Improving Opportunities in Supply Chain Processes Using the Internet of Things and Blockchain Technology

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Abstract—The present study looks at how the internet of things and blockchain technology might be used to improve prospects in supply chain procedures. The current pandemic has highlighted the significance of resilient and dependable supply chain systems that are less dependent on humans and more efficient in cycling goods supply chains. The present study included and excluded records from two recognised databases, Scopus and Web of Science, using the PRISMA declaration 2020. After following the inclusion and exclusion criteria details, investigated the forty-seven articles with two significant data streams (traceability of supply chain management, resin and sustainability). Results illustrated that in today's environment, the rivalry has shifted from "firm vs firm" to "supply chain vs supply chain." As a result, the ability to optimise the supply chain has arisen as a significant issue for organisations seeking a competitive advantage. However, it has become increasingly challenging to traceability of products and merchandise while they are moving through the value chain network. The Internet of Things (IoT) applications and blockchain technologies can help companies observe, track, and monitor products, activities, privacy, security and processes within their respective value chain networks. Other applications of IoT include product monitoring to optimise operations in warehousing, manufacturing, food supply chain and transportation. Combined with IoT, Blockchain technology can enable various application scenarios to enhance supply-chain transparency and trust. When combined, IoT and Blockchain technology can increase the effectiveness and efficiency of modern supply chains. First, we illustrate how deploying Blockchain technology in combination with IoT infrastructure can streamline and benefit modern supply chains and enhance value chain networks. Second, we also identified that the resilience of big data analytics, machine learning and artificial intelligence is helpful for the sustainable development of social, economic and environmental contexts.

Keywords—blockchain, internet of things, supply chain, traceability, resilience, sustainability

1 Introduction

Industry 4.0, or the fast digitisation of industry, is popular in supply chain management. The opportunities presented by digitisation have enabled supply chains to access, store, and process important internal and external data (Schniederjans et al., 2020). According to (Q. Feng & Shanthikumar, 2018) manufacturing companies may now receive personalised client data to customise the sales process, product design, and service. One example is intelligent gadgets that use learning algorithms to capture and exchange data to find possibilities. In addition, digital disruption is already affecting supply chains and necessitating new manufacturing strategies, including a shift from traditional production planning and control to digital manufacturing (DM) large-scale to micro-scale manufacturing with multiple manufacturing locations (Srai et al., 2016). Digitisation also enables demand information to be transmitted directly to actuators in production plants, resulting in faster changeover times and higher service levels. The amount of data recorded and disseminated has also improved predicted accuracy and the ease of implementing prescriptive solutions. Forecasting uses of big data have lately developed in domains such as entertainment (Verma et al., 2011). According to (Queiroz & Fosso Wamba, 2019), the supply chain management (SCM) profession is experiencing unprecedented problems because of the digital revolution enabled by cutting-edge technology.

Despite the recent emphasis on Industry 4.0 still lacks a specific, widely recognised definition (Hofmann & Rüsch, 2017). The SCM literature shows a growing interest in exploring Industry 4.0 (Yasir et al., 2022). According to (Sikandar et al., 2022), Industry 4.0 solutions boost overall operational performance by allowing faster and more cost-effective responses. (Parvin et al., 2013) Highlight essential and operational performance factors in Industry 4.0. To increase business alignment, the authors identify areas for improvement and establish process initiatives, key performance indicators, and actions. Although, the intricate and dynamic features of these elements raise uncertainty in supply networks (Chauhan & Singh, 2020). To solve these difficulties, industry 4.0 technologies have been created to rebuild supply chains and create digital networks (Garay-Rondero et al., 2020). (Ardito et al., 2019) emphasise the need to use big data to analyse trust, cultures, and behaviours in supply chains and cross-industry networks to promote sustainability. In addition, Inter-organizational connections are supported by various technologies in the industry 4.0 era since the relationship between stakeholders in the supply chain demands a particular amount of openness and security of data transferred inside the supply chain (Bag et al., 2018; Benzidia et al., 2021; Mustapha et al., 2022). Blockchain is a viable solution that might be coupled with other inter-organizational technologies to reduce trust, traceability, and cooperation concerns across supply chain operators (Aslam et al., 2018; Qureshi et al., n.d.).

Blockchain is one of the most current disruptive Industry 4.0 cutting-edge technologies. Among the most promising, blockchain technologies can alter Supply Chain Management (SCM) business models due to their decentralised peer-to-peer model and tamper-proof characteristics (Kshetri 2018)(Akhtar et al., 2022). According to (Wamba & Queiroz, 2020) blockchain enhanced openness and information sharing among SCM members, accountability, uncertainty reduction, trust and security, fraud prevention, and process confidence. These advantages are possible primarily because blockchain is a tamperproof system in which transactions cannot be changed, and all network participants have a copy of the transactions (Saberi et al., 2018). In addition, blockchain technology can improve the sustainability of social supply chains (Chang et al., 2020). Keeping information solid and immutable ensures supply chain social sustainability (Pérez-Salazar et al., 2019). Also, blockchain traceability contributes to sustainability by improving the assurance of human rights and fair, safe work practices. For example, a thorough product history record increases customer confidence that things purchased are from ethical sources (Chaudhuri et al., 2021).

In the above characteristics and features, the current study aims to investigate Improving opportunities in supply chain processes using the internet of things and blockchain technology. The current pandemic realised the importance of robust and reliable supply chain processes that is less human-dependent and more efficient in circulating the supply chain of products. The present study used the PRISMA statement 2020 to include and exclude records from the two reputable databases, Scopus and Web of Science.

2 Research methodology

2.1 Materials and method

To incorporate high-quality materials, the current study employed the PRISMA statement 2020 to include and exclude records from Scopus and Web of Science databases. The data were screened using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) methodology, as recommended by (Moher et al., 2009) and shown in Figure 1. However, the current study used the PRISMA statement 2020 for better reporting for records and relevant reports associated with the literature. We used the search terms “Internet of things” AND “Blockchain” AND “Supply chain” for our literature survey. Initially, 675 records were obtained. The current review covered publications from social science, computer sciences, engineering, business management, accounting, economics, econometrics, finance, and interdisciplinary articles. In such a case, the results are reduced to 105 documents. Furthermore, we chose just the articles, reviews, and book chapters for the current study, reducing the number of records to 59. Additionally, only published and English-language documents were considered to replicate the study's scope for important literature outcomes. This step decreased the number of records to 50. The next stage was to remove unnecessary and missing document information duplication. A careful selection was created for each detected categorisation to analyse linked materials. To synthesise it, only 47 papers were included in the assessment. Figure 1 displays the PRISMA statement selection and rejection mechanism used in the current investigation.

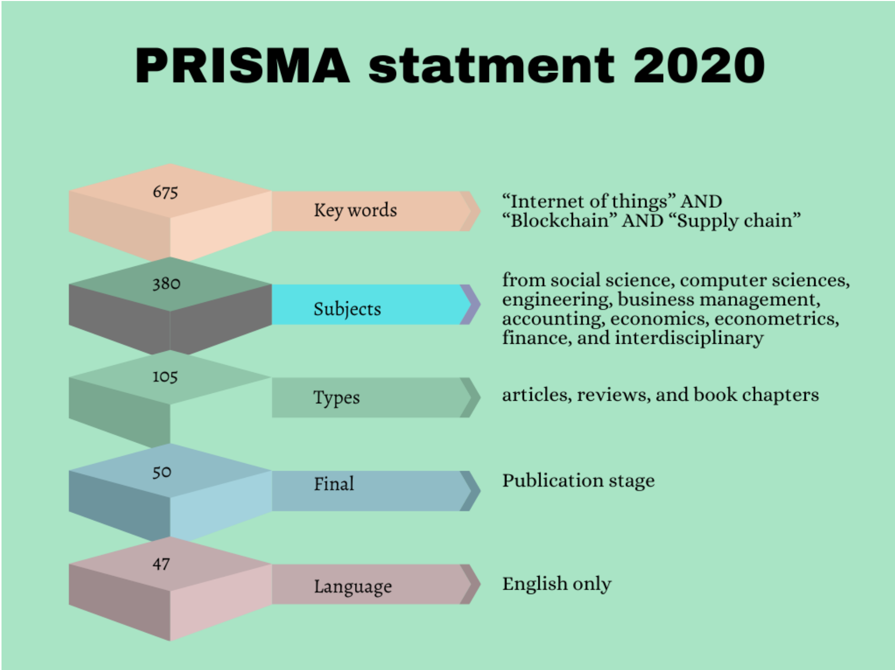

Fig. 1. PRISMA statement 2020 methodological procedure

3 Descriptive analysis

The multidisciplinary research question highlights the different disciplines' contributions to the supply chain process with IoTs and blockchain. The most contributing field is computer science, with 26% of records in the study selected. In addition, business management and accounting with 24% of studies included in the review; economics, econometrics and finance; engineering field 9 % of studies; psychology, social sciences and multidisciplinary with 6% of studies, and finally, contribution of environmental sciences with 4%. The details in Figure 2 show the subject percentage contribution from each subject.

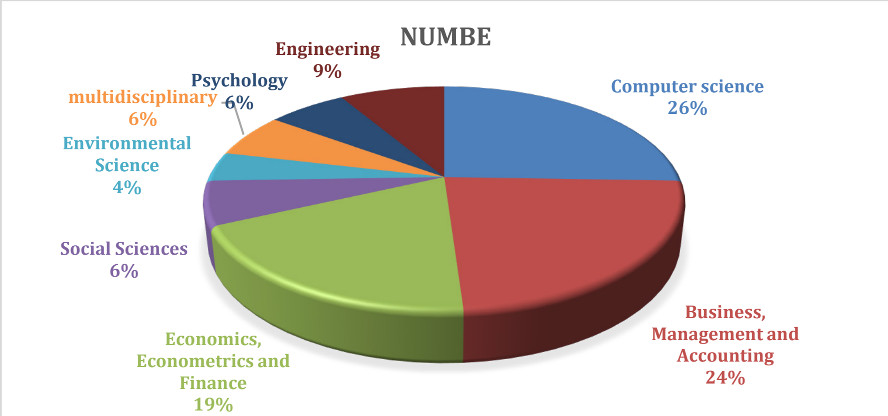

Fig. 2. Distribution of subjects included in the study

Additionally, the records for the current study were picked mainly from recent years for two key reasons. First, the current pandemic has produced an unprecedented need for supply chain relevance, and second, the participation of advanced digital technologies like blockchain and IoT (Hald & Coslugeanu, 2022). the records from 2016-to 2022 were dominant in the current review, as depicted in Figure 3. A significant number of articles are included from 2019 to 2021 due to the recent increase in supply chain intention from the researcher's and academicians' perspective; fourteen records were selected from 2020, which is significantly higher than other years. The significant additional contribution is from 2021 to 2019 with eleven and seven documents from each year, illustrated d in Figure 3.

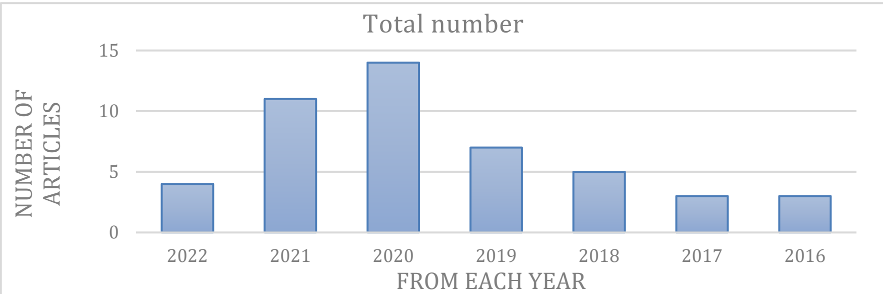

Fig. 3. Distribution of articles from each year

Furthermore, the source-based results are depicted in Table 1 with the source titles, the number of records from sources, citation details and average of citations from each journal. The significant contribution of articles is recorded from the Sustainability (Switzerland) with ten records and 15% of total citations. However, the journal of Cleaner Productions total records and 4, but citation average and number is higher than the other sources included in the review. The number of articles selected from Journal of cleaner production is 4, total citations are 360 and the average is 17%. In addition, the other significant contribution is recorded from Intelligent Systems in Accounting, Finance and Management journal, International Journal of Production Economics, and Computers and Security. The sources details, the number of articles, citation reports, and citations average have illustrated the Table 1.

Table 1. Source title, article numbers, citation, and citation average

Source title	Article numbers	Cited by	Citation average
Sustainability (Switzerland)	10	329	15%
Journal of Cleaner Production	4	360	17%
Intelligent Systems in Accounting, Finance and Management	3	340	16%
International Journal of Production Economics	3	258	12%
Computers and Security	2	113	5%
Environmental Science and Pollution Research	2	26	1%
Environmental Technology and Innovation	2	42	2%
IEEE Engineering Management Review	2	20	1%
International Journal of Environmental Research and Public Health	2	98	5%
International Journal of Information Management	2	179	8%
International Journal of Production Research	2	107	5%
Internet of Things (Netherlands)	2	31	1%
Resources, Conservation and Recycling	2	162	8%
Scientometrics	2	37	2%
Technological Forecasting and Social Change	2	11	1%

Moreover, we employed key terms occurrences analysis to identify the significant themes in the review literature. The VOS Viewer emphasised the number of keywords and key phrases used in the published articles. Forty-five selected papers analysed the critical occurrence, with 55 essential terms appearing more than ten times. Three significant data streams were assigned during the key term's occurrence research: Sustainability and traceability of supply chain management. We also offer the relevancy score for each sentence and the average score. In addition, a minimum of eight occurs was included in the table, and the sign's used term was 32 times. Moreover, we also have a relevance score for each word extracted from the VOS viewer software. Table 2 depicts the terms, classification, occurrences of critical terms and relevance score of each time below.

Table 2. Key term occurrences, terms selected, and relevance score

Term	Classification	occurrences	relevance score
business	Sustainability	12	0.8514
development		22	0.2689
environment		21	0.526
field		20	0.4545
organisation		19	0.5431
service		16	0.4392
smart contract		10	1.1638
solution		19	0.5156
area	Traceability	20	0.4901
benefit		12	0.9398
control		11	0.7355
food supply chain		19	1.1178
insight		9	2.6401
lack		8	1.1738
literature		23	0.4257
logistic		10	0.4287
privacy		11	0.6608
product		17	0.8867
stakeholder		16	0.8088
traceability		23	0.9902
transaction		11	1.6204

Additionally, the documents were examined using bibliometric key term occurrences and content analysis to determine the classifications of the study. VOS Viewer software analyses the published literature’s content—data clusters created on the text established to group the related ideas. The current study found that in more detail in the journals' indexing procedure outlined in the databases, researchers' keywords and keywords are equally accurate for bibliometric analysis designed to uncover the structures of the examining field. Hence, we involved both class keywords for the co-occurrence analysis within the study area associated with social media and organisational sustainability. In total, 47 records were contained within the research, and the data delivered 56 keywords. We have thoroughly established and selected only the most numerous 55 repetitive keywords in at least two records. Figure 4 illustrates the content analysis results. The cluster is represented by blue displays traceability, food supply chain, security, disruptive technologies, and consumers. The cluster in red is primarily ascribed to cloud computing, big data, machine learning, artificial intelligence, and business. The brown cluster signifies research, development, originality value, new technology, and knowledge. However, the clusters are further divided into four major classification streams.

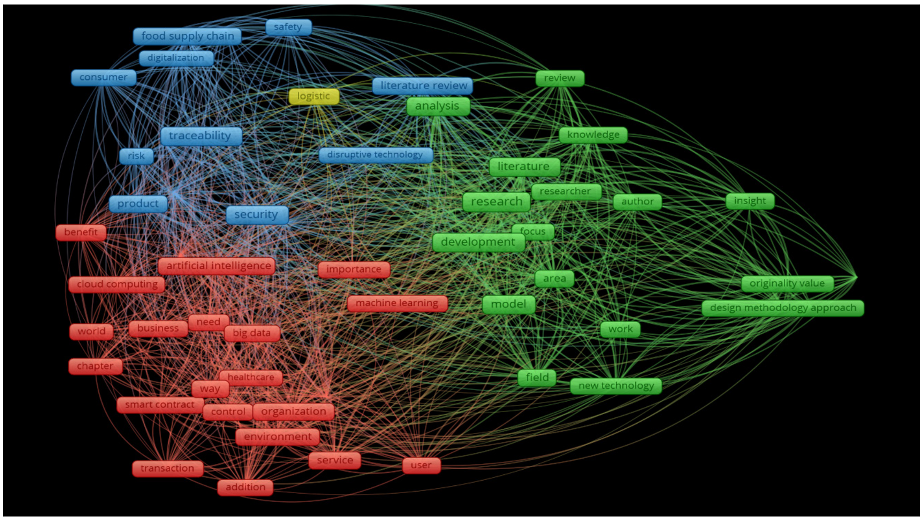

Fig. 4. The classification of literature using the VOS viewer

4 Classification

4.1 Traceability in supply chain management

Traditional Internet of Things (IoT) traceability systems use Radio Frequency Identification (RFID), Wireless Sensor Network (WSN), and Near Field Communication (NFC) tech Every organisation is exposed to supply chain interruption in today's dynamic and uncertain market and consumption (H. Feng et al., 2020). According to (M. A. Khan & Salah, 2018), It can give valuable data for monitoring and traceability. However, because it is built on the centralised server-client paradigm, stakeholders and consumers must rely on a single information point to store, send, and distribute traceability data. In addition, traceability optimises profitability through transparency while ensuring product quality and safety (Iftekhar & Cui, 2021). Proposals for product traceability began in the food and pharmaceutical industries. Other firms are incorporating blockchain technology as a means of achieving the aim of transparency (Pérez et al., 2020). However, product quality at each stage of the supply chain depends on the quality of the previous steps. Thus, the final product's quality depends on suitable traceability methods along the supply chain. Implementing automatic data capture systems is costly, and the variety of technologies makes it difficult to implement them (M. M. Khan et al., 2022; Nurgazina et al., 2021). Also, Sensor technologies such as IoT and cyber-physical systems (CPS) have been widely integrated to maintain logistics monitoring, product quality tracking, process control, and assure data-driven decision-making (Pillai et al., 2022). Additionally, blockchain technology not only enables transparency but also aids in creating distributed and immutable records, allowing for the traceability of inputs. Blockchain technology's traceability mechanism also aids in the prevention of fraud across the supply chain (Boschi et al., 2018). Table 3 below shows the authors' details, articles' citations, sub-classification details, segments and settings in which the research was conducted.

Table 3. Authors, cited by sub-classification, segments, and settings

Authors	Cited by	Sub-classification	settings	segment
Feng et al., 2020	204	food quality and safety management	Internet of Things (IoT)	blockchain-based food traceability systems
Bumblauskas et al., 2020	179	production and supply chain	eggs from farm to consumer	blockchain and internet of things (IoT)
Duan et al., 2020	98	WHO	food insecurity	security, immutability
Iftekhar & Cui, 2021	27	COVID-19	frozen meat packages	supply chain architecture
Pillai et al., 2022	23	authenticity and security	tracing suppliers and customers	Blockchain
Tsiulin et al., 2020	22	shipping industry	blockchain-based applications	supply chain
Nurgazina et al., 2021	18	consumers and stakeholders	novel technological and sustainable practices	scalability, security, and privacy
X. Li et al., 2021	17	enabled building information modelling (BIM)	blockchain	stakeholders

According to (Duan et al., 2020), traceability enables detailed logging of product movements, allowing businesses to understand the supply chain better, make smarter decisions, and prevent potential quality problems. Tracing items backwards and forward along the supply chain helps speed up the process of isolating and locating specific products from certain suppliers, making quality inspections and product recalls more efficient. Customers gain knowledge and trust in purchasing items by exhibiting the movement of resources and products (Fraga-Lamas et al., 2020). In addition, blockchain was discovered to be a viable method for attaining effective traceability in the food supply chain. One of the first blockchain studies in food traceability was conducted (Tsiulin et al., 2020). In addition, prior research has demonstrated that blockchain technology offers various advantages, including identity management (Li et al., 2021). In the supply chain, blockchain may be used to store and communicate data with other parties, such as suppliers, customers, and so on, or to compare the data received with other node data or outside data for verification. Blockchain enables supply-chain visibility into who executes what actions, where, and when (Bumblauskas et al., 2020). According to (Senyo et al., 2019), information is digitally linked to each unique product on the blockchain, producing a digital record to show provenance, compliance, authenticity, and quality. This information is available to all stakeholders and follows the product throughout the supply chain. In addition, calls for blockchain integration are becoming increasingly common in the traceability context of the supply chain management process.

4.2 Sustainability

Blockchain and IoTs are particularly essential in terms of sustainability. Because of its tracking capabilities, blockchain and IoTs can help reduce product recall and rework; (2) it is easy to trace the actual footprint of products and determine the exact amount of carbon tax that each company should be charged; (3) it facilitates recycling behaviour by incentivising individuals to participate in deposit-based recycling programmes; and (4) it improves the efficiency of emission trading (Esmaeilian et al., 2020). According to (Zhang et al., 2020), introducing blockchain technology may considerably facilitate green and sustainable supply chain processes. When combined with other technologies such as big data analytics and the internet of things (IoT), blockchain technology "could be utilised to establish a permanent, shareable, measurable record of every moment of a product's trip through its supply chain," supplying smooth product traceability, authenticity, and legitimacy. In addition, sustainable and environmentally friendly supply chains are a big problem for all worldwide sectors. Many organisations strive to protect the environment through process changes, new strategies, and international certifications such as ISO 14000 (Rane & Thakker, 2020). According to (Rane et al., 2021), blockchain and IoT are new technologies integrated into supply networks. Although they have the potential to alter the dynamics of the green supply chain, they are still facing obstacles. Security and transparency are critical considerations for a green supply chain that include a variety of parties and processes, such as supplier selection, shipping, packaging, and distribution (Tan et al., 2020). Table 4 below shows the authors' details, articles' citations, sub-classification details, segments and settings in which the research was conducted.

Table 4. Authors, cited by, sub-classification, segments, and settings

Authors	Cited by	Sub-classification	settings	segment
Esmaeilian et al., 2020	162	Industry 4.0	energy management	blockchain and internet of things (IoT)
Zhang et al., 2020	102	Life cycle assessment	environmental impacts of a product or service	internet-of-things (IoT) and big data analytics
Tan et al., 2020	40	business organisations	Internet of Things and big data	green logistics
Rane & Thakker, 2020	32	integration of blockchain and IoT	green procurement	Environment issues and challenges
Rane & Thakker, 2020	18	greening of the supply chain	managers and practitioners planning	blockchain and internet of things (IoT) technologies
Ada et al., 2021	14	circular economy	food supply chains	machine learning
Hrouga et al., 2022	12	environmental regulations	supply chain	Blockchain technology and the Internet of Things (IoT)
Tijan et al., 2019	138	sustainable logistics and supply chain management	delay, damage to goods, errors	blockchain technology
Kamble et al., 2020	258	sustainable agriculture supply chains	Internet of things, the blockchain	agriculture supply chains

There is increasing awareness of and concern about food production and consumption's environmental, social, and economic impacts. As a result, consumer organisations, social and environmental advocacy groups, agricultural organisations, and governments have increased their push to build sustainable supply chains (Kamble et al., 2020). In addition, rising food waste is becoming a worldwide challenge regarding food security, necessitating simultaneous environmental, economic, and social management. It is critical to developing a more sustainable food supply chain to eliminate these consequences (Ada et al., 2021). However, digital tools like Big Data, IoT, Blockchain, Augmented Reality, and Cloud Computing has evolved recently and are being utilised to digitise supply chains and logistics. These tools' primary goals are to offer real-time data, enhance supplies, reduce transportation costs, optimise delivery, build intelligent warehouses, and improve demand forecasting in supply chains. In addition, blockchain and IoT digitise the supply chain for hazardous waste collection and management (Hrouga et al., 2022). Unlike current digital supply chain technologies, its use will be utilised to geolocate, collect, transport, and track dangerous trash. Blockchain allows for the control of hazards and the significant consolidation of data generated by IoT devices (Tijan et al., 2019).

5 Conclusion and future agenda

The current study's findings indicate that the supply chain is essential in supplying goods. Organisational reliance on the state relies heavily on supply chain resilience, transparency, and traceability. Blockchain technology and IoT devices significantly increase supply chain channels' standards in many industries. Most notably, food supply traceability is frequently covered in preceding literature, formerly a severe problem. Blockchain integration improves supply chain management's privacy, data availability, authentication, and dependability. In addition, IoT-based devices and sensors are also vital for supply chain management decisions for sustainable development. In addition, IoT enables businesses to acquire new data from various stages of their supply chain. Such devices, for example, may trace the manufacture of a packaged food product from ingredient sourcing to production, transportation, and sale, including inventory status and working conditions in manufacturing and logistics facilities. Figure 5 shows the outcomes of the study.

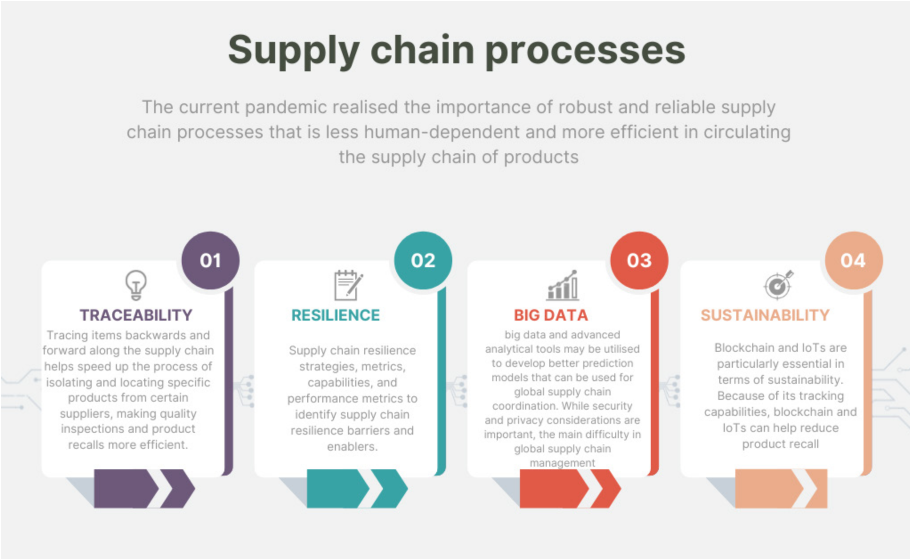

Fig. 5. Outcomes from the literature

Furthermore, the importance of big data analytics and machine learning is boosting supply chain management agility. Future academics must investigate the utility of big data analytics and machine learning algorithms in supply chain management. The present study's findings also suggest that blockchain technology and IoTs play an essential role in environmental, economic, and social sustainability. Food waste during the supply chain process is a significant concern, and integrating blockchain with IoT sensors addresses this problem.

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