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A review of challenges and opportunities of blockchain adoption for operational excellence in the UK automotive Industry

Abstract

Purpose – This paper aims to explore the challenges and opportunities of blockchain technology adoption from the lens of the TOE framework for operational excellence in the UK automotive industry context.

Design/methodology/approach– The research methodology of this study follows a systematic review approach, which analyses existing academic published research papers in the top 35 academic journals. There was no specific timeframe established for this study and shortlisting the articles through a set of used keywords. A sample of 71 articles was shortlisted and analysed to provide a discussion on technological and management challenges and opportunities of blockchain adoption from the lens of the TOE framework for operational excellence.

Findings– The findings of this study present significant theoretical and managerial implications and deep understanding for firms seeking to understand the challenges and opportunities of blockchain adoption for their operational excellence.

Research limitations/implication – Systematic literature approach was considered for the present study to explore existing academic papers on technological and management challenges and opportunities from the lens of TOE framework for operational excellence, whereas a more specified method meta-analysis can be considered for future research. The study has been explored in the UK automotive industry context, which has been considered as the limitation of generalization across countries and industries.

Originality/value – This paper represents the most comprehensive literature study related to the technological and management challenges and opportunities of blockchain from the TOE framework angle for operational excellence.

Keywords **-** Blockchain, Operational excellence, Technological and Management challenges and opportunities of Blockchain Adoption.

Article Classification: A literature review

1. Introduction

The UK automotive industry has become one of the main driving industries for employment as the "employees reported by signatories in 2017 increased by 7.5% to 113,500, agency workers also accounted for 17.4%, jobs that are dependent on the UK automotive industry increase to 856, while direct employment increasing by 2.8% to 186,000 in the UK automotive

manufacturing" (SMMT, 2019). It was revealed that the UK automotive industry is one of the key pillars that has transformed the UK economy (Bailey and Propris, 2017). For example, in July 2018, it was reported that there was "12.8%" increase in manufacturing commercial vehicles such as buses, trucks, vans, and coaches in the UK because of customers demand from overseas which was the driving output (SMMT, 2018a), which also contributed to the UK economy tremendously.

Despite the UK automotive industry economic contribution, there has been increasing pressure for UK carmakers to adopt technologies that can enhance their operations and supply chain due to the current trend of different technologies that are rapidly changing in the automotive industry (KPMG, 2017). To provide solutions to the current innovation challenges in this industry, blockchain technology was recommended as one of the technologies that can provide solutions to "seven key innovation opportunities", regarding the creation of new and superior customer experiences in the age of hyper convenience (SMMT, 2018b). It has been shown in the previous studies that were conducted over two decades that a lot of UK carmakers have attempted to enhance their supply chains operations such as delivery method and manufacturing processes (Caldwell and Smallman, 1996; Turner and Williams, 2005; Mortimer, 2005; Shaw, 1989). To support this commitment, empirical research conducted a few years ago and systematic literature review have also revealed that this industry has adopted various operations management approaches such as Japanese manufacturing model, in particular, Just-in-Time (JIT) manufacturing system (Turnbull *et al.* 1992), Japanese employment policies (Turnbull, 1988), total quality control (TQC) principles (Yusof and Aspinwall, 2001), supplier relations (Demirbas and Wilkinson, 2018), lean and agile production (Qamar and Hall, 2018; KPMG, 2017), team building via outdoor training (Lowe, 1991) without any concern about blockchain technology despite how blockchain has been recommended as one of the solutions to "seven key innovation opportunities" in the UK automotive industry (SMMT, 2018b) as stated earlier. Similarly, it was revealed in the report some of the largest car manufacturers in the world, including BMW and General Motors have joined software groups to create a new initative to use blockchain technology due how this industry is facing different innovative technologies (McGee, 2018). Therefore, this call for attention that needs to be focused on limited studies on blockchain technological and management challenges and opportunities in this industry within the UK context.

Blockchain is a technology that underpins bitcoin, is a distributed, decentralised, and public ledger structure that disintermediates third service provider in terms of transaction based on

Peer-to-Peer (P2P) network (Nakamoto, 2008; Larios-Hernández, 2017; Chen, 2018). Empirical evidence found that blockchain technology is a value of technology in supply chain management to extend visibility and traceability, supply chain digitalisation and disintermediation, improved data security and smart contracts (Wang *et al*. 2019a). According to Larios-Hernández (2017) in specific contexts, blockchain can lower transactional costs when individuals informal networks are exploited by local usury or led into labour, as well as when formal banking is not an option. Mani and Chouk (2018) asserted that investing in blockchain technology may be of interest in enhancing operational safety. Blockchain technology is an innovative approach that can contribute to the enhancement of operational excellence (Upadhyay, 2020). For example, empirical evidence found that blockchain can contribute to the business process to automatic reduce cost and enhance operations efficiency (Oh and Shong, 2017; Holotius *et al*. 2019). Similarly, one of the findings of research conducted by Sanders *et al.* (2018) suggested that the adoption of blockchain technology is connected to the success of traceability and transparency in which customer demands in terms of delivery of products are met.

It was asserted that blockchain technology is a radical innovation (Holotius *et al*. 2019). The adoption, implementation, and use of blockchain technology are growing gradually in different areas such as airline sector (Ying *et al.* 2018), while some firms and manufacturers such as car manufacturers that include Toyota has started using blockchain in its internal operations (Kouhizadeh et al. 2020) Though there have been relatively few studies on blockchain technology conducted by different researchers in the UK (White, 2017; Wang *et al.* 2019a; Cole *et al.* 2019) context, while there are ample of studies outside the UK (Queiroz *et al.* 2019; Yin *et al.* 2019; Saberi et al. 2018; Kamble *et al.* 2019), in particular, in other industries such as financial institution (Oh and Shong, 2017; Meijer and R.W, 2016). Despite the exploration of blockchain challenges and opportunities research in other areas (AI-Saqaf and Seidler, 2017; Upadhyay, 2020), most importantly, despite the degree of studies on blockchain technology in the automotive industry outside the UK (Kang *et al.* 2017), and the degree of studies in predicting the future of applications of blockchain in business and management in the UK (White, 2017), there is still limited empirical and systematic review studies on technological and management challenges and opportunities of blockchain adoption from TOE theoretical angle for operational excellence in the UK automotive industry (Cole et al. 2019; Wang et al. 2019a). Though this might be due to the novelty of this technology. Therefore, the present study aims to fill this research gap by reviewing and providing evidence of technological and

management challenges and opportunities blockchain adoption from the lense of TOE framework for operational excellence in the UK automotive industry. Additionally, it appears that comprehensive and systematic review study on technological and management challenges and opportunities of blockchain adoption for operational excellence outside the UK automotive industry has not received much attention in the academic literature compared with other innovation and management approaches such as supply chain management (Turner and Williams, 2005; Benito *et al.* 2013; Queiroz *et al.* 2019; Queiroz and Wamba, 2019), Lean Six Sigma (Habidin and Yusof, 2013; Swarnaker and Vinodh, 2016) etc.

Even though the academic researchers have agreed that blockchain technology will disrupt the business structure i.e status quo (Wang et al. 2019a; Clohessy and Acton, 2019; Treiblmaier, 2018; Gurtu and Johny, 2019; Boukis, 2019; Kouhizadeh et al. 2020), provide cybersecurity to supply chain (Min, 2019), in particular, to facilitate operational excellence (Moktadir et al. 2020), yet, there are still need to be aware of possible challenges facing blockchain technology (Min, 2019; Kher et al. 2020; Upadhyay, 2020; Ali et al. 2020; Vincent, 2020; Helliar et al. 2020) such as cybercrime (Chang et al. 2020a) or cyberattack (Biswas and Gupta, 2019) and its opportunities (Jianchao et al. 2020; Upadhyay, 2020; Herian, 2017) for operational excellence in the automotive industry. These challenges and opportunities are classified as technological and management challenges and opportunities and incoporated into TOE farmewoke. for a holistic understanding of firms that are not familiar with these challenges and opportunities Therefore, technological context includes blockchain technological challenges such as open network designs (O'Leary, 2017; O'Leary, 2018), security and privacy challenges (Upadhyay, 2020; Chang et al. 2020a), wasted resources or energy consumption (Frizzo-Barker, et al. 2020; Chang et al. 2020a), lack of interoperability challenges (Upadhyay, 2020), scalability challenges (Min, 2019; Upadhyay, 2020; Chang et al. 2020a; Biswas and Gupta, 2019); blockchain technological opportunities include disintermediation of third-party service provider opportunities (Shermin, 2017; Manski, 2017; Herian, 2017; Upadhyay, 2020; Schuetz and Venkatesh, 2019), transaction cost reduction opportunities (Upadhyay, 2020), security opportunities (Kouhizadeh et al. 2021; Wang et al. 2019b); Organisational conext includes blockchain management opportunities such as knowledge sharing management opportunities (Li et al. 2018; Chang, et al. 2020a), supply chain management opportunities (Wang et al. 2019a), and new business model opportunities (Delafenestre, 2019; Tiscini et al. 2020; Upadhyay, 2020); the blockchain management challenges that were revealed include lack of advanced level of blockchain technical expertise, and enviormntal conext includes government regulatory and legal issue that can affect the adoption of blockchain at the firm level

(Upadhyay, 2020; Min, 2019; Manski, 2017; Herian, 2017; Orji et al. 2020; Biswas and Gupta, 2019). Even though these studies have explored challenges and opportunities of blockchain technology and even if a few of these studies (Upadhyay, 2020; Ali et al. 2020; Chang et al. 2020a; Kumar et al. 2020; Min, 2019; Queiroz, et al. 2019; Cole, et al. 2019) have laid a research foundation for the present study, exploring the technological and management challenges and opportunities of adoption from technological – organisational – environmental (TOE) angle for operational excellence in the automotive industry is yet to be explored (Kouhizadeh et al. 2021; Liu et al. 2020; Clohessy and Acton, 2019; Orji et al., 2020).

Technology – organisational – environmental (TOE) explains factors that affect the adoption of technology and likelihood (Tornatzky and Fleischer, 1990). TOE framework has been used to explore different issues in different industries (Orji et al. 2020), in particular, the automotive industry (Wang et al. 2020; Lin et al. 2018). The technological, organisational, and environmental (TOE) represented challenges/constraints and opportunities for technological innovation and influenced the technological innovation of the firm's level according to Tornatzky and Fleischer (1990). Therefore, this concept is appropriate to explore the challenges and opportunities of blockchain adoption (Clohessy and Acton, 2019). Other factors that are impacting technology adoption, which differs from common constructs of TOE framework such as top management (Puklavec et al. 2020), complexities (Orji et al. 2020) etc can be incorporated into technology – organisation – environment (TOE) framework (Nam et al. 2019; Aboelmaged, 2014). Therefore, the present study provides in-depth understanding into an analysis of information systems (IS) adoption by exploring 12 factors incorporating into the technology – organisation – environment (TOE) context to discuss technological and management challenges and opportunities of blockchain adoption based on the research published in the business and management academic journals for operational excellence in the UK automotive industry. In general, the key aim of the present study is to systematically review the existing academic literature on the technological and management challenges and opportunities of blockchain adoption to identify research topics that have been addressed, which can be considered for operational excellence in the UK automotive industry. Therefore, to achieve this objective the present study aims to address the following research question through a systematic literature review (SLR) (Srivastava, 2007; Tranfield et al. 2003; Denyer & Tranfield, 2009):

1. What are the technological and management challenges and opportunities of blockchain adoption from the lens of the TOE framework for operational excellence in the UK automotive industry?

The rest of this paper is structured as follow. Section 2 of this paper provides the theoretical foundation for the present topic at hand, section 3 explains systematic literature review methodology followed in this paper in detail, section 4 reports the findings based on the shortlisted sample articles from this study, section 5 discusses blockchain, operational excellence, blockchain technological challenges, blockchain management challenges, blockchain opportunities, and blockchain management opportunities. Section 6 is the conclusion of this paper, which highlights both limitations and future research direction of this paper.

2. Theoretical Background

2.1. Technological – organisational – environmental (TOE)

Different academic studies have shown that several theories can be used to explore the challenges and opportunities of new technology adoption (Fuchs et al. 2020; Egi, 2020; Dhirasasna et al. 2020) such as the technological – organisational – and environmental (TOE) framework that has been used frequently for challenges and opportunities of technology adoption (Abed, 2020; Maroufkhani et al. 2020), in particular, to understand various challenges and barrier for blockchain adoption within supply chain management context (Kouhizadeh et al. 2021; Liu et al. 2020). Tornatzky and Fleischer (1990) developed Technology – organisational – environmental (TOE). TOE framework explains factors that affect the adoption of technology and likelihood (Tornatzky & Fleischer, 1990) such as blockchain adoption barriers and drivers (Kouhizadeh et al. 2021; Liu et al. 2020). The technology – organisation – environment (TOE) provide challenges and opportunities for technology innovation according to Tornatzky and Fleischer (1990). In their book, technology context

represents the availability and the features of technological innovation; organisation context describes top management, the resources of the firm such internal tool and specialisation, human capital size; and environment context refers to certain operational inhibitors and facilitators, importantly, these include environment or government regulatory, infrastructures that include technology support by connecting to technology consultants in quality ICT.

Previous studies have used various technology adoption theories such as TAM, UTAUT etc as their basis to study the challenges and opportunities of technology adoption at the individual level (Li and Chang, 2020; Patil et al. 2020). TOE framework takes a view of the organisation as a whole beyond the individual perspective. Though this approach differs from the work of Kouhizadeh et al (2021) who used the TOE framework approach to explore the challenges and opportunities of blockchain adoption at the individual level. Largely, the TOE framework has been used at the firm level to understand the challenges/barriers and opportunities for technology adoption (Ali et al. 2020; Abed, 2020). The adoption of blockchain by the firm is important since the adoption of technology is usually implemented by the decision of the firm rather than the decision of a single employee. After all, the adoption of blockchain technology signifies a major investment for the firm. Though the diffusion of innovation theory would have been considered for the present study, however, despite the popularity of this theory it does not usually accommodate other constructs. Therefore, since the present study aims at exploring challenges and opportunities of blockchain adoption for operational excellence in the UK automotive industry context by targeting the firm as a whole and since this theory is suitable at TOE framework to discuss technological and management opportunities of blockchain adoption for operational excellence.

2.2. Blockchain Technology

Blockchain technology was revealed as a technology that underpins Bitcoin in a white paper by Nakamoto (2008), the progress of blockchain literature and author productivity of

blockchain in different areas have been reviewed and are increasing (Miau and Yang, 2018; Adams, et al. 2017; Chang, et al. 2020a). Blockchain is one of the transformative technologies transforming different industries across the globe (O'Dair and Beaven, 2017; O'Dair and Owen, 2019; Sanders et al. 2018; Diestelmeier, 2019; Zhang et al. 2020) such as financial sector (Scott et al. 2017; Cai, 2018; Zhang et al. 2020), fish industry (Tsolakis et al. 2020) in particular, the automotive industry (Kang, *et al*. 2017) in which researchers proposed "blockchain-based distributed framework" for the automotive industry (Sharma *et al*. 2018), and it has been examined for different areas such as supply chain, operations management etc. (Treiblmaier, 2018; Wang et al. 2019a; Thurner, 2018; Queiroz et al. 2019; Queiros and Wamba, 2019). The truth about blockchain is that it helps to make existing systems more efficient, and Ethereum smart contract technology allows developers to build applications to create a business that run themselves with distributed and decentralised profit margins, management, services according to Manski (2017).

There are various applications of blockchain technology, which can be used for achieving operational excellence. These applications of blockchain include blockchain-based smart contracts (Sheth and Subramanian, 2019), blockchain-based decentralised cryptocurrencies (Yuan and Wang, 2018), traceability in the supply chain (Behnke and Janssen, 2019), international payment (Ali et al. 2020) etc. According to Iansiti and Lakhani (2017) "blockchain is a foundational technology: it has the potential to create new foundations for our economic and social systems". For example, exploration study shows the potential impact of blockchain technology enables a new system of value that will better support the dynamics of social sharing (Pazaitis *et al*. 2017) and change how people interact around the globe. Initially, Nakamoto (2008) presented blockchain as a technology that underpins Bitcoin, which is one of the cryptocurrencies to permit any two persons that are willing to transact directly with each other without requiring for a trusted third party or provider, for example, the trusted third

parties that used to be required between two parties that are willing to transact with each other include banks or certification authorities (CA), legal practitioners, brokers etc (Iansiti & Lakhani, 2017).

2.3. Operational Excellence

According to Dungan (2012) "operational excellence is one of today's key management themes for-profit and non-profit organisations". The meaning and the use of operational excellence is different from one scholar to another (Olhager and Person, 2006), from one company to another (Treacy and Wiersema, 1993; Power, 2013), and there are lots of different operational excellence models that had been built by different scholars (Edgeman, 2018; Sony, 2019). Similarly, they have been different academic published literature reviews on how operational excellence was originated (Sony, 2019; Olhager and Person, 2006).

Definitions of operational excellence differ from one scholar to another. For example, Treacy and Wiersema (1993) defined operational excellence as "the provision of reliable products or services to customers at competitive prices and delivered with minimal difficulty or inconvenience". Similarly, operational excellence in the recent study conducted by Cui et al. (2020) shows that "operational excellence is a management system designed to achieve customer value through innovation and technology development". They argued that operational excellence aims at continuously improving the process of operation and the effectiveness and efficiency of the industrial system. A lot of papers have suggested different methods of how operational excellence can be implemented and achieved in different industries. For instance, a study revealed that operational excellence can be the adoption of technological innovation for the reduction of operational cost and meeting customer demand (Santa *et al*. 2014). Similarly, different concepts such as "audit sheet" and "Lean Six Sigma"

were suggested by Vrellas and Tsiotras (2015) for the implementation of operational excellence as one of the methods for solving problems. A research conducted by Cui et al. (2020) argued that operational excellence can be achieved through the internet of things (IoT) to improve supply chain collaboration.

As different researchers have conducted different studies for achieving operational excellence through the use of different approach such as "audit sheet" and Lean Six Sigma", in particular, the internet of things (IoT) to achieve operational excellence, there is still a limited study on exploration of blockchain adoption for operational excellence to understand its technological and management challenges and opportunities, in particular, in the automotive industry despite how the researchers have encouraged a study of blockchain technology "from an operations" viewpoint (Cole et al. 2019) and despite how it was revealed that operational excellence can be the adoption of technological innovation (Santa *et al*. 2014). Therefore, understanding the technological and management challenges and opportunities of blockchain adoption for operational excellence called for attention.

3. Methodology

The present study focuses on discussions and analyses of existing literature in business and management, to explore the challenges and opportunities of blockchain adoption and for operational excellence in the UK automotive industry context. There are several studies based on different methods in which various journals have published. For example, in the UK, empirical research conducted by White (2017) only focused on the future of blockchain applications without any concern about the challenges of blockchain adoption. Similarly, the present study finds related studies that were conducted by the researchers in the UK (Cole et al. 2019; Wang et al. 2019a). For example, various opportunities and challenges of blockchain for supply chain were explored by Cole et al. (2019) without any concern about the lack of interoperability, which is one of the blockchain challenges. Also, the drivers and challenges/barriers of blockchain were identified by Wang et al. (2019a) within the supply chain in their research without any concern about open network design challenges. These two studies that were found in the UK have not explored this issue from the TOE framework angle

despite the fact TOE framework has been used for barriers and drivers of blockchain adoption at the individual level in another country (Kouhizadeh et al. 2021).

Similarly, there have been some studies that have explored challenges (Upadhyay, 2020; Min, 2019; Manski, 2017; Herian, 2017; Biswas and Gupta, 2019; Frizzo-Barker et al. 2020; Chang et al. 2020a; O'Leary, 2018; O'Leary, 2017) and opportunities of the blockchain (Li et al. 2018; Chang et al. 2020a; Wang et al. 2019a; Delafenestre, 2019; Shermin, 2017; Manski, 2017; Tiscini et al. 2020; Upadhyay, 2020) in other countries, but these studies have only emphasised on a limited scope of blockchain challenges and opportunities and have not considered exploring this area for operational excellence in the automotive industry without any concern about TOE framework (Upadhyay 2020; Ali et al. 2020; Chang et al. 2020a; Kumar et al. 2020; Min, 2019). Therefore, it is fair to say that comparatively less study exists in the automotive industry to explore the challenges and opportunities of blockchain among automakers aiming to achieve operational excellence (Kouhizadeh et al. 2020). As blockchain technology promises to revolutionise business activities in the future, focuses on eliminating trusted third party between two people who are willing to transact together, and cutting cost for firms, calls for attention to be aware of the challenges and understanding of the opportunities of blockchain in the business operations. Understanding the basic blockchain technological and management challenges and opportunities of blockchain adoption from the TOE framework in the UK automotive industry for operational excellence is a gap in the literature that this study aims to fill by systematically review existing academic journal articles(Cole et al. 2019; Wang et al. 2019a).

Systematic literature review means exploring existing and selected journal articles from various databases and sources for research study purposes (Hohenstein *et al*. 2014) and is being used as well-organised methods for accomplishing wide literature review (Agarwal *et al*. 2017). Several systematic literature review papers have been published in business and management focused on various significant topics (Steininger, 2019; Queiroz *et al*. 2019; Cai, 2018). According to Tranfield *et al*. (2003) "systematic review provides a means for practitioners to use the evidence provided by research to inform their decision". A systematic literature review assists to recognise the theoretical content of the field and it can add to theory development

(Atewolohun *et al*. 2017; Nolan and Garavan, 2016). Recently, there have been limited literature review papers within the area of related research (Cole et al. 2019; Wang et al. 2019a). For example, Miau and Yang (2018) selected articles ranging from 2008 to 2017, resulting in a timeframe of 9 years for a blockchain literature review. Recently, 27 peer-reviewed journals in blockchain between 2008 and 2018 were reviewed and analysed by Queiroz *et al*. (2019). While a systematic literature review was conducted by Wang *et al*. (2019a) between the periods of December 2017 and January 2018. The researchers selected 24 published articles for understanding blockchain for the future supply chain. As stated earlier, there is a limited study of blockchain technological and management challenges and opportunities for operational excellence (Upadhyay, 2020; Ali et al. 2020; Chang et al. 2020a; Kouhizadeh et al. 2021 Cole et al. 2019; Wang et al. 2019a), in particular, in the automotive industry (Culot et al. 2020). Therefore, it seems proper to address this research gap due to the report, discussion, and concerns in adopting cutting-edge technologies such as blockchain in the UK automotive industry(SMMT, 2018b) as a report by the UK government has predicted that the adoption of blockchain technology would play a significant role in the UK where the technology might transform "financial markets, supply chains, customer and business-to-business services, and publicly-held registers" (Government Office for Science, 2016).

A systematic literature review approach was adopted based on collecting and analysing a set of published academic journal articles (Chugani *et al*. 2017; Queiroz et al. 2019). The present study aims to follow a related methodology and structure of selected articles from academic journals, which related to the works of Chugani *et a.l* (2017), Garza-Reyes (2015), Tian *et al*. (2018), Jensen, (2012), Strivastava (2007). However, based on these indicated studies, the method of analysis comprises five steps that have been used in the previous study (Jensen, 2012). Following this systematic process guarantees an effective and well-organised review. Therefore, these five steps are adapted from the published academic journal articles for this

study (Srivastava, 2007; Jensen, 2012). These five steps include (1) defining the unit of analysis, (2) classification context, (3) material evaluation, (4) collecting publications, and (5) delimiting the field. These steps are shown in Table 1. Similarly, starting from the research question to the discussion of the research findings will also be based on the systematic review process of Tranfield et al. (2003).

Table 1. Summary of research methodology

Unit of analysis	The unit of analysis in this study is based on the exploration of existing academic research articles through a systematic literature review search
Classification context	The articles used in the present study are structured and categorised based on the five contexts: First, classification of academic articles according to the published journal, second; classification of numbers of published journal articles found on the blockchain, blockchain technological challenges, blockchain management challenges, blockchain technological opportunities, and blockchain management opportunities; third; classification of the used articles into model approach context, blockchain application context, main theoretical approach, author, and the year, fourth; this classification was based on the publication year of the articles, while the fifth classification was based on the categorization of blockchain application in different industries, the year, and the number of articles found in the present study.
Material evaluation	The present study analysed all selected articles within the classification context described above.
Collection of publications	The present research searched for articles based academic journals by using the keywords 'Blockchain', 'Blockchain Technological Challenge', 'Blockchain Management Challenges', 'Blockchain Technological Opportunities', and 'Blockchain Management Opportunities' in the abstract and the main body of the searched articles. The criterion used to search for articles includes English academic published peer-reviewed article based academic journals and by using a list of Association of Business School (ABS) Journal Quality Guide from 2010 to 2018 to select academic journals and using a few appropriate good journals that are non- ABS journals.
Delimiting the field	Articles that did not provide references to academic sources or viewpoints were excluded.
Selected journals	*Accounting and Finance*
1.	*British Food Journal*
2.	*Business Horizons*
3.	*Computers and Industrial Engineering*
4.	*Decision Sciences Journal*
5.	*Energy Policy*
6.	*Foresight*
7.	*Harvard Business Review*
8.	*IEEE Transactions on Industrial Informatics (non-ABS Journal)*
9.	*IEEE Transactions on Systems Man and Cybernetics Part C*
10.	*Industrial Management and Data Systems*
11.	*Information Technology and People*
12.	*International Journal of Information Management*
13.	*International Journal of Production Economics*
14.	*International Journal of Production Research*
15.	*International Journal of Retail and Distribution Management*
16.	*Intelligent Systems in Accounting, Finance and Management*
17.	*Journal of Business Research*
18.	*Journal of Business Logistics*
19.	*Journal of Economics and Business*

20.	*Journal of Enterprise Information Management*
21.	*Journal of Financial Economics*
22.	*Journal of Financial Regulation and Compliance*
23.	*Journal of Management Information Systems*
24.	*Journal of Manufacturing Technology Management*
25.	*Journal of Service Management*
26.	*Management Decision*
27.	*Managerial Finance*
28.	Production Planning and Control
29.	*Strategic Change*
30.	*Supply Chain Management: An International Journal*
31.	*Systems Research and Behavioral Science*
32.	*Technology Analysis and Strategic Management*
33.	*Technological Forecasting and Social Change*
34.	*Transportation Research Part C: Emerging Technologies*
35.	
Total numbers of articles used	71 academic articles were thoroughly searched from selected academic journals and considered for the present

Source: Designed by the authors

2.1 Journal selection

It has been acknowledged in the academic settings across the globe that some journals are of higher quality than other journals (ABS, 2010; ABS, 2015; ABS, 2018). The present study selected journal based ABS Journals Quality Guide because it provides broad coverage of journals; has a high degree of external and internal reliability; is sensitive to minor variations in journals ratings and is widely accepted as a fair means of the ranking journal with its user group (Morris et al. 2009). Though other good academic non-ABS journals that are appropriate for the area of study were considered and selected as well. This study does not have any limited timeframe for the reviewing of existing published academic articles due to the inadequate articles and available information on the comprehensive topic area in blockchain technological and management challenges and opportunities in operational excellence due to the novelty of blockchain technology. To ensure high and strong quality literature reviewed in the present study, only published academic journal articles from the reliable source were selected and focused on peer-reviewed English-language articles that include journals on databases such as Emerald Insight, Taylor and Francis, Wiley Online Library, Elsevier, and IEEE Xplore. Only one non-ABS journal was selected in the present study, which is *IEEE Transactions on Industrial Informatics* journal. This journal was incorporated because the academic articles in this journal were significant to the present study and generally, this selected journal is an academic and popular journal for research. A total of 35 journals were selected for the present study. Figure 1 shows the process and the shortlisted journals for the present study are shown in (Table 1). Shortlisting through the use of keywords method, which is as an effective way of

shortlisting that has been adopted in different studies (Tang and Musa, 2011; Chugani *et al*. 2017; Jensen, 2012) was used in the present research.

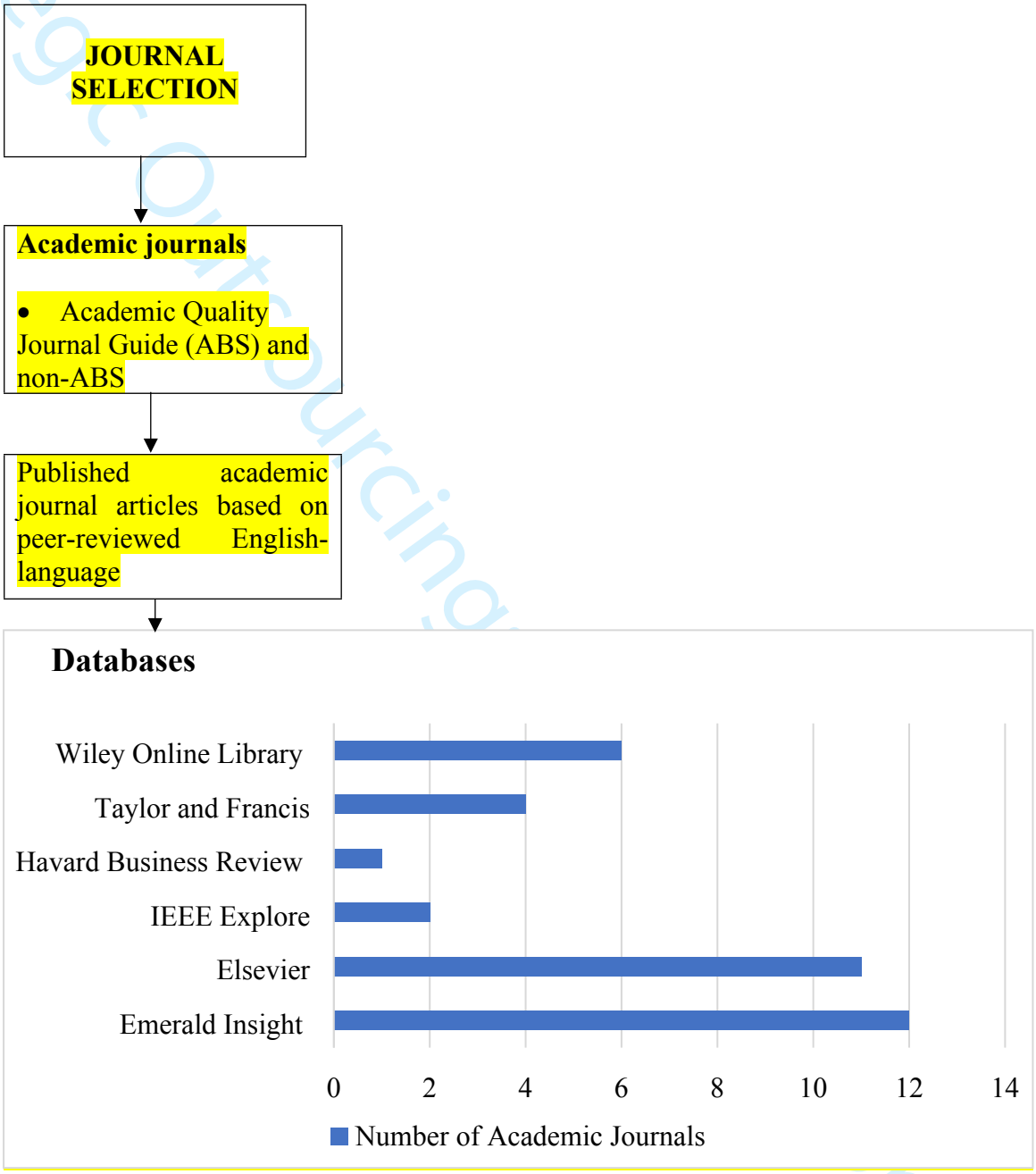


Figure 1: The process of the selection of the journal (Source: Designed by the authors)

2.2 Selection of articles

As stated earlier, there was no timeframe set for the present study due to the few numbers of articles available on the present research topic due to the novelty of blockchain. All related articles to the present study were selected and employed from selected academic journals. To

search for articles in the journals, five searches were performed in the present study, which includes, first with the title or keywords by using the keyword 'blockchain" and later added blockchain to the remaining keywords such as technological challenges, management challenges, technological opportunities, and management opportunities to the blockchain, which resulted to the use of keywords 'blockchain management challenges', 'blockchain technological challenges', 'blockchain management opportunities', and 'blockchain technological opportunities' in the abstract of the articles and main body of the articles. The first search of the results of the number of articles at the time of searching is summarised in Table 2 and shows the number of articles that were found in the selected journals that are related to the keywords, which were used for the search. For example, when searching was performed on the search engine with the keywords 'Blockchain' on the databases such as Wiley Online Library within the subject of business and management, only 3 articles were found in the *Intelligent Systems in Accounting, Finance and Management* journal. While 23 articles were found in the *Strategic Change* journal.

Since a lot of numbers of articles on Blockchain Technology were found in the journals, the search went further by combining and filtering with the keywords 'Blockchain Management Challenges', the number of articles was reduced drastically. For example, *Intelligent Systems in Accounting, Finance and Management* journal yielded 2 articles when keywords "Blockchain Technological Challenges" was placed in the search engine. While only 1 article likewise appeared when the use of keywords 'Blockchain Technological Challenges' was applied under the same journal. Additionally, only 1 article appeared under the same journal when the keywords 'Blockchain Technological Opportunities' in the search engine. Hence, the abstracts and the main body of the articles were scanned for relevance to blockchain technological and management issue since several academic articles that were shortlisted are not comprehensively related to the topic of the present study, importantly regarding the Blockchain Technological and Management Challenges and Opportunities for Operational Excellence, where the keyword "Blockchain" refers to a distributed database for digital transactions without a trusted third service provider such as a bank to authenticate transaction between two parties that are willing to do business. During the search of the articles in the journals, there were some of the same academic articles that appeared for different keywords that were used. For example, *Strategic Change* journals yielded some of the same academic articles for 'Blockchain Management Challenges' and Blockchain Management

Opportunities." Hence, it was compulsory to explore and filter the articles and thoroughly select appropriate articles for the sample of the present study.

After an inclusive search and consideration of articles, a sample size of 70 academic articles was finalised and considered for the present study. For an effective analysis, consideration of the sample size of academic articles differs from one study to another (Natalicchio *et al*. 2017; Zimmermann *et al*. 2016). In the present study, the number of articles was limited to 71 articles. All 69 articles were used to include the sample. Hence, a sample size of 71 articles was explored, finalised, and considered from 35 academic journals for the analysis of the present study.

No	Journal	Blockchain	Blockchain Technological Challenges	Blockchain Management Challenges	Blockchain Technological Opportunities	Blockchain Management Opportunities
1.	*Accounting and Finance*	5	3	3	4	3
2.	*British Food Journal*	1	1	1	0	0
3.	*Business Horizons*	13	6	11	6	10
4.	*Computers and Industrial Engineering*	17	8	13	9	12
5.	*Decision Sciences Journal*	12	11	9	5	5
6.	*Energy Policy*	10	5	9	6	9
7.	*Foresight*	12	15	12	9	7
8.	*Harvard Business Review*	10	4	9	4	7
9.	*IEEE Transactions on Industrial Informatics*	25	0	2	0	0
10.	*IEEE Transactions on Systems Man and Cybernetics Part C*	9	0	1	0	0
11.	*Industrial Management and Data Systems*	6	6	6	4	4
12.	*Information Technology and People*	13	9	8	5	3
13.	*International Journal of Information Management*	42	27	16	26	36
14.	*International Journal of Production Economics*	24	23	16	23	14
15.	*International Journal of Production Research*	18	17	17	14	14
16.	*International Journal of Retail and Distribution Management*	9	3	3	8	3
17.	*Intelligent Systems in Accounting, Finance and Management*	3	3	3	4	4
18.	*Journal of Business Research*	21	14	18	15	20
19.	*Journal of Business Logistics*	14	10	11	13	14
20.	*Journal of Economics and Business*	5	3	4	4	4
21.	*Journal of Enterprise Information Management*	12	23	12	11	23
22.	*Journal of Financial Economics*	3	0	1	0	2
23.	*Journal of Financial Regulation and Compliance*	15	2	4	2	1
24.	*Journal of Management Information Systems*	23	26	19	17	16
25.	*Journal of Manufacturing Technology Management*	20	4	6	5	4
26.	*Journal of Service Management*	7	7	7	7	7
27.	*Management Decision*	12	2	1	1	1
28.	*Managerial Finance*	14	9	4	5	3
29.	*Production Planning and Control*	20	19	19	20	20
30.	*Strategic Change*	23	19	10	10	10
31.	*Supply Chain Management: An International Journal*	5	5	5	4	4
32.	*Systems Research and Behavioral Science*	123	9	23	11	11
33.	*Technology Analysis and Strategic Management*	3	5	5	4	4
34.	*Technological Forecasting and Social Change*	15	17	15	16	14
35.	*Transportation Research Part C: Emerging Technologies*	3	0	1	0	1

Table 2. Number of articles found in the first search
Source: Design by the authors

3.1. Articles Categorisation

The reviewed papers in the present study are based on the work of different authors that have previously discussed and analysed blockchain technology challenges and opportunities. The classification of the articles was guided by the works of Wong *et al.* (2012), Queiroz *et al*. (2019), and Chugani *et al.* (2017), while this method was used in the work of Chugani *et al.* (2017). The same method was used for the present study to classify blockchain, blockchain technological and management challenges and opportunities research by first categorised the articles according to the academic published journals to agree on which academic journals published more information around blockchain technological and management challenges and opportunities based on the results of business and management search engine tools. The evidence in the present study shows that the *International Journal of Information Management* journal contributes 11 published articles to this area. This may be because articles in this journal discussed blockchain technology challenges and opportunities profoundly and as such hold large suitability towards the present study. Similarly, the *Strategic Change* Journal contribute an important number of 8 published articles to the area, while the rest of the remaining journals contribute with a limited number of articles in this area**.**

The second categorisation of the articles was based on the numbers of articles found on the Blockchain Technological and Management Challenges and Opportunities. This allows us to assume which method was extensively discussed in academic literature in the present study.

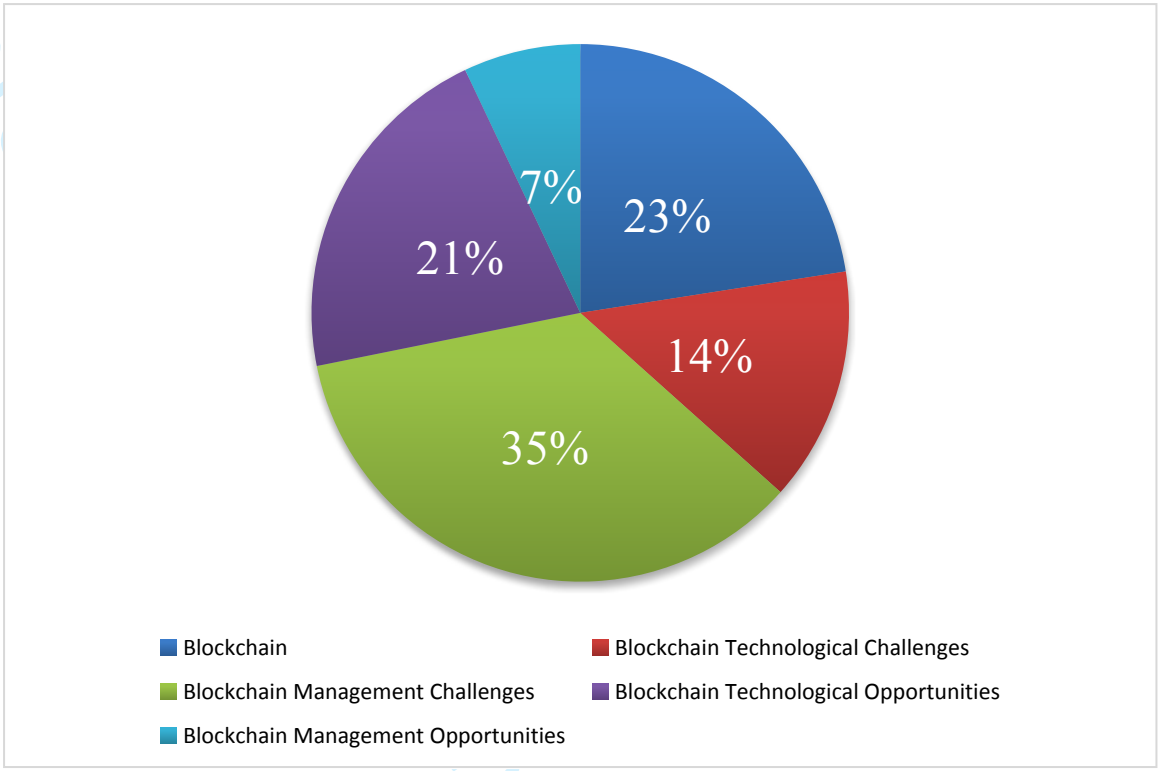


Figure 2 Categorisation of article (Source: Designed by the authors)

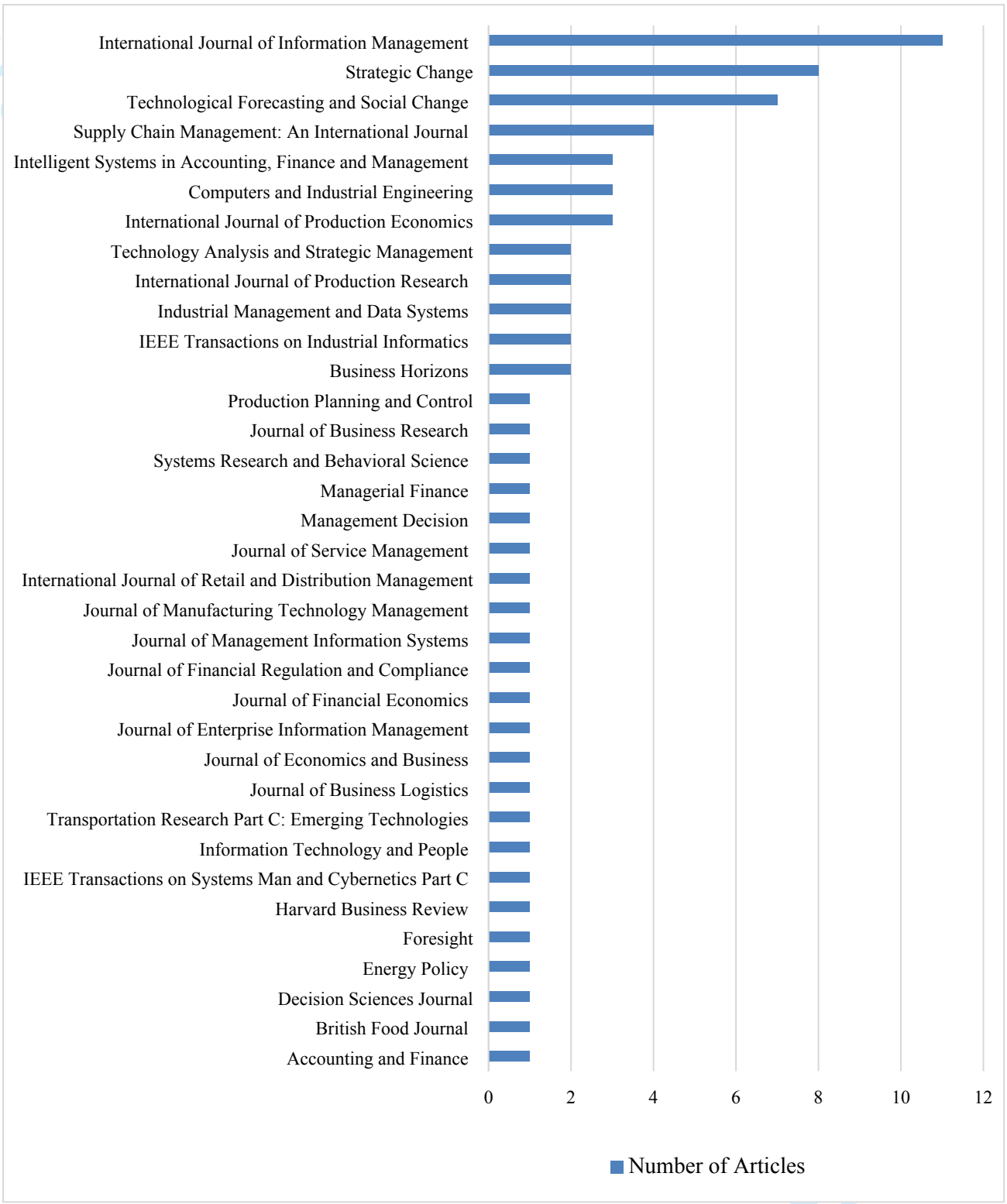


Figure 2 shows that blockchain management challenges received more attention compare to blockchain technological challenges. This perhaps might be because the technology is still in its early stage or a lack of expertise (Kumar et al. 2020; Upadhyay, 2020; Min, 2019; Morkunas

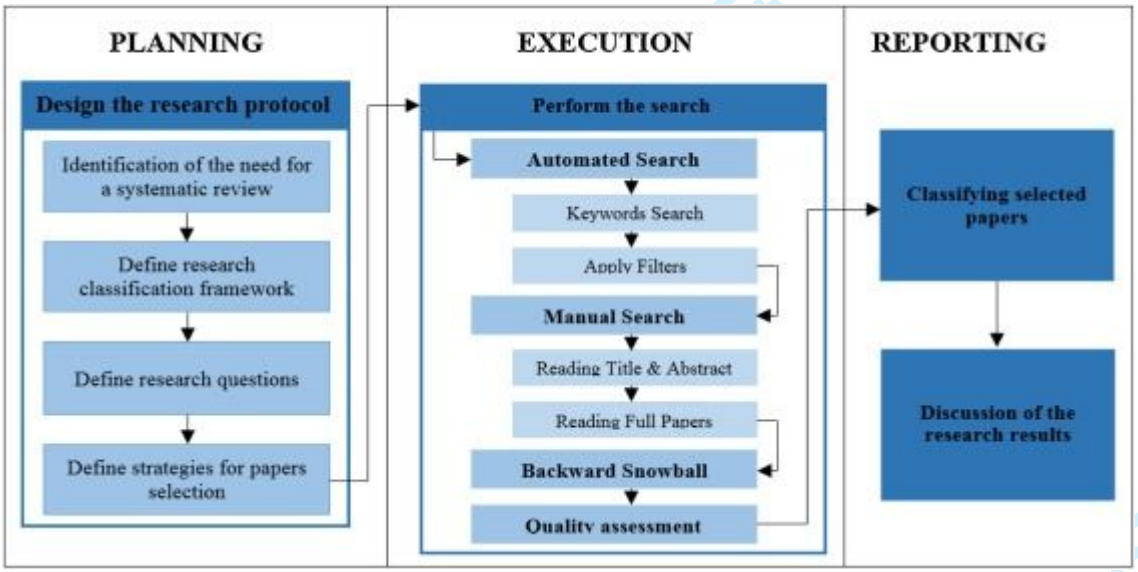
et al. 2019), lack of many participants (Helliar et al. 2020), or because a large number of blockchain technology has yet to be adopted (Morkunas et al. 2019), which made blockchain management challenges received more attention compared to its blockchain technological challenges. Whereas blockchain technological opportunities received more attention compared to blockchain management opportunities. As blockchain technological opportunities received more attention than blockchain management opportunities might be as a result that blockchain aims to disintermediary third service provider (Ali et al. 2020; Min, 2019) to reduce transaction cost among two parties that are willing to engage in business (Nakamoto, 2008; Morkunas et al. 2019; Bhaird et al. 2019). Though one of the blockchain management opportunities aims to manage the cost of operation (He *et al.* 2018). These challenges and opportunities call for research to be conducted in blockchain for a deeper understanding of these challenges and opportunities before its adoption by the UK carmakers for firms aiming to achieve operational excellence.

The third categorisation of articles separates the articles found in the present study into model approach context, blockchain application context, main theoretical approach, author, and the year of publication. This classification is based on the works of Queiroz *et al.* (2019), Chugani, *et al* (2017), and Wong *et al.* (2012). For example, some articles discussed blockchain challenges and exclusively rely on applications of blockchain to give details of a phenomenon. This study placed those articles under "blockchain application context". Some articles solely rely on using certain research approaches such as the Delphi study approach for blockchain to investigate certain issues, this study likewise placed those articles under "main theoretical approach". The articles that used model such as the business model with blockchain, such model was placed under the "model approach context". While the authors and the year of the article's publication were placed under the author and the year category. The third

categorisation went further to categorise authors who indicated blockchain challenges and opportunities in their work and the area they addressed.

The fourth categorisation of articles was based on the year of selected articles for this study were published. However, this method was adapted based on the works of Garza-Reyes (2015) and Chugani *et al.* (2017), which has been adopted in different academic published studies (Chugani *et al*. 2017). This is crucial in this study to show recent articles that have been published around this study and it shows if this study is based on recent information or investigation of academic scholars. The results in the graph of this study show evidence that most of the articles on blockchain were published in 2017, 2018, 2019, and 2020 which indicated research of a good formulation on a recent study. Though only one article published in 2021.

The final categorisation, which is the fifth categorisation was adapted from the works of Queiroz *et al*. (2019) to categorise blockchain application in different industries, the year, and the number of articles that were found in this study.



Figue 3: Process for systematic review study (Source: Designed by the authors)

Sources: Adapted from (Tranfield et al. 2003; Ali et al. 2020)

3. Findings

This study aims to explore blockchain technological and management challenges and opportunities in operational excellence. To achieve this aim, 69 articles from the top 35 journals were considered and shortlisted after systematic research in **Error! Reference source not found.**

Table 3. Shortlisted final sample of articles

No	Journal / Keywords	Blockchain	Blockchain Management Challenges	Blockchain Technological Challenges	Blockchain Management Opportunities	Blockchain Technological Opportunities
1.	*Accounting and Finance*	1	0	0	0	0
2.	*British Food Journal*	0	0	0	1	0
3.	*Business Horizons*	0	0	0	0	1
4.	*Decision Sciences Journal*	0	1	0	0	0
5.	*Computers and Industrial Engineering*	0	2	0	0	0
6.	*Energy Policy*	1	0	0	0	0
7.	*Foresight*	1	0	0	0	0
8.	*Harvard Business Review*	0	0	0	0	1
9.	*IEEE Transactions on Industrial Informatics*	2	0	0	0	0
10.	*IEEE Transactions on Systems Man and Cybernetics Part C*	1	0	0	0	0
11.	*Industrial Management and Data Systems*	0	1	0	1	0
12.	*Information Technology and People*	0	1	0	0	0
13.	*International Journal of Information Management*	2	5	2	0	2
14.	*International Journal of Production Economics*	0	1	1	0	1
15.	*International Journal of Production Research*	0	0	1	1	0
16.	*International Journal of Retail and Distribution Management*	0	0	0	1	0
17.	*Intelligent Systems in Accounting, Finance and Management*	0	2	1	0	0
18.	*Journal of Business Research*	0	1	0	0	0
19.	*Journal of Business Logistics*	0	1	0	0	0
20.	*Journal of Economics and Business*	0	0	0	0	1
21.	*Journal of Enterprise Information Management*	0	0	1	0	0
22.	*Journal of Financial Economics*	0	1	0	0	0

23. *Journal of Financial Regulation and Compliance*	0	1	0	0	0
24. *Journal of Management Information Systems*	0	0	1	0	0
25. *Journal of Manufacturing Technology Management*	0	1	0	0	0
26. *Journal of Service Management*	0	1	0	0	0
27. *Management Decision*	0	0	0	0	1
28. *Managerial Finance*	1	0	0	0	0
29. *Production Planning and Control*	0	0	0	1	0
30. *Strategic Change*	3	2	2	0	1
31. *Supply Chain Management: An International Journal*	2	1	0	0	1
32. *Systems Research and Behavioral Science*	1	0	0	0	0
33. *Technology Analysis and Strategic Management*	0	0	0	0	2
34. *Technological Forecasting and Social Change*	1	3	1	0	2
35. *Transportation Research Part C: Emerging Technologies*	0	0	0	1	0

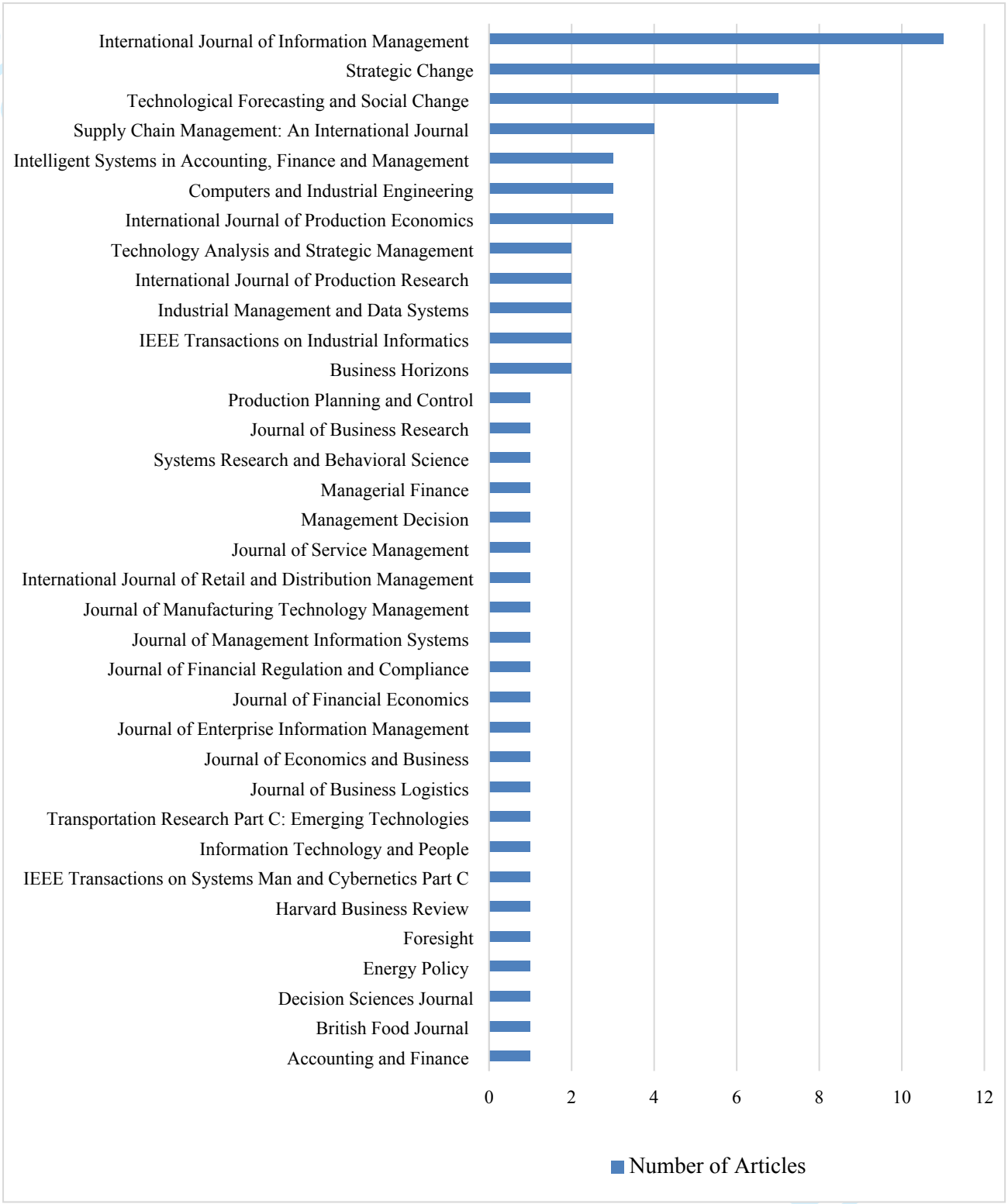


Figure 3. Categorisation of number of articles in journal publication (Source: Designed by the authors)

Figure 3 shows the distribution of journals in this study shows that most papers that were published around the area of blockchain technological and management challenges and

opportunities are recent papers. This indicates that blockchain has become an important area for study.

Findings show that part of the objectives of blockchain technology is to transform operations of supply chain management, to enhance product safety and security, to improve quality management; to reduce the cost of supply chain transactions etc (Cole et al. 2019). Likewise, this study found that managers that consider blockchain challenges before aiming to adopt this technology are considering the impact of blockchain outcome on their operations (Oh and Shong, 2017), while managers that are considering in adopting blockchain to make use of its opportunities are aiming to achieve operational excellence (Yeoh, 2017; Angelis and da Silva, 2019). Companies that adopt blockchain and make use of the blockchain opportunities are considered to achieve operational excellence (Cole et al. 2019). This is supported by the research conducted by Kamble *et al*. (2019). Kamble et al. (2019) implied that blockchain would improve supply chain effectiveness. Blockchain technological challenges include hacking, which it can occur as a group of miners temporarily control 50% of the network's mining hash-rate, which is the measurement of a unit of the processing power of a network of nodes that power a blockchain (Wang et al. 2019a) and one of the blockchain management challenges include limited knowledge of blockchain that most managers of companies lack, which is one of the barriers for them to adopt and implement blockchain technology (Angelis and da Silva, 2019). The findings of the present study on blockchain technological opportunities reveal that not only it will protect theft of cryptocurrency (Mahmoud *et al*. 2019), but it will create a new business model (Oh and Shong, 2017). Additionally, one of the blockchain management opportunities is to reduce the cost of the transactions, which ensures the safety of data, it can help operations and supply chain to detect unethical suppliers and counterfeit products etc (Saberi *et al*. 2018). Figure 4 shows the categorisation of articles according to year of publication

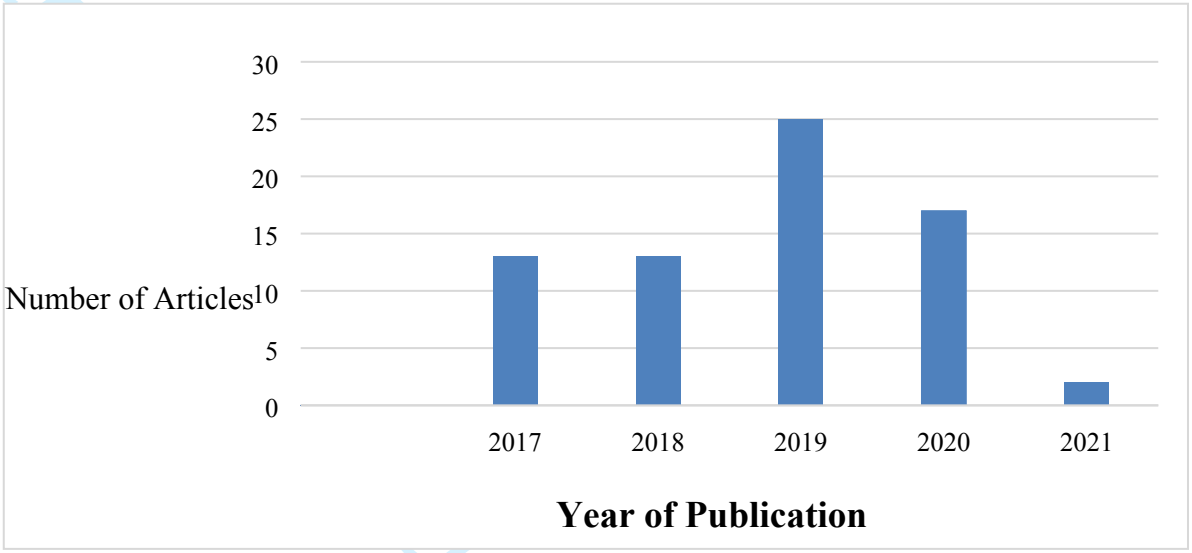


Figure 4 Categorisation of articles according to year of publication (Source: Designed by the authors)

No	Journal Name	Model Approach Context	Blockchain Application Context	Main Technologies Approach	Main Theoretical Approach	Author	Year
1.	*Accounting and Finance*	Crowdfunding	-	Blockchain	Systematic Review	Cai	2018
2.	*British Food Journal*		Blockchain traceability and transparent system	Blockchain	Survey and interview study	Sanders *et al.*	2018
3.	*Business Horizons*	Risk management/security perspectives	Smart contracts, asset tracking, cybersecurity	Blockchain	Review/conceptual framework	Min	2019
		Business Model	Private and public blockchain	Blockchain	Review/framework	Morkunas et al.	2019
4.	*Computers and Industrial Engineering*	DEMATEL technique and experts' opinions	-	Blockchain	Framework/literature review, experts' opinions	Biswas and Gupta,	2019
		blockchain-based logistics monitoring system (BLMS)	Ethereum	Blockchain	Review	Helo and Hao,	2019
5.	*Decision Sciences Journal*	-	Hyperledger fabric	Blockchain	Review	Kumar et al.	2020
6.	*Energy Policy*	-	Blockchain Peer-to-peer	Blockchain	Use cases	Diestelmeier	2019
7.	*Foresight*	-	Peer-to-peer value exchange systems, group consensus mechanisms and smart contracts	Blockchain	Book review/Literature review	Thurner	2018
8.	*Harvard Business Review*	Business Model	-	Blockchain	Framework	Iansiti and Lakhani	2017
9.	*IEEE Transactions on Industrial Informatics*		Blockchain-based distributed network architecture	Blockchain	Framework	Sharma *et al.*	2018

		Peer-to-peer electricity trading model	Consortium blockchain technology	Blockchain	Theory building	Kang *et al.*	2017
10.	*IEEE Transactions on Systems Man and Cybernetics Part C*	Six-layer reference model	Bitcoin and cryptocurrencies	Blockchain	Framework	Yuan and Wang	2016
11.	*Industrial Management and Data Systems*	-	-	Blockchain and edge computing	Case study, a cross-enterprises framework	Li *et al.*	2018
			Smart Contracts	Blockchain	Use cases	Chang et al.	2019
12.	*Information Technology and People*	–	Finance, digital property, cybersecurity, smart contracts	Blockchain	Literature research, research agenda and framework development	Tang et al.	2020
13.	*International Journal of Information Management*	-	-	Blockchain	Systematic literature review	Ali et al.	2020
		–	Blockchain traceability	Blockchain	Conceptual framework, qualitative research	Behnke et al	2020
		–	Blockchain Traceability	Blockchain	Use Case Design	Bumblauskas et al.	2020
		Sustainable performance	–	Blockchain	Review	Di Vaio and Varriale	2020

	–	–	Blockchain	A systematic review	Frizzo-Barker et al.	2020
		–	Blockchain	Quantitative research	Queiros and Wamba	2020
	The unified theory of acceptance and use of technology (UTAUT)		Blockchain			
	–	–		Literature review, Use cases	Schuetz and Venkatesh	2020
			Blockchain			
	–	Bitcoin cryptocurrency		Systematic review	Upadhyay	2020
			Blockchain			
	Self-determination theory	–	Blockchain	Qualitative approach	Wang et al.	2019
		–				
	Information security		Blockchain	Conceptual paper	Warkentin and Orgeron	2020
		Cryptocurrency		Case study	Ying et al.	2018
	–					
14. *International Journal of Production Economics*	Technology, organizational, and environmental (TOE) framework and Force Field theories	–	Blockchain	Decision-Making Trial and Evaluation Laboratory (DEMATEL) tool	Kouhizadeh et al.	2021
	Sensemaking theory	–	Blockchain	Qualitative research	Wang et al.	2019
	A fuzzy rule-based industry 4.0 maturity	–	Industry 4.0	The mixed-method study, inductive theory building	Caiado et al.	2021

		model					
15.	*International Journal of Production Research*	Technology Acceptance Model (TAM), Theory of planned behaviour (TPB), Technology readiness index (TRI)	–	Blockchain	Quantitative research	Kamble et al.	2019
		–	Traceability	Blockchain	Use cases	Saberi et al.	2018
16.	*Intelligent Systems in Accounting, Finance and Management*		Blockchain architecture	Blockchain	Case study	O'Leary	2017
		–	Blockchain traceability, smart contract, Ethereum	Blockchain	Use cases	Kim and Laskowski	2018
			Consortium Blockchain	Blockchain	Analysis study	O'Leary	2018
17.	*Journal of Business Research*	–	Traceability of products	Internet of Things, Artificial Intelligence, Machine Learning, and Blockchain	Use cases	Kumar et al.	2020
18.	*Journal of Business*	–	–	Blockchain, Additive	Inductive in-depth	Kurpjuweit et al	2019

Logistics			manufacturing	interviews with the Delphi method		
19. *Journal of Economics and Business*	Behavioural perspective	–	–	Use cases	Anagnostopoulos	2018
20. *Journal of Enterprise Information Management*	–	–	Blockchain	Use cases, Systematic fit analysis/ Descriptive literature review	Siegfried et al	2020
21. *Journal of Financial Economics*	Game-theoretic model	Bitcoin blockchain	Blockchain	Use cases	Easley et al.	2019
22. *Journal of Financial Regulation and Compliance*	–	–	Blockchain	Qualitative research, case study	Yeoh	2017
23. *Journal of Management Information Systems*	–	Bitcoin Blockchain	Blockchain	Review	Yin et al.	2018
24. *Journal of Manufacturing Technology Management*	-	-	Industry 4.0	Conceptual approach and review	Claudia Lizette Garay-Rondero et al.	2019
25. *International Journal of Retail and Distribution Management*	–	–	New business models	Bibliometric study	Delafenestre	2019
26. *Journal of Service Management*	-	Smart contracts	Blockchain	Conceptual	De Keyser *et al*.	2019
27. *Management Decision*	Sustainable business model innovation	–	Blockchain	Value Triangle framework, case study	Tiscini et al	2020

28. *Managerial Finance*	Economic model using demand–supply and equilibrium economics, principal–agent modeling using constrained optimization	Smart contracts, Ethereum blockchain	Blockchain	Contract theory	Sheth and Subramanian	2019
29. *Production Planning and Control*	–	Transparency – traceability, reliability – security, smart execution	Blockchain	Uses case/review	Kouhizadeh et al.	2020
30. *Strategic Change*		Blockchain smart contracts	Blockchain	Use cases	Manski	2017
		Applications of blockchain	Blockchain	Review	Adams *et al*.	2017
	–					
		–	Blockchain, Internet of Things, Smart property	Review	Herian	2015
	–	Blockchain traceability and transparency	Blockchain	Review	O'Dair and Beaven	2017
	–	Bitcoin blockchain Cryptocurrencies and blockchain	Blockchain	Delphi study	White	2017
	–		Blockchain	Case study	O'Dair and Owen	2019
	–	smart contracts	blockchains	Use cases	Shermin	2017

	–		Blockchain	Use uses	Scott *et al.*	2017
31. *Supply Chain Management: An International Journal*	–	Blockchain smart contracts	Blockchain	Review	Queiroz *et al.*	2019
	Principal agent theory (PAT), transaction cost analysis (TCA), the resource-based view (RBV) and network theory (NT)	Blockchain applications	Blockchain	The framework, theory building	Treiblmaier	2018
	–	Blockchain applications	Blockchain	Review	Wang *et al.*	2019
	–	–	Blockchain	Analysis study	Cole *et al.*	2019
32. *Systems Research and Behavioral Science*	–	–	Blockchain	Systematic analysis	Zhang et al.	2020
33. *Technology Analysis and Strategic Management*	–	Smart contracts	Blockchain	Delphi study, framework	Holotius *et al.*	2019
	–	Blockchain applications	Blockchain	Review	Miau and Yang	2018
34. *Technological Forecasting and Social Change*	Model of blockchain-based decentralized	Blockchain-based technological solution	Blockchain	Case study, framework	Pazaitis *et al.*	2017

		cooperation					
		Michael Porter five forces model, SWOT Analysis	–	Blockchain	Use cases	Jianchao et al.	2020
		Transactional cost economics		Blockchain	Use cases	Ahluwalia et al.	2020
		–	Bitcoin	Bitcoin	Uses cases	White et al	2020
		Theory of Planned Behavior (TPB)	–	Blockchain	Qualitative method	Chang et al.	2020a
		–	–	Blockchain	Experimental approach	Pólvora et al.	2020
		–	Smart-contract	Blockchain	Conceptual framework	Chang et al.	2019b
35.	*Transportation Research Part C: Emerging Technologies*	Game theory	–	Blockchain	Conceptual framework	Lopez and Farooq	2020

Table 4. Findings and limitations of related studies: the categorisation of blockchain challenges and opportunities of blockchain

No	Journal Name	Main Technologies Approach/Model	Blockchain Challenges	Blockchain Opportunities	Area of Approach	Industry	Author	Year
1.	*Accounting and Finance*	Blockchain	-	Financial intermediation	FinTec	Financial Institution	Cai	2018
2.	*British Food Journal*	Blockchain	-	Traceability and transparency	Meat supply chain	Meat industry	Sanders *et al*	2018
3.	*Business Horizons*	Blockchain	Scalability, lack of expertise, optimum platform, organisational resistance, computing processing power	Smart contracts, cybersecurity, asset tracking	Supply chain resilience	-	Min	2019
		Public and private blockchain	Blockchain is slow in operation, Data breaches of cryptocurrency trading platforms, Blockchain systems are not standardised, blockchain architectures is difficult, lack of a critical mass of users	New Consensus Mechanisms used for Hyperledger	Firm's business model	-	Morkunas et al.	2019
4.	*Computers and Industrial Engineering*	Blockchain	Scalability and market-based risks, Transactional-level	-	Barriers to the adoption and implementation of	Industry and service sector	Biswas and Gupta,	2019

			uncertainties, Technology risks, High sustainability costs, Poor economic behaviour, in the long run, Privacy risks, Usages in the underground economy, Risk of cyber-attacks, Legal and regulatory uncertainties		blockchains			
		Blockchain	-	Tamper-proof transaction records, Information sharing & synchronization, Smart contract execution,	Operations and supply chain	-	Helo and Hao	2019
5.	*Decision Sciences Journal*	Blockchain			Supply chain management	Food industry	Kumar et al.	2020
6.	*Energy Policy*	Blockchain	-	To select a clean energy source, trade with neighbours, receive more money for excess power, benefit	Energy transition	Electricity sector	Diestelmeier	2019

				from transparency of all your trades on a blockchain and very low-cost settlement costs all leading to lower power bills and improved returns for investments in distributed renewables				
7.	*Foresight*	Blockchain	-	The visualisation of the physical flow of goods, as well as other B2C applications	Supply chain finance		Thurner	2018
8.	*Harvard Business Review*	Blockchain	-	Reduce transaction costs, to track items through complex supply chains, reduce external payment processors	Supply chain		Iansiti and Lakhani	2017
9.	*IEEE Transactions on Industrial Informatics*	Blockchain	-	Transfer of assets, supply chain management, unparalleled, security, transparency, execution speed and cost reduction, ability	Smart city	Automotive industry	Sharma *et al.*	2018

			to audit records,				
	Blockchain	-	System initialization and key generation, choosing different roles in electricity trading, selling and buying energy, paying and earning energy coins, carrying Out consensus process, building Blocks and Finding Proof-of-Work	Localise buy and selling electricity	Automotive industry	Kang *et al.*	2017
10. IEEE Transactions on Systems Man and Cybernetics Part C	Blockchain	-	Blockchain-Powered Smart Devices	Stimulate detailed investigation and innovative research	-	Yuan and Wang	2018
11. Industrial Management and Data Systems	Blockchain	-	-	sharing of knowledge and services		Li *et al.*	2018
	Blockchain	Efficiency (transaction throughput and latency), scalability,	Cost reduction without losing the needed control of authority and	International trade	-	Chang et al.	2019

			security and privacy that still require technical solutions	security principles				
12.	*Information Technology and People*	Blockchain	Ethical challenges	Data protection, luxury goods registry, document tracking, ownership authentication, healthcare records sharing, copyright management and supply chain management, data authentication, transparency, and efficient sharing	Blockchain ethics	-	Tang et al.	2020
13.	*International Journal of Information Management*	Blockchain	Interoperability, scalability, regulation challenges, Financial challenges	Point-to-point (P2P) transmission, establishing data ownership, promoting data sharing, data protection, distributed innovations in financial transactions	Financial services	Financial service sector	Ali et al.	2020
		Blockchain	–	Traceability	Food supply chains	Food industry	Behnke et al	2020

Blockchain	–	Traceability	Production and supply chain delivery system	Food industry	Bumblauskas et al.	2020
Blockchain	–	–	Supply chain management	Airport Industry –	Di Vaio and Varriale	2020
Blockchain	Trust-free, decentralized transactions, lower costs, and privacy	Regulation, interoperability, scalability, security, and volatility.	Different areas	–	Frizzo-Barker et al.	2020
Blockchain	–	–	Supply chain	Different industries	Queiros and Wamba	2020
Blockchain	–	Ability to remove the need for the intermediary, Blockchain-based transactions can be facilitated with very low transactions fees, offer more suitable products to customers in three ways: (a) digitalizing existing practices, (b) resolve current problems, (c) open up new opportunities to users,	Financial inclusion	Financial institution	Schuetz and Venkatesh	2020

Blockchain	Lack of clarity, governance and legal, security and privacy, The legal understanding and coverage of smart contracts between participating parties are still unclear, miners having the power of hashing can manipulate the blockchain network,	Business practice and excellence, Sectoral specific, legal, smart contracts for processing and storing information	An analysis of challenges, applications and opportunities	Explored different industries	Upadhyay	2020
Blockchain	–	–		–	Wang et al.	2019
Blockchain	–	Non-reputability	Customer LP engagement	–	Warkentin and Orgeron	2020
Blockchain	Trust around the coins	Issuing cryptocurrency, protecting sensitive information, and, eliminating institutional intermediaries	Public sector processes Blockchain-enabled E-commerce	Airline	Ying et al.	2018

14.	*International Journal of Production Economics*	Blockchain	Scalability, usability, and interoperability, latency and throughput issues, hardware and software, with maintenance, to sustain it, new technology will be costly for the organization and the system partners	–	Sustainable supply chain	–	Kouhizadeh et al.	2021
		Blockchain	Transparency, authenticity, trust and security, efficiency and cost/waste reduction,	Disintermediation, transparency with pseudonymity, security, automation	Supply chain	–	Wang et al.	2019

	Industry 4.0			Operations and supply chain management	–	Ciado et al	2021
15. *International Journal of Production Research*	Blockchain	"51% attack", technical know-how, data governance and privacy-related concerns	Opportunity to create numerous sharing applications, e.g. peer-to-peer automatic payment mechanisms, foreign exchange platforms, digital rights management and cultural heritage	Supply chains	–	Kamble et al.	2019
	Blockchain	Different privacy policies, data usage, new IT tools are needed, 'bloat' problem in Bitcoin, Data security and privacy concerns,	Tracking substandard products accurately, identification of transactions of the products to reduce the rework and recall, to ensure that purportedly green products are environmentally friendly, reduce carbon emissions in the journey of	Sustainable supply chain	–	Saberi et al.	2018

				products by providing the fundamentals for supply chain mapping and applying low-carbon product design, improve the recycling, emission trading process by improving emission trading schemes (ETS) efficacy				
16.	*Intelligent Systems in Accounting, Finance and Management*	Blockchain	Open network designs, Scalability.	Disintermediation of financial intermediaries, payment networks, stock exchanges and money transfer services, provides each participant end-to-end visibility, traceability.	Accounting and supply chain systems	–	O'Leary,	2017
		Blockchain	Interoperability	Traceability	Supply-chain provenance	–	Kim and Laskowski	2018

	Blockchain	Spoofing, wash, and off-blockchain transactions at Bitcoin: business manipulation, spoofing wash accounts, and off-blockchain accounting and supply chain, Crime and Information Disclosures in Bitcoin or Peer-to-Peer Systems.	Peer-to-Peer Public Blockchain, smart contracts	Open information transactions	–	O'Leary	2018
17. *Journal of Business Research*	Blockchain	Technological expertise	Disintermediation and direct engagement, Customer outcomes, Personalization of marketing mix elements, better prediction of future trends, productivity enhancement, enhanced functional ease, Greater personal relevance, Greater traceability of products,	Marketing	–	Kumar et al.	2020

				effective firm-customer engagement				
18.	*Journal of Business Logistic*	Blockchain	Absence of blockchain-skilled specialists on the labour market, missing governance mechanisms, and a lack of firm-internal technical expertise	Improve the competitiveness of AM in parts' production, catalyzing the trend toward more decentralized manufacturing resulting in more agile, resilient, and flexible supply chains and reduced logistics costs. Beyond that, blockchain-based AM platforms are expected to enhance supply chain visibility, drive supply chain digitalization, support supply chain finance, and contribute to the emergence of shared factory systems	Additive manufacturing Supply Chains	–	Kurpjuweit et al	2019
19.	*Journal of Economics and*	Blockchain	–	B2B solutions, Peer-to-peer	Banking and regulatory	Banking industry	Anagnostopoulos	2018

	Business			(P2P) marketplaces for customers unable to secure loans from other traditional sources	issues			
20.	*Journal of Enterprise Information Management*	Blockchain	Blockchain's resource inefficiency, scalability, confidentiality and performance, reliability, nonrepudiation and adaptability,	Has a great potential to substitute a trusted third party in supply-chain coordination, enable distributed manufacturing (e.g., dynamic use of free capacities and on-demand manufacturing). tracking and tracing applications that allow to closely monitor and reenact production steps on a single product level.	Applications in the Industrial Internet of Things (IIOT)	–	Siegfried et al.	2020
21.	*Journal of Financial Economics*	Blockchain	Exogenous structural constraints, Increasing transaction fees will	–	bitcoin blockchain	–	Easley et al.	2019

		increase the number of miners, but this, in turn, will trigger increases in the difficulty level to control the creation rate of new blocks, thereby raising the costs to miners, Transactions and the mempool, Waiting times and transaction fees.					
22. *Journal of Financial Regulation and Compliance*	Blockchain	Regulatory issue,	–	Regulatory issues	Financial Services	Yeoh	2017
23. Journal of Management Information Systems	Blockchain	Legal and Regulatory Perspective, Anonymity Perspective	–	Regulating Cryptocurrencies	–	Yin et al.	2019
24. *Journal of Manufacturing Technology Management*	Industry 4.0	Interoperability	–	Digital Supply Chains (DSCs)	–	Garay-Rondero et al.	2019
25. *International Journal of Retail and Distribution Management*	New business models	–	New business model	Supply chains	–	Delafenestre	2019

26. *Journal of Service Management*	Frontline Service Technology infusion	–	Smart contracts, new business models, removal of traditional third-party service intermediaries	Conversational agents, extended reality (XR) and blockchain technology	–		De Keyser *et al*.	2019
27. *Management Decision*	Blockchain	Scalability, Technical essential facilities, sophisticated ICTs are needed	Information about quality (e.g. geographic origins and freshness), safety (e.g. healthiness and no modification) and sustainability (e.g. fair-trade) of the products are guaranteed and ensures data transparency, integrity and security, eliminates the waste of safe food, being able to promptly locate and trace contaminated products, allow agri-food companies to reduce natural resources	Sustainable business model innovation	Agric-industry	food	Tiscini et al	2020

				consumption				
28.	*Managerial Finance*	Blockchain	Sustainability and security	Smart contracts: decreasing information asymmetry; reducing transaction costs; reducing transaction settlement times; incentivizing efficiency; incentivizing a broad base of innovation by encouraging different apps in the ways in which risk is pooled; and risk is transferred.	Ethereum blockchain platform	Insurance industry	Sheth and Subramanian	2019
29.		Blockchain	Infrastructure challenges including failures of interoperability, technological security, and stability issues	Transparency – traceability, Reliability – security, Smart execution	Circular economy	Use cases	Kouhizadeh et al.	2020
30.	*Strategic Change*	Blockchain	Increasing mining costs, energy usage, average block size, median confirmation time, mempool	Disintermediation, trustless exchange, increased user control of information,	Technological commonwealth	–	Manski	2017

	transaction count, and user fees, limited user-friendliness and superior technical expertise required are acting as barriers to adoption, Unsettled regulatory environment	durable, secure decentralized networks, transparency and immutability, maintenance of high-quality, accurate data				
Blockchain	–	Decentralization, disintermediation, and the removal of trusted third parties.	Future of money	–	Adams *et al*.	2017
Blockchain		Private express trusts, proof-of-work, privacy,	(re)imagining of trusts jurisprudence	–	Herian	2017
Blockchain	Underlying cryptocurrencies, from the legal and regulatory to the ethical and environmental, the issue of suspicion based on the strong association of	Accuracy and availability of copyright data, facilitate near-instant micropayments for royalties, improve the transparency of	Record industry	Record Industry	O'Dair and Beaven	2017

	blockchain technology with Bitcoin, associated with "dark web" sites such as Silk Road, governance and regulation, the integrity of the data,	the value chain.				
Blockchain	Security concerns, technical limitations, growth and sustainability, and environmental impact.	Transfer of bonds, payment of medical bills, register of electronic voting, recording personal, transfer of bonds,	Business and management	–	White	2017
Blockchain	–	new creative enterprise		Music Industry	O'Dair and Owen	2019
Blockchain	Scalability, the speed of the network, or lack thereof	Reduce transaction costs of reaching an agreement, formalization and enforcement of relationships between people, institutions, and the assets they own, by standardizing	New creative enterprise Disrupting governance	–	Shermin	2017

				transaction rules, create novel opportunities for economic alignment, shared purpose, and coordination between distributed, trustless individuals, at negligible cost, decentralized virtual borderless nations.				
		Blockchain	Bitcoin as a currency is that it is rarely used by vendors within the "real economy" as a means of exchange, the use of Bitcoin is its perception as a "risky" currency.	Greater security, transparency, auditability, and efficiency to currency transactions	Distributed collaborative organizations	Financial industry	Scott *et al*.	2017
31.	*Supply Chain Management: An International Journal*	Blockchain	–	Smart contracts will contribute to several SCM improvements such as improved responsiveness, lead-time	Supply chain management	–	Queiroz *et al.*	2019

		reduction, transaction costs, visibility and more trust, security and transparency in the network, traceability, improve network transparency, dramatically reducing the costs of monitoring processes, traceability disruptions, the ability to combat counterfeiting and fake drugs will be significantly improved in the coming years.				
Blockchain	–	Data transparency and non-repudiability offer opportunities for cost	Supply chain	–	Treiblmaier	2018

		reduction and independence from the services of intermediaries, new business models,				
Blockchain	Technological challenges: a group of miners temporarily control over 50 per cent of the network's mining hash-rate, latency; operational challenges: For a blockchain to work in the supply chain, all related supply chain actors should be on board	Extended visibility and product traceability, Supply chain digitalisation and disintermediation, Improved data security for information sharing, smart contracts,	Supply chains	–	Wang *et al*.	2019
Blockchain	Building human capital expertise to	Enhancing product safety and security; improving quality	Operations and supply	–	Cole *et al*.	2019

			develop, implement, and exploit applications of	management; reducing illegal counterfeiting; improving sustainable supply chain management; advancing inventory management and replenishment; reducing the need for intermediaries; impacting new product design and development; and reducing the cost of supply chain transactions	chain management			
32.	*Systems Research and Behavioral Science*	–	Problems of financial regulation, complexity in global collaboration,	Cybersecurity	Finance and economics	Finance	Zhang et al.	2020
33.	*Technology Analysis and Strategic Management*	Blockchain	Integration and adoption, standardisation, unification, and interoperability, latency and response time, availability and robustness,	P2P and direct transactions, cross-border and cross-currency, a connection between contract and transaction, cost reduction, new business	Payments industry	Payment Industry	Holotius *et al*.	2019

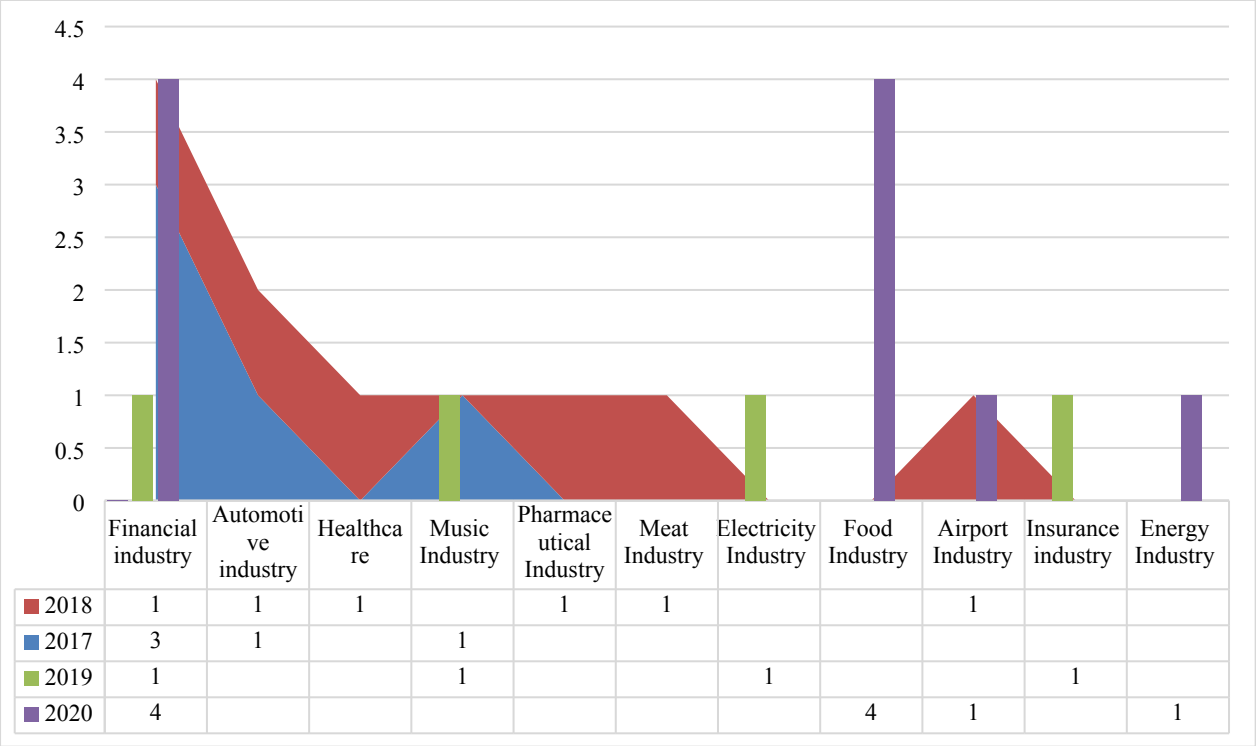
			models in payments, changed income structure,				
	Blockchain		–	–	–	Miau and Yang	2018
34. *Technological Forecasting and Social Change*	Blockchain	legal and regulatory challenges	To efficiently allocate their resources in a more fair and sustainable fashion	value systems in the sharing economy	–	Pazaitis *et al*.	2017
	Blockchain	The legal and regulatory, Optimization of measurement and certification, Insufficient computing power and response speed, Fault tolerance challenge, The lack of responsible parties in smart	Competitiveness of distributed energy resources, Construction of market transactions, Development of energy finance	Competitiveness of distributed energy resources	Energy Industry	Jianchao et al.	2020

	contracts					
Blockchain	–	Blockchain reduce opportunism having a verifiable smart, blockchain reduces uncertainty by completing transactions quickly without the need of the third party.	Startup financing	–	Ahluwalia et al.	2020
Bitcoin	regulatory issues,	–	Technology-based product	–	White et al.	2020
Blockchain	Ethical issue: privacy, regulations and law, cybercrime; scalability, security, privacy leakage, energy consumption; changed the ways that employees work and communicate	Optimization of global financial infrastructure or transfer assets more effectively than the existing financial system, it reduces costs and value transfers, it can control risks more effectively, it seeks innovative	Financial services	Financial Industry	Chang et al.	2020a

	within the organization, employees are required to learn new skills and knowledge, difficult to get professional help, "experts" are still learning new knowledge themselves, not all the organizations have been entirely ready for the Blockchain adoption	ways to profit					
Blockchain	Interoperability, fragmentation of frameworks across Member States, legal recognition, acceptance or guidance concerning Blockchain solutions or mechanisms, such as electronic signatures,	New business and economic models, trust and decentralized governance, Emerging regimes for data management.	Industrial Transformations	–	Pólvora	2020	

			creation of tokens or coins, transactions performed via smart contracts, management of personal data, or decentralized governance models					
		Blockchain	legal issues, lack of standards and protocols, privacy issues, and error intolerance	Fast payment, traceability, disintermediation of the service third provider	Supply chain re-engineering	–	Chang	2019b
		–						
35.	Transportation Research Part C: Emerging Technologies	Blockchain	Scalability, the monetization of users mobility information,	Improve various aspects in the current way of sharing and collecting mobility data,	Smart mobility data-markets	–	López and Farooq	2020

Source: Designed by the authors



	Financial industry	Automotive industry	Healthcare	Music Industry	Pharmaceutical Industry	Meat Industry	Electricity Industry	Food Industry	Airport Industry	Insurance industry	Energy Industry
2018	1	1	1		1	1			1		
2017	3	1		1							
2019	1			1			1			1	
2020	4							4	1		1

Figure 5 Categorisation of blockchain application articles found in different industries (Source: Designed by the authors)

Figure 5 shows that research studies on the blockchain in the financial industry received a lot of attention in the present research, which is related to the findings of Frizzo-Barker et al. (2020) conducted recently. Their systematic literature review study showed the bank sector received more attention compared to other industries. Based on the exploration of understanding blockchain technological and management challenges and opportunities for operational excellence, the literature review highlights various blockchain technological and management challenges and opportunities. This is shown from the sample of 69 articles in the present study in which only 5 articles were used to discuss blockchain management opportunities, 10 articles were used to discuss blockchain technological challenges, 24 articles were used to discuss blockchain management challenges, while 13 articles were used to discuss blockchain technological opportunities and 16 articles were used to discuss blockchain technology.

Furthermore, studies that focused on the specific industry in Figure 5, differ from one industry to another and issues they focused differ from one to another. For example, in the financial industry, a literature review conducted by Cai, (2018) explored two major innovations such as blockchain and crowdfunding, and they argued it will provide further insight and understanding into a coming FinTec revolution. They argued that since the basic structure of technology allows individual to reach a general agreement in a decentralised manner will break the existing system of needing trusted centralised service providers to determine the authenticity of a transaction, as this has traditionally often been a major role of banks (traditional financial intermediaries. This may affect the operational excellence of the banks.

4. Research Gap

Research on blockchain adoption from the lens of TOE framework for operational excellence has not received much attention (Cui et al. 2020) to provide a clear understanding of technological and management challenges and opportunities of blockchain adoption. Although there is a study that asked the future research questions about "how blockchain can be used in a better way to receive operational excellence?" (Upadhyay, 2020) without any concern about what technological and management challenges of blockchain adoption that need to be explored and understood for operational excellence in the automotive industry context? Some studies have identified the challenges of the blockchain (Upadhyay, 2020) to be major barriers (Kouhizadeh et al. 2021) and opportunities of the blockchain (Upadhyay, 2020), to be key drivers for blockchain adoption in different areas (Kouhizadeh et al. 2021), while one of the researchers in the UK has explored blockchain applications as the key technology for business and management practitioners (White, 2017).

The classification and differentiation of challenges and opportunities of blockchain adoption into technological and management challenges and opportunities in the present study differentiated from previous academic studies in particular, by exploring these technological and management challenges and opportunities from the TOE framework angle for operational excellence in the UK automotive industry context (Cole et al. 2019; Wang et al. 2019a) as shown in the findings and limitations of related studies in Table 4 of the present study. Though there are limited studies that have focused on the use of TOE framework to explore different factors that influence blockchain adoption outside the UK in different companies (Clohessy and Acton, 2019) and challenges and opportunities that can influence blockchain adoption in different industries such as freight logistics industry (Orji et al. 2020) that have been published in different academic journals. Yet, these studies are fragmented because they did not include significant technological and management challenges and opportunities of blockchain adoption in the context of operational excellence, nor do they consider to explore these challenges and opportunities in the automotive industry context. Though it was stated in the future studies of Orji et al. (2020) that other industrial sectors can be studied to have a clear understanding of the critical factors to the blockchain adoption process. Therefore, the present study found a significant gap that exists in the literature regarding the technological and management challenges and opportunities of blockchain adoption from the TOE framework for operational excellence in the automotive industry as shown in Table 4.

5. Discussion

Following the main findings, RQ1 is addressed in the following:

3. RQ1. What are the technological and management challenges and opportunities of blockchain adoption from the lens of the TOE framework for operational excellence in the UK automotive industry?

5.1. The Management and Technological Challenges and Opportunities of Blockchain Technology Adoption Through The Lens of Technology – Organisation – Environment (TOE) Framework for Operational Excellence

5.1.1Technological Context

The technological context comprises technological equipment, processes and infrastructure. Blockchain as a distributed ledger technology promises to improve the automotive industry to achieve operational excellence (Kouhizadeh et al. 2020) in such a way that it will eliminate a lot of shortcomings of the traditional supply chain (Delafenestre, 2019; Wang et al. 2019a), it will enable the sustainable supply chain management (Saberi et al. 2018; Kouhizadeh et al. 2021), enable circular economy (Kouhizadeh et al. 2020), enhance efficiency, reduce paperwork, lower costs, lower workload, and contribute to customer satisfaction such as customer order management, show order traceability and enhance visibility for different supply chain participants (Martinez et al. 2019). Blockchain is decentralised and encompasses data server that is not controlled by a single firm.

5.1.2 Blockchain technological challenges

5.1.2.1 *Open network designs challenges*

Studies revealed that open network in blockchain designs can draw criminals, make it easy for illegal activity and possibly let access to content (O'Leary, 2017; O'Leary, 2018). For example, research article shows that based on public peer-to-peer blockchain those that aim to adopt blockchain technology who are interested in legal transactions and legal collaborators or participants might not be able to implement blockchain for their operations due to how easy it

is to disguise transactions that are used to capture illegal transactions (O'Leary, 2018). However, due to the criminality on this open network design that will draw criminals to perform an illicit transaction, implementing predictive capacity and a machine learning system that can collect and analyse data automatically from blockchain bitcoin and other external data sources and apply search criteria to fit, index, and a cluster is an ideal approach to detect suspicious behaviour (Yin et al. 2019). This may pose a serious challenge to various stakeholders who are in the operations and supply chain of the firms to participate in using a blockchain platform, which may, in turn, hinder the firms to achieve operational excellence.

5.1.2.2. *Blockchain security and privacy challenges*

One of the technological challenges facing blockchain is the security challenges (Kouhizadeh et al. 2021) from the attacker (Warkentin and Orgeron, 2020), individual personal information and privacy of the individual from those who created blockchain (Upadhyay, 2020). However, irrespective of the decentralised transparent structure of blockchain technology, the present study finds that blockchain technology is still vulnerable to manipulation, which means there are security challenges in the blockchain. For example, empirical research conducted by Herian (2017) revealed that as the block is chain to the next as well as the one before it, it becomes less likely that a greedy attacker looking to intermeddle with a chain to defraud, would be able to undo or change a particular chain without affecting all the blocks associated with it. Another security challenge includes "51% attack" in blockchain (Warkentin and Orgeron, 2020; Kamble et al. 2019; Chang et al. 2020a). This means that an attacker controls 51 per cent of the computing power of the entire participant network and could vote to remove all the participants, which is hypothetical for such an attack (Warkentin and Orgeron, 2020; Kamble et al. 2019).

Also, it was revealed that irrespective of how private or closed blockchain provides more privacy for the transaction (Morkunas et al. 2019), it was found that the privacy of transactions histories of individual blockchain has been a concern in which transactions histories of individual blockchain are not as private as personal financial management such as bank accounts and often closely guarded and privacy of individual blockchain user identities, as well as the general anonymity enjoyed by those who facilitate the proliferation of blockchain architecture according to the empirical research by Herian (2017). Therefore these concerns can be worrisome for automakers stakeholders or actors who are contributing to the operational excellence of the firms to join the blockchain. Without various stakeholders who involved in the operations and supply chain, the aim to achieve operational excellence might not be possible.

5.1.2.3. *Wasted resources or energy consumption challenges*

One of the critical challenges facing the adoption of blockchain technology is being regarded as an extent of computing resources and energy consumption (O'Leary, 2017; Kumar et al. 2020; Min, 2019). Since blockchain technology underpins bitcoins and uses Proof of Work as a consensus algorithm (Nakamoto, 2008), the energy that Bitcoin consumes (Chang et al. 2020a) has been compared to the electricity consumption in the country of Ireland according to Siegfried et al. (2020) and O' Leary (2018). Similarly, it has been reported that the energy required to manage one Bitcoin transaction is equal to that required to power nine households in the United States for one day (Frizzo-Barker et al. 2020). Moreover, hydroelectric dams in China has been reported to power the largest Bitcoin mines in the world as discussed by Frizzo-Barker et al. (2020). The blockchain energy consumption can be one of the concerns for manufacturers such as car manufacturers because their operations have been consuming electricity already (Mohamad and Songthaveephol, 2020). A lot of manufacturers such as car

manufacturers might not want to use blockchain due to how it consumes energy, which may, in turn, stand as a barrier for adopting and implementing this technology for their operations such as tracing their raw materials from the origin of the product, manufacturing of the products, and selling the completed products to the end customers.

5.1.2.4. *Lack of interoperability challenges*

Even if interoperability has been indicated as one of the keys to widespread blockchain adoption as asserted by Frizzo-Barker et al. (2020) that involves a partnership between tech firms and regulators to identify widely known protocols and industry standards, the technical elements of interoperability have been argued as one of the adoption barriers. Blockchain technology provides a share identification of devices from birth, interoperability, and projection. Interoperability has been characterised as one of the concepts of industry 4.0 (Garay-Rondero et al. 2019). Interoperability means free communication between blockchain systems. Since interoperability is one of the key properties that are central to blockchain technology, the question is being asked by researchers regarding interoperability. For example, questions such as if interoperability can communicate with other blockchains, The internet of Things, etc? (De Keyser et al. 2019). Such question might be asked because the majority of the blockchains in the market are currently working in silos (Warkentin and Orgeron, 2020; Bumblauskas et al. 2020; Di Vaio and Varriale, 2019) unable to pull or send information from existing IT system or integrate with existing IT systems (Wang et al. 2019a).

Deloitte as one of the blockchain vendors reported that the lack of interoperability gives independence to blockchain developers and coders and can give headaches to IT departments when they discover that without translation assistant platform cannot communicate and interoperability appears to be critical in building the network effect within the business

ecosystem (Upadhyay, 2020) Interoperability in blockchain can be categorised as one of the most pressing managerial challenges (Min, 2019). Due to these challenges, the present research finds that effort has been developed for managers to overcome these challenges in the area of the supply chain, which requires data interoperability among multiple organisations between diverse IoT over a supply chain (Kim and Laskowski, 2018; Pólvora et al. 2020). Therefore, blockchain interoperability may not communicate with most of the UK automakers' existing network and if firms wish to navigate the rapid financing options directly via their Enterprise Resource Planning ERP system, they may need to incorporate smoothly into these new systems, which can impact their operations and give their IT department a headache.

5.1.2.5 *Scalability challenges*

Storage capacity and scalability are part of the critical management challenges facing blockchain technology (Upadhyay, 2020; Chang et al. 2019a; Chang et al. 2020a; Min, 2019; Biswas and Gupta, 2019). It was reviewed that in the first year of Bitcoin, Bitcoin faced technological challenges such as important in increase in mining costs, the average block size, median confirmation time, mempool transaction count, and user fees (Manski, 2017). Though the mempool transaction account was asserted to be one of the unresolved technical challenges in the work of Manski (2017). Since blockchain underpinning Bitcoin as one of the cryptocurrencies that have been widely used and revealed in different studies (Morkunas et al. 2019), and one of the approaches and applications of blockchain (Ying et al. 2018; Wang et al. 2019) to carry out monetary transactions by individuals that adopt its use by putting nearly all of their transactions on the public blockchain (White et al. 2020), the chain grows constantly at a rate of 1 MB for each block every 10 minutes (O'Leary, 2017), while there are copies that are stored amongst the nodes in the network (Easley et al. 2019).

It was explained by O' Leary (2017) that in Bitcoin, blockchain transactions need to be verified by miners that ultimately create that mined roughly every 10 minutes. By taking into account the overwhelming quantity of transactions that take place through a manufacturer's operations and supply chain, including locations, products, and different business partners, the operations of firms need to be accessible to the demand of a firm service and the technology needs to perform these transactions immediately. Because the transaction rate for blockchain needs to be far higher until blockchain can handle today's business operations that are rapidly changing involving sales of products via various geographical locations.

5.1.3 Blockchain technological opportunities

5.1.3.1 *Disintermediation of third-party service provider opportunities*

It has been revealed by Schuetz and Venkatesh (2019) that it has the potential to minimise the need for intermediary institutions such as banks and lower the cost of transactions. They also argued that blockchain can provide customers with more suitable products in three ways: (1) digitalising traditional practices; (2) solving existing problems; (3) opening up new opportunities for users. Also, smart contract as one of the applications of blockchain has been reviewed by different researchers as one of the applications of blockchain that can bridge the gap of a third service provider (Shermin, 2017; Manski, 2017; Herian, 2017; Wang et al. 2019b; Ali et al. 2020). For example, Herian (2017) explained that smart contacts offer several distinctive opportunities to enhance current legally binding relations, such as minimising threats to those relationships which generally require legal intervention.

Though different questions have been asked on smart contract such as when are customers willing to convert to smart contracts? To what extent do smart contracts enhance service quality level (e.g. convenience, speed) (De Keyser et al. 2019). However, empirical research conducted

by Chang et al. (2019b), which concentrated on both the feasibility and initiation of supply chain application processes showed the proposed of the blockchain-based framework together with the use of smart contracts to extract the viable advantages of the process design of the supply chain. Through a descriptive layout of a unified system, they presented a potential use case for the disintermediation of business operations through a conceptual, shared knowledge ledger. Also, they claimed that this ledger not only promotes or facilitates tracking information sharing, but it facilitates a multilateral collaboration network among supply chain participants or members. Similarly, smart contract, which has been reviewed as one of the ground-breaking characteristics of blockchain technology known as one of the of applications and the use of blockchain can enhance supply chain contract formation to prevent contractual disputes that can result from fraud, misunderstanding, and performance failures that can destroy the supply chain partnership and supply chain activities (Min, 2019).

Academic literature revealed the smart contract can send a payment to a supplier as soon as a shipment is received by buyer Wang *et al*. (2019a). One of the opportunities of smart contract in blockchain technology is that it can trigger non-functioning lawyer's activities by establishing a legal agreement between two parties that are willing to do business together and allows independent partners in mediation transactions without having to trust another party (Upadhyay, 2020).

5.1.3.2 *Transaction cost reduction opportunities*

One of the opportunities of blockchain technology is that transactions or payment can be made without the third service providers such banks to avoid paying high commission fee when making overseas payment (Ahluwalia et al. 2020; Schuetz and Venkatesh, 2019; Upadhyay, 2020). One of the truths about blockchain technology according to Iansiti and Lakhani (2017)

is that it can dramatically reduce the cost of transactions, in particularly, blockchain technology can be adopted to reduce the cost of supply chain transactions (Cole et al. 2019). Based on the findings of a research by Holotius et al. (2019), they revealed that since blockchain technology enables cost reduction, increasing efficiency would solve the growing costs of compliance and enable more streamlined enforcement due to greater transparency. They cited an example that the know-your-customer process can be simplified or streamlined, resulting in lower costs, too. Additionally, they argued that faster transaction execution leads to reduced default risk and thus to lower cost.

5.1.3.4 *Security opportunities*

Though security has been argued as one of the technological challenges of blockchain adoption (Kouhizadeh et al. 2021). Fascinatingly, security is one of the opportunities that blockchain aims to provide for the customers (Kouhizadeh et al. 2020). This is supported by the research conducted by Wang et al. (2019a) as their findings showed that blockchain can enhance data security for information sharing such that the data security and protection provided by blockchains also protect against cybercrime and fraud. They argued that blockchain will provide direct transparency of shipments to customs authorities in real times, positively enhancing the relevant information or data for risk identification, safety, and security control. Security opportunities provided by the blockchain would enable customers to make a direct payment to suppliers of their products in a secure way without a third service provider (Wang et al. 2019a). Kouhizadeh et al (2020) argued that blockchain technology comprises a particular system layout where data can only be added to the ledger, while data history remains. They asserted that the security that will be performed on of blockchain will improve sustainable standards where customers will be ensured the sources, activities performed, and authenticity

or provenance of the green products and goods. These activities may, in turn, enhance the operational excellence of the firm.

5.1.3. Organisational Context

Organisational context is descriptive and relates directly to the usage and availability of resources (Ali et al. 2020). The propensity for technology adoption is influenced by informal and formal intra-organisational contact and control mechanisms (Ahmadi, et al., 2018); as well as organisational resources and innovativeness (Abed, 2020). The important organisational variables include infrastructure and expertise, technology or innovation support, technological resources, knowledge capability, technological infrastructure (Aboelmaged, 2014), innovation capacity, and top management (Orji et al. 2020). Therefore, lack of advanced level of blockchain technical expertise challenges, knowledge sharing management opportunities, supply chain management opportunities, and new business model opportunities provided by the blockchain can influence firms in adopting blockchain.

5.1.3.1. Blockchain management challenges

5.1.3.1.1. *Lack of advanced level of blockchain technical expertise challenges*

It was revealed in the previous and recent academic literature that lack of technological expertise may hinder the effective implementation of blockchain technology as one of the new age technologies (Kumar et al. 2020; Upadhyay, 2020; Min, 2019). Similarly, it was found that a lack of technical expertise in blockchain technology is one of the barriers in terms of blockchain technology adoption (Kurpjuweit et al. 2019). Blockchain technical expertise is required to manage blockchain technology effectively (Manski, 2017). This research finds that blockchain technology could be determined through individual, academics, and most

importantly practitioners in blockchain technology (White, 2017). Blockchain will not go far when there is a lack of expertise or talent for blockchain or knowledge of blockchain. Therefore, to use blockchain to achieve operational excellence in terms of tracking of raw materials from the origin of the product to the plant would be difficult to achieve. It was shown that the creation of blockchain applications is still isolating the ability of the average user and centralises the power to decide regarding the type of blockchain applications that are created by developers (Manski, 2017). The present study finds that lack of expertise in the area of blockchain technology is also limited from academics and individuals, which was indicated as one of the limiting factors in the empirical study conducted by White (2017) as it was revealed in the study that the lack of knowledge of blockchain principles seems to limit the ability of panel members to picture the future of applications of blockchain in his research.

5.1.3.2. Blockchain management opportunities

5.1.3.2.1. *Knowledge sharing management opportunities*

The recent advances in blockchain development have been revealed as a technology capable of secure, distributed information, and knowledge sharing requirement (Li et al. 2018; Chang, et al. 2020a). When data is managed securely it will give customer rest assured and confident on the firms. Data in blockchain can be used in various ways to achieve operational excellence. For example, the findings of a research analysis by Holotius *et al.* (2019) suggested that blockchain could be used to offer data analytics to provide deeper insights into payments, which contributes to enhanced fraud detection and prevention. It can enable a secure and standardised approach in achieving a higher level of sharing between producers (Li et al. 2018). According to Wang et al. (2019a) blockchain refers to a distributed data infrastructure or method for recording data using the crypto-analytic hash function. For example, academic

research revealed that blockchain technology can create quite notable opportunities for data management (López and Farooq, 2020). Using blockchain will enable firms to manage their operations data securely.

5.1.3.2.2. *Supply chain management opportunities*

Blockchain reduces transaction fees, asset integrity, fraud detection and prevention, P2P connectivity, improved order to fulfilment, and increased trust among supply chain partners (Min, 2019; Delafenestre, 2019). Blockchain is increasingly receiving attention in the area of supply chain management. The opportunities of blockchain technology in the supply chain were revealed, which include extended visibility and traceability, supply chain digitalisation and disintermediation, data security, and smart contract (Wang et al. 2019a). Traceability of the raw materials and products to the plant can be achieved through blockchain-based traceability, which may, in turn, enhance the traditional tracking operation systems of the car manufacturers (Kouhizadeh et al. 2020). One of the findings of survey research revealed that implementation of blockchain has a significant positive influence on consumer's purchasing decisions, mediated by consumer's quality perceptions (Sanders *et al*. 2018). It was critically examined that blockchain technology and smart contract are potential application to supply chain management to gain supply chain sustainability (Saberi *et al*. 2018), which may, in turn, contribute to environmental performance Also, traceability of the products has been part of the operations of car manufacturers and tracking of products recall are essential in the automotive industry. Therefore, blockchain-based traceability in the supply chain can do this job for car manufacturers.

5.1.3.2.3. *New business model opportunities*

Blockchain is one of the technologies that can create a new business model (Holotius et al. 2019). It was asserted that inventors of new business models can use blockchain in their new business venture proposals (Delafenestre, 2019). Recent research that was conducted by Tiscini et al. (2020), which explored the potential innovation of blockchain technology has shown that not only applications of blockchain would create new business model, but there is a propensity to create sustainable business model innovation. Car manufacturers aiming to achieve operational excellence in the area of traditional supply chain management and customer satisfaction, new technologies such as blockchain most likely to create a sustainable performance (Di Vaio and Varriale, 2019), sustainable supply chain (Saberi et al. 2018; Kouhizadeh et al. 2021), new services, new products, and enhance customers' experience to meet customer requirements. According to White (2017) applications of blockchain appears to offer considerable performance improvement and commercialisation opportunities. For example, these opportunities include handling transaction beyond the traditional financial transaction, blockchain can be used to prove authentication between exchanges, such as for digital content (Miau and Yang, 2018) etc.

The present research finds that entire new business could be grown through blockchain (Upadhyay, 2020) in terms of being reached and served an existing customer, the value could be created for customers, firms can communicate with and reach their customers' segments to deliver value proposition with reduced or eliminated middle or third party, it can enhance a relationship that firms established with specific customer segments by acquiring customers and retain a customer or to boost sales, technology firms that provides blockchain-related professional services can generate revenue from network transaction fees, business customer support level agreements, or software-as-a-service (SaaS) contracts platform fees etc (Morkunas et al. 2019). According to De Keyser *et al*. (2019), the rise of the blockchain-

enabled smart contract also opens significant opportunities to service innovation and new business model. Likewise, empirical research findings, which is based on the Delphi study by Holotius *et al.* (2019) found that blockchain paves the way for new business models and makes certain existing business models obsolete. For example, one of the ways that blockchain can enhance certain existing obsolete business model is to make existing intermediary reduced (Anagnostopoulos, 2018).

5.1.4. Environmental: External Context

Environmental context represents areas where an organisation performs its operations (Siew, et al., 2020), with the primary concern provided to external forces such as governments regulation and laws (Kouhizadeh et al. 2021) can influence the adoption of blockchain in the automotive industry. Therefore, government regulatory and legal issue challenges are considered as an environmental factor that this industry needs to be considered when planning to adopt and implement blockchain. It was asserted by Kouhizadeh et al. (2021) that government regulations are not yet completely supportive of blockchain technology, despite the technology's novelty hampers its adoption in the supply chain. This is supported by the research study conducted by Chang et al, (2020a) in the area of financial services. They revealed in their study that some governments are still restricting the use of blockchain payment systems such as cryptocurrencies. Because some of these governments in their countries regard cryptocurrencies such as Bitcoin as unconstitutional or illegal coin (Kyriazis et al. 2020). Though the use of cryptocurrencies in some countries is unrestricted (Chang, et al., 2020a). Therefore, exploring government regulatory and legal issue challenges as an environmental factor that can affect the adoption of blockchain in achieving operational excellence in this industry is considered in the present study.

5.1.4.1. *Government regulatory and legal issue challenges*

It was asserted in the work of Orji et al. (2020) that government policy and support is an influential environmental factor of blockchain adoption. It was explained that regulatory issue has been one the challenges that are impacting the adoption of blockchain technology (Yeoh, 2017; Tang, et al. 2020). Also, the contracting party to the smart contract was described as a digital account rather than a real individual as well as a variety of legal issues arise (Jianchao et al. 2020) because blockchain has ever been applied to any legal or regulatory background (Herian, 2017). On the other hand, blockchain was predicted by Min (2019) that since blockchain technology relies on the distributed ledger that can bypass the interference of government; the government may increase pressure on blockchain technology through different regulations and legal restrictions and thus may hinder the usefulness of blockchain technology for ensuring the integrity and privacy of transactions and asset transfers. This is supported by the work of Helo and Hao (2019) as they argued that regulatory restrictions, for example, have hindered the rollout of smart contracts, which is one of the applications of blockchain in several countries. Since there is no obligation on blockchain-supported firms to abide by data privacy laws in different countries, Biswas and Gupta (2019) asserted that Businesses built on blockchain platforms can face enormous migration costs following the adoption of country-wise regulations.

It was revealed in the general findings of research conducted by Ciaido et al. (2021) that blockchain and its potential benefits for information security are yet to be considered by the organisation as an evolving technology, without relevant regulation and is not yet fully understood. Therefore, government regulation and support are significant in this context and it includes the willingness of different government agencies aimed at proving assistance and implement rules and regulations to promote the adoption of blockchain technology in the

automotive industry. Though a report by the UK government has predicted that the adoption of blockchain technology would play a significant role in the UK where the technology might transform "financial markets, supply chains, customer and business-to-business services, and publicly-held registers" (Government Office for Science, 2016). Therefore, there still hope that the UK government may reduce the pressure on using various features of blockchain such as blockchain-based payment systems, blockchain-based smart contracts etc for industries, in particular, the automotive industry in which the firms and customers can be using the systems for the transactions in the UK since smart contracts as one the applications of blockchain, for example, may permits fast and direct payment from customers to suppliers (Wang et al. 2019a) may, in turn, contribute to operational excellence. The UK automakers may as well consider the adoption and implementation of blockchain for their supply chain operations such as using blockchain-based payment systems that include cryptocurrencies for transactions and cross border payment in the future.

5.2. Research Implications

5.2.1. Theoretical implications

There has been increasing attention on the study of challenges and opportunities of blockchain adoption (Upadhyay, 2020) in different industries such as financial industry (Schuetz & Venkatesh, 2019), fright logistics industry (Orji et al. 2020), while there are limited studies that have focused on the use of TOE framework to explore different factors that influence blockchain adoption for different companies (Clohessy and Acton, 2019), to explore challenges and opportunities that can influence blockchain adoption in different industries such as freight logistics industry (Orji et al. 2020) that have been published in different academic journals. Yet, these studies are fragmented because they did not include significant technological and management challenges and opportunities of blockchain adoption in the context of operational

excellence, nor do they consider to explore this approach in an automotive industry context. Though it was stated in the future studies of Orji et al. (2020) that other industrial sectors can be studied to have a clear understanding of the critical factors to the blockchain adoption process. Therefore, the literature of challenges and opportunities of blockchain adoption was brought forward in the present study in two ways:

1. There have been no studies yet that have systematically reviewed the technological and management challenges of blockchain adoption for operational excellence (Cui, et al., 2020). The present study presents technological-organisational-environmental (TOE) framework as a set of challenges and drivers of adoption of new technology, which aimed at identifying and understanding the technological and management challenges and opportunities of blockchain adoption in operational excellence.
2. The present study extends the literature of challenges and opportunities of blockchain technology adoption and differentiates the technological and management challenges and opportunities of blockchain adoption incorporating the theory of TOE framework.

5.2.2. Managerial implications

Even if it has been revealed that Toyota as one of the car manufacturers has implemented blockchain technology in its internal supply chain networks, marketing communication, and internal operations since 2017 for promoting a digital ecosystem for mobility, accelerating autonomous driving technology, and enhancing its business intelligence (Kouhizadeh, et al., 2020), our findings also have significant managerial implications and insights that can enable companies such as carmakers that have yet to adopt and implement blockchain to understand technological and management challenges and opportunities of blockchain adoption in two way:

1. The findings are considered to benefit government, blockchain service providers, in particular, the automotive industry to focus specifically on the high rated critical factors identified in the present study to adopt and implement blockchain successfully.
2. Operations managers in the automotive industry may implement the systmtic direction of implementation perspectives into the important parts for the blockchain adoption to help develop successful strategies for competitive advantage.

6.1. Conclusion and Limitations

Existing academic studies on technological and management challenges and opportunities have been thoroughly searched, reviewed, and discussed through the lens of technology – organisation – environment (TOE) framework. Different academic articles were selected from the reliable online database and categorised into different areas. The present systematic literature review provides an overview and understanding of studies on technological and management challenges and opportunities of blockchain adoption and its technical application and implications for the automotive industry.

There are some limitations that the present study faced. One of the limitations is that the journals used in this study are limited to 35 journals and the academic articles selected are limited to 71 articles through the specific keywords. However, if more journals and articles were included by expanding the search it could have provided a more comprehensive opinion of the issue explored. Likewise, a lack of several journal articles on blockchain technological and management challenges and opportunities articles affected the sample size to be studied for operational excellence research, in particular, in the automotive industry. The study has been explored in the UK automotive industry context and the outcome is the limitation of generalization to the rest of the countries and industries. Systematic literature approach was considered for the present study to explore existing academic papers on technological and

management challenges and opportunities from the lens of TOE framework for operational excellence, whereas a more specified method meta-analysis can be considered for future research. The environmental context of the TOE framework used in this study gave high priority to government regulatory and legal issues challenges without any concern about customer pressure and competitive pressure, which may provide some significant and additional directions for future studies as well as further studies studies of the topic in this industry.

6.2. Future research directions

Since blockchain is still in its nascent stage, it is obvious from the present study that there is limited research in exploring categories and differentiate its technological and management challenges and opportunities based on the analysis conducted for the present study. However, this provides many directions for future research. The blockchain technological and management challenges and opportunities for operational excellence in the context of the automotive industry have not received increase attention compare to other industries such as the financial industry across the globe. Exploring more study in this area can provide the automotive industry with an insight into the uses of blockchain. Also, blockchain technology has received increasing attention from different researchers in the financial institutions, business and management etc, more study can also be explored in the automotive industry. This gap can be filled by investigating different carmakers in adopting blockchain technology from the theoretical angle such as TOE framework. Subsequently, the study would show if there is a great future in blockchain technology within the automotive industry as blockchain has been hyped by expertise, academics, journalists etc.

Figure 5 highlights some industry specific papers addressing blockchain issues in which we were unable to map the addressed issues with respect to block chain adoption affecting

operational performance. The future research may extend this area and map the addressed issues with respect to blockchain adoption affecting operational performance. Finally, how future technological and management challenges and opportunities of blockchain can be more explored may be expected to be studied for operational excellence in the UK automotive industry, such as that of "how blockchain may be expected to change the future business" that was examined by White (2017), may likewise be examined from an operational excellence perspective in the future.

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