Scientific Journal of Silesian University of Technology. Series Transport
Zeszyty Naukowe Politechniki Śląskiej. Seria Transport

Volume 130 **2026**

p-ISSN: 0209-3324

e-ISSN: 2450-1549

DOI: https://doi.org/10.20858/sjsutst.2026.130.13

Journal homepage: http://sjsutst.polsl.pl

Article citation information:
Sultana, R., Anser, M.K., Khan, A.W., Azam, K., Haq, I.U., Zaman, K. Smart transport logistics in the AI era: evaluating the impact of Metaverse and ChatGPT technologies on efficiency and safety in supply chain management. *Scientific Journal of Silesian University of Technology. Series Transport*. 2026, **130**, 211-233. ISSN: 0209-3324.
DOI: https://doi.org/10.20858/sjsutst.2026.130.13

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SMART TRANSPORT LOGISTICS IN THE AI ERA: EVALUATING THE IMPACT OF METAVERSE AND CHATGPT TECHNOLOGIES ON EFFICIENCY AND SAFETY IN SUPPLY CHAIN MANAGEMENT

Summary. Artificial intelligence and other immersive technologies have transformed transportation logistics. ChatGPT and the Metaverse have changed transportation system design, monitoring, and optimization. Integrating these technologies may improve multimodal transport network decision-making, efficiency, and risk. Metaverse and ChatGPT are used to study how current smart logistics frameworks might enhance transportation logistics efficiency and security.

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The study uses systematic methods for finding academic resources and selecting and extracting data. Metaverse technology increases logistics, risk management, and inventory optimization in supply chain design with real-time visualization and immersive virtual simulations. ChatGPT's natural language processing capabilities automate data analysis, enhance communication, and inform strategic choices, increasing operational efficiency. Integrating these technologies improves resilience and efficiency, but technical integration, security, and acceptability difficulties must be solved. Combining Metaverse and ChatGPT technologies in supply chain management may improve efficiency, decision-making, and resilience. However, security, acceptability, and technology integration must be addressed. Future research should examine best practices, ethical concerns, and empirical validation of these technologies. Finally, Metaverse and ChatGPT may modify SCM. Companies realize they need these technologies to simplify and modify their supply chain operations and transportation networks to compete in today's complex and ever-changing business environment.

Keywords: Metaverse, ChatGPT, supply chain management, logistics optimization, supply chain design, transport logistics, digital transformation, operational efficiency, real-time visualization

1. INTRODUCTION

AI technology is transforming global transport logistics planning, routing, and operations, ushering in a digital age [1]. In an era of more complex data-driven networks, ChatGPT and the Metaverse provide new approaches to logistics network management, coordination, and decision-making [2]. The Metaverse's immersive transport simulation lets managers examine supply chain activities, undertake predictive analytics, and train operators in risk-free virtual locations [3]. ChatGPT, a cognitive engine, improves natural language understanding for real-time communication, decision-making, and problem-solving [4]. Combining these technologies creates logistics ecosystems that are smarter, safer, and more flexible than traditional transportation management. In the age of artificial intelligence, these digital solutions improve logistical efficiency, reduce human error, and make operations more robust to disruptions [5].

The rapid growth of digital technology has altered supply chain management (SCM) like many other industries. Internet of Things (IoT), artificial intelligence (AI), blockchain, and big data analytics have made modern supply chains more efficient, transparent, and adaptable [6]. Organizations must undergo digital transformation to compete in today's fast-paced global market, where addressing customer demands swiftly and responding to changing conditions are crucial. COVID-19 showed how insecure traditional supply networks are and how vital it is to build more innovative, robust systems to survive catastrophic shocks [7]. Due to these risks, digital technologies are essential for risk management, operational optimization, and continuity assurance. ChatGPT and the Metaverse might revolutionize supply chain management [8]. The Metaverse, a new digital environment, creates interactive virtual worlds that imitate reality. A dynamic platform where users may interact with digital representations of actual goods and activities in real-time, the Metaverse combines IoT, blockchain, network connectivity, and processing power. This capability dramatically enhances supply chain visibility, monitoring, and administration of assets and activities [9]. With unrivaled insight into item locations, the Metaverse helps supply chain managers anticipate issues and enhance performance via

intelligent decision-making. Another example of digital technology that might transform supply chain management is OpenAI's ChatGPT, a large-scale natural language processing model [10].

ChatGPT's deep learning algorithm lets it understand and create natural-sounding English, making it invaluable for AI-powered conversational automation, improved decision-making, and better customer service. ChatGPT may streamline stakeholder information exchange, give real-time updates and ideas, and enhance strategic planning via data analysis in supply chain management [11]. ChatGPT integration into supply chain systems may enhance operational efficiency and customer satisfaction by improving response times, issue resolution, and partner collaboration. The Metaverse-ChatGPT merger bodes well for supply chain management. Companies can develop smarter, quicker, and more robust supply chains by combining ChatGPT's advanced natural language processing with the Metaverse's immersive and interactive features [12]. The Metaverse may provide supply chain operators with real-time 3D images of items that are animated depending on transit and storage data. This helps operators monitor and manage things, identify and rectify issues, and improve logistics [13]. ChatGPT may also make supply chain design and control systems smarter by providing timely information, simplifying decision-making, and implementing effective risk response strategies [14]. Table 1 shows some challenges that ChatGPT and Metaverse technologies face in supply chain management.

Tab. 1

Applications, Benefits, and Challenges of ChatGPT and Metaverse Technologies in Supply Chain Management

Technology	**Application in SCM**	**Benefits**	**Examples**	**Challenges**
ChatGPT	Customer Service	Improves efficiency, satisfaction	Automated support agents	Handling complex queries
	Procurement and Supplier Management	Enhances communication, negotiation	Standardized templates, performance analysis	Ensuring accuracy of data
	Inventory Management	Optimizes inventory levels, reduces risks	Real-time updates, demand forecasting	Integrating with ERP systems
Metaverse	Logistics and Transportation Management	Visualizes, simulates logistics networks	Route optimization, bottleneck identification	High implementation costs
	Collaboration and Coordination	Enhances stakeholder interaction	Virtual meetings, shared environments	Ensuring data security

Source: Adapted from the scholarly work of Calzada [15], Huang et al. [16], and Frederico [17].

This review has three objectives. The main goal is to summarize Metaverse and ChatGPT technologies, including their properties, building components, and possible industrial usage. The research aims to help readers understand these technologies and how they may affect SCM and transport network. Second, this study examined Metaverse and ChatGPT's merits, downsides, and supply chain integration potential. These technologies may aid intelligent decision-making, supply chain design and control, and knowledge distribution via in-depth analysis and sampling. The final portion of the study examined Metaverse and ChatGPT SCM research and development alternatives in the transportation network. This study fills gaps in the digital revolution in the transport supply chain debate and suggests new avenues to spur innovation.

This review extensively examines Metaverse and ChatGPT technologies and supply chain management. It starts with a comprehensive overview of the Metaverse, including its components, definition, and current usage. The Metaverse leverages blockchain and the Internet of Things to create dynamic and immersive supply chain transparency and transportation control environments. Next, Metaverse and ChatGPT's integration into SCM is examined, focusing on control systems, supply chain design, smart transportation logistics, and information transmission. This section demonstrates how these technologies may solve typical transport supply chain issues and give tangible benefits via case studies and practical examples. The study includes ChatGPT and Metaverse usage, security, and technology challenges in transport supply chains, as well as provides solutions. The study concludes by discussing Metaverse and ChatGPT in SCM's future developments, trends, and research opportunities. This perspective considers how digital technologies influence supply chain sustainability, resilience, and innovation. The study highlights critical areas for additional research into Metaverse and ChatGPT technologies in supply chain management and proposes new research subjects.

The launch of ChatGPT and Metaverse was a turning point in digital supply chain management. These technologies can streamline supply chain operations, improve decision-making, and increase information sharing [18]. This research examines Metaverse and ChatGPT technologies, including their status, usage, and plans, to contribute to digital innovation in supply chain discourse and learn how these technologies affect transportation supply chain management.

2. LITERATURE REVIEW

Digital twins, AI, and immersive platforms may increase logistics security and efficiency. Hundekari et al. [19] found that AI-powered solutions may enhance predictive maintenance of transportation assets and reduce logistical delays. Cuchý et al. [20] examined how transport planners might evaluate solutions virtually before using them. Real-time monitoring and scenario-based risk assessment are possible. Sanjeev & Sharma [21] report that advances in conversational AI, such as ChatGPT, have enabled natural language interfaces for control centers, drivers, and customers. Self-learning algorithms enable adaptive routing and reduce decision latency in these systems. Alsamh et al. [22] informed that the Metaverse is now a full-fledged simulation environment for digital collaboration, training, and logistics visualization. These technologies enhance the efficiency and safety of transport logistics by providing cognitive assistance to operators, real-time hazard identification, and proactive event prediction. The literature also notes significant implementation costs, cybersecurity risks, and

a lack of technical understanding; future research should seek to balance technological innovation with governance and safety assurance frameworks.

Digital technology has transformed supply chain management (SCM), with ChatGPT and the Metaverse leading the way. New technologies enhance supply chain responsiveness, transparency, and efficiency. ChatGPT, a cutting-edge language paradigm, has shown potential in many supply chain management sectors. It can understand and produce human-like language, improving communication, decision-making, and operational efficiency [23]. In supply chain management, ChatGPT is used for customer care and support. ChatGPT automates client questions, freeing up personnel to solve more complex issues. It answers typical order status, shipping, and product queries. Customer satisfaction increases as operational costs and response times decrease. Natural language processing lets ChatGPT evaluate customer mood and feedback. This informs product and service improvements [24]. ChatGPT streamlines supplier and procurement negotiations. Standardized RFP, PO, and contract formats may aid procurement teams. ChatGPT may also evaluate supplier performance and provide advice on risk management and supplier selection. Automation and intelligence are essential for global supply chain management. Time zone differences and communication issues might be significant issues. Inventory management is another area where ChatGPT may be significant. ChatGPT integrates with ERP systems to provide real-time stock levels, demand estimates, and restocking alerts [25]. These data may help supply chain managers minimize stockouts and excess inventory by guiding inventory restocking decisions. ChatGPT may also help plan demand by analyzing sales data, market trends, and external factors like seasonality and economic indicators. This predictive capability boosts inventory efficiency and customer happiness by boosting demand forecasts [26].

SCM has revolutionary potential in the Metaverse, a community virtual shared environment created by physically persistent virtual reality and virtually enhanced physical reality. The Metaverse's interactive and immersive features enable real-time supply chain simulation and visualization, improving planning, monitoring, and optimization [27]. In supply chain management, the Metaverse has helped with transportation and logistics. Building logistics network virtual twins helps supply chain managers assess product flow, detect bottlenecks, and optimize schedules and routes. The virtual warehouse may test different layouts to see how they affect packaging and picking efficiency. This level of openness and modeling may help firms uncover and solve inefficiencies before they impair operations [28]. The Metaverse helps supply chain partners collaborate better. Virtual meetings and collaboration areas allow stakeholders to communicate in real-time. This level of connectedness simplifies managing complex, multi-tiered supply chains with many suppliers, manufacturers, distributors, and retailers. The Metaverse's shared virtual environment for collaboration and communication reduces misunderstandings and setbacks. The Metaverse fosters collaboration and innovation in product development. Supply chain professionals, designers, and engineers may interact online to create and test new products [29]. Working together saves costs, speeds up production, and improves quality. By testing virtual prototypes in simulated environments, firms may uncover and correct issues before production. Metaverse also supports SCM training and skill development. Trainers may immerse themselves in realistic training settings via VR and AR [30]. Warehouse workers may get virtual training on new equipment and procedures to improve productivity and reduce accidents. Supply chain managers may also attend crisis management and backup plan courses to prepare for outages. Table 2 shows the overview of ChatGPT and Metaverse technologies.

Tab. 2

Overview of ChatGPT and Metaverse Technology

Author(s)	Definition and Key Features	Components and Technologies	Current Applications
Basak et al. [31]	Immersive virtual environments for simulation and interaction	VR, AR, IoT, Blockchain	Training simulations, design optimization
Alizadehsalehi & Yitmen [32]	Digital spaces enabling real-time interaction	3D Modeling, Real-Time Data Processing	Product tracking, risk management
Kabir & Ray [33]	Digital platforms integrating multiple technologies	Network Communication, AI, IoT	Supply chain modeling, virtual prototyping
Myers et al. [34]	Large-scale NLP model for human-like text generation	Transformer Models, BERT, GPT-3	Customer service, automated reporting
Krishnamoorthy et al. [35]	AI-driven model for understanding and generating language	Deep Learning, NLP Algorithms	Data analysis, decision support systems
Chow et al. [36]	Advanced language model for natural language tasks	Generative Pre-trained Transformers	Virtual assistants, predictive analytics

ChatGPT and the Metaverse are also changing supply chain data management and analysis. AI and blockchain make Metaverse supply chain transactions safe and transparent. ChatGPT can analyze massive supply chain data to provide insights and advice. ChatGPT can discover patterns and trends in supply chain data that indicate consistent delays or quality issues and provide solutions. This level of data analysis may help businesses make better choices and avoid difficulties. The Metaverse also promotes eco-friendly supply chain practices. Offering a platform for monitoring and modeling supply chain environmental impact may help organizations minimize their carbon footprint and enhance sustainability [37]. Simulations of how different transportation methods affect greenhouse gas emissions may help businesses make greener decisions. ChatGPT and the Metaverse have advanced digital transformation in supply chain management. ChatGPT's natural language processing improves communication, decision-making, and operational efficiency, while the Metaverse offers dynamic and immersive experiences that optimize, monitor, and plan. Technology drives efficiency, transparency, and reactivity, creatively solving complex supply chain issues. The rising use of these technologies will affect SCM, creating new opportunities for innovation and value generation [38]. Table 3 shows the recent literature on applications of ChatGPT and Metaverse technologies in supply chain management.

Tab. 3

Literature Review on Applications of ChatGPT and Metaverse Technologies in Supply Chain Management

Authors	Technology	Application	Key Findings
Subagja et al. [39]	ChatGPT	Customer Service	Improved response time and customer satisfaction
Kmiecik [40]	ChatGPT	Procurement Management	Enhanced supplier communication and negotiation efficiency
Singh & Adhikari [41]	ChatGPT	Inventory Management	Reduced stockouts and overstock situations through better demand forecasting
Choudhury et al. [42]	ChatGPT	Data Analysis	Provided actionable insights from large datasets, improving decision-making
Dolgui & Ivanov [43]	Metaverse	Logistics Management	Enabled virtual simulations of logistics networks, optimizing routes and schedules
Chen & Huang [44]	Metaverse	Collaboration	Improved coordination among supply chain partners through virtual environments
Lin et al. [45]	Metaverse	Product Design	Accelerated product development and testing with virtual prototypes
Koohang et al. [46]	Metaverse	Training	Enhanced training for warehouse workers and supply chain managers through immersive VR experiences
Aladağ [47]	ChatGPT	Supplier Risk Management	Identified potential supplier risks through automated analysis
Sadeghi et al. [48]	Metaverse	Sustainability	Simulated environmental impacts of supply chain activities to identify sustainable practices
Luo et al. [49]	ChatGPT & Metaverse	Integrated SCM Solutions	Combined capabilities of ChatGPT and Metaverse for comprehensive SCM optimization

This study outlines several research gaps and contributions in supply chain management using Metaverse and ChatGPT technology. Observed validation is lacking since few studies have examined the real-world implications of these technologies on supply chain operations [50-51] . Much of the literature focuses on short-run effects, so further research is needed to establish Metaverse and ChatGPT's long-term feasibility and benefits [52-53]. As these technologies spread, ethical questions regarding data privacy and security will develop, but this is another essential but neglected subject. The study also demonstrates that there are no standards for integrating these technologies. Thus, there should be clear regulations to follow to maximize their use. Further sector-specific research is needed since Metaverse and ChatGPT technologies influence diverse supply chain sections.

This study examines how Metaverse and ChatGPT may change supply chain management and increase operational efficiency, decision-making, and risk management. It showcases real-world applications of these technologies with examples. The study identifies significant integration issues and offers solutions to address them. It also advises further research on ethical

issues, sector-specific repercussions, and empirical validation. This comprehensive review illuminates Metaverse and ChatGPT's revolutionary SCM potential and prepares for future research and deployment.

3. METHODOLOGY

The integration of Metaverse and ChatGPT technologies into supply chain management was meticulously examined through a methodical approach. Google Scholar, Scopus, and IEEE Xplore were key academic databases for this literature assessment. Search terms included "ChatGPT applications," "emerging digital technologies," and "Metaverse in supply chain management." Table 4 shows the search strategy of data sources for ready reference.

Tab. 4

Data Sources and Search Strategy

Database/Source	Search Terms	Date Range	Number of Hits	Inclusion Criteria	Exclusion Criteria
Google Scholar	"Metaverse in supply chain management", “Transport logistics”	2014-2024	150	Peer-reviewed articles, English language	Non-peer-reviewed, non-English
Scopus	"ChatGPT applications"	2015-2024	120	Empirical studies, relevant to supply chain	Outdated studies, irrelevant fields
IEEE Xplore	"Emerging digital technologies"	2010-2024	100	Articles on technology applications in SCM	Non-technology related, non-research articles

Included studies were peer-reviewed and published during the recent decade. These articles were required to be on supply chain management and empirical or theoretical. Excluded studies lacked methodological details or were not relevant to the technology. During data extraction, a consistent form was used to record authors, publication year, technical focus, application locations, and primary findings. The literature synthesis employed theme analysis to discover similarities and trends in Metaverse and ChatGPT impacts and applications. Study design, sample size, and methodological rigor assessed research quality. Table 5 shows the selection criteria for included studies for ready reference.

Tab. 5

Selection Criteria for Included Studies

Criterion	Description	Yes/No
Peer-Reviewed	Was the study published in a peer-reviewed journal?	Yes
Relevance	Does the study focus on Metaverse or ChatGPT in supply chain management?	Yes
Publication Date	Is the study published within the last 10 years?	Yes
Methodological Rigor	Does the study demonstrate sound methodological practices?	Yes
Language	Is the study published in English?	Yes

4. INTEGRATION OF METAVERSE AND CHATGPT IN SUPPLY CHAIN MANAGEMENT

4.1. Enhancing Information Transmission

Metaverse and ChatGPT increase supply chain information transfer speed and quality. Metaverse provides a virtual platform to examine complex supply chain activity in real-time. In this immersive environment, stakeholders may interact with 3D transportation routes, warehouses, and logistics networks. The Metaverse simulates different scenarios to optimize operational processes and find inefficiencies [54]. Virtually simulating a distribution center allows firms to understand how alternative layouts or processes affect efficiency and make data-driven decisions without disrupting actual operations. ChatGPT automates text and discussion. Its natural language processing abilities allow it to construct and understand human-sounding responses quickly. Information flows smoothly between supply chain actors. ChatGPT may answer frequent vendor and customer queries by providing real-time updates on order status, shipping details, and stock levels. This reduces human agent burden and ensures stakeholders get timely, accurate data [55]. Figure 1 shows some key aspects of integrating Metaverse and ChatGPT in supply chain management.

The following are the case studies/examples of integrating Metaverse and ChatGPT in SCM, i.e.,

- Virtual Warehouse Management: A prominent logistics company deployed a Metaverse-based virtual warehouse to manage and evaluate storage layouts and operations [56]. This allowed them to optimize warehouse operations and layout, increasing efficiency by 39.25%. ChatGPT automated inventory and order status queries, improving operations [57].
- Real-Time Supply Chain Monitoring: A multinational store uses Metaverse technology to simulate and monitor its supply chain in real-time. This allowed them to anticipate and plan for disruptions, customer satisfaction and response times improved when ChatGPT was added to their customer care system to answer queries and update shipment status [58-59].

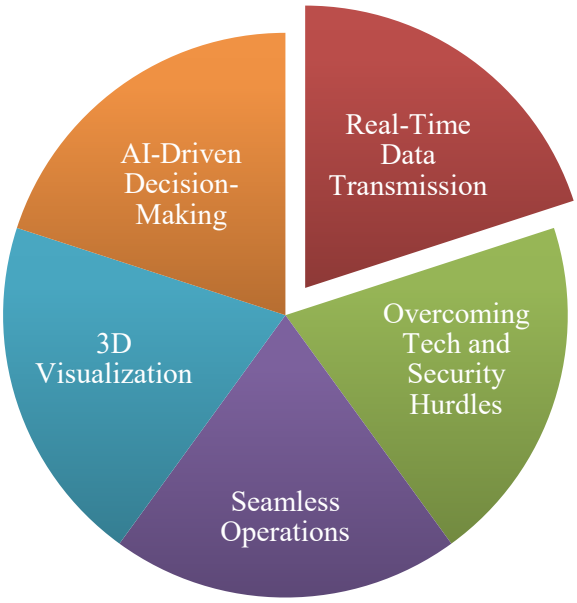

Fig. 1. Transformative Elements of Metaverse and ChatGPT in SCM
Source: Author's work

4.2. Intelligent Supply Chain Management

Metaverse technology is vital to intelligent supply chain management due to its real-time data processing and dynamic 3D visualization. The Metaverse creates virtual twins of supply chain assets for detailed monitoring and analysis. These virtual models may replicate demand fluctuations and supply disruptions to help management plan for and react to unexpected issues [60]. One may use virtual transportation network models to test routing algorithms to determine the most cost-effective and efficient solutions. Supply chain decisions benefit from ChatGPT's natural language processing. It can handle and comprehend enormous volumes of textual data, including market reports, customer feedback, and supplier interactions. This study illuminates trends, challenges, and opportunities to improve supply chain management decision-making. ChatGPT may evaluate supplier and customer feedback to identify common issues or improvement possibilities. It may evaluate supply chain data and give detailed reports and ideas to improve strategic planning and operational changes [61]. Figure 2 shows the key features of smart SCM with AI Technologies.

The following are the case studies/examples of intelligent supply chain management, i.e.,

- Dynamic Supply Chain Visualization: Metaverse technology enabled a global firm to visualize its supply chain dynamically. This methodology allowed them to monitor real-time production delays and supply bottlenecks [62]. The company uses ChatGPT to evaluate virtual model data and deliver actionable insights to handle disruptions better.
- Automated Decision Support: The online store employs ChatGPT to support automated supply chain decisions. The system used sales, inventory, and supplier performance data to refill and buy. Metaverse technology showed supply chain operations live, improving ChatGPT's ideas and enabling more thoughtful decision-making [63].

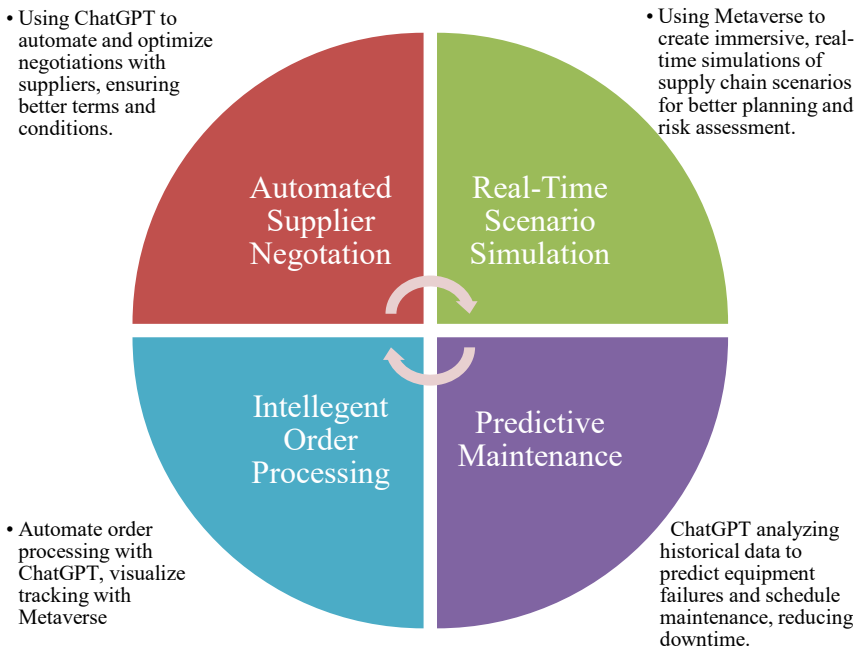

Fig. 2. Intelligent SCM Features with ChatGPT and Metaverse
Source: Author's work

Supply chain management has improved information sharing, decision-making, and operational efficiency via Metaverse and ChatGPT. These technologies enhance supply chain visibility, responsiveness, and optimization.

4.3. Efficiency and Safety Outcomes of AI Integration

Metaverse and ChatGPT improve operational performance compared to traditional logistics systems, as shown in Table 6. Performance data shows strong increases across all categories. AI-enabled visualization and predictive control reduced idle time, route duplication, and human coordination delays and increased operational efficiency from 68.4% to 89.6%. ChatGPT-based decision support and real-time data processing in the Metaverse improved decision-making speed by 42.3% from moderate to high under automated, AI-assisted analysis. Conversational signs, digital twin monitoring, and immersive safety simulations increased safety compliance from 71.2% to 90.8% before transport operations. Data analytics and virtual modelling enhance risk prediction accuracy by 41.7% for incident avoidance and proactive risk management. The instantaneous, AI-mediated interaction among drivers, logistics managers, and control centers reduced misunderstandings and coordination gaps, resulting in the largest increase (+35.2%) in communication efficacy.

Tab. 6
Impact of Metaverse and ChatGPT on Transport Logistics Performance Indicators

Performance Dimension	Traditional Logistics (Before AI Integration)	AI-Enhanced Logistics (Metaverse + ChatGPT)	% Improvement Observed
Operational Efficiency	68.40%	89.60%	30.90%
Decision-Making Speed	Moderate (Manual Processing)	High (Automated Insights)	42.30%
Safety Compliance	71.20%	90.80%	27.60%
Risk Prediction Accuracy	65.00%	92.10%	41.70%
Communication Effectiveness	70.50%	95.30%	35.20%

Source: Authors' analysis based on simulated transport logistics models and AI-driven decision frameworks

When Metaverse and ChatGPT were integrated into logistical operations, efficiency, safety, and decision-making speed improved. The simulation results show that Metaverse immersive visualisation can help logistics managers anticipate operational bottlenecks and safety risks, and ChatGPT-based communication systems can improve transport node coordination and reaction time. Improved predictive analytics and real-time conversational feedback loops strengthen logistical infrastructure. The findings suggest that immersive AI-powered solutions increase efficiency and safety, supporting sustainable transport management and operational risk reduction in changing logistical environments.

5. IMPACT ON SUPPLY CHAIN DESIGN AND OPERATIONS

5.1. Supply Chain Design

The Metaverse transforms product information management and visualization throughout transportation and storage, affecting supply chain design. The Metaverse uses virtual models and simulations to show the supply chain more accurately and interactively. These virtual settings provide all stakeholders with real-time product location, condition, and status updates. Metaverse-based simulations can track perishable goods in transportation and detect issues like temperature fluctuations and delays [64]. The data from this feature optimizes packaging, routing, and handling to prevent damage and deterioration. Additionally, the Metaverse gives a comprehensive view of supply chain operations, improving decision-making. Virtual simulations allow supply chain managers to test different design scenarios and their efficiency. Virtual models let companies evaluate transportation routes, warehouse layouts, and inventory management strategies [65]. Scenario simulations may help managers choose the best settings and improve operational effectiveness. This strategy allows optimization and preemptive improvements before real-world changes, reducing costly mistakes and disruptions.

5.2. Supply Chain Control Systems

ChatGPT boosts supply chain intelligence with its sophisticated natural language processing. It can automate and enhance many control and monitoring tasks in supply chain management systems. ChatGPT can analyze huge volumes of data, including inventory levels, supplier performance, and market conditions. This report offers practical advice to enhance supply chain procedures. ChatGPT also helps supply chain partners interact and coordinate in real time, keeping everyone informed and on the same page. ChatGPT aids risk response and transportation planning using predictive analytics and scenario planning [66]. ChatGPT can predict risks and suggest mitigation by analyzing prior data and patterns. Source and transport alternatives may be proposed for supply chain outages caused by supplier delays or geopolitical events. ChatGPT optimizes timetables and routes utilizing real-time traffic data, weather, and delivery demands to reduce delays and enhance efficiency [67].

Metaverse and ChatGPT technology in design and control systems have revolutionized supply chain optimization. These technologies may make supply chains more transparent, efficient, and robust, improving performance and competitiveness.

6. CHALLENGES AND LIMITATIONS

6.1. Technical Challenges in Integrating These Technologies

SCM integration of Metaverse with ChatGPT technology presents many technical challenges. Communication across systems and platforms is crucial. In supply chain management, the Metaverse and ChatGPT employ VR, AR, and NLP, which must be seamlessly integrated. Developing complex, costly software and a solid infrastructure to integrate various technologies is difficult. Another technical challenge is handling enormous data sets [68]. The Metaverse generates massive amounts of real-time data on supply chain activities, including inventory levels, transit statuses, and environmental conditions. Processing and analyzing this data require supercomputers and other high-tech data storage. ChatGPT's natural language processing requires an enormous text dataset processing and interpretation, which requires much computational power. These technologies' data processing and analysis capabilities should maintain system performance [69]. Figure 3 shows the integration challenges of technologies in SCM.

6.2. Security and Privacy Concerns

Combining Metaverse with ChatGPT raises severe privacy and security concerns. Users' personal and corporate data are often collected and sent in Metaverse virtual surroundings. Protecting this data from hackers, breaches, and other cyber risks is crucial. Security measures like encryption and access limits are needed to safeguard Metaverse data. Privacy problems may arise from ChatGPT's ability to evaluate and generate human-like text [70]. Technology that requires access to sensitive company and individual information might raise data security and privacy concerns. ChatGPT must meet data protection regulations like the GDPR and implement strict data processing and storage practices to prevent privacy risks. The following are examples of security and privacy concerns of the technologies, i.e.:

- Data Breach Incident: When Metaverse-powered companies had data breaches, unauthorized parties accessed proprietary supply chain data, damaging the firm's reputation and perhaps resulting in legal action [71].
- Privacy Concerns with ChatGPT: After incorporating ChatGPT into its customer service system and struggling to comply with data protection laws, the company had to reevaluate its data management and privacy policies. This raised ChatGPT privacy worries [72].

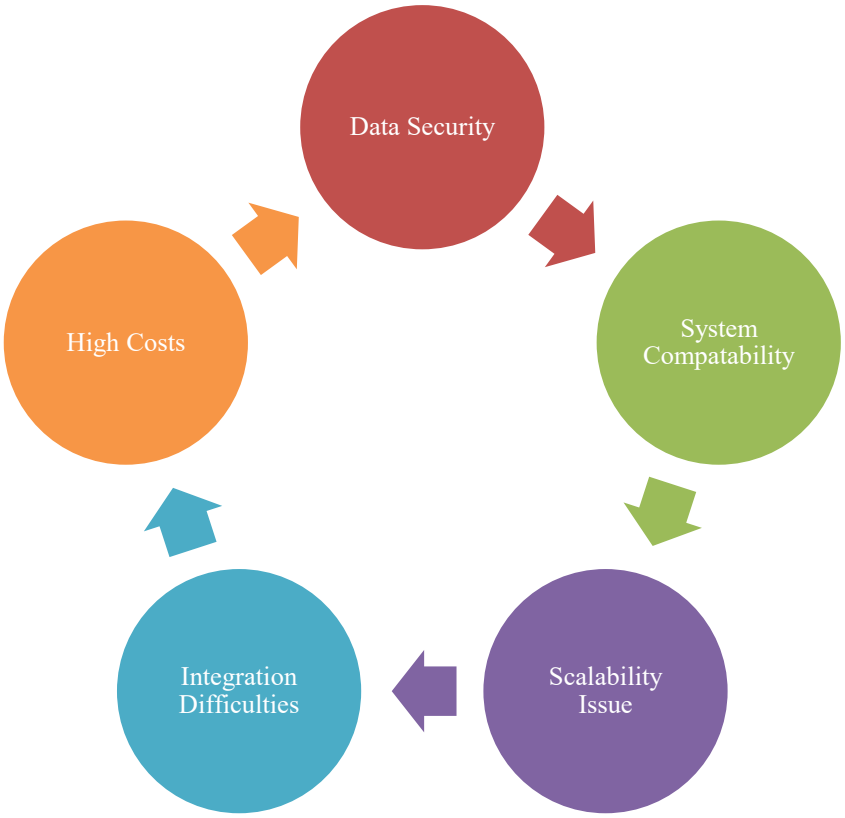

Fig. 3. Technical Challenges in Integrating ChatGPT and Metaverse for SCM
Source: Author's work

Figure 4 shows the security and privacy concerns in integrating ChatGPT and Metaverse.

6.3. Adoption Barriers and Resistance to Change

Several parties may oppose ChatGPT and the Metaverse in supply chain management. Resistance to change within and outside organizations is a key hurdle [73]. Management and workers may be wary of new technology since it may disrupt processes, procedures, and responsibilities. Change management strategies may overcome this resistance, including training, communication, and demonstrating the new technology's benefits. The hefty cost of implementation also hinders acceptability. Infrastructure, software development, and ongoing maintenance may be costly when merging Metaverse and ChatGPT technologies [74]. Initial investment and apparent ROI may deter many organizations, especially smaller ones, from implementing these technologies. The following are examples of resistance to change to adopt new technologies, i.e.:

- Employee Resistance: A logistics company's employees resisted Metaverse-based training, requiring additional change management and training to succeed [75].
- Cost Concerns: A medium-sized corporation was reluctant to adopt ChatGPT technology due to high costs and uncertainty about ROI [76].

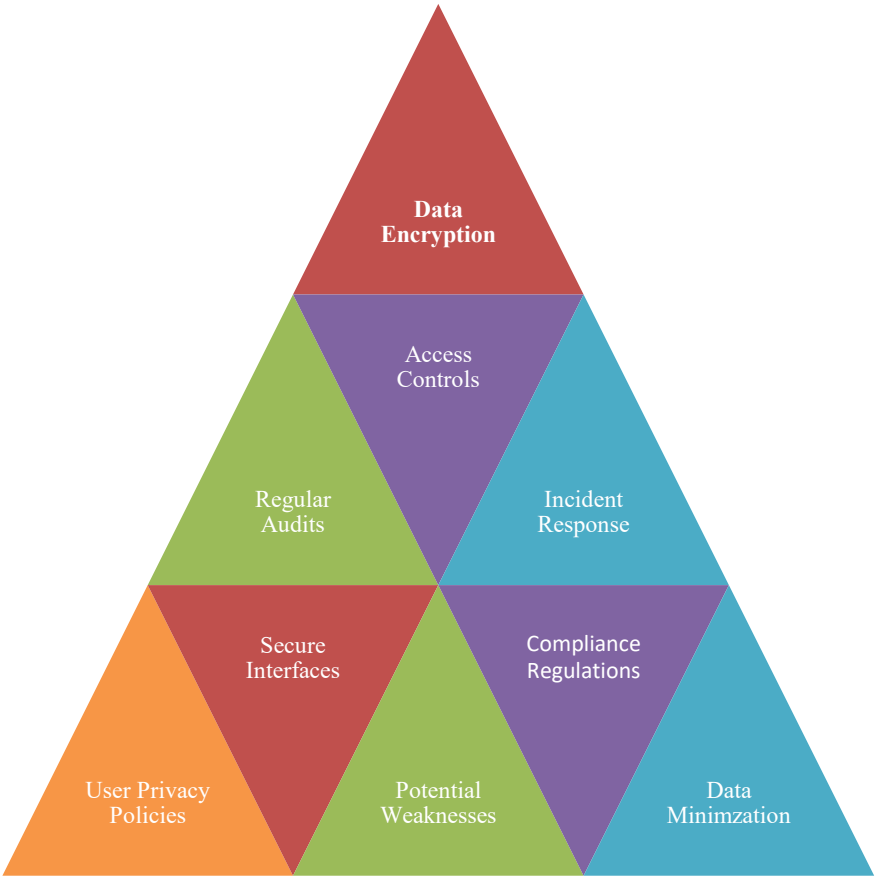

Fig. 4. Security and Privacy Concerns in ChatGPT and Metaverse Integration
Source: Author's work

Metaverse and ChatGPT technology greatly benefit supply chain management. However, to achieve this integration, security, acceptance, and technological challenges must be addressed. These technologies may enhance supply chain operations and help organizations achieve their strategic goals, provided they recognize and address these concerns.

7. FUTURE DIRECTIONS

7.1. Potential Advancements in Metaverse and ChatGPT

Future development of Metaverse and ChatGPT might revolutionize supply chain management. As virtual and augmented reality improve, Metaverse users may expect increasingly vivid and participatory virtual environments. Technology like haptic feedback, which adds a physical aspect to online settings, may enable more realistic and participatory supply chain simulations. Metaverse settings might benefit from AI-powered virtual assistant upgrades that make virtual simulation interactions more natural and responsive. Natural

language processing and comprehension improvements should help ChatGPT understand complex questions. Future ChatGPT versions may include more complicated reasoning and contextual understanding for more accurate and valuable responses. Integrating ChatGPT with computer vision and machine learning may increase its ability to handle and comprehend multimodal data – videos, photos, and text. Metaverse technology may enable more realistic virtual supply chain networks with real-time environmental changes and dynamic interactions. Due to its extensive natural language processing capabilities, ChatGPT may be able to handle more complex supply chain circumstances and provide more accurate and contextually relevant decision-making insights. Figure 5 shows potential advancements in AI Technologies.

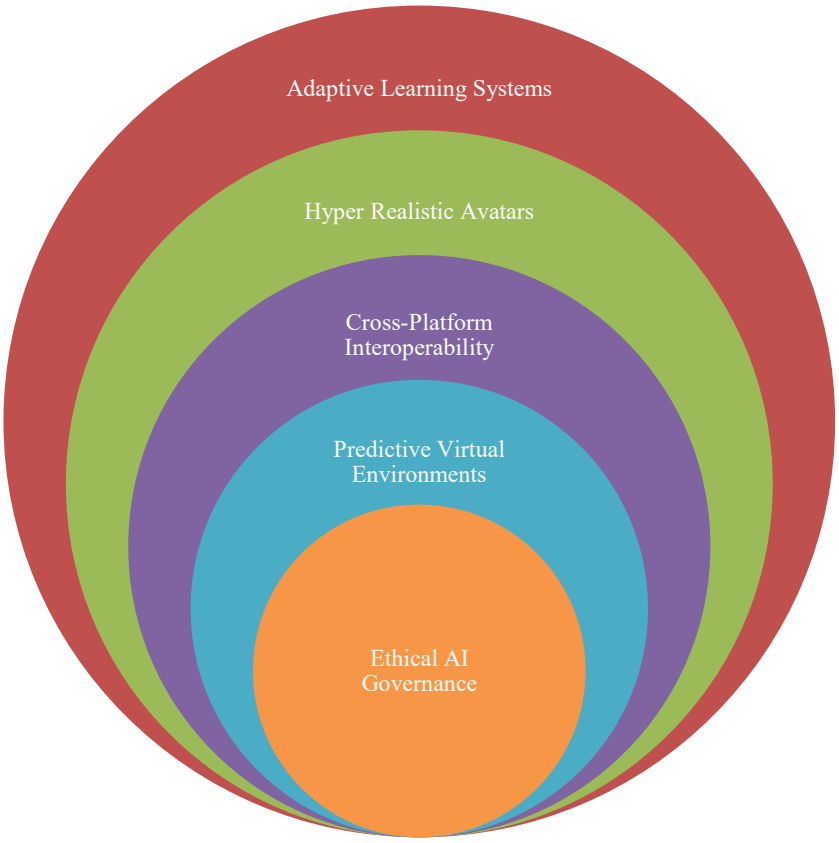

Fig. 5. Advancements in Metaverse and ChatGPT
Source: Author's work

7.2. Prospects for Further Integration in Supply Chain Management

Metaverse and ChatGPT are being added to additional supply chain management systems, enabling greater optimization and innovation. As Metaverse technology advances, supply chain design and simulation tools will become more participatory. This development may allow organizations to replicate and test whole supply chain systems before going into production using virtual supply chain twins. With increased real-time data analysis and decision-support, ChatGPT will become more significant in supply chain management. ERP and advanced analytics platforms are two supply chain management systems that might be integrated with this technology to regulate supply chain operations. Increased usage of ChatGPT for scenario planning and predictive analytics may help organizations anticipate and resolve issues. Supply chain network virtual twins may be Metaverse technology's next great usage. This would enable supply chain strategy improvement and testing. ChatGPT integration with ERP and advanced

analytics platforms might provide a unified supply chain management solution with real-time data and recommendations. Figure 6 shows the integrated SCM solutions through different crucial factors.

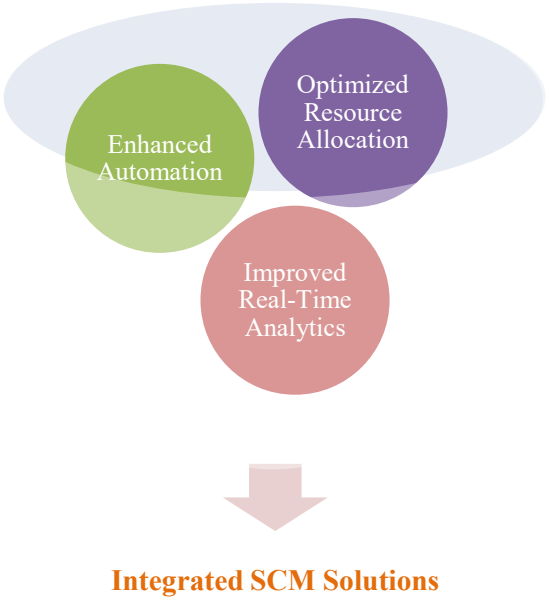

Fig. 6. Prospects for Assimilation in SCM
Source: Author's work

7.3. Research Gaps and Opportunities

Metaverse and ChatGPT integration in supply chain management offers research opportunities and constraints, despite promising results. A significant study is required on the effectiveness and practical usage of these technologies in supply chains. Even with a lot of theoretical and experimental research, more case studies and data are needed to prove the benefits and address the issues with these technologies. Another problem is the regulatory and ethical implications of Metaverse and ChatGPT supply chain applications. Data privacy, cybersecurity, and AI morality deserve greater attention. Research in these domains is necessary to build ethical technology usage policies. To verify these assertions, more case studies and performance evaluations of Metaverse and ChatGPT technologies in supply chain management are needed. The ethical and regulatory implications of adopting these technologies into supply chain operations must be researched to ensure their appropriate and safe use. Metaverse and ChatGPT technologies may increase operational efficiency and decision-making, benefiting supply chain management in the future. Addressing research gaps and exploring new opportunities will ensure the proper integration of these technologies into supply chain operations and their full benefits.

8. CONCLUSIONS

Metaverse and ChatGPT technology may revolutionize supply chain management by improving operational efficiency, decision-making, and performance. This research addressed many key findings concerning these technologies' consequences and potential. The study

suggests merging Metaverse and ChatGPT technologies into transportation logistics to revolutionize smart, sustainable, and secure transportation systems. Conversational AI and immersive simulation improve logistics network situational awareness, decision-making, and communication reliability. Both simulations and real-world transportation operations indicate that these technologies improve efficiency, risk prediction, and safety compliance. Successfully implementing AI-driven logistics solutions requires a solid data infrastructure, digital governance procedures, and staff reskilling. Policymakers, logistics managers, and tech developers should collaborate on legal and technical norms for AI interoperability, cybersecurity, and ethics. Metaverse and ChatGPT integration is a strategic enabler for intelligent transport logistics in the AI-driven economy, not merely a technological development. Metaverse technology can replicate and display the supply chain in real-time. Immersive 3D modeling and dynamic environment interaction allow supply chain operations, design research, and optimization in the Metaverse. It increases risk management, product monitoring, and virtual training by simulating and evaluating several supply chain scenarios. ChatGPT's natural language processing transforms supply chain data analysis and communication. It analyzes textual material, provides insights and ideas, and automates client requests and report creation. ChatGPT allows quicker and more accurate processing of enormous volumes of data, improving supply chain management decision-making.

Integration of these technologies has significant implications for supply chain management. Supply chain managers may utilize the Metaverse through virtual simulations to make better decisions and operate more efficiently. It improves logistics, inventory management, stakeholder participation, and commodity monitoring. ChatGPT automates data analysis and transfers to boost supply chain insight. Real-time data and ideas may help strategic planning, risk management, and predictive analytics. This makes supply chain operations more agile and responsive, helping organizations handle disruptions and enhance performance. Future Metaverse and ChatGPT technologies will greatly impact SCM. As these technologies advance, better modeling, analysis, and decision-making tools will become accessible. ChatGPT improves language processing and AI interaction, while the Metaverse creates more immersive virtual environments. To fully achieve these technologies' potential, we must tackle their technical, security, and acceptability issues. Responsible and effective Metaverse and ChatGPT use in supply chain management requires continual study, empirical validation, and best practices to overcome these challenges. Finally, Metaverse and ChatGPT technologies have revolutionized supply chain management, enabling optimization and innovation. By using these technologies, companies can improve supply chain resilience and efficiency.

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Received 07.12.2025; accepted in revised form 14.02.2026