

A Review of Smart Manufacturing Supply Chain Management Focusing on Automation Predictive Analytics Sustainability Resilience

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ABSTRACT: Smart Manufacturing Supply Chain Management (SM-SCM) is one of the most important parts of Industry 4.0. It uses smart digital technologies to make manufacturing networks more sustainable, resilient, and efficient. This review examines the fundamental concepts, data-driven supply chain functions, automation technologies, and core digital innovations that support modern manufacturing systems. It discusses the role of data in procurement, planning, production, inventory management, transportation, and customer service for enhancing real-time visibility and decision-making. The examination delves deeper into the topic of automation by way of smart factories, robots, cyber-physical systems (CPS), the Industrial Internet of Things (IIoT), PLCs, SCADA, and digital twin technologies. Analysis also takes a look at the ways in which important supporting technologies like blockchain, AI, ML, cloud, and the Internet of Things have impacted predictive analytics, safe data sharing, and smart manufacturing. The paper also highlights practical application scenarios in automotive, aerospace, electronic equipment, manufacturing equipment, and energy and process industries, demonstrating how these technologies improve productivity, flexibility, quality, and resource utilization. Finally, the review identifies current challenges and future opportunities for developing sustainable, resilient, and autonomous manufacturing supply chains, providing valuable insights for researchers, industry practitioners, and policymakers working toward next-generation smart manufacturing ecosystems.

KEYWORDS: Smart Manufacturing, Supply Chain Management, Industry 4.0, Automation, Internet of Things (IoT), Artificial Intelligence (AI).

1. Introduction

The sustainable operational performance of cyber-physical manufacturing systems in terms of Internet of Things-based real-time production logistics is the subject of an expanding corpus of research. The adoption of sustainability practices, both internal and external, across supply chains can boost organizational performance [1][2]. An organization's supply chain is a powerful and complementary factor in its competitive advantage. More operational strategies can be implemented to take advantage of the expected facilities provided by sustainable business practices as organizations become more sensitive to environmental protection and adapt to changing business environments [3].

The AI-driven manufacturing systems optimize production processes while minimizing downtime through the use of robotic automation, IoT-enabled

smart factories, and AI for predictive maintenance [4][5]. AI-based supply chain solutions contribute to improved demand forecasting, inventory management, and logistics coordination, thereby strengthening resilience and responsiveness in industrial supply networks. Tesla, Siemens, or Amazon all have implemented such ecosystems and - many, many more, or- with great savings and productivity gains. This type of innovation progressively changes manufacturers into rapidly converting suppliers into manufacturing firms.

One definition of supply chain management is the proactive measurement of the four flows: materials, process, cases, and information [6][7][8]. The SC's logistics department is in charge of the organization, distribution, and storage of all SC-related goods, services, and data. The removal of national borders has led to more intense rivalry in today's globalized marketplaces. In order to stay in business and keep growing, companies need to figure out how to take use of new digital

technology [9]. Supply chains on a global scale need to be rethought in order to take advantage of possibilities that provide more adaptability. Maintaining a competitive edge requires methodical clever implementations [10]. Modern SC apps use the Industry 4.0 framework to digitize more products and services and to increase the scope of internal operations.

A. Structure of the paper

This paper is structured as follows. Section II explains how Smart Manufacturing Supply Chain Management actually works. Section III delves into automation technologies, Section IV assesses the most current literature, and Section V wraps up the work by outlining potential avenues for further research.

2. Fundamentals of Smart Manufacturing Supply Chain Management

The goal of implementing a Smart Manufacturing Supply Chain Management system is to enhance the visibility, efficiency, and decision-making capabilities of the manufacturing and logistics processes through the integration of complex digital technology. The system makes use of automation, big data analytics, cloud

computing, the Internet of Things (IoT), and artificial intelligence (AI) to allow for planning in advance, monitoring in real-time, and optimizing the use of resources. Smart supply chains can swiftly adapt to shifting market needs and interruptions because they are data-driven, highly-connected, and unconventional [11]. This approach enhances production planning, inventory management, quality control, and transportation while reducing operational costs and improving customer satisfaction. By integrating intelligent technologies across the entire value chain, smart manufacturing supply chain management supports sustainable operations, operational resilience, and continuous process improvement, making it a critical component of modern Industry 4.0 environments[12].

A. Data Use in Supply Chain Management Functions

Supply chain efficiency depends on well-managed data, which allows for quicker responses, more accurate decisions, and constant enhancements [13]. Data is used in Fig. 1 to assist coordination, visibility, and decision-making across six major areas of the supply chain, from procurement to customer service.

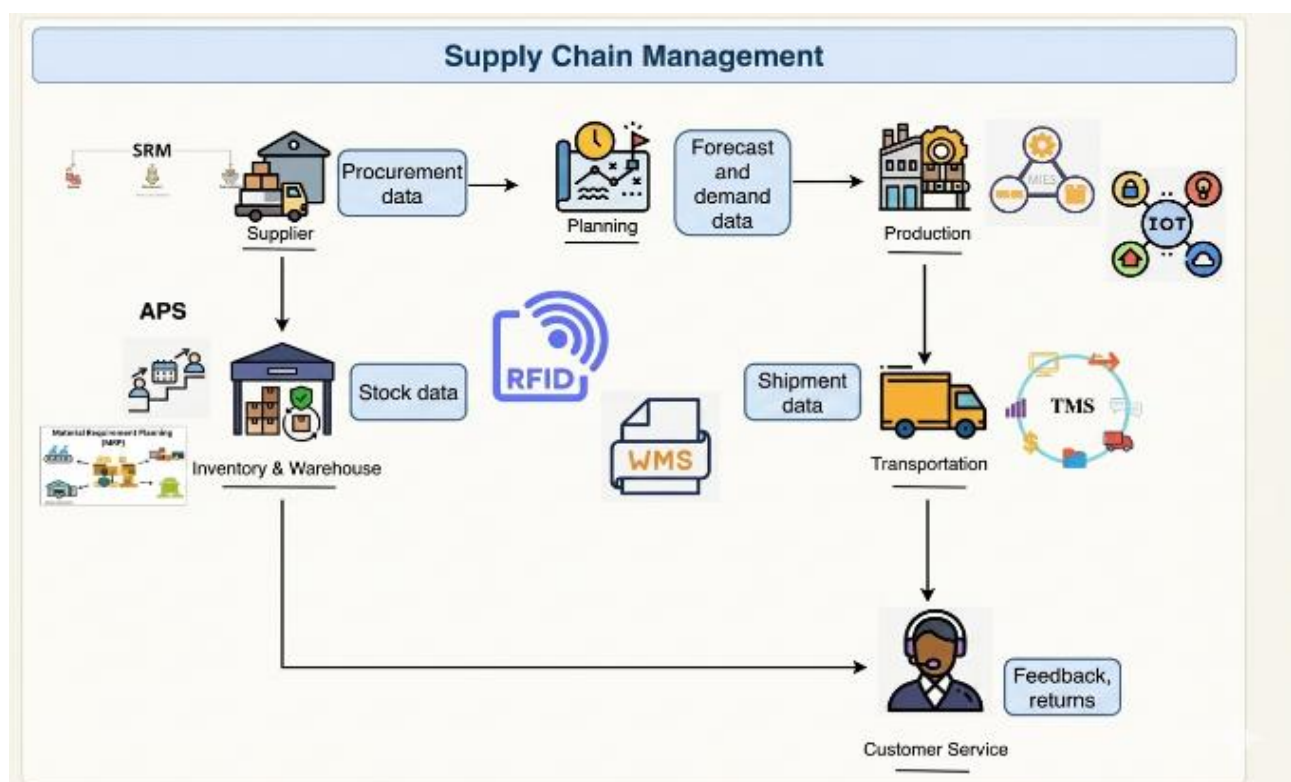


Fig. 1. Data Flows Across Supply Chain Functions

1) Procurement

Sourcing strategies, supplier appraisal, and risk reduction are all supported by procurement's reliance on market knowledge, supplier performance measures, and historical purchase records [14][15]. Electronic sourcing and Supplier Relationship Management (SRM) systems compile information from many vendors,

allowing businesses to choose trustworthy partners, improve contract conditions, and guarantee supply chain continuity.

2) Planning

Data that is both timely and accurate is essential for planning activities to ensure that supply meets demand. Materials Requirements Planning (MRP) and Advanced

Planning Systems (APS) utilize forecast data, manufacturing capacities, and lead times incorporated into their tools [16]. Capacity optimization, inventory planning, and dynamic production scheduling are all made possible through worldwide networks.

3) Production

Data enables predictive maintenance, product tracking, and real-time control on the manufacturing floor. Machine status, quality metrics, and operational events can be captured using Internet of Things (IoT) sensors, digital twins, and Manufacturing Execution Systems (MES) [17]. Manufacturers may use this to their advantage to spot irregularities, cut down on downtime, boost OEE, and guarantee consistent product quality.

4) Inventory and Warehousing

A warehouse management system (WMS) may monitor inventory, expiration dates, and whereabouts using data collected via sensors, radio frequency identification (RFID), and barcodes [18][19]. This information is the backbone of effective internal material flows, slotting optimization, and automatic replenishment. Modern technologies like 3D mapping and digital twins make intralogistics visibility and decision-making even better.

5) Transportation and Distribution

Transportation Management Systems (TMS), GPS trackers, and telematics gather transportation data such as route limits, fleet availability, traffic conditions, and carrier performance [20]. These technologies include route optimization, freight cost reduction, and delivery process transparency, which enhance efficiency and customer satisfaction.

6) Customer Service and Returns

The information gained from customer-facing and reverse logistics operations are invaluable for achieving continual improvement. The performance of after-sale service, complaint rates, feedback, and return rates are all tracked via CRM platforms and returns management systems [21]. Improvements in product design, quality, and customer experience are all guided by this data.

3. Automation in Smart Manufacturing Supply Chains

Automation in smart manufacturing supply chains uses robotics, IoT, artificial intelligence, and cyber-physical systems to improve production, reduce human intervention, enhance operational efficiency, optimize inventory, minimize costs, and enable faster, data-driven decision-making.

A. Automation in Smart Factory

Automation of manufacturing procedures. Improving real-time data collecting and process control using sensor networks and the IIoT becomes the primary emphasis in the intermediate stage [22][23]. At this point, we're optimizing processes and maximizing productivity with the use of AI-driven predictive analytics and autonomous decision-making. Research in recent years has pointed to the IoT, IIoT, and industry 4.0 as the key to smart manufacturing's potential.

1) Factory Autonomous Systems

Factory automation solutions that address this type of issue are based on current control theories that are extensively employed in engineering, especially in the aerospace industry [24]. Problems with system automation need the development of information and communication technologies (ICT), which encompass sensor technology, computer and intelligent technology, communication technology, and control technology.

2) Smart Automation of PLC & SCADA

The research is focusing on the control logic controllers and communication interfaces that are compatible with the thinger.io local server IoT platform [25]. The goal of the study is to show that Arduino and Raspberry Pi can be used to make low-cost embedded platforms based on PLCs. These platforms can provide communication functions, variable pre-processing, and control schemes. The study also wants to show that traditional PLCs have programming limitations so that Arduino and Raspberry Pi powered processors can be used as industrial solutions [26][27]. For SCADA (Supervisory Control and Data Acquisition) systems, the idea of using open source hardware and software arises.

B. Robotics in Smart Manufacturing

The versatility, precision, and longevity of robotics in production have made them famous for raising output and product quality [28]. Intelligent perception, simulation, comprehension, prediction, and optimization of production processes are all made possible by DTs' ability to define, control, and show the behavior of robotic systems in real time [29].

C. CPS and IoT in Smart Factory Manufacturing

There has been a tremendous acceleration of technical growth due to CPS, which may be seen as a new generation of digital systems. When a physical process and a cyber system are tightly integrated, a CPS is born [30]. The term refers to a system that integrates computing and communication capabilities to manage and engage with a physical process [31]. The computing-process feedback loop enhances real-time interactions with the physical system, allowing for safe, efficient, and dependable real-time monitoring or control of the physical entity.

1) Digital Twin Technology

DT is a tool for smart asset management that lets connect real objects to their virtual counterparts at any point in their life cycle to make them behave like they do in the real world. New and improved technology allows for more rapid and effective management, monitoring, and control.

2) Smart Decision-Making Through CPSs

Smart Cities are leading the way in innovation by utilizing cutting-edge technology to improve the lives of citizens and tackle important urban issues. Cyber-Physical Systems (CPSs) are pivotal to this change because they allow for the seamless integration of physical components with computational and communication capabilities to optimize, manage, and monitor many parts of city life. Symbiotic CPS has been growing in popularity in recent years [32]. Intelligent manufacturing and supply chain operations are made possible by core technologies including the IoT, AI, ML, BDA, CC, DT, BL, and Robotics [33]. With the help of these technologies, supply chain performance, sustainability, and efficiency may be enhanced through real-time monitoring, automation, predictive analytics, secure data exchange, and better decision-making..

D. Edge Computing

The edge computing problem in IoM has attracted a lot of attention from academics in the past several years. In order to deal with some of the system's low latency and scarce resources [34], developed a new method for scheduling tasks using a container role and suggested a new visualization service that uses fog computing [35][36]. Task latency and concurrent performance on fog nodes may both be enhanced by the system. He forth a plan for adaptive transmission that incorporates edge computing and software-defined networks (SDN) to address the issue of data exchange in IIoT and smart devices.

E. Blockchain

Trust and safety are big issues in blockchain technology, which can be used to keep information and data safe in any area that is related. The same holds true for this innovative solution for distributed and decentralized computer architecture, which stores the dataset in a chain of encrypted blocks [37]. Blocks include all of the digital information required to complete a transaction, including the date, time, amount, and any other details provided by the user. Any member in the distributed network may access the stored data and use it to verify the transaction's legitimacy [38]. Each node in the blockchain communicates with every other node and backs the crypto and transaction codes. The mathematical

algorithms used in blockchain technology are also crucial, and they are very robust in this network. Blockchain ensures security and transparency by validating blocks at minor nodes without affecting data transmitted via the network.

F. Internet of Things (IoT)

There is a lot of backing for the digitization environment from the expansion of the IoT system. Smart cities, smart farms, traffic monitoring, etc. are only a few examples of the many angles covered by IoT applications. In a similar vein, IoT systems encompass machine-to-machine (M2M) approaches, paving the way for the digitalization of the production system. The ideal way to increase smart manufacturing's efficiency and productivity is the cyber-physical system (CPS), which is where the industrial internet of things (IIoT) meets [39]. This is where the abstraction of Industry 4.0 becomes obvious. offers the Internet of Things (IoT) uses and problems with smart manufacturing [40].

G. Application Scenarios of Smart Manufacturing

Smart manufacturing technologies featuring data interconnection, real-time analytics, flexible scheduling, and Predictive Maintenance (PdM), have been widely applied across industries. As global manufacturing evolves toward high-end, intelligent, and green development, industry-specific requirements drive diversified and customized applications. This section examines representative sectors including automotive, aerospace, electronic equipment, manufacturing equipment, and process industries, summarizing technological pathways and practical outcomes. Fig. 2 displays the landscape of smart manufacturing.

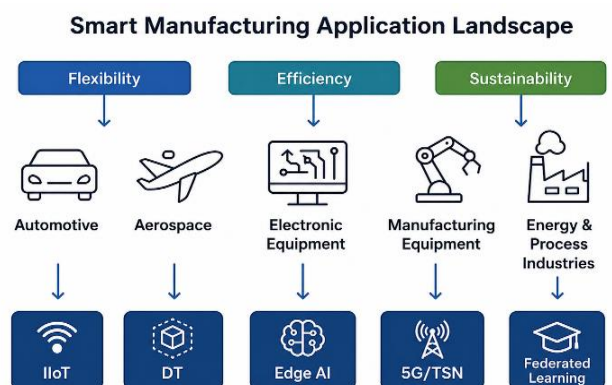


Fig. 2. Smart Manufacturing Application Landscape.

1) Automotive Manufacturing

Automotive manufacturing, a representative discrete sector, is transitioning toward multi-variety and mixed-line production, demanding flexibility and precision while managing complex scheduling and cost constrain[41] The integrated application of Digital Twin (DT) and Edge Computing (EC) has effectively mitigated

these challenges. DT enables real-time visualization of workstation states and predictive simulation of bottlenecks, while EC ensures millisecond-level response and rapid production switching [20]. Evidence shows this combination reduces takt time variance and enhances equipment utilization.

2) Aerospace

Aerospace manufacturing is characterized by high complexity, extreme precision, and long cycles, where design–manufacturing–inspection consistency is vital. The convergence of DT, virtual assembly, Edge Intelligence (EI), and 5G/TSN networks enables real-time deviation correction and collaborative assembly. High-fidelity DT models align with machining data for predictive correction, while 5G/TSN ensures low-latency synchronization. Empirical studies report substantial reductions in assembly errors and validation cycles and improved first-pass yield [42]. Moreover, edge-based DT frameworks deployed on aero-engine testbeds allow real-time simulation of performance degradation, improving fault prediction accuracy and maintenance efficiency while minimizing downtime risk.

3) Electronic Equipment Manufacturing

The electronic equipment industry faces challenges from short product lifecycles and large-scale heterogeneous data. Traditional cloud-centric PdM systems often suffer from latency and data bottlenecks. To address this, the edge–cloud collaborative architecture combined with federated learning has emerged as an effective paradigm. Edge nodes perform feature extraction and inference locally, achieving sub-100 ms latency, while federated learning allows parameter-level sharing among factories without exposing raw data, thus ensuring privacy and model generalization [43]. This approach reduces unplanned downtime and enhances prediction accuracy, especially in high-speed Surface-Mount Technology (SMT) lines demanding real-time quality assurance.

4) Manufacturing Equipment

In the field of large-scale manufacturing equipment (e.g., machine tools, forming systems), long production cycles and high customization pose serious efficiency challenges. Traditional experience-based planning often leads to prolonged debugging and unstable performance. A recent study proposed a DT-driven tool life prediction framework, integrating DL with multi-source sensing data for real-time tool wear modelling. The framework effectively captures rapid wear transitions and improves predictive robustness in both experimental and shop-floor environments.

5) Energy and Process Industries

Process industries (e.g., petrochemicals, metallurgy, and power generation) are particularly sensitive to production continuity and energy efficiency. Smart manufacturing initiatives in this domain aim to achieve integrated safety, efficiency, and emission control[44]. In energy-intensive industries, an edge cloud collaborative sustainable production architecture has been proposed to enhance energy efficiency and support green transformation.

4. Literature of Review

Smart manufacturing supply chain management has progressed with the help of cutting-edge digital technology, according to recent studies. This has allowed businesses to become more efficient, sustainable, and resilient. Table I summarizes research on the topic of how digital twins, AI, the IoT, predictive analytics, blockchain, and automation might revolutionize conventional manufacturing supply chains into data-driven, intelligent ecosystems.

H. Guo et al. (2025) focuses on the role of a common complementary capital flow instrument, supply chain finance (SCF), in driving PSCM. By clustering the main decisions under the three patterns, the results show that financing risks and costs under SCF operations change lenders' decisions (e.g., lending rates, credit cycles, etc.), which in turn change borrowers' decisions (e.g., price, quantity, etc.) in the purchasing process, and ultimately drive the development of PSCM[45].

D. Kulasekara et al. (2025) data collected from Supply Chain (SC) experts working for garment factories was used in a quantitative study to assess the situation. The study shows that SCF is a mediator between ITI and SCP, which means that a versatile SC is crucial for turning investments in ITI into increases in functional performance. The present climate necessitates that clothing producers use strategies that connect the dots between ITI capabilities and the SC's responsiveness to demand changes [46].

I. Kishor et al. (2025), a system that integrates Blockchain with the Internet of Things (IoT) to solve important problems with data security, environmental regulation, and supply chain visibility in order to make production more sustainable. The following established criteria are used to implement ESG check automation using smart contracts: CO₂>450 ppm, energy >1.2 kWh/batch, and temperature variation >3C. Within a 72-hour timeframe, the system is tested on eight hundred fifty mock production batches. An impressive 95% decrease in data tampering risks, 87% improvement in traceability efficiency, and an impressive 88.7% success rate for ESG compliance were all accomplished by the test system [47].

R. Bala et al. (2024), the supply chain: ensuring the

correct things are available in the right quantities, in the right place, at the right time, and at the lowest possible cost requires expertise from a wide range of fields. Because the building itself necessitates the production of several industrial objects, this is particularly true in the construction instance. Supply chain communications are a hot topic in the industrial sector, and this study delves into the ongoing research and development of MAS (Multi-Agent System) as it pertains to supply chain management [48].

Adebunmi Okechukwu Adewusi et al. (2024) a game-changer in supply chain management, predictive analytics paves the way for new innovations, more efficiency, and stronger resilience. Integration of new technology, ethical data usage standards, and removing adoption hurdles should be the subjects of future studies, with an emphasis on SMEs and developing nations. Research and practice in SCM are being propelled ahead by this study, which highlights the crucial role of predictive analytics in the future of SCM [49].

R. Ejjami and Khaoula Boussalham et al. (2024)

suggests establishing positions like AI Supply Chain Quality Assurance Officer (AISQAO), AI Supply Chain Compliance Officer (AISCCO), and AI Supply Chain Oversight Officer (AISCO) to handle implementation issues, maintain supply chain operations' integrity and efficiency, and oversee the responsible utilisation of AI. The research finds that AI has great potential to revolutionize supply chains, but caution is key to ensuring the reliability and security of these systems [50].

A Iftikhar et al. (2024) study reveals the important groups of researchers working in the field, how their work has changed over time, the paths that knowledge has taken, and how the field's methods have advanced. Comprehensive review adds to the current body of knowledge on the topic by bringing together the scattered literature on the importance of data analytics, new technology, and supply chain resilience; this allows us to identify key areas of study and promising avenues for further investigation. Because it summarizes important findings from a wide body of literature in one location, the review also aids in raising practitioners' understanding of the topic's latest research [51].

TABLE I. SUMMARY OF RECENT LITERATURE ON AI-ENABLED SUPPLY CHAIN MANAGEMENT

Author & Year	Methods	Key Findings	Challenges	Limitation
H. Guo (2025)	Supply Chain Finance (SCF)	Investigated the impact of SCF on purchasing and supply chain management. Financing costs and lending decisions significantly influence purchasing decisions and PSCM development.	Managing financing risks, fluctuating lending rates, and balancing borrower-lender decisions.	Focuses mainly on financial decision-making and does not incorporate AI-based predictive optimization.
D. Kulasekara (2025)	Information Technology Integration (ITI) & SCF	Demonstrated that SCF mediates the relationship between ITI and supply chain performance, improving organizational flexibility and responsiveness.	Integrating IT infrastructure with supply chain finance while adapting to dynamic market demands.	Limited to the apparel manufacturing sector and lacks advanced machine learning-based analysis.
I. Kishor (2025)	Blockchain, IoT, Smart Contracts	Proposed a Blockchain-IoT framework for sustainable supply chains. Achieved 95% reduction in data manipulation risk, 87% improvement in traceability, and 88.7% ESG compliance success.	Ensuring interoperability, scalability, secure IoT communication, and real-time ESG monitoring.	Validation was performed on simulated production data rather than real industrial environments.
R. Bala (2024)	Multi-Agent System (MAS)	Reviewed MAS applications in manufacturing supply chains to improve coordination, communication, and resource allocation.	Agent coordination, communication overhead, and scalability in large supply chain networks.	Primarily a conceptual review without quantitative performance evaluation.
Adebunmi Okechukwu Adewusi (2024)	Predictive Analytics	Highlighted predictive analytics as a key enabler for supply chain efficiency, resilience, and decision-making while identifying future research opportunities.	Data quality, integration of heterogeneous data sources, and adoption barriers in SMEs.	Does not propose or validate a specific predictive analytics model.
R. Ejjami and Khaoula Boussalham (2024)	Artificial Intelligence Governance	Proposed governance roles such as AISCO, AISCCO, and AISQAO to ensure responsible AI adoption in supply chain operations.	Ensuring AI transparency, regulatory compliance, ethical governance, and organizational acceptance.	Focuses on governance frameworks rather than implementation or performance evaluation.

A. Iftikhar (2024)	Bibliometric & Systematic Review	Identified research trends, technology adoption, and knowledge evolution related to innovative technologies, data analytics, and supply chain resilience.	Consolidating fragmented research, technology adoption, and translating research into industrial practice.	Provides literature synthesis but lacks experimental validation and practical implementation.
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A. Research gap

Although recent studies have explored automation, artificial intelligence, blockchain, IoT, predictive analytics, and supply chain resilience, most focus on individual technologies rather than their integrated application in smart manufacturing supply chains. Limited research examines the combined impact of these technologies on automation, sustainability, predictive decision-making, and resilience. Additionally, empirical studies across diverse manufacturing sectors and developing economies remain scarce. Future research should develop comprehensive, scalable, and intelligent frameworks that improve operational efficiency, sustainability, and resilience through integrated digital technologies.

5. Conclusion and Future Work

Smart Manufacturing Supply Chain Management has transformed traditional manufacturing by integrating advanced digital technologies that enhance efficiency, flexibility, transparency, and resilience. This review highlights the significance of automation, data-driven decision-making, IoT, AI, blockchain, edge computing, digital twins, cyber-physical systems, and the optimization of supply chain management, manufacturing, inventory control, and customer service. The analysis of recent literature demonstrates that these technologies improve operational performance, predictive maintenance, resource utilization, and supply chain visibility while supporting sustainable manufacturing practices. Furthermore, application scenarios across automotive, aerospace, electronics, manufacturing equipment, and process industries illustrate the practical benefits of intelligent manufacturing systems. High installation costs, cybersecurity concerns, interoperability problems, and skill shortages in the workforce are still obstacles to broad adoption, notwithstanding these improvements. Overall, smart manufacturing supply chain management represents a critical foundation for Industry 4.0, enabling organizations to achieve greater competitiveness, operational excellence, and long-term resilience in increasingly dynamic and complex global markets.

Future research should focus on integrating Industry 5.0 concepts, generative AI, explainable AI, quantum computing, and advanced digital twins into smart manufacturing supply chains. Developing secure,

interoperable, energy-efficient, and human-centric manufacturing ecosystems will further improve sustainability, resilience, autonomous decision-making, and real-time optimization across global industrial networks.

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