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Blockchain for next generation services in banking and finance: cost, benefit, risk and opportunity analysis

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Abstract
Purpose – The purpose of this paper is to help in providing a better understanding of the application of blockchain technology in the context of the banking and finance sectors. The aim is to outline blockchain's benefits, opportunities, costs, risks as well as challenges of the technology in the context of banking and finance services.
Design/methodology/approach – Careful examination of the extant literature, including utilising relevant academic-based research databases has been carried out. It covered reviewing various research contributions published in peer-reviewed journals, academic reports, as well as technical reports to help in identifying related benefits, opportunities, costs and risks.
Findings – The findings reveal that there are limited contributions in utilising blockchain in the banking and finance sectors when compared with other sectors. As such, the study highlighted the relevant perspective of benefits, opportunities, costs and risks within such sectors.
Practical implications – This study helps in offering a focal point to banking and financial sector managers and decision-makers for realising the value and offerings of blockchain technology as well as associated strategies and programmes.
Originality/value – This study highlights the need for a holistic understanding of the various aspects of cost, benefits, risk and opportunities to create blockchain applications that work for banking and finance sectors

Keywords Blockchain, Cost, Benefit, Risk, Opportunity, Banking and finance
Paper type Literature review

1. Introduction
Over the years, the use of emergent digital innovative technologies, through telebanking, online and mobile banking and fintech, has contributed towards offering new experiences. In this regard, convenience, availability, speed, efficiency, effectiveness and transparency of banking and financial processes have enabled the sector to tackle some of the common challenges associated with facilitating transactions across various sectors (Peters and Panyi, 2016; Frame and White, 2014). The emergence of blockchain technology has been heralded as the next revolution that will transform the shape and size of the banking and finance industry and the way business transactions are conducted (Ceremeno, 2016). Blockchain technology is focused on having an open, universally accessible decentralised ledger for establishing trust

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in an unsecured environment without relying on a third party. The ledger contains the shared and agreed-upon state of the blockchain, including a list of all past transactions that are immutable. Moreover, it can also be utilised along with other technologies, such as encryption, business rules and identity management, in order to make such technology fit for the challenges at hand (van Engelenburg *et al.*, 2018).

Furthermore, blockchain has also the potential to disrupt the banking sector by exploiting it across various financial services. As such, it includes facilitating global money remittance, smart contracts, automated banking ledgers and digital assets (Peters and Panayi, 2016). It can transform a considerable number of existing traditional banking services through improving transaction security and expediting transfers at a lower cost (Lee and Shin, 2018). Therefore, it offers the opportunity to help in enhancing issues surrounding transparency, trust and privacy for relevant stakeholders. Nonetheless, as much as blockchain has brought opportunities for organisations, it is pivotal to realise that there will be several challenges and complexities across technical, regulatory and adoption-related areas (Attaran and Gunasekaran, 2019). Recent events such as digital currency theft and cybersecurity breaches have demonstrated the high-level of risks related to the use of blockchain technologies in banking and finance (Deshpande *et al.*, 2017; Attaran; Gunasekaran, 2019).

While exploiting the potential of new-disruptive technologies, specifically blockchain, it is equally vital to comprehend the potential benefits, risk and challenges associated with them to mitigate risks and avoid the technical, social and political consequences of failure. Therefore, this study aims to outline blockchain's benefits, opportunities, costs, risks, as well as challenges of technology in the context of banking and finance services. The remainder of this paper is organised as follows: section two presents a state of the art review of blockchain technology within the banking and finance sectors. This is followed by highlighting the overall challenges of blockchain technology in section three. After that, in section four, the integrative literature review methodology is then introduced. Section five, cost, benefit, risk and opportunities framework is then introduced to examine blockchain technology within the banking and finance sector. After that, section six presents the discussions, and finally, section seven offers the concluding remarks of the study.

2. Blockchain for next generation banking and financial services

Financial technologies have created a new paradigm shift in driving innovation in the financial sector, and blockchain technology is a significant part of this transformation (Lee and Shin, 2018). While there has been a wide range of traditional banking products from payments to investment services, blockchain technology has challenged this through offering innovative, more secured and faster transfers at lower costs (Lee and Shin, 2018). Blockchain technology can be explained, as "*A blockchain is essentially a distributed database of records or public ledger of all transactions or digital events that have been executed and shared among participating parties. Each transaction in the public ledger is verified by the consensus of a majority of the participants in the system. Once entered, information can never be erased. The Blockchain contains a certain and verifiable record of every single transaction ever made*" (Crosby *et al.*, 2016, p. 7). As such, this will help in eliminating centralised points of vulnerability, which cybercriminals can potentially exploit. At the same time, making data manipulation is exceptionally impracticable (Mason, 2017; Mearian, 2017).

The blockchain technology underpinning cryptocurrencies such as Bitcoin, Ethereum and other alternative coins was perceived by most of the banks with much criticism and scepticism (Attaran and Gunasekaran, 2019). However, this has started to change recently and became a prevalent topic within the banking and finance sectors. The primary reason is that it is far less expensive, and the transactions processing time is significantly faster. Banks have been looking at ways to use the blockchain technology for clearing and settlement, trade finance and syndicated loans (Arnold, 2017). As a result, this will enable banks to process payments more quickly and accurately while reducing transaction-processing costs. Accenture digital (2017) interviewed thirty-two commercial banking professionals to study the potential of blockchain technology, and the results indicated that nine in ten executives said their bank is currently exploring the use of blockchain. McKinsey also surveyed banking executives globally and found that around half of executives think that blockchain will have a significant impact within three years (Guo and Liang, 2016). Likewise, IBM has indicated that, in 4 years, 66% of banks will have commercial blockchain in four years (Shen, 2016).

Since 2015, several major international financial institutions have begun to prepare proposals for the blockchain sector. For example, Goldman Sachs, J.P. Morgan and other banking giants have all established their blockchain laboratories, working in close collaboration with blockchain platforms and published a series of studies on this topic (Guo and Liang, 2016). J. P. Morgan with two global partners, Royal Bank of Canada and Australia and New Zealand Banking Group Limited, announced the launch of the largest blockchain payments networks called Interbank Information Network (INN) (Guo and Liang, 2016). The new initiative can use blockchain technology to minimise friction in the global payments process and hence, allow payments to reach beneficiaries faster with fewer steps and better security. Furthermore, IIN will enhance the client experience, decreasing the amount of time from weeks to hours and costs linked with settling payment delays (Mearian, 2017). By leveraging blockchain technology, IIN will aim to significantly reduce the number of participants currently needed to respond to compliance and other data-related enquiries that delay payments.

Additionally, various national stock exchanges, such as the Nasdaq Stock Market and the New York Stock Exchange have also conducted in-depth research on blockchain technology. In 2015, Nasdaq announced that it had completed its first securities transaction using the blockchain transaction platform named Linq (Zhu *et al.*, 2016). Furthermore, the US Depository Trust and Clearing Corporation, Visa, the Society for Worldwide Interbank Financial Telecommunication and other financial entities have also expanded their plans in the blockchain technology sector (Guo and Liang, 2016). Furthermore, most recently American Express introduced instant blockchain-based payments using Ripple, a fintech start-up, marking one of the first major users of the technology. These discussions highlight that the world's biggest banks are looking for opportunities in this area by researching innovative blockchain applications. Furthermore, the banking and finance sector no longer see blockchain technology as a threat to traditional business models (Crosby *et al.*, 2016).

Nonetheless, governments across the globe have foreseen the benefits in utilising innovative blockchain technology within its services. In this regard, Gibraltar is the first country in the world that will introduce a customised licence for fintech firms using blockchain distributed ledger technology to attract start-ups. Other developed nations such as the US, the UK and Japan, have paid close attention to the development of blockchain and investigated their application in various fields. Similarly, China, Russia, India, South Africa and other countries have also successively initiated research on blockchain technology (Guo and Liang, 2016). However, many cities in Europe, the United States and Asia have yet to take the regulatory step, mainly because the adoption of blockchain technology is not systemically significant enough to warrant specific regulation. The decentralisation and self-governance of blockchain technology are considered a risk, which reduces the idea of regulation and has a critical impact on the existing system. Therefore, blockchain regulation is necessary and should be formulated sooner rather than later (Guo and Liang, 2016). According to Cermeno (2016), many critical regulatory challenges need to overcome before blockchain technology can be used in the financial sector.

3. The status quo of blockchain technology in banking and finance services

The introduction of any new innovative technology would offer various opportunities as well as challenges (see Table 1) that can considerably influence the adoption process (El-Haddadeh, 2019). In the context of blockchain technology, one of the main critical challenges can be associated with regulatory issues. While the technology itself, by definition, does not object to being regulated, the diversified use of the technology demands such matter (including cryptocurrencies, blockchains, shared ledgers and smart contracts). Therefore, depending on specifics of the financial processes are being offered on the blockchain (such as payments, lending and investment), appropriate regulation mechanisms will need to be applied. In this regard and at the global level, policymakers and regulators have been mainly focussing on regulating the use of cryptocurrencies to avoid taxation and criminal activities (Cermeno, 2016). While some countries consider cryptocurrencies as digital money, others treat them as commodities. In 2015, the European Court of Justice (ECJ) ruling identified cryptocurrency transactions are exempted from VAT and treated it as money or currency (Court of Justice of the European Union, 2015). As such, this could be recognised as a mechanism influencing the development rate of blockchain technology. Therefore, regulatory approaches would need to cleverly balance against its innovative spirits while recognising the possibility of the technology unintentionally contributing to systemic risks to the financial system (Yeoh, 2017). Yeoh (2017) claimed that there are challenges to broader blockchain adoption and use despite the opportunities it offers. He argued that blockchain

Identified blockchain challenges in banking and finance	References
Regulatory challenges	Cermeno (2016), Guo and Liang (2016)
Lack of collaborative governance to provide trust in the financial markets	Attaran and Gunasekaran (2019), Crosby *et al.* (2016), Yeoh (2017)
Technical and scalability challenges	Harwood-Jones (2016), Pennathur (2001), Bauer and Hein (2006)
Business model challenges	Harwood-Jones (2016)
Scandals and public perception	Harwood-Jones (2016)
Government rules and privacy challenges	Harwood-Jones (2016), Pennathur (2001), Bauer and Hein (2006)
Interoperability	Pazaitis *et al.* (2017), Kshetri (2018), Kshetri (2017)
Security and privacy of data	Deshpande *et al.* (2017), Pennathur (2001), Bauer and Hein (2006)
The integrity of data and secure encryption	Deshpande *et al.* (2017)
Energy cost of the technology	Deshpande *et al.* (2017), Caplen (2018), Bauerle (2018), Zheng *et al.* (2018), Marr (2017), Hillsberg (2018), Hassani *et al.* (2018)
Lack of clarity regarding smart contracts	Deshpande *et al.* (2017)
Perceived risks in the early adoption	Deshpande *et al.* (2017), Atzori (2015)
Disruption to existing industry practice	Deshpande *et al.* (2017)
Insufficient evidence on business gains and broader economic impact	Deshpande *et al.* (2017)
Lack of clarity on how the technology would be governed	Deshpande *et al.* (2017), Attaran and Gunasekaran (2019), Crosby *et al.* (2016), Yeoh (2017)
Uncertainty around regulation	Deshpande *et al.* (2017), Cermeno (2016), Guo and Liang (2016)
Multiple non-interoperable implementations and resulting fragmentation	Deshpande *et al.* (2017), Pazaitis *et al.* (2017), Kshetri (2018), Kshetri (2017)
Re-engineering of processes and integration with legacy systems	Deshpande *et al.* (2017)
Blockchain technology as a threat to traditional business models	Crosby *et al.* (2016)

Table 1.
Challenges of blockchain technology

relies on collaborative governance to provide trust in the financial markets to ensure that all play by agreed rules. The absence of such governance has been one of the main reasons behind various blockchain cybercrimes and other criminal activities (Attaran and Gunasekaran, 2019; Crosby *et al.*, 2016). Such governance with right policies, procedures and mechanisms as well as enforcements are needed to realise the real societal benefits of blockchain. Harwood-Jones (2016) also claimed that blockchain's broader and deeper applications are potentially constrained by limitations posed by technical and scalability challenges, business model challenges, scandals and public perception, government rules and privacy challenges. Regulation concerns laws are designed to control behaviour, while governance concerns stewardship, collaboration and incentives to act on common interests. In this respect, governments have been genuinely expected to regulate technologies such as blockchain and at the same time function as a collaborative peer to other constituents of society rather than as the heavy hand of the law (Tapscott and Tapscott, 2016). It can be done by participating as players in a bottom-up governance ecosystem instead of as enforcements of top-down regimes of control (Yeoh, 2017).

The financial instability derived from the decentralised nature of blockchain technology has created several challenges across various industries and government authorities (European Securities and Markets Authorities, 2017; Lee and Shin, 2018). In this respect, regulatory activities can be expected to help in providing the required environment that can facilitate the broader adoption, specifically in the banking sector (Fan, 2018; Kshetri, 2018; Larios-Hernández, 2017). By doing so, it will help maintain the required safeguards towards the sustainability and continuity of blockchain within this industry and beyond. From a system infrastructure perspective, the disruptive nature of blockchain technology has created a paradigm shift in the banking and finance ecosystems (Pazaitis *et al.*, 2017; Kshetri, 2017). The innovative approach, based on utilising peer-to-peer distributed networks while applying open-source cryptographic protocol, has demonstrated its potential with fast, cost-effective and secure transfers of financials and assets across the globe (Mansfield-Devine, 2017).

Nonetheless, interoperability has ascended as a challenge, specifically for banks, in facilitating the process of maintaining the required operation at internal and external levels (European Securities and Markets Authorities, 2017). At the internal level, re-engineering of processes and integration with legacy systems is a challenge, which banks will need to acknowledge as part of their implementation process. On the other hand, enabling a functional cross-chain depends on retaining a rigorous, trustworthy relationship across various blockchain applications and platforms (Pazaitis *et al.*, 2017; Kshetri, 2017, 2018). As such, various financial institutions have realised the need for utilising conventional technology standards and protocols in order to offer necessary support of a seamless distributed digital transaction process. (Kshetri, 2018)

Furthermore, the decentralised, transparent, equality and accountability have driven nature of this disruptive technology has created some new settings where individuals can be less dependent on controlled, sometimes inefficient, services offered through associated service providers (Al-Saqaf and Seidler, 2017; Vranken, 2017). As a result, it has been shaping a new and unprecedented environment, which is affecting the socioeconomic as well as the cultural settings. Hence, this has created the need for realising how this innovative technology can be integrated within businesses strategies and individuals' activities in order to understand its societal impact (Marsal-Llacuna, 2018). For the banking industry, the increased levels of trusts, based on the distributed ledger network nodes and associated transparency and the faster and more cost-effective financial transfers can contribute towards providing a convincing argument for customers towards speedy participation (Kshetri, 2018; European Securities and Markets Authorities, 2017). According to Deshpande *et al.* (2017), some of the main challenges facing blockchain technology are: lack of clarity on the terminology, perceived immaturity of the technology, perceived risks in early adoption and likely disruption to existing industry practice, insufficient evidence on business gains and broader economic impact, lack of clarity on how the technology would be governed, uncertainty around regulation, multiple non-interoperable implementations and resulting fragmentation, maintaining security and privacy of data, ensuring the integrity of data and secure encryption, energy-intensive nature of the technology, lack of clarity regarding smart contracts and how to implement them through blockchain.

4. Integrative literature review methodology

There are various approaches and methodologies in conducting a literature review. These can be classified into three broad categories (see Table 2): a systematic review, the semi-systematic review and the integrative review (Snyder, 2019). As discussed in previous sections, this study aims to help in providing a better understanding of the application of blockchain technology in the context of the banking and finance sectors. To achieve this purpose, an integrative literature review method is deemed to be suitable and appropriate. By adopting the integrative review approach, this study can assess, critique and synthesise the literature on blockchain technology that enables to develop a taxonomy or classification of essential challenges. Relevant literature on blockchain's benefits, opportunities, costs, risks as well as challenges of the technology in the context of banking and finance services was extracted from Scopus, Web of Science and Google Scholar. The search criteria included the following keyword combinations: (Blockchain OR Block chain) AND '(Banking and Finance' OR Fintech) AND (Challenges OR Benefits OR Costs OR Benefits OR Risks). The extracted literature and secondary research are then used to capture the benefits and challenges associated in blockchain and then developed a blockchain analysis framework and taxonomy that identified and clustered the key influencing issues, including benefits, challenges, opportunities and risks for banking and finance services.

Table 2.
Literature review methods

Literature review approaches	Description
Systematic review (Davis *et al.*, 2014; Liberati *et al.*, 2009)	A systematic review is defined as a tool and process of study to classify and critically evaluate relevant research and to collect and analyse data from such research. A meta-analysis is a statistical tool for integrating findings from various studies to measure, compare and classify trends, disagreements or relationships that occur on the same topic in the context of multiple studies
Semi-systematic review (Wong *et al.*, 2013; Braun and Clarke, 2006)	The semi-systematic analysis explores how research has evolved within a chosen field or how a topic has developed across research traditions. Thematic or content analysis is a technique commonly used to identify themes, theoretical perspectives or common issues within a specific research discipline
Integrative review (Torraco, 2005; Snyder, 2019)	The integrative review aims to assess, criticise and synthesise research literature in such a way that new theoretical frameworks and perspectives can emerge. In the case of emerging themes, the aim is more to create initial or preliminary conceptualisations and theoretical models than to review old models. An integrative review method will result in the advancement of knowledge and will contribute to the literature in the form of development of theoretical frameworks and taxonomy or classification

5. Blockchain for banking and finance: cost, benefit, risk and opportunity analysis

This study used SWOT theory as a theoretical lens to develop cost, benefit, risk and opportunity framework to understand the determinants of blockchain adoption. SWOT analysis is a short form for strengths, weaknesses, opportunities and threats and is a structured planning method that evaluates those four elements of an organisation, services or products. In the current study (see Figure 1, blockchain strength relates to benefits, weaknesses to costs, threats to risk and opportunities are the same (Osman *et al.*, 2014). Costs of blockchain technology are related to operating costs such as transaction costs, energy and storage costs and the benefits are related to the technical aspects such as privacy, transparency, security, trust and faster transactions. While the risk of using blockchain technology is referred to as technical, operational and regulatory legal risks, opportunities are related to whether the market would embrace the technology or not.

5.1 Examining blockchain costs for banking and finance services

Cost reduction will always play an influential role in the adoption of blockchain technology (Hassani *et al.*, 2018). Accenture (2017) suggested that blockchain-based solutions could help banks save up to eight billion USD, while Santandar report claimed that they could generate cost savings of up to 20 billion USD per annum (Meola, 2017). Blockchain technology can reduce infrastructure costs by 30% for banks and will result in cost savings of 8–12 billion USD annually (Ngo, 2017). By making the banking transaction more efficient by eliminating, the need for intermediaries and associated charges will result in further cost reductions (Marr, 2017; Hillsberg, 2018).

The operating costs of using blockchain technology for banks can be classified into three factors: transaction costs, energy costs and storage costs. The cost of storage is a rising concern for blockchain technology in banking, for example, it is expected that in the long-term storage cost per gigabyte for a Bitcoin node will exceed 22 million USD (Bloomberg, 2018). The increase in the amount of energy required to assist blockchain algorithms is another major challenge for the banking sector, for example, if cryptocurrencies were to grow

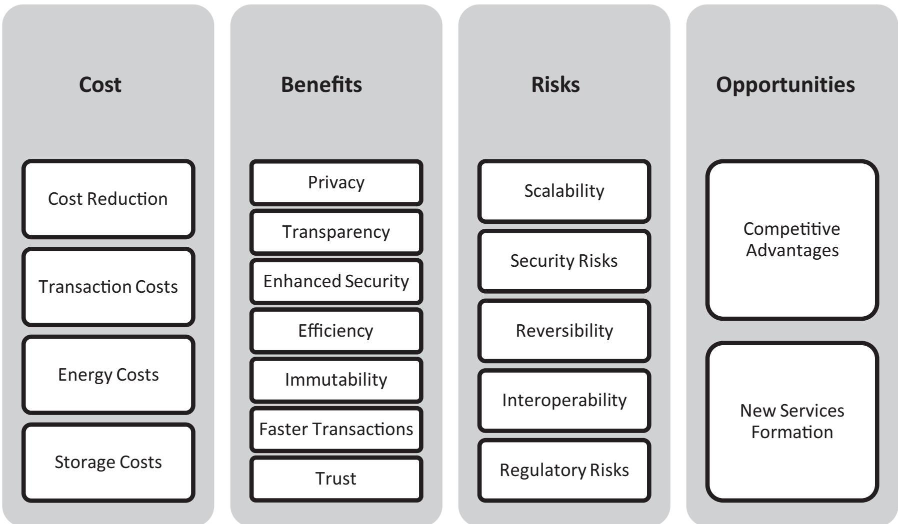

Figure 1. Cost, benefit, risks and opportunity analysis framework

to 5% of global money supply, it is estimated that the processing would require 10% of the energy consumed by China (Caplen, 2018). Finally, transaction costs are influenced with both cost of storage and energy costs, for example; currently, each bitcoin transaction costs about 0.20 USD (Bauerle, 2018) and as a result of electricity costs, the single transaction cost for Bitcoin can vary between 75–160 USD (Bloomberg, 2018). Zheng *et al.* (2018) also claimed that energy costs and storage cost would rise as the transaction volume increases, and a blockchain database must store data indefinitely, which means that the database will grow substantially over time, as will the storage costs.

5.2 Exploring blockchain benefits for banking and finance services

Blockchain provides Banks with operational benefits such as privacy, transparency, enhanced security, cost savings, immutability and faster transactions (Mendling *et al.*, 2018; Lakhani and Lansiti, 2017; Kiayias; Panagiotakos, 2016; Kosba *et al.*, 2016; Zyskind and Nathan, 2015). Park and Park (2017) claimed that using blockchain provides higher security compared to storing all data in a central database and will prevent damage from attacks on the database. Besides, blockchain has an openness attribute, and as a result, it provides transparency in data when applied to an area requiring the disclosure of data. Therefore, due to such benefits, blockchain can be utilised in diverse areas, including the financial sector and its applications are expected to expand. Wang *et al.* (2019) mentioned that blockchain is a distributed technology that increases the visibility and transparency of the stored, and as an immutable ledger, blockchain ensures a single version of the truth that helps to build trust in the stored information. Queiroz and Wamba (2019) also argued that blockchain transparency is a significant predictor of the behavioural intention to use blockchain. Furthermore, Queiroz and Wamba (2019) argued that transparency is strengthened because the transactions are shared across the network, together with any useful information, thus enabling all network actors to informed of all in due time, also resulting in creating trust. Clohessy and Acton (2019) examined the primary reasons of organisations adopting blockchain and found that the intention to adopt was related to benefits such as reduced costs, enhanced security, efficiency and transparency of the transaction.

5.3 Vindicating blockchain risks for banking and finance services

Banks adopting new technologies such as blockchain must be prepared to tackle technical and operational risk, regulatory and legal risk as well as reputation risk that may arise from these (Pennathur, 2001; Bauer and Hein, 2006; Deshpande *et al.*, 2017) The Basel committee report defines operational risk as to the potential for loss due to significant deficiencies in system reliability and integrity. The Federal Deposit Insurance Company describes this risk as hardware/software failures, disruptions, protections, systems or database compromise. Operational risk is mainly arising from external hacking. Hackers may obtain confidential information by manipulating data or altering account balances (Attaran and Gunasekaran, 2019). For example, when small banks outsource their web operations, internal controls may not cover vendors who establish web-based functionalities (Pennathur, 2001). In addition, customers may intentionally or unintentionally misuse the website leading to an increase in operational risk. Overall, inadequate technical and operational controls, policies and procedures can create operational and security risk that can lead to theft and fraud in a digital environment (Deshpande *et al.*, 2017). These issues can ultimately influence the reputation of the banks, a critical risk, as relationships in the sector are based on trust (Fiordelisi *et al.*, 2014).

From a technical point of view, several issues need to be investigated and taken into consideration that may potentially affect the use of blockchain technology to deliver sector-leading banking and finance processes. Issues such as scalability, security and interoperability and reversibility are some of the technological challenges highlighted in the existing literature (e.g. Vukolić, 2015; Ølnes, 2016; Cermeño, 2016) that the banking and finance sector could face when using blockchain technology. When it comes to the blockchain as a tool for regulators and supervisors, research claims (e.g. Atzori, 2015; Cermeño, 2016, Swan, 2019) that it brings about fundamental advantages to the financial services regulators. Nevertheless, there also remains regulatory challenges with the blockchain initiatives as its applications (such as payments, lending and investment) are currently immature and in exploratory phases in the financial services sector which make it even more complex and challenging to undertake its regulation. Legal risks arise due to ambiguity and uncertainty related to legal rights (Pennathur, 2001; Swan, 2019). This risk is primarily amplified through internet-based banking activities. Legal issues arising from customer privacy and disclosure, money laundering and liability concerns of banks, which have links to other websites. Computer theft can raise the concerns of banks about their liability for loss of customer funds. The legal nature including territoriality and liability, legal recognition of blockchain as a tamper-proof source, legality for treatment on shared information and regulatory reporting information standards are few regulatory issues extracted from the existing literature to highlight some of the challenges that the banking and finance sector could face using blockchain technology.

5.4 Exploiting blockchain opportunities for banking and finance services

The blockchain technology is becoming attractive in the operation of commercial banks all over the world as it ensures them the opportunity to gain competitive advantages of financial contracts based on reduction of the costs on economic agents' interaction, provision of information transparency and effective control over operational risks and controlling costs on the network and financial transactions (Vovchenko *et al.*, 2017). Yudina (2016) argued that the use of digital technologies such as blockchain would provide sustainable competitive advantages for business development in terms of economy virtualisation. The blockchain technology competitive advantages are not only the ability to expand the tools of operations but also the formation of the new service in the future (Vovchenko *et al.*, 2017). The global financial services market is becoming highly competitive. Therefore, banks are inclined to apply new innovative technologies such as blockchain to gain a competitive advantage over their competitors successfully.

6. Discussion

When examining the literature, various studies have offered insights into the challenges of adopting new-disruptive technologies in banking and finance sector such as mobile banking and cryptocurrency (Guo and Liang, 2016; Larios-Hernández, 2017; Lee and Shin, 2018). Although online and mobile banking is already well established, there are still adoption challenges which need to be overcome before digital banking becomes well established (Pazaitis *et al.*, 2017; Kshetri, 2017). The use of technology in the banking and finance sector is creating a new paradigm shift in which emergent technology is driving innovation in the field. Currently, the financial industry is experiencing extraordinary change with the introduction of blockchain technology (Lee and Shin, 2018). Blockchain products are challenging a wide range of traditional banking products from payments to investment advice. Lipton (2018) argued that blockchain might be the end of a "bank" as an organisation, although the function of banking and the need for government regulation will remain. In addition, blockchain might make currencies global instead of country-based, as crypto currents are not geographical bound. While there are all kinds of doom scenarios, there is consensus that the banking and financial industry will change due to these technology developments.

In order to understand the application of blockchain technology and the complexities involved in the adoption process, this study uses cost, benefit, risk and opportunity framework to highlight the factors that influence the adoption of blockchain in business and finance sector (see Table 3). Blockchain is already transforming many traditional banking practices in several countries with offering benefits such as privacy, transparency, immutability, improved transaction security and faster transfer of money at a lower cost both at national and international levels (Lee and Shin, 2018). Furthermore, blockchain can be used to create trust and reduce fraud (Mainelli and Smith, 2015). In addition to these benefits, blockchain technology offers opportunities for banks to gain a competitive advantage in terms of economy virtualisation over their competitors and introduce new services in future. Although blockchain may bring enormous benefits and opportunities to the banking industry and give birth to a whole new generation of services (Ølnes *et al.*, 2017), there remains significant risk and cost implication of adopting the technology (Atzori, 2015; Ølnes *et al.*, 2017). As shown in Table 3, various risk factors such as scalability, security risks, interoperability reversibility and regulatory risks are some of the main challenges facing blockchain technology. In addition, operating cost (transaction costs, energy costs, storage costs) of blockchain technology are some of the other challenges for banks. Such issues need to be taken into consideration before the mass adoption of these technologies in this field. Nevertheless, most research has been focused on addressing the technological challenges, and many initiatives remain in their infancy. As such, there is a need for a holistic understanding of the various aspects of cost, benefits, risk and opportunities to create blockchain applications that work for banking and finance sector.

7. Concluding remarks

This study highlights the need for a holistic understanding of the various aspects of cost, benefits, risk and opportunities to create blockchain applications that work for banking and finance sectors. It has been quite evident how financial technologies created a new paradigm shift in driving innovation in the financial sector, and blockchain technology is a significant part of this transformations. This study attempted to offer some insights that can help in developing the required understanding of the application of blockchain technology in the context of the banking and finance sectors. The acquired findings identify that there are limited contributions in utilising blockchain in the banking and finance sectors when compared with other sectors.

Overall, there can be several acumens that can be drawn from this study of understanding of the application of blockchain technology to both theory and practice. From a theoretical stance, the cost, benefit, risk and opportunity analysis of blockchain technology examined in this study offers several insights, especially those that are targeting banking and finance sector: this include, the various aspects related to its characterisation and conceptualisation in existing research. Furthermore, since this emerging field of study is still in its infancy, the analytical literature perspective of the adopted analysis has been deemed appropriate. The key findings in this study can help others in guiding them towards adopting an empirical-based work and research within this identified context. Besides, this specific perspective and approach offer a comprehensive and synthesised literature analysis to the status quo related to the specifics of blockchain technology in banking and finance. This paper extends further the research of blockchain through identifying key factors related to cost, benefit, risk and opportunity in the context of banking and finance.

On the other hand, the practical implications for this study can be specifically related to helping and supporting decision-makers and policymakers across the financial sector; such as central banks, traditional banks and other financial organisations. In particular, this study can offer much-needed guidance and insights to help in establishing various governance

	Factors	Description	References
Cost	Cost reduction	Blockchain can help in making banking transaction more productive by eliminating the need for intermediaries resulting cost reduction	Caplen (2018), Bauerle (2018), Zheng *et al.* (2018), Marr (2017), Hillsberg (2018), Hassani *et al.* (2018)
	Transaction costs	The future rise in energy costs and storage cost will increase the transaction cost of blockchain affecting the cost per transaction	
	Energy costs	The increase in transactions volumes will rise energy required to assist blockchain algorithms throughout the performed financial transactions	
	Storage costs	Blockchain database must store data indefinitely, which means that the database will grow substantially over time, as will the storage costs for relevant financial institutions	
Benefit)s	Privacy	Blockchain transactions can provide users with better privacy, allowing users to own their data and not allowing third-party intermediaries to misuse and obtain data	Wang *et al.* (2019), Clohessy and Acton (2019), Queiroz and Wamba (2019); Mendling *et al.*, 2018, Lakhani and Lansiti, 2017, Kiayias and Panagiotakos (2016), Kosba *et al.* (2016), Zyskind and Nathan (2015), Mainelli and Smith (2015)
	Transparency	Transparency is strengthened because the transactions are shared across the network	
	Enhanced security	Blockchain provides financial institutions with higher security compared to storing all data in a central database and prevent damage from attacks on the database	
	Efficiency	Blockchain offers banks a quick reduction in overhead costs	
	Immutability	Transaction history in the blockchain cannot be modified since blockchain ledger can remain permanent and unaltered	
	Faster transactions	Blockchain will allow payments to reach beneficiaries faster with fewer steps	
	Trust	Blockchain relies on collaborative governance to provide trust in the financial markets to ensure that all play by agreed rules	

(*continued*)

Table 3. Blockchain cost, benefits, risks and opportunities analysis framework for banking and finance services

	Factors	Description	References
Risks	Scalability	In comparison to 1,000 traditional banking transactions per second, blockchain can process around five transactions per second on average. This gap implies a considerable challenge for the adoption of blockchain for banking on a global scale	Pennathur (2001), Bauer and Hein (2006), Vukolić (2015), Ølnes (2016), Cermeño (2016), Atzori (2015), Deshpande *et al.* (2017)
	Security risks	Hackers may obtain confidential information by manipulating data or altering account balances	
	Reversibility	Financial institutions cannot recall a mistaken transaction since on the blockchain transactions are irreversible and final	
	Interoperability	There is limited interoperability between different networks in blockchain, which is crucial for financial institutions to transact with each other	
	Regulatory risks	Blockchain applications (payments, lending, investment, etc.) are currently immature and in exploratory phases in the financial services sector which make it more complex and challenging to undertake its regulation	
Opportunities	Competitive advantages	Blockchain provides sustainable competitive advantages for banks in terms of financial contracts based on reduction of the costs, provision of information transparency and effective control over operational risks and controlling costs on the network and financial transactions	Vovchenko *et al.* (2017), Yudina (2016)
	New Services formation	Blockchain will help banks form new services in the future	

Table 3.

practices and policies in order to facilitate the successful adoption of blockchain technology within the banking and finance sector. Furthermore, this study offers the opportunity to businesses, including entrepreneurs, to explore prospects for exploiting this innovative technology as a new entrant to offer new products and services in order to achieve competitive advantages.

While this study offers several valuable insights on blockchain technology in the context of banking and finance, it can be recognised that there are some limitations which future research can address. By utilising the current state of the art in this specific research domain, this study proposed benefits, opportunities, costs, risks framework; future research needs to validate the framework empirically. This study focused on the banking and finance sector. Therefore, future research should use the framework and focus on other sectors. This study outlined several challenges that affect the adoption of blockchain technology; future research should look into providing solutions for these issues.

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