2024) and Rentschler et al. (2022), synchromodality leverages real-time data and advanced optimization algorithms to dynamically reassign transport modes based on changing operational conditions and demand forecasts. This level of operational agility not only enhances cost-efficiency but also improves service reliability and environmental outcomes. The modular systems supported by IoT and big data analytics form the technical backbone of synchromodal logistics. These systems facilitate predictive maintenance, real-time load balancing, and route re-optimization, ensuring that logistics networks remain resilient against unforeseen disruptions.

Nonetheless, synchromodality's effectiveness hinges on cohesive collaboration between regional governments and private sector actors. Without joint strategic planning and synchronized investment efforts, even the most advanced technologies may fall short of their potential. Rentschler et al. (2022) emphasize the need for multi-stakeholder engagement models that

integrate regional development plans with private sector logistics innovations. This approach ensures that synchromodal solutions are not only technologically viable but also institutionally and economically sustainable across various geographies.

Beyond current applications, future research must confront the dynamic complexities of multimodal logistics. Existing mathematical models, while effective under static assumptions, often fail to capture the uncertainty and fluidity inherent in real-world logistics operations. There is a pressing need for optimization algorithms that can accommodate stochastic variables such as traffic delays, weather disruptions, and fluctuating demand. Furthermore, the integration of IoT, big data, and artificial intelligence into unified logistics platforms remains underexplored. Although studies such as Brochado et al. (2024) illustrate the feasibility of IoT-driven systems, the full potential of AI-enabled logistics—such as machine learning-based demand forecasting and intelligent mode selection—has yet to be fully realized. The creation of integrated platforms that consolidate real-time data from diverse sources could significantly enhance logistics responsiveness during crises, a feature particularly crucial in the post-pandemic global supply landscape.

Another critical dimension is the divergence between developed and developing economies in adopting these technologies. As shown by Okyere et al. (2019), developing regions often grapple with insufficient digital literacy, fragmented regulatory oversight, and limited capital for technological upgrades. These challenges necessitate a differentiated policy approach that includes capacity-building initiatives, technology transfer mechanisms, and flexible regulatory schemes. Comparative research exploring how synchromodal strategies can be adapted to diverse infrastructural and institutional contexts is essential. Such research could inform the development of hybrid models that align cutting-edge logistics innovations with local realities.

Despite the promising trajectory of multimodal logistics, several limitations persist in the current body of research. Many studies remain focused on theoretical models or region-specific case studies, with limited cross-national comparative analyses. Moreover, empirical validations of proposed frameworks are often constrained by the availability of granular operational data, particularly in low-resource settings. As a result, the scalability and generalizability of these models are not always well established. Addressing this gap will require collaborative data-sharing platforms and policy support for open-access logistics datasets. Encouraging partnerships between academia, industry, and government can foster more robust empirical inquiry and real-world testing of innovative logistics models.

In conclusion, the advancement of multimodal logistics hinges on synergizing technological innovation with systemic reform. While technological solutions such as synchromodal logistics offer compelling pathways toward efficiency and sustainability, their success ultimately depends on the alignment of public policies, infrastructure readiness, and institutional coordination. The challenges identified in this review—ranging from infrastructural disparities to regulatory fragmentation—underscore the importance of holistic, context-sensitive strategies. Future research should focus on developing adaptive models that not only integrate cutting-edge technologies but also navigate the socio-political landscapes in which logistics systems operate.

CONCLUSION

This narrative review reveals the strategic potential of multimodal transportation in transforming integrated logistics networks by improving cost-efficiency, system resilience, environmental sustainability, technological integration, and network planning. Empirical findings highlight that multimodal systems significantly reduce operational costs and carbon emissions when supported by optimization models and real-time data. Moreover, the integration of diverse transport modes enhances supply chain adaptability during crises, while digital tools such as IoT and predictive analytics further strengthen coordination and decision-making capabilities.

However, the effectiveness of multimodal logistics depends on broader systemic factors such as public policy, regulatory alignment, and infrastructure maturity. Disparities between developed and developing regions underline the importance of context-sensitive interventions that accommodate regional capabilities and limitations. In response, this review stresses the need for harmonized regulations, collaborative public-private investment in infrastructure, and the adoption of synchromodal strategies that enable dynamic mode switching and real-time responsiveness.

Future research should prioritize the development of adaptive optimization algorithms that accommodate operational uncertainty and incorporate AI-driven decision support tools. Comparative studies across geographic regions are also necessary to tailor digital and regulatory solutions to specific infrastructural and institutional environments. By strategically combining technological innovation with systemic reform, multimodal logistics can serve as a cornerstone in building efficient, sustainable, and resilient global supply chains.

REFERENCE

Alam, T., Gupta, R., Ahamed, N., Ullah, A., & Almaghthwi, A. (2024). Smart mobility adoption in sustainable smart cities to establish a growing ecosystem: challenges and opportunities. Mrs Energy & Sustainability, 11(2), 304-316. https://doi.org/10.1557/s43581-024-00092-4

Alves, P., Melo, I., Branco, J., Bartholomeu, D., & Filho, J. (2021). Which green transport corridors (GTC) are efficient? A dual-step approach using Network Equilibrium Model (NEM) and Data Envelopment Analysis (DEA). Journal of Marine Science and Engineering, 9(3), 247. https://doi.org/10.3390/jmse9030247

Brochado, Â., Rocha, E., & Costa, D. (2024). A modular IoT-based architecture for logistics service performance assessment and real-time scheduling towards a synchromodal transport system. Sustainability, 16(2), 742. https://doi.org/10.3390/su16020742

Chen, S., Yan, Y., & Song, H. (2010). Optimal logistics hubs locations on the multimodal transportation network., 2850-2855. https://doi.org/10.1061/41139(387)399

Dérpich, I., Durán, C., Carrasco, R., Moreno, F., Fernández-Campusano, C., & Espinosa-Leal, L. (2024). Pursuing optimization using multimodal transportation system: A strategic approach to minimizing costs and CO2 emissions. Journal of Marine Science and Engineering, 12(6), 976. https://doi.org/10.3390/jmse12060976

Fernando, S., & Jha, P. (2021). Exploring the impacts of economic corridors on South Asian countries. India Quarterly: A Journal of International Affairs, 77(3), 404-423. https://doi.org/10.1177/09749284211027145

Ghiara, H., & Ne'Tori, G. (2013). ICTs as a mighty resource for cutting edge cities: Case study – Genoa and its port. https://doi.org/10.2495/sc130862

Heddebaut, O., & Ciommo, F. (2017). City-hubs for smarter cities: The case of Lille "EuraFlandres" interchange. European Transport Research Review, 10(1). https://doi.org/10.1007/s12544-017-0283-3

Liu, H., Song, G., Liu, T., & Guo, B. (2022). Multitask emergency logistics planning under multimodal transportation. Mathematics, 10(19), 3624. https://doi.org/10.3390/math10193624

Makarova, I., Serikkaliyeva, A., Gubacheva, L., Mukhametdinov, E., Buyvol, P., Barinov, A., … & Mavlyautdinova, G. (2023). The role of multimodal transportation in ensuring sustainable territorial development: Review of risks and prospects. Sustainability, 15(7), 6309. https://doi.org/10.3390/su15076309

Okyere, S., Yang, J., Aning, K., & Zhan, B. (2019). Review of sustainable multimodal freight transportation system in African developing countries: Evidence from Ghana. International Journal of Engineering Research in Africa, 41, 155-174. https://doi.org/10.4028/www.scientific.net/jera.41.155

Pongsayaporn, P., & Chinda, T. (2022). Long-term strategies for multimodal transportation of block rubber in Thailand. Sustainability, 14(22), 15350. https://doi.org/10.3390/su142215350

Rentschler, J., Elbert, R., & Weber, F. (2022). Promoting sustainability through synchromodal transportation: A systematic literature review and future fields of research. Sustainability, 14(20), 13269. https://doi.org/10.3390/su142013269

Ri-Qing, L., Liu, W., & Yuan, Y. (2023). Resilience improvement and risk management of multimodal transport logistics in the post–COVID-19 era: The case of TIR-based sea–road multimodal transport logistics. Sustainability, 15(7), 6041. https://doi.org/10.3390/su15076041

Şahan, D., & Tuna, O. (2021). Policy implications on transport infrastructure–trade dynamics: Case of Turkey. Logistics, 5(3), 47. https://doi.org/10.3390/logistics5030047

Steenbergen, R., Brunetti, M., & Mes, M. (2021). Network generation for simulation of multimodal logistics systems., 1-12. https://doi.org/10.1109/wsc52266.2021.9715497

Sun, Y., Lang, M., & Wang, D. (2015). Optimization models and solution algorithms for freight routing planning problem in the multi-modal transportation networks: A review of the state-of-the-art. The Open Civil Engineering Journal, 9(1), 714-723. https://doi.org/10.2174/1874149501509010714

Xu, Z., Zheng, C., Zheng, S., Ma, G., & Chen, Z. (2024). Multimodal transportation route optimization of emergency supplies under uncertain conditions. Sustainability, 16(24), 10905. https://doi.org/10.3390/su162410905

Zhang, J., Li, H., Han, W., & Li, Y. (2024). Research on optimization of multimodal hub-and-spoke transport network under uncertain demand. Archives of Transport, 70(2), 137-157. https://doi.org/10.61089/aot2024.1g17bx18

Zhang, X., Jin, F., Yuan, X., & Zhang, H. (2021). Low-carbon multimodal transportation path optimization under dual uncertainty of demand and time. Sustainability, 13(15), 8180. https://doi.org/10.3390/su13158180

Negesse, A., Woyraw, W., Temesgen, H., Teka, Y., Yismaw, L., Akalu, T., … & Desalegn, B. (2022). Spatial exploration of non-resilience to food insecurity, its association with COVID-19 and household coping strategies in East Gojjam districts, northwest Ethiopia, 2020. Scientific Reports, 12(1). https://doi.org/10.1038/s41598-022-19963-2

Song, M., Ma, X., Zhao, X., & Zhang, L. (2022). How to enhance supply chain resilience: A logistics approach. The International Journal of Logistics Management, 33(4), 1408-1436. https://doi.org/10.1108/ijlm-04-2021-0211

Tang, Y., Chau, K., Lau, Y., & Zheng, Z. (2023). Data-intensive inventory forecasting with artificial intelligence models for cross-border e-commerce service automation. Applied Sciences, 13(5), 3051. https://doi.org/10.3390/app13053051