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Digital Twin Models for Capacity Forecasting in Supply Chains: Methods and Pitfalls

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Abstract: Digital twin technology is a next-generation technology in supply chain management that portrays advanced capabilities in predicting capacity, performance optimization, and responsiveness. Predictive modeling and decision-making can be supported using digital twins by applying real-time data from physical assets and virtualized environments to enhance operational efficiency and flexibility. The methodological basis, technological frameworks, and industry-focused implementations of digital twin models in supply chain capacity forecasting will be examined in this review. It also describes how it enhances logistics, manufacturing, humanitarian endeavors, and food systems, especially emphasizing the significance of incorporating artificial intelligence, generative algorithms, and sustainability-focused analytics. The analysis exposes pitfalls such as data inconsistency, cybersecurity risks, and scalability issues that make wide adoption difficult. In addition, future trends, including blockchain, quantum computing, and edge technologies, are mentioned in the review as enablers of simpler and more sustainable capacity forecasting. Such findings point to the need to align technological innovation with organizational preparedness and governance systems as a way of realizing the full potential of digital twin–driven forecasting systems.

Keywords: Digital twins, capacity forecasting, supply chain resilience, artificial intelligence.

INTRODUCTION

The idea of digital twins has gained significant popularity in the realm of supply chain management, in particular due to the possibility of integrating physical and virtual environments to make superior decisions and improve operations. A digital twin represents a real-time virtual model of a physical system that enables organizations to simulate, predict, and optimize their work. These are dynamic analytical tools which can be utilized in the supply chain to forecast demand, assess risks, and identify limitations in the production and logistics chain [Guo, D., & Mantravadi, S. 2025]. The need for such tools becomes even more obvious in environments of global uncertainty, market volatility, and increasing supply chain complexity. Digital twin models enable companies to observe the entire system, assess interdependencies, and predict potential disruptions before they happen [Guo, D., & Mantravadi, S. 2025].

The growing interconnectivity of data analytics, artificial intelligence, and the Internet of Things has made digital twins more applicable in terms of capacity forecasting. They present predictive information by continuously matching data between production units, warehouses, and transport systems with their digital counterparts [Srivastava, G., & Bag, S. 2025]. This synchronization makes supply chains more responsive and flexible. Despite these merits, predicting capacity using digital twin models faces challenges such as complexity in data integration, computational complexity, and expensive implementation. Moreover, companies must find a compromise between technological development and human decision-making, data privacy, and fairness. In this review, the strategies adopted in capacity forecasting using digital twins are analyzed, and the challenges encountered in their implementation are outlined.

METHODOLOGY

The proposed research will presuppose the use of a structured literature review methodology in order to review the existing literature on digital twins in supply chains in terms of capacity forecasting. It aims to establish current practices, technological systems, and implementation issues discussed in peer-reviewed and high-impact academic literature.

Search Strategy

The literature was identified through systematic searches of multidisciplinary academic databases, including engineering, operations management, and information systems. This search was limited to the period from 2019 to 2025 because the most recent trends in digital twin technologies and supply chain forecasting were to be covered. Key terms and operators such as “digital twin,” “capacity forecasting,” and “supply chain resilience” were utilized. Only academic and peer-

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reviewed materials were used to ensure academic rigor.

Inclusion and Exclusion Criteria

The inclusion criteria were based on:

1. Studies explicitly addressing the application of digital twin models in supply chain capacity forecasting.
2. Research focusing on methodological development, implementation frameworks, or empirical evaluation of digital twin systems.
3. Sources published in English and in peer-reviewed journals, edited volumes, or conference proceedings.

Purely theoretical studies that lacked application relevance or were not related to forecasting processes were excluded. Articles that mention digital twins in areas not related to the supply chain, e.g., smart cities, health diagnostics, or autonomous vehicles (not within the supply chain context), were also filtered out.

Selection Process

An initial search of over 180 studies was identified. Filtering was performed manually to exclude duplicates and non-relevant entries. Relevance to capacity forecasting was assessed through titles and abstracts, and approximately 60 papers were read in full text. Among them, 10 core studies were retained for the final analysis and subjected to in-depth qualitative synthesis based on their thematic and methodological relevance.

Data Extraction and Synthesis

Each selected paper was analyzed according to four dimensions:
(a) conceptualization of digital twin frameworks,
(b) methodological approach to capacity forecasting,
(c) technological enablers and integration tools (AI, IoT, cloud, etc.), and
(d) challenges, limitations, or pitfalls noted by the authors.

The data were thematically coded using an interpretive synthesis approach. Patterns emerging across studies-such as emphasis on AI-driven forecasting, sustainability integration, or challenges of interoperability-were grouped into analytical categories that structured the subsequent review sections.

This methodological process ensured comprehensive coverage of the state of the art while maintaining transparency and replicability of the review.

FOUNDATIONS OF DIGITAL TWINS IN SUPPLY CHAIN CAPACITY FORECASTING

Digital twin models in the sphere of supply chain forecasting are based on the fact that they bridge the gap between real-time data and strategic decision-making. A strategic digital twin ensures that sensor data and enterprise data are continuously recorded; this data is processed with predictive models, and the virtual image of the supply chain is reconfigured [Guo, D., & Mantravadi, S. 2025]. Such dynamic representation enables decision-makers to test scenarios, such as a spurt of demand, equipment failure, or unavailability of resources, without affecting actual processes.

Recent studies have found that digital twin technology has significantly helped in lean supply chain management due to its capacity to identify and eliminate waste in production processes [Guo, D., & Mantravadi, S. 2025]. To ensure that forecasting models not only predict capacity boundaries but also provide optimal responses, a combination of lean principles and digital twins is needed. Some of the ways such responses could be implemented include redistribution, re-scheduling of suppliers, and reconfiguration of transport paths to balance supply and demand.

Digital twin technology is a predictive and resource forecasting tool applied in crises such as humanitarian supply chains, where there is greater uncertainty and disruption [Srivastava, G., & Bag, S. 2025]. The logistics of the humanitarian sector is driven by rapid response and flexible planning to ensure that aid reaches affected regions on time. Digital twins can support such processes by modeling various crisis scenarios and pre-determining the logistics capacity required based on changing conditions such as terrain, infrastructure damage, and population displacement [Srivastava, G., & Bag, S. 2025].

TECHNOLOGICAL FRAMEWORKS AND INTEGRATION APPROACHES

The application of digital twin models to achieve capacity predictions entails integrating different technological pillars to be successful. These include the Internet of Things to gather real-time data, artificial intelligence to make predictions, and cloud computing to store and process data on a scalable basis. These technologies have synergies that help create an environment that can track and predict supply chain performance continuously.

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Interoperability and data quality are critical in digital twins. Data received from production lines, warehouses, and transport vehicles must be standardized to create a unified structure. Higher-order data structures such as digital thread systems can ensure that every stage of the life cycle of a product or process has an electronic connection [Srinivasarao, L. B. 2025]. Such connectivity makes it possible to have holistic forecasts, in which capacity assessment may include both upstream and downstream elements throughout the supply chain.

Digital twins are also more predictive with the help of other technological advances such as AI-based simulations [Srinivasarao, L. B. 2025]. They are able to optimize predictions using past data, with the aim of reducing uncertainty through machine learning algorithms. This predictive flexibility makes them popular among industries that experience a high rate of demand fluctuation or have limited resources. Nonetheless, integration is still a complex undertaking and requires modification of technological systems, organizational procedures, and human expertise [Srinivasarao, L. B. 2025].

BARRIERS AND CHALLENGES IN IMPLEMENTATION

Despite the high potential of digital twins to predict capacity, they are subject to many challenges in their adoption. A key issue lies in the cost of technology implementation and data management [Sharma, A. K. *et al*., 2026]. In order to keep physical and digital systems aligned in real time, organizations are required to invest in IoT sensors, edge computing, and analytics platforms. These investments can have prohibitive effects on small and medium enterprises, which often lack the funds or technical ability to undergo such transitions [Sharma, A. K. *et al*., 2026].

The second challenge is the lack of standardization in the development of digital twins. Without standardized approaches, different organizations may develop incompatible models, thus restricting the potential for cooperation and information exchange between supply chains. Moreover, concerns about data security and privacy also limit the level of information exchange needed for integrated forecasting [Sharma, A. K. *et al*., 2026]. Compliance with regulatory standards, especially in sensitive sectors such as healthcare supply chains where patient data is involved, adds extra complexity to digital twin adoption [Sharma, A. K. *et al*., 2026].

Another issue of paramount importance is organizational resistance. The transition to digital twins requires a cultural shift toward digitalization and data-driven decision-making in supply chain management systems. Employees and managers need to be trained to trust predictive analytics systems and algorithms, which often replace intuition with model-based insights. The successful implementation of digital twins depends not only on technological preparedness but also on the adaptability of human resources in many cases [Sharma, A. K. *et al*., 2026].

APPLICATIONS IN LOGISTICS AND TRANSPORTATION SYSTEMS

Digital twins introduce a paradigm shift in the sphere of logistics and transportation management, where capacity forecasting is essential for efficiency and reliability. The virtual modeling of vehicles, routes, and infrastructure allows logistics managers to plan transport flows and assess network performance under a range of conditions with the assistance of digital twins [Vashishth, T. K. *et al*., 2025]. These models are used to determine optimal fleet sizes, and maintenance activities are planned and executed based on estimated demand.

Perhaps the most important advantage of digital twins in the logistics industry is the ability to capture interdependencies between transportation nodes. For example, a digital twin can predict the effects of a delay at one distribution center in real time on downstream delivery paths and capacity utilization [Vashishth, T. K. *et al*., 2025]. This visibility helps managers reallocate resources to minimize disruptions. The result is a robust and flexible transport system capable of absorbing external shocks such as weather changes or traffic congestion.

In addition to predictive modeling, digital twins may also be utilized for sustainable logistics to reduce resource consumption and carbon emissions [Vashishth, T. K. *et al*., 2025]. Inefficiencies in fuel consumption, vehicle routing, and warehouse operations can be detected using real-time data analysis, and alternative strategies can be proposed by these systems. Sustainability-focused forecasting models enhance operational efficiency and assist in achieving environmental objectives and green logistics goals [Vashishth, T. K. *et al*., 2025].

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ROLE IN CIRCULAR VALUE CHAINS AND SUSTAINABLE MANUFACTURING

Digital twins are applied in the sphere of manufacturing and the circular economy to predict capacity, with a focus on reusing and recycling components [Thakuri, P. K. *et al*., 2025]. Digital twins may be applied alongside IoT and robotic technologies to monitor the lifecycle of products and estimate how much time is required before parts return to the manufacturing company to be refurbished or reused. This prediction capability is useful in the capacity planning of recycling centers and remanufacturing plants to ensure that supply is sufficient to handle the expected volume of returned components [Thakuri, P. K. *et al*., 2025].

The digital representation of production assets also allows firms to assess the effectiveness of resource flows in connection with circularity goals. For example, manufacturers can estimate the impact of material substitution or process changes on capacity and sustainability outcomes. Digital twins provide quantitative feedback on energy consumption, waste, and recovery, and support informed decisions on improving material productivity [Thakuri, P. K. *et al*., 2025]. This kind of understanding has been widely adopted in industries such as construction and electronics manufacturing, where reuse of parts plays a significant role in reducing environmental impact and production costs [Thakuri, P. K. *et al*., 2025].

DIGITAL TWIN IN FOOD SUPPLY CHAINS AND INDUSTRY 5.0

Digital twin models have been utilized to provide capacity prediction and optimization of food industry processes that face issues of perishability, demand fluctuations, and quality assurance [Sanfiya, S., & Sabitha Banu, A. 2025]. Digital twins in this industry represent the entire supply chain, from farm to retail store, recording temperature, humidity, and transport conditions in real time. Based on such data, they forecast inventory levels, optimize logistics, and minimize food waste.

The potential of digital twins is further enhanced by Industry 5.0, as the concept is designed to incorporate human-centric and sustainable values [Sanfiya, S., & Sabitha Banu, A. 2025]. Digital twins improve capacity predictions with a high degree of accuracy while also considering ethical and ecological aspects through collaboration between humans and intelligent systems. In food management, this integration helps ensure that production meets fluctuating demand and sustainability goals [Sanfiya, S., & Sabitha Banu, A. 2025]. Another application of digital twins is real-time tracking of supply chain resilience during disruptions in food systems, enabling improved food security [Sanfiya, S., & Sabitha Banu, A. 2025].

Table 1: Comparison of Digital Twin Applications across Supply Chain Domains

Sector	**Primary Use**	**Forecasting Focus**	**Key Benefits**
Manufacturing	Predictive maintenance and capacity forecasting	Production and resource utilization	Reduced downtime and waste
Logistics & Transportation	Route and fleet optimization	Delivery and throughput capacity	Improved responsiveness and efficiency
Humanitarian Supply Chain	Emergency logistics planning	Resource allocation under crisis	Enhanced flexibility and resilience
Healthcare Supply Chain	Inventory and demand management	Storage and delivery capacity	Compliance and safety assurance
Circular Manufacturing	Component reuse and recycling	Material recovery and reuse forecasting	Sustainability and cost efficiency
Food Supply Chain	Perishability management and traceability	Storage and distribution capacity	Waste reduction and quality improvement

Figure 1 illustrates how data flows from physical supply chain elements through IoT devices and cloud systems into an AI-driven digital-twin model that generates capacity forecasts.

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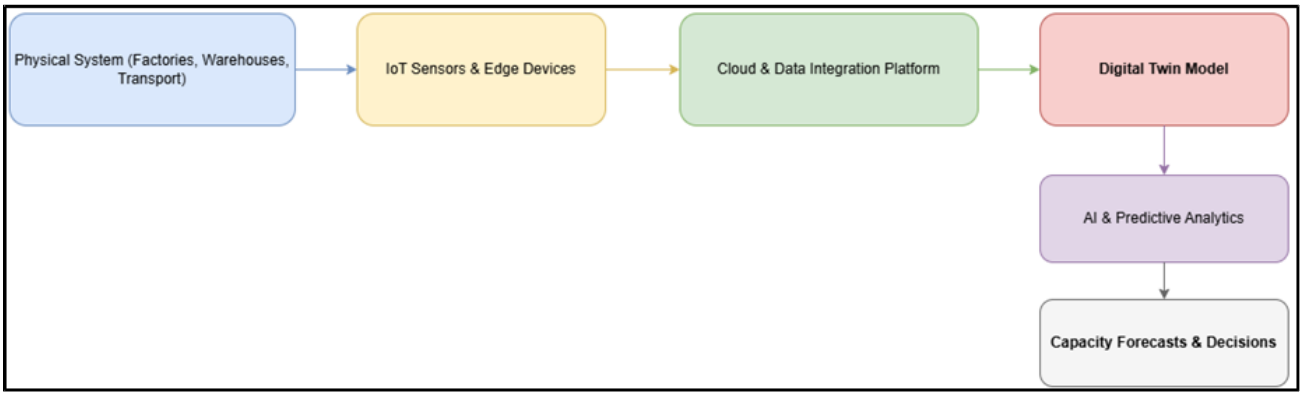

Figure 1: Conceptual Diagram of a Digital Twin Framework for Supply Chain Capacity Forecasting

A visual representation showing physical systems feeding real-time data into digital models, supported by AI analytics and IoT networks for predictive forecasting.

ARTIFICIAL INTELLIGENCE AND PREDICTIVE CAPACITY MODELLING

AI has now become a crucial component of digital twin modeling for supply chain capacity prediction. It enhances the predictive and analytical potential of digital twins, which are trained on past data trends and continuously updated with new information [Ashok, S. 2025]. Digital twins can identify correlations that are otherwise difficult to detect using traditional statistical models due to the use of machine learning algorithms, particularly those supporting time-series forecasting and neural networks. Through this, organizations can forecast production constraints, peaks, and capacity limits with greater accuracy [Ashok, S. 2025].

With the incorporation of AI, digital twins become active, self-learning systems rather than passive ones. AI-powered digital twins can simulate various production and logistics scenarios, assess their probable impacts, and propose efficient response actions [Ashok, S. 2025]. These models are particularly useful when dealing with complex networks where multiple variables-such as supplier reliability, transportation delays, and market demand fluctuations-interact simultaneously. Predictive AI models expand the capability of digital twins to provide both short- and long-term capacity projections while accounting for uncertainty and changing market conditions [Ashok, S. 2025].

Additionally, AI-driven digital twins support cross-functional decision-making by linking forecasting with financial planning and procurement. These models can optimize supply chain objectives, including cost minimization and service level maximization. However, data quality remains a critical requirement for their success. Even the most advanced AI algorithms cannot produce reliable predictions without timely and accurate data inputs, which can undermine the effectiveness of digital twin applications in capacity management [Ashok, S. 2025].

GENERATIVE AI AND RESILIENT SUPPLY CHAINS

Generative AI has created new possibilities in digital twins in supply chains. Unlike traditional predictive models that work with already available data, generative AI can generate synthetic data and simulate hypothetical disruptions to determine system resilience [Boone, T. *et al*., 2025]. This feature allows companies to evaluate the effectiveness of their supply chains under extreme conditions, such as demand spikes, supplier breakdowns, or geopolitical disruptions. By integrating generative AI with digital twins, companies can develop capacity forecasting models that not only predict but also stress-test operational limits [Boone, T. *et al*., 2025].

Generative AI is employed to expand scenario diversity, as it creates a range of alternative futures and assists in strategic decision-making. For example, in logistics networks, it can generate simulated transport paths and warehouse layouts to identify configurations with the highest resilience under various constraints [Boone, T. *et al*., 2025]. This capability supports long-term capacity planning by identifying weak points in the supply chain and providing practical recommendations for improvement. As a result, decision-makers are better equipped to understand systemic vulnerabilities, enabling more effective contingency planning and adaptive resource allocation [Boone, T. *et al*., 2025].

However, challenges exist in applying generative AI in digital twins. The interpretation of generated

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outputs is a significant issue, as decision-makers may struggle to understand the rationale behind model recommendations. Ethical concerns, such as data privacy and potential bias in synthetic data generation, also pose implementation challenges. Nevertheless, despite these concerns, the introduction of generative AI represents a significant advancement toward more robust and intelligent supply chain forecasting systems [Boone, T. *et al*., 2025].

METHODS FOR CAPACITY FORECASTING USING DIGITAL TWINS

Capacity forecasting using digital twins makes use of several methodological instruments that involve the incorporation of simulation, optimization, and data-driven analytics. These include discrete event simulation, system dynamics, and hybrid models that combine data analytics with physics-based simulations as the main approaches [Guo, D., & Mantravadi, S. 2025]. Supply chain activities are modeled in discrete event simulation, where events are represented in a time-based manner, e.g., production batches or the arrival of transport. These models can be used to estimate system capacity under various levels of workload and resource constraints [Guo, D., & Mantravadi, S. 2025].

System dynamics, however, focuses on understanding feedback loops and interactions between various elements of a supply chain. This method permits long-term capacity forecasting and modeling of cause-and-effect relationships [Srivastava, G., & Bag, S. 2025]. The use of hybrid modeling techniques has recently gained popularity because of their ability to combine the strengths of mathematical optimization with the flexibility of AI-based learning models [Srinivasarao, L. B. 2025]. Such models have parameters that are continuously re-calibrated as new data is received, allowing real-time adjustments to forecasts.

A common feature of these approaches is their reliance on online connectivity and continuous data exchange. IoT-enabled sensors and data acquisition systems are essential to ensure that physical parameters, such as production rates, machine utilization, and transport loads, are accurately reflected in digital models [Vashishth, T. K. *et al*., 2025]. Scalability is also enhanced because cloud computing enables organizations to perform complex simulations without being limited by local infrastructure. The effectiveness of these methods depends on model accuracy, data fidelity, and the degree of alignment between physical and digital systems [Thakuri, P. K. *et al*., 2025].

COMMON PITFALLS IN DIGITAL TWIN-BASED FORECASTING

Despite the promise, digital twin technology comes with several challenges when deployed to predict capacity in supply chains. The heterogeneity of information, i.e., data from a variety of sources and formats that cannot be easily standardized, is one of the key issues [Sharma, A. K. *et al*., 2026]. Incomplete or inconsistent data can lead to incorrect predictions and reduce model accuracy. Besides, digital twins are highly sensitive to parameter calibration; even small errors in input values may lead to substantial prediction errors [Sharma, A. K. *et al*., 2026].

Another issue is the overreliance on technology without sufficient consideration of human judgment. Although predictive models provide quantitative insights, they do not always adequately capture qualitative factors such as managerial experience, supplier relationships, and geopolitical risks [Sharma, A. K. *et al*., 2026]. Consequently, organizations may risk making strategic decisions based on incomplete models without considering contextual variables.

Cybersecurity is also a major concern. Digital twins are prone to cyberattacks because they require continuous data transfer between interconnected systems, and such attacks can disrupt operational integrity [Vashishth, T. K. *et al*., 2025]. Sensitive supply chain information may be compromised, leading to financial losses and reputational damage. Moreover, the computational cost of high-fidelity digital twins can be too high, especially in large-scale global supply chains [Thakuri, P. K. *et al*., 2025]. Digital twin projects may stall or fail to scale unless they are adequately resourced to realize their full potential.

Lastly, scalability remains a challenge when applying digital twin models across different levels of the supply chain. Integrating data from suppliers, manufacturers, and distributors often involves complex negotiations and interoperability issues [Vashishth, T. K. *et al*., 2025]. Overcoming these barriers requires collaborative frameworks, standardized data-sharing processes, and trust among supply chain partners.

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Future Directions and Emerging Trends

The future of digital twins in supply chain capacity forecasting is characterized by increasing integration with emerging technologies. The use of blockchain will elevate the degree of openness and traceability within digital twin ecosystems and ensure the authenticity of information and secure interactions [Thakuri, P. K. *et al.*, 2025]. Through the integration of blockchain and digital twins, businesses can establish an immutable record of transactions and performance data, thereby increasing trust among supply chain participants.

Another opportunity lies in accelerating complex simulations in digital twins with the help of quantum computing [Ashok, S. 2025]. It can significantly reduce computation time, as quantum algorithms are capable of processing large volumes of data and analyzing multiple capacity scenarios simultaneously. This development has the potential to enable real-time decision-making in highly dynamic environments such as global manufacturing and logistics.

The rise of edge computing has also contributed to the advancement of digital twins. Latency is reduced and responsiveness is improved in capacity forecasting models through the use of edge devices that process data closer to its source [Vashishth, T. K. *et al.*, 2025]. This capability is particularly important in time-sensitive operations where real-time data is required for decision-making.

In addition, sustainability considerations in digital twins are an emerging area of research. Metrics such as carbon footprint, energy consumption, and waste reduction can be incorporated into future capacity forecasting models [Sanfiya, S., & Sabitha Banu, A. *et al.*, 2025]. These developments align with global sustainability goals and regulatory requirements, ensuring that capacity forecasting is not only efficient but also environmentally sustainable [Sanfiya, S., & Sabitha Banu, A. 2025].

Figure 2 Shows a line graph comparing forecast accuracy, demonstrating that digital-twin-enhanced models consistently outperform traditional forecasting approaches over time.

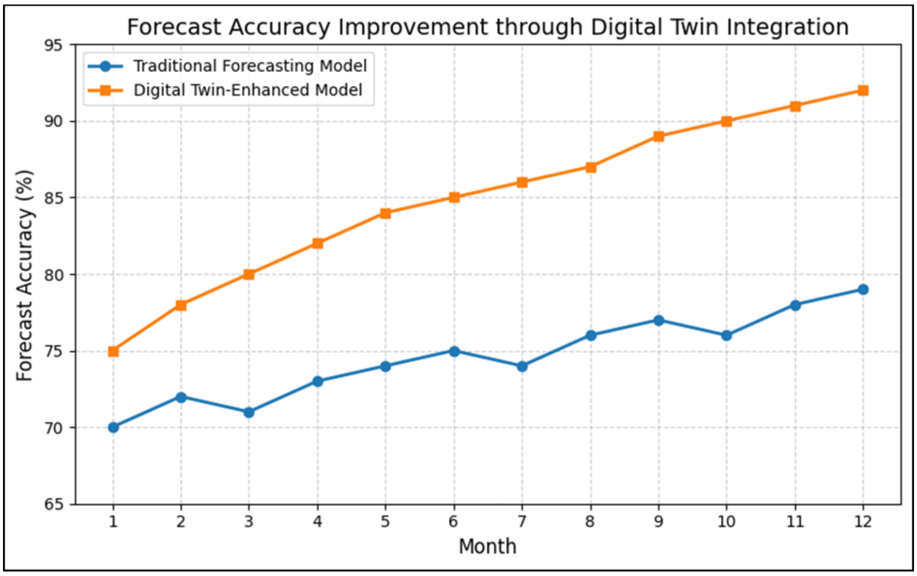

Figure 2: Graphical Representation of Forecast Accuracy Improvement through Digital Twin Integration

DISCUSSION

The review of the literature indicates that theoretical models of digital twins have become instruments for dynamic capacity planning. Their adoption has been driven by advances in AI, IoT, and data analytics, as each contributes to improved forecasting and operational visibility [Ashok, S. 2025]. However, these advantages are hampered by challenges in data management, model validation, and cost justification [Sharma, A. K. *et al.*, 2026]. This dichotomy between opportunities and constraints highlights the importance of strategic alignment between technological implementation and organizational preparedness.

Digital twins also change conventional supply chain collaboration. They simplify information sharing and transparency but introduce challenges related to information ownership and competitive sensitivity [Vashishth, T. K. *et al.*, 2025]. These paradoxes must be addressed through governance systems that define the ethics and boundaries of digital twin usage. In addition, interdisciplinary

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collaboration among engineers, data scientists, and supply chain managers is required to develop robust forecasting models that integrate both technical and managerial aspects of decision-making [Guo, D., & Mantravadi, S. 2025].

Moreover, digital twins must remain responsive to changing supply chain conditions to be effective. This involves continuous calibration and learning processes to ensure that models remain synchronized with evolving market trends and production patterns [Boone, T. *et al*., 2025]. The integration of emerging technologies, such as generative AI and blockchain, further emphasizes their evolving role as central components of modern supply chain ecosystems. Nevertheless, the gap between digital innovation and organizational capability persists and must be addressed through continued research and investment [Ashok, S. 2025].

FUTURE DIRECTIONS

The evolving research on digital twins in supply chain capacity forecasting indicates that a great number of changes are taking place, but there are still significant gaps that define the future of the discipline.

Strengths of the Current Research Landscape

The literature on the subject has already formed strong theoretical foundations linking digital twins with real-time forecasting, predictive analytics, and resilience management. The identification of AI-powered learning models, IoT-enabled sensing, and cloud-based data processing has transformed digital twins from mere simulators into interactive and effective prediction systems. The inclusion of sustainability and circular economy models, particularly in manufacturing and food systems, represents an initial move toward environmentally conscious forecasting models.

Such benefits add to the fact that modern studies are interdisciplinary due to the abundance of techniques available, and the implementation of digital twins across numerous industries presents a valuable practical solution. Both academic and business communities are increasingly aligning toward common goals of performance and resilience.

Weaknesses and Limitations of Existing Studies

Despite these improvements, methodological fragmentation and limited empirical validation have been observed in the reviewed literature. Most studies rely on conceptual or simulation-based demonstrations rather than longitudinal or real-world applications, which reduces generalizability. Furthermore, there are no standardized frameworks for digital twin design and performance measurement to ensure cross-organizational comparability.

There is also a lack of research on data governance and cybersecurity issues, especially in multi-level supply chains where data sovereignty and privacy policies complicate integration. Most studies focus on technical feasibility without adequately considering organizational readiness, cultural adaptation, and change management, which are also critical for successful implementation.

Emerging Research Opportunities

The next generation of research ought to use multi-method empirical research procedures that involve quantitative modeling and qualitative analysis of implementation outcomes. Longitudinal case studies can be utilized to monitor the dynamic evolution of digital twin functioning in real industrial contexts. Another urgent need is to develop standardized interoperability protocols that are going to make data sharing among digital twin ecosystems possible.

The integration of blockchain technologies offers sufficient prospects for ensuring data provenance and enhancing the degree of trust, and quantum computing can offer a solution to the limits of computational scalability by enabling much faster optimization of complex network models. Moreover, the combination of generative AI and reinforcement learning should be considered because, in this manner, proactive capacity management can be attained, as systems do not merely anticipate changes but also adjust to them on their own.

Theoretical Implications

In principle, future work should steer toward aligning systems theory with data-driven forecasting paradigms, such that digital twins are placed within the perspective of a broader governance framework of the supply chain. The current disparity between digital twin design rooted in engineering and management-oriented capacity planning can be bridged through the development of consistent ontologies and structures.

Practical and Policy Implications

From a managerial aspect, this should consider future trends regarding training and the development of cross-disciplinary competencies to support digital transformation. The development of

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open data standards and compliance frameworks that permit the use of data in an innovative and ethical manner can be facilitated by policymakers and industry consortia. The viability of digital innovation, organizational readiness, and governance structures remain central to realizing the promise of digital twin–based forecasting platforms.

CONCLUSION

Digital twin models have redefined capacity forecasting in supply chains by providing data-driven, dynamic insights to improve decision-making performance and operational resilience. The combination of physical and virtual systems enables scenario simulation, constraint prediction, and optimization of resource utilization across different industries. The synthesized methods include simulation-based, AI-based, and hybrid modeling approaches that utilize real-time data from interconnected systems [Guo, D., & Mantravadi, S. 2025; Srivastava, G., & Bag, S. 2025; Srinivasarao, L. B. 2025; Sharma, A. K. *et al*., 2026; Vashishth, T. K. *et al*., 2025; Thakuri, P. K. *et al*., 2025; Sanfiya, S., & Sabitha Banu, A. *et al*., 2025; Sanfiya, S., & Sabitha Banu, A. 2025; Ashok, S. 2025; Boone, T. *et al*., 2025].

They are applied in logistics, manufacturing, healthcare, and food supply chains; however, implementation costs remain high, and challenges related to data integration and cybersecurity risks act as barriers to widespread adoption. The accuracy and effectiveness of forecasts are expected to improve with emerging trends such as generative AI, quantum computing, and blockchain integration. Ultimately, the alignment of technology with human skills, ethical leadership, and long-term organizational adaptability supports the sustainable development of digital twin–based capacity forecasting.

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