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# An integrated framework to prioritize blockchain-based supply chain success factors



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## Abstract

**Purpose** – The purpose of this study is to identify and prioritize the factors that can positively influence the implementation of a blockchain-based supply chain via an integrated framework. To the best of the authors' knowledge, no previous study has focused on prioritizing these factors.

**Design/methodology/approach** – First, this study conducts a multivocal literature review, and a total of 48 success factors (SFs) are identified and mapped into 11 categories. Second, the identified success factors and their categories are further validated by industry practitioners using a questionnaire survey approach. Finally, this study applies an analytical hierarchy process to prioritize the identified SFs and their categories and to assess their importance for successful blockchain implementation in the supply chain management process.

**Findings** – The "Accessibility" category has the highest importance, and the "Overall efficiency" category has the second highest rank. As far as the success factors are concerned, "Trackability" and "Traceability" are considered to be the prime success factors of a blockchain-based supply chain. The taxonomy of the categories and their success factors provide an outline for supply chain organizations to establish a strategy to implement blockchain technology.

**Practical implications** – This technology can be practically applied in a sustainable supply chain. Another vital application of this blockchain technology is in banking and finance because of the blockchain's immutable data recording property.

**Originality/value** – To the best of the authors' knowledge, there is no previous study focused on building a taxonomic model that allows supply chain organizations to compare this paper's model with existing models and outline the necessary actions to improve supply chain activities. The questionnaire-based survey developed to validate the success factors in real-world practices and the factors' prioritization can help academic researchers and industrial practitioners to set their strategic goals accordingly.

**Keywords** Blockchain, Supply chain management, Success factors, Analytic hierarchy process

**Paper type** Research paper

## 1. Introduction

A supply chain is a channel for the delivery of products, and services start with suppliers, manufacturers, distributors, retailers and ultimately conclude with end-users. Blockchain

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technology provides the best solution; makes a supply chain secure, transparent and distributed; and improves the process quality (Saberi *et al.*, 2019). In a supply chain network, it is challenging to manage harmful factors and obtain authentic information because of globalization, natural causes, human behaviour and the reputation policies of a firm (Ivanov *et al.*, 2019). The word blockchain was first used by Nakamoto (2008) to refer to the shared ledger of the bitcoin cryptocurrency. Today, blockchain provides a whole new approach to decentralize information and achieve stability (Clohessy and Acton, 2019). Companies incorporating new ideas and methods will experience more advantages related to transparency (Ward, 2017) to build customer trust, and this increases their sales. In a supply chain, the main issues are related to the system and organization. Reducing risk in a supply chain is an important objective (Kshetri, 2018). In the past couple of years, transparency has become an issue for industrial supply chains. Customers are suffering from food safety scandals including toxic milk powder, trench oil (Jing *et al.*, 2012), pharmaceutical products (Benedetti *et al.*, 2014), artificially grown food (Aung and Chang, 2014), agricultural products (Costa *et al.*, 2013) and luxury products (Bandelj *et al.*, 2017).

Transparency in a supply chain not only improves customers' trust but also provides quality-related feedback that helps firms take better initiative to improve their sales (Yiannas, 2018). Where products are manufactured, processed and by which route they are delivered must be known (Abeyratne and Monfared, 2016). Transparency also helps food outlets, restaurants and cafeteria owners to know when their products are arriving, and customers will benefit from fresh products at lower prices (Kharif, 2016). In addition, retailers and distributors must have space in their locations for the arrival of a new shipment. Transitions in a blockchain occur without involving trust because of its immutability property, so a trustless environment is created (Swan, 2015). In addition, the security of high-value products is also a challenge for supply chains. It is difficult for customers to verify the value of luxury items (Saberi *et al.*, 2019). Sometimes, forms providing proof/certifications are lost, so the product value may be lost or changed. The objective of blockchain technology is to verify a transaction, make a record of all the data and conduct peer-to-peer transfers without third-party involvement (Chang Shuchih *et al.*, 2019). Another main problem in a sustainable supply chain is to validate and verify the product manufacturing process and its phases so they will meet the stability standard of a supply chain (Grimm *et al.*, 2016). The characteristics of a blockchain are the establishment of a peer-to-peer network, advanced new agreements known as smart contracts between two partners and the construction of a distributed network (Pattison, 2017). Blockchain is still in its development phase, so there are still some difficulties related to its development, technological aspects and organizational policies (Lemieux, 2016). This study aims to answer four research questions.

(1) What are the factors that can positively influence a supply chain while adopting blockchain technology as identified in the literature?

(2) What are the key factors of the blockchain-based supply chain in real-world practice?

(3) What is the taxonomy of the success factors that help in implementing blockchain technology in a supply chain?

(4) How should the identified success factors be prioritized?

Blockchain technology is still in its early phase, so limited literature is available on it. Hence, the research objectives of this study are the following.

(1) To identify the success factors of a blockchain-based supply chain via a multivocal literature review (MLR), associated with the successful supply chain using blockchain technology.

(2) To map the identified success factors to their related categories, which provide in-depth knowledge for supply chain industrial practitioners and academic researchers to manage projects in a blockchain-based supply chain.

(3) To validate the identified success factors chosen from the MLR in the real world by conducting a survey to determine whether these factors hold in the real world.

(4) To prioritize and build a taxonomy of these factors.

Our primary focus is to determine and prioritize the identified success factors via a literature review. This research uses an integrated framework approach to prioritize the success factors of a blockchain-based supply chain. The analytic hierarchy process method was applied as a tool to resolve managerial and technical issues (Sato *et al.*, 2020).

The rest of this paper is organized as follows: Section 2 provides a definition of a blockchain-based supply chain. Section 3 describes the detailed research methodology. Section 4 discusses the results and research questions seeking to achieve the objectives of this paper. Section 5 provides the theoretical and practical implications. The final section presents the conclusion and future work.

## 2. Blockchain-based supply chain

A blockchain is a chronological chain of blocks, where each block has complete information of all activities done inside the network, that are linked together to make a distributed ledger (Bogart and Rice, 2015).

For transferring transactions, blockchain is ranked first due to being an Internet protocol that does not need help from a third party (Tapscott and Tapscott, 2017), which saves time and money since it does not need to pay a third-party, such as banks, to transfer transactions. Blockchain provides the best solution for tracing the origin of medicine and assessing the authenticity of pharmaceutical companies (Mackey and Nayyar, 2017).

Using a blockchain with other integrated applications can make a supply chain more sustainable than before (Huo *et al.*, 2019). For a supply chain to be sustainable, the product must be delivered at the right time, in excellent condition and at a low cost (Flint, 2004). Blockchain provides sustainability to an environmental supply chain since it can track and control the system to stop the recall of products, which reduces the consumption of carbon dioxide and saves energy and costs (Saberi *et al.*, 2019). Blockchain also increases the efficiency of the supply chain by monitoring products, decreasing waste and reducing food contamination, thus decreasing operational costs (Kharif, 2016). It eliminates the need for double verification and saves labour/administration and physical costs (Field, 2017). Efficiency plays an essential role in a supply chain. Trading activities, digital documentation and high-speed data flow make supply chains more efficient (Barnard, 2017). Last-mile delivery is also a large issue in supply chains, as it decreases the efficiency of the supply chain. Over the last couple of years, production firms have also started implementing blockchain-based supply chain networks to gain more sustainability (Korpela *et al.*, 2017). Blockchain can also provide quality fairness (Grover and Malhotra, 2003), durability (Abeyratne and Monfared, 2016), longevity (Bogart and Rice, 2015) and scalability (Scherer, 2017); reduce costs (Jiang *et al.*, 2020); streamline processes; and solve the double-spending problem (Saberi *et al.*, 2019). As far as the adoption/implementation of blockchain technology is concerned, IBM and Walmart are able to trace products by using their blockchain network (Carter and Koh, 2018) and trace approximately 1.1 million products from their origin to end-users, especially for fresh food items (Mims, 2018). In May 2017, Walmart stated that the tracking time for food was reduced from days to minutes (Yiannas, 2018), and despite it taking many weeks to deliver food, it takes “2.2 s to trace a region for the food” (Kamath, 2018).

Maersk and IBM have developed a system for managing containers based on the blockchain protocol, and the method has saved billions of dollars.

## 3. Research methodology

The identification and prioritization of success factors is the main objective for a blockchain-based supply chain. These factors will be helpful for academic researchers and industrial practitioners to understand and investigate supply chain activities using blockchain technology. The search methodology involves three main steps: Step 1 is the "Identification and categorization of success factors from MLR"; Step 2 is the "Empirical evaluation of the success factors and their categories"; and Step 3 is the "Application of AHP".

### *3.1 Multivocal literature review*

Literature review plays an essential role in identifying success factors (Wang *et al.*, 2019b). As mentioned in Section 2, there is limited literature on blockchain technology. A systematic literature review (SLR) has excellent value in collecting useful information from the published primary studies (formal literature) (Ghadimi *et al.*, 2019). In addition, there is grey literature (Butijn *et al.*, 2019) produced by industrial practitioners, the government and the private sector in which publication is not the primary concern. Chen *et al.* (2010) mentioned that the grey literature interprets the pure industry practices. A systematic literature review only includes academic articles, and an MLR includes academic papers along with grey literature (Garousi *et al.*, 2019), such as white papers, blogs, books, magazines, website links, videos and technical and annual reports. Because of its high capacity to obtain information, MLRs are frequently used in education research (Patton, 1991; Ogawa and Malen, 1991), health sciences (Alberani *et al.*, 1990; Saleh *et al.*, 2014) and management (Adams *et al.*, 2017). Garousi *et al.* (2019) provided the three main steps of an MLR: "planning the review", "conducting the review", and "reporting the review". The steps followed to conduct this MLR study are described and discussed in Figure 1.

Step 1: Planning the review

The literature data were collected from digital libraries and search engines following the method suggested by Khan *et al.* (2011). Table 1 shows the search sources and searched items for the academic and grey literature.

A search string plays a vital role in data collection. Well-defined key terms from research questions and their alternatives used for making search strings are important (Wang *et al.*, 2020; Butijn *et al.*, 2019). Alternatives to search strings and their synonyms were developed based on the published articles related to blockchains and supply chains. Boolean operations (OR and AND) were used to make the following search strings (Akbar *et al.*, 2019): ("Factors" OR "Aspects" OR "Items" OR "Elements" OR "Characteristics" OR "Motivators" OR "Variables") AND ("Blockchain" OR "Blockchains" OR "Distributed" OR "Decentralized") AND ("Ledger" OR "Technology" OR "Database") AND ("Implementation" OR "Execution" OR "Adoption") AND ("Supply chain" OR "Supply chain Management" OR "Logistics").

The inclusion criteria were used to find which type of literature (grey and formal) helps gather data using the search strings. Butijn *et al.* (2019) and Khan *et al.* (2011) highlighted some key concepts related to the development of inclusion criteria for the blockchain and the search strings that were applied in the digital libraries to search the formal publications. In contrast, for the grey literature, the search strings were applied in search engines, and the data were extracted from annual reports, blogs, magazines, technical reports, white pages and so forth.

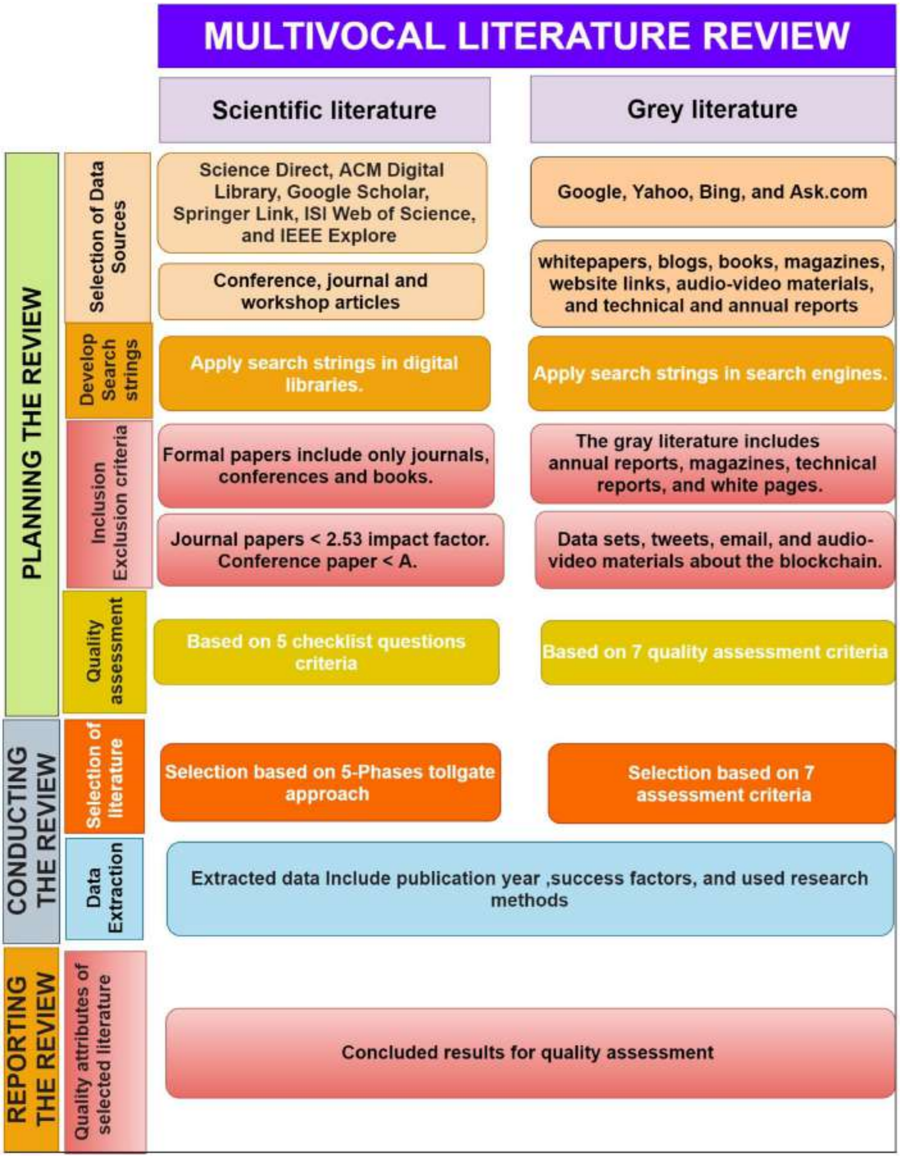


**Figure 1.**
Steps for a multivocal literature review

We checked the quality assessment of both literature types (grey and formal) to validate our sources and to reduce researcher bias (Niazi *et al.*, 2016; Butijn *et al.*, 2019). We performed an inter-rater reliability test (Wang *et al.*, 2019a) in which we calculated Kendall's coefficient of concordance (W). The value of Kendall's coefficient of concordance (W) varies from 0 to 1. A value of 0 indicates strongly disagree, and 1 indicates strongly agree (Akbar *et al.*, 2019).

In formal publications, quality assessment was checked based on five checklist questions (Afzal *et al.*, 2009; Akbar *et al.*, 2019). Table 2 describes the five checklist questions.

| Literature type | Search sources | Searched items |
|---|---|---|
| Academic literature (pre-reviewed published papers) | Science Direct<br>ACM Digital Library<br>Google Scholar<br>Springer Link<br>ISI Web of Science<br>IEEE Explore | Conference, journal and workshop articles |
| Grey literature | Google<br>Yahoo<br>Bing<br>Ask.com | White papers, blogs, books, magazines, website links, audio-video materials and technical and annual reports |

**Table 1.**
Data search sources

| QA questions | Checklist questions |
|---|---|
| Q1 | Are the research questions adequately described by the research methods? |
| Q2 | Does the literature report the success factors of BC? |
| Q3 | Does the literature discuss the background and applications of BC? |
| Q4 | Are the gathered data associated with BC in SCM? |
| Q5 | Are the research questions justified by our research methods? |

**Table 2.**
Selected QA criteria for formal literature

Compared to systematic literature, it is more challenging to check the quality of grey literature because the publication processes of grey literature (e.g. articles, blogs and videos) vary, and this study does not conduct a precise review. Garousi *et al.* (2019) and Butijn *et al.* (2019) suggested seven quality assessment criteria. These categories are briefly discussed in Table 3.

Step 2: Conducting the review

Afzal *et al.* (2009) suggested a five-phase protocol, known as the tollgate approach, to filter the formal studies. By using this approach, he selected 24 out of approximately 500 publications. The phases of the tollgate approach are given below.

(1) Phase 1: "Search using search terms".

(2) Phase 2: "Exclusion based on title and abstract".

| Category | Assessment criteria |
|---|---|
| Publisher authority | Publishers must have deep awareness about blockchains, and the organization must be trustworthy |
| Study objectivity | The objectives and conclusion of the report must be mentioned |
| Methodology | The document must contain goals, methodology, references, limits and specific questions |
| Date | Mentioned date |
| Position related sources | Must contain linked sources |
| Innovation | Adds something unique to the research, adds a sharp point or discusses weaknesses |
| Impact | Has citations and backlinks to support its statements |

**Table 3.**
Quality assessment criteria for grey literature

(3) Phase 3: "Exclusion based on introduction and conclusions".

(4) Phase 4: "Exclusion based on full text".

(5) Phase 5: "Final selection of primary studies".

Using the search string, 748 articles were selected from the mentioned data sources based on the inclusion and exclusion criteria. We invited three external reviewers to participate. We gave them random papers to select the research papers that satisfy phase 1 of the tollgate approach (search using search terms) and continue this process until finishing phase 5. Table 4 shows that in total, 29 publications were selected after applying the 5 phases of the tollgate approach to 748 publications, which is approximately 3.8% of the total publications. Figure 2(a) shows the complete phases of the final selected study using the tollgate approach.

Next, we applied the search strings in search engines and selected 80 grey literature papers based on the inclusion and exclusion criteria, which is quite less than that for formal

| Electronic databases | Phase 1 | Phase 2 | Phase 3 | Phase 4 | Phase 5 | Final selection (%) |
|---|---|---|---|---|---|---|
| ACM Digital Library | 108 | 65 | 29 | 14 | 6 | 21 |
| Science Direct | 165 | 64 | 20 | 10 | 5 | 17 |
| Springer Link | 153 | 82 | 25 | 14 | 6 | 21 |
| IEEE Xplore | 140 | 85 | 40 | 10 | 4 | 14 |
| Google Scholar | 85 | 60 | 18 | 4 | 3 | 10 |
| ISI Web of Science | 97 | 48 | 15 | 10 | 5 | 17 |
| Total | 748 | 404 | 147 | 62 | 29 | 100 |

**Table 4.** Tollgate approach

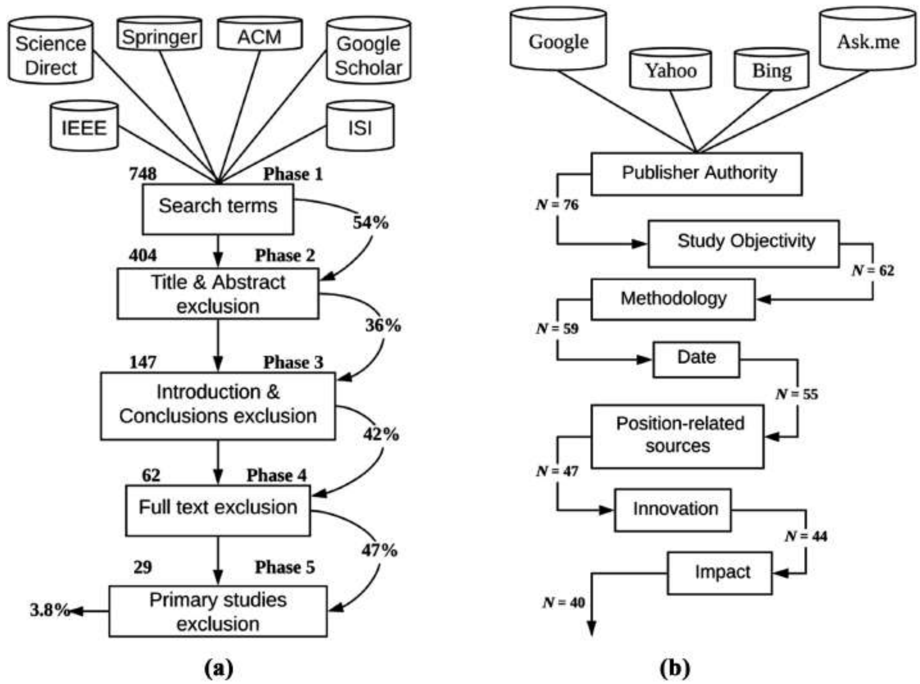


**Figure 2.** (a) Final selected studies using the tollgate approach, and (b) final selected studies using the grey literature assessment criteria

publications. Three external reviewers were involved in evaluating these 80 articles based on the grey literature assessment criteria. First, we checked all articles using the first assessment criteria (publisher authority) and selected $N = 76$, where $N$ is the number of grey literature papers, and we continued with the same step for the next 6 criteria. In the end, we were left with $N = 40$. Figure 2(b) describes the complete steps of the final selected studies using the grey literature assessment criteria.

After data extraction and synthesis and applying search strings to the data search sources, we finally have $N = 69$ (29 formal publications + 40 grey data). To answer the research questions, the following data have been extracted from this study.

(1) "Publication year";

(2) "Research methods";

(3) "Success factors".

These are the factors that positively influence the adoption of a blockchain-based supply chain. From the 69 studies, we classify these factors and reference them accordingly. Since our main objective is to find the success factors of a blockchain-based supply chain, these factors are identified, and the research questions are answered accordingly.

Both authors and three external reviewers participated in the quality assessment. After the selection of 69 studies, two authors were continually involved in performing the quality assessment process. Three external reviewers casually selected 10 articles from both types of literature and performed an inter-rater reliability test for these studies by evaluating Kendall's coefficient of concordance (W). Kendall's coefficient of concordance (W) for the 10 articles was calculated as 0.83 for the formal literature and 0.74 for the grey literature, which indicate that there is no divergence/disagreement between the authors and external reviewers.

Step 3: Reporting the reviews

The authors and external reviewers evaluated the quality assessment scores for both kinds of literature, and 40% was considered to be the beginning value for the formal literature (Afzal *et al.*, 2009). Overall, scores of 89% and 75% were calculated for the formal and grey literature, respectively, which is very high. These numbers prove that there is firm agreement between the authors and independent researchers. From the given results, we conclude that this selected research study is appropriate to evaluate the research questions.

The selected literature was published from 2000 to 2019. Figure 3(a) illustrates the distribution of the formal literature on blockchains, supply chains and both, along with several publications per year. It is clear that there were few publications on blockchains before 2015, except Nakamoto (2008). The number of published articles on blockchains in 2017 was twice the number of articles published before 2017 (Butijn *et al.*, 2019).

The publication period is further divided into two subgroups since there are not many publications on supply chains and blockchains before 2015. We divide the whole interval into two periods: 2000–2015 and 2015–2019. In the years 2016–2017, IBM and Walmart used a blockchain to establish their supply chain activities, so several more publications (case studies) exist in those years compared to before those years (Kshetri, 2018).

Figure 3(b) shows the research methods adopted in the 29 selected formal publications. Approximately 41% of the publications conduct case studies, 4% conduct questionnaire surveys, 10% conduct content analysis, 21% conduct action research and 24% use mixed methods.

The results in Figure 3(c) show that 67% of the research in 2016 used case studies, 62% in 2017 used case studies and only 33% used case studies in 2018. In 2018, there were diverse

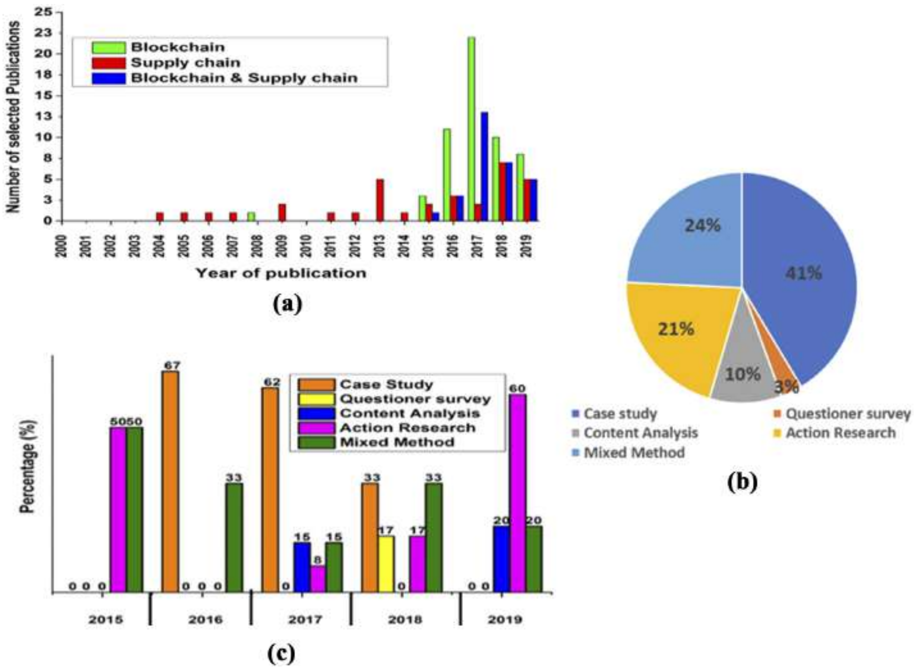


**Figure 3.**
(a) Sample selection result, (b) research method adopted in the selected publication and (c) temporal distribution of selected articles

types of research, including 33% of the research conducting a case study, 17% of the research conducting a questionnaire survey, 17% of the research conducting action research and 33% of the research using mixed methods. In 2017, 8% of the publications adopted action research, and this number increased to 17% in 2018. In 2019, the percentage is 60%, which shows that, currently, researchers have shifted their focus from case studies and mixed methods to action research. The majority of the publications in 2019 apply action research methods since researchers want to implement blockchain-based supply chains.

*3.2 Validation of investigated success factors and their categories*

Based on the research questions and identified success factors, we developed an online survey questionnaire using Google forms (Appendix A1). Participants were asked to answer questions using a five-point scale including "strongly agree, agree, neutral, disagree, and strongly disagree" (Singh, 2013).

A pilot study involved the research team of Chongqing University, including three persons having industrial experience (manufacturing, distribution and warehousing). A pilot study mainly collects suggestions and comments from the research team based on the final drafts created. Participants are assured that their survey data will remain anonymous and that data will be used only for research purposes.

The selection of participants plays an essential role in the authenticity of data. As far as supply chains are concerned, our participants were from different fields as follows: education and research, manufacturing, sellers, distributors, retailers and warehouse management. They have sufficient knowledge on sustainable supply chains integrated with current software technologies for the efficient distribution of goods and services. To distribute the online survey questionnaire, we used social media, that is, Facebook and LinkedIn. In addition, we invited researchers and different supply chain industrial actors by sending personal emails and messages through WhatsApp and WeChat. The data collection process continued for three months. Within this time interval, in total, 76 respondents responded to the survey, and 12 of those 76 responses were incomplete or seemed not to be serious; therefore, those 12 responses were removed. The remaining 64 responses were considered and analyzed later on.

### *3 3 Application of analytical hierarchy process*

Applying AHP was the final process to prioritize and categorize the success factors in order to check their importance. Eigenvalues were used to assess the consistency. Yao *et al.* (2009) described a comparison of two factors, $x_p$ and $x_q$, which are compared based on the importance of factors.

$$a_{pq} = \frac{x_p}{x_q} \tag{1}$$

$$A = (a_{pq})n \times n \tag{2}$$

$$a_{pq} = \frac{1}{a_{qp}},\ a_{pq} > 1,\ a_{pp} = 1$$

Finally, matrix $A$ will be

$$A = \begin{pmatrix} 1 & a_{12} & a_{1n} \\ a_{21} & 1 & a_{2n} \\ a_{n1} & a_{n2} & 1 \end{pmatrix} \tag{3}$$

The standard matrix is formed by dividing each entity of the pairwise comparison matrix (denoted by $M1$) by the column sum value. The average value of the rows in the normalized matrix gives the value of the priority vector (priority weight) and is denoted by $W1$.

$$M2 = M1 \times W1 \tag{4}$$

$$M3 = \frac{M2}{W1} \tag{5}$$

$$\text{Consistency index } (CI) : \frac{(\lambda_{\max} - n)}{(n-1)} \tag{6}$$

$$\text{Consistency ratio } (CR) : \frac{CI}{RCI} \tag{7}$$

$n$: Evaluation factor of matrix $A$.

$\lambda_{\max}$ = Average of matrix $M3$.

$RCI$: Random consistency index

**Table 5.** Random consistency index

| Size of matrix | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *RCI* | 0 | 0 | 0.58 | 0.9 | 1.12 | 1.24 | 1.32 | 1.41 | 1.45 | 1.49 | 1.52 |

## 4. Results and discussion

### 4.1 Identified success factors during MLR

Following the MLR process in Section 3.1, the success factors are identified and given in Table 6. Each factor is given a specific serial number and reference mentioned in the column.

Singh (2013) suggested a model in which he categorized the factors of a coordinated supply chain into five main categories: "top management support", "mutual understanding", "relationship and decision making", "flow of information" and "organizational factors". Along the same lines, Faisal (2009) and Moktadir *et al.* (2018) also categorized the "risks in supply chains" and "pharmaceutical supply chain" into four main categories, respectively. We used the same model to build a taxonomy of the success factors. Based on their concerned domain, these factors are further divided into sublevels. Other categories are mentioned in Figure 4.

### 4.2 Empirical investigation

The identified success factors in Section 4.1 are further investigated by conducting an online survey questionnaire. The surveys were conducted to analyze the effects of using a blockchain in supply chain activities according to the respondents. The data were collected from 22 countries, as mentioned in Figure 5(a). Overall, Figure 5(b) shows that most respondents have 3–7 years of experience and that few participants have 20+ years of supply chain experience.

Participants were further analyzed based on the size of their organization. Figure 5(c) depicts that approximately 28% of our respondents are from small organizations, 34% are from large organizations and 38% are from medium-sized organizations. We also analyze the survey data based on the functional area of the organization. Figure 5(d) reveals that 33% of the respondents are from education and research, 25% are from operations, 10% are from distribution, 8% are from manufacturing and 24% are from other areas. Regarding the adoption of the blockchain technology in the supply chain, the pie chart illustrates that 16% of responding organizations are using blockchain technology to share information and transactions, approx. 50% are still using the traditional supply chain system and 34% are not sure about their organization's adoption of blockchain technology.

### 4.3 Survey responses

After completing the survey, we checked the responses for each identified success factor and their categories. The participants are divided into three main categories. The first category is the favourable category, and the second category includes the negative (strongly disagree and disagree) responses. The third and last category includes the neutral respondents; these participants were not sure whether these factors play an essential role in making a supply chain sustainable. The data of the survey respondents are given in Appendix A2. The questionnaire survey results with these three categories are given in Table 7. The results show a clear-cut picture of all three categories mentioned above. Within the favourable category, all the success factors have a percentage higher than 70%, except for one factor, "Feedback" at 64%, which shows that most respondents believe that these are critical success factors for a sustainable blockchain-based supply chain.

All the factors related to the core properties of a blockchain mainly score greater than 70%, which indicates that a blockchain provides transparency, security, immutability and transactions without using a third party (Saberi *et al.*, 2019; Abeyratne and Monfared, 2016; Tian, 2017). Regarding the positive categories, (SF4) "Security" 86%, (SF30) "Administration cost reduction" 84%, (SF25) "Traceability" 88% and (SF41) "Accounting" 88% received the highest scores.

| S.No | Success factors | References |
|---|---|---|
| SF1 | Transparency | Abeyratne and Monfared (2016), Ward (2017), Swan (2015), p. 1, p. 2, p. 27 |
| SF2 | Trustless environment | Baker and Steiner (2015), Tian (2016), Saberi *et al.* (2019), Iansiti and Lakhani (2017), p. 3, p. 4 |
| SF3 | Disintermediation | Peters and Panayi (2016), Futurethinkers (2017), Mougayar (2016), Swan (2015), p. 5, p. 6, p. 1 |
| SF4 | Security | Tian (2016), Abeyratne and Monfared (2016), p. 7, p. 8, p. 9 |
| SF5 | Durability and attack resistance | Tian (2017), p. 1 |
| SF6 | Immutability and encryption | Baker and Steiner (2015), p. 8, p. 9, p. 10 |
| SF7 | Developing just-in-time | Pilkington (2016), Hofmann *et al.* (2018), Ward (2017), p. 3 |
| SF8 | Feedback | Gereffi *et al.* (2005), p. 3 |
| SF9 | Customer centricity | Francisco and Swanson (2018), Hofmann and Rüsch (2017), p. 11, p. 12 |
| SF10 | Effectiveness and efficiency | Seifert and Seifert (2011), Mangla *et al.* (2018), p. 2, p. 8 |
| SF11 | Automation | Bartling and Fecher (2016), Xu *et al.* (2018), p. 13 |
| SF12 | Problem solution | Crosby *et al.* (2016), Zohar (2015), p. 1 |
| SF13 | Simplification of current paradigms | Dickson (2016), Mackey and Nayyar (2017), p. 14, p. 15 |
| SF14 | Quality control | Tian (2017), Staples *et al.* (2017), p. 13, p. 16 |
| SF15 | Quality fairness | Abeyratne and Monfared (2016), Grover and Malhotra (2003), Saberi *et al.* (2019), p. 17 |
| SF16 | Laws | Du *et al.* (2019), p. 10, p. 18 |
| SF17 | Government policy | Mackey and Nayyar (2017), Spink and Moyer (2011), p. 19, p. 20 |
| SF18 | Consensus | Swan (2015), Tian (2017), p. 10, p. 18 |
| SF19 | Reliability and longevity | Ivanov *et al.* (2019), Swan (2015), Kshetri (2018), p. 21, p. 22 |
| SF20 | No data loss | Tian (2017), Abeyratne and Monfared (2016), p. 1, p. 7 |
| SF21 | Scalability in SCM | Saberi *et al.* (2019), p. 3, p. 8 |
| SF22 | Decentralization | Crosby *et al.* (2016), Tapscott and Tapscott (2017), Bocek and Stiller (2018), p. 1, p. 7 |
| SF23 | Environment-friendly | Ward (2017), p. 22, p. 23 |
| SF24 | Human safety | Saberi *et al.* (2019), p. 24, p. 25 |
| SF25 | Traceability | Carter and Koh (2018), Saberi *et al.* (2019), Tian (2016), p. 1, p. 2, p. 26 |
| SF26 | Integrity | Tian (2017), Abeyratne and Monfared (2016), Francisco and Swanson (2018), p. 13, p. 16 |
| SF27 | Trackability | Tian (2016), Rosencrance (2017), p. 13, p. 26 |
| SF28 | Cost | Hofmann *et al.* (2018), Tapscott and Tapscott (2017), Ward (2017), p. 1, p. 2 |
| SF29 | Save energy | Futurethinkers (2017), Saberi *et al.* (2019), p. 17, p. 23 |
| SF30 | Administration cost reductions | Delmolino *et al.* (2016), Pilkington (2016), p. 27, p. 28 |
| SF31 | Solving double spending problems | Zohar (2015), Crosby *et al.* (2016), p. 29, p. 30 |
| SF32 | Smart contracts | Saberi *et al.* (2019), Iansiti and Lakhani (2017), p. 10 |
| SF33 | Streamlined | Saberi *et al.* (2019), p. 3 |
| SF34 | Inventory improvements | Tapscott and Tapscott (2017), p. 7, p. 31 |
| SF35 | Permanence | Saberi *et al.* (2019), Babich and Hilary (2019), p. 7 |
| SF36 | High availability | Tapscott and Tapscott (2017), p. 1 |
| SF37 | Long-term growth | Saberi *et al.* (2019), p. 32, p. 33 |
| SF38 | Interoperability | Pilkington (2016), Delmolino *et al.* (2016), Abeyratne and Monfared (2016), Swan (2015), p. 4 |
| SF39 | Data access control in SCM | Hofmann *et al.* (2018), Swan (2015), p. 17 |
| SF40 | Authentic data | Babich and Hilary (2019), p. 34 |
| SF41 | Accounting | Pilkington (2016), Swan (2015), p. 18 |
| SF42 | Auditability in SCM | Hofmann *et al.* (2018), Du *et al.* (2019), p. 10, p. 35 |

*(continued)*

**Table 6.**
List of identified success factors from MLR

| S.No | Success factors | References |
|---|---|---|
| SF43 | Higher flexibility in production systems | Pazaitis *et al.* (2017), p. 36 |
| SF44 | Logistics synchronization | Saberi *et al.* (2019), Iansiti and Lakhani (2017), p. 37 |
| SF45 | Development of reliable suppliers | Mangla *et al.* (2018), Gorane and Kant (2015), p. 3, p. 38 |
| SF46 | Demand sharing In SCM | Saberi *et al.* (2019), Morabito (2017), p. 39 |
| SF47 | Focus on core strengths | Saberi *et al.* (2019), p. 40 |
| SF48 | Identifying issues | Swan (2015), Delmolino *et al.* (2016), p. 3 |

**Table 6.**

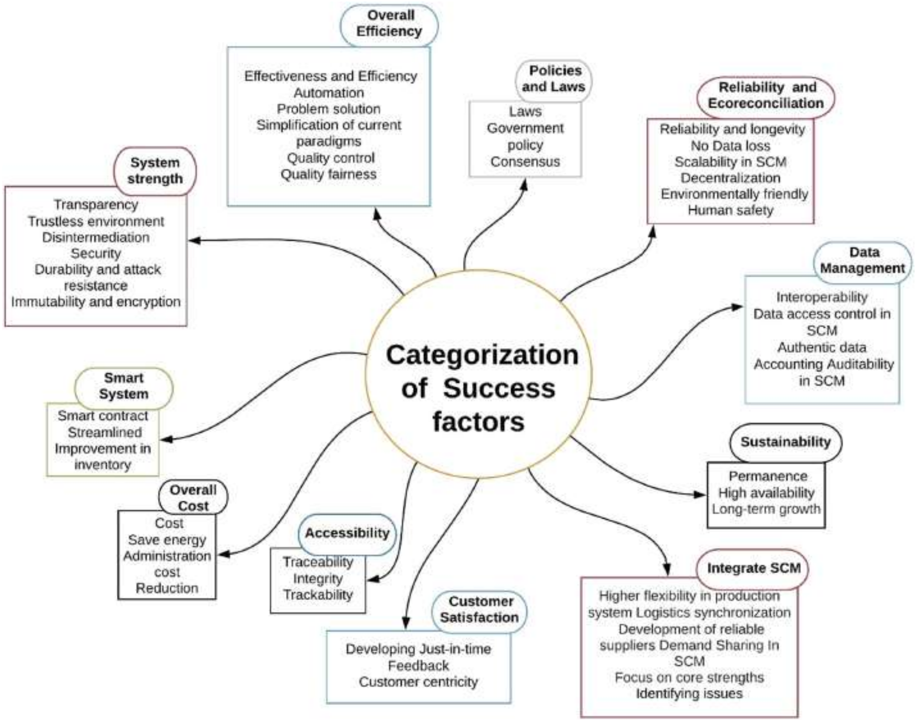


**Figure 4.** Categorization of the investigated success factors

Regarding the negative categories, (SF47) "Focus on core strengths", (SF29) "Save energy" and (SF39) "Data access control in SCM" were 19%, 16% and 16%, respectively. Moreover, (SF36) "High availability" at 22% had a very negative score. This is because industrial participants might think that the implementation of blockchain technology is somewhat difficult and expensive. Sensors and cloud-based systems require too high of installation costs. The tuna fish industry in Indonesia is suffering problems due to data access because the installation of blockchain technology is a large challenge for them (Kshetri, 2018).

Empirical observations for the neutral category illustrate that (SF8) "Feedback" received the highest score of 23%, and (SF33) "Streamlined" received the second highest score of 22%; (SF32) "Smart contracts" and (SF34) "Inventory improvement" both have 20% in this category.

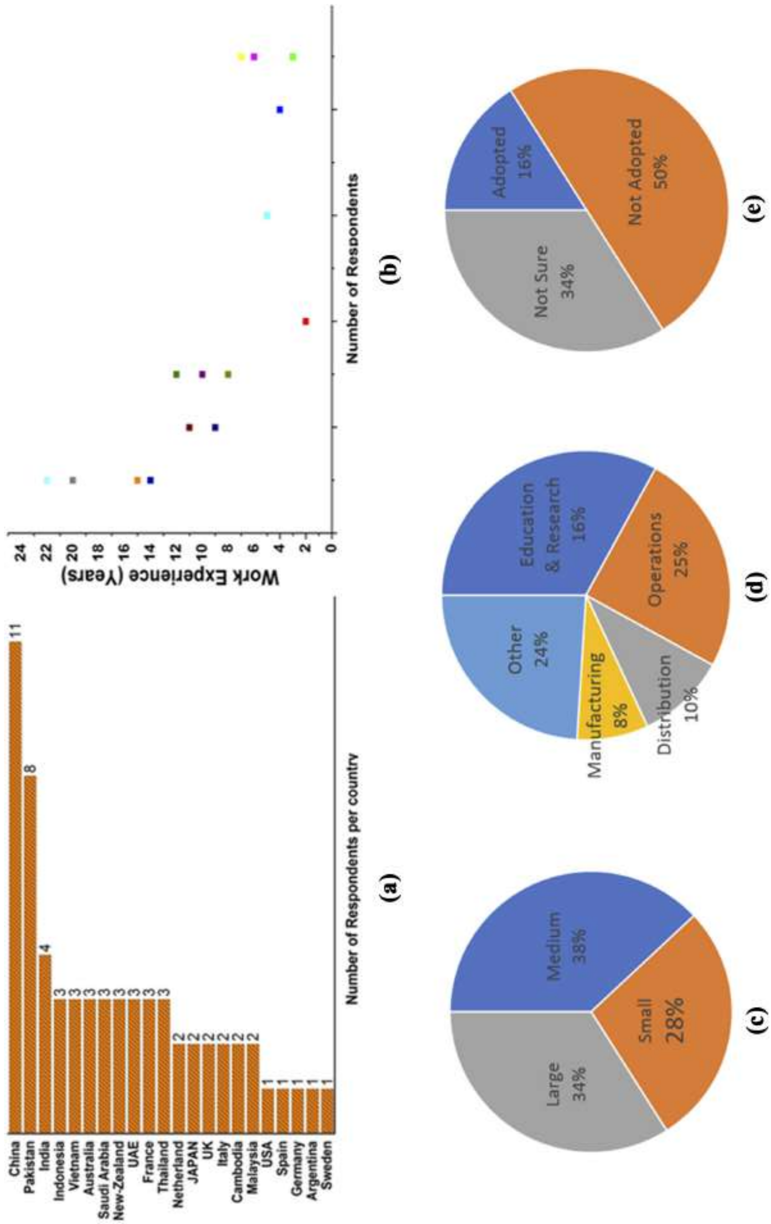


**Figure 5.**
(a) Survey respondents' countries, (b) experience of survey respondents, (c) shares of respondents based on organization size, (d) shares of respondents based on functional area and (e) shares of respondents based on the adoption of blockchain technology in a supply chain

| | | Empirical observations ($N$ = 64) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Positive | | | Negative | | | Neutral | |
| S.No | Success factors and categories | S.A | *A* | % | S.D | *D* | % | *N* | % |
| *C1* | *Category: System strength* | *15* | *35* | *78* | *1* | *4* | *8* | *9* | *13* |
| SF1 | Transparency | 17 | 30 | 73 | 1 | 5 | 9 | 11 | 17 |
| SF2 | Trustless environment | 20 | 28 | 75 | 1 | 4 | 8 | 11 | 17 |
| SF3 | Disintermediation | 13 | 38 | 80 | 1 | 6 | 11 | 6 | 9 |
| SF4 | Security | 13 | 42 | 86 | 1 | 2 | 6 | 5 | 8 |
| SF5 | Durability and attack resistance | 10 | 40 | 78 | 2 | 4 | 9 | 8 | 13 |
| SF6 | Immutability and encryption | 15 | 34 | 77 | 2 | 3 | 8 | 10 | 16 |
| *C2* | *Category: Customer satisfaction* | *11* | *35* | *72* | *1* | *5* | *9* | *12* | *18* |
| SF7 | Developing just-in-time | 11 | 36 | 73 | 1 | 6 | 11 | 10 | 16 |
| SF8 | Feedback | 12 | 29 | 64 | 1 | 6 | 13 | 15 | 23 |
| SF9 | Customer centricity | 11 | 39 | 78 | 1 | 3 | 16 | 10 | 16 |
| *C3* | *Category: Overall efficiency* | *13* | *35* | *74* | *2* | *5* | *10* | *10* | *15* |
| SF10 | Effectiveness and efficiency | 17 | 33 | 78 | 3 | 1 | 6 | 10 | 16 |
| SF11 | Automation | 13 | 34 | 73 | 3 | 5 | 13 | 9 | 14 |
| SF12 | Problem solution | 16 | 32 | 75 | 2 | 4 | 9 | 10 | 16 |
| SF13 | Simplification of current paradigms | 16 | 34 | 78 | 1 | 3 | 6 | 10 | 16 |
| SF14 | Quality control | 8 | 37 | 70 | 2 | 7 | 14 | 10 | 16 |
| SF15 | Quality fairness | 9 | 37 | 72 | 1 | 8 | 14 | 9 | 14 |
| *C4* | *Category: Policies and laws* | *14* | *34* | *76* | *2* | *4* | *9* | *10* | *15* |
| SF16 | Laws | 13 | 37 | 78 | 1 | 2 | 5 | 11 | 17 |
| SF17 | Government policy | 14 | 34 | 75 | 2 | 4 | 9 | 10 | 16 |
| SF18 | Consensus | 16 | 31 | 73 | 2 | 7 | 14 | 8 | 13 |
| *C5* | *Category: Reliability and ecoreconciliation* | *14* | *37* | *79* | *1* | *3* | *7* | *9* | *14* |
| SF19 | Reliability and longevity | 19 | 32 | 80 | 2 | 2 | 6 | 9 | 14 |
| SF20 | No data loss | 12 | 35 | 73 | 0 | 5 | 8 | 12 | 19 |
| SF21 | Scalability in SCM | 12 | 41 | 78 | 2 | 5 | 11 | 7 | 11 |
| SF22 | Decentralization | 14 | 38 | 80 | 0 | 3 | 5 | 10 | 16 |
| SF23 | Environmentally friendly | 12 | 42 | 83 | 2 | 3 | 8 | 6 | 9 |
| SF24 | Human safety | 14 | 38 | 81 | 1 | 1 | 6 | 8 | 13 |
| *C6* | *Category: Accessibility* | *19* | *35* | *84* | *1* | *2* | *6* | *6* | *9* |
| SF25 | Traceability | 19 | 37 | 88 | 1 | 2 | 5 | 5 | 8 |
| SF26 | Integrity | 22 | 29 | 80 | 2 | 3 | 11 | 6 | 9 |
| SF27 | Trackability | 15 | 39 | 84 | 1 | 2 | 5 | 7 | 11 |
| *C7* | *Category: Overall cost* | *17* | *34* | *80* | *2* | *4* | *9* | *7* | *11* |
| SF28 | Cost | 16 | 35 | 80 | 3 | 2 | 8 | 8 | 13 |
| SF29 | Save energy | 13 | 34 | 73 | 4 | 6 | 16 | 7 | 11 |
| SF30 | Administration cost reduction | 19 | 35 | 84 | 0 | 3 | 6 | 6 | 9 |
| SF31 | Solving the double spending problem | 21 | 31 | 81 | 2 | 4 | 9 | 6 | 9 |
| *C8* | *Category: Smart system* | *16* | *31* | *73* | *1* | *3* | *6* | *13* | *21* |
| SF32 | Smart contract | 19 | 28 | 73 | 1 | 3 | 6 | 13 | 20 |
| SF33 | Streamlined | 11 | 35 | 72 | 2 | 2 | 6 | 14 | 22 |
| SF34 | Inventory improvement | 17 | 30 | 73 | 1 | 3 | 6 | 13 | 20 |
| *C9* | *Category: Sustainability* | *17* | *31* | *75* | *3* | *6* | *15* | *6* | *10* |
| SF35 | Permanence | 21 | 30 | 80 | 1 | 6 | 11 | 6 | 9 |
| SF36 | High availability | 14 | 32 | 72 | 6 | 8 | 22 | 4 | 6 |
| SF37 | Long-term growth | 16 | 31 | 73 | 2 | 5 | 13 | 9 | 14 |
| *C10* | *Category: Data management* | *12* | *40* | *82* | *2* | *3* | *7* | *7* | *12* |
| SF38 | Interoperability | 15 | 36 | 80 | 1 | 2 | 8 | 10 | 16 |
| SF39 | Data access control in SCM | 12 | 41 | 83 | 4 | 4 | 16 | 3 | 5 |
| SF40 | Authentic data | 9 | 40 | 77 | 2 | 4 | 11 | 9 | 14 |
| SF41 | Accounting | 12 | 44 | 88 | 0 | 1 | 3 | 7 | 11 |
| SF42 | Auditability in SCM | 14 | 39 | 81 | 1 | 2 | 5 | 8 | 13 |

(*continued*)

**Table 7.**
Investigated success factors in the empirical study

| S.No | Success factors and categories | Empirical observations (*N* = 64) Positive S.A | *A* | % | Negative S.D | *D* | % | Neutral *N* | % |
|---|---|---|---|---|---|---|---|---|---|
| *C11* | *Category: Integrate SCM* | *17* | *32* | *77* | *3* | *4* | *10* | *9* | *13* |
| SF43 | Higher flexibility in production system | 20 | 30 | 78 | 3 | 2 | 8 | 9 | 14 |
| SF44 | Logistics synchronization | 15 | 35 | 78 | 1 | 1 | 3 | 12 | 19 |
| SF45 | Development of reliable suppliers | 14 | 35 | 77 | 2 | 5 | 11 | 8 | 13 |
| SF46 | Demand sharing in SCM | 18 | 34 | 81 | 1 | 3 | 6 | 8 | 13 |
| SF47 | Focus on core strengths | 18 | 28 | 72 | 5 | 7 | 19 | 6 | 9 |
| SF48 | Identifying issues | 15 | 32 | 73 | 3 | 6 | 14 | 8 | 13 |

**Table 7.**

**Note(s)**: S.A = strongly agree, *A* = agree, S.D = strongly disagree, *D* = disagree and *N* = neutral

Regarding the importance of the categories, the table clearly shows that category (C6) "Accessibility" had the highest positive frequency value at 84%. This shows that blockchain provides a quick tracing of products from weeks to seconds (Kamath, 2018). Categories (C5) "Reliability and ecoreconciliation" and (C7) "Overall cost" were 80% and 79%, respectively, since a blockchain improves the sustainability of an environmental supply chain. Tracking and the controlling system stop the recall of products, thus reducing carbon dioxide emissions, energy consumption and costs (Saberi *et al.*, 2019).

*4.4 Application of analytic hierarchy process*

Figure 6 presents the hierarchical structure of the success factors based on the responses to the survey questions.

The local weight of any factor represents the factor's worth within a category, and the global weight represents the factor's worth among all identified factors. The global weight of each factor is given in Table 8.

The AHP helps to prioritize the factors since it categorizes them (Faisal, 2009) and makes it easy to solve decision-making problems (Partovi *et al.*, 1990). Table 9 shows the priority order for each factor. The factor with the highest global weight is the factor that is the most critical among all success factors and is ranked 1.

Figure 7(a) reveals the local ranking of each category. (C6) The "Accessibility" category had the highest rank at 0.228. This shows that this category is more important among all the categories. The (C9) "Sustainability" category with a weight of 0.016 had the lowest ranking.

Regarding the prioritization of these factors within a group, Figure 7(b) depicts that two factors from the (C6) "Accessibility" category had the highest priority. The (C3) "Overall efficiency" and (C10) "Data management" categories also received high importance compared to other categories. The factors in the (C11) "Integrate SCM" category received the lowest importance.

Based on the local and global weights of the categories and factors, a taxonomy was developed. Figure 8 gives the taxonomic model of the categories and success factors. The (C6) "Accessibility" category (GW: 0.228) is ranked first in the priority list and is the most important. The (C3) "Overall efficiency" category (GW: 0.206) is second, and (C9) "Sustainability" is ranked the least important among the success factor categories. (SF27) "Trackability" (GW: 0.130) is considered to be the most important factor compared to the overall factors. (SF25) "Traceability" (GW: 0.083), (SF13) "Simplification of current paradigms" (GW: 0.064), (SF39)"Data access control in SCM" (GW: 0.059) and (SF24) "Human safety" (GW: 0.052) are also considered to be critical factors.

The figure clearly reveals that the "Accessibility" category ranks first, and its factors of tracing and tracking are the key factors according to the survey (AHP). The literature review

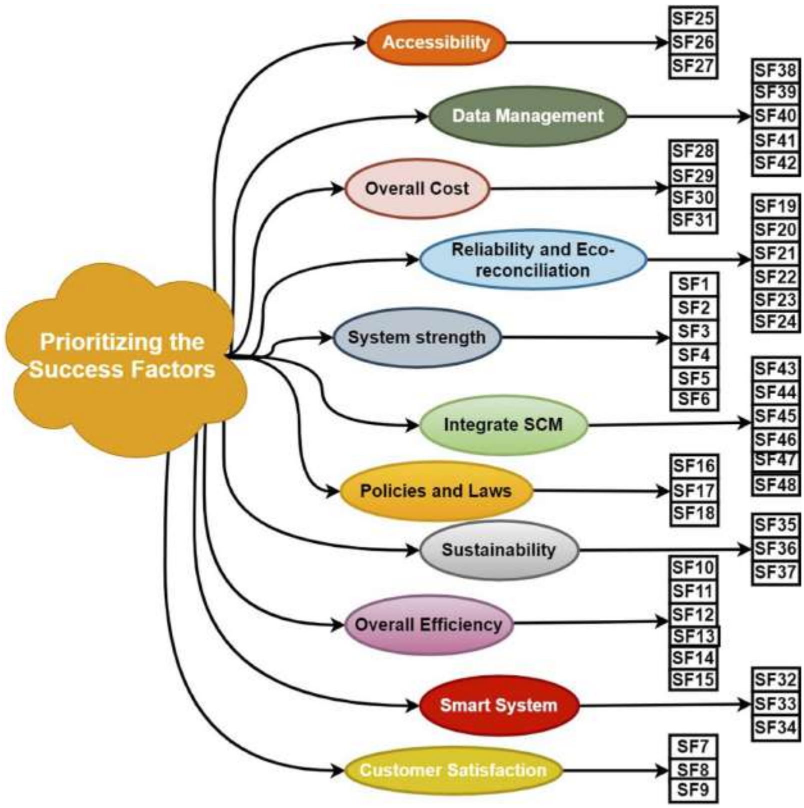


**Figure 6.**
Hierarchical structure of the success factors using AHP

also supports these factors and shows that these factors play important roles in the adoption of a blockchain-based supply chain.

## 5. Theoretical and practical implications

Currently, the main focus of industrial experts, academics and practitioners is to enhance supply chain performance. In this study, we identify the factors that positively influence a blockchain-based supply chain.

### *5.1 Theoretical implications*

As mentioned in the study, blockchain has the potential to enhance supply chains; therefore, it provides an opportunity for companies and firms to acquire competitive advantages from blockchain technology. The identified success factors help industrial practitioners to implement blockchain technology. Project managers use these prioritized success factors while adopting blockchain-based supply chains. Blockchain offers a quick solution that keeps records safe and secure and strengthens the transparency of the product. The previous research shows that organizations working with IBM are not afraid of security problems. IBM provides a permissioned blockchain in which a close group of participants are involved. Therefore, there is a large problem when companies want to bring all partners onto a single platform.

| Categories | Weights of the categories | Success factors | Local weights | Local ranking | Global weights | Global ranking |
|---|---|---|---|---|---|---|
| System strength | 0.057 | SF1 | 0.062 | 5 | 0.004 | 42 |
| | | SF2 | 0.050 | 6 | 0.003 | 46 |
| | | SF3 | 0.159 | 2 | 0.009 | 27 |
| | | SF4 | 0.506 | 1 | 0.029 | 13 |
| | | SF5 | 0.145 | 3 | 0.008 | 30 |
| | | SF6 | 0.079 | 4 | 0.005 | 40 |
| Customer satisfaction | 0.042 | SF7 | 0.263 | 2 | 0.011 | 24 |
| | | SF8 | 0.110 | 3 | 0.005 | 39 |
| | | SF9 | 0.460 | 1 | 0.019 | 16 |
| Overall efficiency | 0.206 | SF10 | 0.053 | 6 | 0.011 | 25 |
| | | SF11 | 0.169 | 4 | 0.035 | 10 |
| | | SF12 | 0.185 | 2 | 0.038 | 7 |
| | | SF13 | 0.309 | 1 | 0.064 | 3 |
| | | SF14 | 0.103 | 5 | 0.021 | 15 |
| | | SF15 | 0.182 | 3 | 0.037 | 8 |
| Policies and laws | 0.029 | SF16 | 0.312 | 2 | 0.009 | 28 |
| | | SF17 | 0.198 | 3 | 0.006 | 35 |
| | | SF18 | 0.490 | 1 | 0.014 | 21 |
| Reliability and ecoreconciliation | 0.147 | SF19 | 0.061 | 1 | 0.009 | 29 |
| | | SF20 | 0.108 | 4 | 0.016 | 19 |
| | | SF21 | 0.034 | 6 | 0.005 | 37 |
| | | SF22 | 0.199 | 3 | 0.029 | 12 |
| | | SF23 | 0.241 | 2 | 0.035 | 9 |
| | | SF24 | 0.357 | 1 | 0.052 | 5 |
| Accessibility | 0.228 | SF25 | 0.363 | 2 | 0.083 | 2 |
| | | SF26 | 0.066 | 3 | 0.015 | 20 |
| | | SF27 | 0.571 | 1 | 0.130 | 1 |
| Overall cost | 0.039 | SF28 | 0.199 | 4 | 0.008 | 32 |
| | | SF29 | 0.178 | 5 | 0.007 | 33 |
| | | SF30 | 0.347 | 2 | 0.014 | 23 |
| | | SF31 | 0.276 | 3 | 0.011 | 26 |
| Smart system | 0.051 | SF32 | 0.544 | 1 | 0.028 | 14 |
| | | SF33 | 0.110 | 6 | 0.006 | 36 |
| | | SF34 | 0.346 | 5 | 0.018 | 18 |
| Sustainability | 0.016 | SF35 | 0.198 | 3 | 0.003 | 44 |
| | | SF36 | 0.312 | 2 | 0.005 | 38 |
| | | SF37 | 0.490 | 1 | 0.008 | 31 |
| Data management | 0.165 | SF38 | 0.111 | 4 | 0.018 | 17 |
| | | SF39 | 0.357 | 1 | 0.059 | 4 |
| | | SF40 | 0.202 | 3 | 0.033 | 11 |
| | | SF41 | 0.084 | 5 | 0.014 | 22 |
| | | SF42 | 0.246 | 2 | 0.041 | 6 |
| Integrate SCM | 0.021 | SF43 | 0.314 | 1 | 0.007 | 34 |
| | | SF44 | 0.068 | 6 | 0.001 | 48 |
| | | SF45 | 0.195 | 2 | 0.004 | 41 |
| | | SF46 | 0.147 | 4 | 0.003 | 45 |
| | | SF47 | 0.158 | 3 | 0.003 | 43 |
| | | SF48 | 0.120 | 5 | 0.003 | 47 |

**Table 8.**
Summary of the local and global rankings of the success factors

Inventory tracing and tracking are the most important aspects of a blockchain-based supply chain according to the research. Product monitoring helps managers to fix inventory management issues, and this is done by sharing information among supply chain partners (Babich and Hilary, 2019). The main idea of the study is to assess whether the shared

| S.No | Success factors | Priority |
|---|---|---|
| SF27 | Trackability | 1 |
| SF25 | Traceability | 2 |
| SF13 | Simplification of current paradigms | 3 |
| SF39 | Data access control in SCM | 4 |
| SF24 | Human safety | 5 |
| SF42 | Auditability in SCM | 6 |
| SF12 | Problem solution | 7 |
| SF15 | Quality fairness | 8 |
| SF23 | Environmentally friendly | 9 |
| SF11 | Automation | 9 |
| SF40 | Authentic data | 10 |
| SF22 | Decentralization | 11 |
| SF4 | Security | 11 |
| SF32 | Smart contract | 12 |
| SF14 | Quality control | 13 |
| SF9 | Customer centricity | 14 |
| SF38 | Interoperability | 15 |
| SF34 | Inventory improvement | 15 |
| SF20 | No data loss | 16 |
| SF26 | Integrity | 17 |
| SF18 | Consensus | 18 |
| SF41 | Accounting | 18 |
| SF30 | Administration cost reduction | 19 |
| SF7 | Developing just-in-time | 20 |
| SF10 | Effectiveness and efficiency | 20 |
| SF31 | Solving the double spending problem | 21 |
| SF3 | Disintermediation | 22 |
| SF16 | Laws | 22 |
| SF19 | Reliability and longevity | 23 |
| SF5 | Durability and attack resistance | 24 |
| SF28 | Cost | 24 |
| SF37 | Long-term growth | 24 |
| SF29 | Save energy | 25 |
| SF43 | Higher flexibility in production system | 25 |
| SF17 | Government policy | 26 |
| SF33 | Streamlined | 26 |
| SF21 | Scalability in SCM | 27 |
| SF36 | High availability | 27 |
| SF8 | Feedback | 27 |
| SF6 | Immutability and encryption | 27 |
| SF45 | Development of reliable suppliers | 28 |
| SF1 | Transparency | 28 |
| SF47 | Focus on core strengths | 29 |
| SF35 | Permanence | 29 |
| SF46 | Demand sharing in SCM | 29 |
| SF2 | Trustless environment | 29 |
| SF48 | Identification issues | 29 |
| SF44 | Logistics synchronization | 30 |

**Table 9.** Prioritization of success factors

information within a supply chain partner is authentic and on time. The blockchain provides a complete authentication mechanism to its users inside a chain so that one can check data and add values. Furthermore, the property of immutability (no one can change the data) can improve the trust among two parties without involving a middleman. The trust of the customer means extra sales, and it also helps in finding the best supplier and best customer

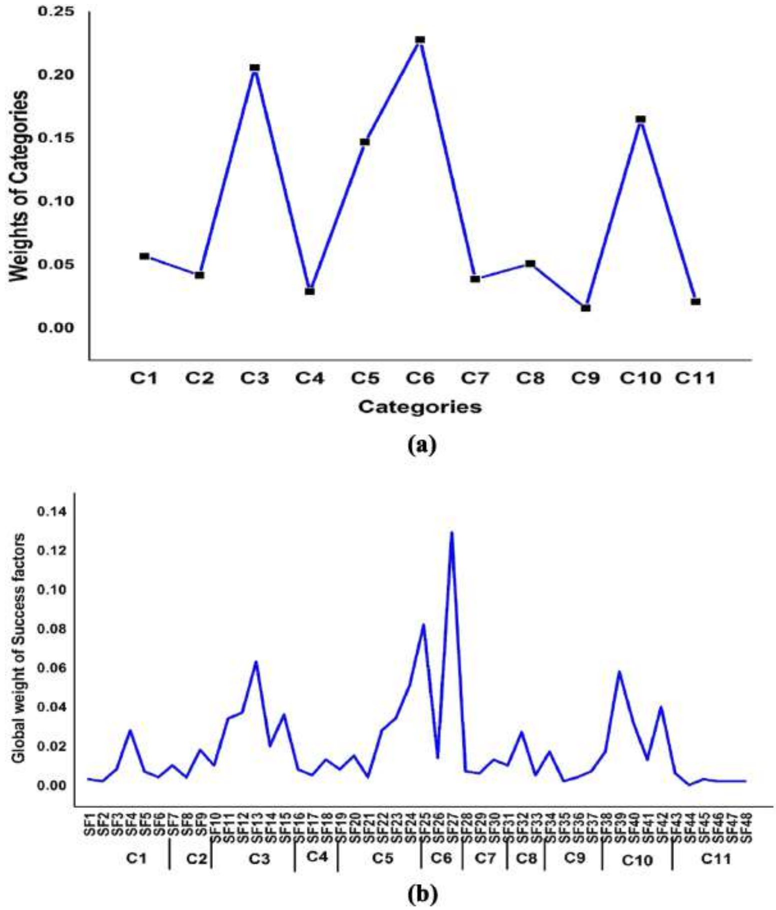


**Figure 7.**
(a) Prioritization of the categories, and (b) prioritization of the success factors

market for a specific product. This also enhances the processes by creating a smart contract. In this way, pioneer organizations not only improve customer trust but also make their supply chains smoother and more sustainable.

*5.2 Practical implications*

The identified success factors can help industrial practitioners to implement blockchain technology. Project managers can use these prioritized success factors while adopting blockchain-based supply chains. In supply chain activities, communication is the main problem since participants want efficient communication to obtain information. A blockchain-based supply chain helps to solve this problem. Maersk's blockchain can "solve the messaging problem more than the financial problem" (Kshetri, 2018).

The main challenge for an industrial manager is to check whether his or her industry needs blockchain technology or not. In some circumstances, RFID and other IoT devices provide the best results in small industries, so there would be no need to invest in blockchain technology. Many firms have started to integrate blockchain technology with IoT devices to track products from their origin to end-users. Blockchain provides a quick solution to improve safety and security by protecting records and strengthening the transparency of a

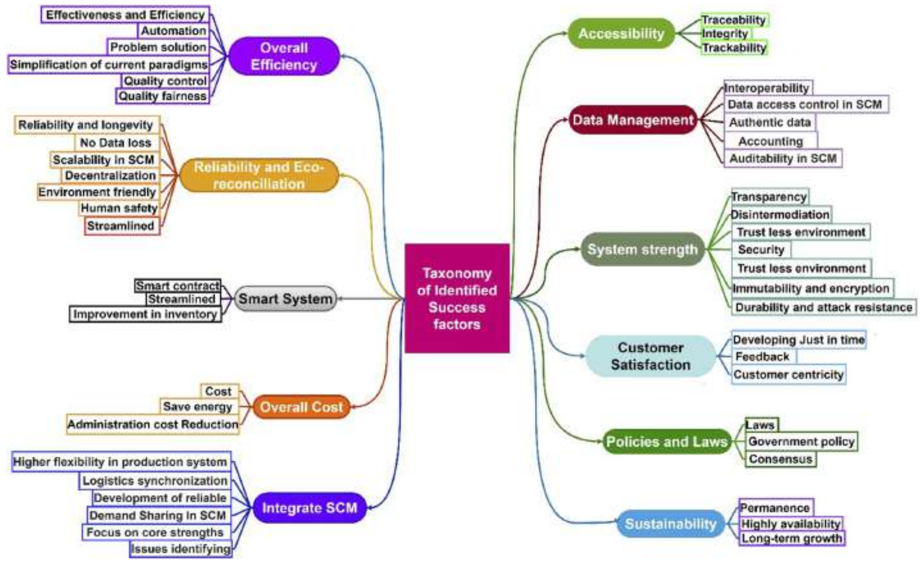


**Figure 8.** Taxonomy of the identified success factors

product. One of the practical implications of this technology in banking and finance is that transactions are more secure and timely and less expensive (Peters and Panayi, 2016). Blockchain enhances the security of valuable products and drug supply chains by providing immutable data records between pharmaceutical companies, wholesalers, retailers, pharmacies, hospitals and patients (Tseng *et al.*, 2018). Another vital implication of this technology will be experienced by sustainable supply chains. Blockchain helps to determine carbon footprints so that government organizations can easily calculate the carbon taxes for each firm and reduce excess carbon emissions. A blockchain-based supply chain network also promotes the recycling process. Empty bottles and cans can be recycled to save the environment.

Auto and tech industries adopt blockchain-based supply chains because they have fewer suppliers. Conversely, the oil industry has 13 supplier layers (Castillo, 2017), and they adopt blockchain technology to handle their financial matters (Kshetri, 2018). Companies can also pressure other supply chain partners to adopt blockchain technology. For example, if a raw material company registers on a blockchain, a manufacturing company can also adopt the blockchain network.

## 6. Conclusion and future work

In this paper, we introduce an integrated framework method to build a taxonomy established on the prioritization of success factors in a supply chain using blockchain technology. These success factors provide a brief review of the blockchain-based supply chain to academic researchers and help industrial practitioners to build a strategy for future projects. A pilot study was conducted with the research team and experts and a questionnaire-based survey was developed to validate the success factors in real-world practices. In total, 64 researchers and practitioners from 22 countries validated 48 success factors, which are further grouped into 11 major categories. All the factors received more than 70% positive responses (strongly agree and agree), which justifies that the factors we stated from the literature review are also practised in the real world. Moreover, a second survey was conducted to prioritize the success factors using the AHP approach.

The (C6) "Accessibility" category was the most important category, and the (C3) overall efficiency category had the second-highest rank. (SF27) Trackability and (SF25) traceability were considered to be prime success factors of the blockchain-based supply chain. The taxonomy of categories and the success factors provide an outline for supply chain organizations to establish a strategy to implement blockchain technology.

The main objectives of this study were to identify the key success factors for blockchain-based supply chain technology and to establish a taxonomic model of the success factors and their categories. This taxonomic model will help in comparison for supply chain organizations' existing models and provide them with guidelines for the necessary actions to improve their supply chain activities. The prioritization can help academic researchers and industrial practitioners to set their strategic goals accordingly.

Regarding the adoption of blockchain technology, survey reports state that approximately 48% of organizations still have not adopted a blockchain-based supply chain. Out of 26,000 blockchain projects in 2016, only 8% of blockchain applications were implemented in 2017 (Pournader, 2020). This shows that there are some barriers to the adoption of blockchain technology. Future work will be to find the barriers/obstacles to the successful implementation of blockchain technology.

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## Appendix

### Supplementary data

### Appendix A1. Survey Links

Based on the research questions and identified success factors, we developed an online survey questionnaire using Google forms. Participants were asked to answer questions based on five-point scales including "strongly agree, agree, neutral, disagree, and strongly disagree". The survey link is as follows:

(1) https://docs.google.com/forms/d/e/1FAIpQLSeV7XvSAYAisdu7oXSd3EjrOHG0utbFKbNo5DwJ_W01pSirHQ/viewform?usp=sf_link

### Appendix A2. Data of the Survey Respondents

After completing the survey, we assessed the responses for each identified success factor and their categories. The participants were divided into three main categories (positive, negative and neutral).The data of the survey respondents are given in the following link:

(1) https://docs.google.com/spreadsheets/d/1kkEiFsQAHZCVDL_JEaliZ7pI9iyxJKQCLO6SnBDoiXY/edit?usp=sharing

### Notes

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(2) https://www.investopedia.com/terms/b/blockchain.asp

(3) https://www.splunk.com/en_us/data-insider/what-is-blockchain.html

(4) https://www.ibm.com/blogs/cloud-computing/2017/06/02/challenges-shared-processes-blockchain/

(5) https://infocastinc.com/market-insights/technology/blockchain-a-platform-for-disintermediation/

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