Investigating the themes in supply chain finance: the emergence of blockchain as a disruptive technology

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Abstract

Blockchain has gained momentum as a disruptive technology in supply chain management against its introduction as a finance-related instrument. Nevertheless, the developing academic understanding and the limited practical implications lead to insufficient insights into the use of blockchain technology, particularly in the supply chain finance (SCF) domain. Therefore, the expected potential of blockchain technology and relatively veiled benefits in supply chain operations remain underexplored. This study aims to investigate the emerging themes of the SCF concept and explain how blockchain can emerge as a disruptive SCF-oriented technology. The study employs a web analytics method, Search Engine Results Page (SERP) analysis which considers the trends in blockchain technology use and the interactions between blockchain, supply chain and finance appearing in Google searches. The SERP method examined real-time clicks, web traffics and most commonly asked questions about blockchain. The findings revealed that the interest in blockchain technology neither focused on finance nor data privacy but mainly on the benefits to increase digitalisation and efficiency in supply chains. The results offered practical implications to capture blockchain- and supply chain-related recent trends and design more digital and efficient supply chains.

Keywords: Blockchain, Search engine results page (SERP), Supply chain finance, Web analytics, Web traffic.

1. Introduction

The supply chain is a systematic process in which many players operate and is inherently composed of a connected series of diverse activities such as procurement, manufacturing and logistics services (Francisco and Swanson, 2018). Numerous technologies that are emerged in the Industry 4.0 era, i.e. big data, artificial intelligence, machine learning, and Internet of Things (IoT), are utilised in this complex and systematic supply chain network (Hofmann and Rüsch, 2017; Gebhardt et al., 2021). In addition to the use of Industry 4.0 technologies, some eminent issues such as financial transactions and goods, loss of data, and fraud, come to the forefront and make the supply chain even more complicated (Issaoui et al., 2019). To address the finance- and security-based challenges and mitigate the potential risks, blockchain technology within the concept of supply chain finance (SCF) was put forward in the supply

chain environment (Dutta et al., 2020; Lahkani et al., 2020). The concept of SCF refers to the integration of information flow, capital flow, and logistics by connecting financial institutions and upstream and downstream enterprises (Zheng et al., 2020). Since current operations in SCF require a high level of trust, blockchain has been considered a major technology to be applied in the field of SCF (Fernández-Caramés et al., 2019; Choi, 2020a).

Supply chain management depends mainly on data, yet data sharing is not entirely administered in traditional supply chain processes (Ma et al., 2019). Firms' resistance to data sharing and transition to digital technologies (World Economic Forum, 2019) because of the concerns about digitalisation costs hinders the advancement of the SCF concept through unique blockchain implementations and technologies (Lahkani et al., 2020). The insufficient knowledge about the implementation and performance of blockchain technologies (Perboli et al., 2018; Batwa and Norrman, 2020) adds more complexity to the previously mentioned supply chain management challenges, particularly in its emergent field of application, i.e. finance. These suggestions find support from the Gartner surveys (2018), which reveal the scarcity of current blockchain deployments in the SCF field. Yet, the use of blockchain technologies is precious in improving efficiency and data traceability (Ma et al., 2019) and holds a promise to advance the SCF concept (Zheng et al., 2020). In this regard, several researchers (e.g. Ma et al., 2019; Choi, 2020a; Du et al., 2020) consider blockchain as a practical technology to provide convenient and instant solutions to financial services in the supply chain environment. Therefore, the economic and practical side of blockchain technologies that remains underexplored in the area of SCF deserves more multidisciplinary and empirical investigation in the international context (Ahluwalia et al., 2020; Erol et al., 2020). Based on these arguments, this study aims to answer the following research questions: "*what are the current and emerging themes discussed on the SCF concept?*" and "*how are blockchain technologies utilised in the supply chain, especially for operations in the SCF area?*".

The concepts mentioned by the research questions have received relatively higher interest in the developed contexts (see Dutta et al., 2020), yet similar type studies in emerging markets are scant. Given that emerging market economies accounted for nearly 45 per cent of the world's production in 2021 (Cavusgil et al., 2021), it becomes evident that they are critical components of global value chains in which blockchain technologies can extensively be

utilised. Therefore, more applied research that may help firms use blockchain technologies in supply chains in more efficient and effective ways is required (Schuetz and Venkatesh, 2020).

Relying on these motivations and research gaps, this paper contributes three ways to supply chain finance research. First, as an emerging disruptive SCF theme, the vagueness of blockchain use in supply chain finance can be clarified. Second, the findings can extend the understanding of the extent to which connections between blockchain and supply chains are mutually used to deal with inherent challenges in designing a digital and efficient supply chain ecosystem. Finally, practical insights into ways to capture recent trends, determine engagements among different related concepts, and take action to design digital and efficient supply chains are provided.

The paper is structured as follows. The study starts by identifying the gap in the field. In this respect, the following section presents a structured review of the normative literature on blockchain technologies in the SCF area. Then, the research methodology is introduced. Next, the analyses conducted to uncover the interactions of blockchain technologies with finance and supply chain concepts are presented. Finally, the findings are discussed within the theoretical frame of technology adoption, research implications are explained with future research directions, and the paper is concluded.

2. Supply chain finance and blockchain

2.1. Coverage of the supply chain finance concept and the need for blockchain use

Supply chain finance was initially associated with accounts receivable in business finance and inventory financing in logistics (Du et al., 2020). Starting from the early-2000s, when the global financial crisis occurred, the scope of SCF has broadened by the integration of various parties throughout the supply chain network, i.e. financial institutions, core enterprises, and upstream and downstream enterprises (Zheng et al., 2020; Chen et al., 2020). Financial flows regarding product, service and information in the whole supply chain process were coordinated through three main tools: factoring, order financing, and inventory financing (Chen et al., 2020; Li et al., 2020). The drawbacks of the classical structure of SCF, i.e. insufficient digitalisation, operational inefficiency, problems in data mining and data protection, and risks in fraud and cybersecurity, can be addressed by Industry 4.0-based themes, such as smart contracts, big data analytics, and blockchain technologies. According to Bogucharskov et al. (2018), improving software systems through blockchain technologies

emerges as a central theme for dealing with the extant flaws of finance and building its successful development in the supply chain area.

Blockchain technology was initially propounded to support cryptocurrencies' operations, and its popularity has increased with the Bitcoin effect (Ma et al., 2019). Over time, blockchain technology has exceeded the realm of cryptocurrency by moving into different areas in the supply chain. However, the insights of blockchain technologies in finance have mainly remained technical (Hooper and Holtbrügge, 2020) or conceptual (Schuetz and Venkatesh, 2020). Besides, Batwa and Norrman (2020) mentioned a definitional fuzziness about the blockchain concept. Blockchain technology is still primarily associated with the finance domain (Justinia, 2019). However, the outcomes obtained from using these technologies fall within the overarching scope of SCF.

The traditional SCF concept is intrinsically based on multi-subject participation, asymmetric information, and non-standard credit mechanisms (Du et al., 2020; Ma et al., 2019). The flaws in the traditional supply chains may increase the challenges firms and institutions face, particularly in times of unprecedented financial crises and lead to a lack of trust among different actors in the supply chain network. At this point, supply chains can utilise blockchain technology to create trust, data immutability, protection and security, operational efficiency, and collaboration in the whole supply chain network (Novotny et al., 2018; Chen and Wang, 2020; Peronja et al., 2020).

As a technical explanation, operations in blockchain technology are conducted by cryptographies and hashes used in transactions. Each transaction is shrouded in a block, including multiple transactions secured by cryptographic algorithms (Issaoui et al., 2019). The user members anonymously verify the algorithms, and each block incorporates a hash value of the previous block's header, which, in turn, forms the blockchain structure (Justinia, 2019). Since data are stored in multiple locations and information is disseminated between peers, blockchain technology becomes more secure against cyber-attacks in contrast to conventional database structures (Kimani et al., 2020)

Blockchain technology has expanded at the country and organisational levels in different forms (e.g. public, private, and consortium). While several countries, such as Singapore and the United Kingdom, have begun to adopt blockchain technology in their regulations (Kimani et al., 2020), blockchain technology has disrupted various industries, such as banking, healthcare, and transportation (De Aguiar et al., 2020; Dutta et al., 2020).

Firm-specific blockchain use is apparent in the literature as well. For example, Siemens captures data across supply chains by employing a cloud-based operating system called MindSphere (Siemens, 2020). Similarly, HTC introduced a blockchain-based phone which can only be bought in cryptocurrencies in the smartphone market (HTC Exodus, 2020). IBM and Maersk jointly developed a blockchain-enabled platform to improve shipping operations (Maersk, 2019). Accordingly, blockchain technologies hold significant potential to become a sound system of record in the supply chain domain by exceeding its widely explored financial practices (Justinia, 2019).

Although blockchain technology is widely used by organisations and proposed to overcome the inherent limitations in the classical structure of SCF, their utilisation and implementation on the way of achieving significant advancements in SCF remain questionable. The current literature explains this outcome through the technical challenges and limitations for adopting and implementing blockchain technology in multidisciplinary areas (Li et al., 2020). However, we argue that the way and for the purpose blockchain is used may not match the actual requirements of the stakeholders of the SCF field.

2.2. A literature review on the use of blockchain technology in the supply chain finance area

Although blockchain is utilised as a disruptive emerging SCF-oriented technology in the supply chain, its use remains hazy and needs to be disambiguated (Li et al., 2020; Karakas et al., 2021). From this point forth, in this study, specific keyword pairs were searched in two databases, ScienceDirect and Scopus, to draw the whole picture of the literature on the intersections between blockchain and SCF. The searches included peer-reviewed articles and available reviews until October 2020. Our investigation was carried out within the abstracts, titles, and keywords of the relevant studies (see Becker and Smidt, 2016) written in English. As presented in Table 1, we ended up finding 39 relevant studies; however, some articles were either inaccessible or outside the scope of the study (see Kucukaltan et al., 2020), thus they have been left aside.

Table 1. The number of studies regarding the use of blockchain and SCF in two databases

Keyword Pairs	ScienceDirect	SCOPUS	Total
“supply chain finance” ; “blockchain”	1	15	39
“supply chain” ; “finance” ; “blockchain”	6	36	

The literature review revealed that blockchain was investigated based on the related concepts used in supply chain-wide operations at the global level and context-specific studies at the country level. The concepts were also elaborated according to their specific relations with trade transaction processes and banking systems, cryptocurrencies and privacy protection, blockchain in reducing logistics costs, and supply chain financing across different industries.

From a broader perspective, Hooper and Holtbrügge (2020) examined the use of blockchain technologies within SCF in the international business domain and supply chain-wide operations. The study, which exploited secondary data sources, focused on the challenges and benefits of blockchain in multiple industries such as international finance, banking and insurance, supply chain management and logistics for global governance implications. Similarly, the study by Kimani et al. (2020) conceptualised the impacts of blockchain technology in the banking industry, capital markets and the sphere of corporate governance and international trade. The study concluded some emerging benefits of using blockchain technology, such as cost reduction and efficiency enhancement. Dutta et al.'s (2020) systematic review revealed several blockchain-related opportunities, possible societal impacts, trends, and challenges. In addition to the discourses in the literature, the authors also exemplified real-life applications in the finance, shipping, and manufacturing industries and proposed a research agenda for future studies.

The feasibility of blockchain technology for financial inclusion was explored through specific empirical studies. Erol et al. (2020) used a two fuzzy-based multi-criteria decision-making method to assess the feasibility of blockchain technology. The study that examined several industries in Turkey, i.e. logistics and supply chain, health, energy, finance and automotive, found finance the most feasible industry for blockchain implementations. The study by Lahkani et al. (2020), which utilised the data of Alibaba's open reporting for 2019, found a significant positive relationship between the use of blockchain technology and the effectiveness of e-commerce supply chain operations. In another study, Schuetz and Venkatesh (2020) described several challenges associated with blockchain usage for financial inclusion. They proposed some research questions on the antecedents, adoption, and outcomes of blockchain technology implementation in rural India.

More sophisticated research methods explored blockchain technology in banking systems and trade transaction processes. The study by Chen and Wang (2020), which employed a fractional-order calculus game model framed by the theory of nonlinear dynamics, verified

the feasibility of blockchain use in the financial credit banking system. Yu et al.'s (2020) study focused on the impact of supply chain financing in multi-sided market settings. The authors analysed both a traditional model with Platform Undertakes Guarantee strategy and a novel model with Customer Undertakes Guarantee strategy by using the method they developed based on the principles of the Stackelberg game. The study yielded optimal decisions for four leading players: a multi-sided platform, a customer, a bank, and multiple transportation service providers. In a conceptual paper, Bogucharskov et al. (2018) discussed the impact of blockchain application on two key trade finance instruments, factoring and digital letter of credit. The researchers concluded that blockchain technology could provide firms with a high level of functionality and security and reduce transaction costs in SCF processes. Although trust and security concerns were slightly stated, the focal concern of the blockchain papers in the banking and trade finance domain was cost reduction and processes facilitation.

The risk attitudes and privacy protection mechanisms in blockchain networks and applications in which cryptocurrencies and smart contracts were considered pioneering blockchain technologies were also studied. Choi (2020b) examined whether different risk attitudes (e.g. risk-averse, risk-neutral, risk-prone) influence the use of cryptocurrency or not in a three-echelon supply chain system. Additionally, the authors argued that the critical predictive factors might affect the optimal pricing decisions in the supply chain. In another operational risk-related paper, Choi (2020a) developed analytical models for both traditional and blockchain-supported garment supply chain systems and compared the optimal system performances of both types. Zheng et al. (2020), who explained the impact of risk-averseness on the selection of blockchain technology, performed a coupling analysis between blockchain and the supply chain factoring business. The researchers proposed several application scenarios of blockchain-based smart contract technology in the supply chain factoring business by adopting a game-theoretical perspective.

Regarding the privacy protection issue, Ma et al. (2019) introduced the architecture and privacy protection mechanisms of Hyperledger Fabric. They illustrated business scenarios of SCF by considering the actors in upstream and downstream segments. The different choices of blockchain-based accounting methods and traditional ledgers under various SCF scenarios were presented in the results. The use of blockchain is not limited to private mechanisms. Hütten (2019) searched an open-access and public blockchain, Ethereum, and analysed a

crisis on a failure of the decentralised autonomous organisation-DAO by exploring the discrepancies between the purported governance of blockchains and the practical control of them through expertise and reputation. In a public cloud, Laplante (2020) conceptually discussed how to create personal blockchains and presented the architecture of a life chain with different actors and components to build upon ideas and cases for using blockchain technologies. Lastly, Du et al. (2020) created a new SCF platform to solve fraud and trust issues of traditional SCF and then offered a method of using homomorphic encryption in blockchain to provide sensitive data privacy protection in the supply chain financial scenarios.

As a result, the studies that focus on banking systems, trade transaction processes, risk attitudes, and privacy protection mechanisms show that blockchain is mainly employed to overcome trust and security issues in finance-related supply chain operations. Such studies remained relatively limited in explaining other concepts and fields integrated with blockchain in supply chains. Therefore, additional research is needed to unveil more projections about the extensive use of blockchain technologies and their applications in different industries. Moreover, the distinctive characteristic of each industry requires more in-depth analyses.

In parallel to this need, blockchain-related financial operations were examined in the logistics industry. The study by Issaoui et al. (2019) discussed the gains, risks, and challenges that might emerge from the blockchain integrated smart logistics concept. From the angle of strategic management, Perboli et al. (2018) considered the effect of blockchain technology on reducing logistics costs and optimising operations. The researchers adopted a GUEST methodology (e.g. go, uniform, evaluate, solve, and test) and implemented the solution canvas in a case study on fresh food delivery. As a unique smart contract service implementation, Li et al. (2020) developed a blockchain-enabled logistics finance platform grounded in cross-layered architecture. Then, an experimental case study in e-commerce retail was conducted on this platform. Peronja et al.'s (2020) descriptive study compared traditional smart contracts (bill of lading) with a blockchain solution in the maritime industry. The study concluded that blockchain technologies hold great potential to save time and money and provide value throughout transportation processes. With a focal concern on warehousing activities, Fernández-Caramés et al.'s (2019) study simulated the design and evaluation of crewless aerial vehicles and a blockchain-based system for Industry 4.0 inventory and traceability applications. The performance of blockchain-enabled smart contracts was tested under various scenarios in which different warehouse environments were created.

Blockchain implementation relating to the SCF domain was also observed in industries such as academic publishing (Novotny et al., 2018), the airline industry (Di Vaio and Varriale, 2020) and healthcare and biomedical (Kim and Kim, 2018; Justinia, 2019; De Aguiar et al., 2020). For example, Novotny et al. (2018) analysed how the Hyperledger network can be used and leveraged in academic publishing. They exemplified the architecture of the IBM blockchain platform grounded on LinuxONE and described analytics tools for developing blockchain solutions. Batwa and Norrman's (2020) study investigated the integration of blockchain technology applications with supply chain components through semi-structured interviews carried out with four example companies (e.g. IBM and Maersk as a joint project) where these technologies were applied. In another study, Di Vaio and Varriale (2020) explored the link between blockchain technology, operations management, sustainability, and the airline industry through an extensive literature review, followed by a case study in the airport industry. Chen et al. (2020) introduced a blockchain-based IoT-driven platform for SCF in the auto retail industry and conducted a case study. Apart from the studies conducted from a financial standpoint, Kim and Kim (2018) explored the use of blockchain technologies in the healthcare field to increase the visibility of the whole blood cold chain system and minimise blood transfer time in particular situations. The authors proposed a private blockchain type relying on shared ledger technologies and presented the new blood supply process design on the Hyperledger. Likewise, Justinia (2019) discussed the use of blockchain technologies in the health and biomedical areas and synthesised several problems encountered in real-life practices that blockchain tends to address. Lately, De Aguiar et al. (2020) performed a literature review analysis on blockchain technology in healthcare. They summarised the methods and features and the pros and cons of the application domains.

All in all, based on the findings obtained from the comprehensively reviewed literature, it is apparent that diverse conceptual and contextual applications were highlighted at different levels. In this regard, a taxonomical summary of the normative literature on blockchain and SCF concepts is illustrated in Table 2.

Table 2. A summary of the literature review on blockchain and SCF

Standpoints	**Approaches**	**Integrated Concepts/ Applied Fields**	**Related Studies**

Financial-Oriented Use	General Exploration of the Concepts	International Business Domain and Supply Chain-Wide Operations	Hooper and Holtbrügge (2020); Kimani et al. (2020); Dutta et al. (2020)
		Contextualisation at the Country-level	Erol et al. (2020); Lahkani et al. (2020); Schuetz and Venkatesh (2020)
	Specific Exploration of the Concepts	Banking Systems	Chen and Wang (2020); Yu et al. (2020)
		Trade Transaction Processes	Ahluwalia et al. (2020); Bogucharskov et al. (2018)
		Risk Attitudes	Choi (2020a); Choi (2020b); Zheng et al. (2020)
		Privacy Protection	Ma et al. (2019); Hütten (2019) Laplante (2020); Du et al. (2020)
		Logistics Industry Scope	Issaoui et al. (2019); Perboli et al. (2018); Li et al. (2020); Peronja et al. (2020); Fernández-Caramés et al. (2019)
		Other Interested Fields: - Academic Publishing, - Application-Oriented, - Airport Industry, - Retail Industry	Respectively: Novotny et al. (2018); Batwa and Norrman (2020); Di Vaio and Varriale (2020); Chen et al. (2020)
Non-Financial-Oriented Use	Specific Exploration of the Concepts	Healthcare and Biomedical Applications	Kim and Kim (2018); Justinia (2019); De Aguiar et al. (2020)

As indicated in Table 2, it is apparent that trends, interests, and engagements of the use of blockchain technologies in SCF were largely neglected in previous studies. That is to say, extant studies in this intersected area remained either technical, anecdotal, or case-based rather than presenting the whole picture of the extent to which and in which connections these concepts have started to be used over time and how they are both mutually and with other associated notions discussed in different supply chain contexts. Furthermore, in terms of proposing and adopting theoretical approaches, the existing literature has remained silent on the role of blockchain technologies in supply chains, especially for the operations in the SCF area. The detailed and overarching investigation of engagements and interest of blockchain and SCF concepts with other notions in the supply chain can create impact and value for decision-makers on how to transfer blockchain technologies into organisations. We aim to address this issue by conducting a big-data enabled exploration, namely analysing the real-time searches of stakeholders using big data in Google. Therefore, the present study aims to address the academic and practical voids for different contexts by adopting a research method incorporating a structured literature review and a web analytics approach.

3. Methodology

This study adopts a web analytics approach. Web analytics refers to "a tool that collects clickstream data regarding the source of website traffic, navigation paths, and the behaviour of visitors during their website visits and that presents the data in a meaningful format" (Järvinen and Karjaluoto, 2015, p. 117). Web analytics is mainly used to track the behaviours of web users through querying combined sets of keywords selected by researchers (Nakatani and Chuang, 2011). This study examines how blockchain technologies are utilised in finance-related supply chain operations by encapsulating what searches, applications, and word pairs are employed in this connection.

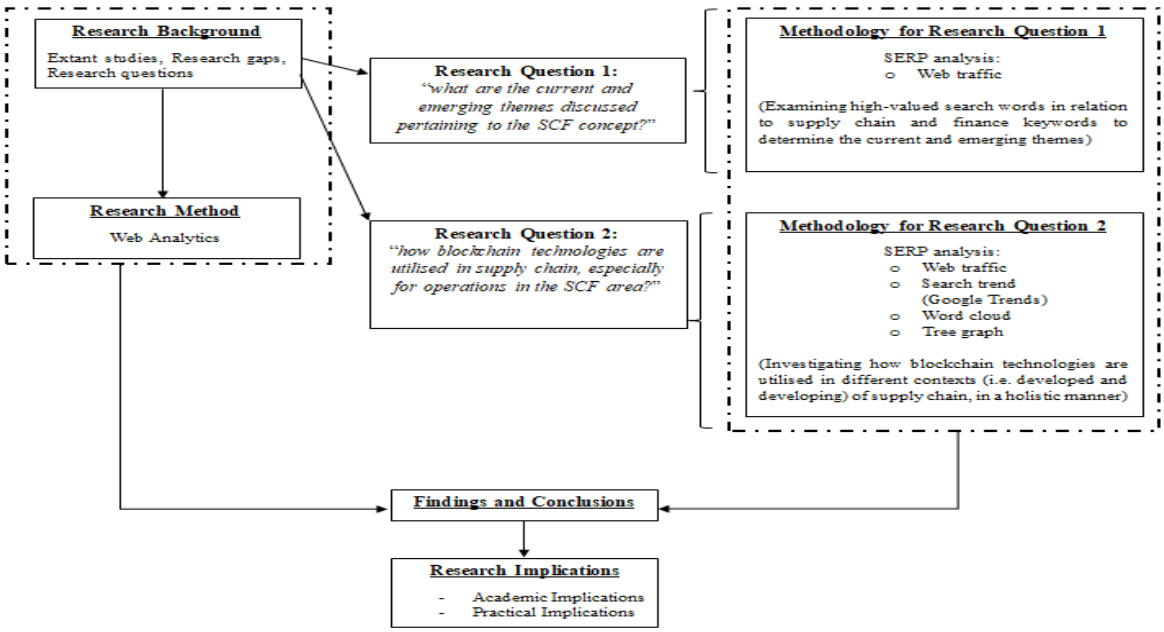

Figure 1. Research design

Figure 1 Alt Text: The three-phased research diagram consists of the research background and method in the first section. The second section shows the outcomes of the third section, which includes the methodologies for research question 1 and research question 2, in connection with research question 1 and question 2. At the bottom of these three sections, findings, conclusions, and research implications are linked to the first and the third sections.

The methodological process of the study that includes the research questions is illustrated in Figure 1. The present research deepens the way of exploring the current and emerging SCF-related themes and understanding how blockchain is utilised as an emerging SCF technology across the supply chain domain. A data set across the world business context that could provide sufficient information about these concerns becomes requisite for this research. Exploring global trends necessitates the use of objective and accurate data. However, traditional qualitative or quantitative research methods may not be suitable, producing

subjective and biased evaluations. Moreover, the use of big data for trend analyses compels researchers to discard traditional data collection methods, such as interviews or questionnaires, which may have sampling limitations. Thus, we selected the web analytics method since it covers real clickstream and accurate user data that show reliable human behaviour (Guercini et al., 2014; Katuu, 2018).

Web analytics techniques can be conducted by pursuing website traffic from user-web interactions occurring in several webs' drains, such as e-mail, search engines, display ads, and social links (Chaffey and Patron, 2012). Among these drains, search engines are considered critical gateways to the web. They have gained popularity in scientific research due to their effect on researchers who trace trends, interests, and interactions of items appearing on the web (Kamasak et al., 2017; Jiang et al., 2018; Gao and Shah, 2020).

Concerning the scientificness of the data, the web analytics technique relies on the big data concept about the contents shared on the whole web. From the epistemological and scientific perspective, different researchers have examined big data in terms of its ability and suitability to discover, appraise or validate theories and inductive inferences (Frické, 2009, 2015; Rodgers, 2010). Ongoing debates on the role of big data in the scientific investigation (Hey et al., 2009; Schmidt and Lipson, 2009; Järvinen and Karjaluoto, 2015; Park and Kipp, 2019) suggest that active experimentation can be used mainly for theory testing yet pragmatic studies, i.e. future trend analyses and predictions, require passive observation (Worrall, 2007; Floridi, 2012). This study unveils social and economic trends about SCF, blockchain, and supply chain through passive observation. Therefore, passive observation is deemed suitable, and big data is considered a reliable data source (Freedman, 2008; Frické, 2015). With its large-size web data and search volumes, the Google search engine was particularly favoured and extensively used by academics and practitioners in the area of interactive information retrieval (e.g. Lewandowski and Kammerer, 2020; Sanchiz et al., 2020) as well as in the fields of marketing and management (e.g. Jansen et al., 2007; Xiang et al., 2010; Geradin and Katsifis, 2019).

The large volume of data related to online activities in the Google network has led to a plethora of research focused on unveiling consumers' interests, social trends, and prediction of economic behaviours (Hubbard, 2011; Yang et al., 2014). The study by Choi and Varian (2009) used search engine data to forecast unemployment rates. Similarly, Ginsberger et al. (2009) searched for flu-related keywords on Google and predicted the influenza trend two

weeks ahead of the Centres for Disease Control and Prevention. Thus, these studies show that researchers broadly utilised search engine volume data for different purposes, including the help health centres combat diseases.

Several studies (e.g. Bar-Ilan et al., 2009; Haas and Unkel, 2017) criticised search engines on the production of potentially biased results. Yet, a recent paper by Lewandowski et al. (2020) suggested that biased, unrealistic (or at least simplistic) search results might only emerge in small-scale studies where commercial ads were entered into the analysis. The authors suggested that "large-scale interaction studies using real user data" (p. 7) should be the priority of the studies in which "cooperation between search engine companies and academia" (p. 79) is required. In line with this suggestion, commercial ads, traffic forwarding, and items labelled as commercial were excluded from our large-scale analysis, which covered all searches done across the world in the English language to increase the reliability of our findings. By doing so, we aimed to ensure that unrealistic user behaviour was not transferred to real search situations (Lewandowski et al., 2018; Schultheiß et al., 2018; Lewandowski et al., 2020). Since we were interested in the behaviour of real users, we performed a Google Search Engine Results Page (SERP) analysis which presented the search results where only organic pages were included (and paid ones were excluded). The primary rationale for mainly using Google was based on the fact that Google holds over 90% worldwide market share and dominates global digital (Kemp, 2021).

Consequently, we explored the trends, interactions, and appearance of togetherness of the used keywords on Google through a SERP analysis. The SERP query was conducted by well-known search engine toolsets, namely Ahrefs, Alexa, and Similarweb. Our investigation also aimed to reveal the real-time discussions and track the most recent review posts and popular terms about SCF on the web (White, 2016). The findings of SERP analysis were presented by web traffic charts and word clouds, which provide visual communication based on the most frequent words of documents.

4. Analyses of the interactions of blockchain technologies with finance and supply chain

The research was carried out in two stages. In parallel to the first research question, our analysis started to determine current and emerging themes about the SCF concept by searching web traffic for the following two keywords: supply chain and finance. This analysis helped us understand how supply chain and finance keywords interacted and find which contexts and discourses these two keywords were thematically used on Google searches. The

results would provide sufficient insights about the supply chain- and finance-related interests, behaviours, and emerging trends. Thus, we employed the SERP analysis using supply chain and finance keywords for a year between September 1, 2019, and September 1, 2020. As presented in Table 3, we obtained the competition level indexed values as the indicators (from 0-100) to show significant interest in the selected keywords in existing available data (otherwise, a dash is seen) for different search words. The competition level values of several prominent search words were higher than other search words.

Table 3. The competition level of several search words about the supply chain and finance keywords

Search words	**Competition Level**	**Competition Level (indexed value)**
financial supply chain management	Low	22
supply chain finance	Low	28
supply chain finance program	Medium	46
supply chain finance providers	Medium	48
supply chain finance software	Medium	65
top supply chain finance companies	High	69
supply chain finance for dummies	High	80

As seen in Table 3, since the search words of "supply chain finance for dummies" received a higher interest, the need for a deeper investigation on this particular search word directed us to the best-selling books, in which blockchain was primarily discussed within the concept of SCF. Thus, the SERP analysis at the first stage revealed a higher volume of web traffic concerning blockchain in SCF-related contents. The first research question was addressed at this step, and the findings emphasised the use of blockchain technologies as the primary current and emerging theme about the concept of SCF.

All keywords: 972 | Total volume: 7,170 | Average KD: 70.60%

Keyword	Volume	Trend
blockchain supply chain	2,400	
blockchain and supply chain	210	
blockchain supply chain management	90	
blockchain supply chain use cases	90	
blockchain supply chain walmart	90	
blockchain technology and supply chain	90	
blockchain technology in supply chain management	90	
implementing blockchain in supply chain	90	
mckinsey blockchain supply chain	90	
supply chain blockchain white paper	90	

Figure 2. The web traffic of supply chain and blockchain keywords

Figure 2 Alt Text: A supply chain and blockchain keywords web traffic graph including volume numbers and trend graphs.

The results of the first stage formed the basis of the second stage. We further analysed another web traffic through the SERP analysis where supply chain and blockchain were mutually used. Figure 2 shows more than 300 daily queries (in English) with supply chain and blockchain words in Google. To examine the reliability of these results, Google trends, which only cover high volume searches, were employed as an additional tool.

The Google trends tool encapsulates webpage duration, another critical element for enhancing reliability and revealing the established bonds between search words. Thus, the supply chain and blockchain togetherness was examined through the Google trends tool.

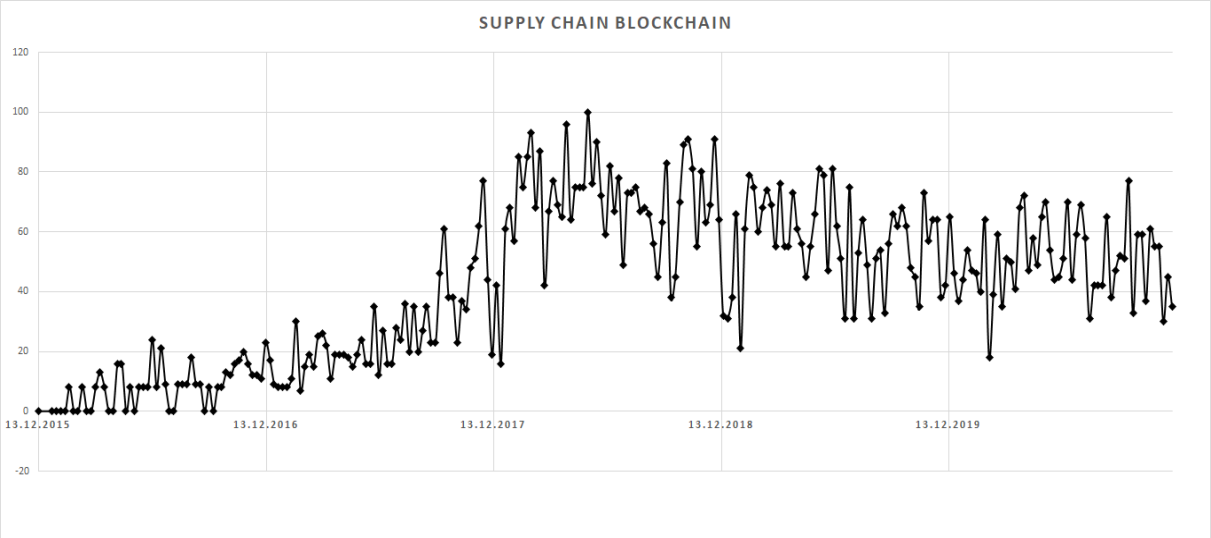

Figure 3. The togetherness of supply chain and blockchain queries on Google trends

Figure 3 Alt Text: A five-section line graph presenting the increase of supply chain and blockchain queries on Google trends between 2015 and 2019.

Figure 3 presents a rising trend of combined supply chain and blockchain queries. Moreover, the root of this trend shows that the first supply chain and blockchain query started at the end of October 2015 and peaked in May 2018, while the peak level for 2020 occurred at the beginning of May 2020. Considering the trend after 2015, we may infer that the supply chain and blockchain combination is a relatively new and potentially disruptive technology in the supply chain environment. The rising trend and interest in blockchain in the area of the supply chain requires a deeper analysis of these concepts. The interaction of supply chain and blockchain keyword pairs with other words in similar searches was also investigated to delve into the concepts and texts searched concerning these findings, as depicted in Figure 4.

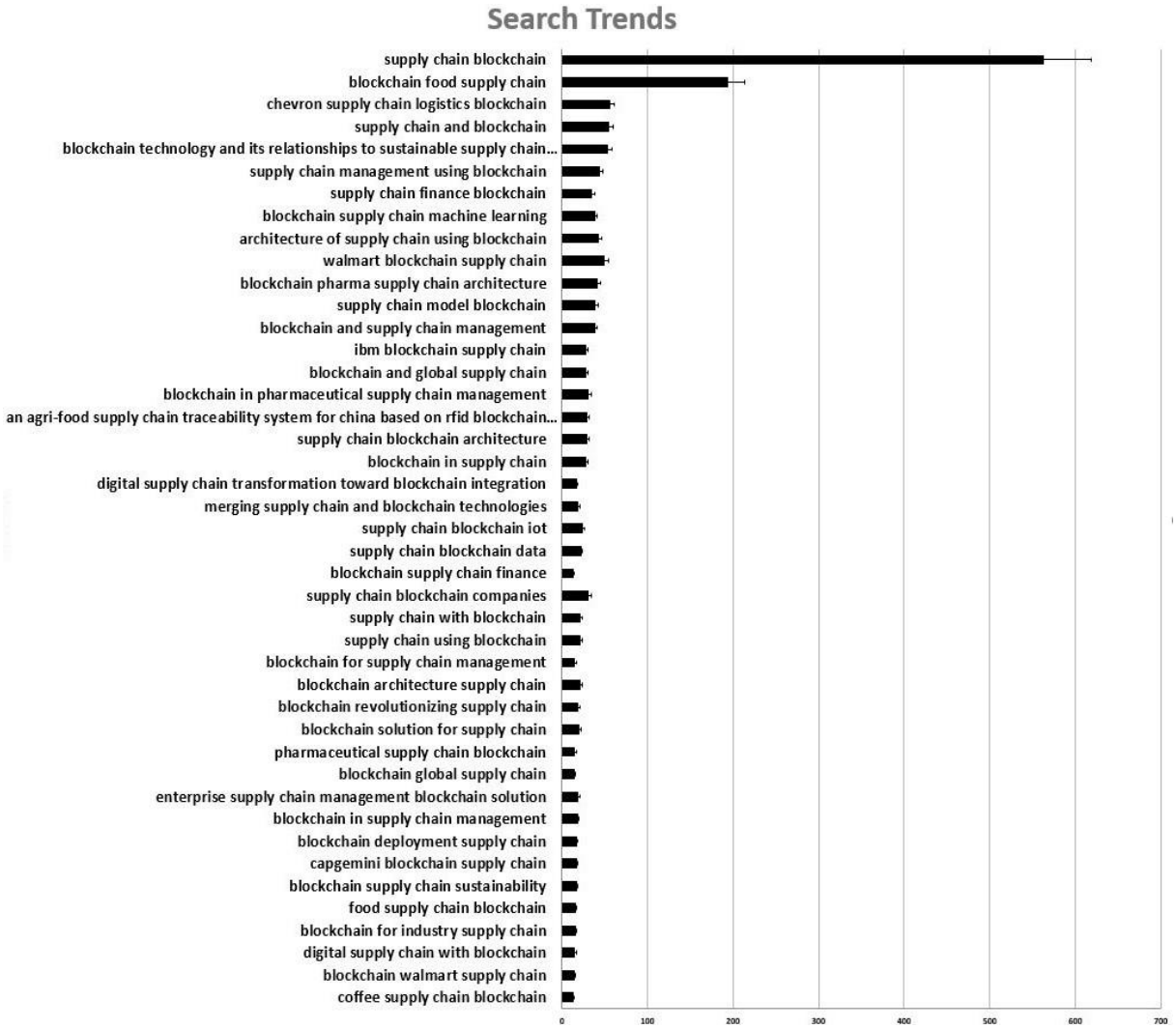

Figure 4. The text-based search trends used about the supply chain and blockchain keywords

Figure 4 Alt Text: A two-column diagram showing the text-based search trends of various supply chain and blockchain-related keywords

Moreover, using a word cloud as a follow-up approach can be a suitable option for showing the intensities of these interplays so that a more precise picture concerning the discussed concepts can be presented. Based on the frequency of words accumulated around the supply chain and blockchain keywords, a word cloud was formed to visualise the concepts depicted in Figure 4 (Figure 5).

Figure 5. The word cloud about the supply chain and blockchain keywords

Figure 5 Alt Text: A word cloud of various keywords in different sizes due to their frequent supply chain and blockchain keywords.

The word cloud in Figure 5 shows a strong association between the supply chain and blockchain. Namely, the related visible words provide some idea about the context in which supply chain and blockchain might interact. Thus, we can infer that the associated conspicuous word chunks may explain a business context where large companies (i.e. Walmart, IBM, and Chevron) might use blockchain technology for a more efficient and sustainable supply chain management. We can understand this from the search trends in which sentences, such as "supply chain blockchain and logistics", "supply chain management and blockchain", "digital supply chain and technology", were frequently mentioned.

The trend exploration also revealed that blockchain and finance were rarely used together in searches in the supply chain context. However, blockchain searches were usually done within the queries of SCF-related themes. The query results of "supply chain blockchain finance"

and “supply chain blockchain” word pairs were also compared and presented in a graphical form in Figure 6.

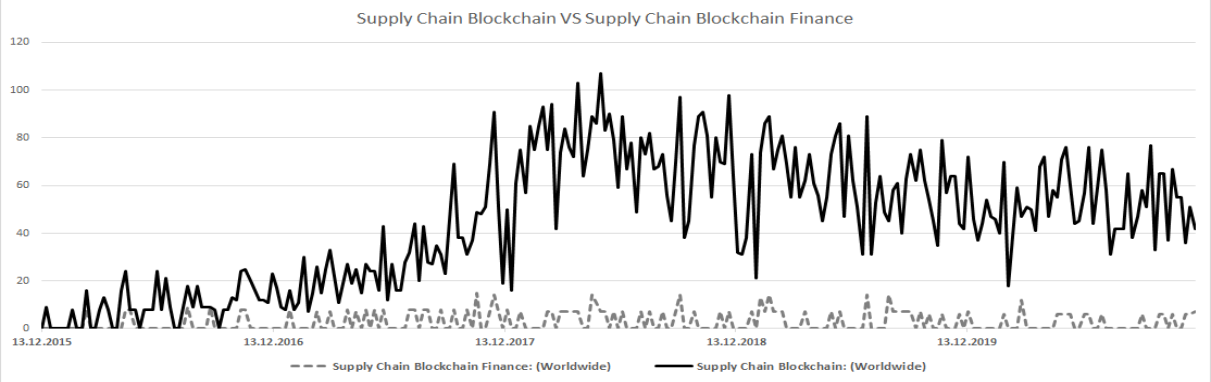

Figure 6. A comparison between the “supply chain blockchain finance” and “supply chain blockchain” word pairs

Figure 6 Alt Text: A five-section line graph compares the “supply chain blockchain finance” and “supply chain blockchain” word pairs between 2015 and 2019. The upper line, which represents the “supply chain blockchain” word pair, has a higher volume than the “supply chain blockchain finance” word pair shown in the lower line.

Comparing these trends, which explore the interest for both word pairs over time (between 2015 and 2020), reveals that the “supply chain blockchain” trend is significantly favourable in searches. Thus, it can be deduced that blockchain is mainly used to refer to the concept of SCF, particularly to tackle SCF-related themes in the supply chain environment.

It is also essential to probe into the supply chain and blockchain search words in different contexts to present a clearer picture. To this end, the volume of these searches for specific countries was explored by analysing web traffic interests. As indicated in Figure 7, the top ten countries worldwide are listed based on their search volumes.

Figure 7. Web traffic interest by region regarding the interest on supply chain and blockchain

Figure 7 Alt Text: A two-row word map indicating interest on supply chain and blockchain by region, and ten countries are ranked. Singapore, Malaysia, India, Netherlands, and Australia are listed first. Bangladesh, Canada, the United Kingdom, Germany, and United States are listed in the second row based on the volume of interest in these regions.

As seen in Figure 7, the regional web traffic regarding the supply chain and blockchain interest came from the countries where English was either the mother tongue (i.e. UK, Canada, US, Australia) or the official and widely spoken second language (i.e. Singapore, India, Malaysia, Netherlands). The only exceptions were Germany and France on the list. However, given the generic use of blockchain and supply chain words across global business contexts, we assumed that the influence of the queries in German and French might be negligible in this research.

Moreover, to have more detailed insights about supply chain and blockchain queries, especially in investigating what users made follow-up searches, a further analysis was conducted through “People also asked on Google Search” in this research. “People also asked” is a widget in SERP that hints at how the search engine tries to help users refine their search. The obtained data were analysed by “Gquestions.py”, a Python script, and Selenium, an automation browser library. A powerful JS library, “d3.js”, was used for the visualisation process, and the findings were visualised in the tree graph form. The searches were conducted in English since it is accepted as the lingua franca worldwide. As presented in Figure 8, a tree graph illustrates searches and queries mainly made in four different countries.

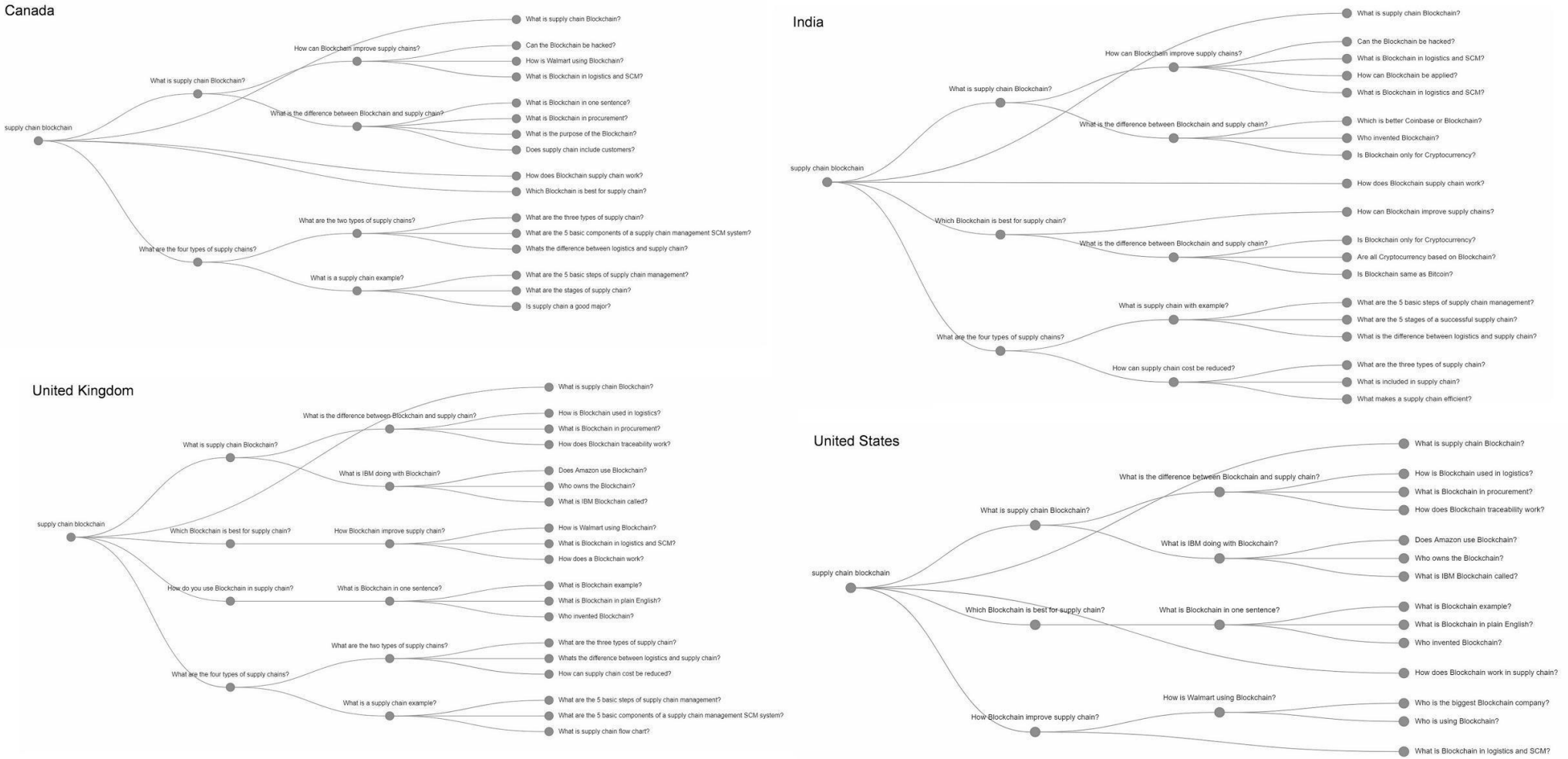

Figure 8. The search results regarding the UK, US, Canada, and India on the queries of supply chain and blockchain

Figure 8 Alt Text: In each country, similar, i.e. “What is supply chain blockchain?”, and different, i.e. “Who is using blockchain?”, search queries were made in the blockchain and supply chain context.

In Figure 8, the detailed search results regarding the UK, US, Canada, and India provide the nature of interest on supply chain and blockchain queries. In these contexts, the primary searches were: definitions of supply chain and blockchain, different types of the supply chain, the reasons for using blockchain in the supply chain, the types of blockchain which might improve supply chain performance, the use of blockchain in logistics, and performance effects of blockchain on supply chain and logistics. The typical questions that the searchers asked were, "what is supply chain and blockchain?", "which blockchain is best for the supply chain?", "how do you use blockchain in the supply chain?", "how does blockchain improve supply chain?". Thus, the word and question clusters reveal that blockchain is still in its early stages and is mainly considered an SCF-oriented technology in the adoption phase in supply chain practices.

5. Findings

In parallel to the research methodology that adopts a sequential approach starting with a comprehensive literature review and continuing with big data-driven web analytics, research findings are presented in two ways. Firstly, we analyse the findings that stem from the literature review. Our extensive literature review shows diverse conceptual and contextual applications of blockchain technology at different levels in the SCF area. Yet, the review reveals that studies (e.g. Perboli et al., 2018; Ma et al., 2019) are primarily discursive and majored around a few specific issues such as cost and security. Emerging trends, interests, and engagements of using blockchain technologies in SCF seem neglected. The vagueness and ambiguity in adopting practical blockchain implementations in different contexts are also apparent. One conspicuous finding was the overly emphasised relationship between blockchain and Bitcoin as well as other cryptocurrencies such as Ethereum and Ripple that might have decelerated organisations' adoption of blockchain technology (Francisco and Swanson, 2018; Saberi et al., 2019).

Furthermore, the findings of many anecdotal or single case-based studies conducted in particular industries, i.e. logistics and finance, offered a limited contribution to the field. The results of our systematic review corroborate with Kamble et al. (2019), who remarks blockchain is still a developing phenomenon with many unknowns on efficiency, effectiveness, and implementation issues in supply chains. Hence, additional empirical exploration of the extensive use of blockchain technologies and their applications in different industries is needed since each industry has several distinctive characteristics that may require

unique treatments (Wong et al., 2020). Concerning the intrinsic aspects of blockchain, blockchain technology adoption and implementation in the supply chain includes the integration of individual features, i.e. decision makers' personalities and attitudes and organisational features, i.e. availability of technology and social influence (Kamasak, 2017; Kamble et al., 2019; Wang et al., 2021). The interplay between blockchain technologies and the concept of technology adoption and relevant emerging trends that might shape organisational preferences should also be mastered. This situation requires sufficient information about the mechanisms enabling the collaboration between internal and external players at different levels (Dubey et al., 2020; Wong et al., 2020). However, the current literature remains inadequate in presenting a whole picture in which the connections of blockchain and SCF-related concepts and their interactions with other associated notions are clarified. The extant literature is also silent in proposing and offering theoretical approaches that may help organisations increase the operational effectiveness of blockchain technology in the SCF area. The lack of integration of blockchain and SCF-related emerging trends and notions domain of research manifests itself *inter alia* in the failure to understand the interactive effects between the mechanisms throughout the supply chain process to achieve the best financial and operational performance.

Secondly, we analyse the findings of web analytics. Our big data-driven web analysis yielded noteworthy results on blockchain and SCF-related emerging trends and notions. Against the extant literature that overly emphasises blockchain's role to finance supply chain operations, our queries in Google analytics diverted us to a different booming trend on blockchain and supply chain association. We cannot completely deny the interest in blockchain's cost, finance, and security benefits in supply chain operations. The analysis still showed web traffic on the usefulness and value of the blockchain in dealing with finance-oriented supply chain problems while establishing reliable and efficient financial structures. We may suggest that blockchain, which is still in its infancy, emerges as a disruptive technology in the supply chain from this angle. These findings corroborate the bibliometric analysis of Wamba and Quiero (2020), showing that the use of blockchain in the SCF field had a rising trend in academic publications until 2018. Blockchain adoption seemed like an immediate technological solution in the SCF area. However, our search reveals that finance and supply chain are rarely used together in the supply chain context. The real-time search words on the Internet illustrate the different engagement of blockchain in the supply chain. The web traffic results indicate a mismatch between blockchain's offering with its current use and what

organisations need or expect from blockchain in the SCF field. The queries provided clues about how blockchain technologies were utilised in the supply chain and the current state of the art for blockchain adoption. The findings imply the objective of using blockchain technology to increase and maintain the efficiency of supply chain systems.

The findings also offer insights into the country- and industry-based interest in blockchain technology. The tree graph analysis presented the web traffic interest in countries, enriching the knowledge in explaining the connections between supply chain and blockchain queries. While developed countries, i.e. the UK, US and Canada, remained fairly dominant in exploiting blockchain within the operational effectiveness and efficiency domain, the search results indicated an ongoing interest in developing countries, i.e. India and Bangladesh (not visualised in this study), regarding the use of blockchain for cryptocurrencies, finance and cost concerns in supply chain management.

This result might be explained by the higher level of financial exclusion in developing countries compared to developed ones (Larios-Hernandez, 2017; Schuetz and Venkatesh, 2020). Financial exclusion refers to lack of "access to appropriate, low cost, fair and safe financial products and services from mainstream service providers" (Varghese and Viswanathan, 2018, p. 2). Financial exclusion puts many people, i.e. marginal farmers, migrants, ethnic minorities, seniors, and women, out of using advantageous financial instruments, such as affordable credit and insurance products (Schuetz and Venkatesh, 2020). It is also common for citizens not to have bank accounts in developing countries (World Bank, 2017). Yet, without bank accounts and other digital instruments, farmers and micro firms, in particular, cannot connect to supply chain networks (Banerjee, 2016). Additionally, cost concerns in financial transactions can be more prioritised by rural developing country citizens. Therefore, the relatively more oncoming interest of developing countries in blockchain technology to resolve finance-related issues might be elucidated in this manner. In contrast, developed countries that addressed their finance-related issues through robust digital banking systems have already achieved high financial inclusion. Moreover, sophisticated logistics facilities can also help geographically distributed developed country firms connect to global markets. Thus, more interest in the efficiency and effectiveness of blockchain in supply chain management in developed countries where other supply chain-related issues were resolved might be explained in this manner.

Regarding the industry-based findings, food, agri-food, coffee and logistics were the most frequently mentioned industries in our web-analytics search. The traditional association between the supply chain and logistics and blockchain is a well-known issue (Wolfert et al., 2017; Yadav and Singh, 2020). Healthy water and food are the most vital elements for human beings, thus food traceability is critical in global value chains. Furthermore, agriculture and food industries include many suppliers, producers and service providers geographically dispersed worldwide in global value chains. The importance of connecting food and agriculture stakeholders with the worldwide supply chain to prevent breakings came to the fore with the emergence of the Covid-19 pandemic. In the hard times of the Covid-19 pandemic, the availability of commodities has been subject to operational effectiveness and efficiency rather than financial issues in global supply chains. Many developed countries with no financial limitations suffered from unreaching commodities. This situation made reformation needs more visible in supply chain operations. A radical shift in the interest from finance to effectiveness and efficiency in supply chains might be triggered by the Covid-19 pandemic. The need to improve supply chain effectiveness and efficiency through blockchain technology might fuel stakeholder interest that reflects our web analytics findings.

6. Discussion

This paper aimed to investigate the current and emerging themes about the SCF concept and the effectiveness of blockchain technologies in SCF operations based on a literature review and web analytics method. The study shows that proposing and adopting particular theoretical backgrounds were largely neglected by researchers in the field. From this point of view, previous studies remained mainly descriptive or problem-solving oriented in highly specific cases. Moreover, studies mostly were cost- and security-focused. Thus, the contribution of the extant literature to offer blockchain-based universal solutions that might help organisations address supply chain-related global challenges has been somewhat limited. The significant interest paid to blockchain's cost and security aspects seemed to be impactful to reducing costs but also restricted the ability of organisations to control critical processes such as monitoring labour practices (Kim and Davis, 2016), sourcing of suppliers (Niu et al., 2021), quality assurance (Yik et al., 2021), food and water security (Yadav and Singh, 2020), waste management (Franca et al., 2020), biodiversity (Kochupillai et al., 2021), and accountability (Hussien et al., 2019) in the supply chain. The potential of blockchain technologies to address these global challenges was frequently mentioned by several authors (e.g. Kim and Davis,

2016; Yadav et al., 2022), yet the vagueness about the adoption and implementation of these technologies in different contexts still exists in the literature.

Despite a considerable amount of studies that highlight the crucial role of blockchain in addressing the needs of supply chain stakeholders and producing and delivering services effectively (Büyüközkan and Göçer, 2018; Di Vaio and Varriale, 2020) in the global supply chain operations, a thorough explanation on the execution of this vital role is missing. Exploring supply chain stakeholders' real needs and expectations helps theorists and practitioners offer the best research and service through blockchain-enabled solutions. Yet, given the burgeoning background of the blockchain, deciding on implementing blockchain technologies in supply chain operations becomes rather challenging (Wamba and Quieroz, 2020). At this point, decision-makers at organisations may usually resist implementing emerging technologies under the realm of supply chain management. When decision-makers at organisations are not committed to tackling complicated issues, they do not undertake the necessary roles and transformation towards successful blockchain-enabled supply chain operations can be impeded (Mathivathanan et al., 2021). However, the actions of decision-makers can be prudently directed by concrete and insightful evidence from the supply chain field (Mathivathanan et al., 2021). Therefore, this research may support decision-makers for optimal strategic decisions and resource allocations in the supply chain ecosystem through advancing the literature and revealing the expected benefits from blockchain technologies.

A considerable amount of cryptocurrency-related web searches in developing countries, i.e. India, Turkey and Argentina, were observed, even if the queries were conducted using blockchain and supply chain words. According to the Global Crypto Adoption Index (2021), developing countries are the contexts where cryptocurrencies are most heavily used. One of the reasons for this result can be developing country citizens' and firms' efforts to preserve the value of their savings when local currencies are frequently faltering in financial markets. However, the rationales for cryptocurrency interest, which are shaped by unique culture and circumstances, may change from country to country. For example, while individuals and firms in India and Vietnam use cryptocurrencies as an investment tool instead of other good options irrespective of the inflation rate, African countries, i.e. Nigeria and Kenya, use cryptocurrency in peer-to-peer payments due to low crypto transaction costs. Therefore, the appearance of cryptocurrency-related issues in our web search, specifically in developing countries, is not surprising.

The search queries on blockchain, finance and supply chain togetherness revealed weaker web traffic on the cost and security than efficacy concerns in the supply chain. Thus, we can suggest that organisations might be considering the effectiveness- and efficiency-related effects of blockchain technology rather than cost, finance and data security. Specifically, our speculative yet guiding detailed search results regarding supply chain and blockchain queries in the top-listed countries emphasised the efficiency impacts of blockchain on supply chain operations. Therefore, the results of our literature review and big data-driven web analysis show a further need to identify the driving factors, challenges, and impediments to adopting and implementing effective and efficient blockchain technologies in the supply chain.

7. The implications for theory and practice

7.1. Implications for theory

The lack of a theoretical basis to explain the role of blockchain technologies in supply chain operations becomes apparent in this research. The literature review unveiled that previous research adopted a dualistic way, i.e. technical and case-based, for articulating the use of blockchain technologies within SCF. The insufficient understanding of how connections between blockchain, finance and supply chain concepts have been used over time to deal with inherent challenges limited the development of blockchain use in supply chain practices. Therefore, our findings on the web analytics exploration further expand the conceptual and contextual understanding of blockchain and how blockchain technologies are thoroughly utilised in supply chains. To our best knowledge, this is the first research of its kind enriching knowledge of the use of blockchain in supply chains as a disruptive SCF theme, using the degree of adoption and related connections (also with other notions) developed over time. Accordingly, the findings shed light on the vagueness of current discourses on emerging themes in this intersected area and on how these themes are used in the business ecosystem.

7.2. Implications for practice

The findings prove that the use of blockchain technologies in the SCF area remains a shallow field of application. However, there appears to be rising search interest for the togetherness of supply chain and blockchain queries made worldwide. Based on the probing questions for different countries, the research findings present how blockchain-related queries within SCF are made in various supply chain contexts. In this sense, the findings visualised by word cloud, trend plots and tree graphs may help practitioners who strive to establish efficient and

advanced supply chain management structures. The results may also offer implications to practitioners to capture recent trends, determine engagements among different related concepts, and take action to achieve sustained competitive advantage. Therefore, the projections and trends regarding the needs and use of blockchain can show strategic directions for practitioners to promote digital, efficient, and sustainable processes in the supply chain field.

7.3. Limitations and future research directions

The present research is not free from limitations. First, the word pairs were searched for in the abstracts, titles, and keywords of the studies, and two widely-known databases were used. Second, our literature review and Google search included only the material in the English language. However, similar research using other languages, i.e. French and German, may offer additional insights into SCF and blockchain concepts to capture and present the substantial traffic robustly and realistically rather than focusing on a narrow domain. Third, while addressing the first research question, the one with the highest competition level value was solely examined among the revealed search words concerning the supply chain and finance keywords. Consequently, the existing knowledge on the use of blockchain technologies in the SCF domain can be advanced in future studies by overcoming the mentioned challenges of this research.

8. Conclusions

The vital needs of people to survive could not be addressed in life without efficiently operating supply chain systems during the Covid-19 pandemic. Therefore, coupled with the increasing demand of people and businesses existing in the supply chain, more research was conducted to deepen the insights about what contributes to the supply chain processes. Several issues, such as fraud and the multitude of expenses of financial transactions and goods, caused concern in supply chains. Organisations employed technology-enabled solutions, such as blockchain technologies, to deal with these finance-oriented issues. However, previous research on the utilisation of blockchain in the supply chain field remained implicit and impotent to offer theoretical and practical insights. This study aimed to explore the current and emerging themes, notions and trends that might play different roles in increasing the effectiveness and efficiency of blockchain as a disruptive technology in supply chain operations. Therefore, this study:

- determines that blockchain is a prominent and widely-discussed SCF-oriented technology to overcome the inherent highlighted problematics in supply chain management.
- presents that the role of blockchain in security and trust issues in the finance domain is still apparent.
- provides evidence on the insufficient knowledge on blockchain implementation in the supply chain. Furthermore, the outcomes contribute to the effectiveness and efficiency of supply chain systems by revealing the trends (e.g. search words and search trends), themes (e.g. supply chain blockchain, blockchain food supply chain) and notions (e.g. efficiency and performance) that may play roles in the interactions between blockchain and supply chain in developed and developing countries.
- reveals that the purpose of blockchain implementation and use varies in developed and developing countries. While blockchain is widely associated with cryptocurrencies in developing countries, it is mainly employed to increase efficiency and effectiveness in supply chains.
- employes web analytics, an out-of-the-box research methodology, to analyse searches and queries made in Google regarding blockchain, supply chain and finance interaction and reveal emerging themes and trends that may help practitioners make prudent strategic decisions.

Data availability statement

The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

References

Ahluwalia, S., R. V. Mahto, and M. Guerrero. 2020. "Blockchain technology and startup financing: A transaction cost economics perspective." *Technological Forecasting and Social Change* 151: 119854.

Banerjee, M. M. 2016. “We routinely borrow to survive: Exploring the financial capability of income-poor people in India.” *Social Work* 61(4): 349-358.

Bar-Ilan, J., K. Keenoy, M. Levene, and E. Yaari. 2009. "Presentation bias is significant in determining user preference for search results—A user study." *Journal of the American Society for Information Science and Technology* 60 (1): 135-149.

Batwa, A., and A. Norrman. 2020. "A Framework for Exploring Blockchain Technology in Supply Chain Management." *Operations and Supply Chain Management: An International Journal* 13 (3): 294-306.

Becker, K., and M. Smidt. 2016. "A risk perspective on human resource management: A review and directions for future research." *Human Resource Management Review* 26 (2): 149-165.

Bogucharskov, A. V., I. E. Pokamestov, K. R. Adamova, and Zh N. Tropina. 2018. "Adoption of blockchain technology in trade finance process." *Journal of Reviews on Global Economics* 7: 510-515.

Büyüközkan, G., and F. Göçer. 2018. "Digital Supply Chain: Literature review and a proposed framework for future research." *Computers in Industry* 97: 157-177.

Cavusgil, S. T., Ghauri, P. N. and Liu, L. A. (2021). *Doing business in emerging markets* (3rd ed.). London: Sage Publications.

Chaffey, D., and M. Patron. 2012. "From web analytics to digital marketing optimization: Increasing the commercial value of digital analytics." *Journal of Direct, Data and Digital Marketing Practice* 14 (1): 30-45.

Chen, J., T. Cai, W. He, L. Chen, G. Zhao, W. Zou, and L. Guo. 2020. "A Blockchain-Driven Supply Chain Finance Application for Auto Retail Industry." *Entropy* 22 (1): 95.

Chen, T., and D. Wang. 2020. "Combined application of blockchain technology in fractional calculus model of supply chain financial system." *Chaos, Solitons & Fractals* 131: 109461.

Choi, H., and H. Varian. 2009. "Predicting initial claims for unemployment benefits." *Google Inc* 1: 1-5.

Choi, T. M. 2020a. "Supply chain financing using blockchain: impacts on supply chains selling fashionable products." *Annals of Operations Research*: 1-23.

Choi, T. M. 2020b. "Creating all-wi by blockchain technology in supply chains: Impacts of agents' risk attitudes towards cryptocurrency." *Journal of the Operational Research Society*: 1-16.

De Aguiar, E. J., B. S. Faiçal, B. Krishnamachari, and J. Ueyama. 2020. "A Survey of Blockchain-Based Strategies for Healthcare." *ACM Computing Surveys (CSUR)* 53 (2): 1-27.

Di Vaio, A., and L. Varriale. 2020. "Blockchain technology in supply chain management for sustainable performance: Evidence from the airport industry." *International Journal of Information Management* 52: 102014.

Du, M., Q. Chen, J. Xiao, H. Yang, and X. Ma. 2020. "Supply Chain Finance Innovation Using Blockchain." *IEEE Transactions on Engineering Management* 67 (4): 1045-1058.

Dubey, R., A. Gunasekaran, D. J. Bryde, Y. K. Dwivedi, and T. Papadopoulos. 2020. "Blockchain technology for enhancing swift-trust, collaboration and resilience within a

humanitarian supply chain setting." *International Journal of Production Research* 58 (11): 3381-3398.

Dutta, P., T. M. Choi, S. Somani, and R. Butala. 2020. "Blockchain technology in supply chain operations: Applications, challenges and research opportunities." *Transportation Research Part E: Logistics and Transportation Review* 142: 102067.

Erol, I., I. M. Ar, A. I. Ozdemir, I. Peker, A. Asgary, I. T. Medeni, and T. Medeni. 2020. "Assessing the feasibility of blockchain technology in industries: evidence from Turkey." *Journal of Enterprise Information Management* :(Ahead-of-print).

Fernández-Caramés, T. M., O. Blanco-Novoa, I. Froiz-Míguez, and P. Fraga-Lamas. 2019. "Towards an autonomous industry 4.0 warehouse: A UAV and blockchain-based system for inventory and traceability applications in big data-driven supply chain management." *Sensors* 19 (10): 2394.

Floridi, L. 2012. "Big Data and their epistemological challenge." *Philosophy of Technology* 25(4): 435–437.

Franca, A. S. L.; Amato Neto, J.; Goncalves, F.; Almeida, C. M. V. B. 2020. "Proposing the use of blockchain to improve the solid waste management in small municipalities." *Journal of Cleaner Production* 244: 118529.

Francisco, K., and D. Swanson. 2018. "The supply chain has no clothes: Technology adoption of blockchain for supply chain transparency." *Logistics* 2 (1): 2.

Freedman, D.A. 2008. "Oasis or mirage?" *Chance* 21(1): 59–61.

Frické, M. 2009. "The knowledge pyramid: A critique of the DIKW hierarchy." *Journal of Information Science* 35(2), 131–142.

Frické, M. 2015. "Big data and its epistemology." *Journal of the Association for Information Science and Technology* 66(4): 651–661.

Gao, R., and C. Shah. 2020. "Toward creating a fairer ranking in search engine results." *Information Processing & Management* 57 (1): 102138.

Gebhardt, M., M. Kopyto, H. Birkel and E. Hartmann. 2021. "Industry 4.0 technologies as enablers of collaboration in circular supply chains: a systematic literature review." *International Journal of Production Research*. https://doi.org/10.1080/00207543.2021.1999521

Geradin, D., and D. Katsifis. 2019. "An EU competition law analysis of online display advertising in the programmatic age." *European Competition Journal* 15 (1): 55-96.

Ginsberg, J., M. H. Mohebbi, R. S. Patel, L. Brammer, M. S. Smolinski, and L. Brilliant. 2009. "Detecting influenza epidemics using search engine query data." *Nature* 457 (7232): 1012-1014.

Global Crypto Adoption Index. 2021. “Worldwide Adoption Jumps Over 880% With P2P Platforms Driving Cryptocurrency Usage in Emerging Markets”. https://blog.chainalysis.com/reports/2021-global-crypto-adoption-index/ (Accessed 4 February 2022)

Guercini, S., A. La Rocca, A. Runfola, and I. Snehota. 2014. “Interaction behaviors in business relationships and heuristics: Issues for management and research agenda.” *Industrial Marketing Management* 43(6): 929–937.

Haas, A., and J. Unkel. 2017. "Ranking versus reputation: perception and effects of search result credibility." *Behaviour & Information Technology* 36 (12): 1285-1298.

Hey, T., S. Tansley, and K. Tolle. 2009. “The fourth paradigm: Data-intensive scientific discovery.” Redmond, WA: Microsoft Research.

Hofmann, E., and M. Rüsch. 2017. "Industry 4.0 and the current status as well as future prospects on logistics." *Computers in industry* 89: 23-34.

Hooper, A., and D. Holtbrügge. 2020. "Blockchain technology in international business: changing the agenda for global governance." *Review of International Business and Strategy* 30 (2): 183-200.

HTC Exodus (2020). Available at: https://www.htcexodus.com/eu/newsroom/2019-02-15/ , Accessed: 01.11.2020

Hubbard, D. W. 2011. *Pulse: The New Science of Harnessing Internet Buzz to Track Threats and Opportunities*. John wiley & sons.

Hussien, H. M., S.M. Yasin, S.N.I. Udzir, A.A. Zaidan, and B.B. Zaidan, B. B. 2019. “A Systematic Review for Enabling of Develop a Blockchain Technology in Healthcare Application: Taxonomy, Substantially Analysis, Motivations, Challenges, Recommendations and Future Direction.”, *Journal of Medical Systems* 43(10): 1-35

Hütten, M. 2019. "The soft spot of hard code: blockchain technology, network governance and pitfalls of technological utopianism." *Global Networks* 19 (3): 329-348.

Issaoui, Y., A. Khiat, A. Bahnasse, and H. Ouajji. 2019. "Smart logistics: Study of the application of blockchain technology." *Procedia Computer Science* 160: 266-271.

Jansen, B. J., A. Brown, and M. Resnick. 2007. "Factors relating to the decision to click on a sponsored link." *Decision support systems* 44 (1): 46-59.

Järvinen, J., and H. Karjaluoto. 2015. "The use of Web analytics for digital marketing performance measurement." *Industrial Marketing Management* 50: 117-127.

Jiang, Z., Z. Dou, W. X. Zhao, J. Y. Nie, M. Yue, and J. R. Wen. 2018. "Supervised search result diversification via subtopic attention." *IEEE Transactions on Knowledge and Data Engineering* 30 (10): 1971-1984.

Justinia, T. 2019. "Blockchain Technologies: Opportunities for Solving Real-World Problems in Healthcare and Biomedical Sciences." *Acta Informatica Medica* 27 (4): 284-291.

Kamasak, R. 2017. “The contribution of tangible and intangible resources, and capabilities to a firm’s profitability and market performance”. *European Journal of Management and Business Economics* 26 (2): 252–275.

Kamasak, R., U. Yozgat, and M. Yavuz. 2017. “Knowledge process capabilities and innovation: Testing the moderating effects of environmental dynamism and strategic flexibility.” *Knowledge Management Research & Practice* 15(3): 356–368.

Kamble, S., A. Gunasekaran, and H. Arha. 2019. "Understanding the Blockchain technology adoption in supply chains-Indian context." *International Journal of Production Research* 57 (7): 2009-2033.

Karakas, S., A. Z. Acar and B. Kucukaltan, 2021. “Blockchain adoption in logistics and supply chain: a literature review and research agenda.” *International Journal of Production Research*: DOI: 10.1080/00207543.2021.2012613

Katuu, S. 2018. “Using web analytics to assess traffic to the Mandela Portal: The case of African countries.” *New Review of Information Networking* 23(1–2): 1–18.

Kemp, S. 2021. “Digital 2021: Global Overview Report (27 January 2021)”, Available at: https://datareportal.com/reports/digital-2021-global-overview-report , (Accessed: 21.03.2021)

Kim, S., and D. Kim. 2018. "Design of an innovative blood cold chain management system using blockchain technologies." *ICIC Express Lett. B, Appl., Int. J. Res. Surv.* 9 (10): 1067-1073.

Kim, Y. H., and G. F. Davis. 2016. “Challenges for global supply chain sustainability: evidence from conflict.”, *Academy of Management Journal*, 59(6): 1896–1916.

Kimani, D., K. Adams, R. Attah-Boakye, S. Ullah, J. Frecknall-Hughes, and J. Kim. 2020. "Blockchain, business and the fourth industrial revolution: Whence, whither, wherefore and how?." *Technological Forecasting and Social Change* 161: 120254.

Kochupillai, M., U. Gallersdörfer, J. Köninger, and B. Roman. 2021.”Incentivizing research & innovation with agrobiodiversity conserved in situ: Possibilities and limitations of a blockchain-based solution.”, *Journal of Cleaner Production* 309:127155.

Kucukaltan, B., Z. Irani, and A. Z. Acar. 2020. "Business model canvas for humanitarian operations of logistics service providers." *Production Planning & Control*: 1-16.

Lahkani, M. J., S. Wang, M. Urbański, and M. Egorova. 2020. "Sustainable B2B E-Commerce and Blockchain-Based Supply Chain Finance." *Sustainability* 12 (10): 3968.

Laplante, P. 2020. "It Is Time to Seriously Consider Personal Blockchains." *IT Professional* 22 (5): 17-23.

Larios-Hernandez, G. J. 2017. “Blockchain entrepreneurship opportunity in the practices of the unbanked.” *Business Horizons 60*: 865-874.

Lewandowski, D., and Y. Kammerer. 2020. "Factors influencing viewing behaviour on search engine results pages: a review of eye-tracking research." *Behaviour & Information Technology*: 1-31.

Lewandowski, D., F. Kerkmann, S. Rümmele, and S. Sünkler. 2018. "An empirical investigation on search engine ad disclosure." *Journal of the Association for Information Science and Technology* 69 (3): 420-437.

Lewandowski, D., S. Sünkler, and S. Schultheiß. 2020. "Studies on Search: Designing Meaningful IIR Studies on Commercial Search Engines." *Datenbank-Spektrum*: 1-11.

Li, M., S. Shao, Q. Ye, G. Xu, and G. Q. Huang. 2020. "Blockchain-enabled logistics finance execution platform for capital-constrained E-commerce retail." *Robotics and Computer-Integrated Manufacturing* 65: 101962.

Ma, C., X. Kong, Q. Lan, and Z. Zhou. 2019. "The privacy protection mechanism of Hyperledger Fabric and its application in supply chain finance." *Cybersecurity* 2 (1): 1-9.

Maersk (2019). Available at: https://www.maersk.com/news/articles/2019/07/02/hapag-lloyd-and-ocean-network-express-join-tradelens , Accessed: 31.10.2020

Mathivathanan, D., K. Mathiyazhagan, N. P. Rana, S. Khorana, and Y. K. Dwivedi. 2021. "Barriers to the adoption of blockchain technology in business supply chains: a total interpretive structural modelling (TISM) approach." *International Journal of Production Research*: 1-22.

Nakatani, K., and T. T. Chuang. 2011. "A web analytics tool selection method: an analytical hierarchy process approach." *Internet Research* 21 (2): 171-186.

Niu, B. , Z. Shen and F. Xie. 2021. “The value of blockchain and agricultural supply chain parties' participation confronting random bacteria pollution.”, *Journal of Cleaner Production* 319: 128579.

Novotny, P., Q. Zhang, R. Hull, S. Baset, J. Laredo, R. Vaculin, D. L. Ford, and D. N. Dillenberger. 2018. "Permissioned blockchain technologies for academic publishing." *Information Services & Use* 38 (3): 159-171.

Park, H, and M. Kipp. 2019. “Library Linked Data Models: Library Data in the Semantic Web” *Cataloging & Classification Quarterly* 57(5): 261-277.

Perboli, G., S. Musso, and M. Rosano. 2018. "Blockchain in logistics and supply chain: A lean approach for designing real-world use cases." *IEEE Access* 6: 62018-62028.

Peronja, I., K. Lenac, and R. Glavinović. 2020. “Blockchain technology in maritime industry.” *Pomorstvo* 34 (1): 178-184.

Rodgers, J.L. 2010. “The epistemology of mathematical and statistical modeling: A quiet methodological revolution.” *American Psychologist* 65(1): 1–12.

Saberi, S., M. Kouhizadeh, J. Sarkis, and L. Shen. 2019. "Blockchain technology and its relationships to sustainable supply chain management." *International Journal of Production Research* 57 (7): 2117-2135.

Sanchiz, M., F. Amadieu, and A. Chevalier. 2020. "An evolving perspective to capture individual differences related to fluid and crystallized abilities in information searching with a search engine." In *Understanding and Improving Information Search*, pp. 71-96. Springer, Cham.

Schmidt, M., and H. Lipson. 2009. "Distilling free-form natural laws from experimental data." *Science* 324(5923): 81–85.

Schuetz, S., and V. Venkatesh. 2020. "Blockchain, adoption, and financial inclusion in India: Research opportunities." *International Journal of Information Management* 52: 101936.

Schultheiß, S., S. Sünkler, and D. Lewandowski. 2018. "We still trust in Google, but less than 10 years ago: an eye-tracking study." *Information Research: An International Electronic Journal* 23 (3): 799.

Siemens (2020). Available at: https://new.siemens.com/global/en/markets/food-beverage/exclusive-area/blockchain-iot.html, Accessed: 01.11.2020

Varghese, G., and L. Viswanathan. 2018. "Normative perspectives on financial inclusion: Facts beyond statistics." *Journal of Public Affairs* 18: 1-5.

Wamba, S. F., and M. M. Queiroz. 2020. "Blockchain in the operations and supply chain management: Benefits, challenges and future research opportunities." *International Journal of Information Management* 52: 102064.

Wang, Y., C. H. Chen, and A. Zghari-Sales. 2021. "Designing a blockchain enabled supply chain." *International Journal of Production Research* 59 (5): 1450-1475.

White, R.W. 2016. *Interactions with search systems*. Cambridge University Press.

Wolfert, S. L. Ge, C. Verdouw and M.J. Bogaardt. 2017. "Big data in smart farming–a review." *Agricultural Systems*, 153: 69-80.

Wong, L. W., L. Y. Leong, J. J. Hew, G. W. H. Tan, and K. B. Ooi. 2020. "Time to seize the digital evolution: Adoption of blockchain in operations and supply chain management among Malaysian SMEs." *International Journal of Information Management* 52: 101997.

World Bank. 2017. "The unbanked". Retrieved fromhttps://globalfindex.worldbank.org/sites/globalfindex/files/chapters/2017%20Findex%20full%20report_chapter2.pdf (Accessed 3 February 2022)

World Economic Forum. 2019. The Global Competitiveness Report; WEF: Geneva, Switzerland.

Worrall, J. 2007. "Why there's no cause to randomize." *British Journal for the Philosophy of Science* 58: 451–488.

Xiang, Z., B. Pan, R. Law, and D. R. Fesenmaier. 2010. "Assessing the visibility of destination marketing organizations in Google: A case study of convention and visitor bureau websites in the United States." *Journal of Travel & Tourism Marketing* 27 (7): 694-707.

Yadav, S. and S.P. Singh. 2020. "Blockchain critical success factors for sustainable supply chain". *Resources, Conservation and Recycling*, 152: 104505.

Yadav, V.S., A.R. Singh, A. Gunasekaran, R. D. Raut, B. E. Narkhede. 2022. "A systematic literature review of the agro-food supply chain: Challenges, network design, and performance measurement perspectives." *Sustainable Production and Consumption* 29: 685-704.

Yang, Y., B. Pan, and H. Song. 2014. "Predicting hotel demand using destination marketing organization's web traffic data." *Journal of Travel Research* 53 (4): 433-447.

Yik, M. H. Y., V.C.W.T. Wong, V. C. W. T., T.H. Wong, T. H., and P.C. Shaw. 2021. "HerBChain, a blockchain-based informative platform for quality assurance and quality control of herbal products.", *Journal of Traditional and Complementary Medicine*, 11(6): 598-600.

Yu, Y., G. Huang, and X. Guo. 2020. "Financing strategy analysis for a multi-sided platform with blockchain technology." *International Journal of Production Research* 1-20.

Zheng, K., Z. Zhang, and J. Gauthier. 2020. "Blockchain-based intelligent contract for factoring business in supply chains." *Annals of Operations Research*: 1-21.