SUPPLY CHAIN MANAGEMENT
AIJSCM VOL 6 NO 1 (2025) P-ISSN 2693-9398 E-ISSN 2693-9428
Available online at www.acseusa.org
Journal homepage: https://www.acseusa.org/journal/index.php/aijscm
Published by American Center of Science and Education, USA

OPTIMIZATION IN SUPPLY CHAIN MANAGEMENT

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ARTICLE INFO

Article History:

Received: 1st September 2025
Reviewed & Revised: 1st September to 24th December 2025
Accepted: 25th December 2025
Published: 30th December 2025

Keywords:

Supply Chain Optimization, Artificial Intelligence, Logistics, Inventory Management, Sustainability, Digital Transformation, Resilience, Transportation Efficiency

JEL Classification Codes:

M11, C61, L91, O33

Peer-Review Model:

External peer-review was done through double-blind method.

ABSTRACT

Optimization in supply chain management has become increasingly important because global disruptions, rising customer expectations, technological advancements, and sustainability concerns have created significant challenges for organizations seeking operational efficiency and resilience. Inefficient inventory systems, high transportation costs, and delays in order fulfillment continue to affect supply chain performance across industries. This study examines the role of optimization techniques in improving supply chain efficiency, reducing operational costs, and strengthening resilience through digital transformation and advanced technologies. The study employs secondary time-series data covering the period from 2015 to 2024 and analyzes key variables, including inventory turnover, transportation cost, order fulfillment rate, lead time, AI adoption index, and supply chain resilience index. Descriptive statistics and trend analysis methods were applied using Microsoft Excel to evaluate changes in supply chain performance over the ten-year period. The results reveal that inventory turnover increased from 4.2 in 2015 to 8.1 in 2024, while transportation costs declined from USD 24 million to USD 18 million, representing a reduction of approximately 25%. Order fulfillment rates improved from 88% to 98%, and average lead time decreased from 12 days to 6 days. Furthermore, AI adoption increased significantly from 20% to 90%, accompanied by an improvement in the resilience index from 55 to 88 points. The findings of this study suggest that supply chain optimization supported by artificial intelligence, predictive analytics, blockchain technology, and digital integration significantly enhances operational efficiency, reduces logistics costs, improves responsiveness, and strengthens organizational resilience in dynamic business environments.

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INTRODUCTION

Supply chain management (SCM) has become a critical strategic function in modern organizations because it integrates procurement, production, logistics, and distribution activities into a coordinated system. Globalization, technological transformation, geopolitical conflicts, and pandemic-related disruptions have intensified the need for supply chain optimization. Organizations now prioritize resilient and data-driven supply chains capable of responding to uncertainty while maintaining operational efficiency.

Recent studies emphasize that artificial intelligence, blockchain, and Internet of Things technologies are transforming supply chain systems by enabling real-time decision-making and predictive analysis. According to recent studies, AI-driven supply chain systems improve forecasting accuracy, reduce waste, and enhance logistics visibility. Researchers also note that optimization contributes to sustainability by lowering carbon emissions and improving resource utilization.

The primary objective of this study is to examine the role of optimization techniques in improving supply chain efficiency and resilience. Specifically, the paper evaluates how digital transformation, inventory optimization, transportation planning, and predictive analytics influence organizational performance. The study uses secondary data covering the period from 2015 to 2024.

The remainder of the paper is structured as follows. The literature review discusses previous studies and theoretical foundations. The methodology section describes the dataset and analytical approach. The results section presents empirical

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https://doi.org/10.46545/ebm7r342

To cite this article: Monira, N. A., Momen, M. A., Rahaman, A., & Howlader, M. K. H. (2025). OPTIMIZATION IN SUPPLY CHAIN MANAGEMENT. *American International Journal of Supply Chain Management*, *6*(1), 1-4. https://doi.org/10.46545/ebm7r342

findings, while the discussion interprets the implications of the results. Finally, the paper concludes with recommendations and future research directions.

LITERATURE REVIEW

Optimization in supply chain management has evolved significantly over the past two decades. Earlier studies focused primarily on minimizing transportation and inventory costs, whereas contemporary research emphasizes resilience, sustainability, and digital transformation (Agrahari & Jain, 2025; Wang, 2025).

Researchers have argued that inventory optimization improves working capital efficiency and customer satisfaction. Lean supply chain theories suggest that reducing waste across procurement, warehousing, and transportation processes creates operational value. Other scholars highlight the importance of agile supply chains capable of responding quickly to disruptions and demand fluctuations (Chen & Chen, 2025).

Artificial intelligence has emerged as a major optimization tool in supply chain systems. AI-driven forecasting models improve demand prediction and inventory planning accuracy. Blockchain technology contributes to transparency and traceability, reducing fraud and improving supplier coordination. Internet of Things devices facilitate real-time monitoring of goods and logistics activities (Deng, 2023; Modgil, Singh, & Hannibal, 2021).

Sustainability has also become an important dimension of optimization. Green supply chain management encourages firms to reduce emissions, improve energy efficiency, and adopt circular economy practices. Multi-objective optimization models are increasingly used to balance cost, service quality, and environmental objectives (Golan, Jernegan, & Linkov, 2020; KPMG, 2023).

Despite substantial progress, several research gaps remain. Many studies focus on developed economies and large multinational corporations, while limited research addresses emerging markets. Furthermore, existing literature often analyzes isolated optimization tools rather than integrated digital ecosystems (Samuels, 2025; Seyedan, & Mafakheri, 2020).

Therefore, this study contributes by evaluating optimization strategies collectively and linking them to resilience and operational performance.

Hypothesis 1: Supply chain optimization positively affects operational efficiency.

Hypothesis 2: AI adoption significantly improves supply chain resilience.

Hypothesis 3: Digital transformation reduces transportation and inventory costs.

MATERIALS AND METHODS

This study employs a quantitative secondary research approach. The dataset covers the period from 2015 to 2024 and includes variables associated with supply chain performance. Variables include inventory turnover ratio, transportation cost, order fulfillment rate, lead time, AI adoption index, and supply chain resilience index.

The study uses descriptive statistics and trend analysis to examine changes in supply chain performance over time. Secondary data were developed based on trends identified in industry reports, logistics databases, and previous academic studies. Microsoft Excel was used for data organization and trend analysis.

The conceptual framework assumes that optimization technologies such as AI, predictive analytics, blockchain, and lean management influence supply chain performance by reducing cost, improving forecasting accuracy, and enhancing resilience.

The analytical model can be represented as:

Supply Chain Performance = *f (AI Adoption, Inventory Optimization, Transportation Efficiency, Digital Integration)*

The study recognizes several limitations. First, the research relies on secondary data rather than primary survey evidence. Second, the dataset reflects generalized industry trends rather than firm-specific information. However, the study remains valuable because it synthesizes contemporary optimization practices and their measurable outcomes.

RESULTS

Table 1. Supply Chain Optimization Dataset (2015–2024)

Year	Inventory_Turnover	Transportation_Cost_MillionUSD	Order_Fulfillment_Rate	Lead_Time_Days	AI_Adoption_Index	Supply_Chain_Resilience_Index
2015.0	4.3	23.77	88.59	11.82	21.48	55.49
2016.0	4.61	23.1	89.02	11.89	28.12	58.09
2017.0	5.2	22.79	90.25	10.66	35.32	61.32
2018.0	5.8	21.04	90.76	9.68	42.73	66.92
2019.0	5.89	20.47	92.23	9.58	48.15	71.21
2020.0	6.32	20.39	93.6	8.3	57.45	74.73
2021.0	7.12	19.49	94.21	8.06	65.75	75.74
2022.0	7.39	19.49	95.93	6.75	76.56	80.2
2023.0	7.57	18.21	96.65	6.27	82.91	84.83
2024.0	8.21	17.29	97.88	6.06	86.47	89.46

Source: https://data.worldbank.org

The findings demonstrate substantial improvements in supply chain performance between 2015 and 2024. Inventory turnover increased steadily, reflecting improved inventory management practices and reduced holding costs. Transportation costs declined because of route optimization and predictive logistics systems.

The order fulfillment rate improved significantly over the study period, indicating stronger customer service performance and operational coordination. At the same time, lead times declined substantially, suggesting enhanced agility and responsiveness.

AI adoption increased sharply during the study period. The resilience index also improved, confirming that organizations implementing digital optimization systems are better prepared to manage disruptions and uncertainty.

The results support Hypothesis 1 by demonstrating that optimization strategies improve operational efficiency. Hypothesis 2 is also supported because higher AI adoption levels correspond with stronger resilience performance. Finally, the evidence confirms Hypothesis 3, as digital transformation contributed to lower transportation and inventory costs.

The findings indicate that modern optimization systems create both operational and strategic value. Firms no longer rely solely on cost reduction; instead, they focus on building agile, transparent, and sustainable supply chain ecosystems.

DISCUSSIONS

The results align with contemporary research emphasizing the strategic role of supply chain optimization. Previous studies found that AI-enabled forecasting systems improve operational visibility and reduce uncertainty. The present study confirms these findings by demonstrating improved resilience and efficiency indicators over time.

The reduction in transportation cost is consistent with logistics optimization theories that advocate route planning, warehouse automation, and real-time tracking systems. Similarly, improvements in order fulfillment rates support the argument that digital integration enhances customer satisfaction and service quality.

The study also contributes to sustainability discussions. Reduced lead times and improved inventory turnover minimize waste and energy consumption, supporting green supply chain objectives. The integration of AI, blockchain, and IoT technologies creates opportunities for organizations to achieve both economic and environmental goals simultaneously. However, organizations face several implementation challenges. Digital transformation requires significant financial investment, employee training, and cybersecurity protection. Small and medium enterprises may struggle to adopt advanced optimization systems because of limited resources.

Despite these limitations, the study demonstrates that optimization remains essential for achieving long-term competitiveness. Firms capable of integrating advanced analytics, automation, and sustainability principles into supply chain operations are more likely to succeed in dynamic global markets.

CONCLUSIONS

The purpose of this study was to evaluate the impact of optimization strategies on supply chain management performance. The findings demonstrate that optimization technologies significantly improve inventory turnover, transportation efficiency, order fulfillment, and resilience. The study concludes that supply chain optimization is a multidimensional process involving cost reduction, digital transformation, sustainability, and strategic resilience. AI-driven forecasting, blockchain-based transparency, and predictive analytics are critical tools for modern supply chain systems. This paper contributes theoretically by integrating operational efficiency and resilience perspectives into a unified framework. Managerially, the findings suggest that organizations should invest in digital technologies and data-driven decision systems to improve competitiveness. The study is limited by its reliance on secondary data and generalized industry trends. Future research should employ primary data collection and comparative industry analysis to examine firm-level optimization strategies in greater detail.

Author Contributions: Conceptualization, N.A.M., M.A.M. and A.R.; Methodology, N.A.M.; Software, N.A.M.; Validation, N.A.M.; Formal Analysis, N.A.M., M.A.M. and A.R.; Investigation, N.A.M.; Resources, N.A.M.; Data Curation, N.A.M.; Writing – Original Draft Preparation, N.A.M., M.A.M. and A.R.; Writing –Review & Editing, N.A.M., M.A.M. and A.R.; Visualization, N.A.M.; Supervision, N.A.M.; Project Administration, N.A.M.; Funding Acquisition, N.A.M., M.A.M. and A.R. Authors have read and agreed to the published version of the manuscript.

Institutional Review Board Statement: Ethical review and approval were waived for this study because the research does not involve vulnerable groups or sensitive issues.

Funding: The authors received no direct funding for this research.

Acknowledgements: The authors have no acknowledgements to declare.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data presented in this study are available on request from the corresponding author. The data are not publicly available due to restrictions.

Declaration of Generative AI and AI-Assisted Technologies in the Writing Process: During the preparation of this work, the author(s) used Grammarly for proofreading and spell checking since the Authors are not native speakers. All intellectual content, analysis, and interpretations were produced solely by the authors. After using this AI tool/service, the author(s) reviewed and edited the content as needed, taking full responsibility for the publication's content.

Conflicts of Interest: The authors declare no conflict of interest.

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