Bringing Blockchain Technology in Innovating Industries: A Systematic Review

Daimler Benz, Muzaffar Hamzah , **Mohd Fahmi Ghazali** , **and Mohammad Fadhli Asli**

Abstract The mainstream digital technology uses significantly changes how industry protect their records due to new security and vulnerability challenges. Leveraging cryptography, blockchain technology enables large agile value chains, transaction transparency, and flexible integration with many digital technologies like Internet-of-Things and cloud computing. The capabilities of blockchain technology further empower secure transferable wide-range collaboration between industry allies and public sectors. Recognized by its potentials in driving innovation in industries, blockchain is expected to play significant roles in industrial transformation. This paper reviews the significant developments of blockchain applications in information systems of many industries. The review aims to provide insights on the advances of blockchain industrial applications including use cases, classifications, and emerging trends. We conducted a systematic review on published blockchain works from high-quality sources using formulated review questions, selection criteria, and processes. Summarizations of blockchain applications across many industries are presented including use cases, objectives, and application examples. Moreover, we classified and characterized the innovative features of presented blockchain applications based on the application's distinct characteristics. Subsequently, summarization of emerging trends in blockchain applications based on recent industry use cases and implemented features are discussed. This paper highlights the consequential advances of blockchain in industries that eventually lead to research opportunities for future undertaking.

Keywords Blockchain · Industry 4.0 · Distributed Ledger · Use cases

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1   Introduction

As we move into the new era of technological advances, most of our daily activities
are digitalized or mechanized for better convenience. This majorly differs from
previous advances from our predecessors in the 90s to early 2000, where most of
our daily tasks are carried out manually. These tasks include monitoring, recording,
managing, organizing and other repetitive tasks such as buying a ticket to watch a
movie or to watch a baseball game. Recent literature show that many systems have
been implemented in a digital format, from the automated toll system to the
attendance system implemented in the workplace and higher learning institutions
[1, 2]. Blockchain technology gained attraction in the light of rising popularity of
cryptocurrency. Over the years, blockchain has gained popularity due to popularity
of cryptocurrency. The application of blockchain has developed since then and has
been incorporated in several real business cases within industries. Current block-
chain applications are observed in the financial sector, food supply chain, inter-
national documentation, and music distribution.

  Blockchain technology can bring forth tremendous innovation in industrial
transformation to industry 4.0 [3]. There is yet to be a systematic review on the
trend of blockchain development in various industry enclose with use cases and
classification. And by the year goes, new use cases and emerging industry is
expected as their implementation scale is large and need to be observe so that
blockchain matters can be understood in depth to enhance the mainstream adoption
of its technological environment.

  The aim of this paper is to report the overview of significant developments in
blockchain usage within information systems in various industrial sectors. Insights
gained via this overview help profound understanding about the blockchain
development and identify innovative factors that blockchain brought to the indus-
tries. In this study, we carried out a systematic review of recent blockchain literature
to gain insights on industrial innovations brought by blockchain technology
development. First, we examined each industry and compose it throughout relevant
blockchain use cases. Next, we observed and classified blockchain features that
were set as distinctive characteristics in these industries. Besides, this review
examined the recent trends on blockchain use cases and blockchain features that are
frequently used in industrial works. To summarize, the contributions of this paper
are:

1. Summarization of overviews on blockchain technology use cases including type
    of use cases, development context, and tangible benefit of blockchain for
    each use cases at any form of innovation in many industries.
2. Classifications of blockchain concatenation according to recent industry oper-
    ational. For each of the classification, we discuss the performance that generally
    has provide a solution onto industry flaw.
3. Summarization of emerging trends covering blockchain use cases and its
    classification.

The remainder of this paper is organized as follows. Section 2 introduces the underlying concept and background works of blockchain implementation. Section 3 describes the methods used in conducting this systematic review including research questions, review workflow, and selection process. Section 4 then presents the results of our systematic review based on each formulated research question. Section 5 then provides detailed discussions and summarizations of findings based on review results. Finally, the conclusion of this review paper is presented in Sect. 6.

2 Background

Securing communications and transactions is a crucial aspect of information security especially with the mainstream adaptation of digital information technologies. Leveraging cryptography, the concept of blockchain was introduced to help to secure securing public transaction records with manipulative-resistant design. Blockchain is related to a database technology called distributed ledger that catalog a digital event record and interlinked by each data collection on every device that integrates with the transactions over the database. This data is protected as private property in blockchain, no computing or person and even the admin can change this protected data after the approval transaction takes place for the data to be recorded [4]. Blockchain essentially provides a public network for everyone to use by adding their data into the system, besides there are also includes private blockchain to be applied [5]. The data within the chain itself use 'distributed concurrence' which the data cannot be stored into the blockchain database if and only the agreement has been verified, whether a new data is inserted into specific blocks that are placed according to blockchain transactions and it is lawful or illegitimate to be recorded to the chain. Nowadays, massive amount of data is interconnected globally, and it is a valuable asset in various industry to be protected [6]. Researcher in academia and industry realize the benefits of blockchain through strengthened security, better traceability, and accountability. For example, an investigation on integrating blockchain technology and supply chain discovered that the food industry needs blockchain to ease their customer for checking the origin of product details [7]. Another study found that the educational system can be integrated with blockchain to record a permanent credential for students' achievement in the academia area [8].

We found 6 studies that reviewed the leading edge of the blockchain in various industries. One of the papers is focused on blockchain application and use cases that affect blockchain design, while another is focused on blockchain implementation for various industry applications. One paper discussed the emerging management of supply chain, logistics, and transportation using blockchain application, another one papers elaborate the vital factors on blockchain implementation in supply chain

management (SCM). Two papers focused on the blockchain aspect, which is industry 4.0 in blockchain and blockchain on security and privacy. The paper mentioned above is divided into four categories like use cases, industry application, industry 4.0, security, and supply chain as lists in Table 1.

A survey [9] reviewed the influencing factors brought from blockchain application and lay claim that the features of blockchain application offer endless new, while its use cases bring a solution for real-world problems. Meanwhile, a survey [10] highlighted the obtainable opportunity, benefits, and challenges in various industries for utilizing blockchain. The emerging of blockchain applications in industry and services (e.g. supply chain, logistics, and transportation) is discussed in a study [13], by leveraging the framework of technology, traceability, trust, and trade. Another review [14] elaborated the vital factors towards industry and put into words that the factors found in their study could be applied for SCM development, indicating that latest technology can be implemented to enhance performance, lowering costs, improve safety, and strengthen productivity by adopting blockchain in SCM. A study [11] focused on the capability and solution of blockchain when integrating with industry 4.0 based applications, and they found blockchain solved much current security that failed to cope with traceability, network inactivity, information processing, and more. Besides, a systematic review [12] presents summarizations of the aspect of security and cyber-attack within the blockchain, and their analysis results indicate blockchain is under imminent threat. These surveys and reviews discussed many of the related aspects of our review focus. Nevertheless, these papers did not discuss the blockchain leading edge based on trends within use cases and its utilization in various industries.

The premise offered by blockchain technology is the elimination of unnecessary third parties. Blockchain significantly reduces transaction fees and time, clearing, and settlement systems. Blockchain turns every transaction to be open, direct, and convenient, thus re-establishing trust among purchasers and providers. Moreover, blockchain features the elements of security, trustworthiness, and transparency. Awareness in making collaboration between industry allies, competitors, and customers contribute to the quality of values, including capital, intellectual, and technology investment. The transparency and security of blockchain, or distributed ledger technology, lower costs for many programs and projects. These instances do occur for countries with weak or underdeveloped legacies of telecommunication and financial infrastructures.

Table 1 Categorization of existing reviews on blockchain implementation

	Use cases	Industry application	Industry 4.0	Security	Supply chain
Survey	[9]	[10]			
SLR			[11]	[12]	[13, 14]

3 Methodology

In this section, we describe our methodology in conducting the systematic review including research questions, review process, eligibility criteria, search strategy, and data collection. Referring to PRISMA [15] and reference models [16, 17], we conducted a systematic review to deliver an overview of the blockchain development. Additionally, we refer to the existing model concept [18] for conducting this study, which consists of the review process, the following paragraphs and sections process illustrated in Fig. 1.
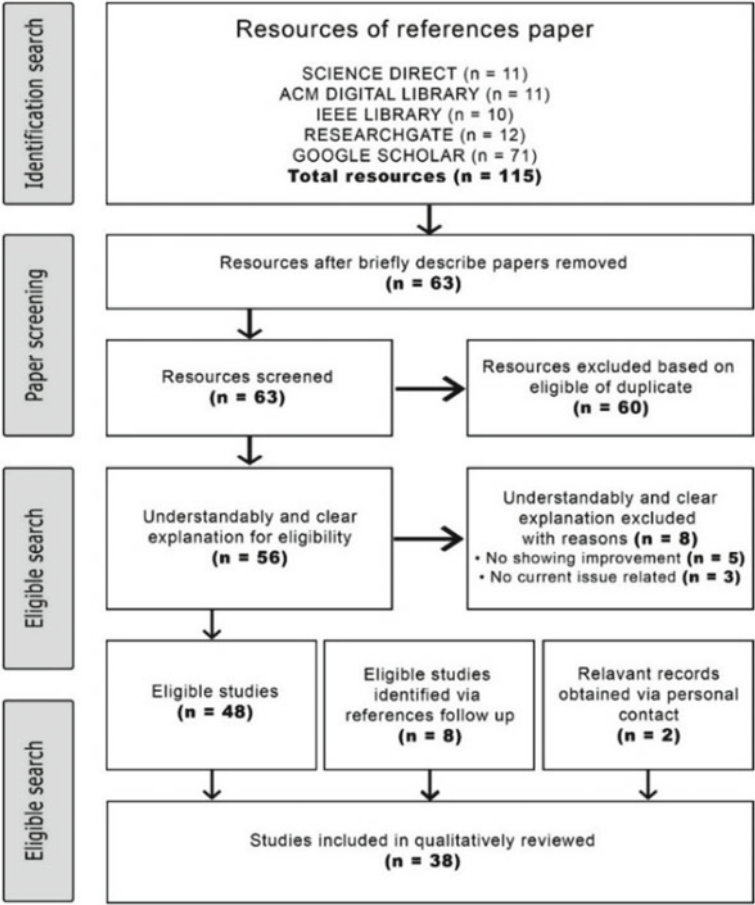

Fig. 1 Review workflow of this systematic review

3.1 Review's Research Question

A systematic review begins with the formulation of guiding research questions [16]. Therefore, the following research questions by this study are as follows:

> **RQ1: What are the recent developments of blockchain that innovate productivity in various industries?**
>
> **RQ2: What are the classifications of improvement brought by blockchain technology in industries?**
>
> **RQ3: What are the emerging trends of blockchain utilization in industries?**

RQ1 aims to identify the classification of blockchain adoption and operations in the various industrial sector. Although not all the industrial sector implemented blockchain, there are several industries still uses traditional transactions. Hence, it is useful for classifying blockchain capability relation to all industries, include the early stage to get used blockchain. By highlighting the blockchain classification might help to inform the improvement directions that blockchain brings in various industries, as well to increase blockchain adoption.

RQ2 aims to gather the existing development brought from blockchain features for selected industrial sector. Classifying the outcome of use cases enable other researchers and experts to interpret for a better understanding on the main research area, that could contribute towards more investigation on blockchain use cases in future research.

RQ3 aims to examine recent works to offer insights on the recent trends of blockchain. New technology, use cases, and development might be introduced in the future. Determining recent trends of blockchain uses by various industries eventually supports other researchers and experts to obtain insights on blockchain development over the half decades.

3.2 Review Protocol and Phases

This analysis applies the developed standard guidelines [19] to assess planning for review, to analyzing the review by interpreting selected studies through e-databases, and to outcome the final review. This protocol process is illustrated in Fig. 1.

3.3 Inclusion and Exclusion Criteria

This review selected peer-reviewed papers that fulfill the predefined eligibility criteria to be included in the review. The descriptions and justifications of the selection criteria are shown in Table 2.

Table 2 Inclusion and exclusion criteria in review selection

Criteria	Justification
IC-1: The paper describes the use of blockchain in different industries	This review investigates relevant studies on blockchain adoption in various industry
IC-2: The paper clearly illustrates the improvements that have emerged due to blockchain in various industries	The aim of this paper is to deliver an overview on significant developments of blockchain technology industrial sector
EC-1: Papers describe the implementation of blockchain in today's technology	Paper that only overviewing blockchain implementation in general do not always contains an integration with industry aspect
EC-2: Duplicates or identical research regarding the usage of blockchain and their advantages to the various industries	Duplicate content is always subject to confidentiality and uncertainty, thus we compared date published and status of the author

3.4 Information Search Strategy and Sources

The papers were extracted from online electronic databases as demonstrated in Table 3. Two main search keywords were used: "blockchain" and "industry". Since not all papers have similar topics, the related papers in which the point are relevant to the topic were manually searched to identify any additional relevant work to be included in the review.

4 Results

This section presents the results of data collection with regards to each formulated research questions.

Table 3 Distribution of papers by sources throughout screening process

Sources	Identification search	Paper screening	Eligible search	Selected for review
ScienceDirect	11	10	9	9
ACM DL	11	10	9	9
IEEE Xplore	10	8	8	7
ResearchGate	12	10	8	6
Google Scholar	71	37	35	7
Total	115	63	48	38

4.1 Results for RQ1

What existing development of blockchain innovates productivity in various industries? Out of 38 studies, two studies [20, 21] are discussing blockchain-based use cases practical in the emerging industry, followed by the use cases of supply chain [22–24], and financial [25–27] as well music industry [28–30] with three studies each. One study is focusing the document management [31] while another gaming industries [32], and another one is conducting humanity resources management [33]. With some of the studies we got above, we analyzed it together with an innovation-based paper [34].

The application of blockchain allows for a decentralized and distributed environment that does not require central authorities [4, 35]. Most of the blockchain application is associated to data management and authentication [36]. All data transactions are trustworthy and secure because of cryptographic principles in the blockchain [5, 37]. Nowadays, blockchain technology has penetrated different domains gaining recognition for wider audiences leading to an increase in the proposed services and software application [38]. These industries are labeled based on their category sectors as shown in Table 4.

(a) Supply Chain

Problem and challenges might happen at anytime and this leads to postponement activity in supply chain management. Universal and global practicalities in the

Table 4 Classifications of blockchain use cases

Use cases	Usage of blockchain	Industrial sector
Supply chain	Traceability for products Quality assurance	• Walmart: Tracking food safety and supply chain • DNV GL MyStory: Track provenance of wine from grape to bottle
Financial	Microloans International trade Retail lease guarantees	• Twiga Foods: Small Business Microloans in Africa • ANZ and Westpac: Retail lease guarantees • HSBC: Improve efficiencies and reduce time
Document Management	Document distribution Digital documentation Digital certificate	AB InBev, Accenture, APL, Kuehne + Nagel: Eliminate printed shipping documents • Accedible: Digital educational certificates • North and South Korea: Recording the Peace Declaration
Music Streaming	Music distribution Track and store digital. information	• Spotify: Validate and register transaction without a need for a central authority • Musicoin: Streaming catalog of music from independent musicians
Humanity Welfare	Welfare distribution	• UN World Food Programme: Refugee relief
Gaming	Digital collectible assets	• CryptoKitties: Digital collectibles assets

context of supply chains are incompatible, resulting difficulties in monitoring or organizing manpower and technology. Moreover, human workers are prone to technical mistakes either intentionally or unintentionally on global logistics service. Blockchain technology transforms the workflows for logistics in the supply chain to be more efficient and optimized. A study [39] explained that this optimization is designed to facilitate accurate inventory tracking, which allowing for further service licensing, improves accountability from source to production point of consumer satisfaction.

As the food supply chain management is important in addressing current limitations on the blockchain, a recent work [40] investigated the effect of blockchain on food supply and found that blockchain is used by Walmart and DNV GL as a digital assurance solution by providing traceability to its products mainly for food supply in their supply chain. In addition, a study [41] critically examined the supply chain management relationships and stated that blockchain featuring traceability that can be integrated to every secure transaction entity in the domain supply chain. The transaction is validated and provided in the blockchain by immutability functions, only mutually accepted participants are involved in it [42]. Overall, the adoption of blockchain to supply chain or logistic process strengthens the performance, reduces cost, augments risk measures, and improves productivity dramatically [14].

(b) Financial

From the financial perspective, some aspects can be achieved by using blockchain such as linking banks around the world without middlemen. A recent work pointed that financial services are struggling to cope with outdated and obsolete financial operations, and also gaps in security systems slow payment transactions and limited transparency [43]. These financial problems can be solved using blockchain to transform significant financial markets into operations with faster accountability processes, transparent technology [44], as well as efficient and secure industrial systems and infrastructure systems [45].

Blockchain is used by Twiga Foods to enable Small Business Microloans in Africa which has growing financial services to overcome the common issues in least developed countries. Microfinance is one of the critical service tools that stand against poverty as an important behalf of IFC's to make a quality transformation of a vibrant private sector in the country. Within the microloans itself, it is focused on the peer-to-peer approach. Peer-to-Peer (P2P) lending, knowing as "social lending," the functionality is to make transactions among individual-to-individual to lend money.

HSBC bank also uses blockchain for international trade with Corda or known as R3. A study [46] claimed that Corda is third wave blockchain which promises security and efficiency, especially in the way it operates. By using Corda, an issue letter of credit can be made especially for US for an agreement of food, agriculture film, and Cargill. Since it normally takes the range of 10 days to complete the agreement, blockchain reduces the time for consensus, which takes only 24 h to complete the agreement.

ANZ and Westpac use blockchain technology to retail lease guarantees because it is an open source, secure in transmitting information, and esteem. Blockchain able to make the banks to be more productive, where the expenses of instalment be prepared immediately, produce new items and administrations aware of producing new income streams. Banks were using blockchain to identify each individual and their authorization as it plays a vital part both in the banking business and the customers [47].

(c) Document Management

A study [48] examined the digital learning credential assessment and management on blockchain and found that the everyday activity in documents management are processed either by people or automation machine such as digital certificate digital learning credential. Also, a study [49] investigated the applicability of blockchain-based electronic transfer bills and found a long heterogeneous alignments document like bills sometimes are difficult to index in a current traditional database. A recent work [50] explained the emerging research and opportunity of smart contract management in which document management is one of the blockchain most incontestable features, integrating and implementing these technologies not only has improved document management but it also enabled standard audibility as most other of its activities are provable and data distribution. To address the data distribution issues, decentralized blockchain features for metadata are suggested [51] that supports the key features and examine consequences for digital documents management and information conservation.

Blockchain is used by AB InBev, Accenture, APL and Kuehne + Nagel to eliminate printed shipping documents and transition to digital copy. Throughout this research of documentation review processes, AB InBev, Accenture, APL and Kuehne + Nagel determine and re-allocate of accountability, forecast risk and ownership information with blockchain technology trust. A recent study [52] discussed the blockchain capabilities in which able to make the process management faster for the entire flow of transport documents, making data entry requirements more productive. Moreover, blockchain capabilities make easy for data amendments during shipping, align monitor and overcome unpredictable cargo processes of penalties conflict or cases complaint from most customer that are not satisfying for the services [53].

Blockchain is also used for international documents—North and South Korea use blockchain to record the peace treaty. International documents are records pertaining government policies, thus extremely crucial to secure via safe platforms to ensure longevity and integrity of the documents. A smart contract is one of the blockchain applications that execute as a program by consensus protocol [54, 55]. And there are many blockchain technologies that can store smart contracts such as Stellar, EOS, Cardano, NEO, Tron, and Ethereum. Smart contracts are recorded on their platform to have some form of transparency, security, and no possibilities of bias, manipulation, and error [56, 57].

(d) Music Streaming

The digital world has revamped the music industry, and the implementation of streaming platforms has accelerated the speed of the value chain. However digital duplication, fake cloning, infringement of property rights of production companies is causing disruptions that causes losses in revenue production. A study found that blockchain-based media corporations enhance the effectiveness of rights, which offer an innovative platform to redeem attraction to the ecosystem [58]. One of the biggest issues throughout the music industry today is the inexistence of worldwide registry of creative music. As blockchain developing to be more mature, it facilitates the entities that are involved in making or engaging with music with a faster and more streamlined system. Blockchain can transform both the database as well as the network infrastructure, thus reduces the issue of intellectual property piracy, property rights dispute.

Blockchain is used by Spotify to unlock hardware limitations for music streaming. Besides, a study [59] investigated the impact of blockchain in the music industry and found that the uptime is also almost 100%, the transfer rate is the highest, data integrity is always confirmed, service availability is now for everyone, the storage size is almost unlimited, and all the limitations are enabled to achieve freedom transaction from a centralized authority. With the rise of blockchain, latency is decreasing significantly, uptime 100% is achievable and high transfer rate data and transaction is possible. Musicoin uses blockchain for streaming catalogs of music from independent musicians by tracking and saving analytics broadcast, with distribution to pay the artist in real-time. Blockchain allowing its distribution database to record digital information without enabling the modification mode toward its goal. Musicoin uses blockchain to power a decentralized peer-to-peer platform, hosting music available to everyone and transactions become transparent and secure.

(e) Humanity Welfare

Blockchain is useful to the UN for its world food program to refugee relief, a study [60] reported that blockchain application can expand outside of business and government use cases and be applied to the social realm of improving the lives of individuals. The blockchain laboratory posts that 15 UN agencies undertake the blockchain initiative. Several campaigns have chosen to use blockchain technology for various humanitarian disasters, especially to the crisis of refugees. For example, in a recent review [61], the blockchain initiative program aims at over 100,000 refugees in Jordan living with their own camp known as the Azraq refugee camp. Moreover, most assume that these refugee issues can be resolved by an approach to self-sovereign identity (SSI). This method seeks to assign control to individuals by enabling them to register their own identity data. This registration can be performed appropriately with blockchain [62], that SSI platform may also permit refugees that unable to acquire government identification to create a composite ID through multiple assertions.

(f) Gaming

A study [63] found that blockchain technology have a great impact on digital games, particularly people with really large multi-player scenarios. Additionally, over recent years the game industry has expanded rapidly, mainly because the computer game world has managed to keep up and is attempting to address the new technical advances [64]. However, traditional game technologies are implemented in enclosed loops, preventing external creation of another version and access for the core concept or use the current data (domain). A study [65] claimed that the most core concept and current data (domain) are managed by smart agreements, which may be extracted and replicated. Blockchain game domain is circulated between 'players' rather than controlled within a central server. Blockchain games either generate by using their own token or a current token [66]. Additionally, blockchain is used by CryptoKitties as digital collectible assets. Gamifying features like CryptoKitties leverage on blockchain's unique applications. A crypto collectible is a digital piece of non-fungible data that is specific to cryptography. Therefore, the overall tokens in circulation are the same when it comes to a regular cryptocurrency [67]. While CryptoKitties itself is not a digital currency, yet it does offer the same security. CryptoKitties is an online game built over the Ethereum platform where players buy images of cats with specific traits and 'breed' them to produce new cats that can have rare traits.

4.2 Results for RQ2

What classification of improvement is brought by blockchain technology in various industries? Some industries are hesitant in transforming their conventional transactions practice due limited blockchain knowledge and risks consideration. The classifications of blockchain features are explained as shown in Table 5.

Table 5 Classifications of blockchain features

Classification	Definition
Security	Every one of the blocks of information, for example block or hash (#), are secured and bound to one another by utilizing the cryptographic standards
Trust	Blockchain overcomes the issue of trust by eliminating human intervention from the equation
Traceability	The inviolability of blockchain gives traceability chain an even more convincing value
Efficiency	Efficiency concerns the level of performance of using blockchain, particularly how efficient blockchain application is in bitcoin if used based on time and energy. Fundamentally, blockchain reduces the number of wasted resources used to produce a given number of goods or services
Reliability	The hallmark of the blockchain system is reliability, which concerns how much the data are retrievable when there is still somehow connection that exists somewhere. Blockchain secures the data and allows us to access even if there is a problem occurring in network mesh

5 of the studies focus on the capability of blockchain security [68–72]. Besides 4 studies classification focusing the blockchain traceability in the supply chain [73–75] and its issue challenges along with solution [76, 77]. Besides, another 3 studies are discussing blockchain trust [78–80], and as well efficiency [81–84]. Another 2 studies are discussing reliability for blockchain [85, 86].

(a) Secure

Blockchain functions as a distributed database where all information is stored through each partition chain named "Hash" or "Node". Also, it is called a "Decentralized System" [4] where there is no central administration, no modification to existing data, and no deletion of data. The information can be retrieved by the user to display or show a record. In [87] interpret that there is no secrecy in the blockchain implementation, and it is called the "Open Ledger System". Unlike centralized systems, such as banks, the system is controlled by them that is certainly easy to manipulate. Therefore, it is extremely crucial to secure the documents on a safe platform by using Ethereum [88], which is proven to be secure yet to allow developers to develop decentralized applications and deploy them. Ethereum is an application that utilizes blockchain security, it has the capability to maintain and storing transaction, so the apps have no authority to steal data. There are some vulnerabilities in the existing Ethereum [55] with 8833 out of 19,366 and this may lead to losses. Besides, a study [89] highlighted that it promises a protected centralized platform to make things easier with all consumers and third parties to communicate, exchange, and sharing information.

(b) Trust

A study [90] reported that blockchain incorporates 'trustworthiness' through a distributed computer network that seeks to achieve a common set of goals, by eliminating third parties, reduce costs and generate more profit for various industries. Furthermore, trust in blockchain becomes a central factor and important to emerging technology [91], many researchers require thorough research to verify the heuristic relation in both trust feature and technological background. This relation significantly aligns the verification process data, allowing for cheap and fast deals. More importantly, blockchain has tremendous potential to confirm the transition without requiring any central authorities. It is suggested by concerning trust, industries need to create a confidentiality platform for participants by improving features standards [80]. In addition, the rise of blockchain technology allows for the creation of digitized, shared, and trackable sets of data. 'Trustworthiness' in blockchain transparent features enable the information sharing to publicly accessible through its network infrastructure and ensure the credibility of data sets transaction [92].

(c) Traceability

Monitoring and verifying the production chain is critical to take certainty on ensuring how sources of contamination throughout the entire supply chain are processed. The innovation of blockchain has numerous points of interest to solving

traceability issues. Blockchain is programmable, dependable, and provides constant real-time operations throughout its traceability feature. The aim of traceability in the blockchain is for user to respond as fast as conceivable in any situation [93], as well as curbing unethical activity; improved services of sustainable practices; increased operational efficiency; increased coordination of the supply chain; and sensed market growth. The traceability feature makes blockchain a quality certification for industry, by local server and central management communication technologies. In addition, a study [94] reported that powerhouse retailers in Walmart cases, which have worked with IBM Food Trust to implement blockchain technology for their food chains for safety provenance. Such provenance is crucial to be emphasized to provide consumers, suppliers, retailers, manufacturers, and with more transparency on their goods and regulators to achieve the increase of ability to meet the pressure of the new custom for key participants. Blockchains help make the process more transparent by confirming each step with a block entry.

(d) Efficiency

Blockchain technology has attracted the attention of industry leaders with the potential to improve the efficiency and transparency of existing systems, particularly in system transactions and management data [95]. As a result, numerous industries include the government sector and early adopters made efforts to acquire blockchain capability and they explored blockchain as one of the important qualities necessary to generate innovative business models and evolve services significantly [96]. Countries around the world are seen committing to blockchain technology deployment, especially for the banking industry. For instance, HSBC implements the third wave of blockchain called Corda [97]. In terms of utilization, HSBC uses international trade that involves Malaysia and the United States. Corda offers security and efficiency in transactions. For example, Corda reduces the time for consensus financial transactions with bulk shipment to Malaysia of soya beans. This process normally takes about 5–10 days to organize and complete with numerous paper records. Since it is paperless, blockchain application resolves the issue in less than 24 h. Paper reconciliation is no longer relevant because every party is linked to the platform together and updates are available instantly.

(f) Reliability

Blockchain is more reliable traditional centralized due to improvement in the areas of incentive and sanction strategies, the process of manufacturing technology, restoration of the consensus network, and data restoration. As blockchain continues to be trending, many parties start to invest in the ecosystem, which makes the incentive for blockchain platforms massive by its nature. This popularity occurs due to blockchain decentralized nodes [98], in which there is no way for the government to find and tax the money stored in the blockchain, which means the sanction of business could be helpful. Proofs of retrievability technology of the blockchain store the core files in fragments, which to ensure reliability after the record has been

Fig. 2 Distribution of blockchain features adopted by industries
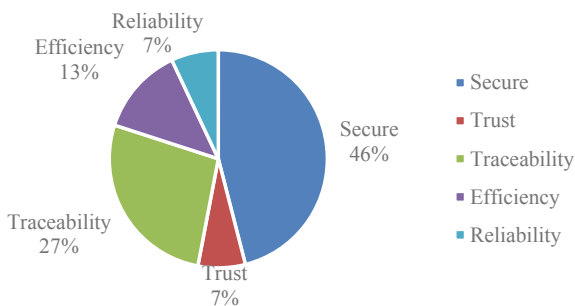
modified or added. As result, industries that rely on high reliability and security can attract more customers through the implementation of blockchain [10]. Indeed, blockchain technology is a distributed layer that prevents a single stage of malfunction situation.

In Fig. 2, it is shown that the highest percentage used in 12 industries in various contexts is "secure" with a total of 7 over 12 of 46%. AB InBev, Accenture, APL, and Kuehne + Nagel, Accredible, Spotify, North, and South Korea-international documents, Musicoin, CryptoKitties-visual arts, ANZ. and Westpac-commercial property are part of the industries that adopt blockchain due to the nature of transparency, payment bills, while transparency in document storage creating convenience for users to control their energy consumption. Besides, "traceability" is the second classification after "secure" with a total of 4 over 12 by having 27%. Industries such as Walmart, DNV GL, MyStory, AB InBev, Accenture, APL and Kuehne + Nagel and ANZ and Westpac use the supply chain platform to consolidate their statistics on the timeliness and quality of transactions provided to other participants of the chain. In addition, "efficiency" takes a total of 2 over 12 with 13%. HSBC in the banking sector and UN World Food Programme in Food and Agriculture Organization use blockchain to achieve efficient and accurate operations in a secured environment that enables them to deliver meaningful results in a safe and risk-free environment. Furthermore, "trust" and "reliability" classifications take a total of 1 over 12 with a percentage of 7%. Twiga Foods implement blockchain in terms of "trust" classification by helping reduce fraud as no party can add blockchain without the approval of the entire network that can be implemented in real-time. In a "reliability" classification, dredible-digital educational certificates ensure that the information is reliable and assures the representation of credentials with a record of qualitatively cryptographic credentials.

4.3 Results for RQ3

What are the recent trends of blockchain utilization in various industries?
Based on the results for RQ1 and RQ2, valuable insights of use cases and classification have been identified. The insights help in establishing the annual trends of
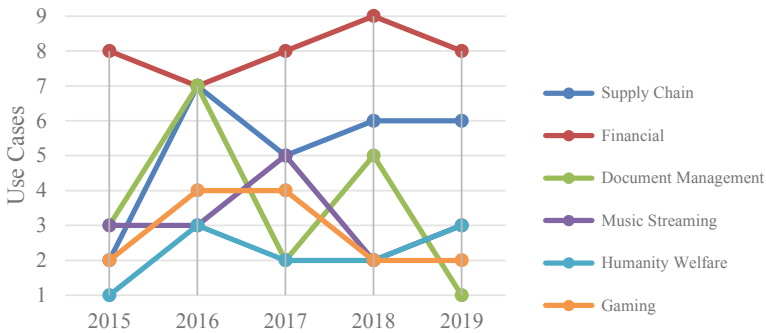
Fig. 3 Recent trends of blockchain use cases in industrial sectors

blockchain utilize in the industrial sector. Answering RQ3 supports other researchers and experts to concentrate further investigation in which such research is expected. Also, defining the current trends as shown in Fig. 3 allows us to understand the blockchain adoption evolution over the years.

We examined the research paper extracted from the data collection process to determine the emerging trends in blockchain advances. Four studies were found that support our analysis of blockchain use cases and feature classifications towards innovation [99–102]. In addition, all these research activities are becoming increasingly relevant in the current era of digitalization.

Figure 3 illustrates the trends of blockchain use cases, this use cases trend is in the form of graphs where it illustrates the percentage frequency adopted in the industrial sector. Within the year range, unstable agreement or encouragement can be observed for each use case in terms of percentage followed by the year. The most discussed and usage use cases in the review paper are financial with 80%, wherein a study [103] clarify that financial technology is offering a comprehensive range of services as such fees, exchange of local and foreign currency via P2P, investments, and fundraising. The lowest use cases in 2015 are humanity welfare, and this comes into an issue when a study [104] found that the cause is because of the coercion challenges that the problem regarding socioeconomic political systems is not being solved by the blockchain-based government. The changes in supply chain apparent spike can be seen rapidly increasing from 2015 to 2016, there's been a proof when a study [105] found that a developed series of logistics, methodologies, and principles to identify the supply chain with differ businesses strategy. Besides, a surge of increase in music streaming shows a change of percentage since for 2 years it just remains constant, where this investigation highlights [30] findings for the block-chain enhances the patterns to address and obtaining the music producer easier. In the year 2018, the use cases of gaming decreases, and the same goes to the remaining percentage in 2015 in constant horizontal from 2016 to 2017. In 2019 only human welfare use cases increase significantly, while documentation man-agement is decreasing slightly as well financial, and the others remain constant as such gaming and supply chain. We can determine that the blockchain use cases

could be continued to expand by evolving the momentum platform of blockchain, new developments build an innovation industrial strategies and solution conventional blockchain-based networks.

Figure 4 illustrates the improvement that the blockchain brings that can be classified into 5 main categories: *security, trust, traceability, efficiency*, and *reliability*. The information in the graph is based on the 50 selected review papers, where a discussion of the author is reviewed to capture a frequent usage of blockchain classification. The highest classification discussed in 2015 is *trust* with 9 studies. One study [106] found that e-commerce websites are explicitly associated mostly with malicious third parties that control any purchases in the websites. Besides, the lowest classification in 2015 is traceability. A study [107] discovered that *traceability* of operations has become an important issue with the electronic currency world, this is why a domain controller with any payment method is formally instructed to increase exponentially in difficulty attack. In the year 2016, *trust,* and *security* increases usage in industry application. Blockchain technology is expected to revolutionize the industry via driving international trade transformation in the upcoming years [108]. There are decrease for most of the classification in 2017 excluding the classification of *efficiency* remain constant since 2016. Although, in 2018 all the 5 classifications increase slightly especially for the *reliability* feature. In the year 2018, and as reported by a study [109], reliable data becomes a tool required to maintain management plan as well as to establish a potential resource distribution management, industries thereby focus on building and upgrade the existing data system that ensures secure access controls. In 2019, only the *efficiency* decreases significantly, yet we can conclude that the trends show an improvement for the industrial sector because there is no significant fall in late 2018 and 2019. Blockchain research derives from multiple subject areas, which including science, businesses, and information system procedures for blockchain applications. Therefore, research and innovation started to focus on the solution for the biggest security threats in global, which include major potential threats that involve anonymous attackers who manipulated most of the network as such scam, denial-of-service attack, phishing. Initially, blockchain study started on industrial problems, thus more fields are expected to be associated as an effect of blockchain would reach improvement for the industrial, economic, and government.
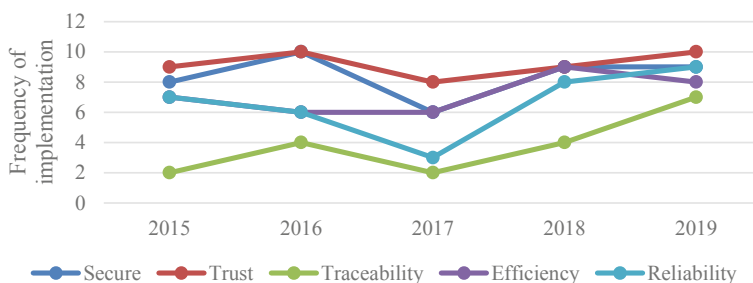

Fig. 4 Recent trends of implemented blockchain features in industrial sectors

5 Discussions

This section discusses the results and findings obtained from the review based on the formulated research questions. The discussions on each research question are presented as follows.

5.1 Overview of Blockchain Use Cases

In a total of 12 industries that this review observed, these industries adopted blockchain as the reliable mechanism for storing and processing their records securely. The aspect of trust seems to get attention significantly at the most outstanding factor throughout all use cases. A considerable part of the research of blockchain in industry emphasizes matters of privacy and security as well. In the use cases reviewed, blockchain is hugely useful for a transaction in various industries because of its competitiveness to numerous relations of stakeholders, customers, vendors, investors, and third parties. Such relations have significantly improved business processes, financial services, quality of service processes, expand the capability of overall use cases mentioned, and the reliability of data between businesses, services, and data exchange. Based on findings for RQ1, we learn that blockchain is not limited to improving processes in industries but also in the public sectors. Public sectors can leverage blockchain as a medium for social interaction exchange in improving the lives of citizens in the country.

5.2 Classifications of Blockchain Features

Based on the review results, five classifications of blockchain features are identified: security, trust, traceability, efficiency, and reliability. With this brief description, we also present issues and solutions to various industries as an understanding of blockchain's ability to overcome constraints. Therefore, we show that blockchain technology is not limited to any industry that wants to implement cryptocurrency into its systems. Instead, the ledger concept is distributed but not decentralized with trust and security features in the systems that can be customized with so many other techniques in the current business or industry sector. In addition, we have identified that 'security' is one of the key classifications for industry improvement. We also discovered that the industry adopts blockchain because the technology behind it promises secure transactions, where the industry processes a huge amount of data with the intention of implementing transparent storage through private transactions. This type of classification is expected to increase significantly, and it also remains to be a concern for various sectors in the long term because privacy and security are key aspects of establishing a decentralized transaction relationship with the industry.

5.3 *Summarization of Blockchain Implementation Trends*

Our findings on RQ3 indicates the blockchain capabilities in addressing industry issues with several interesting trends emerging. Our discussion shows that blockchain technology plays an important part in a growing industry by ensuring that its classification is maintained between use cases, and as well in future integration of newer implementation technologies such as cloud computing and IoT. The use of blockchain changes the performance of traditional data processes across various industries, also for the use of governments and other industries that have not yet used blockchain. At the same time, blockchain can be used by governments to improve efficiency in administration, as there are still public services that hesitate to adopt blockchain. With all the key classifications, the industry has recognized its strengths in using blockchain, this is due to many beneficial classifications adopted and more solutions to issues. Although blockchain has become more implemented, not all sectors use blockchain especially to the government when it does not improve the whole process because there are still shortcomings in terms of regulation. Nevertheless, there are several nations that are still amid integrating blockchain technology, while developed nations have consistently implemented blockchain into their operations and conducted high-level research.

6 Conclusions

Evidently, blockchain is a revolutionary technology that significantly transform the processes or approaches of many industries with innovative security features. In this paper, we provided the insights on significant blockchain advances and usage within information systems of many industries. Recent blockchain advances were analyzed to elicit notable applications, classifications, and emerging trends in blockchain technology. The presented classifications and characterizations of blockchain technology offer future researchers with fundamental comprehension to further support their investigation.

Our findings indicate that blockchain is becoming mainstream with various applications including securing supply chains, document management, entertainments, and public services. We learn that many notable enterprises have solidified the integration of blockchain unto their information systems or infrastructures. The concerns of privacy and security remain to be the utmost important aspects in integrating the blockchain in their systems. Based on the review, blockchain application features are classified into five categories based on their objectives: security, trust, traceability, efficiency, and reliability. Reinforcing security is the most sought-after feature in most of the blockchain applications and use cases presented in this review. Security is expected to remain the most important feature of blockchain integration, especially for future decentralized transactions. Our results presented broad applications of blockchain technology across many industry

domains, indicating growing interest and demand for blockchain integration. Despite the observed mainstream integration of blockchain, we found that the public sector has yet to fully leverage this technology. We infer that integrating blockchain into the public sector's existing systems or infrastructure also raises concern on policies and regulations.

Based on the findings, many new features are expected in future blockchain applications and innovations especially its adaptation in the public sectors. The existing works evidently emphasized the persistent transparency and conflict of interest issues in many public record transactions. Future studies can investigate the public's perception and acceptance of blockchain integration in public service information systems and infrastructures. The classifications of innovations brought by blockchain applications discussed in this paper are based on reported works in recent years. However, the advances of blockchain applications in the industry are realistically expeditious compared to reported works in literature. Therefore, future reviews can gather information from external sources like corporate reports, media, whitepapers, and patents to complement their findings. In addition, the presented discussions on use cases in this paper are based on notable blockchain applications recently reported in academic literature. Future studies can further enrich the blockchain use case discussions by gathering additional insights from industry experts via collaboration.

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