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## Article

# Fantastic beasts: Blockchain based banking

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## Review

# Fantastic Beasts: Blockchain Based Banking

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**Abstract:** Blockchain is one of the primary digital technologies utilised in the finance industry with huge future potential. This study conducts a systematic literature review of a final sample of 407 prior literature from an initial set of 1979 records for the sample period of 2013–2020 with regard to blockchain adoption in banking. This review is further supplemented by a machine learning based textual analysis that identifies key themes, trends, divergences and gaps between academic and practitioner led industry literature. Moreover, the study highlights present, future use cases, adoption barriers and misconceptions of blockchains in banking, especially given COVID-19. Furthermore, this study identifies behavioural, social, economic, regulatory and managerial implications of blockchain based banking. In addition, our study identifies the cross-industry potential of blockchains via banking, thus, linking much disconnected prior literature. Finally, we develop a blockchain adoption framework and an adoption life cycle for banking. This study would be of interest to academics, bankers, regulators, investors, auditors and other stakeholders in financial markets.

**Keywords:** fintech; disruptive technology; financial services; banking; COVID-19; cryptocurrencies

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## 1. Introduction

Banks and payment services have been around for centuries and predate modern capitalism (Ferguson 2008; Hodgson 2015). Fintech is defined as “products and companies that employ newly developed digital and online technologies in the banking and financial services industries” (Aggarwal and Stein 2016). Blockchain (BC) is one of these key innovative technologies (Biais et al. 2019). Blockchains are distributed ledgers that can maintain, secure verifiable records and proof of transactions, reducing double spending of tracked transactions. However, even with an abundance of prior literature on general blockchain characteristics and applications, plethora of literature on cryptocurrencies, there is limited understanding of blockchain based applications and their regulation and governance specific to banking. In addition, during COVID-19 crisis, China is leveraging blockchain in the country's COVID-19 recovery. The Blockchain-based Service Network (BSN) developed by China is estimated to decrease blockchain-based business transaction costs in China by 80% (World Economic Forum 2015). Moreover, The People's Bank of China is in the process of implementing a digital yuan with many other Central banks entertaining digital currency options. Hence, research, especially regarding blockchain adoption in banking is becoming more significant as countries worldwide follow suit to aid businesses and banks transform digitally. Blockchains may have significant potential in many industries including the financial services sector (Adhami et al. 2018; Athwal 2016). However, as addressed in our study, it is also important to understand its limitations, adoption challenges, misconceptions, social, ethical, economical and legal impact. Prior literature is proliferated by media articles, cryptocurrency related research and focus on most popular general financial or cross industry applications of blockchains. Thus, identifying industry and academic literature with some relevant factors for banking can be challenging. Moreover, collating scattered literature on blockchain in a coherent manner for better understanding for future research, collaborations with the industry, and to identify gaps underexplored by prior literature remain important.

Given this setting, the purpose of this study is to develop new insights into blockchain adoption in banking by systematically reviewing a final sample of 407 prior studies (out of an initial set of 1979 records) for the sample period of 2013–2020. Moreover, we provide a behavioural view of blockchain based banking in terms of social, ethical, economical and legal impact on financial markets and stakeholders. In addition, we discuss present and future use cases, impact and challenges regarding blockchain adoption in banking. Furthermore, our study identifies similarities, trends and gaps among academic and practitioner led prior literature. Finally, we develop a framework for blockchain adoption in banking and discuss adoption potential during and post COVID-19. Our study sourced articles from key databases such as Science Direct, Scopus, and Business Source premier which allows us to include both high and low tiered journal articles along with vital industry sources such as premier IT and business media outlets. Lower tiered journal articles and industry sources are important as often they provide key novel trends and important developments regarding blockchains. In addition, our systematic review collates articles relevant to blockchain from information systems, supply chain management, accounting and taxation that can be linked via banking. We further highlight potential future cross disciplinary research in these fields that can be connected via banking.

Our research questions are as follows: 1. What are the present and future blockchain use cases in banking? 2. What are the gaps, similarities and trends between academic and industry literature in blockchain adoption in banking? 3. What are the behavioural, social, economic, regulatory and managerial implications of blockchain adoption in banking? 4. What are the barriers and misconceptions for blockchain adoption in banking? Our study would support interested stakeholders to effectively collaborate and identify over- and underexplored applications of blockchain adoption in banking. Furthermore, this study would be of interest to academics, industry practitioners, investors, regulators, professional bodies, governments and large multinational organisations.

Key results of the study include the following: 11 key domains are identified through our systematic review. These 11 domains include 1. BC governance, 2. Corporate voting and BC, 3. Cryptocurrencies, 4. Exchanges and BC, 5. Payment systems and BC, 6. Trading and BC, 7. Smart contracts, 8. Data management and BC, 9. Disruptive technologies, 10. Fintech, 11. Miscellaneous. According to our systematic review, the maximum number of academic articles (99 studies) are observed in 2017, while only 21 are observed from the industry. However, the greatest number from articles for the industry (35 studies) is observed in 2016. Academic articles primarily focus on cryptocurrencies with 110 studies and the industry on fintechs (pertaining to blockchain technology) with 27 studies. Several domains such as corporate voting (12 studies in academia and six studies in the industry), trading (four studies in academia and eight studies in the industry) and exchanges (20 studies in academia and six studies in the industry) emerge as underexplored areas.

Our study differs from previous literature as follows: 1. This study conducts a systematic review of an extensive final collection of 407 out of 1979 articles. 2. Conducts a comparison between industry and academic literature on blockchains in financial services. 3. Uses machine learning based textual analysis to survey prior literature and further identify key themes and subthemes. 4. Identifies the behavioural, social, economic, regulatory and managerial impact of blockchain based banking. 5. Develops a framework based on prior literature for blockchain adoption in banking. 6. Discusses Artificial Intelligence (AI) integration with blockchain and potential impact during and post COVID-19.

This study is organised in the following manner: Section 2 provides the review of prior literature. Section 3 details the methodology. Section 4 identifies blockchain based banking uses cases, including blockchain integration with Artificial Intelligence (AI) and provides the results of our systematic review and blockchain based banking framework. Section 5 explores the impact of blockchain adoption in banking including impact during COVID-19. Section 6 identifies challenges and misconceptions of blockchain adoption in banking. Section 7 concludes the study.

## 2. Literature Review

Financial technology or ‘FinTech’, is the use of technology in the finance industry. Within fintech, blockchain is one such technology with considerable potential (Berg et al. 2019). According to (Balyuk 2017) technology innovations in the financial sector results in increased demand for credit without overborrowing. The entrance of large tech companies and fintech into the financial services sector will have huge implications to banks’ business models, margins and the way banks operate (Accenture 2016). Given this setting, it is imperative to identify one of the primary fintech technologies such as blockchain, their present and future use cases, social, economic and regulatory impact in banking.

### 2.1. Blockchains in General

For successful blockchain adoption and sustainability in banking, it is important to firstly recognise the technology itself and its limitations. Then the bank needs to further consider the feasibility of such a project as mentioned in our framework. Blockchain is a peer-to-peer network, distributed ledger system (Evans 2014; Swan 2015) or database that maintains a list of transactions confirmed by connected nodes (mining nodes) with no third-party intermediary. Primarily known for its application in Bitcoin (Nakamoto 2008), blockchain features a distributed transactional database. Hacking into this network and altering a block would require significant computational power (Wood 2016). Another key decision on blockchain adoption is the selection of token or coin type. Any asset that is digitally transferable between two parties is called a token. These tokens are issued on an existing blockchain. Whereas, a digital coin is an asset native to its own blockchain (Liu et al. 2017b). For example, Bitcoin, Litecoin, or Ether all exist on their own blockchain. Choosing the appropriate blockchain platform also involves selecting certain protocols as mentioned in our framework. Moreover, miners or mining computer nodes is a key component behind blockchains (Asharaf and Adarsh 2017). They validate transactions in the network by solving cryptographic puzzles to reach a consensus ensuring security. Each time a puzzle is decrypted first, most likely by a miner with the greatest resources, a transaction is written to the block. The miner earns a reward, often in the form of bitcoins (Wright and De Filippi 2015). The puzzles that miners solve are called proof-of-work (PoW) (Nakamoto 2008).

Blockchain technology can be utilised for any asset that can be stored, transacted and distributed and thus, have great potential and implications for the financial services industry (Peters and Panayi 2016). Enhanced security and efficiency can benefit many sectors including banks. With decentralised ledgers, verification of each party in transactions would result in faster transaction completion. This would result in instantaneous settlement once the ledger is updated (O’Leary 2017). Thus, blockchains can enable secure digital asset (bonds and shares) transfers. In addition, with public blockchains, banks would be able to observe customer payment histories aiding lending decisions (Raskin and Yermack 2016). From a banking customer’s perspective, blockchains provide transparency regarding internal mechanisms in transaction settlement and faster completion (Raskin and Yermack 2016).

Moreover, for blockchain adoption, the type of blockchain platform needs to be identified as being public or private. Blockchains are initially developed to be public networks with full transparency (Románova and Kudinska 2016). Permissioned blockchains which exist in many banking use cases are, however, the opposite of this. Additionally termed private blockchains, only the selected agents are provided access to the blockchain (Carvalho 2020). Table 1 provides a summarised comparison of characteristics of public, private and federated blockchains.

**Table 1.** Public, private and federated blockchain characteristics.

Characteristic	Public	Private	Federated
Ownership	Public	Centralised	Partially centralised management
Management	Permissionless	Permissioned list	Permissioned nodes
Mechanism	All miners	Centralised organisation	Collection of leader nodes
Identity	Anonymous	Identified users	Identified users
Anonymity	Probably malevolent	Trusted	Trusted
Consensus	Costly PoW or PoS	Light PoW, multiple preapproved stakeholder/voting consensus.	Light PoW, multiple preapproved stakeholder/voting consensus
Immutability	Near impossible	Attacks with collusion	Attacks with collusion
Read/write access	Every node can read, write and validate transactions	Only authorised nodes read, write and validate transactions	All nodes can read, write and validate transactions
Network	Decentralised	Semi decentralised	Semi decentralised
Asset	Native asset	Any asset	Any asset
Efficiency of protocols	Low efficiency	High efficiency	High efficiency
Energy consumption	High energy	Low energy	Low energy
Approval time of transactions	In minutes	In milliseconds	In milliseconds
Use cases	e.g., Bitcoin, Ethereum, Litecoin	e.g., Hyperledger, Quorum, Corda	e.g., Ripple and Stellar

Furthermore, a key development of blockchains is Smart contracts ([Szabo 1994](#)), which is a software procedure that executes contract terms ([Cheng et al. 2018](#)). All the clauses in the contract are coded into the procedure and automatically executed when certain contingencies occur without being reliant on a central intermediary. Table 2 provides a summarised comparison between the traditional centralised and blockchain enabled banking systems with regard to efficiencies, costs, security and overall customer experiences, as identified by prior literature and industry reports.

**Table 2.** Comparison between the traditional centralised and blockchain enabled banking systems.

	Traditional Banking (In General)	Blockchain Based Banking
Efficiency	Many intermediate links, complex clearing processes, low efficiency However, centralised banking is capable of processing enormous amounts of transactions per second, which decentralised systems have yet to replicate successfully Countries such as Canada, Finland, Sweden are known to have the safest and China, U.S. and Japan the best performing banks as of 2020	Decentralised peer-to-peer transmission, high efficiency
Cost	Considerable paperwork, duplication of tasks and records, high operational and administrative costs, time consuming	Complete automation, disintermediation and low costs
Security	Centralised storage prone to hacks and failures, easy to leak sensitive information, low security	Distributed storage less easy to hack, complex encryption and higher security
Overall Customer Experience	Geographically limited, homogeneous services, limited customer experience	Geographically independent, new products and services, real time executions, good customer experience

Sources: Publicly available information sources, Bankers database, FintechFutures.com, CBI [Insights.com](#) (accessed on 18 October 2020) and BIS Quarterly Review, September 2017.



## 2.2. Blockchain and Banking

Why do banks exist and what impact would blockchains have on banking? Banks conduct asset transformation and store liquidity and utilise economies of scale providing services based on any storable asset (Bunea et al. 2016). They form a centralised intermediary, facilitating a myriad of marketplaces for stored assets for uses and sources of funding with different exit mechanisms for stakeholders (Coase 1937). Therefore, this view of banks can also be interpreted differently as a set of centralised ledgers of transactions for payments, storage, services revolving around assets for stakeholders involved (Frame and White 2014). Blockchains can decentralise these banking functions and provide more cost effective, efficient, transparent and secure banking solutions. Therefore, directly disrupting the banking business model (Bunea et al. 2016).

For example, fintechs (e.g., [lendoit.com](https://lendoit.com), accessed on 18 October 2020) using blockchain technology have implemented P2P lending platforms where sellers of capital are matched with buyers with minimum transaction costs. These fintechs are mimicking the two-sided market model for banks explained by Rochet and Tirole (2003) for matching excess capital savers with excess demand from borrowers in a decentralised manner. In our present and future use cases sections, we further explain additional areas of blockchain adoption in banking.

Presently, blockchains are utilised in a diverse array of banking applications including financial asset settlement, economic transactions, market predictions and business-related services (Haferkorn and Diaz 2015). Blockchain is anticipated to be central for sustainable global economic development in the future, benefiting society and consumers in general (Nguyen 2016). Several studies explore blockchain based applications developed for fiat currencies, securities and derivatives (Christensen et al. 2015; Fanning and Centers 2016; Peters and Panayi 2016; Paech 2017; Nijeholt et al. 2017). Blockchains provide significant innovation to financial markets with increases in efficiency and operational performance with regard to digital payments and settlement (Papadopoulos 2015; Min et al. 2016; Beck et al. 2016; English and Nezhadian 2017; Yamada et al. 2017; Lundqvist et al. 2017; Gao et al. 2018), derivatives and securities trading (Van de Velde et al. 2016; Wu and Liang 2017), commercial banking processes (Cocco et al. 2017), auditing (Dai and Vasarhelyi 2017) processes for loan management (Gazali et al. 2017), or digital currency exchanges, settlement and payments (Rizzo 2014; Cawrey 2014). Other financial applications include casualty and commercial claims processing, contingent convertible bonds, syndicated loans, automated compliance, asset rehypothecation, proxy voting and over-the-counter markets (McWaters et al. 2016; Deloitte 2016a; F.R. Ltd. 2016; Infosys Consulting 2016). Cost savings can be achieved by applications of blockchains such as centralised operations, reporting, compliance and business operations (Accenture 2017a, 2017b). However, regulatory uncertainty or the lack thereof, still remains an issue as discussed in Section 6. Shanaev et al. (2020) identify the relevance of regulatory frameworks for cryptocurrencies by analysing 120 regulatory events. They find economically and statistically significant impact from 300 tokens and coins of issuance and anti-money laundering regulation.

## 2.3. Blockchain Economics

Buterin (2015) states that the potential and economic value of blockchain is independent of Bitcoin value. Blockchains can be viewed as a decentralised database that is transparent and efficient (Bresnahan and Trajtenberg 1995; Lipsey et al. 2005). Blockchains can be utilised to disrupt any existing centralised transaction-based system with valuable information (Wright and De Filippi 2015). Although centralised databases are unable to compete with blockchains, regulation and initial investment costs might still be a deterrent for blockchain technology adoption from an economic point of view. Another feature of blockchain in banking is reducing exit costs for stakeholders. For example, blockchains can reduce the transfer or transition costs from one institution to another due to their permissionless nature (Thierier 2015). In our opinion, due to the nonterritorial global nature of the internet, they can allow stakeholders to partially exit the present institution. However,

permissionless exit from a blockchain financial system cannot exist for functions where competing blockchain systems are unavailable. Although, it is worth noting that the initial transition from the traditional bank-based market to a blockchain based financial system will have costs (Pagano and Vatiello 2015). Competing set ups may arise among different banking consortiums such as R3 using different blockchain technologies bringing in interoperability issues, eroding frictionless blockchain enabled banking. Thus, Blockchains may be able to provide banking services uninhibited by geographical locations to some extent (Guo and Liang 2016).

The majority of blockchain related literature focuses on cryptocurrencies. Our focus is solely on blockchain adoption in banking and not cryptocurrencies. These literature focus on many cryptocurrency aspects such as price bubbles (Cheah and Fry 2015; Fry and Cheah 2016; Cheung et al. 2015; Corbet et al. 2018a; Gandal et al. 2018; Bianchetti et al. 2018; Chaim and Laurini 2019; Geuder et al. 2019; Kallinterakis and Wang 2019; Sifat et al. 2019; Xiong et al. 2019; Shu and Zhu 2020), Bitcoin price determinants and characteristics (Akyildirim et al. 2020; Ammous 2018; Beneki et al. 2019; Bianchetti et al. 2018; Bouoiyour et al. 2016; Cagli 2019; Caporale et al. 2018; De Sousa and Pinto 2019; Dwyer 2015; Corbet et al. 2018b; Corbet et al. 2019a, 2019b, 2019c; Flori 2019; Corbet et al. 2020a, 2020b; Handika et al. 2019; Hayes 2019; Fry 2018; Mensi et al. 2019; Ma and Tanizaki 2019; Nadler and Guo 2020; Nguyen et al. 2019a, 2019b; Panagiotidis et al. 2018; Phillips and Gorse 2018; Puljiz et al. 2018; Pyo and Lee 2019; Sensoy 2019; Urquhart 2016; Urquhart 2017; Su et al. 2018; Wheatley et al. 2019; Wei 2018; Van Vliet 2018; Zargar and Kumar 2019), Bitcoin futures (Akyildirim et al. 2019; Corbet et al. 2018c; Fassas et al. 2020).

However, we do identify the importance of such research and find that price bubbles and volatilities in cryptocurrencies are key barriers against wider adoption by banks as an alternative for fiat currencies. Jayasuriya Daluwathumullagamage and Sims (2020) discuss blockchains in corporate governance. Felix and von Eije (2019) and Dean et al. (2020) discuss initial coin offering related literature at length. Kyriazis et al. (2020) conducts an excellent review on bubble dynamics and cryptocurrency prices. They identify bubble periods for various digital currencies including Ethereum that effectively distort cryptocurrency prices. Symitsi and Chalvatzis (2019) find diversification benefits of including Bitcoins into a portfolio. Nguyen et al. (2019a) identify new altcoin creation reduced Bitcoin returns by 0.7%. This result is significant as Bitcoins obtain average and daily mean returns of 0.63% and 0.27%, respectively. Kumar et al. (2020) discuss blockchain based applications and future research in the marketing sector. Although the latter study is not related directly to banking, they still provide interesting insights into blockchain applications in marketing that would be of use within the financial services industry in general.

#### 2.4. Blockchain Adoption Framework

Our blockchain adoption in banking framework is developed by identifying key domains/themes and subthemes from the systematic review and textual analysis. In addition, careful review of the final sample of articles is conducted to identify additional factors of interest for the adoption framework. The framework developed based on prior industry and academic literature is designed to help banks create a clear mission, achieve clarity, ensure value from their efforts, maintain scope and focus on blockchain adoption and sustainability in banking. This section defines the key domains and factors included in the framework. The framework is linked to our research questions 3: What are the behavioural, social, economic, regulatory and managerial implications of blockchain adoption in banking? and 4: What are the barriers and misconceptions for blockchain adoption in banking? by the key components included by analysing prior literature. Figure 1 outlines the adoption framework. The latter six components identified in our framework such as 'Blockchain governance factors', 'Barriers to adoption', relate to research question 4 and 'Limitations' and 'Stakeholders' relate to research question 3.



**Figure 1.** Blockchain adoption framework.

### 2.5. Why Use This Adoption Framework?

Most bank transactions revolve around the financial intermediation function of asset transformation, payment systems and the use of financial market exchanges (Brynjolfsson and McAfee 2014). Maintaining focus with all these applications of blockchain and achieving shareholder objectives such as wealth and profit maximisation, managing complications, risks and costs, privacy and security can be challenging (Buchak et al. 2017). Hence, our framework aids banks and collaborators to maintain the larger picture in mind. Frameworks aid us to unify how we foresee and link unclear, novel and complex concepts. Thus, a suitable framework at an advanced level on the key factors of blockchains would deliver clearness and purpose for all interested parties and ensure successful adoption. Our framework has five main components: 1. Adoption steps, 2. Value addition from AI integration, 3. Blockchain governance factors, 4. Barriers to adoption, 5. Limitations, and 6. Stakeholders.

The adoption process identified in our framework can be further explained as a blockchain adoption life cycle model. In the adoption process at the exploration and assessing stage it is important to draw a timeline for adoption. In the first 6 months identify potential use cases within the bank, key collaborators on fintechs, if required, and obtain bank-wide buy in for the project. Next year would involve building a proof of concept and identifying business partners. Within the following three years, the bank can integrate the blockchain into the core customer eco systems. Following these three years, the bank can maintain the blockchain adoption life cycle and establish blockchain as the standard technology for information systems and deployment (Ernst and Young 2017). Section 4.1



explores the barriers to adoption and impact identified in our framework. Section 6 in this study outlines limitations and governance factors identified in our framework in more detail. Section 4.1.8 discusses blockchain integration with AI. Apart from all the literature cited throughout our study, the framework and textual analysis further incorporates concepts from the below mentioned studies: (Financial Stability Board 2013; King 2013; Kroll et al. 2013; Maxwell 2013; Meiklejohn et al. 2013; Möser 2013; Miers et al. 2013; Ron and Shamir 2013; Sompolinsky and Zohar 2013; Eyal and Sirer 2014; Financial Stability Board 2014; Komlos 2014; Kitahara et al. 2014; Rochard 2014; Powell 2014; Ruffing et al. 2014; Segendorf 2014; Viacoin 2014; Garrett 2015; Greenspan 2015a, 2015b, 2015c; Gulamhuseinwala et al. 2015; Herbert and Litchfield 2015; Hoskins and Labonte 2015; Hyperledger Project 2015; Hutchinson and Dowd 2015; Kanzler 2015; Jakšič and Marinč 2015; KPMG and H2 Ventures 2015; Lomas 2015; Morse 2015; Noizat 2015; Pagano and Vatiero 2015; Pass and Shelat 2015; Price Waterhouse Coopers 2015a, 2015b; Robertson 2015; Sarr et al. 2015; Swanson 2015; The Decentralized Library of Alexandria 2015; World Economic Forum 2015; Wright and De Filippi 2015; Eris Industries 2016; Ernst and Young 2016; Eysers 2016; FED 2016; Federal Reserve Bank of Chicago 2016; Frey et al. 2016; Gerstl 2016; Greenspan 2016; Harwick 2016; Hung and Luo 2016; IBM Corporation 2016, 2017; Huertas 2016; Ivashchenko 2016; Jaag and Bach 2016; Jooyong and Eun Jung 2016; Jopson 2016; Kosba et al. 2016; Kraft 2016; Kravchenko 2016; Kursh and Gold 2016; Lemieux 2016; Liu 2016; McConaghy 2016; McKinsey Company 2016; Mills and McCarthy 2016; Mukhopadhyay et al. 2016; Mori 2016; Office of the Comptroller of the Currency 2016; Parker et al. 2016; Parliament 2016; Philippon 2016; Primm 2016; Proof-of-Stake 2016; Reijers et al. 2016; Shedden and Malna 2016; Siegel 2016; Symp Koulou 2016; Tschorsch and Scheuermann 2016; Van Alstyne et al. 2016; Vigna and Casey 2016; Walport 2016; Wang et al. 2016; World Bank 2016; Zavolokina et al. 2016; Zhao et al. 2016; Zhu and Zhou 2016; Gaetani et al. 2017; García-Barriocanal et al. 2017; Gattermayer and Tvrdik 2017; Goldfeder et al. 2017; Gomber et al. 2017; Greenwood et al. 2017; Hull 2017; Infosys Limited 2017; Jagtiani and Lemieux 2017; Irrera 2017; Jiang et al. 2017; Jin et al. 2017; Kaal 2017; Kaal and Vermeulen 2017; Kalra et al. 2017; Kendall 2017; Kim et al. 2017; Kiyomoto et al. 2017; Klems et al. 2017; KPMG International 2017; Kshetri 2017; Kumar and Rahman 2017; Lai and Van Order 2017; Lamberti et al. 2017; Larios-Hernández 2017; Leiding and Norta 2017; Li et al. 2017; Lin and Liao 2017; Liu et al. 2017a; López-Pintado et al. 2017; Mainelli 2017; Malinova and Andreas 2017; Malwarebytes 2017; Meter 2017; Moura and Gomes 2017; Neisse et al. 2017; Nofer et al. 2017; Nordrum 2017; Nowiński and Kozma 2017; Ou Yang et al. 2017; Parity Wallet Security Alert 2017; Pauw 2017; Pazaitis et al. 2017; Pokrovskaia 2017; Proof of Existence 2017; Prybila et al. 2017; Rimba et al. 2017; Sankar et al. 2017; Schindler 2017; Schulz and Schafer 2017; Scott et al. 2017; Scuffham 2017; Seebacher and Schüritz 2017; Spearpoint 2017; Subramanian 2017; Sullivan and Burger 2017; Sullivan 2017; World Government Summit 2017; Sutton and Samavi 2017; Tama et al. 2017; Tapscott and Tapscott 2017; Vo et al. 2017; Vranken 2017; White 2017; Wijaya et al. 2017; Xia et al. 2017; Xu et al. 2017; Yamada et al. 2017; Yermack 2017; Yue et al. 2017; Zachariadis and Ozcan 2017; Zikratov et al. 2017; Economist 2018; Fridgen 2018; Governatori et al. 2018; Government Accountability Office 2018; Kalra et al. 2018; Hawlitschek et al. 2018; Holub and Johnson 2018; International Standards Organization 2018; Khalilov and Levi 2018; Kodak 2018; Li and Mann 2018; Makridakis 2018; Mavridou and Laszka 2018; Meng et al. 2018; Mengelkamp et al. 2018; Office of the Comptroller of the Currency 2018; Panagiotidis et al. 2018; Pearson 2018; Suhaliana et al. 2018; Wang et al. 2018; Wei 2018; Yoo and Won 2018; Zalan 2018; Zheng et al. 2016; Foley et al. 2019; Li and Yi 2019; Li et al. 2019; Mussomeli 2019; Philippi et al. 2019; Schuetz and Venkatesh 2019; Song and Thakor 2019; Vallee and Zeng 2019; Zhu 2019; Frizzo-Barkera et al. 2020; Jayasuriya Daluwathumullagamage and Sims 2020; Kyriazis et al. 2020; LedgerInsights 2020; Shanaev et al. 2020).

### 3. Methodology

Systematic reviews are a meta-analysis technique designed to collate, analyse, and summarise existing knowledge and gaps in literature and specific concepts (Briner et al. 2009). Academic and industry literature on blockchain use cases in general and benefits are beginning to proliferate the knowledge domain. Nevertheless, these prior studies possess limited scope regarding applications in banking and reflect diverse findings. Moreover, the web is proliferated with short articles, notes on blockchain adoption in general in finance, across various industries and technical articles. This results in risks towards knowledge aggregation and integration of findings in both the industry and academia (Briner et al. 2009). Thus, our study attempts to effectively collate these fragmented, dispersed articles in a coherent manner to identify gaps, trends and parallels between industry and academic discourse.

In addition, as depicted in the literature review section, we further developed a blockchain adoption framework for banking based on our analysis of prior industry and academic literature.

Given this setting, to provide a systematic review of literature on blockchain based banking we follow Moher et al. (2009) and Briner and Denyer (2012). The key methodological steps are as follows: 1. Identifying the motivation and research question development, 2. Identifying the pertinent literature from academia, industry reports, quality assessment, data extraction and data synthesising. 3. Conduct extensive analysis for framework development and identification of gaps and trends between industrial and academic (we supplement our systematic review findings by textual analysis using machine learning techniques). 4. Finally, the results of the review are discussed.

#### 3.1. Research Question Definition

A systematic review's first phase involves research question definition (Coghlan and Holian 2007). This study provides a synopsis of present academic and industry literature in blockchain technology with some factors relevant for blockchain adoption in banking. In addition, the study explores use cases that are relevant for banking, identifies common trends and gaps and develops an adoption framework. To this end, we developed the research questions formulated below:

1: What are the present and future use cases in banking according to academic and industry literature?

This simple research question unentangles, present and potential applications of blockchains from a myriad of industries to that of banking.

2: What are the gaps, similarities and trends between prior academic and industry literature in blockchain adoption in banking?

This research question is formulated to obtain a complete overview of which areas the industry and academia overexplore and underexplore specific to blockchain adoption in banking. This would aid in facilitating future research and collaborations between academia and industry.

3: What are the behavioural, social, economic, regulatory and managerial implications of blockchain adoption in banking?

Identifying and understanding the impact of blockchain adoption in banking on the relevant stakeholders is important for successful deployment and sustainability of the technology in banking. This will aid academics and practitioners to better understand present use cases of blockchain that can effectively address bank, customer, regulator and societal needs.

4: What are the barriers and misconceptions for blockchain adoption in banking?

Understanding the limitations, challenges, common misconceptions and barriers of adoption is beneficial, especially at the early stage of deployment. This further aids in the decision making of future projects, effective maintenance of the adopted technology and future development efforts of blockchain adoption in banking.

### 3.2. Locating and Selecting Articles

To answer our research questions, a systematic literature search was carried out in Scopus, Science Direct and Google Scholar. The methodological approach to firstly identifying the key papers relevant for the literature survey and framework development are as follows: (1) Identify the databases (Scopus, google scholar and Science direct); (2) select keywords and search criteria (for the original search which excludes news and magazine articles, and subsequently refine search criteria); (3) identify relevant papers and analyse further; (4) classify the papers and group them into major themes; (5) highlight the research gaps, trends, similarities between industry reports and academic literature; (6) use textual analysis to further identify key themes and subthemes to create the blockchain adoption framework. In addition, we supplement the gaps, parallels and trends identification between industry and academic literature from the systematic review via textual analysis.

Our sample period was selected from 2013 to 2020. We decided upon 2013 as the beginning of our sample period as Yli-Huumo et al. (2016) identifies the first blockchain related technical being published in 2013. The papers were searched using various permutations of the following keywords: “Blockchain+financial intermediaries”, “Artificial intelligence+banking”, “banking+blockchain”, “decentralised system+banking”, “decentralised network+banking”, “decentralised ledger+banking”, “cryptocurrencies+financial services”, “digital currencies+banking”, “bitcoin+financial services”, “Ethereum+financial services”, “financial services+blockchain”, “security+blockchain”, “ethics+blockchain”, “fintech+blockchain”, “COVID-19+blockchain”, “regulation+blockchain” in the title, keywords and abstract fields of the search engine. In addition, relevant articles’ reference lists were also searched to identify any missed key articles. Initial search of all databases yielded 1979 records. These articles include published and in press research articles, conference papers, book chapters and short notes etc. Subsequently, industry and academic articles were segregated. Our final sample included 407 blockchain articles that have factors relevant for blockchain adoption in banking. Out of these, 102 were industry articles. Table 3 summarises the inclusion and exclusion criteria implemented in our study to obtain the final article sample.

**Table 3.** Exclusion and inclusion criteria.

Selection Criteria	Scientific Database	
Inclusion rules	Peer-reviewed high and lower tiered research papers and ones in press, conference papers, consulting reports, technical reports, and short articles	Scopus, Science Direct, Business Source Premier
	Sample period beginning from 2013	
Exclusion rules	Before being uploaded to the bibliographic manager	Non-English language articles, missing abstract articles, editorials
	Screening of titles	Generic blockchain architecture articles with no application possibility in finance
	Screening of abstracts	Blockchain related software development articles
	Screening of full-texts	Studies purely on technical hardware and software aspects of blockchain development

### 3.3. Final Article Sample Selection and Evaluation

Articles in the final sample were selected based on the predefined inclusion and exclusion criteria discussed in Table 3. The exclusion criteria are based on document type (notes, editorials), language, and subject relevance. In the first phase, all article abstracts and introductions were evaluated. Afterward, any article that met the exclusion criteria was removed from the sample. After a full text review, several more articles were also further excluded from the sample. Several research studies from finance and survey methodologies

were incorporated to the reference list but excluded from the systematic review analysis as they were not on blockchain technologies. Finally, several articles were excluded for being purely focused on blockchain's architecture and other technical aspects. Articles that met the inclusion criteria were carefully read and further analysed using 'Leximancer', a machine learning based textual analysis software. Significant themes and subthemes were further identified through Leximancer to aid in the development of our blockchain adoption framework. Additional factors were included into the framework through careful review of the final sample of articles.

### 3.4. Textual Analysis

Traditional methods of collating, analysing a large number of studies both from academia and the industry for qualitative studies are time consuming and resource heavy. Therein comes the use of machine learning to analyse a large number of textual data and identify key concepts, their interlinks and subthemes. To this end, we utilised machine learning based software Leximancer to identify the key concepts, subconcepts and themes emerging from the academic and industry reports. Leximancer helped us narrow down the key themes relevant to banking from the vast sea of research on blockchain studies, industry reports and regulatory body publications. We further used these key themes and subthemes to develop our blockchain adoption framework and to identify impact of blockchain in banking to various stakeholders. The algorithms used were statistical, but they employed nonlinear dynamics and machine learning. The conceptual map provides a broad view of the content, identifying the key concepts contained in the collections of documents of interest. This analysis further helped us compare and differentiate between industry reports and academic literature as discussed in Section 5.2.

### 3.5. Limitations of Our Study

Systematic reviews can face selection bias issues due to search and selection criteria distortions used to finalise the article sample. To mitigate selection bias, we used several combinations of different search keys, back tracked other key literature key words on blockchains without a primary relevance to finance. Furthermore, we used search database alterations of the search criteria through several layers of searches. Moreover, our study enhanced our article sample by perusing the reference list of already collected articles to identify any missing key articles from prior literature. Another limitation of our study is that of inconsistent coding or data interpretation. Thus, we supplemented our analysis through Leximancer by reviewing the articles manually.

Finally, given the lack of valid databases and the reluctance of banks to disclose blockchain related investments individually, we followed the systematic review and textual analysis approach using machine learning to answer our research questions rather than collecting empirical data on the topic. Leximancer usage limitations happen to be the significant time required to prepare the data and obtaining meaningful insights from the Leximancer output.

## 4. Results and Discussion

Firstly, this section details the Blockchain banking use cases, provides the results from the systematic review that identify, gaps, parallels and trends among industrial and academic literature. Moreover, this section discusses the results from the textual analysis and adoption framework. Studies included in the final sample of 407 articles possess factors that can be repurposed or relevant for blockchain adoption in banking.

### 4.1. Blockchain Based Banking Use Cases

This section answers our research question 1: What are the present and future use cases of blockchain applications in banking? In sum, this section identifies that blockchain based banking would result in reduced costs, faster processing times for transactions, no intermediary requirement for authentication, independence from centralised repositories,

less paperwork, more transparency, security and data integrity (Energy Web Foundation 2018). The global appetite for blockchain investments in banking is expected to significantly grow during the next couple of years (Wang et al. 2016). Blockchains are expected to reduce transaction costs by over 50% by eliminating intermediary costs and increased efficiencies and security (PwC 2016). The key blockchain service providers in banking can be categorised as applications and solutions, middle ware, services and infrastructure and base protocols (Románova and Kudinska 2016). Present blockchain applications in banking primarily revolve around core banking, payments, smart contracts, supply chains, trade finance, financial markets, risk management, compliance, insurance, digital identity management (Disparte 2017; Watson 2017; Beikverdi and Song 2015; Benet 2014). In banking, the interaction channel in blockchain adoption is segmented into bank branches, websites, call centres and mobile applications for large to small and medium sized enterprises (McKinsey and Co 2015, 2016). The key fintech players involved in competing with banks and also partnering with banks according to our findings are IBM Corporation (US), Microsoft Corporation (US), Ripple (US), Amazon Web Services, Inc. (US), Bitfury Group Limited (US), Oracle Corporation (US), Digital Asset Holdings (US), Chain Inc (US), Earthport PLC. (UK), Auxesis Group (India), RecordsKeeper (Spain) and BTL Group (Canada). Table 4 provide examples of blockchain use cases by application category and their advantages and disadvantages.

**Table 4.** Blockchain use cases by application category and their advantages and disadvantages.

Area in Banking	Present Use Cases	Pros	Cons
Exchanges and Trading Platforms	Nasdaq reported its first stock trade on 30 December 2015 using Blockchains. Linq platform established with Chain.com and IDEO facilitated this transaction.	Blockchain based trading decreases information redundancies and results in performance improvements (Economist 2016).	Trading with blockchain can impose risks such as losing private keys.
	In 2015, the Australian Stock Exchange (ASX) initiated replacement possibilities for the Clearing House Electronic Sub Register System (CHES) and collaborated with Digital Asset Holdings, LLC to establish a blockchain based clearing and settlement system.	To control blockchain size, only large transactions can be on the chain. Whereas, smaller transactions between traders can be completed off chain. Multisignature transactions that can be integrated into the asset trading applications running on blockchain technology may alleviate this issue.	All transactions being placed on a blockchain results in much larger blockchains being replicated in several computers and gives rise to a storage issue.
	International Business Machines Corporation (IBM) and the Japanese Exchange Group (JPX) are collaborating on blockchain based trading platform developments.	Signatures of all parties before agreeing upon a transaction can prevent the keys from being stolen and the ownership from being changed.	
	Moscow Exchange (MOEX) collaborated with the National Settlement Depository (NSD) to develop a blockchain network and completed e-e-voting for bondholders.		
	Korea Exchange collaborated with Blocko to establish start-up Korea Start-up Market (KSM) for start-up firm shares to be traded in the open market.		
	India's National Stock Exchange (NSE) implemented a trial for blockchain based know-your-customer (KYC) data test with ICICI, HDFC Securities, IDFC, Kotak Mahindra, RBL and IndusInd.		



Table 4. Cont.

Area in Banking	Present Use Cases	Pros	Cons
	Deutsche Börse Group has explored blockchain based solutions for cross border share transfers by collaborating with Liquidity Alliance.		
	The London Stock Exchange is exploring blockchain based post-trade settlement options.		
	The Luxembourg Stock Exchange has established a blockchain based security system that maintain official signatures by Appointed Mechanism (OAM), document type and URL.		
	Santiago Exchange is collaborating with IBM to explore blockchain based solutions for Chile's financial industry.		
	The Toronto-based TMX Group reported the development of a blockchain based service for the Natural Gas Exchange (NGX).		
	Blythe Masters' Digital Asset Holdings with the Hyperledger, Epiphyte, Clearmatics Overstock with T0 and SETL are all examples of blockchain based solutions in the financial industry.		
Know Your Customer	The Pit supports a collection of fiat and cryptocurrencies in 200 countries. USD, GBP and EUR can deposit via bank transfers to buy or sell BTC, ETH, LTC, BCH, PAX and USDT.	With blockchain based banking, customers would only have to register once, any other service provider within the blockchain network would not require repeat registration.	Blockchain based identity verification applications are underdeveloped and all nodes would have visibility of data on the blockchain.
	Tradle and Cambridge Blockchain are working on blockchain based customer identification.		
	ID2020 is a blockchain based application aimed at creating digital identities for individuals without paper identities. This development is funded by the Rockefeller Foundation in collaboration with Accenture, Microsoft.		
Payments	Ripple is a "real-time gross settlement system" (RTGS) is a blockchain based currency exchange and remittance platform established in 2012. This is an application that can be used by banks that would benefit their customers.	Blockchain based banking cross-border payment and settlement systems are much speedier, efficient and less expensive relative to legacy systems.	Blockchain service provider's bankruptcy or hacking would result in the funds being lost without an intermediary to reimburse customers.
	Westpac collaborated with Ripple to facilitate blockchain based payments and settlement in 2016 for cross border transactions.	Costs for remittances are approximately 2–3% of the total transaction amount relative to 5–20%, presently held by third party intermediaries.	Fluctuating exchange rates between fiat and cryptocurrencies may make blockchain based cross border payments problematic. (Bitcoin ETf Channel 2018)

Table 4. Cont.

Area in Banking	Present Use Cases	Pros	Cons
Remittances and P2P	CBA, in 2015 collaborated with Ripple to develop a blockchain based payment system between its subsidiaries.	Without third party authorisation and verifications, blockchain based payments can be processed significantly faster compared to legacy systems.	
	U.S. Federal Reserve collaborated with IBM in 2016 to establish a digital payment system. Other banks such as Deutsche Bank, BNP Paribas and Barclays Banks followed suit.		
	BitPesa, Abra, and Circle are examples of blockchain based remittance and P2P platforms. Circle facilitate social payments and BitPesa allow B2B payments in Africa.	Blockchain based P2P transactions would not have geographical limitations allowing remittances to originate and be transferred anywhere in the world (Biryukov et al. 2014).	P2P users need to expect cryptocurrency price volatilities would affect conversion values to fiat currencies and subsequent transaction costs.
Trade Finance	LHV Bank of Estonia is exploring with coloured coins named “Cuber” as a form of deposits that are cryptographically protected. This would allow the banks’ fintech arm called Cuber Technology to implement blockchain based apps that can facilitate free P2P fiat currency transactions.	Blockchain based transactions occur in real time resulting in recipients receiving the funds without daily or weekly time lags.	Additions of fiat currencies to cryptocurrency transactions may slow down even blockchain based P2P platforms.
	Collab, VISA and the BTL Group are collaborating to provide blockchain based cross-border payments among banks in Europe.		
	Ornua, a dairy products manufacturer from Ireland collaborated with Barclays to complete the first blockchain based banking transaction in 2016.	In traditional international trade legacy systems, participants would need to maintain their own database of transactions unlike with blockchains.	Blockchain use in trade finance maybe hindered by trade embargos.
Syndicated Lending	IBM and Maersk partnered to explore blockchain based solutions in supply chain management.	A single error in any of the legacy systems between two parties would be duplicated unlike in blockchains where one digital document updates all in real time approved by all members reducing errors.	Blockchain-based networks could not be used to impose sanctions without a proper BIS licence or OFAC.
			Difficult to transfer information on a blockchain to non-blockchain users.
	Credit Suisse, R3, Ipreo and Symbiont collaborated to develop blockchain based solutions for the syndicated loan market.	Compliance procedures completed by one bank in the blockchain would not have to be repeated by other banks.	Blockchains cannot overcome all syndicated loan market issues as all banks in the syndicate needs agree on protocols (Cohen et al. 2017).
	BNP Paribas, HSBC, BNY Mellon, State Street, ING and Natixis developed a blockchain based syndicated loan platform by collaborating with Fusion LenderComm by Finastra in 2018.	Information can be easily shared through blockchains across all participating banks.	Interoperability issues, and negotiations of control, read, write access may persist across the banks in the syndicate with regard to blockchains.
		Blockchains reduces regulatory requirement process costs and time to be compliant for all banks in the syndicate.	

Table 5 summarises blockchain use cases in banking by fintechs and their impact on banking. Table 6 provides a summary of present use cases of blockchain by banks and partnerships between banks and fintechs. The section below discusses in more detail numerous applications of blockchain in banking and focuses on several underexplored areas of adoption as identified from our systematic review and textual analysis.

**Table 5.** Blockchain adoption in banking by fintechs and their impact.

Fintechs in Banking	Location	Description	Impact
PAXOS	New York, NY	Paxos is a blockchain based trust that makes payments and settlements simultaneously.	New York Department of Financial Services has approved Paxos which is one of the few stable coins approved by them.
		With trust powers similar to a traditional bank, 1 PAX token is equal in value to USD 1. PAX is an Ethereum-based stable coin that can facilitate digital transactions of instant settlement.	PAX is presently listed in eight different platforms.
JIBREL NETWORK	New York, NY	Jibrel is blockchain based platform that allows the tokenisation of assets such as loans, commodities and ICOS.	Jibrel is a member of the Enterprise Ethereum Alliance (EEA) which is the largest open source blockchain initiative in the world for blockchain based industry architecture and best practices implementation.
		Asset tokenisation allows Jibrel users to obtain higher liquidity.	
REPUBLIC	New York, NY	Republic is a blockchain based investment platform that provides users opportunities to invest in ICOs starting from USD 10.	Republic at present has 14 firms listed on their platform.
		Republic has a variety of firms with different purposes and businesses to invest from. These firms can raise capital either using fiat or cryptocurrencies from investors.	Examples of these firms are BANDWAGON which is a start-up concentrated on stopping fraudulent ticket sales and Nori which is a start-up concentrated on mitigating climate change.
		Republic's DPA token allows firms to presell and manage crowd sale tokens.	
SALT LENDING	Denver, CO	SALT lending platform allows members to use their cryptocurrencies as leverage for cash-based loans without having to sell digital assets.	SALT is operating across 35 states in U.S. since 2016 and is expanding to include more tokens as collateral.
		Platform users have the choice of loan maturity from 1 to 36 months, interest rate and type of cryptocurrency that are leveraged such as Ether, Bitcoin, Litecoin and Dogecoin.	Proof of access allows users on to modify loan conditions using SALT tokens.
AIRFOX	Boston, MA	Airfox is an emerging market blockchain based banking platform catering to the underbanked. Users are able to receive loans without credit rating checks.	Airfox collaborates with Via Varejo, a Brazilian retail giant to provide its financial services to 60 million users in Brazil. The platform is supported by approximately 1000 Via Varejo stores for digital banking.
		AirToken (AIR) is a blockchain based digital utility token where an individual's creditworthiness is verified using cell phone data. Phone records are used to assess credit worthiness to provide loans based on immutable data.	Airfox ecosystem interactions on a daily basis allows users to earn AIR tokens granting them credit.
UULALA	Irvine, CA	Uulala's blockchain based P2P platform provides banking services to the underbanked and unbanked.	Uulala is exploring further expansions in Mexico, Brazil and U.S.
		Uulala ecosystem allows cash to be loaned via decentralised ledgers using cell phones essentially making these cell phones portable ATMs.	This app reduces time and costs related with borrowing by eliminating the need for intermediation.

Table 5. Cont.

Fintechs in Banking	Location	Description	Impact
RIPPLE	San Francisco, CA	Ripple's blockchain based financial services platform allows banks to conduct real time cross border transactions. Banks are able to access a standardised decentralised network of institutions for efficient, transparent and faster transactions.	Approximately 75 financial institutions use Ripple for cross border payments including BMO, BBVA, Santander, MoneyGram and American Express.
PAYGINE	New York, NY	Paygine is banking infrastructure blockchain based network that processes close to USD 115 million worth of transactions on a monthly basis.	Paygine plants to expand to U.S. and Asia after establishing core banking processes in Europe.
		Paygine provide remittances, payments, cryptocurrency exchange facilities, KYC and lending.	
SPRING LABS	Marina del Rey, CA	Spring Labs is a permissioned blockchain based network that allows information sharing among financial institutions without having to actually share the underlying data. This sharing mechanism allows more security for data.	Spring Labs was founded in early 2018 and Avant, a Chicago based online lending platform is one of its first participating institutions.
BLOCKFI	New York, NY	BlockFi is a blockchain based lending platform that lends cash by maintaining cryptocurrencies as collateral. Online loan applications are provided to customers and once approved, cryptocurrencies such as Bitcoin and Ethereum can be transferred to a secure storage address on a blockchain.	Customers include Block 8 Ventures and Climb Credit CEO Angela Ceresnie where the loans are utilised to fund new projects. These loans are available for individuals and corporations.
ALPHAPOINT	New York, NY	AlphaPoint is a blockchain based platform that allows the trading and digitisation of assets such as currencies, loans, shares. Processes and workflows are automated using smart contracts.	AlphaPoint Indexes is an extension of AlphaPoint and is a statistical platform where the index is used to benchmark the performance of most liquid and high values cryptocurrencies and measure their performance.
TRADLE	New York, NY	Tradle is a blockchain based platform used by financial institutions for KYC purposes. Tradle uses bots to scan relevant information such as employment history, finances to obtain verifiable background checks on customers. The gathered information is held securely on a blockchain that can be shared across bans and to other external data transfer mechanisms.	Lloyd's, R3 and AIA have tested their products and Tradle has won numerous awards such as the blockchain company 2016 by KPMG and the Citi KYC company to watch award.
Overstock (OSTK)	New York, NY	Coinsetter is set to establish a corporate bond asset exchange blockchain based platform called T0 that can clear over the counter transactions in T + 10 min.	General U.S. exchange-based share or bond purchase would involve around T + 3 days to settle.

**Table 6.** Present use cases of blockchain by banks and partnerships between banks and fintechs.

<b>Banks and Fintech Partnerships</b>	<b>Description</b>
<b>Banks</b>	
JP Morgan Chase	Quorum is a division established to explore blockchain based applications such as annual certificate of deposits at variable rates with smart contracts to ensure speedy transactions.
Bank of America	Has filed a patent for a permissioned blockchain network to maintain secure records, authentication of personal and business data. Allowed users will be able to access the data and keep a record of all entries and existing legacy storage systems would be combined into one blockchain based ledger.
Goldman Sachs	Circle is a blockchain based cryptocurrency start up focused on solving volatility issues of digital currencies enabling crypto options to be more viable in the financial services sector.
Barclays (BCS)	Is exploring both internal applications and external collaborations of blockchain based services with start-ups in the financial sector.
BNP Paribas	Is exploring the use of blockchain based solutions for order processing and its currency funds.
Citigroup Inc	Has initiated around three blockchain-based applications such as creating CitiCoin, its own cryptocurrency.
JPMorgan blockchain initiative	Standard Chartered, Société Générale, Deutsche Bank, The Bank of England, DBS Bank, LHV Bank, BBVA, BNY Mellon, CBW Bank, Commonwealth Bank of Australia and Westpac are all exploring blockchain based banking solutions.
	JPMorgan, ANZ and Royal Bank of Canada have been testing The Interbank Information Network which has expanded to more than 75 banks. IIN is developed is developed by Quorum and is a permissioned Ethereum based blockchain that allows frictionless cross border payments with transactions speeds due to compliance responses and data related inquiries.
<b>Fintech Partnerships with Banks</b>	
UBS	Batavia was established by collaborating with IBM in 2015, to facilitate live transactions for corporate clients. Cross border transactions such as car sales and textiles in Austria has been completed so far.
Credit Suisse	By partnering with ING, the bank explores the establishment of a blockchain based transaction network maintained via smart contracts which in future can enable customer networks and cryptocurrency systems.
Santander Group	Several financial institutions collaborated with Clearmatics, a blockchain development firm from London to develop a blockchain based transaction platform.
Bain & Company	Bain & Company, a U.S. based large management consulting firm is collaborating with several financial institutions to launch Voltron a blockchain based documentary trade platform. Voltron partners include CTBC Holding, Standard Chartered, ING,
	Bangkok Bank, BNP Paribas, HSBC, NatWest, CryptoBLK and SEB.
we.trade	Developed on the IBM blockchain, we.trade enables real time trade settlement and incorporates KYC verifications, and automatic payment settlement via smart contracts. The application has 14 financial institution partners including HSBC, Nordea, Santander, Rabobank, Eurobank, Deutsche Bank, KBC, Natixis and Société Générale. These banking customers can trade across 14 European countries.
Fujitsu	Fujitsu is collaborating with the Japanese Bankers Association (JBA) to test digital currencies and blockchain based interbank settlement applications. Trials will be implemented by Payment Clearing Network, (Zengin-net).
Ripple	SBI Holdings is launching a Ripple powered mobile application for payments named MoneyTap which will be used by a consortium of Japanese banks including Suruga bank, Resona Bank and Sumishin Bank.
R3CEV	R3CEV is establishing a private blockchain for over 40 banks including JP Morgan, Barclays, Bank of America, UBS and RBS.
Depository Trust and Clearing Corporation (DTCC)	Rebuilding trade information warehouse using blockchain technologies in partnership with IBM, R3 and Axoni.
Dianrong	The Chinese P2P partnered with R3 to facilitate supply-chain financing by the distributed ledger technology that underpins cryptocurrencies.



#### 4.1.1. Exchanges

Blockchains provide a novel method for asset trading without intermediaries or a centralised system and the risk of double spending (Economist 2015). Some of the key exchanges in the world as shown in Tables 4 and 5 are implementing and exploring blockchain based solutions for their pre-trade, post-trade, trade transaction, custodial and security servicing functions. Although algorithmic trading enables trade execution in a matter of seconds, trade settlement remains a bottleneck being time consuming, error prone and cost inefficient (Khaqqi et al. 2018). This is primarily due to intermediation, operational trade clearance and regulatory processes. Old or existing systems are centralised, tedious to upgrade, not transparent and require an intermediary such as a bank resulting in lesser security (PwC 2017). Thus, the adoption of blockchain has the potential to streamline these processes through decentralised automation by cutting transaction costs, increased security, compatibility and trust (Goldstein et al. 2019). Blockchains can securely automate post-trade processes, ease the paperwork burden of legal ownership, trade and security (Da Rin and Penas 2017). The instructions, guidelines and regulations can be hard coded in via smart contracts and imposed with every trade with the blockchain network itself working as the intermediary and regulator alike (Cortez 2014; Financial Conduct Authority 2016).

Automation of post-trade events would reduce counter parties and operational risk with security settlement occurring in a matter of minutes improving liquidity and increased transparency (Dapp et al. 2014). In our opinion, the blockchain network would be an automated partial regulator surveying the transactions with built in characteristics to track, block and report illegitimate attempts of trades. Furthermore, intermediaries such as brokerages, clearing house or settlement processes would not be required. Thus, resulting in lesser costs due to eliminated intermediation, reduced record keeping, auditing and trade verification costs (Tanaka et al. 2017). With the reduction of inefficiencies and costs, barriers to entry would be lower with higher market participation and better access ultimately increasing liquidity and investments (PwC 2017). Moreover, margin payments could be executed instantly with more frequent securities valuations even daily as compared to weekly, reducing overall credit risks within the exchange (Crosby et al. 2016). Thus, in the future, clearing houses, intermediaries and exchanges can be replaced by a blockchain network of marketplaces (Cocco et al. 2017).

#### 4.1.2. Primary Market Issuance and IPOs

In addition, stocks and bonds can be issued on a blockchain network where they are sold immediately by an exchange also existing in a blockchain network (De Meijer 2016; Bloomberg 2018). This would significantly cut down disclosure costs, marketing road shows and underwriting fees. Thus, becoming a significant disruptor for investment banks (Watson 2017).

#### 4.1.3. Payments

A key challenge for the banks is to sustain and main existing relationships with payment companies such as VISA. In addition, there are blockchain based cryptocurrency payment fintechs cropping up across the globe (Birch et al. 2016). The majority of present payments specialise in a single payment activity (e.g., B2B payments) with others engaged in three activities or more (Carney 2016). Merchant services involve processing payments for merchants that accept cryptocurrencies (Bolt and Van Oordt 2019; Bonneau et al. 2015). In addition, almost every payment company must perform know your client (KYC) checks which are generally performed internally. Adoption of blockchain for payment systems would increase the speed of money transfers by making payments real-time (Canaday 2017). Thus, with permissioned transparency, real time execution, detection and prevention of fraudulent transactions at faster speeds may be achieved (Accenture 2016, 2018). Furthermore, through tokenisation via cryptography and permissioned access to trade data would ensure the confidential nature of trade transactions. According to several

industry reports, significant cost and time savings of approximately USD 20 billion may be achieved via blockchain adoption in trade finance (CBS 2015).

#### 4.1.4. Fraud Reduction

The traditional centralised nature of banking databases, exchanges and clearing houses have made them more susceptible to hacking and security threats. In contrast, the decentralised nature of blockchains would deter such attacks and the real time execution of payments would allow real-time detection and prevention of fraud (Lo et al. 2017; Bonneau et al. 2014). Moreover, blockchain network transactions would aid in identifying fraudulent entities through a trail of transactions and cryptocurrencies (Nath 2016). Data within the blockchain could be analysed by regulators to identify fraud and illegal activities (Cai and Zhu 2016).

#### 4.1.5. Remittances and Other Peer-to Peer (P2P) Transfers

Several developing countries have significant contributions to their entire gross domestic product (GDP) from remittances. On average, according to world bank, global remittances are approximately 0.7% (USD 1 trillion) of the global annual GDP (Braggion et al. 2020). Remittances allow funds to be transferred from one bank account to an individual's account internationally. All existing P2P transfers have limitations of being able to transfer within a certain geographical area, failure to transfer if both peers in same country, large commissions for transfers, lack of security for sensitive data (Bruce 2013; Deer et al. 2015). These issues can be solved via blockchains. At present, banks and companies such as Western Union provide remittance services across the globe. However, there are already several blockchain based international transfer systems in place such as Abra, BitPesa (Focus on B2B payments for Africa), and Circle (focus on social payments). On the blockchain, these transactions are peer-to-peer (P2P) and encrypted remaining more protected (Infosys Consulting 2016). Not just individuals, but corporates and international banks themselves rely on these remittances. Blockchain based remittances could be an additional revenue stream for banks ((Brühl 2017; Tang 2019).

#### 4.1.6. Syndicated Lending

Syndicated lending involves a group of lenders providing a secure loan to a firm or an individual. With several participating banks in the syndicate to provide the loan, traditional processing times may take up to 19 days (Gazali et al. 2017). Each bank in the syndicate face challenges in KYC, being compliant with anti-money laundering (AML) and bank secrecy acts (BSA). Blockchain based loan syndication can make this process less costly, more transparent among the banks and the customer and more efficient in general (Ernst and Young 2017). Banks can dispense tasks to complete BSA, KYC, and AML compliances and connect the subsequent checks to a single customer (Fuster et al. 2019).

#### 4.1.7. Accounting and Improved Record Keeping

Banks globally collectively maintain trillions of records pertaining to customers, transactions and purchases (Cong et al. 2018). All these records could be moved to a blockchain as a decentralised digital ledger (Karafiloski and Mishev 2017). Thus, increasing the traceability, security and accessibility of these records (Coyne and McMickle 2017). Since counterparties in every transaction would also be connected to the blockchain and have the same record, this would subsequently reduce disputes resolution costs (Hassani et al. 2018). In addition, bank accounts could be represented on a more secure, accessible and less costly manner from a blockchain. Thus, alleviating unsubstantiated rumour driven bank runs (Jagtiani and Lemieux 2017).

Therefore, blockchains even have the potential to disrupt the accounting (O'Leary 2017; Jayasuriya Daluwathumullagamage and Sims 2020) and shadow banking sector (e.g., Dianrong, Libra by Facebook). For banks to adopt blockchains, they would have to

choose permissioned over public blockchains allowing only trusted party's access including regulators ([International Monetary Fund 2017](#)).

#### 4.1.8. Decentralised Intelligent Banks

Are decentralised artificially intelligent banks a match made in heaven or a disruptive integration? This section discusses integration of blockchain with Artificial Intelligence (AI) and the value addition factors identified in our framework. This section also adds to answering research question 1. What are the present and future use cases of blockchain applications in banking? AI integration with blockchains may impact security by providing two layers of protection against cyber-attacks ([Dapp et al. 2014](#)). Thus, integrating Blockchain with AI might aid in overcoming one of the key limitations of blockchain adoption regarding privacy and security ([Dannen 2017](#)). Therefore, we surmise from prior literature that blockchain and AI integration would result in improved business models for banks, efficient global verification systems, innovative bank auditing and regulatory compliance, intelligent retail payment systems, transparent governance, predictive analytics and digital intellectual property rights for financial market assets ([Deloitte 2016a, 2016b, 2016c](#); [PwC 2016](#); [Chen et al. 2019](#)). Apart from these banking related applications, increase of security, efficiency, trust, smart storage would be additional technical benefits of such integration ([Atzei et al. 2017](#)).

#### 4.1.9. Challenges of Merging AI and Blockchain

AI programs may make mistakes and it would be difficult to spot these errors. Compliance might be another issue. Blockchains and AI solutions will necessitate data collation, which can be challenging ([Dapp et al. 2014](#)). Moreover, although data required for AI model training can be acquired utilising IoT devices, expertise knowledge to develop the AI algorithms that can be implemented on a blockchain platform may be difficult to find ([Do and Ng 2017](#)). Finally, merging AI and blockchains would require significant computing hardware resources ([Fan et al. 2018](#)).

### 4.2. Systematic Review Results

Our final sample of studies for the systematic review includes 407 articles where 102 are from industrial literature from 2013 to 2020. Research question 2: What are the gaps, similarities and trends between prior academic and industry literature in blockchain adoption in banking? is answered in this section. By carefully analysing the final sample of articles, 11 key domains or themes are identified. These 11 domains include 1. BC governance, 2. Corporate voting and BC, 3. Cryptocurrencies, 4. Exchanges and BC, 5. Payment systems and BC, 6. Trading and BC, 7. Smart contracts, 8. Data management and BC, 9. Disruptive technologies, 10. Fintech, 11. Miscellaneous.

Figure 2 illustrates the academic and industry article numbers through time and Figure 2 shows the same by domain for academic, industrial articles and the sum of both. Several articles may overlap across few domains in Figure 3. Figure 3 allows us to further identify the gaps, similarities and trends among industrial reports and academic studies.

Figure 2 shows that articles skyrocket in 2017 in academia with 99 articles while only 21 are observed from the industry. However, the greatest number from articles for the industry of 35 is observed in 2016. In this case, the academic literature appears to lag the industry by one year with regard to studies with relevance for blockchain based banking. Following Nakamoto's publication in 2008, it took several years for the research community to focus on blockchain applications in other domains ([Cuccuru 2017](#)). Most research conducted in the early years focused on infrastructure development which led to research on blockchain applications in other domains emerging primarily during 2013 and 2014. However, a steady increase of academic and industry articles can be observed until 2017 from 2015 (26 academic and 21 industry articles) and 2016 (53 academic and 35 industry articles). Stringent regulations and bans in 2018 resulted in considerable decreases in output of articles post 2018 ([Allan and Hagiwara 2018](#)). In our sample 42

academic articles are observed for 2019. However, with China's investment in Blockchain technology (BSN) and COVID-19 crisis may drive many banks and firms towards digital transformation of their businesses. Thus, interest in this area would burgeon in the future with already 15 academic articles observed so far for 2020.

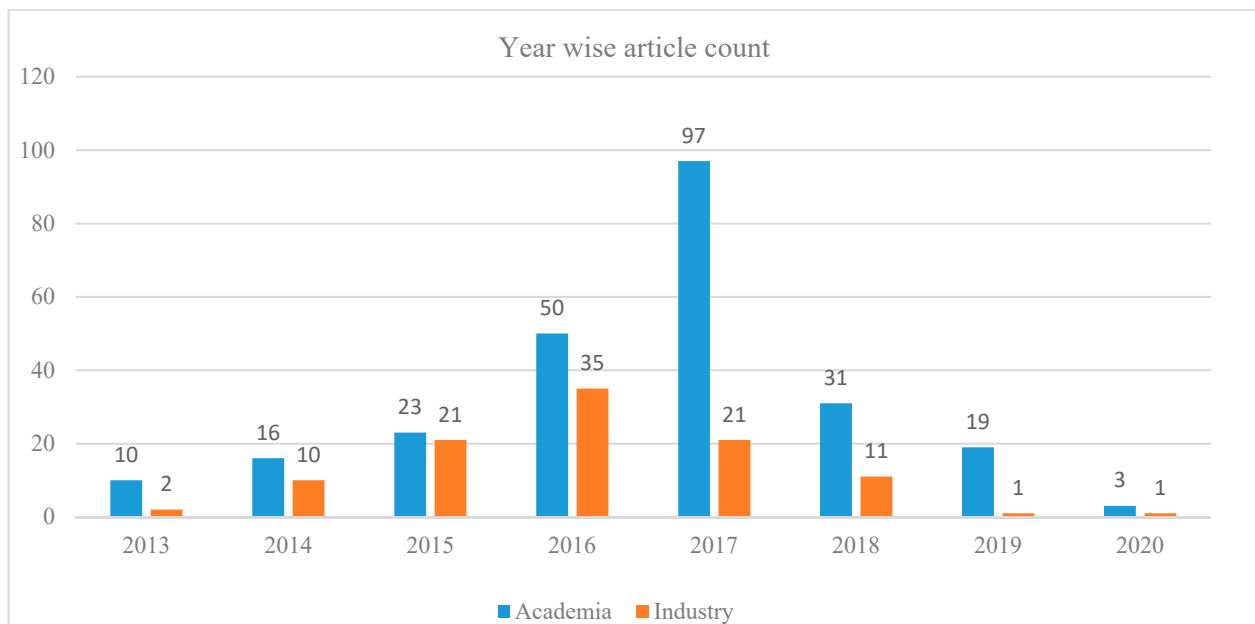


Figure 2. Article count across time.

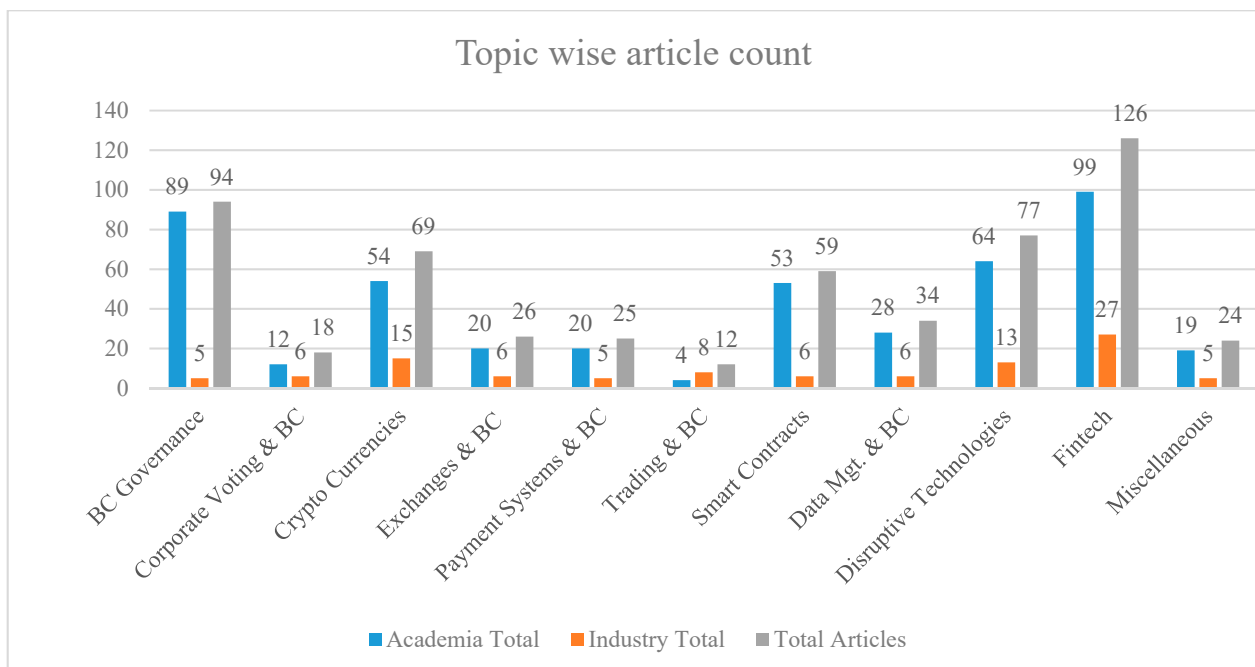


Figure 3. Article count among industry and academia across themes.

Figure 3 outlines the domain dispersal of our 407-final sample of studies. According to Figure 3, the academia mainly focusses on cryptocurrencies with 110 studies and the industry on fintechs with blockchain as the key technology of interest with 27 studies. The second most popular domain for academia is fintech with 99 studies and cryptocurrencies for the industry with 15 studies. The third most popular area for academia is blockchain





Although ‘blockchain’ appears as a prominent theme for both academic and industry resource maps as shown in Figures 4 and 5, respectively, the links to other themes differ in several aspects. In addition, ‘blockchain’ as a theme is placed centrally in industry literature whereas, it is placed to the right in academic literature where ‘bitcoin’ is placed centrally. Moreover, in academic literature ‘blockchain’ as a key theme is closely associated with ‘currency’, ‘competition’, ‘paper’ and ‘governance’. Whereas, in industry literature ‘blockchain’ as a theme is more closely associated with ‘transactions’, ‘information’, ‘credit’, ‘value’ and ‘money’. This again highlights the fact that academic literature focuses mostly on theoretical aspects of blockchain whereas industry literature would primarily focus on blockchain applications and disruptions. It is again interesting to observe that although ‘fintech’ appears as a central theme in academic literature, this is not the case for industry literature and their close associated themes also differ significantly. For industry literature, the ‘fintech’ theme is closely associated with ‘services’, ‘currency’, ‘chain’, ‘finance’ and ‘money’. Whereas, for academic literature the ‘fintech’ theme is closely associated with ‘markets’, ‘discuss’, ‘fees’, ‘model’ and ‘virtual’ themes. ‘Technology’ which is another common key theme also shows similar results where it is more centrally placed in industry literature with several closely associated themes such as ‘bank’, ‘sector’, ‘cost’, ‘bitcoin’ and ‘market’. Meanwhile, in academic literature it is placed at a corner on the top with very few themes closely associated with it such as ‘financial’, ‘review’ and ‘protocol’. Even from the closely associated subthemes to the more prominent themes one can observe a divergence in interests between academic and industry literature. In addition, ‘banking’ is identified as a prominent theme in the industry literature bringing together other subthemes such as ‘ledger’, ‘products’, ‘development’ and ‘business’. Meanwhile, academic literature focuses more towards key themes such as ‘markets’ and ‘exchanges’ which are associated with ‘information’, ‘issue’, ‘settlement’, ‘bitcoin’ and ‘consensus’, ‘digital’, ‘contracts’, ‘special’, ‘fees’, ‘settlement’, respectively.

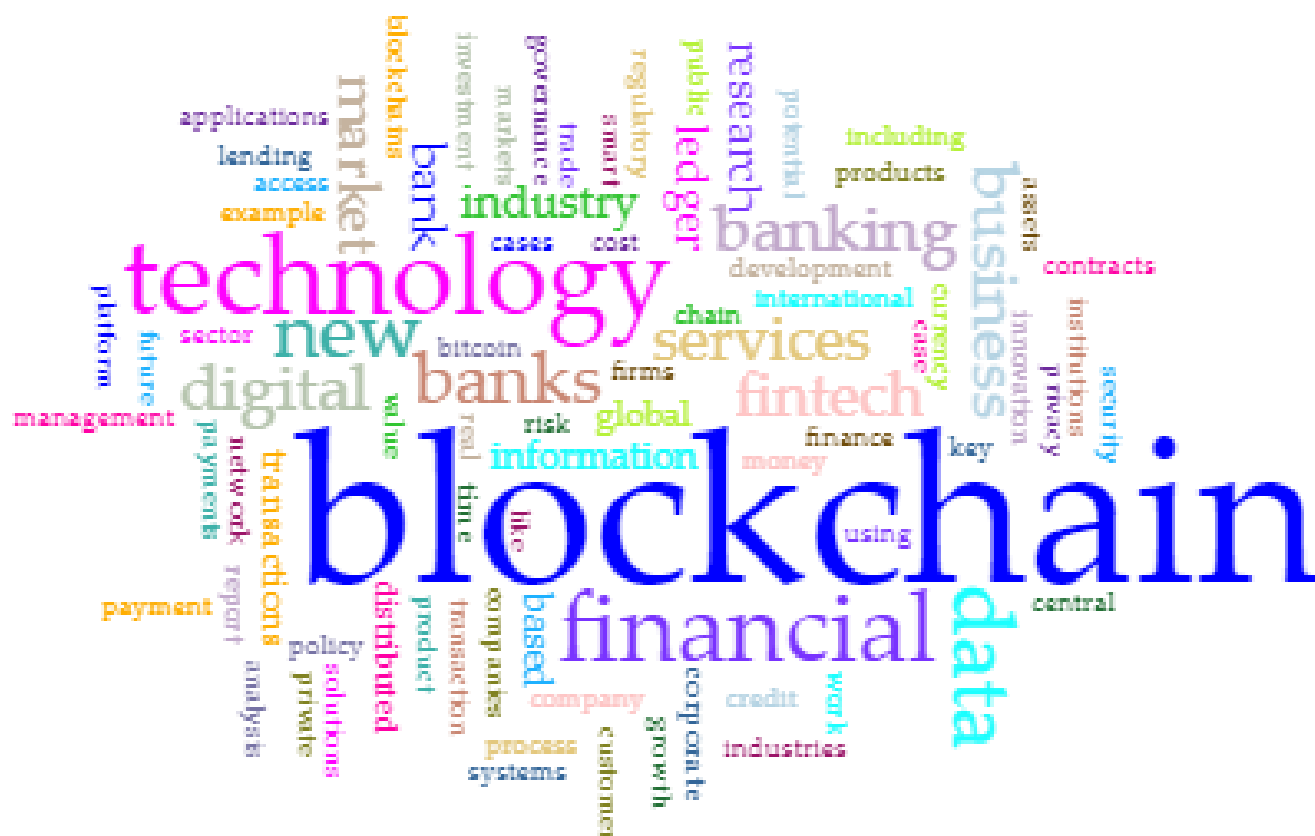


Figure 5. Resource map for industry reports on blockchain.

According to Figure 4 some the key themes arising from prior academic literature (305 studies) are 1. Blockchain (currency, competition, paper, governance) 2. Fintech (markets, discuss, fees, model, virtual) 3. Research (question, future, innovation, protocol, mining, value, time, mechanism) 4. Financial 5. Bitcoin (innovation, market, work, value, information, applications) 6. Cryptocurrency (decentralised, finance, discuss, markets) 7. Exchange (consensus, digital, contracts, special, fees, settlement) 8. Market (information, issue, settlement, bitcoin) and 9. Technology (financial, review, protocol). Within these themes we can further identify interrelated subthemes that we included in parentheses.

According to Figure 5, the key themes emerging from the industry reports are 1. Blockchain (transactions, information, credit, value, money) 2. Technology (bank, sector, cost, bitcoin, market) 3. Financial (data, work, credit, company) 4. Digital (sector, payment, management, value) 5. Services (chain, global, international, fintech) 6. Banking (ledger, products, development, business) 7. Fintech (services, currency, chain, finance, money) 8. Business (innovation, product, currency) 9. Data (central, financial). Again, the subthemes are depicted within parentheses. Thus, when comparing these two resource maps we see similarities in terms of common themes arising such as blockchain, fintech and technology. However, it is interesting to note that very few academic papers solely concentrate on blockchain in banking and the industrial reports focus more on banking use cases.

## 5. Behavioural/Social Impact, Economic, Regulatory and Managerial Impact

This section discusses the impact on the stakeholders identified in our framework. Herein, we answer our research question 3: What are the behavioural, social, economic, regulatory and managerial implications of blockchain adoption in banking? It is vital for banks to identify and explore and identify the impact on all these stakeholders on blockchain adoption to successfully maintain the adoption process and to achieve project objectives of profit maximisation, efficiency enhancements and cost decreases (Davidson et al. 2018).

### 5.1. Behavioural and Social Impact

The social impact of blockchain adoption in banking can be considerable. These would stem from privacy, transparency, security and efficiency gains by blockchains. For individuals who appreciate a stable, more transparent, and efficient banking system, blockchains might be an appealing solution. However, the use of any technology is as good as its users. Therefore, if banks create consortiums and implement permissioned blockchains that are not accessible to all parties, the transparency and security issues might still persist (Braggion et al. 2020).

### 5.2. Challenges

However, several challenges persist from a social and behavioural point of view for mass blockchain adoption in banking, for example, although transparency is a good thing, permissioned and only trusted party access is still important. Public disclosure of trades and transactions by institutional investors such as mutual funds and hedge funds via blockchains to retail investors may trigger market collapses or rallies that are not driven by fundamental value changes (Carvalho 2020). Another issue would be the maintenance of security standards across blockchains. Clearing systems operating on blockchains may result in a new type of fee. For example, if blockchain based exchanges request transaction fees from investors for transaction clearance. Then, investors would be racing against each other to have transactions settled. In addition, speedy scalability, quicker loan originations resulting in fast credit approvals may undermine regulatory loan-to-value (LTV) caps, thus, increasing credit risk (Braggion et al. 2020). Moreover, liquidity risks might increase to some extent from faster maturities, simultaneous retail fund withdrawals that are unexpected.

### 5.3. Economic Impact

Economic impact of blockchains in banking can be mostly identified by the industry (Catalini and Gans 2016). For the financial industry, banks and financial markets, blockchains offer a myriad of benefits including the elimination of single point failures through decentralisation (Beck et al. 2017; Basu et al. 2019). In addition, blockchains would streamline processes, reduce costs, decrease settlement times, digitise processes and workflows, reduce operational risk, counterparty risk and fraud (Akins et al. 2013). Thus, as a result the financial services sector and markets in general would be more accessible, transparent and efficient to its stakeholders and the general public. In addition, alternative fund raising mechanisms for blockchain based startups such as initial coin offerings will have significant impact on banks as these markets develop further (Bedi and Nashier 2020). (Albrecht et al. 2019) explores how sentiment impacts the success of blockchain startup using social media initial coin offering data.

Fichman et al. (2014) state that the banking industry is most suspicious and resistant to disruptive technologies. However, with the identified use cases in our study, we observe a change in this pattern with most banks embracing new technology through partnerships with fintechs or inhouse developments. J.P. Morgan CEO Mr. J. Dimon stated in 2014 that “Silicon Valley is coming with alternatives to traditional banking”. For example, banks have already initiated blockchain based peer-to-peer (P2P) services. However, transferring to new technology such as blockchains can also create problems with existing legacy systems, firm culture, employee training and customer perceptions. In addition, the banking business model would fundamentally change with the adoption of blockchains. They would, in our opinion, become more accountable with increasingly transparent governance systems, more efficient business processes, improved alignment of objectives between banks and stakeholders. Subsequently, banks would gain access to a wider capital base, create new products and services via blockchains and experience efficient regulatory compliance and oversight (Hill 2016).

### 5.4. Blockchain Adoption in Banking during COVID-19 Crisis

This section also aids in answering our research question 3 in a more topical manner regarding the present state of the world. The COVID-19 crisis has accelerated not just banks but whole businesses towards digital transformation. However, blockchain plays a central role in this digital transformation, especially for banks (De Reuver et al. 2017). Key initiatives regarding blockchain in banking during COVID-19 have been on data integrity, prediction and reporting. In our opinion, focusing on payment-related services will be a good starting point for banks with blockchain adoption during COVID-19 through collaborations with fintechs. For example, digital versions of fiat currencies are not a new concept but has recently risen in popularity as a way to disperse cash at a scale (Kewell et al. 2017). International payments in banking will also benefit from regulatory friendly and compliant infrastructure. Countries such as Sweden with the e-Krona, South Korea and Japan are in late stages of implementing central bank based digital currencies (Ying et al. 2018). Management of digital identities would be another blockchain application (which can be linked to track type software and apps designed to reduce pandemic spread via community transmissions). Small to medium enterprises (SMEs) struggle to obtain financing from banks because of transparency issues with their financial data. Ant Duo-Chain is a blockchain based supply chain finance platform developed by Ant Financial that allows corporate customers and suppliers to share transaction details increasing trust among these parties.

### 5.5. Regulatory Impact

Regulatory issues regarding blockchain adoption in banking involve: 1. Privacy, 2. Money transmission, 3. KYC, 4. Informational reporting, 5. Securities law, 6. Financial reporting, 7. Taxation 8. Bank specific regulation such as Basel III, 9. Smart contract enforceability, 10. Geographic specific regulation. In the past, regulation on new technolog-

ical innovations and their applications have met with considerable time lags. Regulators require time to understand the new technology, its evolving nature and applications in banking (Butenko and Larouche 2015). However, proper regulation by legal authorities in each jurisdiction can also be a positive for blockchain adoption in banking. Lack of adequate policy in a certain country may result in losing competitive advantage of using blockchains in banking and developments would move to favourable jurisdictions (Fenwick et al. 2016a, 2016b; Barefoot 2015). In addition, lack of regulation may create criminal enterprises profiting from innovative technology (De Lis 2016). To this end, blockchain access to regulators would enhance monitoring, timely action and improve overall trust and oversight (Chanson et al. 2017). Hendrickson and Luther (2017) discuss adverse regulation (bans) towards blockchain's prime application of bitcoin and its implications. Presently, there are several regulations regarding initial coin offerings (ICOs) which is a fund-raising mechanism for blockchain related start-ups (Chen 2019). Although these financing methods are not widely used by banks, banks may partner in future with fintechs using such funding. Jayasuriya Daluwathumullagamage and Sims (2020) and Dean et al. (2020) discuss regulation on ICOs.

#### 5.6. Managerial Impact and Ownership Rights

Given the question of regulation of blockchains for applications in banking, several issues arise.

For example, digital assets placed on a blockchain for trading or payment purposes need to possess ownership rights. The problem arises from how to enforce ownership rights created via a blockchain. In a blockchain, technically, assets can be transferred only by using the private key, safeguarding ownership to some extent. However, legal enforcement requires analysis of trading profiles and settlement agreements. Thus, blockchains would need to store information of the digital asset holder. Moreover, due to the decentralised nature of blockchains, there is no central party responsible for such information or to reconcile individual holdings (Brummer 2015). This may result in problems regarding investor protection. Nevertheless, the decentralised nature of blockchains increases continuity and eases crisis management especially for trading and payment settlement systems.

In blockchains, securities would be credited to a web account electronically. Then the legal question arises of who is the legal entity? The blockchain operator or the investor? Who has voting rights? However, using blockchains would be more transparent rather than centralised payment and exchange systems (Boucher 2016; Brandon 2016). Moreover, each digital currency used in the blockchain is unique and identifiable relieving enforcement duties of having to trace payments.

### 6. Limitations and Misconceptions of Blockchain in Banking

This section answers our research question 4. What are the challenges, misconceptions and limitations for blockchain adoption in banking? This section identifies that present and future blockchain use cases in banking face the following challenges: upgrades of regulations and legislation, security, standards for identity verification, interoperability, latency, scalability, reputation, transparency and energy consumption (Bartoletti et al. 2017; Baxendale 2016). Along with its numerous advantages in banking, blockchain has challenges unique to its nature. These challenges and limitations are identified in our framework from prior literature and are discussed in detail in this section. A key challenge often lost among the many technical challenges of blockchain adoption is the reputation challenge (Andolfatto 2018). Most customers would perceive blockchain to be connected to cryptocurrencies. Hence, any blockchain based or digital currency application might be met with increased privacy and security concerns (Krugman 2013). In addition, further limitations as identified by our framework include organisational challenges at banks such as bank culture (Llewellyn 2016), proper data governance, lack of skilled employees, attitudes of incumbents and productivity paradoxes (Deitz 2014; Carney 2017). Moreover, absence of good governance practices, user experience and education, understanding and

awareness, absence of, privacy and security controls, regulatory uncertainty (Deloitte 2017; Hughes et al. 2019) further hinders adoption.

#### 6.1. Interoperability

A key problem with regard to blockchains is the lack of international standards, rules and regulations. Therefore, the compatibility and interoperability among blockchains implemented by several banks, exchanges would be a key issue (Koteska et al. 2017). Another challenge would be integrating legacy systems with blockchains (Salah et al. 2019). In addition, there is a low supply of user-friendly blockchain application programming interfaces (Chen and Xue 2017).

#### 6.2. Privacy and Security

Data stored in the blockchain should be kept secure even with trusted party access and permissioned blockchains (Ahram et al. 2017). Private keys are an important element of blockchains (Augot et al. 2017). However, the generated private key must be kept securely as misplaced or lost keys would be problematic. In addition, the encryption methods utilised to store the data may be compromised by accessing network loopholes (Mendling et al. 2018). Blockchain based banking systems need to be made more robust security-wise by using more advanced security protocols that can restrict stakeholders to only access permissions given to them (Chepurnoy et al. 2016; Cong et al. 2020).

#### 6.3. Scalability

Blockchain based banking systems would have to be able to handle large volumes and significant instant growths in real time (Andolfatto 2018). The number of transactions and blocks will keep increasing and the network should be able to sustain this growth, and traffic efficiently while maintaining speeds (Zetzsche et al. 2017; Babich and Hilary 2019).

#### 6.4. Latency

Adequate secure creation of a Bitcoin transaction takes approximately 10 min per transaction (Blockchain Weaknesses 2017). Thus, to obtain security and efficiency gains, more time would need to be spent on creating a block, taking longer to complete transactions (Karafiloski and Mishev 2017). This is problematic as at present VISA takes only a few seconds to complete a transaction.

#### 6.5. Energy Consumption

Energy consumption is increased by using proof-of-work method to reward miners in blockchains due to the massive computational power required (Blockchain Hash Rate Distribution 2017). Thus, banks would have to be conscious about leaving this carbon footprint and wasting energy. For example, mining Bitcoin wastes USD 15million/day. Alternatives such as proof-of-stake may have to be used (World Energy Council and PwC 2018).

#### 6.6. Regulation

Wide adoption of blockchains in banking would require international standards and regulation to become mandatory (Zhou et al. 2015). At present, cryptocurrencies are the most popular application of blockchain and have no uniform regulation making them susceptible to volatile price changes (Tsukerman 2015; Castellanos et al. 2017). Such large prices swings would have to be avoided for wider adoption of blockchains in banking (Dimon 2014). In the U.S., blockchain focused regulation was newly created or present regulation was modified to incorporate minimum identification requirements (Dierksmeier and Seele 2016; Arner et al. 2017). Nevertheless, international exchanges may be used by investors to circumvent such regulation. This shows the significance of even international standards and regulation such as the Basel accords and international accounting standards for blockchains.



In addition, regulations similar to the General Data Protection Regulation (GDPR) may affect data gathered for blockchains from third parties

Firms and stakeholders would be wise not to include personal information on blockchains, rather this information should be stored off-chain (Axon 2015). Additionally, it is yet another reason why permissioned blockchains are likely to be used in financial markets rather than public ones.

## 7. Conclusions

Emergence of blockchain technology especially in banking, simultaneously interacts and challenges firms, traditional financial intermediation methods, stakeholders and financial markets (Christensen 2016; Cai 2018). These factors inform our motivation to focus on the adoption of blockchain in banking. To our knowledge this is the first study to conduct a systematic review of blockchain adoption solely focused on banking, develop a framework for banking based blockchains and identify gaps and parallels among industrial and academic literature. Our systematic review included 407 final articles from 2013 to 2020 from an initial record search of 1979 articles. Our objective was to demystify blockchains and highlight the widespread development and adoption of different blockchain platforms in banking. Moreover, our study brings together the widely dispersed blockchain literature with regard to banking and identify trends, issues and adoption drivers and limitations in a coherent manner. This study further identifies behavioural, social, economic, regulatory and managerial implications of blockchain adoption in banking. Our analysis would be of interest to banks, fintechs, investors in banks and fintechs, regulators and other stakeholders and interested parties.

Based on our systematic review and textual analysis of 407 articles, we conclude that both academic and industry literature focus on common themes such as blockchain, fintech and technology. However, a disparity arises with regard to individual applications of blockchain in banking with industry reports focusing more on banking use cases and academic literature largely focusing on fintech and cryptocurrencies. We were also able to identify underexplored areas in both academic and industry literature such as corporate voting, trading and exchanges. The study further highlights challenges of blockchain adoption in banking which includes but is not limited to reputational issues, culture, interoperability, scalability, latency, privacy and security, regulation and energy consumption. Although blockchain enabled banks may be fantastic beasts, where to find them might yet be in the future.

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## References

- Accenture. 2016. Global Fintech Investment Growth Continues in 2016 Driven by Europe and Asia, Accenture Study Finds. April 13 News Release. Available online: <https://newsroom.accenture.com/news/global-fintech-investment-growth-continues-in-2016-driven-by-europe-and-asia-accenture-study-finds.htm> (accessed on 18 October 2020).
- Accenture. 2017a. Banking on Blockchain. A Value Analysis for Investment Banks, Report. Available online: [https://www.accenture.com/us-en/\\_acnmedia/accenture/conversion-assets/dotcom/documents/global/pdf/consulting/accenture-banking-on-blockchain.pdf](https://www.accenture.com/us-en/_acnmedia/accenture/conversion-assets/dotcom/documents/global/pdf/consulting/accenture-banking-on-blockchain.pdf) (accessed on 21 February 2020).
- Accenture. 2017b. Blockchain for Good. 4 Guidelines for Transforming Social Innovation Organizations. Available online: [https://www.accenture.com/\\_acnmedia/pdf-68/accenture-808045-blockchainpov-rgb.pdf](https://www.accenture.com/_acnmedia/pdf-68/accenture-808045-blockchainpov-rgb.pdf) (accessed on 18 October 2020).
- Accenture. 2018. Banking on Blockchain. Available online: [https://www.accenture.com/\\_acnmedia/accenture/conversion-assets/dotcom/documents/global/pdf/consulting/accenture-banking-on-blockchain.pdf](https://www.accenture.com/_acnmedia/accenture/conversion-assets/dotcom/documents/global/pdf/consulting/accenture-banking-on-blockchain.pdf) (accessed on 18 October 2020).
- Adhami, Saman, Giancarlo Giudici, and Stefano Martinazzi. 2018. Why do businesses go crypto? An empirical analysis of initial coin offerings. *Journal of Economics and Business* 100: 64–75. [CrossRef]

- Aggarwal, Reena, and Peer Stein. 2016. *The Complex Regulatory Landscape for FinTech: An Uncertain Future for Small and Medium-Sized Enterprise Lending*. World Economic Forum White Paper No. 170816. Cologne: World Economic Forum.
- Ahram, Tareq, Arman Sargolzaei, Saman Sargolzaei, Jeff Daniels, and Ben Amaba. 2017. Blockchain technology innovations. Paper presented at the 2017 IEEE Technology and Engineering Management Society Conference, TEMSCON 2017, Silicon Valley, CA, USA, June 8–10; pp. 137–41.
- Akins, Benjamin W., Jennifer L. Chapman, and Jason M. Gordon. 2013. A Whole New World: Income Tax Considerations of the Bitcoin Economy. Available online: [https://papers.ssrn.com/sol3/papers.cfm?abstract\\_id=2394738](https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2394738) (accessed on 18 October 2020).
- Akyildirim, Erdinc, Shaen Corbet, Douglas Cumming, Brian Lucey, and Ahmet Sensoy. 2020. Riding the wave of crypto-exuberance: The potential misuse of corporate blockchain announcements. *Technological Forecasting and Social Change* 159: 120191. [CrossRef]
- Akyildirim, Erdinc, Shaen Corbet, Paraskevi Katsiampa, Neil Kellard, and Ahmet Sensoy. 2019. The development of bitcoin futures: Exploring the interactions between cryptocurrency derivatives. *Finance Research Letters* 34: 101–234. [CrossRef]
- Albrecht, Simon, Bernhard Lutz, and Dirk Neumann. 2019. How sentiment impacts the success of blockchain startups: An analysis of social media data and initial coin offerings. Available online: <https://scholarspace.manoa.hawaii.edu/handle/10125/59892> (accessed on 18 October 2020).
- Allan, Gareth, and Yuki Hagiwara. 2018. Japan Regulation Shakeup Is Seen as a Game Changer for Banks. *Bloomberg*. February 26. Available online: <https://www.bloomberg.com/news/articles/2018-02-26/japan-finance-regulation-shakeup-seen-as-game-changer-for-banks> (accessed on 10 March 2018).
- Ammous, Saifedean. 2018. Can cryptocurrencies fulfil the functions of money? *Quarterly Review of Economics and Finance* 70: 38–51. [CrossRef]
- Andolfatto, David. 2018. Blockchain: What it is, what it does, and why you probably don't need one. *Federal Reserve Bank of St Louis Review* 100: 87–95. [CrossRef]
- Arner, Douglas W., Janos N. Barberis, and Ross P. Buckley. 2017. FinTech, RegTech and the Reconceptualization of financial regulation. *Northwestern Journal of International Law and Business* 37: 371–413.
- Asharaf, S., and S. Adarsh. 2017. *Decentralized Computing Using Blockchain Technologies and Smart Contracts: Emerging Research and Opportunities*. Hershey: IGI Global.
- Athwal, Nav. 2016. 'Online Marketplace Lending—RECENTLY Misunderstood? *Forbes*. Available online: [www.forbes.com/sites/navathwal/2016/07/18/online-marketplace-lendingrecentlymisunderstood/#76d20408412f](http://www.forbes.com/sites/navathwal/2016/07/18/online-marketplace-lendingrecentlymisunderstood/#76d20408412f) (accessed on 18 October 2020).
- Atzei, Nicola, Massimo Bartoletti, and Tiziana Cimoli. 2017. A survey of attacks on Ethereum smart contracts (SoK). Paper presented at the International Conference on Principles of Security and Trust Springer, Uppsala, Sweden, April 24–25; pp. 164–86.
- Augot, Daniel, Hervé Chabanne, Thomas Chenevier, William George, and L. Lambert. 2017. A user-centric system for verified identities on the bitcoin blockchain. In *Lecture Notes in Computer Science*. Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics. Berlin: Springer, vol. 10436, pp. 390–407.
- Axon, Louise. 2015. *Privacy-Awareness in Blockchain-Based PKI*. CDT Technical Paper Series 21/15. Oxford: University of Oxford.
- Babich, Volodymyr, and Gilles Hilary. 2019. Distributed Ledgers and Operations: What Operations Management Researchers Should Know About Blockchain Technology. *Manufacturing & Service Operations Management* 22: 223–428. [CrossRef]
- Balyuk, Tetyana. 2017. Financial Innovation and Borrowers: Evidence from Peer-to-Peer Lending. Working Paper No. 2802220. November. Available online: <https://ssrn.com/abstract=2802220> (accessed on 18 October 2020).
- Barefoot, Jo Ann. 2015. Disrupting fintech law. *Fintech Law Reporter* 18: 1–18.
- Bartoletti, Massimo, Salvatore Carta, Tiziana Cimoli, and Roberto Saia. 2017. Dissecting Ponzi schemes on Ethereum: Identification, analysis, and impact. *Future Generation Computer Systems* 102: 259–77. [CrossRef]
- Baxendale, Gareth. 2016. Can blockchain revolutionise EPRs? *ITNOW* 58: 38–39. [CrossRef]
- Basu, Soumya, David Easley, and Maureen O'Hara. 2019. From mining to markets. *Journal of Financial Economics* 134: 91–109.
- Beck, Roman, Michel Avital, Matti Rossi, and Jason Bennett Thatcher. 2017. Blockchain technology in business and information systems research. *Business & Information Systems Engineering* 59: 381–84. [CrossRef]
- Beck, Roman, Stenum J. Czepluch, Nikolaj Lollike, and Simon Malone. 2016. Blockchain—The gateway to trust-free cryptographic transactions. Paper presented at the 24th European Conference on Information Systems, ECIS 2016, Istanbul, Turkey, June 12–15.
- Bedi, Prateek, and Tripti Nashier. 2020. On the investment credentials of bitcoin: A cross-currency perspective. *Research in International Business and Finance* 51: 101087. [CrossRef]
- Beikverdi, Alireza, and JooSeok Song. 2015. Trend of centralization in Bitcoin's distributed network. Paper presented at the Software Engineering, Artificial Intelligence, Networking and Parallel/Distributed Computing (SNPD). 2015 16th IEEE/ACIS International Conference, Takamatsu, Japan, June 1–3.
- Beneki, Christina, Alexandros Koulis, Nikolaos Kyriazis, and Stephanos Papadamou. 2019. Investigating volatility transmission and hedging properties between bitcoin and ethereum. *Research in International Business and Finance* 48: 219–27. [CrossRef]
- Benet, J. 2014. Filecoin: A Cryptocurrency Operated File Storage. Available online: <http://filecoin.io/filecoin.pdf> (accessed on 18 October 2020).
- Berg, Tobias, Valentin Burg, Ana Gombovic, and Manju Puri. 2019. On the Rise of FinTechs: Credit Scoring Using Digital Footprints. *The Review of Financial Studies* 33: 2845–97. [CrossRef]
- Biais, Bruno, Christophe Bisière, Matthieu Bouvard, and Catherine Casamatta. 2019. The Blockchain Folk Theorem, Review of Financial Studies. *The Review of Financial Studies* 32: 1662–715. [CrossRef]

- Bianchetti, Marco, Camilla Ricci, and Marco Scaringi. 2018. Are Cryptocurrencies Real Financial Bubbles? Evidence from Quantitative Analyses. A version of this paper was published in Risk, 26 January 2018. September 10. Available online: <https://ssrn.com/abstract=3092427> (accessed on 18 October 2020).
- Birch, David, Richard G. Brown, and Salome Parulava. 2016. Towards ambient accountability in financial services: Shared ledgers, translucent transactions and the technological legacy of the great financial crisis. *Journal of Payments Strategy & Systems* 10: 118–31.
- Biryukov, Alex, Dmitry Khovratovich, and Ivan Pustogarov. 2014. Deanonimisation of Clients in Bitcoin P2P Network. In *Paper presented at the 2014 ACM SIGSAC Conference on Computer and Communications Security, CCS '14*. New York, NY, USA: ACM, ISBN 978-1-4503-2957-6. [CrossRef]
- Bitcoin ETf Channel. 2018. Available online: <http://www.etf.com/channels/bitcoin> (accessed on 18 October 2020).
- Blockchain Hash Rate Distribution. 2017. Available online: <https://blockchain.info/pools> (accessed on 18 October 2020).
- Blockchain Weaknesses. 2017. Available online: <https://en.bitcoin.it/wiki/Weaknesses> (accessed on 18 October 2020).
- Bloomberg. 2018. A New Crop of Fintech IPOs Will Face Sceptical Investors. Available online: <https://www.bloomberg.com/news/articles/2018-05-01/a-new-crop-of-fintech-ipos-willface-skeptical-investors> (accessed on 18 October 2020).
- Bolt, Wilko, and Maarten R. C. Van Oordt. 2019. On the Value of Virtual Currencies. *Journal of Money Credit and Banking* 52: 835–62. [CrossRef]
- Bonneau, Joseph, Andrew Miller, Jeremy Clark, Arvind Narayanan, Joshua A. Kroll, and Edward W. Felten. 2015. Sok: Research perspectives and challenges for bitcoin and cryptocurrencies. Paper presented at the 2015 IEEE Symposium on Security and Privacy (SP) IEEE, San Jose, CA, USA, May 17–21; pp. 104–21.
- Bonneau, Joseph, Arvind Narayanan, Andrew Miller, Jeremy Clark, Joshua A. Kroll, and Edward W. Felten. 2014. *Mixcoin: Anonymity for Bitcoin with Accountable Mixes*. Berlin and Heidelberg: Springer, pp. 486–504.
- Boucher, Philip. 2016. *What If Blockchain Technology Revolutionised Voting?* Brussels: Scientific Foresight Unit (STOA), European Parliamentary Research Service.
- Bouoiyour, Jamal, Refk Selmi, Aviral Tiwari, and Olaolu Olayeni. 2016. What drives bitcoin price? *Economics Bulletin* 36: 843–50.
- Braggion, Fabio, Alberto Manconi, and Haikun Zhu. 2020. Can Technology Undermine Macroprudential Regulation? Evidence from Online Marketplace Credit in China. Available online: [https://papers.ssrn.com/sol3/papers.cfm?abstract\\_id=2957411](https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2957411) (accessed on 1 June 2020). [CrossRef]
- Brandon, Dan. 2016. The Blockchain: The future of business information systems? *International Journal of the Academic Business World* 10: 33–40.
- Bresnahan, Timothy, and Manuel Trajtenberg. 1995. General Purpose Technologies. 'Engines of Growth'? *Journal of Econometrics* 65: 83–108. [CrossRef]
- Briner, Rob B., David Denyer, and Denise M. Rousseau. 2009. Evidence based management: Concept cleanup time? *The Academy of Management Perspectives* 23: 19–32. [CrossRef]
- Briner, Rob B., and David Denyer. 2012. Systematic Review and Evidence Synthesis as a Practice and Scholarship Tool. In *Handbook of Evidence-Based Management: Companies, Classrooms and Research*. Edited by D. M. Rousseau. Oxford: Oxford University Press, pp. 112–29. [CrossRef]
- Bruce, J. D. 2013. Purely P2P Crypto-Currency with Finite Mini-Blockchain. Available online: <https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.1046.128&rep=rep1&type=pdf> (accessed on 18 October 2020).
- Brühl, Volker. 2017. Virtual currencies, distributed ledgers and the future of financial services. *Intereconomics* 52: 370–78. [CrossRef]
- Brummer, Chris. 2015. Disruptive technology and securities regulation. *Fordham Law Review* 84: 977–1051. [CrossRef]
- Brynjolfsson, Erik, and Andrew McAfee. 2014. *The Second Machine Age: Work, Progress, and Prosperity in a Time of Brilliant Technologies*. New York: Norton.
- Buchak, Greg, Gregor Matvos, Tomasz Piskorski, and Amit Seru. 2017. Fintech, regulatory arbitrage, and the rise of shadow banks. Columbia Business School Research Paper No. 17–39. Available online: <https://ssrn.com/abstract=2941561> (accessed on 18 October 2020).
- Bunea, Sinziana, Benjamin Kogan, and David Stolin. 2016. Banks versus FinTech: At last, it's official. *Journal of Financial Transformation* 44: 122–31.
- Butenko, Anna, and Pierre Larouche. 2015. Regulation for innovativeness or regulation of innovation? *Law, Innovation and Technology* 7: 52–82. [CrossRef]
- Buterin, Vitalik. 2015. On Public and Private Blockchains. *Ethereum Blog, Crypto Renaissance Salon*. August 7. Available online: <https://blog.ethereum.org/2015/08/07/on-public-and-private-blockchains/> (accessed on 18 October 2020).
- Cagli, Efe. 2019. Explosive behavior in the prices of bitcoin and altcoins. *Finance Research Letters* 29: 398–403. [CrossRef]
- Cai, Cynthia Weiyi. 2018. Disruption of financial intermediation by FinTech: A review on crowdfunding and blockchain. *Accounting and Finance* 58: 965–92. [CrossRef]
- Cai, Yuanfeng, and Dan Zhu. 2016. Fraud detections for online businesses: A perspective from blockchain technology. *Financial Innovation* 2: 20. [CrossRef]
- Canaday, Tyrone. 2017. Evolving a payments business to meet the demands of a distributed economy. *Journal of Payments Strategy & Systems* 11: 15–22.
- Caporale, Guglielmo, Luis Gil-Alana, and Alex Plastun. 2018. Persistence in the cryptocurrency market. *Research in International Business and Finance* 46: 141–48. [CrossRef]

- Carney, Mark. 2016. Enabling the FinTech Transformation: Revolution, Restoration, or Reformation? Governor of the Bank of England, BoE, Speech. June 16. Available online: <http://www.bankofengland.co.uk/publications/Documents/speeches/2016/speech914.pdf> (accessed on 18 October 2020).
- Carney, Mark. 2017. The Promise of Fintech—Something New under the Sun? Governor of the Bank of England, BoE, Speech, June 16, Deutsche Bundesbank G20 Conference on “Digitising Finance, Financial Inclusion and Financial Literacy”. Available online: <http://www.fsb.org/wp-content/uploads/The-Promise-of-FinTech-%E2%80%93-Something-NewUnder-the-Sun.pdf> (accessed on 18 October 2020).
- Carvalho, Arthur. 2020. A permissioned blockchain-based implementation of LMSR prediction markets. *Decision Support Systems* 130: 113228. [CrossRef]
- Castellanos, J. Alejandro F., Debora Coll-Mayor, and José Antonio Notholt. 2017. Cryptocurrency as guarantees of origin: Simulating a green certificate market with the Ethereum Blockchain. Paper presented at the 2017 5th IEEE International Conference on Smart Energy Grid Engineering, SEGE 2017, Oshawa, ON, Canada, August 14–17; pp. 367–72.
- Catalini, Christian, and Joshua Gans. 2016. Some Simple Economics of the Blockchain. NBER Working Paper No. 22952. Available online: <https://www.nber.org/papers/w22952> (accessed on 18 October 2020).
- Cawrey, Daniel. 2014. 37Coins Plans Worldwide Bitcoin Access with SMS-Based Wallet. Available online: <http://www.coindesk.com/37coins-plans-worldwide-bitcoin-access-sms-based-wallet/> (accessed on 18 October 2020).
- CBS. 2015. Disrupting Banking: The Fintech Startups that Are Unbundling Wells Fargo. *Citi and Bank of America*. Available online: <https://www.cbinsights.com/blog/disruptingbanking-fintech-startups/> (accessed on 18 October 2020).
- Chaim, Pedro, and Márcio Laurini. 2019. Is bitcoin a bubble? *Physica A: Statistical Mechanics and Its Applications* 517: 222–32. [CrossRef]
- Chanson, Mathieu, Elgar Fleisch, Andreas Bogner, and Felix Wortmann. 2017. Blockchain as a privacy enabler: An odometer fraud prevention system. In Paper presented at the UbiComp/ISWC 2017—Adjunct Proceedings of the 2017 ACM International Joint Conference on Pervasive and Ubiquitous Computing and Proceedings of the 2017 ACM International Symposium on Wearable Computers, Maui, HI, USA, September 11–15.
- Cheah, Eng-Tuck, and John Fry. 2015. Speculative bubbles in bitcoin markets? An empirical investigation into the fundamental value of bitcoin. *Economics Letters* 130: 32–36. [CrossRef]
- Chen, Jinchuan, and Yunzhi Xue. 2017. Bootstrapping a blockchain based ecosystem for big data exchange. Paper presented at the 2017 IEEE 6th International Congress on Big Data, BigData Congress, Honolulu, HI, USA, June 25–30; pp. 460–43.
- Chen, Kun. 2019. Information asymmetry in initial coin offerings (ICOs): Investigating the effects of multiple channel signals. *Electronic Commerce Research and Applications* 36: 100858. [CrossRef]
- Chen, Mark A., Qinxu Wu, and Baozhong Yang. 2019. How Valuable Is FinTech Innovation? *Review of Financial Studies* 32: 2062–106. [CrossRef]
- Cheng, Raymond, Fan Zhang, Jernej Kos, Warren He, Nicholas Hynes, Noah Johnson, Ari Juels, Andrew Miller, and Dawn Song. 2018. Ekiden: A platform for confidentiality-preserving, trustworthy, and performant smart contract execution. *arXiv* arXiv:1804.05141.
- Chepurnoy, Alexander, Mario Larangeira, and Alexander Ojiganov. 2016. A prunable blockchain consensus protocol based on non-interactive proofs of past states retrievability. *arXiv* arXiv:1603.07926.
- Cheung, Adrian, Eduardo Roca, and Jen-Je Su. 2015. Crypto-currency bubbles: An application of the phillips-shi-yu (2013) methodology on mt. gox bitcoin prices. *Applied Economics* 47: 2348–58. [CrossRef]
- Christensen, Clayton. 2016. The Innovator’s Dilemma: When New Technologies Cause Great Firms to Fail. Available online: [http://www.amazon.com/The-Innovator-s-Dilemma-Technologies-Cause/dp/1633691780/ref=dp\\_ob\\_title\\_bk](http://www.amazon.com/The-Innovator-s-Dilemma-Technologies-Cause/dp/1633691780/ref=dp_ob_title_bk) (accessed on 18 October 2020).
- Christensen, Clayton M., Michael E. Raynor, and Rory McDonald. 2015. What Is Disruptive Innovation? *Harvard Business*. Available online: <https://hbr.org/2015/12/what-isdisruptive-innovation> (accessed on 18 October 2020).
- Coase, Ronald. 1937. The Nature of the Firm. *Economica. Blackwell Publishing* 4: 386–405. [CrossRef]
- Cocco, Luisanna, Andrea Pinna, and Michele Marchesi. 2017. Banking on blockchain: Costs savings thanks to the blockchain technology. *Future Internet* 9: 25. [CrossRef]
- Coghlan, David, and Rosalie Holian. 2007. Insider action research. *Action Research* 5: 5–10. [CrossRef]
- Cohen, Lewis Rinaudo, Lee Samuelson, and Hali Katz. 2017. How securitization can benefit from blockchain technology. *Journal Structured Finance* 23: 51–54. [CrossRef]
- Cong, Lin William, Ye Li, and Neng Wang. 2020. Tokenomics: Dynamic Adoption and Valuation Columbia Business School Research Paper No. 18–46. Available online: <https://papers.ssrn.com/abstract=3222802> (accessed on 1 June 2020).
- Cong, Yu, Hui Du, and Miklos A. Vasarhelyi. 2018. Technological disruption in accounting and auditing. *Journal of Emerging Technologies in Accounting* 15: 1–10. [CrossRef]
- Corbet, Shaen, Andrew Meegan, Charles Larkin, Brian Lucey, and Larisa Yarovaya. 2018a. Exploring the dynamic relationships between cryptocurrencies and other financial assets. *Economics Letters* 165: 28–34. [CrossRef]
- Corbet, Shaen, Brian Lucey, and Larisa Yarovaya. 2018b. Datestamping the Bitcoin and Ethereum bubbles. *Finance Research Letters* 26: 81–88. [CrossRef]
- Corbet, Shaen, Brian Lucey, Maurice Peat, and Samuel Vigne. 2018c. Bitcoin futures—What use are they? *Economics Letters* 172: 23–27. [CrossRef]



- Corbet, Shaen, Brian Lucey, Andrew Urquhart, and Larisa Yarovaya. 2019a. Cryptocurrencies as a financial asset: A systematic analysis. *International Review of Financial Analysis* 62: 182–99. [CrossRef]
- Corbet, Shaen, Douglas J. Cumming, Brian M. Lucey, Maurice Peat, and Samuel A. Vigne. 2019b. The destabilising effects of cryptocurrency cybercriminality. *Economics Letters* 191: 108741. [CrossRef]
- Corbet, Shaen, Veysel Eraslan, Brian M. Lucey, and Ahmet Sensoy. 2019c. The effectiveness of technical trading rules in cryptocurrency markets. *Finance Research Letters* 31: 32–37. [CrossRef]
- Corbet, Shaen, Charles Larkin, Brian Lucey, Andrew Meegan, and Larisa Yarovaya. 2020a. Cryptocurrency reaction to FOMC announcements: Evidence of heterogeneity based on blockchain stack position. *Journal of Financial Stability* 46: 100706. [CrossRef]
- Corbet, Shaen, Charles Larkin, Brian Lucey, and Larisa Yarovaya. 2020b. Kodakcoin: A blockchain revolution or exploiting a potential cryptocurrency bubble? *Applied Economics Letters* 27: 518–24. [CrossRef]
- Cortez, Nathan. 2014. Regulating disruption innovation. *Berkeley Technology Law Journal* 29: 175–228.
- Coyne, Joshua G., and Peter L. McMickle. 2017. Can Blockchains serve an accounting purpose? *Journal of Emerging Technologies in Accounting* 14: 101–11. [CrossRef]
- Crosby, Michael, Pradan Pattanayak, Sanjeev Verma, and Vignesh Kalyanaraman. 2016. Blockchain technology: Beyond bitcoin. *Applied Innovation* 2: 6–10.
- Cuccuru, Pierluigi. 2017. Beyond bitcoin: An early overview on smart contracts. *International Journal of Law and Information Technology* 25: 179–95. [CrossRef]
- Da Rin, Marco, and María Fabiana Penas. 2017. Venture Capital and Innovation Strategies. *Industrial and Corporate Change*. Available online: <https://ssrn.com/abstract=2594904> (accessed on 18 October 2020).
- Dai, Jun, and Miklos A. Vasarhelyi. 2017. Toward blockchain-based accounting and assurance. *Information Systems Journal* 31: 5–21. [CrossRef]
- Dannen, Chris. 2017. *Introducing Ethereum and Solidity: Foundations of Cryptocurrency and Blockchain Programming for Beginners*. New York: Apress.
- Dapp, Thomas F., Lars Slomka, and Ralf Hoffmann. 2014. Fintech—The Digital (r)Evolution in The Financial Sector. *Deutsche Bank Research*. Available online: [https://www.dbresearch.com/PROD/DBR\\_INTERNET\\_EN-PROD/PROD0000000000345837.pdf](https://www.dbresearch.com/PROD/DBR_INTERNET_EN-PROD/PROD0000000000345837.pdf) (accessed on 18 October 2020).
- Davidson, Sinclair, Primavera De Filippi, and Jason Potts. 2018. Blockchains and the economic institutions of capitalism. *Journal of Institutional Economics* 14: 639–58. [CrossRef]
- De Lis, Santiago Fernández. 2016. RegTech, the New Magic Word in FinTech, Banking Outlook. *MarchBBVA*. Available online: [https://www.bbva.com/wp-content/uploads/2016/03/Banking-Outlook-Q116\\_Cap6.pdf](https://www.bbva.com/wp-content/uploads/2016/03/Banking-Outlook-Q116_Cap6.pdf) (accessed on 18 October 2020).
- De Meijer, Carlo R. W. 2016. Blockchain and the securities industry: Towards a new ecosystem. *Journal of Securities Operations & Custody* 8: 322–29.
- De Reuver, Mark, Carsten Sørensen, and Rahul Basole. 2017. The digital platform: A research agenda. *Journal of Information Technology*, 1–12. [CrossRef]
- De Sousa, Hélder Ribeiro, and António Pinto. 2019. Blockchain based informed consent with reputation support. In *International Congress on Blockchain and Applications*. Berlin: Springer, pp. 54–61.
- Dean, Tobias, Dulani Jayasuriya Daluwathumullagamage, and Alastair Marsden. 2020. Predictability of ICO Success and Returns. *Journal of Applied Business and Economics* 22: 20–36.
- Deer, Luke, Jackson Mi, and Yu Yuxin. 2015. *The Rise of Peer-to-Peer Lending in China: An Overview and Survey Case Study*. London: Association of Chartered Certified Accountants.
- Deitz, Joel. 2014. Decentralized Governance Whitepaper. Available online: <http://distributed-autonomous-society.quora.com/Decentralized-Governance-Whitepaper> (accessed on 18 October 2020).
- Deloitte. 2016a. RegTech is the New FinTech: How Agile Regulatory Technology is Helping Firms Better Understand and Manage Their Risks. IE. Available online: [https://www2.deloitte.com/content/dam/Deloitte/ie/Documents/FinancialServices/IE\\_2016\\_FS\\_RegTech\\_is\\_the\\_new\\_FinTech.pdf](https://www2.deloitte.com/content/dam/Deloitte/ie/Documents/FinancialServices/IE_2016_FS_RegTech_is_the_new_FinTech.pdf) (accessed on 18 October 2020).
- Deloitte. 2016b. Blockchain Applications in Insurance. Turning a Buzzword into a Breakthrough for Health and Life Insurers. Available online: <https://www2.deloitte.com/content/dam/Deloitte/us/Documents/financial-services/us-fsi-blockchain-in-insurance-ebook.pdf> (accessed on 18 October 2020).
- Deloitte. 2016c. Over the Horizon. Blockchain and the Future of Financial Infrastructure. Available online: <https://www2.deloitte.com/content/dam/Deloitte/nl/Documents/financial-services/deloitte-nl-fsi-blockchain-and-the-future-of-financial-infrastructure.pdf>, (accessed on 18 October 2020).
- Deloitte. 2017. The Evolving Fintech Regulatory Environment; Preparing for the Inevitable. Available online: <https://www2.deloitte.com/us/en/pages/regulatory/articles/fintech-riskmanagement.html> (accessed on 18 October 2020).
- Dierksmeier, Claus, and Peter Seele. 2016. Cryptocurrencies and business ethics. *Journal of Business Ethics*, 1–14. [CrossRef]
- Dimon, Jamie. 2014. Bitcoin Will “Try to eat our lunch”. *Inside Bitcoins*. Available online: <http://insidebitcoins.com/news/jp-morgans-jamie-dimon-bitcoin-will-try-to-eat-ourlunch/25378> (accessed on 18 October 2020).
- Disparte, Dante. 2017. Blockchain could make the insurance industry much more transparent. Retrieved October 19. *Harvard Business Review Website*. Available online: <https://hbr.org/2017/07/blockchain-could-make-the-insurance-industry-much-more-transparent> (accessed on 18 October 2020).

- Do, Hoang Giang, and Wee Keong Ng. 2017. Blockchain-based system for secure data storage with private keyword search. Paper presented at the 2017 IEEE 13th World Congress on Services. SERVICES, Honolulu, HI, USA, June 25–30; pp. 90–93.
- Dwyer, Gerald. 2015. The economics of bitcoin and similar private digital currencies. *Journal of Financial Stability* 17: 81–91. [CrossRef]
- Economist. 2015. The FinTech Revolution: A Wave of Startups is Changing Finance—For the Better. Available online: <http://www.economist.com/news/leaders/21650546-wave-startups-changing-finance-for-better-fintech-revolution> (accessed on 18 October 2020).
- Economist. 2016. Artificial Intelligence: Million-dollar Babies—Artificial Intelligence. April 2. Available online: <https://www.economist.com/business/2016/04/02/million-dollar-babies> (accessed on 18 October 2020).
- Economist. 2018. America's Public Markets Are Perking up. Can It Last? March 17. Available online: <https://www.economist.com/finance-and-economics/2018/03/17/americas-public-markets-are-perking-up-can-it-last> (accessed on 18 October 2020).
- Energy Web Foundation. 2018. Energy Web Foundation—Blockchain and Digital Security in Energy. *OECD Workshop*. Available online: <http://www.oecd.org/going-digital/digitalsecurity-in-critical-infrastructure/digital-security-workshop-february-2018-Trbovich.pdf> (accessed on 18 October 2020).
- English, S. Matthew, and Ehsan Nezhadian. 2017. Conditions of full disclosure: The blockchain remuneration model. Paper presented at the 2nd IEEE European Symposium on Security and Privacy Workshops, EuroS and PW, Paris, France, April 26–28; pp. 64–67.
- Eris Industries. 2016. Explainer—Smart Contracts. Available online: [https://docs.erisindustries.com/explainers/smart\\_contracts/](https://docs.erisindustries.com/explainers/smart_contracts/) (accessed on 18 October 2020).
- Ernst and Young. 2016. UK FinTech Census: The Voice of FinTech, HM Treasury. EY and Innovate Finance. Available online: [http://www.ey.com/Publication/vwLUAssets/EY-UK-FinTechCensus-2017/\\$FILE/EY-UK-FinTech-Census-2017.pdf](http://www.ey.com/Publication/vwLUAssets/EY-UK-FinTechCensus-2017/$FILE/EY-UK-FinTech-Census-2017.pdf) (accessed on 18 October 2020).
- Ernst and Young. 2017. FinTech Adoption Index: The Rapid Emergence of FinTech. EY FinTech Adoption Index Bulletin Research. Available online: [http://www.ey.com/Publication/vwLUAssets/ey-fintech-adoption-index-2017/\\$FILE/ey-fintech-adoption-index-2017.pdf](http://www.ey.com/Publication/vwLUAssets/ey-fintech-adoption-index-2017/$FILE/ey-fintech-adoption-index-2017.pdf) (accessed on 18 October 2020).
- Evans, David S. 2014. Economic Aspects of Bitcoin and Other Decentralized Public-Ledger Currency Platforms (April 15). University of Chicago Coase-Sandor Institute for Law & Economics Research Paper No. 685. Available online: <https://ssrn.com/abstract=2424516> (accessed on 18 October 2020). [CrossRef]
- Eyal, Ittay, and Emin Gun Sirer. 2014. *Majority Is Not Enough: Bitcoin Mining Is Vulnerable*. Berlin and Heidelberg: Springer, pp. 436–54.
- Eyers, James. 2016. Welcome to the New World of 'Regtech'. *Australian Financial Review*. June 20. Available online: <http://www.afr.com/technology/welcome-to-the-new-world-of-regtech-20160619-gpmj6k> (accessed on 18 October 2020).
- F.R. Ltd. 2016. *Banking on Blockchain: Charting the Progress of Distributed Ledger Technology in Financial Services, Report*. Singapore: F.R. Ltd.
- Fan, Kai, Yanhui Ren, Yue Wang, Hui Li, and Yingtang Yang. 2018. Blockchain-based efficient privacy preserving and data sharing scheme of content-centric network in 5G. *IET Communications* 12: 527–32. [CrossRef]
- Fanning, Kurt, and David P. Centers. 2016. Blockchain and its coming impact on financial services. *Journal Corporate Accounting Finance* 27: 53–57. [CrossRef]
- Fassas, Athanasios, Stephanos Papadamou, and Alexandros Koulis. 2020. Price discovery in bitcoin futures. *Research in International Business and Finance* 52: 101116. [CrossRef]
- FED. 2016. *G.19 Statistical Release, Consumer Credit*. Washington, DC: Board of Governors of the Federal Reserve System.
- Federal Reserve Bank of Chicago. 2016. *Shifting Ground: The Changing Landscape in Financial Markets and Technology*. Chicago Fed Letter ESSAYS ON ISSUES, No. 367. Chicago: Federal Reserve Bank of Chicago.
- Felix, Thomas, and Henk von Eije. 2019. Underpricing in the cryptocurrency world: Evidence from initial coin offerings. *Managerial Finance* 45: 563–78. [CrossRef]
- Fenwick, Mark D., Wulf A. Kaal, and Erik P.M. Vermeulen. 2016a. Regulation Tomorrow: What Happens When Technology Is Faster than the Law? *American University Business Law Review* 6. Available online: <http://digitalcommons.wcl.american.edu/aubl/vol6/iss3/1> (accessed on 18 October 2020). [CrossRef]
- Fenwick, Mark D., Wulf A. Kaal, and Erik P. M. Vermeulen. 2016b. Regulation Tomorrow: What Happens When Technology is Faster Than the Law? Legal Studies Research Paper, No. 16-23; TILEC Discussion Paper No. 2016-024. University of St. Thomas (Minnesota). Available online: <https://ssrn.com/abstract=2834531> (accessed on 18 October 2020).
- Ferguson, Niall. 2008. *The Ascent of Money: The Financial History of the World*. London: Allen Lane, Penguin.
- Fichman, Robert G., Brian L. Dos Santos, and Zhiqiang Zheng. 2014. Digital innovation as a fundamental and powerful concept in the information systems curriculum. *Management Information Systems, Q* 38: 329–43. [CrossRef]
- Financial Conduct Authority. 2016. Feedback Statement, Call for Input on Supporting the Development and Adopters of RegTech. Feedback Statement 16/4. July 3. Available online: <https://www.fca.org.uk/publication/feedback/fs-16-04.pdf> (accessed on 18 October 2020).
- Financial Stability Board. 2013. Policy Framework for Strengthening Oversight and Regulation of Shadow Banking Entities. Available online: [https://www.fsb.org/2013/08/r\\_130829c/](https://www.fsb.org/2013/08/r_130829c/) (accessed on 18 October 2020).
- Financial Stability Board. 2014. Global Shadow Banking Monitoring Report 2014. Available online: <https://www.fsb.org/2014/11/global-shadow-banking-monitoring-report-2014/> (accessed on 18 October 2020).



- Flori, Andrea. 2019. News and subjective beliefs: A bayesian approach to bitcoin investments. *Research in International Business and Finance* 50: 336–56. [CrossRef]
- Foley, Sean, Jonathan R. Karlsen, and Tālis J. Putnins. 2019. Sex, Drugs, and Bitcoin: How Much Illegal Activity Is Financed through Cryptocurrencies? *Review of Financial Studies* 32: 1798–853. [CrossRef]
- Frame, W. Scott, and Lawrence J. White. 2014. *Technological Change, Financial Innovation, and Diffusion in Banking*. Edited by Allen N. Berger, Philip Molyneux and John O. S. Wilson. , 2nd ed. Available online: <http://ssrn.com/abstract=2380060> (accessed on 18 October 2020).
- Frey, Remo M., Dominic Wörner, and Alexander Ilic. 2016. Collaborative filtering on the blockchain: A secure recommender system for E-commerce. Paper presented at the AMCIS 2016: Surfing the IT Innovation Wave—22nd Americas Conference on Information Systems, San Diego, CA, USA, August 11–14.
- Fridgen, Gilbert. 2018. Cross-organizational workflow management using blockchain technology-towards applicability, auditability, and automation. Paper presented at the 51st Annual Hawaii International Conference on System Sciences, Hilton Waikoloa Village, HI, USA, January 3–6.
- Frizzo-Barkera, Julie, Peter A. Chow-Whitea, Philippa Adamsa, Jennifer Mentankoa, Dung Ha, and Sandy Green. 2020. Blockchain as a disruptive technology for business: A systematic review. *International Journal of Information Management* 151: 102029. [CrossRef]
- Fry, John. 2018. Booms, busts and heavy-tails: The story of Bitcoin and cryptocurrency markets? *Economics Letters* 171: 225–29. [CrossRef]
- Fry, John, and Eng-Tuck Cheah. 2016. Negative bubbles and shocks in cryptocurrency markets. *International Review of Financial Analysis* 47: 343–52. [CrossRef]
- Fuster, Andreas, Matthew Plosser, Philipp Schnabl, and James Vickery. 2019. The Role of Technology in Mortgage Lending. *Review of Financial Studies* 32: 1854–899. [CrossRef]
- Gaetani, Edoardo, Leonardo Aniello, Roberto Baldoni, Federico Lombardi, Andrea Margheri, and Vladimiro Sassone. 2017. Blockchain-based database to ensure data integrity in cloud computing environments. *CEUR Workshop Proceedings* 1816: 146–55.
- Gandal, Neil, JT Hamrick, Tyler Moore, and Tali Oberman. 2018. Price manipulation in the Bitcoin ecosystem. *Journal of Monetary Economics* 95: 86–96. [CrossRef]
- Gao, Feng, Liehuang Zhu, Meng Shen, Kashif Sharif, Zhiguo Wan, and Kui Ren. 2018. A blockchain-based privacy-preserving payment mechanism for vehicle-to-grid networks. *IEEE Network* 32: 184–92. [CrossRef]
- García-Barriocanal, Elena, Salvador Sánchez-Alonso, and Miguel-Angel Sicilia. 2017. Deploying metadata on blockchain technologies. *Communications in Computer and Information Science* 755: 38–49.
- Garrett, Bradley. 2015. Technology will Keep Changing Everything—And Will do it Faster. Captured August 19. Available online: <https://perma.cc/8DAH-M8M8> (accessed on 18 October 2020).
- Gattermayer, Josef, and Pavel Tvrdik. 2017. Blockchain-based multi-level scoring system for P2P clusters. Paper presented at the International Conference on Parallel Processing Workshops, Bristol, UK, August 14–17; pp. 301–8.
- Gazali, Haneffa Muchlis, Rusni Hassan, Rizal Mohd Nor, and Hafizur M. M. Rahman. 2017. Re-inventing PTPTN study loan with blockchain and smart contracts. Paper presented at the ICIT 2017–8th International Conference on Information Technology, Amman, Jordan, May 17–18; pp. 751–54.
- Gerstl, David S. 2016. Leveraging bitcoin blockchain technology to modernize security perfection under the uniform commercial code. *Lecture Notes Business Information Processing* 240: 109–23.
- Geuder, Julian, Harald Kinateder, and Niklas Wagner. 2019. Cryptocurrencies as financial bubbles: The case of bitcoin. *Finance Research Letters* 31. [CrossRef]
- Goldfeder, Steven, Harry Kalodner, Dillon Reisman, and Arvind Narayanan. 2017. When the cookie meets the blockchain: Privacy risks of web payments via cryptocurrencies. *arXiv* arXiv:1708.04748. [CrossRef]
- Goldstein, Itay, Wei Jiang, and G. Andrew Karolyi. 2019. To FinTech and Beyond. *Review of Financial Studies* 32: 1647–61. [CrossRef]
- Gomber, Peter, Jascha-Alexander Koch, and Michael Siering. 2017. Digital Finance and FinTech: Current research and future research directions. *Journal of Business Economics* 87: 537–80. [CrossRef]
- Governatori, Guido, Florian Idelberger, Zoran Milosevic, Regis Riveret, Giovanni Sartor, and Xiwei Xu. 2018. On legal contracts, imperative and declarative smart contracts, and blockchain systems. *Artificial Intelligence Law* 266: 377–409. [CrossRef]
- Government Accountability Office. 2018. FINANCIAL TECHNOLOGY: Additional Steps by Regulators Could Better Protect Consumers and Aid Regulatory Oversight, March, GAO-18-254, Report to Congress Requesters. Available online: <https://www.gao.gov/assets/700/690803.pdf> (accessed on 18 October 2020).
- Greenspan, Gideon. 2015a. Ending the Bitcoin vs Blockchain Debate. Available online: <http://www.multichain.com/blog/2015/07/bitcoin-vs-blockchain-debate> (accessed on 18 October 2020).
- Greenspan, Gideon. 2015b. MultiChain Private Blockchain, White Paper. Available online: <http://www.multichain.com/download/MultiChain-White-Paper.pdf> (accessed on 18 October 2020).
- Greenspan, Gideon. 2015c. Avoiding the Pointless Blockchain Project. Available online: <https://www.multichain.com/blog/2015/11/avoiding-pointless-blockchain-project/> (accessed on 18 October 2020).
- Greenspan, Gideon. 2016. Payment and exchange transactions in shared ledgers. *Journal of Payments Strategy & Systems* 10: 172–80.
- Greenwood, Robin M., Andrei Shleifer, and Yang You. 2017. Bubbles for Fama. NBER Working Paper, No. w23191. Available online: <https://ssrn.com/abstract=2924281> (accessed on 18 October 2020).

- Gulamhuseinwala, Imran, Subas Roy, and Abigail Viljoen. 2015. Innovating with RegTech—Turning Regulatory Compliance into a Competitive Advantage. Available online: <https://www.scribd.com/document/341109297/EY-Innovating-With-RegTech> (accessed on 18 October 2020).
- Guo, Ye, and Chen Liang. 2016. Blockchain application and outlook in the banking industry. *Financial Innovation* 2: 24. [CrossRef]
- Haferkorn, Martin, and Josué Manuel Quintana Diaz. 2015. *Seasonality and Interconnectivity within Cryptocurrencies—An Analysis on the Basis of Bitcoin, Litecoin and Namecoin*. Cham: Springer International Publishing, pp. 106–20.
- Handika, Rangga, Gatot Soepriyanto, and Shinta Havidz. 2019. Are cryptocurrencies contagious to asian financial markets? *Research in International Business and Finance* 50: 416–29. [CrossRef]
- Harwick, Cameron. 2016. Cryptocurrency and the problem of intermediation. *Independent Review* 20: 569–88.
- Hassani, Hossein, Xu Huang, and Emmanuel Silva. 2018. Banking with blockchain-ed big data. *Journal of Management Analytics* 5: 256–75. [CrossRef]
- Hawllitschek, Florian, Benedikt Notheisen, and Timm Teubner. 2018. The limits of trust-free systems: A literature review on blockchain technology and trust in the sharing economy. *Electronic Commerce Research and Applications* 29: 50–63. [CrossRef]
- Hayes, Adam. 2019. Bitcoin price and its marginal cost of production: Support for a fundamental value. *Applied Economics Letters* 26: 554–60. [CrossRef]
- Hendrickson, Joshua, and William Luther. 2017. Banning Bitcoin. *Journal of Economic Behavior and Organization* 141: 188–95. [CrossRef]
- Herbert, Jeff, and Alan Litchfield. 2015. A novel method for decentralised peer-to-peer software license validation using cryptocurrency blockchain technology. *Conference in Research and Practice in Information Technology Series* 159: 27–35.
- Hill, Eleanor. 2016. Is RegTech the Answer to the Rising cost of Compliance? *FX-MM*. June 13. Available online: <https://www.fx-mm.com/article/50368/regtech-rising-cost-compliance/> (accessed on 18 October 2020).
- Hodgson, Geoffrey. 2015. *Conceptualizing Capitalism: Institutions, Evolution, Future*. Chicago: University of Chicago Press, 456p, ISBN 9780226168005.
- Holub, Mark, and Jackie Johnson. 2018. Bitcoin research across disciplines. *The Information Society* 34: 114–26. [CrossRef]
- Hoskins, Sean M., and Marc Labonte. 2015. An Analysis of the Regulatory Burden on Small Banks. *Congressional Research Service*. April 22. Available online: <https://fas.org/sgp/crs/misc/R43999.pdf> (accessed on 18 October 2020).
- Huertas, Thomas. 2016. Six Structures in Search of Stability. LSE Financial Markets Group Special Paper. Available online: <https://ssrn.com/abstract=2662251> (accessed on 18 October 2020).
- Hughes, Laurie, Yogesh K. Dwivedi, Santosh K. Misra, Nripendra P. Rana, Vishnupriya Raghavan, and Viswanadh Akella. 2019. Blockchain research, practice and policy: Applications, benefits, limitations, emerging research themes and research agenda. *International Journal of Information Management* 49: 114–29. [CrossRef]
- Hull, Richard. 2017. Blockchain: Distributed event-based processing in a data-centric world. In Paper presented at the DEBS 2017—Proceedings of the 11th ACM International Conference on Distributed Event-Based Systems, Barcelona, Spain, June 19–23; pp. 2–4.
- Hung, Jui-Long, and Binjie Luo. 2016. FinTech in Taiwan: A case study of a bank's strategic planning for an investment in a FinTech company. *Financial Innovation* 2: 15. [CrossRef]
- Hutchinson, Martin, and Kevin Dowd. 2015. Bitcoin will bite the dust. *The Cato Journal* 35: 357–82.
- Hyperledger Project. 2015. Available online: <https://www.hyperledger.org/> (accessed on 18 October 2020).
- IBM Corporation. 2016. Making Blockchain Real for Business. Explained with High Security Business Network Service. Available online: <https://www.ibm.com/systems/data/flash/it/technicalday/pdf/Making%20blockchain%20real%20for%20business.pdf> (accessed on 18 October 2020).
- IBM Corporation. 2017. 10 Key Marketing Trends for 2017. Available online: <https://www-01.ibm.com/common/ssi/cgi-bin/ssialias?htmlfid=WRL12345USEN> (accessed on 18 October 2020).
- Infosys Consulting. 2016. Blockchain Technology and the Financial Services Market. State-of-the-Art Analysis. Available online: [http://www.infosysconsultinginsights.com/wp-content/uploads/2016/10/InfosysConsulting\\_HHL\\_Blockchain.pdf](http://www.infosysconsultinginsights.com/wp-content/uploads/2016/10/InfosysConsulting_HHL_Blockchain.pdf) (accessed on 18 October 2020).
- Infosys Limited. 2017. Integrating Blockchain with ERP for a Transparent Supply Chain. Available online: <https://www.infosys.com/Oracle/white-papers/Documents/integrating-blockchain-erp.pdf> (accessed on 18 October 2020).
- International Monetary Fund. 2017. Fintech and Financial Services: Initial Considerations, Monetary and Capital Markets, Legal, and Strategy and Policy Review Departments SDN/17/05. June. Available online: [www.imf.org/\\$\sim\\$/media/Files/Publications/SDN/2017/sdn1705.ashx](http://www.imf.org/$\sim$/media/Files/Publications/SDN/2017/sdn1705.ashx) (accessed on 18 October 2020).
- International Standards Organization. 2018. ISO/TC 307—Blockchain and Distributed Ledger Technologies. Retrieved March 8. Available online: <https://www.iso.org/committee/6266604.html> (accessed on 18 October 2020).
- Irrera, Anna. 2017. Bank-Backed R3 Launches New Version of its Blockchain. Available online: [Reutershttps://www.reuters.com/article/us-r3-blockchain/bank-backed-r3-launches-new-version-of-its-blockchain-idUSKCN1C80MS](https://www.reuters.com/article/us-r3-blockchain/bank-backed-r3-launches-new-version-of-its-blockchain-idUSKCN1C80MS) (accessed on 18 October 2020).
- Ivashchenko, Alla Ivanivna. 2016. Using cryptocurrency in the activities of Ukrainian small and medium enterprises in order to improve their investment attractiveness. *Problems of Economy* 3: 267–73.
- Jaag, Christian, and Christian Bach. 2016. Blockchain Technology and Cryptocurrencies: Opportunities for Postal Financial Services. Available online: <https://EconPapers.repec.org/RePEc:chc:wpaper:0056> (accessed on 18 October 2020).

- Jagtiani, Julapa, and Catharine Lemieux. 2017. Fintech Lending: Financial Inclusion, Risk Pricing, and Alternative Information. FRB of Philadelphia Working Paper No. 17-17. Available online: <https://ssrn.com/abstract=3005260> (accessed on 18 October 2020).
- Jakšič, Marko, and Matej Marinč. 2015. The future of banking: The role of information technology. *The Journal of Money and Banking* 64: 68–73.
- Jayasuriya Daluwathumullagamage, Dulani, and Alexandra Sims. 2020. Blockchain Enabled Corporate Governance. *International Journal of Financial Studies* 8: 36. [CrossRef]
- Jiang, Peng, Fuchun Guo, Kaitai Liang, Jianchang Lai, and Qiaoyan Wen. 2017. Searchchain: Blockchain-based private keyword search in decentralized storage. *Future Generation Computer Systems* 107: 781–92. [CrossRef]
- Jin, Tong, Xiang Zhang, Yirui Liu, and Kai Lei. 2017. BlockNDN: A bitcoin blockchain decentralized system over named data networking. Paper presented at the International Conference on Ubiquitous and Future Networks, Milan, Italy, July 4–7; pp. 75–80.
- Jooyong, Jun, and Yeo Eunjung. 2016. Entry of FinTech firms and competition in the retail payments market. *Asia-Pacific Journal of Financial Studies* 45: 159–84.
- Jopson, Barney. 2016. US Community Banks Lash Out at ‘Fintech’ Upstarts. *Financial Times*. June 5. Available online: <https://www.ft.com/content/518095b8-2adc-11e6-bf8d-26294ad519fc> (accessed on 18 October 2020).
- Kaal, Wulf A. 2017. *Dynamic Regulation for Innovation*. Legal Studies Research Paper, No. 16-22. Minnesota: University of St. Thomas, Available online: <https://ssrn.com/abstract=2831040> (accessed on 18 October 2020).
- Kaal, Wulf A., and Erik P. M. Vermeulen. 2017. How to regulate disruptive innovation—From facts to data. *Jurimetrics* 57: 169–209. [CrossRef]
- Kallinterakis, Vasileios, and Ying Wang. 2019. Do investors herd in cryptocurrencies - and why? *Research in International Business and Finance* 50: 240–45. [CrossRef]
- Kalra, Abhinav, Syed Shahzeb Hasnain, Peter Bodorik, and Dawn Jutla. 2017. Access control mechanism using ethereum blockchain. Paper presented at the 26th International Conference on Software Engineering and Data Engineering, San Diego, CA, USA, October 2–4; pp. 107–112.
- Kalra, Sukrit, Seep Goel, Mohan Dhawan, and Subodh Sharma. 2018. Zeus: Analyzing Safety of Smart Contracts. Available online: [http://wp.internetsociety.org/ndss/wp-content/uploads/sites/25/2018/02/ndss2018\\_09-1\\_Kalra\\_paper.pdf](http://wp.internetsociety.org/ndss/wp-content/uploads/sites/25/2018/02/ndss2018_09-1_Kalra_paper.pdf) (accessed on 18 October 2020).
- Kanzler, Viktor. 2015. How Do Fintech Startups and a Changing Consumer Behaviour Reshape the Financial Services Industry? Bachelor’s thesis, Frankfurt School of Finance & Management, Frankfurt am Main, Germany, June.
- Karafiloski, Elena, and Anastas Mishev. 2017. Blockchain solutions for big data challenges: A literature review. Paper presented at the IEEE EUROCON 2017–17th International Conference on Smart Technologies IEEE, Ohrid, Macedonia, July 6–8; pp. 763–68.
- Kendall, Jake. 2017. Fintech companies could give billions of people more banking options. *Harvard Business Review*. January 20. Available online: <https://hbr.org/2017/01/fintechcompanies-could-give-billions-of-people-more-banking-options> (accessed on 18 October 2020).
- Kewell, Beth, Richard Adams, and Glenn Parry. 2017. Blockchain for good? *Strategic Change* 26: 429–37. [CrossRef]
- Khalilov, Merve Can Kus, and Albert Levi. 2018. A survey on anonymity and privacy in bitcoin-like digital cash systems. *IEEE Communications Surveys Tutorials* 20: 2543–85. [CrossRef]
- Khaqqi, Khamila Nurul, Janusz J. Sikorski, Kunn Hadinoto, and Markus Kraft. 2018. Incorporating seller/buyer reputation-based system in blockchain-enabled emission trading application. *Applied Energy* 209: 8–19. [CrossRef]
- Kim, Nam Ho, Sun Moo Kang, and Choong Seon Hong. 2017. Mobile charger billing system using lightweight Blockchain. Paper presented at the 19th Asia-Pacific Network Operations and Management Symposium: Managing a World of Things, APNOMS 2017, Seoul, Korea, September 27–29; pp. 374–77.
- King, Sunny. 2013. Primecoin: Cryptocurrency with Prime Number Proof-of-Work. Available online: <https://bravenewcoin.com/assets/Whitepapers/primecoin-paper.pdf> (accessed on 1 June 2020).
- Kitahara, Motoki, Junpei Kawamoto, and Kouichi Sakurai. 2014. A method of digital rights management based on Bitcoin protocol. Paper presented at the 8th International Conference on Ubiquitous Information Management and Communication, Siem Reap, Cambodia, January 9–11; pp. 1–6.
- Kiyomoto, Shinsaku, Mohammad Shahriar Rahman, and Anirban Basu. 2017. On blockchain-based anonymized dataset distribution platform. Paper presented at the 2017 15th IEEE/ACIS International Conference on Software Engineering Research, Management and Applications, London, UK, June 7–9; pp. 85–92.
- Klems, Markus, Jacob Eberhardt, Stefan Tai, Steffen Härtlein, Simon Buchholz, and Ahmed Tidjani. 2017. Trustless intermediation in blockchain-based decentralized service marketplaces. In *Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*. Berlin: Springer, vol. 10601, pp. 731–39.
- Kodak. 2018. KODAK One Platform & KODAKCoin Cryptocurrency: Helping Photographers Protect their Creative Endeavors. Available online: <https://www.kodak.com/US/en/kodakone/default.htm> (accessed on 18 October 2020).
- Komlos, John. 2014. Has creative Destruction Become More Destructive? NBER Working Paper, No. 20379. August. Available online: <http://www.nber.org/papers/w2037> (accessed on 18 October 2020).
- Kosba, Ahmed, Andrew Miller, Elaine Shi, Zikai Wen, and Charalampos Papamanthou. 2016. Hawk: The blockchain model of cryptography and privacy-preserving smart contracts. Paper presented at the 2016 IEEE Symposium on Security and Privacy (SP), San Jose, CA, USA, May 22–26; pp. 839–58. [CrossRef]



- Koteska, Bojana, Elena Karafilovski, and Anastas Mishev. 2017. Blockchain implementation quality challenges: A literature review. Paper presented at the SQAMIA 2017: 6th Workshop of Software Quality, Analysis, Monitoring, Improvement, and Applications, Belgrade, Serbia, September 11–13; pp. 11–13.
- KPMG and H2 Ventures. 2015. Fintech 100: Leading Global Fintech Innovators Report. Available online: <https://assets.kpmg.com/content/dam/kpmg/pdf/2015/12/fintech-100-leading-innovators-2015.pdf> (accessed on 18 October 2020).
- KPMG International. 2017. Blockchain Accelerates Insurance Transformation. Available online: <https://assets.kpmg.com/content/dam/kpmg/xx/pdf/2017/01/blockchain-accelerates-insurance-transformation-fs.pdf> (accessed on 18 October 2020).
- Kraft, Daniel. 2016. Difficulty control for blockchain-based consensus systems. *Peer-to-Peer Networking and Applications* 9: 397–413. [CrossRef]
- Kravchenko, Pavel. 2016. Ok, I Need a Blockchain, But Which One? Available online: <https://medium.com/@pavelkravchenko/ok-i-need-a-blockchain-but-which-one-ca75c1e2100> (accessed on 18 October 2020).
- Kroll, Joshua A., Ian C. Davey, and Edward W. Felten. 2013. The economics of Bitcoin mining, or Bitcoin in the presence of adversaries. Paper presented at the 2013 WEIS, Washington, DC, USA, June 11–12.
- Krugman, Paul. 2013. Bitcoin is Evil. Retrieved August 30, from Paul Krugman Blog Website. Available online: <https://krugman.blogs.nytimes.com/2013/12/28/bitcoin-is-evil/> (accessed on 18 October 2020).
- Kshetri, Nir. 2017. Blockchain's roles in strengthening cybersecurity and protecting privacy. *Telecommun. Policy* 41: 1027–38.
- Kumar, Deepa S., and M. Abdul Rahman. 2017. Simplified HDFS architecture with blockchain distribution of metadata. *International Journal of Applied Engineering Research* 12: 11374–82.
- Kumar, V., Divya Ramachandran, and Binay Kumar. 2020. Influence of new-age technologies on marketing: A research agenda. *Journal of Business Research* 125: 864–77. [CrossRef]
- Kursh, Steven R., and Natalia A. Gold. 2016. Adding FinTech and blockchain to your curriculum. *Business Education Innovation Journal* 8: 6–12.
- Kyriazis, Nikolaos, Stephanos Papadamou, and Shaen Corbet. 2020. A Systematic Review of the Bubble Dynamics of Cryptocurrency Prices. *Research in International Business and Finance* 54: 101254. [CrossRef]
- Lai, Rose Neng, and Robert A. Van Order. 2017. Fintech Finance and Financial Fragility—Focusing on China. November. Available online: <https://ssrn.com/abstract=3075043> (accessed on 18 October 2020).
- Lamberti, Fabrizio, Valentina Gatteschi, Claudio Demartini, Chiara Pranteda, and V. Santamaria. 2017. Blockchain or not blockchain, that is the question of the insurance and other sectors. *IT Professional* 20: 36. [CrossRef]
- Larios-Hernández, Guillermo Jesús. 2017. Blockchain entrepreneurship opportunity in the practices of the unbanked. *Business Horizons* 60: 865–74. [CrossRef]
- LedgerInsights. 2020. April 7. Available online: <https://www.ledgerinsights.com/un-ant-financial-blockchain-covid-19/> (accessed on 18 October 2020).
- Leiding, Benjamin, and Alex Norta. 2017. Mapping requirements specifications into a formalized lockchain-enabled authentication protocol for secured personal identity assurance. In *Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*. Berlin: Germany, vol. 10646, pp. 181–96.
- Lemieux, Victoria Louise. 2016. Trusting records: Is blockchain technology the answer? *Records Management Journal* 26: 110–39. [CrossRef]
- Li, Jiasun, and Guanxi Yi. 2019. Toward a factor structure in crypto asset returns. *Journal of Alternative Investments* 21: 56–66. [CrossRef]
- Li, Jiasun, and William Mann. 2018. Initial Coin Offering and Platform Building. Available online: [https://www.researchgate.net/publication/323196531\\_Initial\\_Coin\\_Offering\\_and\\_Platform\\_Building](https://www.researchgate.net/publication/323196531_Initial_Coin_Offering_and_Platform_Building) (accessed on 18 October 2020).
- Li, Xiaoqi, Peng Jiang, Ting Chen, Xiapu Luo, and Qiaoyan Wen. 2017. A survey on the security of blockchain systems. *Future Generation Computer Systems* 107: 841–53. [CrossRef]
- Li, Ming, Jian Weng, Anjia Yang, Wei Lu, Yue Zhang, Lin Hou, and Jia-Nan Liu. 2019. CrowdBC: A Blockchain-Based Decentralized Framework for Crowdsourcing. *IEEE Transactions on Parallel and Distributed Systems* 30: 1251–66. [CrossRef]
- Lin, Iuon-Chang, and Tzu-Chun Liao. 2017. A survey of blockchain security issues and challenges. *International Journal of Network Security* 19: 653–59.
- Lipsey, Richard G., Kenneth Carlaw, and Clifford Bekar. 2005. *Economic Transformations: General Purpose Technologies and Long-Term Economic Growth*. Oxford: Oxford University Press.
- Liu, Bin, Xiao Liang Yu, Shiping Chen, Xiwei Xu, and Liming Zhu. 2017a. Blockchain Based Data Integrity Service Framework for IoT Data. Paper presented at the 2017 IEEE 24th International Conference on Web Services, ICWS 2017, Honolulu, HI, USA, June 25–30; pp. 468–75.
- Liu, Paul Tak Shing. 2016. Medical record system using blockchain, big data and tokenization. In *Lecture Notes in Computer Science (including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*. Berlin: Springer, vol. 9977, pp. 254–61.
- Liu, Zhiyong, Shaokun Fan, Harry Jiannan Wang, and J. Leon Zhao. 2017b. Enabling effective workflow model reuse: A data-centric approach. *Decision Support Systems* 93: 11–25. [CrossRef]
- Llewellyn, David T. 2016. Reforming the culture of banking: Restoring trust and confidence in banking. *Journal of Financial Management, Markets and Institutions* 2: 221–35.
- Lo, Sin Kuang, Xiwei Xu, Yin Kia Chiam, and Qinghua Lu. 2017. Evaluating suitability of applying blockchain. Paper presented at the IEEE International Conference on Engineering of Complex Computer Systems, Fukuoka, Japan, November 5–8; pp. 158–61.

- Lomas, Natasha. 2015. *Everledger is Using Blockchain to Combat Fraud, Starting with Diamonds*. Bay Area: Tech Crunch, Available online: <https://techcrunch.com/2015/06/29/everledger/> (accessed on 18 October 2020).
- López-Pintado, Orlenys, Luciano García-Bañuelos, Marlon Dumas, and Ingo Weber. 2017. Caterpillar: A blockchain-based business process management system. Paper presented at the CEUR Workshop Proceedings, Venice, Italy, March 21–24; vol. 1920.
- Lundqvist, Thomas, Andreas De Blanche, and H. Robert Andersson. 2017. Thing-to-thing electricity micro payments using blockchain technology. Paper presented at the GIoT 2017—Global Internet of Things Summit, Geneva, Switzerland, June 6–9.
- Ma, Donglian, and Hisashi Tanizaki. 2019. The day-of-the-week effect on bitcoin return and volatility. *Research in International Business and Finance* 49: 127–36. [CrossRef]
- Mainelli, Michael. 2017. Blockchain Could Help Us Reclaim Control of our Personal Data. Retrieved October 19. From Harvard Business Review website. Available online: <https://hbr.org/2017/10/smart-ledgers-can-help-us-reclaim-control-of-our-personal-data> (accessed on 18 October 2020).
- Makridakis, Spyros. 2018. Forecasting the impact of artificial intelligence: Part 4 of 5: Blockchain (BC) technology, the integration of BC and AI, and the road to intelligence augmentation (IA). *Foresight: The International Journal of Applied Forecasting* 50: 4–9.
- Malinova, Katya, and Park Andreas. 2017. Market Design with Blockchain Technology. July 26. Available online: <https://ssrn.com/abstract=2785626> (accessed on 18 October 2020). [CrossRef]
- Malwarebytes. 2017. Persistent Drive-By Cryptomining Coming to a Browser Near You. Available online: <https://blog.malwarebytes.com/cybercrime/2017/11/persistent-drive-by-cryptomining-coming-to-a-browser-near-you/>.2017 (accessed on 18 October 2020).
- Mavridou, Anastasia, and Aron Laszka. 2018. Tool demonstration: FSolidM for designing secure ethereum smart contracts. *arXiv* arXiv:1802.09949.
- Maxwell, Gregory. 2013. CoinJoin: Bitcoin Privacy for the Real World. Available online: <https://bitcointalk.org/index.php> (accessed on 18 October 2020).
- McConaghy, Trent. 2016. How Blockchains Could Transform Artificial Intelligence. Available online: <http://dataconomy.com/2016/12/blockchains-for-artificial-intelligence/> (accessed on 18 October 2020).
- McKinsey and Co. 2015. Cutting through the FinTech Noise: Markers of Success, Imperatives for Banks Global Banking Practice. December. Available online: [http://webcache.googleusercontent.com/search?q=cache:S4uRnWS04wMJ:www.mckinsey.com/\\$\sim\\$/media/mckinsey/industries/financial%2520services/our%2520insights/cutting%2520through%2520the%2520noise%2520around%2520financial%2520technology/cutting-through-the-fintech-noise-full-report.ashx+&cd=2&hl=en&ct=clnk&gl=uk](http://webcache.googleusercontent.com/search?q=cache:S4uRnWS04wMJ:www.mckinsey.com/$\sim$/media/mckinsey/industries/financial%2520services/our%2520insights/cutting%2520through%2520the%2520noise%2520around%2520financial%2520technology/cutting-through-the-fintech-noise-full-report.ashx+&cd=2&hl=en&ct=clnk&gl=uk) (accessed on 18 October 2020).
- McKinsey and Co. 2016. A Best-Practice Model for Bank Compliance. January. Available online: <http://www.mckinsey.com/business-functions/risk/our-insights/a-best-practice-model-forbank-compliance> (accessed on 18 October 2020).
- McKinsey Company. 2016. Blockchain in Insurance—Opportunity or Threat? Available online: <https://www.mckinsey.com/industries/financial-services/our-insights/blockchain-in-insurance-opportunity-or-threat> (accessed on 18 October 2020).
- McWaters, R. Jesse, Rob Galaski, and Soumak Chatterjee. 2016. *The Future of Financial Infrastructure: An Ambitious Look at How Blockchain can Reshape Financial Services*. Cologny: World Economic Forum.
- Meiklejohn, Sarah, Marjori Pomarole, Grant Jordan, Kirill Levchenko, Damon McCoy, Geoffrey M. Voelker, and Stefan Savage. 2013. A fistful of bitcoins: Characterizing payments among men with no names. In *Proceedings of the 2013 Conference on Internet Measurement Conference, IMC '13*. New York: ACM, pp. 127–40.
- Mendling, Jan, Ingo Weber, Wil Van Der Aalst, Jan Vom Brocke, Cristina Cabanillas, Florian Daniel, Søren Debois, Claudio Di Ciccio, Marlon Dumas, and S. Dustdar. 2018. Blockchains for business process management-challenges and opportunities. *ACM Transactions on Management Information Systems* 9: 4. [CrossRef]
- Meng, Weizhi, Elmar Wolfgang Tischhauser, Qingju Wang, Yu Wang, and Jinguang Han. 2018. When intrusion detection meets blockchain technology: A review. *IEEE Access* 6: 10179–88. [CrossRef]
- Mengelkamp, Esther, Benedikt Notheisen, Carolin Beer, David Dauer, and Christof Weinhardt. 2018. A blockchain-based smart grid: Towards sustainable local energy markets. *Computer Science Research and Development* 33: 207–14. [CrossRef]
- Mensi, Walid, Yun-Jung Lee, Khamis Hamed Al-Yahyaee, Ahmet Sensoy, and Seong-Min Yoon. 2019. Intraday downward/upward multifractality and long memory in Bitcoin and Ethereum markets: An asymmetric multifractal detrended fluctuation analysis. *Finance Research Letters* 31: 19–25. [CrossRef]
- Meter, Christian. 2017. Design of Distributed Voting Systems. *arXiv* arXiv:1702.02566.
- Miers, Ian, Christina Garman, Matthew Green, and Aviel D. Rubin. 2013. Zerocoin: Anonymous distributed E-cash from bitcoin. Paper presented at the 2013 IEEE Symposium on Security and Privacy, Berkeley, CA, USA, May 19–22; pp. 397–411.
- Mills, Karen Gordon, and Brayden McCarthy. 2016. The State of Small Business Lending: Innovation and Technology and the Implications for Regulation. Harvard Business School Entrepreneurial Management Working Paper No. 17-042. November 29. Available online: <https://ssrn.com/abstract=2877201> (accessed on 18 October 2020).
- Min, Xinping, Qingzhong Li, Lei Liu, and Lizhen Cui. 2016. A permissioned blockchain framework for supporting instant transaction and dynamic block size. Paper presented at the Trustcom/BigDataSE/ISPA, 2016 IEEE, Tianjin, China, August 23–26; pp. 90–96.
- Moher, David, Alessandro Liberati, Jennifer Tetzlaff, Douglas G Altman, and for the PRISMA Group. 2009. Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. *PLoS Medicine* 6: e1000097. [CrossRef] [PubMed]
- Mori, Taketoshi. 2016. Financial technology: Blockchain and securities settlement. *Journal of Securities Operations & Custody* 8: 208–17.

- Morse, Adair. 2015. Peer-to-peer crowdfunding: Information and the potential for disruption in consumer lending. *Annual Review of Financial Economics* 7: 463–82. [CrossRef]
- Möser, Malte. 2013. Anonymity of bitcoin transactions: An analysis of mixing services. Paper presented at the Münster Bitcoin Conference, Münster, Germany, July 17–18.
- Moura, Teogenes, and Alexandre Gomes. 2017. Blockchain Voting and its effects on Election Transparency and Voter Confidence. In *Proceedings of the 18th Annual International Conference on Digital Government Research*. New York: ACM, pp. 574–75.
- Mukhopadhyay, Ujan, Anthony Skjellum, Oluwakemi Hambolu, Jon Oakley, Lu Yu, and Richard Brooks. 2016. A brief survey of cryptocurrency systems. Paper presented at the 2016 14th Annual Conference on Privacy, Security and Trust (PST) IEEE, Auckland, New Zealand, December 12–14; pp. 745–52.
- Mussomeli, Adam. 2019. Building a cognitive digital supply network. *Deloitte Insights*, June 14.
- Nadler, Philip, and Yike Guo. 2020. The fair value of a token: How do markets price cryptocurrencies? *Research in International Business and Finance* 52: 101108. [CrossRef]
- Nakamoto, Satoshi. 2008. Bitcoin: A Peer-to-Peer Electronic Cash System. Available online: <https://bitcoin.org/bitcoin.pdf> (accessed on 18 October 2020).
- Nath, Indranil. 2016. Data exchange platform to fight insurance fraud on blockchain. Paper presented at the IEEE International Conference on Data Mining Workshops, ICDMW, Barcelona, Spain, December 12–15; pp. 821–825.
- Neisse, Ricardo, Gary Steri, and Igor Nai-Fovino. 2017. A blockchain-based approach for data accountability and provenance tracking. *arXiv arXiv:1706.04507*.
- Nguyen, Quoc Khanh. 2016. Blockchain-A Financial Technology for Future Sustainable Development. Paper presented at the 3rd International Conference on Green Technology and Sustainable Development, Kaohsiung, Taiwan, November 24–25; pp. 51–54.
- Nguyen, Thai Vu Hong, Binh Nguyen, Kien Nguyen, and Huy Pham. 2019a. Asymmetric monetary policy effects on cryptocurrency markets. *Research in International Business and Finance* 48: 335–39. [CrossRef]
- Nguyen, Thai Vu Hong, Binh Nguyen, Thanh Cong Nguyen, and Quang Quoc Nguyen. 2019b. Bitcoin return: Impacts from the introduction of new altcoins. *Research in International Business and Finance* 48: 420–25. [CrossRef]
- Nijeholt, Hidde Lycklama A., Joris Oudejans, and Erkin Zekeriya. 2017. DecReg: A framework for preventing double-financing using blockchain technology. In Paper presented at the BCC 2017—Proceedings of the ACM Workshop on Blockchain, Cryptocurrencies and Contracts, co-located with ASIA CCS 2017, Abu Dhabi, UAE, April 2–6; pp. 29–34.
- Nofer, Michael, Peter Gomber, Oliver Hinz, and Dirk Schiereck. 2017. Blockchain. *Business & Information Systems Engineering*, 1–5. [CrossRef]
- Noizat, Pierre. 2015. Blockchain Electronic Vote. In *Handbook of Digital Currency: Bitcoin, Innovation, Financial Instruments, and Big Data*. Singapore: Elsevier, pp. 453–61.
- Nordrum, Amy. 2017. Govern by blockchain dubai wants one platform to rule them all, while Illinois will try anything. *IEEE Spectrum* 54: 54–55. [CrossRef]
- Nowiński, Witold, and Miklós Kozma. 2017. How can blockchain technology disrupt the existing business models? *Entrepreneurial Business and Economics Review* 5: 173–88. [CrossRef]
- O’Leary, Daniel E. 2017. Configuring blockchain architectures for transaction information in blockchain consortiums: The case of accounting and supply chain systems. *Intelligent Systems in Accounting Finance and Management* 24: 138–47. [CrossRef]
- Office of the Comptroller of the Currency. 2016. *Exploring Special Purpose National Bank Charters for Fintech Companies*, Winter/December; Washington, DC: Office of the Comptroller of the Currency. Available online: <https://www.occ.treas.gov/topics/responsible-innovation/comments/special-purpose-national-bank-charters-for-fintech.pdf> (accessed on 18 October 2020).
- Office of the Comptroller of the Currency. 2018. Semiannual Risk perspective Spring/May. Available online: <https://www.occ.treas.gov/publications/publications-by-type/otherpublications-reports/semiannual-risk-perspective/semiannual-risk-perspective-spring-2018.pdf> (accessed on 18 October 2020).
- Ou Yang, Shirley, Carol Hsu, Suprateek Sarker, and Allen S. Lee. 2017. Enabling effective operational risk management in a financial institution: An action research study. *Journal of Management Information Systems* 34: 727–53. [CrossRef]
- Paech, Philipp. 2017. The governance of blockchain financial networks. *Modern Law Review* 80: 1073–110. [CrossRef]
- Pagano, Ugo, and Massimiliano Vatiere. 2015. Costly institutions as substitutes: Novelty and limits of the Coasian approach. *Journal of Institutional Economics* 11: 265–81. [CrossRef]
- Panagiotidis, Theodore, Thanasis Stengos, and Orestis Vravosinos. 2018. On the determinants of Bitcoin returns: A LASSO approach. *Finance Research Letters* 27: 235–40. [CrossRef]
- Papadopoulos, Georgios. 2015. Blockchain and Digital Payments: An Institutional Analysis of Cryptocurrencies. In *Handbook of Digital Currency*. Cambridge: Academic Press, pp. 153–72.
- Parity Wallet Security Alert. 2017. November. Available online: <https://paritytech.io/security-alert-2/> (accessed on 18 October 2020).
- Parker, Geoffrey, Marshall Van Alstyne, and Sangeet Choudary. 2016. *Platform Revolution: How Networked Markets are Transforming the Economy and How to Make Them Work for You*. New York: Norton & Company.
- Parliament, European. 2016. General Data Protection Regulation. Available online: <http://data.consilium.europa.eu/doc/document/ST-5419-2016-INIT/en/pdf> (accessed on 18 October 2020).
- Pass, Rafael, and Abhi Shelat. 2015. Micropayments for decentralized currencies. In *Proceedings of the 22nd ACM SIGSAC Conference on Computer and Communications Security*. New York: ACM, pp. 207–18.



- Pauw, Chrisjan. 2017. In Wake of China ICO ban, Japan, Singapore, US give Crypto Second Look. Retrieved February 15 from Cointelegraph Website. Available online: <https://cointelegraph.com/news/in-wake-of-china-ico-ban-japan-singapore-us-give-crypto-second-look> (accessed on 18 October 2020).
- Pazaitis, Alex, Primavera De Filippi, and Vasilis Kostakis. 2017. Blockchain and value systems in the sharing economy: The illustrative case of Backfeed. *Technology Forecasting Social Change* 125: 105–15. [CrossRef]
- Pearson, Jordan. 2018. Millions of Dollars in Ethereum are Vulnerable to Hackers Right Now. Available online: [https://motherboard.vice.com/en\\_us/article/8xddka/millions-of-dollars-in-ethereum-are-vulnerable-to-hackers-right-now-smart-contract-bugs](https://motherboard.vice.com/en_us/article/8xddka/millions-of-dollars-in-ethereum-are-vulnerable-to-hackers-right-now-smart-contract-bugs) (accessed on 18 October 2020).
- Peters, Gareth W., and Efstathios Panayi. 2016. Understanding modern banking ledgers through blockchain technologies: Future of transaction processing and smart contracts on the internet of money. In *New Economic Windows*. Cham: Springer, pp. 239–78.
- Philippi, Stephan, Monika Schuhmacher, and Nicolai Bastian. 2019. Quality signals in initial coin offerings. In *Academy of Management Proceedings*. Briarcliff Manor: Academy of Management, vol. 2019.
- Philippon, Thomas. 2016. The FinTech opportunity. NBER working paper, No. 22476. August. Available online: <https://www.nber.org/papers/w22476> (accessed on 18 October 2020).
- Phillips, Ross C., and Denise Gorse. 2018. Cryptocurrency price drivers: Wavelet coherence analysis revisited. *PLoS ONE* 13: e0195200. [CrossRef]
- Pokrovskaja, Nadezhda N. 2017. Tax financial and social regulatory mechanisms within the knowledge-driven economy. Blockchain algorithms and fog computing for the efficient regulation. Paper presented at the 2017 20th IEEE International Conference on Soft Computing and Measurements, SCM 2017, St. Petersburg, Russia, May 24–26; pp. 709–12.
- Powell, Bill. 2014. Alibaba: The \$200 Billion ‘Open Sesame’. *NEWS WEEK*. September 8. Available online: <http://www.newsweek.com/2014/09/19/alibaba-200-billion-open-sesame268937.html> (accessed on 18 October 2020).
- Price Waterhouse Coopers. 2015a. Ten Digital Trust Challenges. December 4. Available online: <https://www.pwc.com/gx/en/issues/trust/ten-digital-trust-challenges.html> (accessed on 18 October 2020).
- Price Waterhouse Coopers. 2015b. Achieving Success While Managing Disruption, PwC 18th Annual Global CEO Survey. Key Findings in the Banking and Capital Markets Industry. Available online: <https://www.pwc.com/gx/en/ceo-survey/2015/industry/assets/ceo-survey-2015-indepth-analysis-banking-and-capital-markets.pdf> (accessed on 18 October 2020).
- Price Waterhouse Coopers. 2016. Blurred Lines: How FinTech is Shaping Financial services. Global FinTech Report. March. Available online: <http://www.pwc.com/gx/en/industries/financial-services/fintech-survey/report.html> (accessed on 18 October 2020).
- Price Waterhouse Coopers. 2017. Pricewaterhouse Coopers and Wirtschaftsprüfungsgesellschaft, Use Cases for Blockchain Technology in Energy and Commodity Trading. Available online: <https://www.pwc.com/gx/en/industries/assets/blockchain-technology-in-energy.pdf> (accessed on 18 October 2020).
- Primm, Harold. 2016. Regulating the blockchain revolution: A financial industry transformation. *Review of Banking & Financial Law* 36: 75–91.
- Proof of Existence. 2017. Available online: <https://poex.io/> (accessed on 18 October 2020).
- Proof-of-Stake. 2016. Available online: [https://en.bitcoin.it/wiki/Proof\\_of\\_Stake](https://en.bitcoin.it/wiki/Proof_of_Stake) (accessed on 24 March 2016).
- Prybila, Christoph, Stefan Schulte, Christoph Hochreiner, and Ingo Weber. 2017. Runtime verification for business processes utilizing the Bitcoin blockchain. *Future Generation Computer Systems* 107: 916–31. [CrossRef]
- Puljiz, Mate, Stjepan Begušić, and Zvonko Kostanjčar. 2018. Market microstructure and order book dynamics in cryptocurrency exchanges. Paper presented at the Crypto Valley Conference on Blockchain Technology, Zug, Switzerland, June 20–22.
- Pyo, Sujin, and Jaewook Lee. 2019. Do fomic and macroeconomic announcements affect bitcoin prices? *Finance Research Letters* 37: 101386. [CrossRef]
- Raskin, Max, and David Yermack. 2016. Digital Currencies, Decentralized Ledgers, and the Future of Central Banking. NBER Working Paper No. 22238. Available online: <https://www.nber.org/papers/w22238> (accessed on 18 October 2020).
- Reijers, Wessel, Fiachra O’Brolcháin, and Paul Haynes. 2016. Governance in blockchain technologies & social contract theories. *Ledger* 1: 134–51.
- Rimba, Paul, An Binh Tran, Ingo Weber, Mark Staples, Alexander Ponomarev, and Xiwei Xu. 2017. Comparing blockchain and cloud services for business process execution. Paper presented at the 2017 IEEE International Conference on Software Architecture, ICSA 2017, Gothenburg, Sweden, April 3–7; pp. 257–60.
- Rizzo, Pete. 2014. How Kipochi Is Taking Bitcoin into Africa. Available online: <http://www.coindesk.com/kipochi-taking-bitcoin-africa/> (accessed on 18 October 2020).
- Robertson, Brian J. 2015. *Holacracy: The Revolutionary Management System that Abolishes Hierarchy*. London: Penguin UK.
- Rochard, Pierre. 2014. Speculative Attack. Available online: <http://nakamotoinstitute.org/mempool/speculative-attack/> (accessed on 18 October 2020).
- Rochet, Jean-Charles, and Jean Tirole. 2003. Platform competition in two-sided markets. *Journal of European Economic Association* 1: 990–1029. [CrossRef]
- Románova, Inna, and Marina Kudinska. 2016. Banking and fintech: A challenge or opportunity? In *Contemporary Issues in Finance: Current Challenges from across Europe*. West Yorkshire: Emerald Group Publishing Limited.
- Ron, Dorit, and Adi Shamir. 2013. *Quantitative Analysis of the Full Bitcoin Transaction Graph*. Berlin and Heidelberg: Springer, pp. 6–24.

- Ruffing, Tim, Pedro Moreno-Sanchez, and Aniket Kate. 2014. *CoinShuffle: Practical Decentralized Coin Mixing for Bitcoin*. Cham: Springer International Publishing, pp. 345–64.
- Salah, Khaled, M. Habib Ur Rehman, Nishara Nizamuddin, and Ala Al-Fuqaha. 2019. Blockchain for AI: Review and open research challenges. *IEEE Access: Practical Innovations, Open Solutions* 7: 10127–49. [CrossRef]
- Sankar, Lakshmi Siva, M. Sindhu, and M. Sethumadhavan. 2017. Survey of consensus protocols on blockchain applications. Paper presented at the 2017 4th International Conference on Advanced Computing and Communication Systems (ICACCS) IEEE, Coimbatore, India, January 6–7; pp. 1–5.
- Sarr, Idrissa, Hubert Naacke, and Ibrahima Gueye. 2015. Blockchain-based model for social transactions processing. Paper presented at the DATA 2015—4th International Conference on Data Management Technologies and Applications, Colmar, France, July 20–22; pp. 309–15.
- Schindler, John. 2017. *FinTech and Financial Innovation: Drivers and Depth, Finance and Economics Discussion Series 2017-081*. Washington, DC: Board of Governors of the Federal Reserve System. [CrossRef]
- Schuetz, Sebastian, and Viswanath Venkatesh. 2019. Blockchain, adoption, and financial inclusion in India: Research opportunities. *International Journal of Information Management* 52: 101936. [CrossRef]
- Schulz, Tobias, and Burkhard Schafer. 2017. Legal challenges for the use of blockchain-based E-voting systems in Germany. In *Trends and Communities of Legal Informatics, Proceedings of the 20th International Legal Informatics Symposium IRIS 2017, Jusletter IT, February 23*. Vienna: Österreichische Computer Gesellschaft OCG.
- Scott, Susan, John Van Reenen, and Markos Zachariadis. 2017. The long-term effect of digital innovation on bank performance: An empirical study of SWIFT adoption in financial services. *Research Policy* 46: 984–1004. [CrossRef]
- Scuffham, Matt. 2017. Exclusive: Royal Bank of Canada Using Blockchain for U.S./Canada. Retrieved from Reuters. Available online: <https://www.reuters.com/article/us-rbc-blockchain/exclusive-royal-bank-of-canada-using-blockchain-for-u-s-canada-payments-executive-idUSKCN1C237N> (accessed on 18 October 2020).
- Seebacher, Stefan, and Ronny Schüritz. 2017. Blockchain technology as an enabler of service systems: A structured literature review. In *International Conference on Exploring Services Science*. Berlin: Springer, pp. 12–23.
- Segendorf, Björn. 2014. What is Bitcoin? *Sveriges Riksbank Economic Review* 2: 71–87.
- Sensoy, Ahmet. 2019. The inefficiency of Bitcoin revisited: A high-frequency analysis with alternative currencies. *Finance Research Letters* 28: 68–73. [CrossRef]
- Shanaev, Savva, Satish Sharma, Binam Ghimire, and Arina Shuraeva. 2020. Taming the blockchain beast? Regulatory implications for the cryptocurrency market. *Research in International Business and Finance* 51: 101080. [CrossRef]
- Shedden, Adrian, and Gareth Malna. 2016. Supporting the development and adoption of RegTech: No better time for a Call for Input. *BURGESS SALMON*. January 2. Available online: [https://www.burgess-salmon.com/-/media/files/publications/open-access/supporting\\_the\\_development\\_and\\_adoption\\_of\\_regtech\\_no\\_better\\_time\\_for\\_a\\_call\\_for\\_input.pdf](https://www.burgess-salmon.com/-/media/files/publications/open-access/supporting_the_development_and_adoption_of_regtech_no_better_time_for_a_call_for_input.pdf) (accessed on 18 October 2020).
- Shu, Min, and Wei Zhu. 2020. Real-time prediction of bitcoin bubble crashes. *Physica A: Statistical Mechanics and its Applications* 548: 124477. [CrossRef]
- Siegel, David. 2016. Understanding the DAO Attack. Available online: <https://www.coindesk.com/understanding-dao-hack-journalists/> (accessed on 18 October 2020).
- Sifat, Imtiaz, Azhar Mohamad, and Mohammad Mohamed Shariff. 2019. Lead-lag relationship between bitcoin and ethereum: Evidence from hourly and daily data. *Research in International Business and Finance* 50: 306–21. [CrossRef]
- Sompolinsky, Yonatan, and Aviv Zohar. 2013. Accelerating Bitcoin's Transaction Processing. Fast Money Grows on Trees, Not Chains. Available online: <https://eprint.iacr.org/2013/881> (accessed on 18 October 2020).
- Song, Fenghua, and Anjan V. Thakor. 2019. Bank Culture. *Journal of Financial Intermediation* 39: 59–70. [CrossRef]
- Spearpoint, Michael. 2017. A proposed currency system for academic peer review payments using the blockchain technology. *Publications* 5: 19. [CrossRef]
- Su, Chi-Wei, Zheng-Zheng Li, Ran Tao, and Deng-Kui Si. 2018. Testing for multiple bubbles in bitcoin markets: A generalized sup adf test. *Japan and the World Economy* 46: 56–63. [CrossRef]
- Subramanian, Hemang. 2017. Decentralized blockchain-based electronic marketplaces. *Communications ACM* 61: 78–84. [CrossRef]
- Suhaliana, Norul, Abd Halim, Md Arafatur Rahman, Saiful Azad, and Muhammad Nomani Kabir. 2018. *Blockchain Security Hole: Issues and Solutions*. Cham: Springer International Publishing, pp. 739–46.
- Sullivan, Clare, and Eric Burger. 2017. E-residency and blockchain. *Computer Law Security Review* 33: 470–81. [CrossRef]
- Sullivan, Frost. 2017. Future of Blockchain Technology in Connected Health Ecosystem. Convergence of Blockchain with AI and IoMT set to re-architect Healthcare Sector. Available online: [http://innovationsprint.eu/wp-content/uploads/2017/08/Briefing-Deck-Future-of-Blockchain-Technology-\\_19th-Sept.pdf](http://innovationsprint.eu/wp-content/uploads/2017/08/Briefing-Deck-Future-of-Blockchain-Technology-_19th-Sept.pdf) (accessed on 18 October 2020).
- World Government Summit. 2017. Building the Hyperconnected Future on Blockchains. Available online: <http://internetofagreements.com/files/WorldGovernmentSummit-Dubai2017.pdf> (accessed on 18 October 2020).
- Sutton, Andrew, and Reza Samavi. 2017. Blockchain enabled privacy audit logs. In *Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*. Berlin: Springer, vol. 10587, pp. 645–60.
- Swan, Melanie. 2015. *Blockchain: Blueprint for a New Economy*. Newton: O'Reilly Media, Inc.
- Swanson, Tim. 2015. Consensus-As-A-Service: A Brief Report on the Emergence of Permissioned, Distributed Ledger Systems. Available online: <https://allquantor.at/blockchainbib/pdf/swanson2015consensus.pdf> (accessed on 18 October 2020).

- Symitsi, Efthymia, and Konstantinos Chalvatzis. 2019. The economic value of bitcoin: A portfolio analysis of currencies, gold, oil and stocks. *Research in International Business and Finance* 48: 97–110. [CrossRef]
- Symp Koulu, Riikka. 2016. Blockchains and online dispute resolution: Smart contracts as an alternative to enforcement. *SCRIPTed* 13: 40. [CrossRef]
- Szabo, Nick. 1994. Smart Contracts. Unpublished Manuscript. Available online: [https://pipiwiki.com/wiki/Agoric\\_computing](https://pipiwiki.com/wiki/Agoric_computing) (accessed on 18 October 2020).
- Tama, Bayu Adhi, Bruno Joachim Kweka, Youngho Park, and Kyung-Hyune Rhee. 2017. A critical review of blockchain and its current applications. Paper presented at the 2017 International Conference on Electrical Engineering and Computer Science (ICECOS) IEEE, Yogyakarta, Indonesia, September 19–21; pp. 109–13.
- Tanaka, Kenji, Kosuke Nagakubo, and Rikiya Abe. 2017. Blockchain-based electricity trading with Digitalgrid router. Paper presented at the 2017 IEEE International Conference on Consumer Electronics—Taiwan, ICCE-TW 2017, Taipei, Taiwan, June 12–14; pp. 201–2.
- Tang, Huan. 2019. Peer-to-peer lenders versus banks: Substitutes or complements? *Review of Financial Studies* 32: 1900–38. [CrossRef]
- Tapscott, Don, and Alex Tapscott. 2017. How blockchain will change organizations. *MIT Sloan Management Review* 58: 10–13.
- The Decentralized Library of Alexandria. 2015. Available online: <http://www.alexandria.io/> (accessed on 18 October 2020).
- Thierer, Adam D. 2015. The Internet of Things and Wearable Technology: Addressing Privacy and Security Concerns without Derailing Innovation (February 18). Available online: <https://ssrn.com/abstract=2494382> (accessed on 18 October 2020).
- Tschorsch, Florian, and Björn Scheuermann. 2016. Bitcoin and beyond: A technical survey on decentralized digital currencies. *IEEE Communications Surveys Tutorials* 18: 2084–123. [CrossRef]
- Tsukerman, Misha. 2015. The block is hot: A survey of the state of Bitcoin regulation and suggestions for the future. *Berkeley Technology Law Journal* 30: 1127.
- Urquhart, Andrew. 2016. The inefficiency of Bitcoin. *Economics Letters* 148: 80–82. [CrossRef]
- Urquhart, Andrew. 2017. Price clustering in Bitcoin. *Economics Letters* 159: 145–48. [CrossRef]
- Vallee, Boris, and Yao Zeng. 2019. Marketplace lending: A new banking paradigm? *Review of Financial Studies* 32: 1939–82. [CrossRef]
- Van Alstyne, Marshall W., Geoffrey G. Parker, and Sangeet Choudary. 2016. Pipelines, platforms, and the new rules of strategy. *Harvard Business Review*. Available online: <https://hbr.org/2016/04/pipelines-platforms-and-the-new-rules-of-strategy> (accessed on 18 October 2020).
- Van de Velde, Jo, Angus Scott, Katrina Sartorius, Ian Dalton, Ben Shepherd, Chris Allchin, Matthew Dougherty, Patrick Ryan, and Patrick Rennick. 2016. Blockchain in Capital Markets—The Prize and the Journey. Available online: <https://www.linkedin.com/pulse/blockchain-capital-markets-prize-journey-koen-vanderhoydonk> (accessed on 18 October 2020).
- Van Vliet, Ben. 2018. An alternative model of Metcalfe's Law for valuing Bitcoin. *Economics Letters* 165: 70–72. [CrossRef]
- Viacoin. 2014. Viacoin Whitepaper. Available online: [https://github.com/viacoin/documents/raw/master/whitepapers/Viacoin\\_whitepaper.pdf](https://github.com/viacoin/documents/raw/master/whitepapers/Viacoin_whitepaper.pdf) (accessed on 18 October 2020).
- Vigna, Paul, and Michael J. Casey. 2016. *The Age of Cryptocurrency: How Bitcoin and the Blockchain Are Challenging the global Economic Order*, Reprint ed. New York: Picador.
- Vo, Hoang Tam, Lenin Mehedy, Mukesh Mohania, and Ermyas Abebe. 2017. Blockchain-based data management and analytics for micro-insurance applications. Paper presented at the 2017 ACM on Conference on Information and Knowledge Management ACM, Singapore, November 6–10; pp. 2539–42.
- Vranken, Harald. 2017. Sustainability of Bitcoin and Blockchains. *Current Opinion in Environmental Sustainability* 38: 1–9. [CrossRef]
- Walport, Mark. 2016. Distributed Ledger Technology: Beyond Block Chain. Available online: <https://medium.com/aid-tech/distributed-ledger-technology-beyond-block-chain-a-report-by-the-uk-government-chief-scientific-2eb8e0bda140#:~:text=A%20report%20by%20the%20UK%20Government%20Chief%20Scientific%20Adviser%20Sir%20Mark%20Walport,-Grace%20Ma&text=A%20distributed%20ledger%20is%20essentially,multiple%20sites%2C%20geographies%20or%20institutions> (accessed on 18 October 2020).
- Wang, Huaqing, Kun Chen, and Dongming Xu. 2016. A maturity model for blockchain adoption. *Financial Innovation* 2: 12. [CrossRef]
- Wang, Jingzhong, Mengru Li, Yunhua He, Hong Li, Ke Xiao, and Chao Wang. 2018. A blockchain based privacy-preserving incentive mechanism in crowdsensing applications. *IEEE Access* 6: 17545–56. [CrossRef]
- Watson, Thomas. 2017. FinTech: The Disruptive Enabler. SWIFT Institute and Ivey Business School's Scotiabank. Available online: [https://www.swiftinstitute.org/wp-content/uploads/2017/01/FinTech-The-Disruptive-Enabler-Conference-Summary\\_v5-1.pdf](https://www.swiftinstitute.org/wp-content/uploads/2017/01/FinTech-The-Disruptive-Enabler-Conference-Summary_v5-1.pdf) (accessed on 18 October 2020).
- Wei, Wang Chun. 2018. The impact of Tether grants on Bitcoin. *Economics Letters* 171: 19–22. [CrossRef]
- Wheatley, Spencer, Didier Sornette, Tobias Huber, Max Reppen, and Robert N. Gantner. 2019. Are bitcoin bubbles predictable? Combining a generalized metcalfe's law and the lppls model. *Royal Society* 6. [CrossRef]
- White, Gareth R. T. 2017. Future applications of blockchain in business and management: A Delphi study. *Strategic Change* 26: 439–51. [CrossRef]
- Wijaya, Dimaz Ankaa, Joseph K. Liu, Dony Ariadi Suwarsono, and Peng Zhang. 2017. A new blockchain-based value-added tax system. In *Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*. Berlin: Springer, vol. 10592, pp. 471–86.



- Wood, Gavin. 2016. Blockchains: What and Why. Available online: <https://www.slideshare.net/gavofyork/blockchain-what-and-why> (accessed on 18 October 2020).
- World Bank. 2016. Open Data Catalogue, Population Ages. October 4. Available online: <http://datacatalog.worldbank.org/> (accessed on 18 October 2020).
- World Economic Forum. 2015. The Future of Financial Services: How Disruptive Innovations are Reshaping the Way Financial Services are Structured, Provisioned and Consumed. June. Available online: [http://www3.weforum.org/docs/WEF\\_The\\_future\\_of\\_financial\\_services.pdf](http://www3.weforum.org/docs/WEF_The_future_of_financial_services.pdf) (accessed on 18 October 2020).
- World Energy Council and PwC. 2018. The Developing Role of Blockchain. White Paper. Executive Summary. Available online: [https://www.worldenergy.org/wp-content/uploads/2017/11/WP\\_Blockchain\\_Exec-Summary\\_final.pdf](https://www.worldenergy.org/wp-content/uploads/2017/11/WP_Blockchain_Exec-Summary_final.pdf) (accessed on 18 October 2020).
- Wright, Aaron, and Primavera De Filippi. 2015. Decentralized Blockchain Technology and the Rise of Lex Cryptographia (March 10). Available online: <https://ssrn.com/abstract=2580664> (accessed on 18 October 2020).
- Wu, Tong, and Xiubo Liang. 2017. Exploration and practice of inter-bank application based on blockchain. Paper presented at the ICCSE 2017–12th International Conference on Computer Science and Education, Houston, TX, USA, August 22–25; pp. 219–24.
- Xia, Bingqing, Dongyao Ji, and Gang Yao. 2017. Enhanced TLS handshake authentication with blockchain and smart contract. In *Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*. Berlin: Springer, vol. 10418, pp. 56–66.
- Xiong, Jinwu, Qing Liu, and Lei Zhao. 2019. A new method to verify bitcoin bubbles: Based on the production cost. *The North American Journal of Economics and Finance* 51: 101095. [CrossRef]
- Xu, Yuqin, Qingzhong Li, Xingpin Min, Lizhen Cui, Zongshui Xiao, and Lanju Kong. 2017. E-commerce blockchain consensus mechanism for supporting high-throughput and real-time transaction. In *Lecture Notes of the Institute for Computer Sciences, Social-Informatics and Telecommunications Engineering, LNICST 201*. Berlin: Springer, pp. 490–96.
- Yamada, Yuki, Tatsuo Nakajima, and Mizuki Sakamoto. 2017. Blockchain-LI: A Study on Implementing Activity-Based Micro-Pricing using Cryptocurrency Technologies. Paper presented at the 14th International Conference on Advances in Mobile Computing and Multi Media, Singapore, November 28–30; pp. 203–7.
- Yermack, David. 2017. Corporate Governance and Blockchains. *Review of Finance* 21: 7–31. [CrossRef]
- Ying, Wenchi, Suling Jia, and Wenyu Du. 2018. Digital enablement of blockchain: Evidence from HNA group. *International Journal of Information Management* 39: 1–4. [CrossRef]
- Yli-Huumo, Jesse, Deokyeon Ko, Sujin Choi, Sooyong Park, and Kari Smolander. 2016. Where is current research on blockchain technology?—A systematic review. *PLoS ONE* 11: e0163477. [CrossRef]
- Yoo, Minjae, and Yoojae Won. 2018. Study on smart automated sales system with blockchain-based data storage and management. *Lecture Notes Electrical Engineering* 474: 734–40.
- Yue, Li, Huang Junqin, Qin Shengzhi, and Wang Ruijin. 2017. Big data model of security sharing. Paper presented at the 2017 3rd International Conference on Big Data Computing and Communications, BigCom, Chengdu, China, August 10–11; pp. 117–21.
- Zachariadis, Markos, and Pinar Ozcan. 2017. The API Economy and Digital Transformation in Financial Services: The Case of Open Banking. SWIFT Institute Working Paper No. 2016-001. June 15. Available online: <https://ssrn.com/abstract=2975199> (accessed on 18 October 2020).
- Zalan, Tatiana. 2018. Born global on blockchain. *Review of International Business and Strategy* 28: 19–34. [CrossRef]
- Zargar, Faisal Nazir, and Dilip Kumar. 2019. Informational inefficiency of bitcoin: A study based on high-frequency data. *Research in International Business and Finance* 47: 344–53. [CrossRef]
- Zavolokina, Liudmila, Mateusz Dolata, and Gerhard Schwabe. 2016. The FinTech phenomenon: Antecedents of financial innovation perceived by the popular press. *Financial Innovation* 2: 1–16. [CrossRef]
- Zetzsche, Dirk Andreas, Ross P. Buckley, Douglas W. Arner, and Janos Nathan Barberis. 2017. From FinTech to TechFin: The Regulatory Challenges of Data-Driven Finance. *New York University Journal of Law and Business*. Available online: <https://ssrn.com/abstract=2959925> (accessed on 18 October 2020). [CrossRef]
- Zhao, J. Leon, Shaokun Fan, and Jiaqi Yan. 2016. Overview of business innovations and research opportunities in blockchain and introduction to the special issue. *Financial Innovation* 2: 28. [CrossRef]
- Zheng, Zibin, Shaoan Xie, Hong-Ning Dai, Xiangping Chen, and Huaimin Wang. 2016. Blockchain challenges and opportunities: A survey. *International Journal of Web and Grid Services* 14: 352. [CrossRef]
- Zhou, Weihuan, Douglas Arner, and Ross P. Buckley. 2015. Regulation of digital financial services in China: Last mover advantage. *Tsinghua China Law Review* 8: 26–60.
- Zhu, Christina. 2019. Big data as a governance mechanism. *Review of Financial Studies* 32: 2021–61. [CrossRef]
- Zhu, Huasheng, and Zach Zhizhong Zhou. 2016. Analysis and outlook of applications of blockchain technology to equity crowdfunding in China. *Financial Innovation* 2: 29. [CrossRef]
- Zikratov, Igor, Alexander Kuzmin, Alexander Akimenko, Viktor Niculichev, and Lucas Yalansky. 2017. Ensuring data integrity using blockchain technology. Paper presented at the Conference of Open Innovation Association, FRUCT, Helsinki, Finland, November 6–10; pp. 534–39.