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# Blockchain in Manufacturing: A Systematic Literature Review and Synthesizing Framework

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## Abstract

The research offers a systematic literature review of the adoption of blockchain technology in manufacturing. The systematic literature review (SLR) presented by this paper follows a method of creating clear research questions that probe the relevant studies available to extract and assess the synthesizing of the relevant data to answer the research questions. The review investigates articles that have enquired on the application of blockchain into the different industries and moreover whether their finds can apply in the use of blockchain into the manufacturing industry. The findings of this SLR show that blockchain has been implemented in different manufacturing sections owing to its characteristics in handling, sharing, and processing data and records. A framework that addresses significant areas of future research on the topic is presented. Finally, the literature review lays the foundation for further studies on investigates the application of blockchain technology in manufacturing.

## Keywords
Blockchain, systematic literature review, manufacturing

## 1. Introduction
Industries are adopting advanced technologies to enhance automation and, productivity, reduce costs, and improve traceability and reliability (Mohamed & Al-Jaroodi 2019). Technologies such as cloud computing, fog computing, IoT, blockchain, cyber-physical systems, and data analytics offer manufacturing benefits (Hamzah et al. 2023). Smart manufacturing creates a connected network that improves operations. Product recalls and failures negatively impact manufacturers' sales and reputation, making it essential to address these challenges early (Bortoli & Freundt 2017). The Wall Street Journal highlighted the significance of blockchain (Kursh & Gold 2016), with a predicted market growth of $176 billion by 2025 (Kramer 2019), prompting this research on its application in product lifecycle

management. Therefore, this research therefore investigates through a literature review the application of blockchain technology in manufacturing to support the ideals of product lifecycle management. The research looks at different research articles that investigated the application of blockchain technology as solution to address manufacturing concerns.

### 1.1 Objectives

Systematic literature reviews (SLRs) aim to enhance knowledge by summarizing the research trends related to blockchain technology. Blockchain features allow its use across various fields, including finance, medicine, education, and IoT industries ( Chen et al. 2018). SLRs identify patterns in data predictions (Hasselgren, Kralevska, & Gligoroski, 2020), While extensive research exists on blockchain, focused discussions on its adoption in manufacturing are limited. Literature reviews can help bridge knowledge gaps and guide research towards areas that require more scholarly focus. This paper outlines the current application of blockchain in manufacturing and proposes a framework for further exploration. This research looks at the current application forms of blockchain in manufacturing by providing a thematic view and developing a synthesis framework based on the findings by detailing potential areas that require scholarly attention to further the body of knowledge. This study addresses the following research questions:

- RQ1. What is the current state of blockchain in the manufacturing sector?
- RQ2. What are the primary areas in the manufacturing process where blockchain can be applied?
- RQ3. What are the challenges faced by the manufacturing sector in applying blockchain in their organizations?
- RQ4. What are the prospects of applying blockchain in the manufacturing sector?

## 2. Literature review

This study examines how blockchain can enhance manufacturing processes. Blockchain started with cryptocurrencies, moved to real estate and finance, and later expanded to government and healthcare (Agbo et al. 2019). The fourth phase integrates artificial intelligence with blockchain, which offers secure and traceable data management (Angelis et al. 2019). This study demonstrates the importance of combining blockchain with technologies such as cybersecurity and robotics. An example is the IBM Food Trust project, which improved food supply chain transparency and efficiency, positioning blockchain as vital for smart manufacturing ( Santhi & Muthuswamy 2022). In manufacturing, IoT sensors track process variables and alert manufacturers if product conditions change. Combining blockchain technology with IoT enhances smart manufacturing by improving transparency, competitiveness, and product integrity (Kapitonov et al. 2018). Hash functions gather data from industrial controls and align them it with managerial systems such as manufacturing execution system (MES), enterprise resource planning (ERP), and supervisory control and data acquisition SCADA, giving manufacturers control (Lu 2019). Data flow in smart manufacturing addresses integrity, confidentiality, and availability, which can be improved using blockchain and smart contracts ( Leng et al. 2021). Quality management requires stakeholders to agree on product conditions to include the necessary data in smart contracts ( Chen et al. 2022). Blockchain in supply chain management eliminates middlemen and increasing transaction security.

## 3. Methodology

The research follows the Preferred Reporting Items for Systematic Review and Meta Analyses (PRISMA) guidelines (Page et al. 2021). The SLR identifies, appraises and synthesizes empirical data that meet the specified criteria defined by the research questions by systematically searching a scholarly database for relevant research articles using an approach to comprehensively review the literature. The search used SLR as an effective tool to critically evaluate and examine the body of evidence available in the literature to develop insight through theoretical synthesis (Christofi et al. 2017).

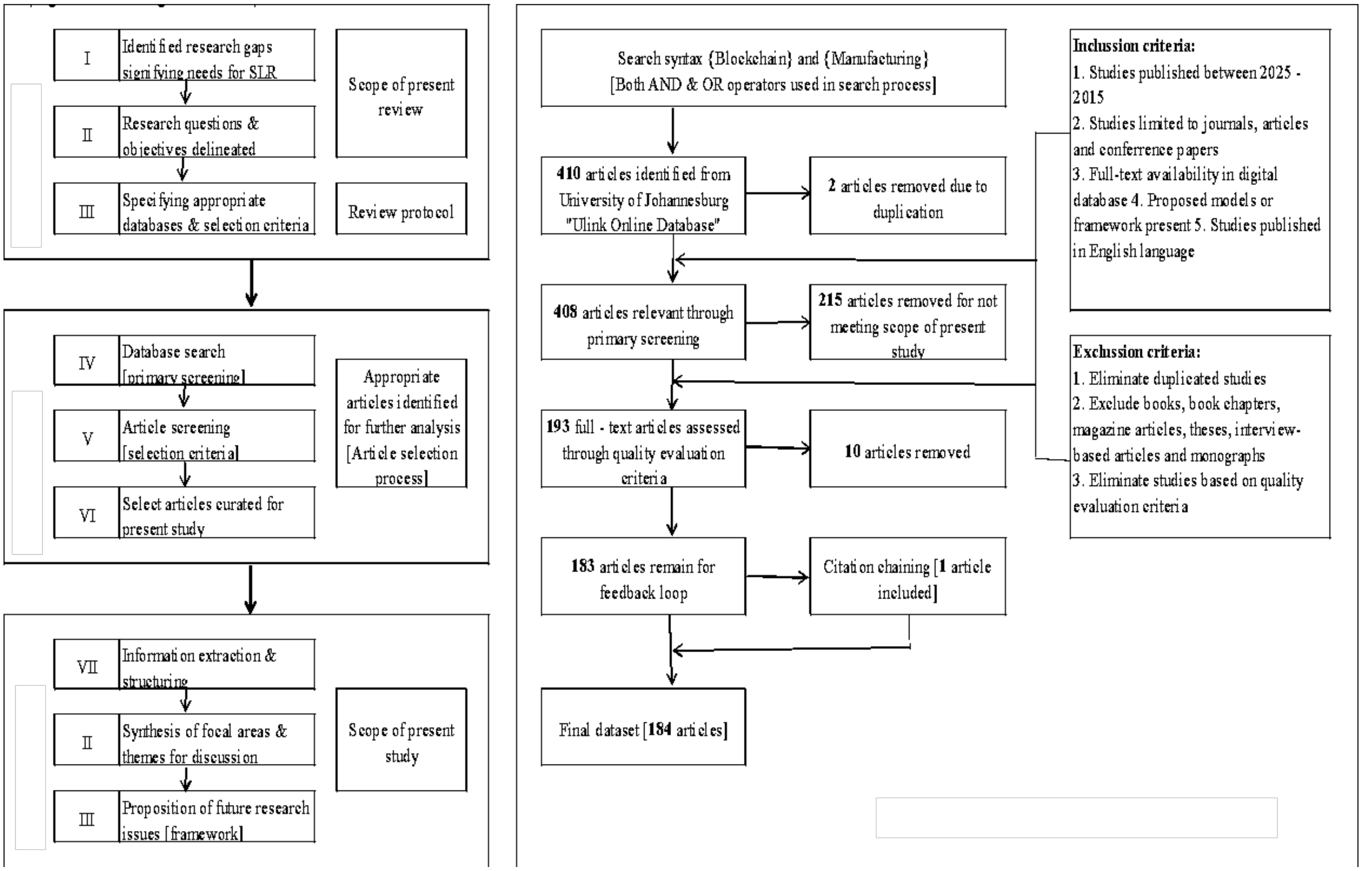



Figure 1. Protocol for systematic literature review.

Accordingly, the research is grounded in a systematic literature review, as it processes the PRISMA method, as depicted in Figure 1. With the aim of reducing bias, the research adopts a predefined protocol that looks at the research questions in relation to the keywords, research database, research study selection criteria procedures and research quality assessment. To address the first research question (RQ1), the research examined the descriptive statistics related to (I) the number of the articles pushed per year as displayed in Figure 2. (II) the average citations per year of reviewed articles as per Figure 3, and (III) the scholarly contributions regarding their publishers as per Figure 4. The rest of the research questions (RQ2, RQ3, and RQ4) are addressed in the following manner (I) identifying previously investigated studies by looking at their abstracts and primary constructs, (II) identifying the current intellectual literature available that addresses the research topic, and (III) identifying emergent research gaps and potential avenues for future research. These focus points allow the research to develop a synthesis and analysis of the final datasets and derive relevant understanding to address the research questions.

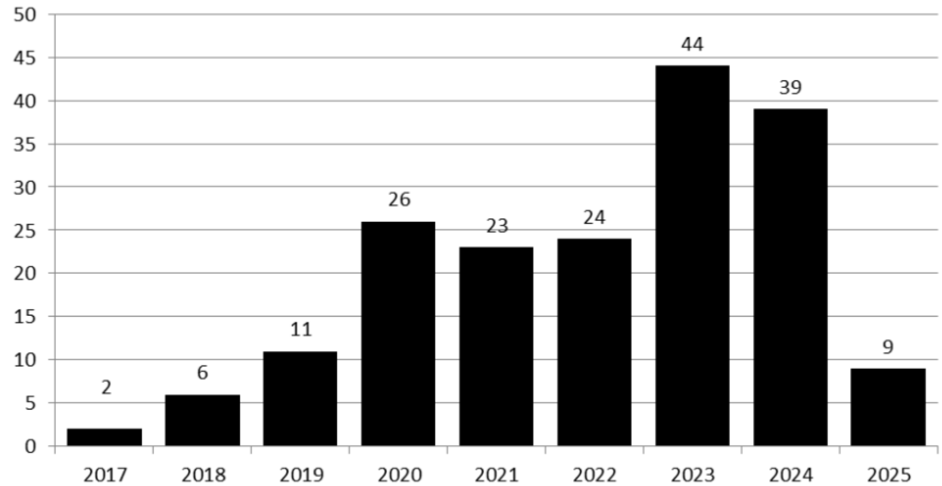
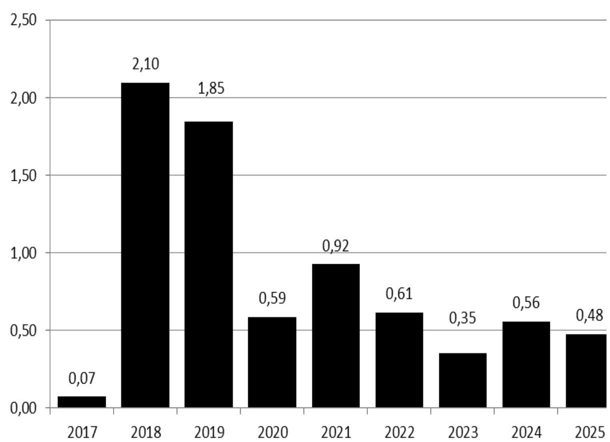



Figure 2. Annual distribution of the publications.



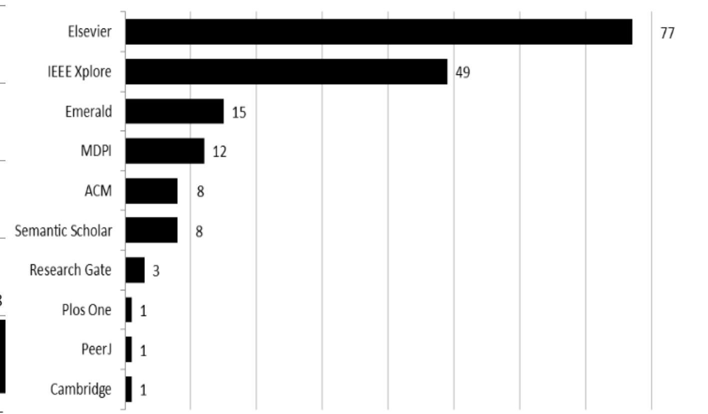




Figure 3. Average citations per year.

Figure 4. Number of articles per publication.

The database consisted of scholarly journals, articles and conference papers that were published by reputable publishers and available at the University of Johannesburg's library. The combination of the keywords as shown on Table 1, are adopted from four research papers that formed the building blocks of this research performed in January 2025, "Blockchain", "Manufacturing", "Blockchain in manufacturing". The literature was screened to obtain the final articles that met the specified criteria to determine the quality, relevance, and robustness of the literature review (Barrera & Shah, 2023).

Table 1. Database search summary.

| Database | Keywords | Total hits appeared | Abstracts read* | Full text downloaded |
|---|---|---|---|---|
| Elsevier | "Blockchain","Manufacturing", "Blockchain in manufacturing" | 184 | 184 | 117 |
| IEEE Xplore | "Blockchain","Manufacturing", "Blockchain in manufacturing" | 146 | 146 | 98 |
| Emerald | "Blockchain","Manufacturing", "Blockchain in manufacturing" | 96 | 96 | 76 |
| MDPI | "Blockchain","Manufacturing", "Blockchain in manufacturing" | 13 | 13 | 7 |
| ACM | "Blockchain","Manufacturing", "Blockchain in manufacturing" | 4 | 4 | 1 |
| Semantic Scholar | "Blockchain","Manufacturing", "Blockchain in manufacturing" | 3 | 3 | 1 |
| Research Gate | "Blockchain","Manufacturing", "Blockchain in manufacturing" | 27 | 27 | 19 |
| Plos One | "Blockchain","Manufacturing", "Blockchain in manufacturing" | 1 | 1 | 0 |
| PeerJ | "Blockchain","Manufacturing", "Blockchain in manufacturing" | 1 | 1 | 0 |
| Cambridge | "Blockchain","Manufacturing", "Blockchain in manufacturing" | 18 | 18 | 14 |

Figure 2 illustrates a sharp increase in publications that reviewed the research topic on a yearly basis, considering that this literature review was prepared in the first quarter of 2025. Figure 3 suggests that the number of citations is becoming saturated as academic literature refines the different studies over the years to include more focused studies blockchain in the manufacturing sector.

Table 2. Quality evaluation (QE) criteria.

| QE# | Criterion |
|---|---|
| QE1 | Literature showing data analysis: "quantitative (+2)", "qualitative (+1.5)" or "no evidence (+0)". |
| QE2 | Literature indicating the challenges of adopting blockchain: "yes (+2)", "partially (+1.5)" and "no (+0)". |
| QE3 | Findings and results of the article a validated in accordance to the research topic: "yes (+2)", "partially (+1.5)" and "no (+0)" |
| QE4 | Are the articles scholarly, peer reviewed from the University of Johannesburg library and other reliable sources:<br>(+2) sum of citations and H Index is > 100<br>(+1.5) sum of citations and H Index is >= 50 and <= 99<br>(+1.0) sum of citations and H Index is >= 1 and <= 49<br>(+0) sum of citations and H Index is 0 |
| QE5 | Comparability of the utilized method(s) with methods popularly used in prior studies:<br>"yes (+1)", and "no (+0)" |

As shown in Table 1 and Figure 4, institute allocations across the 184 articles of the leading sources were Elsevier (n = 77), constituting 41.8% of the publications and IEEE (n = 49), with 26.6% of the publications, emerging as the leading publishers. The research looks a final database of 184 articles was used to evaluate the quality of each article. Category (QE1) considered the quantitative data analysis algorithm protocols, looking at the findings of each article. Qualitative data analysis algorithm is the architecture formed from the results of each article. Category (QE2) considered the research question (RQ3) which investigated the challenges faced by the manufacturing sector in applying blockchain. Categories (QE3), (QE4) and (QE5), investigate the frequency of each paper in relation to the keywords and context literature used in the methodology studies. These categories are illustrated in Table 2 and were applied to the final 184 articles that met the inclusion criteria. The Fleiss' Kappa value in the analyzed literature was

0.78, which indicates agreement among authors from the perspective of the research topic (Helene, Rosen, & Viray, 2021; Sabour, 2020; Datta, Durbin, Odell, Ramirez-Inscoe, & Twomey, 2019).

# 4. Findings

The research utilizes meta-ethnography-based approach to create new insights on the topic by identifying relevant studies and reaching beyond the understanding and findings of a singular study (France, Uny, & Ring, 2019). Meta-ethnography as a method of qualitative synthesis suitable for analytical approaches rather than descriptive approaches (Daker-White, et al., 2015) which allows for the interpretation of conceptual data while being cognizant of the primary data (Sattar, Lawton, & Panagioti, 2021). The research reviews the insights of the 184 included studies to review and synthesize the process by developing themes and identifying the challenges of adopting blockchain in manufacturing.

## 4.1 Research themes

The research looks at the challenges identified from each study, the adoption model applied by the author(s) and the findings of their research on the adoption of blockchain technology.

### (a) Technological challenges

The findings of the review indicate that the research field believes the technology is new and has many technical problems like scalability, usability, and interoperability (Casino, Dasaklis, & Patsakis, 2019). Some authors say the technology has latency issues that decrease the throughput rate of blockchain technology (Mendling, et al., 2018).

### (b) Organizational challenges

The technology needs a lot of hardware and software to set up, along with network maintenance. This raises the overall costs and requires commitment from management for successful blockchain implementation (Mangla, Luthra, Mishra, & Singh, 2018).

### (c) Environmental challenge's internal view

Adopting blockchain faces challenges due to organizations' lack of awareness, leading to resistance from poor management communication (Oliveira & Handfield, 2019). This ignorance often causes technology adoption to fail, adding to blockchain's complexities (Luthra, Mangla, Xu, & Diabat, 2016).

### (d) Security and Privacy

There are risks related to security and privacy when a user controls 51 percent of the computer power, allowing them to change transactions in the ledger (Conti, Kumar, Lal, & Ruj, 2018). Users may also fear losing their encrypted keys (Yang, Xie, Huang, & Wei, 2018), and software upgrades ma lead to information leaks. Multiple copies of distributed ledgers increase vulnerability to cyberattacks or system failures (Gao, Asamoah, Sifah, & Smahi, 2018).

### (e) Lack of clarity

Blockchain technology is facing uncertainties as organizations and stakeholders are unclear about its short-term and long-term developments. Decision makers see it as immature, creating barriers for adoption (Beck & Muller-Bloch, 2017).

### 4.2 Synthesizing framework

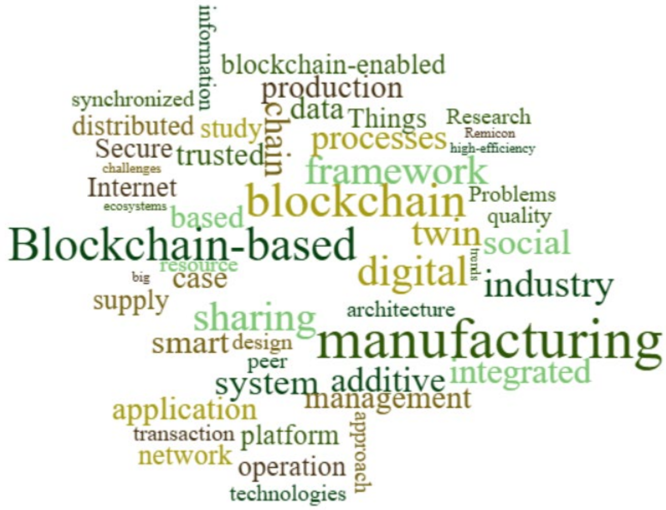



Figure 5. Key framework constructs.

Existing research has made significant strides in advancing the topic of applying blockchain in the manufacturing sector. The literature review illustrates that scholars have directed most research towards three aspects of applying blockchain in manufacturing: supply chain management, smart manufacturing and digital twin manufacturing. The analysis indicates the constructs through a world cloud presented on Figure 5 where the primary focus of the articles pertains to manufacturing weighted at 1.0, blockchain at 0.84, blockchain-based at 0.81, digital at 0.72, sharing at 0.69, framework at 0.69, industry at 0.66, twin at 0.65, and system at 0.62, graphically presented. The literature review analysis developed a research framework from the study to synthesize the research gaps identified from the extant literature and findings of the included articles. The framework is categorized into five sections with a degree of interconnection to create an ecosystem of blockchain in manufacturing that can be studied in the future as illustrated in Figure 6.

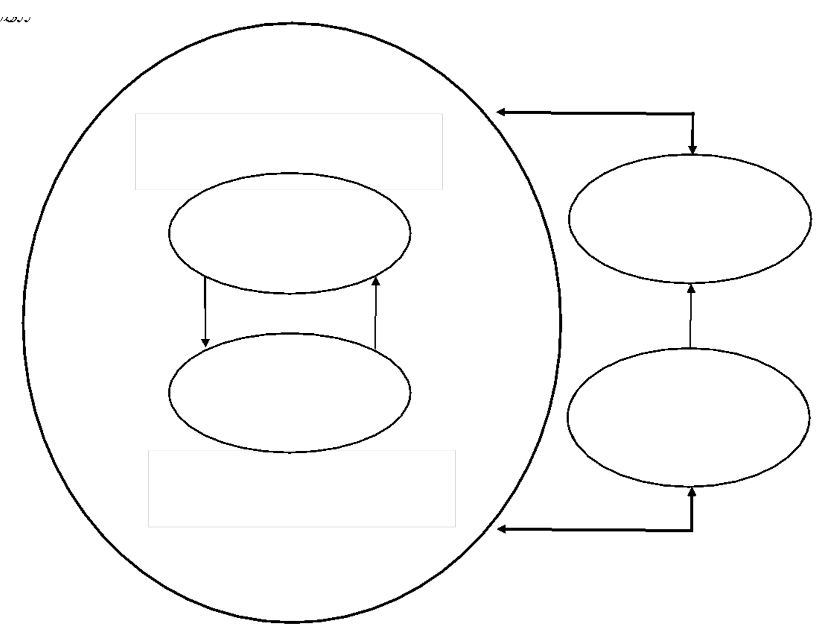


Figure 6. Research framework.

**(a) Data sources.** Manufacturing elements like materials, equipment, and personnel must meet requirements through production planning by keeping strong connections and detailed planning to handle tasks within time, cost, and quality limits. Data must be monitored in real time with traceability to track unauthorized changes. Blockchain aids manufacturers in managing and accessing product or service data, positively impacting the value chain (Morkunas, Paschen, & Boon, 2019).

**(b) Systems architecture**. System architecture enhances the monitoring and dispatching of production materials, data, and transportation in manufacturing (Ding, Jiang, & Su, 2018). Clients create and share transaction proposals within the framework (Shen, Hu, Zhang, & Ma, 2021). The research suggests an architecture linking manufacturing operations to their basic models for better autonomy and flexibility.

**(c) Strategic implementation of blockchain technology.** Blockchain technology links manufacturers, suppliers, production floors, and distribution centers with a permanent record of transactions (Saberi, Kouhizadeh, Sarkis, & Shen, 2019). It can be used in additive manufacturing. The network's consensus mechanism and design influence blockchain adoption (Rožman, Diaci, & Corn, 2021). Data exchange via cyber physical systems and virtualization allows organizations to share resources and services through cloud services for various product life cycle stages.

**(d) Beneficiaries.** Blockchain-based databases can reliably serve beneficiaries in the manufacturing sector, covering production, procurement, quality management, logistics, and inventory. A blockchain framework improves data exchange and addresses scalability issues related to transparency and immutability (Liu, Wang, Guo, Barenji, & Li, 2020). In Addition, past procurement and production data can be managed through cyber-physical systems using a ledger (Pérez, Rossit, & Tohmé, 2022).

**e) Legal, safety and ethical considerations**. Blockchain applications exist in food safety, trading, manufacturing, and healthcare (Pérez, Rossit, & Tohmé, 2022). It helps fight counterfeiting in supply chains, preventing financial loss, customer issues, and brand harm (Modgil & Sonwaney, 2019). It also verifies manufacturing processes with enforceable transactions for task information and legal agreements (Kai , Fan, & Liu, 2021).

## 5. Discussion

The research conducted a systematic literature review on the use of blockchain in the manufacturing industry to understand its current status and identify gaps. Four research questions were posed. RQ1 examined the current state of blockchain in manufacturing by summarizing 184 articles related to the topic. RQ2 identified key areas in manufacturing where blockchain can be applied, developing a research framework for this purpose. RQ3 focused on the challenges in applying blockchain and, summarizing themes to highlight gaps and limitations in existing knowledge. RQ4 explored the future prospects of blockchain in manufacturing, detailing the need for further research in this area.

## 6. Limitations

The findings of the research should be considered with the understanding that there were limitations. It only included peer-reviewed scholarly articles and excluded manufacturer white papers on blockchain from manufacturers that are implementing blockchain in their organizations. The study used "blockchain" and "manufacturing" as keywords and did not consider related terms like smart manufacturing. Future research will focus on specific parts of the manufacturing process to explore blockchain applications.

## 7. Conclusion

The research focused on exploring the use of blockchain in the manufacturing industry. It involved a systematic literature review of 184 articles from the University of Johannesburg. Findings highlighted challenges in applying blockchain technology but also showed its potential in manufacturing. The research suggested areas for further research to address current limitations and gaps while indicating growing scholarly interest in the topic.

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## Biographies

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