International Journal of AI, Big Data, Computational and Management Studies
Noble Scholar Research Group | Volume 3, Issue 1, PP. 161-170, 2022
ISSN: 3050-9416 | https://doi.org/10.63282/3050-9416.IJAIBDCMS-V3I1P118

Survey on Blockchain Integration with Sap S/4hana for Transparent and Secure Supply Chains

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Abstract: The digitally-driven and globalized world has accelerated the evolution of the supply chains and created a harsh realization of the necessity to attain higher levels of transparency, security, and efficiency in the supply chain operations. Enterprise resource planning systems, like SAP S/4HANA, offer real-time data processing, predictive analytics, and automated processes. New technologies, like blockchain, allow decentralized, immutable, and auditable records. Combining blockchains and SAP S/4HANA brings visibility to the whole supply chain and allows securely sharing information and automated processes, increasing trust, transparency, and control over the regulatory authorities. Organizations can choose to adopt an integration model, sidechain, embedded and hybrid models, and there is a huge number of models available to support transparency, scalability and data privacy. The paper is a summary of the history of blockchain technology in business systems, the application of SAP S/4HANA in SCM today and the methods of integrating blockchain and enterprise resource planning software. It also addresses implications on supply chain transparency, data security and compliance, technical concerns, adoption concerns, and organizational preparedness. Lastly, it also offers research opportunities, such as AI-powered predictive analytics, cross-platform interoperability, smart contract development, sustainability monitoring, alignment of global regulations, and the future of blockchain-SAP convergence to create resilient, secure, and transparent supply chains.

Keywords: Blockchain Technology, SAP S/4HANA, Supply Chain Transparency, Smart Contracts, Data Security, ERP Integration.

1. Introduction

The recent years have exposed supply chain management to new challenges at a global scale due to factors such as the need for real-time information, intricate networks of stakeholders, and their impact [1]. Applying blockchain technology to SCM, specifically how this disruptive technology is adding transparency, efficiency, and innovation. Initially conceived as the technology behind the cryptocurrency, blockchain is no longer a financial tool, instead becoming a disruptive technology in industries.

The presence of transparency and visibility helps significantly in efficiency, risk management, and the trust of stakeholders and consumers in the current complex global supply chains. They help companies respond effectively to disruptions and to comply with rules and regulations and respond to the increasing consumer demand in a sustainable and ethical manner [2]. The blockchain also enables complete tracking of the goods along the chain of product origin to its final destinations, and this enables business and consumers to be reassured of the true nature, and ethical provenance of goods. This is particularly in industries such as food, pharmaceuticals and luxury goods.

Global supply chain management is an aspect that suffers too many challenges which are both external and internal. These are unpredictable market environments like variability of demand, variation of the exchange rate of the currency and geopolitical risks that wipe out operations and cause imbalances on stocks and delay of shipments [3]. The current digital supply chain initiatives that organizations have invested in are more flexible, open-ended, end-to-end, which are geared towards making companies competitive and resilient. The core of this change lies in cloud-hosted ERP systems as it is a radical change, the rigid, mono-type systems of infrastructure being replaced by the flexible, intelligent systems capable of assisting in real-time decision-making.

The next generation of the ERP suite, SAP S/4HANA Cloud, is an example of this change and uses an in-memory HANA database. It also integrates high analytics and artificial intelligence (AI) and process automation with business processes and offers a platform to execute end-to-end supply chain performance. Its intrinsic logistics and procurement management tools including live inventory and smart sourcing may be considered as a disruptive power of digital supply chain modernization.

SAP is an enterprise resource planning (ERP) and it is used by most companies around the world in their daily operations such as purchasing, inventories, production, and logistics. Safe, transparent, and real-time tracking of items as they move

through the supply chain is enabled by integrating blockchain technology into SAP, thereby enhancing existing capabilities. The smart contract feature of blockchain can streamline operations like payment verification and inventory management by automating these tasks, which lowers the involvement of human factors and operational expenses.

Blockchain technology provides a secure, transparent platform for parties in the supply chain to share reliable information. Businesses that rely on consumers' confidence to guarantee their products are safe and up to par also need it. Utilizing blockchain technology enhances closed-loop supply chain waste and product return management by connecting trust, transparency, and traceability.

1.1. Structure of the Paper

The paper is structured as follows; Section II includes the discussion of the blockchain integration with SAP S/4HANA, Section III includes the discussion of the effects on the supply chain and the security, Section IV includes the discussion of issues and opportunities, Section V includes the literature review, and Section VI includes the conclusion and the perspectives of the research.

2. Blockchain Integration with Sap S/4hana

The SAP S/4HANA blockchain integration is a significant step on the way to transparent, secure, and resilient supply chains. Blockchain has solved the constraints of centralized enterprise systems, offering them a feeling of decentralization, immutability, and trust. SAP S/4HANA offers real data processing, predictive analytics and better supply chain optimization. When integrated, they allow better visibility, efficient cooperation, and secure access to the exchange of information between stakeholders. Other integration models like sidechain, embedded and hybrid models provide flexibility in maintaining balance between transparency, scalability and privacy. These models are important to understand whenever organizations are aiming at maximizing the synergy between blockchain and SAP to achieve innovation, compliance, and sustainable supply chain transformation.

2.1. Evolution of Blockchain in Enterprise Systems

A disruptor in surpassing the shortcomings of conventional production techniques, blockchain technology has recently broken through. The use of digital technology to improve operational productivity [4], openness, and sustainability is the essential feature of Industry 4.0. Yet, none of these three elements- secure data sharing, real-time adaptation, and flexibility are commonly present in centralized architectures thus this integration could not work. Blockchain technology, with its distributed, immutable, and programmable design, does provide these benefits. Over the past 10 years, Blockchain technology has found uses in operations, SCM, and finance.

Blockchain technology has found use in organizational settings due to its ability to create digital trust between parties inherently distrustful of one another and to provide transparency for digital transactions. Not only that, but blockchain works with many different kinds of ERPs, WMSs, CRMs, and supply chain management systems [5]. It can serve as an accessible, decentralized, and immutable database for all members of the organization, as seen in Figure 1.

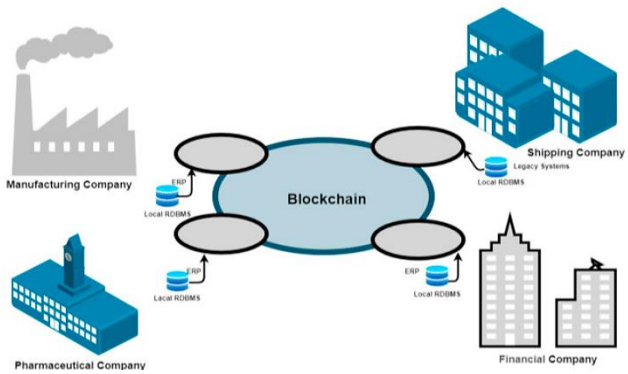

Figure 1: Integration of ERP System with Blockchain

Blockchain technology operates without a central authority or governing entity because it relies on a decentralized network of nodes. Decentralization increases trust and transparency among members while protecting the network from assaults and failures. Defined decentralized finance as an alternative to traditional banking that uses blockchain technology to eliminate middlemen for all financial transactions. The benefits of decentralized financial systems are increased access, lower costs, and better transparency. The findings of the study suggest that to fulfill the potential of decentralized finance, the solution should take care of the issues related to regulation, scalability, and security.

2.2. Role of SAP S/4HANA in Supply Chain Management

The state-of-the-art ERP solution, SAP S/4HANA, employs in-memory computing to access and analyze large volumes of data in real-time. In the background of the supply chain management, SAP S/4HANA provides numerous inventory optimization tools, demand forecasting tools, supplier collaboration tools, and logistics management tools. Integrating the most important supply chain activities onto a single platform improves communication, reduces lead times, and supports demand planning.

The conventional SCM practices based on historic data and linear forecasting models are not always capable of responding to the dynamic markets as demanded. The AI-based optimization of supply chains, which is supported by SAP S/4HANA allows organizations to shift to a state of making decisions reactively to proactive and predictive approaches that enhance efficiency, costs, and resilience. The sustainability tracking feature implemented in the SAP S/4HANA using AI enables corporations to trace their environmental footprint and maintain regulatory compliance, as well as to encourage the trend of green SCM.

SAP S/4HANA enables the coordination of work with suppliers, partners, and consumers, as well as the provision of common communication channels and access to supply chain processes. This, in its turn, allows a better management of work, faster decision-making, and heightened sensitivity to the changes in the market [6]. Transportation management, warehouse management, and order fulfillment technologies are all part of SAP S/4HANA's optimization suite for logistics. This assists in streamlining the logistics operations, lowering transportation costs, and enhancing the accuracy and speed of delivery.

Implementing SAP S/4HANA into supply chain operations has many advantages for companies. One of them is the ability to monitor inventories and spot problems in real-time thanks to SAP S/4HANA's insight into supply chain process activities. Two ways SAP S/4HANA helps organizations enhance operational efficiency, lower expenses, and raise productivity are by streamlining supply chain operations and automating manual procedures.

2.3. Models of Blockchain-SAP Integration

There are various architectural and operational models that can be used to implement blockchain integration with SAP S/4HANA [7]. The choice of the model based on the extent of decentralization, sensitivity of the data, the scale needs and the preferred transparency among the parties involved. The main integration models that are witnessed are the following:

2.3.1. Sidechain Integration Model

This model uses middleware or APIs to communicate between a dedicated blockchain and SAP S/4HANA. Although blockchain changes crucial transactions and supply chain activities, the major ERP system manages key business activities. This model provides better data immutability and traceability without having to transform existing SAP workflows.

2.3.2. Embedded Blockchain Model

Blockchain functionality can be built directly into SAP Cloud Platform Blockchain Services, which can be integrated into the ERP environment via SAP S/4HANA platforms [8]. Here, ERP components which include procurement, inventory, and logistics include distributed ledgers and smart contracts. This model ensures that real-time validation of these nodes of supply chains is achieved and that transactions are automatically performed and that there is minimal human reconciliation.

2.3.3. Hybrid Integration Model

The hybrid architecture takes into consideration some embedded and sidechain architectures. It allows companies to record key supply chain activities selectively to a blockchain network that can be accessed externally by partners but sensitive internal information is retained in SAP. It is a strategy that guarantees compliance and trust among the many stakeholders through a balance that is reached between data privacy and transparency. The summarization made in Table I of the Blockchain- SAP Integration Models is discussed below:

Table 1: Summarizing the Blockchain-Sap Integration Models

Integration Model	Key Features	Advantages
Sidechain Integration	Blockchain records important transactions; ERP oversees primary business operations.	No changes to existing SAP workflows; improves data immutability and traceability.
Embedded Blockchain	ERP modules incorporate distributed ledgers and smart contracts; real-time validation.	Enables real-time supply chain validation; automates transactions; minimizes manual effort.
Hybrid Integration	Critical supply chain events recorded on blockchain; sensitive internal data remains in SAP.	Balances data privacy and transparency; ensures compliance and trust among stakeholders.

To fully leverage blockchain's potential in SAP S/4HANA, it is imperative to select the appropriate integration model, as it affects data security, operational efficiency, and supply chain transparency.

3. Impacts on Supply Chain Transparency and Security

Blockchain in SAP S/4HANA is also essential in increasing transparency and security in supply chain by ensuring trust, accountability and regulatory consistency among stakeholders [9]. Organizations can achieve end-to-end traceability with non-edit records and Real-time visibility to further improve the lifecycle management of products and reduce risks in the process of recall. The cryptographic security offered by blockchain improves the integrity of data, and the validation of transactions is also possible with platforms such as Ethereum and Hyperledger [10]. In addition, its integration with SAP S/4HANA would enable it to adhere to international standards, including GDPR and CCPA, thereby developing trust between supply chain participants. All of these competencies create resilient, open, and secure supply chain ecosystems in a market that is becoming increasingly digitalized.

3.1. Enhancing End-to-End Visibility

SC management is thought to be an important inter-organizational process of developing a competitive advantage, especially where supplier and consumer alliances and networks are considered. Traceability systems have evolved in recent years as an effective tool for improving the transparency of SC, especially in globalized SC networks. The market, liability claims, and lawsuits can all be positively affected by traceability, and process integrity inside SC networks can be safeguarded. In the event of a product recall, SC traceability systems provide substantial operational benefits.

Product lifecycle management (PLM) is now a strategy for making products more competitive in today's market. A distributed ledger that is both safe and decentralized, a blockchain differs in important ways from the conventional PLM methods. The chain is made more auditable and transparent by the fact that each node can access it through an internet connection [11]. Moreover, using blockchain technology, which enables monitoring the data that cannot be changed, one may trace the lifecycle of a product to the end. Therefore, all parties involved can maintain a continuous state of collaboration throughout the product lifecycle. This team-based situation leads to:

- Maximizing information efficiency;
- A flexible and resilient production system;
- Promote creativity;
- A rise in output and efficiency;
- Consistency and auditability of data.

The information representation and the instant interaction among the phases of product lifecycle are vital in the proper decision-making and scheduling of the product development process. As a result, this will reduce the number of barriers and encourage a culture of easy communication, which is impossible with centralised PLMs.

3.2. Ensuring Data Security and Integrity

The functioning of blockchain technology has significantly changed how organizations implement security and integrity of data, which can be seen as a ground-breaking paradigm in digital recordkeeping. Supply chain management can adopt a reliable and transparent system of monitoring the goods flow and ensuring the authenticity of goods with the help of blockchain technology. Complete accountability and openness are ensured since all parties involved are able to share information and data in real-time.

Blockchain technology is finding more and more applications throughout the supply chain, especially for the purpose of streamlining financial and trust-related processes [12]. Two ledgers are used when a blockchain is being used for security purposes and can choose between two blockchain platforms: Hyperledger and Ethereum. One such public distributed ledger system is Ethereum. Hyperledger is a permissioned blockchain network that can protect financial transactions. The only entities that can view network transactions are those that have a valid license.

The transfer of digital information and the presence of records on each ledger make privacy and data flow management difficult in blockchain applications. Security event logs are essential for managing large data sets and preventing unauthorized access to ledgers or nodes. Material, production process, inventory, shipment, payment, and logistics validity may all be confirmed using blockchain's decentralized, real-time ledger.

3.3. Compliance, Trust, and Regulatory Alignment

The concept that technological solutions can facilitate regulatory compliance and monitoring is not particularly novel. Businesses that handle customer data are required to comply with data protection laws like the CCPA and the GDPR [13]. Businesses can safeguard customer information and stay in compliance with data protection regulations by performing privacy assessments, making clear privacy notices, training staff on data protection practices, getting customers' explicit consent, putting data security measures in place, updating policies and procedures often to reflect changes in regulations and industry standards, and creating processes for processing requests from data subjects.

The management of relationships between supply chain partners has long focused on building trust as its foundational principle. Supply chain interactions are often fragile and fraught with uncertainty; trust is essential for their security and for reducing the hazards of opportunistic behaviour [14]. A supply chain is likely to have its members present such qualities as resilience, responsiveness, innovation, agility, and efficiency in their work when they trust each other [15]. These guidelines will help businesses demonstrate their commitment to data security and privacy and ensure that the personal information of their clients is protected to reduce litigation risks.

4. Challenges, Opportunities, and Future Outlook

S/4HANA's introduction of blockchain technology by SAP introduces new opportunities and challenges to supply chain ecosystems. Efficiency is not high due to integration barriers such as breaches of system interoperability, old ERP systems, and privacy-protecting transactions. Also, an organizational concern, e.g. adoption resistance, insufficient standardization and development of legal frameworks contribute to a smooth deployment [7]. Nevertheless, the opportunities for innovation remain enormous. The current trends are joining blockchain and AI to make smart predictions, building cross-platform interoperability systems, supporting sustainability monitoring, and smarter contract systems. Overcoming these challenges and utilizing these opportunities by means of the voyage to resilient, transparent, and secure supply chains.

4.1. Technical and Integration Challenges

A growing focus on the environmental, social, and economic impacts of the production and distribution processes has resulted in the emergence of sustainable supply chains as a critical feature of modern business operations [16]. Even though the importance of sustainability in supply chains is a common understanding, organizations continue to experience major challenges, including:

- Data interoperability: Lack of an integrated data flow also frustrates transparency, and thus businesses cannot trace where the goods began, as well as evaluate their effect on the environment or whether they comply with regulations.
- Legacy ERP integration challenges: Legacy system fragmentation [17], data standards that conflict and lack interoperability between client and supplier systems sometimes cause integration problems.
- Transactional privacy: This is a major issue of blockchain technology. Zero-knowledge proofs are checked by miners, and transactions and the origin of the currency are unlined. A more advanced one conceals the source of finance and the amount of transactions with enhanced privacy.

4.2. Adoption Barriers and Organizational Readiness

The blockchain technology (hereby BT) has expanded very quickly in this context as one of many new game-changing technologies that can store and make a permanent record of an unlimited number of records.

- The first variation is that it is now done in real-time, unlike when it was done after each operation and transaction. This may lead to the minimization of errors and automatic correction, which is immense.
- The number of clients using BT is growing, thus accounting and auditing firms need to be ready and knowledgeable about the technology.

Supply chain management (SCM) can gain much out of blockchain technology, as the technology has the potential to improve traceability, automate services related to trust, and ensure data integrity via cryptographic algorithms and consensus mechanisms [18]. Despite the potential of the technology, there are obstacles in the way of adapting it into the SCM processes in the real world. A lack of organizational preparedness, weaknesses in standardization, and legal ambiguity remain important challenges.

The promised advantages of blockchain technology in supply chain networks increased transparency, more trusted data and decentralized trust may never be realized. Real-world implementations have demonstrated that combining blockchain technology with the dynamic and intricate environment of supply chain management is not an easy task [19]. Limitations in interoperability in most situations, smart contract limitations, resistance to adoption, and disjointed standards continue to hinder the general use of blockchain in the real world in supply chain systems.

5. Opportunities for Future Research and Innovation

The unused potential of new ideas and research is high because the blockchain integration of SAP S/4HANA is still in the initial phase. At present, studies indicate that blockchain can help in tracking and transparency, yet it also has new possibilities to transform supply chains [20]. Future research might examine ways AI and machine learning can collaborate with blockchain in SAP systems to assist in outcome prediction, risk management and automatic decision-making. The other significant area is the development of common standards and methods of communication between various blockchain networks and ERP systems. New solutions helping to follow rules and regulations are also a possibility, with blockchain, in conjunction with SAP, being able to provide transparent, cross-border data sharing that is within the scope of global trade law. These are the main opportunities:

- Cost of the Reduction of Data Breaches: The prevention of breaches enables companies to avoid litigation, financial losses, data compromise, and the cost of interruption. IT budgets usually accommodate over 20% of security and data protection.
- AI and Blockchain Synergy: Using AI along with blockchain-powered SAP to do better predictions in supply chain analysis.
- Interoperability Models: Creating systems that connect different blockchain networks with SAP S/4HANA.
- Sustainability Tracking: Using blockchain with SAP to track carbon footprints and help create more environmentally friendly supply chains [21].
- Smart Contract Innovation: A third party is not required for the execution of programs using smart contracts. A seller and buyer can join a smart contract for sales transactions and conduct a transaction that is cryptographically signed to finalize the sale of products or services.
- Cross-Border Compliance: Looking into blockchain options to help with following global rules and making trade easier

6. Literature Review

The literature on blockchain integration with ERP/SAP is reviewed in this area, with a focus on supply chain sustainability, financial and logistical applications, security, and transparency. Table II summarizes key studies, approaches, findings, challenges, and research gaps.

Basnayake and Rajapakse (2019) The research intended to create a Blockchain-driven technique for tracing the source of produce and verifying the quality of food. The public blockchain concept has been chosen in this study instead of a private one to ensure transparency that would permit anyone to access the network. For each physical product, smart contract instances were created and added to the blockchain network. A QuickResponse code that contained the URL of the instance was used to reference the virtual product. All supply chain actors must be able to interact with the system in order to obtain transparency. Every transaction and event related to a product is verified by peers inside the Blockchain system. Every relevant transaction resulted in a change in product ownership. The farmers' reputation with their commodities was demonstrated via a token-based method [22].

Kulkarni, Hazari and Niamat (2019) suggest utilizing blockchain technology, a highly secure method that has been extensively employed in numerous other domains, to improve the supply chain process. One of the most reliable security methods available today is blockchain, which was initially developed for bitcoin mining and security. This paper proposes a "smart contract" method empowered by blockchain technology to guarantee the security and trust of these integrated circuits (ICs) through the identification of the degree of alteration at which the chip might have been tampered with in the IC supply chain [23].

Linke and Strahringer (2018) Blockchain makes it possible to improve process speed, transparency, and cost-effectiveness while also fostering more trust amongst corporate partners. However, this field's current research is just getting started. Research and experience on integrating Blockchain technologies into current business environments are still lacking. To guarantee a successful application of Blockchain in the procure-to-pay process, numerous obstacles still need to be overcome and additional experience must be acquired. Thus, using the procure-to-pay procedure from the automaker Daimler as an example, the needs and difficulties for integrating Blockchain into ERP systems were determined within the context of this study. Interviews with Daimler experts were conducted for this purpose. A proof-of-concept based on a software prototype is included with the final conceptual architecture model [24].

Mann et al. (2018) examine the use of the new digital technology known as blockchain. The blockchain is a distributed digital ledger that reduces the amount of data that hackers may access by consistently and securely documenting each transaction without the assistance of other parties. By substituting smart contracts for regular contracts, blockchain technology increases productivity. Several important blockchain applications for the mining sector are described in this study[25]. Tse et al. (2017) show that politics, the global economy, and society at large have a bigger influence. The traceability system has been studied, developed, and used in numerous nations and areas as an efficient way to manage and control product quality and safety. On the one hand, these technologies have not been able to produce more precise traceability, and the Chinese market cannot directly benefit from these outcomes. As a result, the essay presents the idea of blockchain technology, proposes its use in food supply chain information security, and contrasts it with the conventional supply chain system [26].

Madathala et al. (2016) explain SAP S/4HANA deployment in detail, emphasizing how it minimizes errors and improves configuration. The architecture overview, best practices for strategic planning prior to deployment, configuration optimization, data quality, testing strategy, and change management are all examined along with common implementation issues of S/4HANA. This article also discusses the implementation of the latest technology in S/4HANA, namely robotic process automation and machine learning. The paper has a conclusion in the form of a cost-benefit analysis and projections of trends of S/4HANA adoption. An argument such as that can be very useful to companies in the direction of digital transformation [27].

Table II presents the main research on blockchain and ERP/SAP integration with an emphasis on study focus, methodology, principal results, challenges, and research recommendations to build secure and transparent supply chains

Table 2: Comparative Analysis of Recent Studies on Blockchain and ERP/SAP Integration for Supply Chain

Reference	Study On	Approach	Key Findings	Challenges	Future Direction
Basnayake & Rajapakse (2019)	Blockchain-based origin verification and food quality tracking in agricultural supply chains	Public blockchain; smart contracts for each product; QR-code-based product identity; token-based farmer reputation	Provides transparent and tamper-proof traceability; enables stakeholder communication; ensures secure validation by blockchain peers; improves trust and food quality assurance	Scalability and performance limitations of public blockchain; need for full stakeholder participation; difficulty ensuring precise traceability	Integration of IoT devices for real-time data capture; development of hybrid blockchain models; expansion to broader agricultural ecosystems
Kulkarni, Hazari & Niamat (2019)	Securing the integrated circuit (IC) supply chain using blockchain	Smart contract–based blockchain model to track IC modification and integrity levels	Ensures tamper detection in IC supply chain; enhances trust and security; blockchain provides robust verification of chip authenticity	High complexity of IC supply chain; potential difficulty in widespread adoption; need for hardware interoperability	Expand blockchain models for semiconductor tracking; integrate with AI-based anomaly detection; industry-wide adoption standards
Linke & Strahringer (2018)	Blockchain integration into ERP systems (Case: Daimler procure-to-pay process)	Interviews with domain experts; conceptual architecture design; proof-of-concept software prototype	Blockchain improves process speed, transparency, trust, and cost efficiency; architecture supports secure distributed records	Immature blockchain standards; integration complexity into ERP environments; organizational resistance; lack of practical research	Development of standardized blockchain–ERP frameworks; large-scale industrial pilots; improving scalability, interoperability, and governance
Mann et al. (2018)	Applications of blockchain technology in the mining sector	Technical analysis of blockchain features and mining use cases; smart contract replacement for conventional contracts	Blockchain improves data security, reduces intermediary involvement, enhances contract automation, and increases operational efficiency	Limited practical implementation in mining; high initial cost; need for specialized workforce skills	Pilot deployment in large mining enterprises; use-case expansion (logistics, asset tracking); development of mining-specific blockchain platforms
Tse et al. (2017)	Blockchain for improving food supply chain traceability and information security	Comparative analysis of blockchain vs traditional supply chain; conceptual blockchain traceability model	Blockchain enhances food safety, authenticity, data accuracy, and information security; reduces fraud and improves trust	Traditional systems unable to achieve high-precision traceability; lack of standardization; Chinese market not fully benefiting	Integration with smart sensors and IoT; development of more precise blockchain traceability frameworks; adoption across global food industries
Madathala et al. (2016)	SAP S/4HANA deployment, configuration, optimization, and digital transformation	Technical examination of S/4HANA architecture, RPA, ML integration, testing, data quality, and best	S/4HANA reduces errors, improves configuration, supports automation, and enhances digital transformation efforts; provides strong cost–benefit insights	High cost of implementation; steep learning curve; legacy system migration challenges; organizational change management issues	Expanded AI/ML integration; cloud-based S/4HANA adoption; industry-specific deployment frameworks; enhanced automation features

		practices			

7. Conclusion and Future Work

SCM is also experiencing a sea change with the integration of new technologies in the field. This is transforming the operations of organizations by making global networks efficient, transparent and resilient. The combination of blockchain technology with the latest ERP applications, such as SAP S/4HANA, has the potential to revolutionize the supply chain operations due to its distributed, immutable, and secure ledgers. This synergy will enable to deliver end-to-end visibility, real-time monitoring, automated workflow using smart contracts, and enhanced compliance with regulatory regimes, which will result in trust among participants. Despite these advantages, the challenges of system interoperability, legacy ERP integration, and organizational resistance and the evolving legal standards are still there to restrict full-scale adoption. The only way these barriers can be overcome is through standardization, technological innovation and organization preparedness. Future research may consider the intersection of blockchain and AI and ML to make supply chains predictive, lower risk, and decide what is intelligent. In addition, developing cross-platform interoperability framework, smart contract work, and blockchain-based sustainability tracking and environmental compliance are also promising. The future of blockchain-based ERP systems is most likely to bring more secure, transparent, and resilient supply chains, which will provide organizations with the tools to respond to disruptions and optimize their operations in response to rising demands on sustainable, and ethical supply chain activities across the world.

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