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A Cluster-Based Bibliometric Analysis of the Emerging Technological Landscape in Logistics using Vosviewer

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ABSTRACT

Emerging technology presents itself as a futuristic solution since its early development stage in the industry. Concurrently, the industry has proposed framework implementations as well as efforts to integrate emerging technologies in the supply chain, particularly in logistics. This study aimed to unveil the applicability of either supply chain or logistic functions in the present industry. This study used Publish and Perish to mine academic document data based on the keyword 'Logistic' and 'Emerging technology' in the past five years. Furthermore, the retrieved data were compiled and processed as a bibliographical map to visualize relevant clusters as the bottom-line discussion for this study. Five clusters had different items/keywords associated with them, excluding clusters three and four which were discussed in tandem. Cluster one revealed that AI and blockchain could support manufacturers for a circular economy business model through reverse logistics operations in the pandemic. Cluster two was a bigger picture discussing enhancement efficiency and risk reduction in the supply chain using AI, blockchain, and IoT. Clusters three and four had overlapping keywords specifying the discussion of blockchain implementation for the Agri-industry in China. Finally, cluster five reaffirmed the conceptualism of emerging technology integration for transportation from other clusters. Despite a unanimous agreement on the potential use of emerging technologies, challenges were also found, such as complex implementation, uncertain investment, and technology immaturity accompany. Thus, as the implication of this research, it reveals the capabilities and issues of the implementation of emerging technologies within multiple aspects of logistics and supply chain.

1. Introduction

Emerging technologies are radically new and relatively rapidly evolving, characterized by a certain degree of coherence and with the potential to deliver considerable socioeconomic changes [1]. These impacts are understood in terms of changes to existing industries, the basis of competition, an understanding of the socioeconomic impact, and human understanding or capabilities [2, 3]. On a side note, such impact is only plausible when the right business models discovered its exact use, thus

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explaining why technologies can still be emerging after 15 years as a second life, which is still in its early revolution and is being discovered [4, 5].

The complexity of a correct integration of emerging technologies does not shun businesses, particularly the logistics field, to benefit from it. Digital technologies in the past two decades have allowed logistics to build a reputable performance by providing better management shown by their revenue and market sentiment. These technologies, along with massive amounts of real-time data, will redefine industrial and service operations across a global supply chain, as well as alter human-machine interactions [6]. As a result, it brings positive benefits in current sales, operation planning, and the logistics process [7]. That is the main reason why digital technology must be added in education [8-25].

Despite the evident benefits of developing technologies in recent decades, it is critical to recognize that the path to their seamless integration is not without hurdles. For this matter, this study aimed to seek the implementation of emerging technology in logistics as a paramount importance for enhancing operational efficiency and competitiveness as well as potential hurdles to its adoption. The study used VOSviewer to present multiple perspectives by relying on items provided within the clusters. Detailed examples on previous studies on bibliometric are presented in Table 1.

Table 1
Previous studies on bibliometric

No	Title	Ref.
1	Involving Particle Technology in Computational Fluid Dynamics Research: A Bibliometric Analysis	[26]
2	Bibliometric Computational Mapping Analysis of Trend Metaverse in Education using VOSviewer	[27]
3	The Use of Information Technology and Lifestyle: An Evaluation of Digital Technology Intervention for Improving Physical Activity and Eating Behavior	[28]
4	Strategies in language education to improve science student understanding during practicum in laboratory: Review and computational bibliometric analysis	[29]
5	How language and technology can improve student learning quality in engineering? definition, factors for enhancing students' comprehension, and computational bibliometric analysis	[30]
6	Mapping of nanotechnology research in animal science: Scientometric analysis	[31]
7	Scientific research trends of flooding stress in plant science and agriculture subject areas (1962-2021)	[32]
8	Introducing ASEAN Journal of Science and Engineering: A bibliometric analysis study	[33]
9	A bibliometric analysis of chemical engineering research using VOSviewer and its correlation with Covid-19 pandemic condition	[34]
10	A bibliometric analysis of materials research in Indonesian journal using VOSviewer	[35]
11	Bibliometric analysis of engineering research using Vosviewer indexed by google scholar	[36]
12	Bibliometric computational mapping analysis of publications on mechanical engineering education using VOSviewer	[37]
13	Research trend on the use of mercury in gold mining: Literature review and bibliometric analysis	[38]
14	Domestic waste (eggshells and banana peels particles) as sustainable and renewable resources for improving resin-based brakepad performance: Bibliometric literature review, techno-economic analysis, dual-sized reinforcing experiments, to comparison with commercial product	[39]
15	Bibliometric analysis of educational research in 2017 to 2021 using VOSviewer: Google scholar indexed research	[40]
16	Corncob-derived sulfonated magnetic solid catalyst synthesis as heterogeneous catalyst in the esterification of waste cooking oil and bibliometric analysis.	[41]
17	The compleat lextutor application tool for academic and technological lexical learning: Review and bibliometric approach.	[42]

No	Title	Ref.
18	Use of blockchain technology for the exchange and secure transmission of medical images in the cloud: Systematic review with bibliometric analysis.	[43]
19	Computational bibliometric analysis of research on science and Islam with VOSviewer: Scopus database in 2012 to 2022.	[44]
20	Digital transformation in special needs education: Computational bibliometrics.	[45]

2. Methodology

This study used two main applications to source, compile, and present data on a research map based on documentary analysis, namely the Publish or Perish and VOS viewer. Publish or Perish is a software program that retrieves and analyzes academic citations. Academic citations retrieved for this paper were sourced from Google Scholar due to its open-source nature. The keywords used to identify selected documents were “Logistics” and “Emerging Technologies” which dated from 2019 to 2023. The retrieval limit was established at 1000 documents, considering the vast repository of over 661,000 records stored in Google Scholar of the same keywords. As a result, a list of 994 documents was successfully retrieved within this limit.

The next step was to use VOS viewer to compile the document list that was saved in research information systems (.ris) format. VOS viewer is a specialized software application for visualizing and analyzing bibliographic networks in bibliometric research. The compiling process used both title and abstract for a more inclusive and redundant term. To prevent menial overlapping qualities, a minimum number of 20 occurrences was determined. This threshold witted 148 initial terms down to 58. In the final data presentation, only 57 were used for more relevant results. Detailed information for the use of VOSViewer, google scholar, and publish or perish is presented in previous studies [46, 47].

Data presented by VOS viewer will indicate the networks of synonymous terms which can be split into clusters. These clusters have multiple items/terms that signify the theme of each cluster. Thematic coherence varies among clusters in the dataset, meaning that each cluster may or may not have the same underlying schematics.

3. Results

3.1 Research Development in The Field of Emerging Technologies in Logistics

Emerging technology has always been the most frequent topic in regards to its implementation, especially in logistics. The initial supposition was that publications related to emerging technology would inch to current years justified by a continuous development of the years. However, an up and down trend line was observed instead. Notably, there was a huge spike in popularity from 2019 to 2020 (as shown in Figure 1), with research articles increasing fourfold. However, the next period, from 2020 to 2021, saw a consistent reduction in publications. This negative trend had continued over the last two years, with a rapid decline. Surprisingly, interest in this issue bottomed in 2023, with a 60% drop compared to the research published in 2019. Figure 2 reveals more than 20 separate publishers responsible for publishing a diverse number of academic documents, ranging from a few hundred to none. Notably, the top five publishers, namely Elsevier, Emerald, Springer, Wiley Online Library, and ResearchGate, emerged as the most significant contributors, accounting for over 808 journals in total.

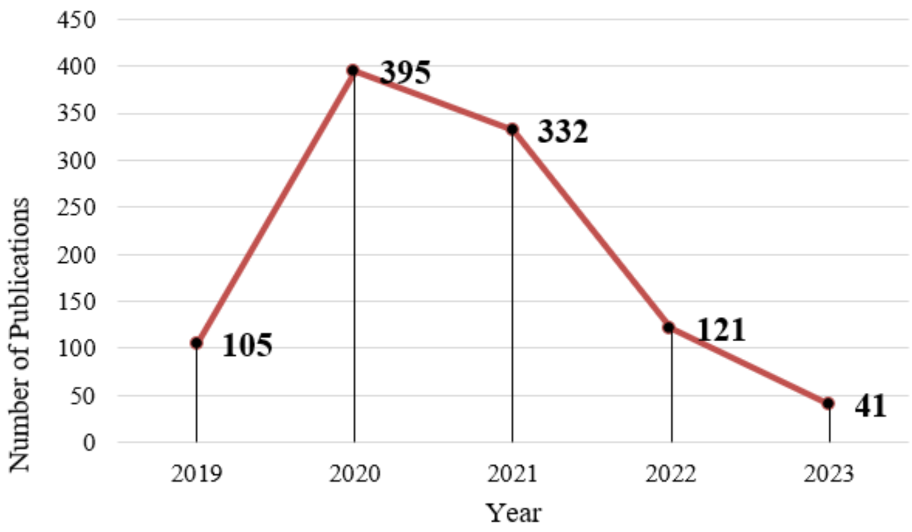

Fig. 1. Yearly number of identified publications from 2019-2023

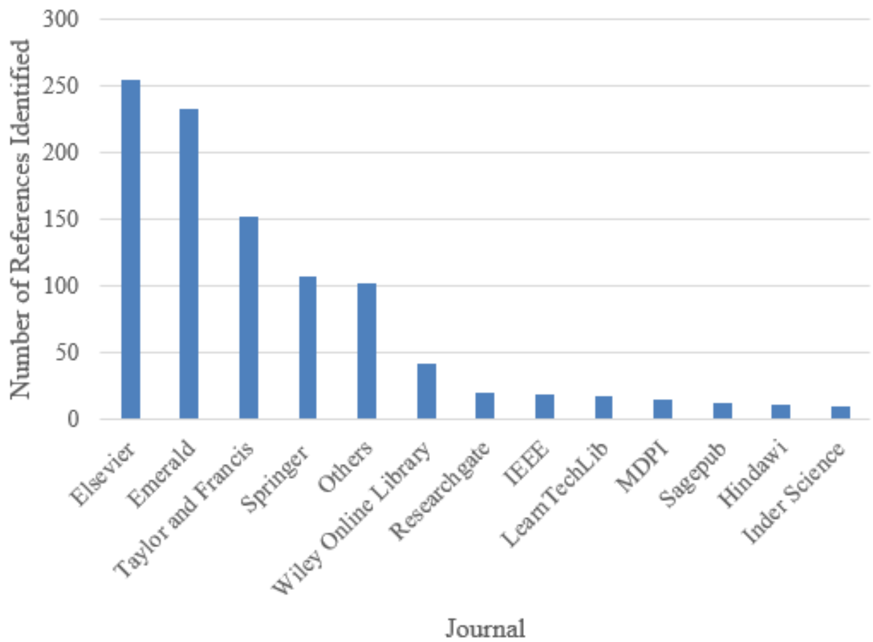

Fig. 2. Academic paper publications based on journals in 2019-2023

3.2 Visualization of Emerging Technologies in Logistics Using VOSviewer

The visualization map in the field of logistics by the term emerging technologies gained 57 related items that were clustered into 5. Each cluster surprisingly had almost no direct reference highlighting out named technologies aside from ‘Blockchain’. However, most clusters had some tangible connections to the implementation of the keyword ‘Technologies’, ‘Application’, and ‘Impact’. The items that represent each cluster are shown in Table 2.

The study mapped the literature documents into three components, including network visualization, overlay visualization, and density visualization as shown in Figures 3-5, respectively. Network visualization is denoted by connection lines that represents link strength. Overlay visualization presents yearly output by keyword clusters to illustrate the yearly research trend. Density visualization employs a heat map to portray the density distribution of each keyword. The bibliographical map uses colored circles to distinguish each cluster. Additionally, different label (circle) size refers to the frequency with which the phrase appears in titles and abstracts, with a positive connection.

Table 2
Emerging technologies in logistics clusters

Cluster	Quantity	Items
1	16	Circular economy, company, context, covid, digital technology, economy, effect, impact, logistics, logistics management, pandemic, paper, performance, research, reverse logistics, study
2	15	Analysis, application, artificial intelligence, big data, development, internet, IoT, logistic regression, review, systematic literature review, technology, use
3	12	Case, case study, China, Information technology, integration, logistic, logistics industry, logistics service provider, logistics system, new technology, perspective, role
4	12	Adoption, barrier, benefit, blockchain, blockchain technology, challenge, industry, literature, operation, opportunity, supply chain, supply chain management
5	2	Framework, literature review

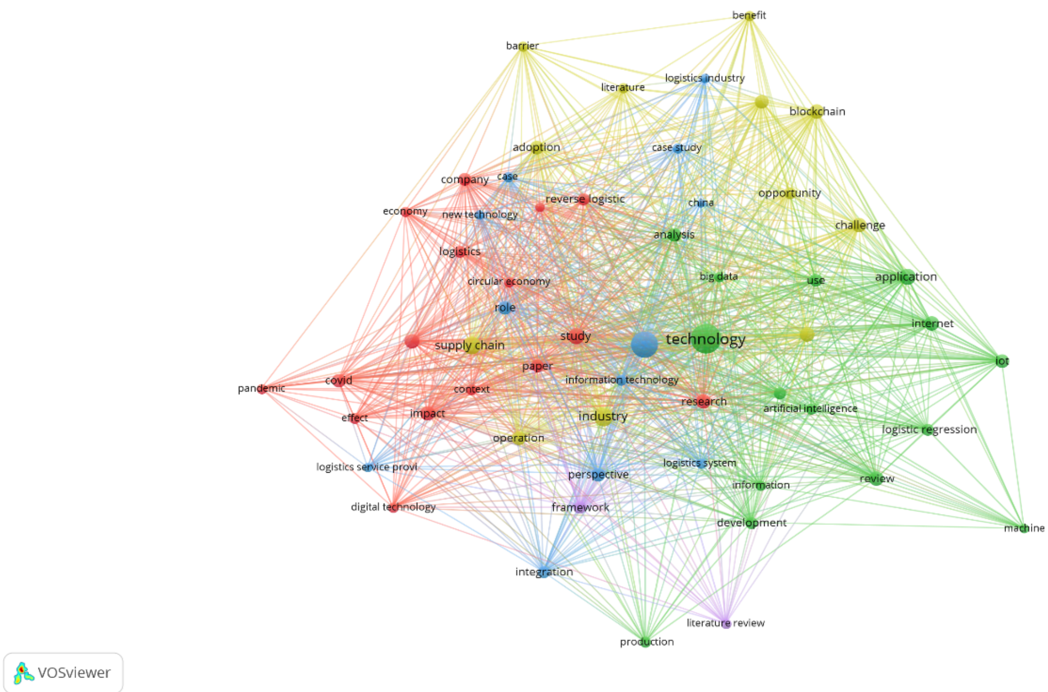

Fig. 3. Emerging technologies in logistics network visualization

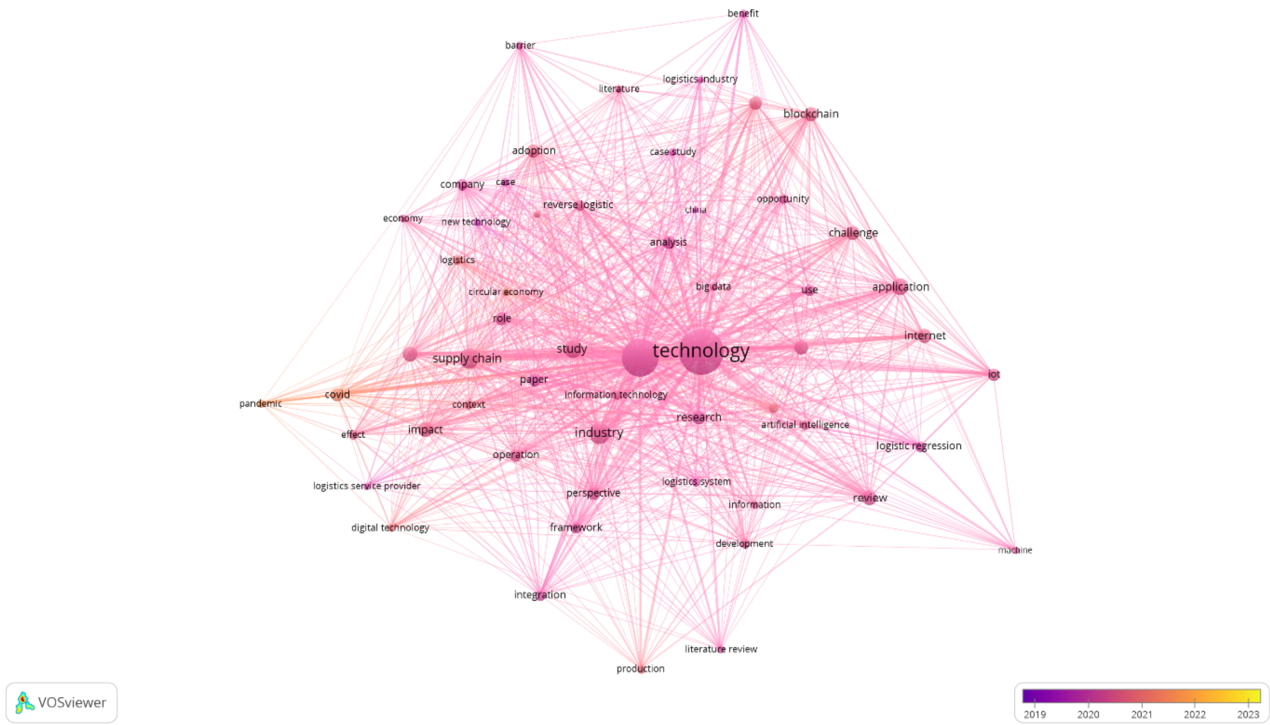

Fig. 4. Emerging technologies in logistics overlay visualization

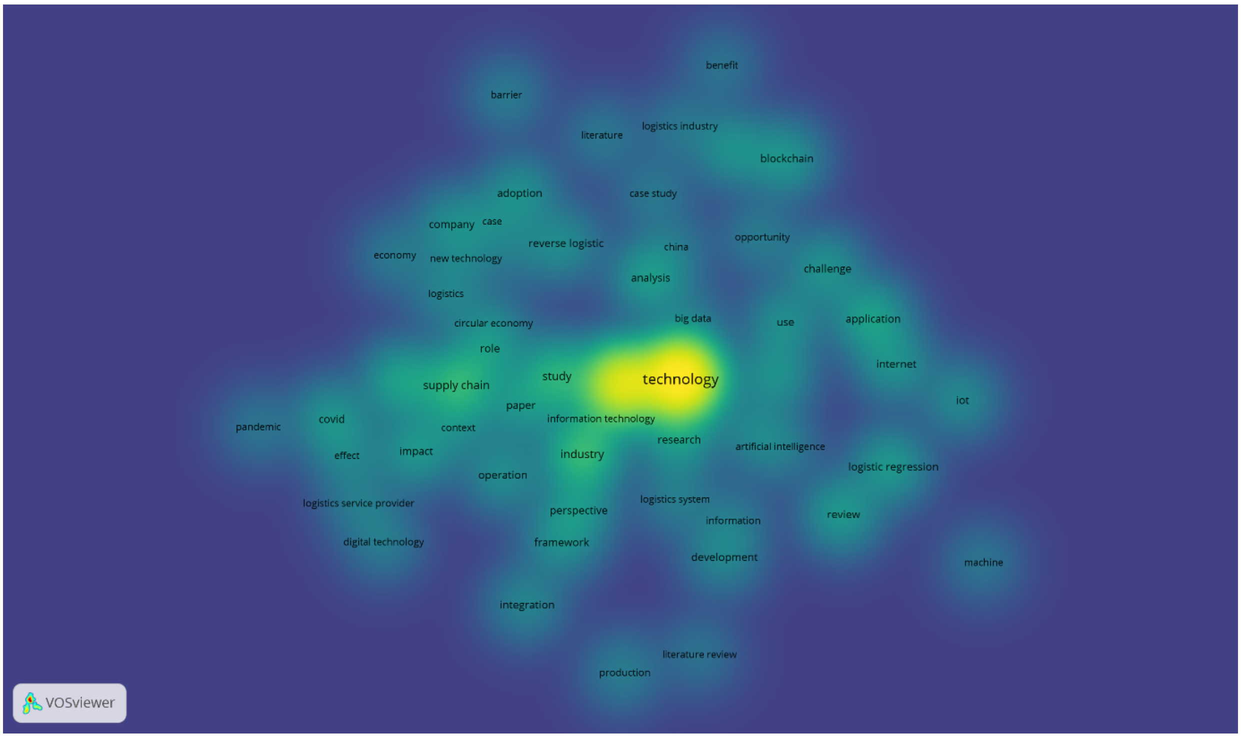

Fig. 5. Emerging technologies in logistics density overlay

The technologies in logistics domain could be efficiently separated into two distinct fields based on network visualization of the clusters. The first field, denoted by the technical term, was found in cluster 2 and had 56 links, a cumulative link strength of 3684, and 1014 occurrences. The second field, related with the logistic term, was in cluster 4, and it had 56 links, a total link strength of 2536, and 629 occurrences.

3.3 Research Focus based on Bibliographic Mapping

Network visualization in Figure 3 visualizes the strength of items bounded by links corresponded to each other derived from academic document titles and abstract data. Two major items had links covering almost the entirety of the map, namely technology and logistic. It implies that the item 'technology' had the strongest link connected to some emerging technologies, such as artificial intelligence (high), IoT (high), and blockchain (low). Link deviation from technology led to a supply chain in the respective industry which also correlated to opportunities and barriers to integration in the industry.

The second largest link forming the item logistic in a blue dot on the left of technology can be hardly seen, yet poses a strong connection that rivals its counterpart. The connections bound to the item logistics are both an extension to the logistics industry and implementation scenarios. Furthermore, a link between logistics and China may imply a unique logistic implementation method worth reviewing.

The second map is overlay visualization Figure 4 which describes the yearly publications based on the existing items. It is quite peculiar as to almost the entirety of the map reins over the 2019-2021 spectrum. This meant that all the aforementioned items were researched intensely over the same period, leaving only both items covid and pandemic past this spectrum portion. The insignificance notion of research related to the pandemic seems counterintuitive since the nature of technology is not abysmal to provide solutions regarding emergencies. However, in retrospect to the network visualization, the item China was mentioned, thus protruding a possibility of an extended result in the endemic instead.

Lastly, the density overlay demonstrates Figure 5 that the largest concentration highlights just two items, technology and logistics. These elements stand out as the visualization focal points of maximum density. The remaining components, on the other hand, have lesser degrees of density or a minimal to negligible presence. This focus emphasizes the importance of technology and logistics in determining the overall thematic environment shown by the density overlay.

3.4 Cluster 1: Blockchain and Artificial Intelligence in Manufacturing and Covid-19 Pandemic Waste for Reverse Logistics Functions

Circular Economy (CE) means exploring and creating opportunities for a change in cradle-to-cradle from the use of renewable energy, from the use of toxic chemicals to their disposal, and from waste to waste through the superior design of materials, goods, systems, and business models [20]. The current CE in manufacturing industries is expanding their approach to production using Reverse Logistics [48]. RL is concerned with recapturing the value of goods at their destination by ensuring the life cycle of the product from end to end [48, 49].

In hindsight, it is possible to undermine the value of reversed products from this activity since the returning goods may either indicate the lack of quality or service from the respective industry. However, given the same scenario, RL provides competitive advantages to companies that value sustainable efforts in their business model. The upper hand of RL can be summarized into three, including higher recovery rates, increased revenue and profits, and enhanced service levels. A full commitment to RL allows the industry to manage and salvage return products 80% more effectively, which in turn leads to increased revenue and profits from a surplus of good quality salvage and customer satisfaction [50].

The benefits of RL allow the transparency in real-time information flow in the supply chain network to be maintained [5]. If fulfilled, RL could result in reducing the lead time of the deliverables, streamlining the business operations efficiently, as well as lessening the bottom line and quality control communication.

The implementation of retail RL follows three main steps, namely deciding the products to recover alongside their options, identifying the reverse logistics processes involved, and mapping CE values to the recovery options and relevant processes [51]. However, in the current CE, establishing nodes of communications throughout RL stakeholders proves to be an additional step in reaching an optimal value of recaptured goods. The best approach from past cases to RL is to involve all actors of society to create and exchange links. These links will aid supply chain collaboration further by inviting third-party firms that specialize in more advanced processes like refurbishing or remanufacturing, adding significant value to the products [52].

Various research has confirmed that the aid of transparency communication indicates the success of RL. An emerging technology, namely blockchain, is believed to greatly contribute to this due to its traceability and transparency. The introduction of Blockchain Technology (BCT) in the automotive industry reverse logistics (RL) has yielded a significant boost in productivity. The integration of BCT in automobile RL provides supply chain members with precise and reliable insights into returned vehicle attributes like quality, condition, and performance. This fusion enhances end-to-end traceability and expedites the recall process for defective vehicles. As a result, supply chain participants gain awareness of potential hazards and necessary preventative and corrective measures, ensuring a seamless flow of safe products to end-users [53].

In a recent case that serves as a reflection of blockchain capabilities provides an example amidst Covid-19 Pandemic. The study proposes an IoT platform for Covid-19 Pandemic Waste (CPWs) – Reverse Supply Chain (RSC) encompassing four layers, including configuration, process, application, and users [54]. In the configuration layer, IoT devices like sensors, monitors, and CCTVs are strategically positioned across CPW production, transportation, and treatment locations, interconnected via Wi-Fi, Bluetooth, and the Internet. These devices collect and transmit data for subsequent analysis.

The layer process undertakes data processing, converting raw information into sector-specific insights. This phase involves data clustering, classification, analysis, and validation, culminating in tailored data for each sector. This approach facilitates pandemic response, curbing virus propagation, mitigating waste management challenges, and ensuring regulatory compliance. Furthermore, it introduced a decentralized blockchain-oriented framework to enhance supply chain traceability, security, and transparency in medical waste management during the pandemic [55].

In addition to communication aid, emerging technologies can perform mundane to complex tasks autonomously. The use of Artificial Intelligence (AI) is a technology that possesses enormous potential in managing, planning, and executing RL processes. Previous research stated that AI can be implemented in RL functions, such as network design, collection, warehousing, and processing [26]. The AI type can also be distinguished into intuitive, analytical, and mechanical. Intuitive AI could think creatively to solve complex and idiosyncratic tasks. Analytical AI could solve complex problems that are systematic and predictable using logic and learning from experience. Lastly, mechanical AI could automatically perform simple, repetitive, and consistent tasks that are well-defined and require minimal ability to adapt and learn. These types are then assigned to suit each RL function depending on their specialties as shown in Table 3.

These benefits have also been accounted to, specifically in identification, inspection, and sorting for reverse logistics in remanufacturing [56]. The research shows that cutting-edge vision-based object recognition mixed with machine learning may effectively detect and memorize multiple cores or product variants. This approach has the potential to have a wide-ranging influence, contributing to the circular economy by simplifying complicated procedures, eliminating uncertainty, and encouraging new players to enter the recycling and remanufacturing markets.

3.5 Cluster 2: The Contributions and Limitations of AI and IoT to Supply Chain Management

The introduction of Industry 4.0 technology has ushered in a new era of supply chain management (SCM) change. The potential of digital technology to modify SCM procedures and lessen disruptive risks has been studied in several studies. One significant use is the development of a horizontally operating smart supply chain capable of synchronizing with supplier delivery timings, quantities, and information. This integration addresses the well-known bullwhip effect, which occurs when fluctuations in demand are amplified across the supply chain [57].

AI is the emerging technology that transforms all aspects of Supply Chain Management, including procurement, production, warehousing, packaging, distribution, and even Customer Relations Management (CRM). It does this by digitalizing the supply chain to bring about a digital transformation by transitioning away from the legacy ERPS to analytics [58]. The AI has similar capabilities to those shown in Table 3, with the exception that the logistics function is forward-oriented rather than reverse-oriented. Table 4 provides a thorough description of these abilities.

Thirdly, companies as of now are still hesitant to invest in terms of research and solutions for AI services. A survey done by [59] revealed that a share of logistics and port stakeholders were hardly willing to pay or join development tracks for AI and data entry solutions. The survey claimed that most businesses were wary about involving themselves in AI-based solutions. Notably, 66% were averse to having their organization participate in AI training and development. Furthermore, a sizable 60% were unwilling to pay for AI-enabled data interpretation and entry, with 20% considering monthly fees of 250-500 EUR. Across willingness-to-pay ranges of 500-1,000, 1,000-2,500, and over 5,000 EUR, a roughly even distribution of 7% was seen. These findings support the ensuing sentiment from logistics stakeholders, particularly port stakeholders, to engage in AI integration today.

Table 3
The role of AI in reverse logistics fuctions (source: the circular economy meets artificial intelligence (AI): understanding the opportunities of AI for reverse logistics)

Reverse Logistics Function	Reverse Logistic Tasks	AI Type	Process
Network design	Selection of 3PL providers	Intuitive	Considering level of specialization, price, quality, customer service, environmental considerations, and flexibility
	The number of location collection points, centralized depots, and processing facilities	Analytical	(Using) RFID to pinpoint and coordinate optimal supply points
Collection	Transportation routing	Analytical	Assisting in determining the number of extended (vs new) collection centers and their location
	Container design	Analytical	Applying algorithms to lower container production cost
Warehousing	Product return forecasting	Analytical	Forecasting return volumes and enhancing inventory management decision support
	Sorting and inspection of materials	Mechanical	(Using) Robots to recognize and sort parts, as well as diagnose part failures after testing
Processing	Selection of alternates recycling reassembly	Intuitive	Identifying, recommending, and ranking recycled product options

Reverse Logistics Function	Reverse Logistic Tasks	AI Type	Process
	Disassembly line balancing	Analytical	Optimizing disassembly by reducing idle time, prioritizing hazardous components and high-demand items.

Table 4
The role of AI in forward logistics functions (source: role artificial intelligence in logistics and supply chain)

Forward Logistics Function	*Forward Logistic Tasks*	*Process*
Procurement	Training	AI algorithms are actively trained to increase confidence to attain goals
	Goal setting	The algorithms are set with specific challenges
	Feedback	Unclassified procurement data are given to AI algorithms to classify
Manufacturing	Information sharing	Digitally transforming manual operations involved in manufacturing of products and in making prompt data-driven decisions
Warehousing	Track and Trace (T&T)	Locating inventory in the production, processing, and manufacturing units and managing customer orders accordingly
Packaging	Automation	Preserving goods, identifying, and offering information about the goods, enhancing efficiency, handling, and distributing the goods, and modifying the product density
Distribution	Consolidation	Collecting data and making recommendations to improve operations and revenues.
	Forecasting	Employing algorithms to process consolidated data to predict consumer demands
CRM	Facilitating vendor management inventory	Making use of collaborative planning, forecasting and replenishment (CPFR)
	Enhancing workplace communication and customer service	Predicting the peak hours in logistic centers and ecommerce

3.6 Cluster 3-4: Blockchain Network to Enhance Safety and Quality of China Agri-Industry

In the context of China, a country that has been pushing for the continuous improvement of logistics information technology, it faces the very challenge of the current ripples in Industry 4.0. The reluctance of information sharing and scattered resources posed two main issues, unable to obtain effective and sufficient logistics information and questionable source of information. These issues directly contribute to all parties involved in logistics inability to accurately understand the state of materials and discover problems in time - including liability claims [60].

Transitioning from the logistics industry concerns to China proactive approach to tackling these issues through new solutions, it is discovered that China has been actively studying the use of blockchain technology across multiple sectors, including agriculture. By embracing blockchain technologies, China hopes to not only reduce the difficulties mentioned above but also greatly improve food safety and quality within its agricultural supply chains.

Traceability and real-time data analysis are made possible by using digital platforms and blockchain technology, resulting in reduced operating costs and delivery timeframes [61]. The incorporation of digital technology, including Tracking and Tracing (T&T) systems and blockchain, shows the potential to improve supply chain resilience. T&T systems provide real-time detection and reporting of potential interruptions, whereas blockchain enables greater visibility and efficiency in record-keeping.

One of the suggestions posed by previous research establishes an agri-food supply chain traceability system based on RFID and blockchain technology to enhance food safety and quality in China [50]. It uses the same concept of T&T in which data about agri-food products is meticulously gathered using RFID and authenticated across all phases encompassing production, processing, warehousing, distribution, and commercial transactions. The validated data are seamlessly integrated into a blockchain framework, shaping a decentralized and inviolable ledger that remains open to scrutiny by all stakeholders within the agri-food supply stakeholders. Lastly, a user-friendly interface poses as an enabler to ease access to agri-food products for the stakeholders. This system updates in real-time, thus is constantly monitored to ensure the integrity, traceability, and safety of the information provided. The proposed blockchain system in China involves cold chain logistics which is designed for agriculture fresh goods. The system comprised of RFID and blockchain for better T&T is shown below in Figure 6.

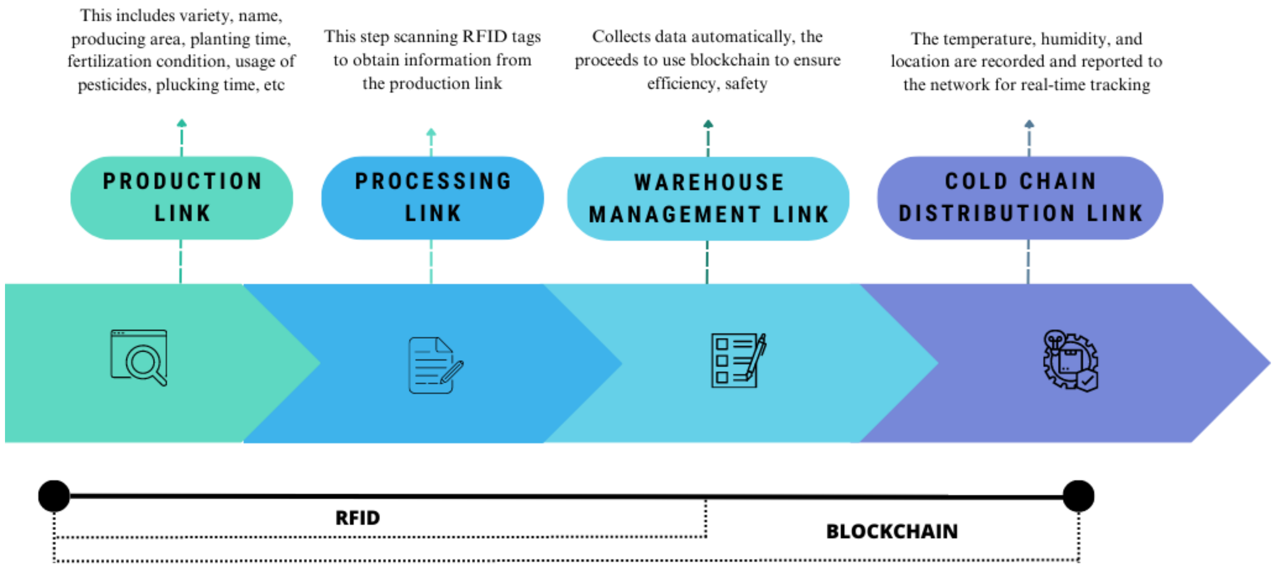

Fig. 6. Blockchain and RFID for agriculture links in china (source: an agri-food supply chain traceability system for china based on RFID & blockchain technology)

its e-commerce. Stakeholders using the full utility of blockchain now have access to real-time information which aids greatly in transporting goods in a more appropriate planning. This means that logistics enterprises can use blockchain technology to understand logistics transportation and transportation at any time, avoid blocked road sections, select roads with smooth roads to operate, which can deliver goods quickly and timely, and reduce the impact on urban areas – environmental pollution [6].

In the present circumstances, the current proposed system describes two main drawbacks of using Blockchain-RFID in agriculture, namely high cost and the immaturity of application. Firstly, the adoption of RFID technology for traceability faces challenges due to high tag costs compared to barcodes [50]. Initial setup investments and system updates further impede RFID logistics integration. Secondly, blockchain is still in its early stage of development which has a transaction limit. For instance, VISA can handle up to 47000 transactions per second to blockchain for only 7 per second.

One might argue that a huge amount of investment is given into the endeavor of emerging technology. However, in the case of the agricultural industry, many of its stakeholders are comprised of individual farmers who are most likely incapable of either investing in technology or decentralizing data for their farmlands, in contrast to corporate farms [62-69]. It is suggested that the future study should try to anticipate which farms could benefit and which could lose from the introduction of blockchain-based solutions [70].

3.7 Cluster 5: Framework for Future Implementations of Emerging Technologies

Emerging technology has an enormous potential given the prior discussions of listed clusters in logistics. However, it is noticeable that most of these capabilities are still in the early development stages, posing questions of what prospects might be for the technologies in question. A framework is always required as a guide to map certain possibilities for integrating these technologies. An initial theoretical approach mapped combinations of emerging technologies to affected variability perspective that were divided into four, including increasing frequency of decision making and planning (+freq), increasing system flexibility (+flex), increasing postponed decisions (+postp), and establishing real-time actions/response (RT) [71]. The framework proposed in practice has already been tested or implemented in network design (see Table 2), collection, and distribution (see Table 3). The overlapping vision between past research indicates a global approach to emerging technology integration in logistics.

4. Conclusions

In conclusion, the integration of emerging technologies (AI, IoT, and blockchain) holds the potential of increased operational efficiency, transparency, and real-time insights across multiple SCM components. AI revolutionary potential, particularly in forward-thinking logistics applications, demonstrates its ability to modify established SCM paradigms. Furthermore, as seen in China agriculture industry, the adoption of blockchain technology has the potential to improve traceability, consequently improving food safety and product quality. These advances, however, are not without their drawbacks. Issues for an instant complex implementation, unpredictable investment, and the immature development of these technologies refrain a total digital automation.

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