Disruption of financial intermediation by FinTech: a review on crowdfunding and blockchain

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Abstract

Based on a systematic review of influential publications among 402 papers published between 2010 and 2018, this paper identifies gaps in Economics and Finance research regarding two applications of FinTech: crowdfunding and blockchain. Analysing these records shows that (i) current research on FinTech is fragmented with limited theoretical grounding; (ii) crowdfunding and blockchain can be regarded as two innovations that may disrupt traditional financial intermediation but in different ways; (iii) crowdfunding platforms substitute for traditional financial intermediaries and serve as a new intermediary, without eliminating the need for intermediation; (iv) similar to crowdfunding, blockchain also creates new intermediaries; and (v) the trust element inherent in blockchain enables blockchain to eliminate the need for intermediaries in some financial areas but not all.

Key words: Blockchain; Crowdfunding; Financial intermediation; FinTech

JEL classification: G00

doi: 10.1111/acfi.12405

Introduction

‘Financial technology’, or FinTech, refers to the use of technology to deliver financial solutions. The term FinTech can be traced back to the early 1990s (Hochstein, 2015); however, the sector has only recently attracted the focused attention of regulators, industry participants, consumers and academics due to its rapid alteration of traditional financial services. Global investment in financial technology increased by more than 2,200 percent from $930 million in
2008 to more than $22 billion in 2015\textsuperscript{1}, further nearly doubling to more than $40 billion in 2017 (Accenture, 2017).\textsuperscript{2} Financial institutions are embracing the disruptive nature of FinTech, and it is necessary for the academic community to be informed of the significance of this revolution, to reconsider the role of finance intermediation, and to make contributions to the birth of a new era for the financial industry.

Although the term FinTech is relatively new, financial innovation has a long history. It is widely accepted that technology has always played a key role in the financial sector, but it is very difficult to characterise the FinTech movement. For example, in the paper ‘150 years of FinTech’, Arner et al. (2016) illustrate the evolution of FinTech through three major eras: FinTech 1.0 (1866–1967); FinTech 2.0 (1967–2008); and FinTech 3.0 (2008–present). The authors argue that the advent of the first transatlantic cable in 1866 allowed the initial combination of finance and technology, culminating in the first period of financial globalisation. Driven by smartphone and application programming interfaces (APIs) and further catalysed by the 2008 global financial crisis (GFC), we are currently in stage 3.0 of FinTech in developed countries and FinTech 3.5 in emerging markets. This paper further argues that the critical difference in FinTech 3.0 lies in who is providing financial services and the speed of development. Examples in FinTech 3.0 are Wealthfront in 2008, which provides online automated investment services; Kickstarter in 2009, which introduces the reward-based crowdfunding platform; and the Bitcoin in 2009, which aims to reform the mobile payments solutions. In emerging markets in Asia and Africa, FinTech 3.5 examples are mobile money such as M-Pesa in Kenya in 2007, SME loans such as Alipay in China in the year of 2010 and new payment banks such as Fino PayTech in India.

In another paper titled ‘The FinTech 2.0 Paper’, the $100 million FinTech venture capital fund of Santander Group, Oliver Wyman and Anthemis Group claim FinTech 2.0 is capable of ‘rebooting’ financial services. Another venture capital firm, Arbor Ventures,\textsuperscript{3} categorises FinTech into two phases. FinTech phase 1 refers to the emergence of technology aimed primarily at digitising the customer experience and moving services online. Examples are online trading and lending and mobile payments with little participation by the banks. FinTech phase 2.0 is being driven by artificial intelligence (AI) and greater computing power with more collaboration and participation among financial institutions and FinTech start-ups. Similarly, Philippon (2016) lists

\begin{footnotesize}
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\item \textsuperscript{1} Accenture, 2017, Global FinTech Investment Growth Continues in 2016. Available at https://www.accenture.com/id-en/company-news-release-global-FinTech-investment-growth-continues
\item \textsuperscript{2} PwC, 2017, Global FinTech Report 2017. Available at https://www.pwc.com/jg/en/issues/redrawing-the-lines-FinTechs-growing-influence-on-the-financial-services-2017.html
\item \textsuperscript{3} Arbor Ventures, 2017, Fintech—Past, Present and Future. Available at https://medium.com/@ArborVentures1/fintech-past-present-and-future-eac0f8df2722
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examples of FinTech innovations such as cryptocurrencies and blockchain, new digital advisory and trading systems, artificial intelligence (AI) and machine learning, equity crowdfunding, peer-to-peer (P2P) lending and mobile payment systems.

Combining different views of the origin and stages of FinTech, this paper focuses on the contemporary two main FinTech innovations that have emerged in the past 10 years: crowdfunding and blockchain. Although FinTech has become one of the ‘hot’ areas in the finance industry, social media and academic research, our understanding of its applications and impacts is quite limited. The main purpose of this paper is to provide a better understanding of FinTech by identifying the development of knowledge and gaps in relevant finance research. Using the HistCite™-generated bibliographic map as guidance, this paper identifies publications on FinTech in Economics and Finance research and their interrelations. This paper therefore provides a comprehensive review of literature pertaining to crowdfunding and blockchain. This paper reveals that (i) research on FinTech and FinTech innovations is in their infancy, and with the exception of crowdfunding studies, other FinTech papers are fragmented with rare interrelations; (ii) crowdfunding and blockchain can be regarded as two innovations that may disrupt traditional financial intermediation but in different ways; (iii) crowdfunding platforms substitute for traditional financial intermediaries and serve as a new intermediary, without eliminating the need for intermediation; (iv) similar to crowdfunding, blockchain also creates new intermediaries; and (v) the trust element inherent in blockchain enables blockchain to eliminate the need for intermediaries in some financial areas but not all. This paper concludes with a discussion of opportunities and pathways for future research on FinTech in Economics and Finance studies.

Methodology: mapping fintech in economics and finance research

This review utilises bibliographic mapping, which is an established approach for reviewing a field of research and its influential publications (see Börner et al., 2003; Janssen et al., 2006; Janssen, 2007 and Linnenluecke, 2017). Data collection and analysis follow the methodological steps outlined by Janssen et al. (2006) and Janssen (2007). The first step is the compilation of a comprehensive data set of relevant publications and their citation records (i.e. a full record of their cited references). Next, the citation data are cleaned. The data can then be analysed and correlated using HistCite™ to map relationships between publications, and the results can be visualised by the software for means of communication.

Data collection and data cleaning

Publications for inclusion in this review were identified through Boolean searches within the Social Sciences Citation Index, an online academic citation
database within the Clarivate Analytics Web of Science™ platform. Within this database, a search was initially conducted for publications with the term ‘FinTech*’ in the title, abstract or keywords. The asterisk (*) was included as a wildcard symbol to search for variations of the term. The search identified 111 records, and 43 records are classified as belonging to the areas of ‘business finance’, ‘business’ or ‘economics’. Among the other 68 records, more than 85 percent of them are classified in the area of ‘computer science’. These 43 papers were reviewed to obtain general insights regarding FinTech. As the term FinTech itself is fairly recent, we further expand our research by including the main FinTech innovations for the last 10 decades: crowdfunding and blockchain. An advanced search then was conducted to include the term ‘FinTech*, ‘crowdfunding’, ‘peer-to-peer lend*’, ‘P2P lend*’ or ‘blockchain*’. This search was further refined in the research area of Business/Economics/Business Finance. The advanced search identified a further 421 records. The 421 records were downloaded and imported into HistCite™ (version 12.03.17). The records were then manually cleaned by checking the title, abstract and keywords of each record, and, if necessary, referring to the full text of the publication to determine its suitability for inclusion in the review. For example, Cameron (2016) included the keyword ‘crowdfunding’, yet this paper explores the impact of digital technology on the consumption of music. Two papers that meet our selection criteria are also deleted from the data due to inaccessibility from the Web of Science™ website: (1) Ge et al.’s (2008) paper titled ‘Individual Credit or Joint Reputation: Tackling Information Asymmetries in Online P2P Lending Markets’; and (2) Hu et al.’s (2008) paper titled ‘Bidding Strategy Analysis for Online P2P Lending’. After the data cleaning process, 23 records were removed, leaving a total of 398 records in the data set.

The scope of this review is limited to crowdfunding and blockchain. Mobile money and artificial intelligence applications such as robot-advisory emerging for the last 10 years are not within the scope of this review. Mobile payment is growing rapidly in emerging markets in Asia and Africa for the recent decade and has attracted research attention. A very brief search suggests that and mobile payment research is fragmented and a large amount of research focuses on developing countries where mobile payment has been growing rapidly. Given financial systems and infrastructure in these countries are underdeveloped and have different attributes, we exclude mobile payment in the scope of the review. Artificial intelligence is a broad subject that covers any technique which enables technology to mimic human intelligence using logic (Altus, 2018). The artificial intelligence technology is still in its primitive stage, and the artificial intelligence applications in finance arrears are immaterial. Current business research is not covering artificial intelligence in detail; therefore, we also exclude it in the scope of this review.

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Manual additions to the data set

To check whether any records were inadvertently overlooked, a cited reference search was conducted within HistCite\textsuperscript{TM}. Omissions can occur when a record does not meet the search criteria. In addition, restricting the search to the field of business and management may have missed contributions not classified by the Web of Science\textsuperscript{TM} as belonging to this domain. Four additional publications were manually added to the final data set (see Table 1). With the manual additions, the final data set contains 402 records published between 2010 and 2018 (cut-off: 24 May 2018, which includes online-first articles published up to this point). Further, there are several cross-disciplinary books/papers pertinent to this review that are not added in our data as they are not in the field of business; for example, the book ‘Bitcoin and Cryptocurrency Technologies’ published by Princeton University Press in 2016 provides a comprehensive introduction to the blockchain revolution, yet it is categorised in the field of computer science.

Results: citation statistics and citation map

The yearly output of research regarding FinTech in the field of Economics and Finance is mapped in Figure 1. This area attracted academic interest in 2010,\textsuperscript{5} followed by a speedy increase in publications, consistent with the rapid growth of aggressive investments in this area. The citation map generated with

\textsuperscript{5} As mentioned earlier in the ‘Data collection and data cleaning’ section, based on the title of papers, there are two conference papers in 2008 that seem to discuss online P2P lending but are deleted in our final data due to access issue. As authors cannot access to these two papers, it is inappropriate for us to include them in our data for discussion.
HistCite™ (see Figure 2) illustrates that unlike other well-established topics, academic research in FinTech is quite fragmented. The area in grey includes the top 30 cited publications within the data set along a timeline (left side of the figure). Papers are displayed as nodes and the citation connections between them as arrows. The size of each node highlights the quantitative importance of the respective publication in the map. The citation graph allows the identification of knowledge development and knowledge gaps in a particular field, as researchers typically cite the prior research they build upon. The corresponding citation details and citation counts for each node in Figure 2 are given in Table 2.

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### Table 1
Manual additions to the data set

| Title                                           | Author(s)                   | Year | Publication details          | LCS | GCS | Reason for manual adding                                                                 |
|-------------------------------------------------|-----------------------------|------|------------------------------|-----|-----|-----------------------------------------------------------------------------------------|
| Crowdfunding of small entrepreneurial ventures   | Schwienbacher and Larralde  | 2010 | SSRN Electronic Journal     | N/A | N/A | The paper is not included in the search, but it offers one of the first definitions of crowdfunding. |
| An Empirical Analysis of Crowdfunding            | Lambert et al.              | 2010 | SSRN Electronic Journal     | N/A | N/A | The paper is not included in the search, but it analyses crowdfunding empirically.         |
| Alternative Types Of Entrepreneurial Finance    | Perrow                      | 2012 | The Oxford Handbook of      | N/A | N/A | This article discusses crowdfunding as an alternative way of financing projects.           |
| Blockchain Technology: Principles and Applications| Pilkington                  | 2016 | SSRN Electronic Journal     | N/A | N/A | Book (not indexed).                                                                        |

Sorted by year in ascending order. The Local Citation Score (LCS) refers to the count of citations to each publication within the collection, while the Global Citation Score (GCS) refers to the count of citations to each publication within the Web of Science."
| Number | Citation | Publication details | LCS | GCS |
|--------|----------|---------------------|-----|-----|
| 1      | Mollick (2014) | Mollick E, 2014, J BUS VENTURING, V29, P1 | 126 | 352 |
| 2      | Belleflamme (2014) | Belleflamme P, 2014, J BUS VENTURING, V29, P585 | 95  | 226 |
| 3      | Ahlers (2015) | Ahlers GKC, 2015, ENTREP THEORY PRACT, V39, P955 | 57  | 98  |
| 4      | Colombo (2015) | Colombo MG, 2015, ENTREP THEORY PRACT, V39, P75 | 38  | 69  |
| 5      | Agrawal (2015) | Agrawal A, 2015, J ECON MANAGE STRAT, V24, P253 | 30  | 57  |
| 6      | Pope (2011) | Pope DG, 2011, J HUM RESOUR, V46, P53 | 29  | 91  |
| 7      | Allison (2015) | Allison TH, 2015, ENTREP THEORY PRACT, V39, P53 | 26  | 42  |
| 8      | Cholakova (2015) | Cholakova M, 2015, ENTREP THEORY PRACT, V39, P145 | 26  | 36  |
| 9      | Bruton (2015) | Bruton G, 2015, ENTREP THEORY PRACT, V39, P9 | 25  | 61  |
| 10     | Duarte (2012) | Duarte J, 2012, REV FINANC STUD, V25, P2455 | 23  | 86  |
| 11     | Herzenstein (2011) | Herzenstein M, 2011, J INTERACT MARK, V25, P27 | 22  | 60  |
| 12     | Lee (2012) | Lee E, 2012, ELECTRON COMMER R A, V11, P495 | 20  | 51  |
| 13     | Vismara (2016) | Vismara S, 2016, SMALL BUS ECON, V46, P579 | 19  | 31  |
| 14     | Stemler (2013) | Stemler AR, 2013, BUS HORIZONS, V56, P271 | 15  | 39  |
| 15     | Yum, 2012 | Yum H, 2012, ELECTRON COMMER R A, V11, P469 | 14  | 34  |
| 16     | Herzenstein (2011) | Herzenstein M, 2011, J MARKETING RES, V48, P138 | 13  | 38  |
| 17     | Emekter (2015) | Emekter R, 2015, APPL ECON, V47, P54 | 12  | 27  |
| 18     | Greiner (2010) | Greiner ME, 2010, INT J ELECTRON COMM, V15, P105 | 9   | 29  |
| 19     | Michels (2012) | Michels J, 2012, ACCOUNT REV, V87, P1385 | 9   | 22  |
| 20     | Pitschner (2014) | Pitschner S, 2014, ECON LETT, V123, P391 | 9   | 17  |
| 21     | Meer (2014) | Meer J, 2014, J ECON BEHAV ORGAN, V103, P113 | 9   | 26  |
| 22     | Moritz (2015) | Moritz A, 2015, QUAL RES FINANC MARK, V7, P309 | 8   | 11  |
| 23     | Lehner (2014) | Lehner OM, 2014, ENTREP REGION DEV, V26, P478 | 7   | 19  |
| 24     | Barasinska (2014) | Barasinska N, 2014, GER ECON REV, V15, P436 | 7   | 7   |
| 25     | Parker (2014) | Parker SC, 2014, ECON LETT, V125, P432 | 7   | 10  |
| 26     | Meyskens (2015) | Meyskens M, 2015, ENTREP RES J, V5, P155 | 7   | 8   |
| 27     | Hu (2015) | Hu M, 2015, MARKET SCI, V34, P331 | 7   | 17  |
| 28     | Belleflamme (2015) | Belleflamme P, 2015, INF ECON POLICY, V33, P11 | 7   | 22  |
| 29     | Ryu (2016) | Ryu S, 2016, ELECTRON COMMER R A, V16, P43 | 7   | 10  |
| 30     | Chen (2014) | Chen N, 2014, GAME ECON BEHAV, V86, P367 | 6   | 10  |
Developments in FinTech research

This section reviews and discusses the main research stream identified in Figure 2. An additional stream, although in its infancy, is also explored due to its future potential and implications.

Crowdfunding

A significant body of FinTech research has developed around crowdfunding, one of the most successful technology-enabled initiatives in the FinTech revolution (see the grey area of Figure 2). Crowdfunding can be viewed as an existing FinTech application that may remove finance intermediaries. Crowdfunding is an open call to provide financial resources (Schwienbacher and Larralde, 2012), which mostly takes place on Internet-based crowdfunding platforms without standard financial intermediaries (Mollick, 2014). Crowdfunding varies in terms of fundraising activities and what is offered in return for the funds. Belleflamme et al. (2015) distinguish crowdfunding into two classes: (i) investment-based crowdfunding and (ii) reward- and donation-based crowdfunding. The first class includes equity-based, royalty-based and

| Table 3
| Blockchain glossary |
|---------------------|
| Term/concept | Explanation | Notes |
| --- | --- | --- |
| Hash/hash function | A hash (output) is the result of a transformation of the original information (input). It is a long, unique string of numbers that identifies each block and its place in the chain. A hash function is a mathematical algorithm that takes an input and transforms it into an output. A cryptographic hash function has three properties: (1) collision resistance (difficult to revert from output to input); (2) hiding (given the output of the hash function, there’s no feasible way to figure out what the input was); (3) puzzle friendliness (difficult to find another value that hits an output value). |
| Block | A secure unit that holds data about a transaction, a unique hash and the hash of the previous block. | |
| Node | Each user who keeps a copy of the blockchain and runs the appropriate software to approve new additions to the blockchain. This is to say, at any given time, each node has a ledger consisting of a sequence of blocks and each block contains a list of transactions they have previously reached consensus on. | |
| Network | The collective group of nodes for each blockchain. Peer-to-peer network without a centralised authority. | Summarised based on Narayanan et al., 2016, Bitcoin and Cryptocurrency Technologies (Princeton University Press, Princeton, NJ).
lending-based crowdfunding (e.g. peer-to-peer lending), where funders are investors in a campaign and may obtain monetary benefits. In the second class, no monetary reward is provided as compensation for supporting such a project and sponsors are often rewarded a token as a return (e.g. music CD, a T-shirt or a discount on products). Investment-based crowdfunding has emerged as an alternative financial investment instrument: without standard financial intermediaries and expensive registration requirements, crowdfunding enables the fundraiser to avoid complicated regulation requirements and to reduce transaction costs.

Research on crowdfunding first emerged in 2010 and has increased speedily since 2015, driven by the substantial change of legislative environment in 2015. Investment-based crowdfunding has been restricted in many countries, but in recent years, the regulatory environment has become more supportive of financial innovations. In the United States, The CROWDFUND Act of Jumpstart Our Business Startups (JOBS) Act in 2015 is considered a milestone for crowdfunding as it enables equity-based crowdfunding to serve as a legal alternative for entrepreneurs and small business owners to sell equity via social networks and various Internet platforms.

Initial research on crowdfunding focuses on the definition of crowdfunding. Schwienbacher and Larralde (2012) offer one of the first descriptions of crowdfunding in their examination of a French music crowdfunding start-up. Lambert and Schwienbacher (2010) define crowdfunding as ‘an open call [...] for the provision of financial resources either in form of donation or in exchange for some form of reward and/or voting rights in order to support initiatives for specific purposes’ (see also Schwienbacher and Larralde, 2012). Mollick (2014) provides a different view, defining crowdfunding in an entrepreneurial context as ‘the efforts by entrepreneurial individuals and groups—cultural, social, and for-profit—to fund their ventures by drawing on relatively small contributions from a relatively large number of individuals using the internet, without standard financial intermediaries’. This definition addresses one of the key features of crowdfunding, namely its attempt to disrupt standard financial intermediation.

Following these earlier efforts to define crowdfunding, Belleflamme et al. (2015) contribute to the literature by describing crowdfunding sectors based on descriptive statistics of existing crowdfunding platform markets. This paper provides a better understanding of the functioning of crowdfunding platforms (CFPs). It also discusses the asymmetric information problems of CFPs, the dynamic behaviour of funders, and of the role of social networks on CFPs, stimulating subsequent research to examine these issues.

Since 2012, a large body of research has begun to explore the determinants of the success of equity-based or lending-based crowdfunding campaigns, with mixed and discrete findings. These studies are primarily empirical and based on existing financial theories. In the context of lending-based crowdfunding (peer-to-peer lending), Duarte et al. (2012) take the initiative to examine the trust
issue based on a peer-to-peer lending site and find that borrowers who appear more trustworthy have higher probabilities of having their loans funded. Michels (2012) further finds that unverifiable disclosures influence peer-to-peer lending. Mollick (2014), in the most cited paper in crowdfunding in the context of equity-based crowdfunding, offers a description of the underlying dynamics of success and failure among crowdfunded ventures by drawing on a data set of over 48,500 projects with combined funding of over $237 million. This paper suggests that personal networks and underlying project quality are associated with the success of crowdfunding efforts and that geography is related to both the type of projects and successful fundraising. Based on signalling theory, Ahlers et al. (2015) empirically examine the effectiveness of signals to induce investors to commit financial resources in equity crowdfunding. Their research highlights that retaining equity and providing more detailed information about risks can be interpreted as effective signals and can therefore strongly impact the probability of funding success. Social capital and intellectual capital, by contrast, have little or no impact on funding success. Colombo et al. (2015) also examine the effect of social capital on the success of an equity-crowdfunding campaign, but reach a different conclusion. Ge et al. (2017) conduct similar research in the context of lending-based crowdfunding (peer-to-peer (P2P) lending), and their results suggest that borrowers’ social information can be used not only for credit screening but also for default reduction and debt collection.

Another key stream of crowdfunding research examines herding behaviour of funders (one of the main concepts in behavioural finance) on crowdfunding platforms. Gordon et al. (2016) suggest that the inclusion of a provision point in an equity-based crowdfunding campaign can mitigate undesirable rational herding behaviour or informational cascades that diminish the quality of the market. Analysing unique information on 127 P2P lending platforms via a large Chinese-language market aggregator’s website, Jiang et al. (2018) examine the extent to which P2P lending exhibits patterns that can be explained by rational herding theory. They find that herding exists at the platform level: the previous lending behaviour of other prior investors does indeed influence their choice of platform for subsequent loans. Jiang et al. (2018) also reveal that government regulatory events dampen the magnitude of the herding effect. In an empirical analysis of peer-to-peer (P2P) lending platforms, Xu and Chau (2018) observe that cheap talk may lead to rational herding behaviour among P2P loan funders. They report that borrower responses do more to enhance funding success than lender comments and questions. They further report that lending performance in payback rate terms cannot be predicted based on the extent to which borrowers and lenders engage in direct social interaction on the P2P lending platform.

Very few theoretical papers exist in crowdfunding research; one exception is Belleflamme et al. (2014), which contributes to the theoretical origin of entrepreneur’s two choices of crowdfunding forms: pre-ordering and profit
sharing (equity crowdfunding). Another attempt is Wei and Lin (2016) that both theoretically and empirically examines the two choices of market mechanisms of P2P lending between platform-mandated posted prices and contract interest rates in auctions.

To date, the majority of crowdfunding research is empirical and based on existing financial theories. Considering the fundraiser’s perspective, the signal theory is heavily used to examine whether and how communication between fundraiser and funders determines the success of a crowdfunding campaign. Research that considers the perspective of the funder (investor) focuses on herding behaviours. These studies provide important insights regarding crowdfunding in the areas of dynamic behaviour among funders and the role of social networks on crowdfunding platforms. A notable research gap is that although one of the key features of crowdfunding is its provision of an alternative way to move money peer-to-peer without financial intermediaries, no research has yet examined how and to what extent this key feature really differentiates crowdfunding from traditional funding channels. The change of financial climate following the 2008 financial crisis has given rise to the culture of crowdfunding. The amount of money raised through crowdfunding world-wide grows from year to year. The volume of funds raised grew from US$1.5 billion in 2011 to over US$100 billion in 2015, then more than 300 billion worldwide in 2016 (see Massolution 2015; and Allied Crowds 2016; Garvey et al. 2017). The lending-based crowdfunding is currently the dominant crowdfunding. Although equity crowdfunding is relatively small, it has experienced dramatic growth in recent years (Allied Crowds 2016). The volumes of crowdfunding are currently still low relative to the size of the global financial services sector, and it is not viewed as a threat to traditional ways of financing. However, given such a rapid growth of this alternative finance, forecasting how crowdfunding will affect traditional funding channels in dollar amounts in medium and long term would also be a potential future work.

Blockchain

Crowdfunding research is the only stream in FinTech that displays clear (although not strong) interrelations. All other FinTech research streams are quite fragmented with very few interrelations at the local and global levels. Among the fragmented FinTech research, blockchain, although in its infancy, emerges as a stream deserving of further examination.

Blockchain is said to have the potential to disrupt the way the global financial system works and change the nature of investment (Fanning and Centers, 2016; Pollari, 2016). The first blockchain was conceptualised by a person (or group of people) known as Satoshi Nakamoto in 2008 (Satoshi 2008). In January 2009, this concept was implemented as a core component of the cryptocurrency Bitcoin. Through the use of a blockchain, Bitcoin became the first digital currency without requiring a trusted authority.
The proposal of a peer-to-peer network that transfers value between participants is not unique to blockchain. Crowdfunding, as discussed in the previous session, is an existing FinTech innovation that enables peer-to-peer money exchange without an intermediary. However, Bitcoin is a unique method for the movement of value. As explained by Fanning and Centers (2016), Bitcoin transaction information is permanently recorded in a block and this is added to prior transaction information (therefore forming a blockchain). With the blockchain, users are able to validate and track their Bitcoin transactions, and the stored information within the block is able to serve as the trust element. Therefore, a blockchain effectively severs the need for a centralised agent, which is normally provided by financial intermediaries. This trust element inherent in blockchain is the main reason that blockchain technology has the potential to be a transformative technology in financial services; in some areas, it may eliminate the need for intermediaries.

To illustrate the inherent trust element of blockchain, let us explore how blockchain works using Bitcoin as an example. Relevant terms and concepts that will come up throughout this discussion are defined in Table 3.

Now let us assume one person called Tom wants to transfer a value ($50,000 equivalent) to his friend Jerry. Let us compare the inherent trust element of traditional and Bitcoin payment mechanisms. In a traditional mechanism, Tom needs to transfer the value through a bank to Jerry, and the bank will therefore record and verify this transaction. In a Bitcoin mechanism, Tom needs to broadcast this transaction to all of the Bitcoin nodes that comprise the peer-to-peer network (Jerry is not necessarily required to be in the Bitcoin network to receive this value) and the majority of nodes must agree on the transaction between Tom and Jerry. Meanwhile, all previous Bitcoin transactions are recorded in a form of hash in blocks (public ledger). Once the network accepts Tom’s transaction, this new transaction will be added into the public ledger as a new hash in a block. Therefore, the traditional bank verification is conducted by a centralised agency with designated authority, while agreement of decentralised nodes and the public ledger facilitates the Bitcoin verification.

But how exactly do nodes reach a consensus regarding Tom’s transaction and how can we guarantee that transaction information is truthfully added? The decentralisation mechanism of Bitcoin is achieved through a combination of technical methods and incentive engineering. Technically, Bitcoin has a mathematical algorithm and protection against invalid transactions is cryptographic. In Tom’s case in the Bitcoin context, there is a publicly accessible ledger containing existing transactions on a block-by-block basis. Tom’s

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6 A brief technical explanation of the blockchain mechanism is summarised in the Appendix 1.

7 We use an individual Bitcoin transaction as an illustrative example for ease of communication. In practice, Bitcoin transactions are grouped together into blocks for efficiency.
transaction information is added to the existing ledger cryptographically (a new
hash), given the consensus of the majority of nodes. If anyone wants to alter
Tom’s transaction, this means the hash will change, which would then
invalidate the whole block as each also contains the hash of the previous block.
Therefore, one incorrect hash in the chain will cause all future hashes to
become invalid. The cryptographic mechanism itself does not solve the
decentralisation problem because even if it becomes obvious to the whole
network that there is an invalid hash attack, whether it is added in the
blockchains (the public ledger) purely depends on the honesty of the nodes; that
is, an invalid hash will be rejected by the nodes/network only because a
majority of the nodes are honest and will not include an invalid transaction in
the blockchain. Bitcoin ‘solves’ this honesty issue by giving nodes an incentive
for behaving honestly and utilising a proof-of-work (PoW) mechanism. The
honest nodes (those creating the blocks that end up in the long-term consensus
chain) will be rewarded with Bitcoin(s) (block reward) and transaction fees\(^8\).
Still, incentives are not sufficient to ensure the honesty of nodes. In addition, a
proof-of-work function using a hash puzzle is built in the Bitcoin protocol. The
Bitcoin PoW function has three properties. First, the hash puzzle is difficult to
solve, requiring computation beyond the scope of a normal laptop. This
process of repeatedly trying to solve hash puzzles is known as Bitcoin mining,
and the participating nodes are called miners. Second, the cost for a miner to
find a block is parameterisable and readjusted when the mining ecosystem
grows. Therefore, weighted by miners ‘efforts, incentives and hash power, a
majority of miners would follow the Bitcoin protocol, namely act in an honest
manner. Third, it is trivial to verify that a node has computed proof-of-work
correctly due to the composition of hash puzzles\(^9\), and thus, once again there is
no need for a centralised authority to verify miners’ jobs: any node can
instantly verify that a block found by another miner satisfies this proof-of-work
property.

We have so far explained how Bitcoin achieves consensus. It is fair to say that
a PoW function is at the heart of block generation in the Bitcoin protocol and it
is a common form (but not the only form)\(^10\) of ensuring blockchain’s consensus
mechanism and thus an inherent trust element. The consensus in Bitcoin works

\(^8\) ‘The creator of any transaction can choose to make the total value of the transaction
outputs less than the total value of its inputs. Whoever creates the block that first puts
that transaction into the block chain gets to collect the difference, which acts a
transaction fee’ (Narayanan et al., 2016, p. 63).

\(^9\) The hash puzzle is designed in such a way that in order to create a block, the node that
proposes that block is required to find a number that falls into a target space. It takes a
node on average 1020 tries to find a number within this target, and this number must
also be published as part of the block. It therefore becomes trivial to verify/repeat this
whole process.

\(^10\) Another form is proof-of-stake, which is beyond the scope of this review paper.
well, but we do not have a developed theory to explain why it works well. As discussed by Narayanan et al. (2016), a possible direction is to use game theory to understand how a system will behave. In this view, instead of thinking about whether nodes are honest and behave arbitrarily in a system (the basic approach used in the research fields of distributed systems and computer security), we assume that every node acts according to its own incentives. Each node will therefore have a strategy to maximise its own payoff while taking other nodes’ possible strategies into consideration. In this scenario, ‘honest’ behaviour is just one strategy of many possible strategies. However, whether this ‘default’ honest behaviour of miners that we see in practice is a Nash equilibrium or not is still a very important question to be answered.

By examining how blockchain is applied in Bitcoin, we can say that the core of blockchain technology is useful for reaching consensus in a decentralised way, which breaks the old paradigm of requiring trusted centralised parties. As summarised by Collins (2016): ‘...(Blockchain) processes information very differently from traditional IT systems, which are essentially hierarchical structures. Accordingly, data are organized into centralized files and administrators have master control over the database. Blockchain systems, however, are networked structures that record information in a distrusted ledger and use consensus dynamics to do work and maintain security’. Since the original application of blockchain technology in Bitcoin, blockchain has now been explored to different industries as more business leaders and entrepreneurs recognise the enormous potential of this transformational technology. For example, in social media industry, Steemit is a blogging and social networking website that uses blockchain-based rewards platform for publishers. In identity protection industry, to combat the growing centralisation of voting processes in Australia, Horizon State aims to apply blockchain technology to let people vote in a more democratic, decentralised way and this voting is not merely politics related. In the emerging cloud computing file sharing industry, Filecoin is a decentralised storage network that turns cloud storage into an algorithmic market.

‘The Bretton Woods System 2015 White Paper’ released in January 2015 proposes three phases of blockchain development (Scribd 2015). In the Blockchain 1.0 stage, encrypted digital currency is introduced, mainly in the form of cryptocurrency applications such as Bitcoin. The Blockchain 2.0 stage involves the addition of intelligent contracts, enabling Blockchain to be used in financial or economic markets, and also extend to stocks, bonds, futures, loans, mortgages, property rights, intellectual property and other contracts. The Blockchain 3.0 stage is the widely innovative application stage. Based on our current application of blockchain technology in 2018, it is probably fair to say we are still in the introduction phase, as a fair amount of the core infrastructure is still being constructed.

Not surprisingly, current business research in blockchain is very limited. Sixty-eight papers directly focus on the blockchain topic within the area of business, including research areas such as accounting/auditing, management,
organisations and finance. Most of these publications conceptualise blockchain innovations in business and/or prescribe business applications of blockchain. Research at the descriptive level is rare as it takes more effort to uncover new explanations and theories underlying the blockchain phenomenon.

Since 2016, several papers have expounded the main principles behind blockchain technology, exploring how blockchain applications might change the financial industry. Fanning and Centers (2016) provide insights into what comprises a blockchain and how blockchains work. They describe a blockchain as ‘a collection of validated pieces of information, blocks, linked to the others by adding the newest blocks to the existing chain’. They view blockchain as a public ledger of all transactions that have ever been executed and highlight that these blocks are added to the existing chain in a linear, chronological order. Furthermore, they note that blockchain is a breakthrough technology capable of changing the back-office handling of transactions in current financial services, such as settlement, regulatory and cross-border payments. By reviewing cutting-edge blockchain applications in Korea, Yoo (2017) finds that blockchains applied in the financial sector are expanding into settlement, remittance, securities and smart contracts and payments between banks based on a closed (private) distributed ledger. Similarly, Guo and Liang (2016) propose that payment-clearing systems and bank credit information systems can serve as appropriate scenarios of blockchain application as the blockchain technology can be used to solve issues such as lack of mutual trust, high transaction cost and fraud. Mills et al. (2017) further identify both the opportunities and challenges facing blockchain implementation in the area of payment, clearing and settlement (PCS) processes such as cross-border payments and post-trade clearing and settlement of securities. Zhu and Zhou (2016) propose that crowdfunding could benefit from blockchain as it has the potential to solve the trust issues related to the registration of shares and the management of funds collected by crowdsourcing, and to facilitate mechanisms of corporate governance that would enable small, distributed shareholders to exercise control over a funded company.

Additional papers discuss how blockchain might change organisations in a more broad sense. Tapscott and Tapscott (2017) believe ‘blockchain technology will have profound effects on the nature of companies: how they are funded and managed, how they create value, and how they perform basic functions such as marketing, accounting, and incentivizing people’. They foresee that new technologies including cloud computing and blockchain will ‘enable

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11 Cloud computing is the practice of using a network of remote servers hosted on the Internet to store, manage and process data, rather than a local server or a personal computer. This technology has been around since the 1960s, though the major innovations started with the launch of Amazon Web Services (AWS) in 2002. Cost saving is one of the main advantages for cloud computing as it enables the organisations (including financial institutions) to outsource some functions (such as data storage).
corporations to outsource overhead, crowdsource innovation, and eliminate middle managers and other intermediaries, thus freeing industries such as accounting, commercial banking, and even music to consolidate assets and operations’. Scott et al. (2017) share a similar view, arguing that blockchain technology may help develop organisations that seek to build social and solidarity-based finance. In addition, Nowinski and Kozma (2017) show that blockchain technology may disrupt existing business models in three crucial ways: by authenticating traded goods, disintermediation and lowering transaction costs.

In addition to a conceptual understanding of blockchain, several papers examine cryptocurrency, one of the existing finance applications built on blockchain. Cryptocurrency is the original application of blockchain technology in the finance industry. Bitcoin is generally considered the first decentralised cryptocurrency, but it is not the only one. As of May 2018, over 1,800 cryptocurrency specifications existed (Badkar, 2018). Table 4 shows the top 15 cryptocurrencies based on market cap as of 29 July 2017. The first two cryptocurrencies that are trading on the marketplace are Bitcoin and Ether. Ether is the cryptocurrency of the Ethereum blockchain platform. Like the Bitcoin blockchain, the Ethereum blockchain allows users to store and transfer Ethers on a peer-to-peer network. In addition, the Ethereum blockchain can empower smart contracts and decentralised applications, which must use Ether to pay for the computational services provided by the Ethereum platform (Buterin, 2014).

At this stage, there are a large number of unsolved issues relating to cryptocurrency. These issues include drivers of the value of cryptocurrency; whether cryptocurrency is a form of speculative investment given its extremely high volatility; whether cryptocurrency can truly function as a form of digital money; and whether cryptocurrency functions more like equities without any underlying assets. Several papers attempt to address these issues, contributing a range of views. Luther (2016a) argues that cryptocurrencies will remain ‘niche monies’ and the only possibility to replace existing currencies exists in countries with very weak and poorly managed currencies. However, cryptocurrencies may be used in areas that do not necessarily require widespread adoption. On the contrary, Berentsen and Schaer (2018) conclude that cryptocurrencies such as Bitcoin have the potential to develop into an interesting investment and diversification instrument (a new asset class). Over time, they could assume a similar role to gold. Bitcoin is compared to gold as both assets have high price volatility and total supply is finite and not controlled by a government. Therefore, the financial capabilities of Bitcoin, such as heading capabilities, diversification possibilities and the arbitrage possibilities, might be similar to those of gold. Mai et al. (2018) assess what drives the value of Bitcoin. Through a blend of machine-based methods and explanatory econometric analysis, they find that social media sentiment affects Bitcoin prices. From a different perspective, Luther (2016b) proposes that the value of using a particular
currency depends on the number of other users who are ready to transact in that currency.

Many people believe that blockchain is a key technology capable of revolutionising the banking industry. The anticipated benefits of the blockchain technology implementation in financial sectors have already motivated market participants as well as infrastructure providers to explore the technology applications. Not only new financial products but also new business models may emerge in the coming years, and the blockchain technology may lead to reshape the market infrastructure and our financial systems. Researchers have already begun to blueprint a new era of the financial industry utilising blockchain, but it is still not clear which specific areas of banking businesses can benefit the most from this disruptive technology.

Discussion and directions for future research

A decade ago, innovative payment applications such as PayPal failed to attract significant attention within the financial industry. Today, technological forces affect all areas of financial services. Sharing the same view with Philippon (2016), we believe that FinTech innovations are capable of disrupting existing financial industry structures and blurring industry boundaries. A key reason is that some FinTech innovations may facilitate disintermediation of financial services. This literature review explores two main innovations (crowdfunding and blockchain) that attempt to disrupt and disintermediate

| Name                  | Market cap (USD) | Price (USD) | Volume (USD) |
|-----------------------|------------------|-------------|--------------|
| Bitcoin (BTC)         | $140,077,000,000 | $8,154.42   | $3,192,070,000 |
| Ether (ETH)           | $46,911,700,000  | $464.52     | $893,989,000  |
| XRP (XRP)             | $17,279,800,000  | $0.45       | $150,808,000  |
| Bitcoin Cash (BCH)    | $14,036,400,000  | $817.11     | $476,552,000  |
| EOS (EOS)             | $8,190,000,000   | $8.19       | $574,277,000  |
| Stellar (XLM)         | $5,840,420,000   | $0.31       | $47,732,800   |
| Litecoin (LTC)        | $4,819,730,000   | $83.65      | $382,048,000  |
| Cardano (ADA)         | $4,160,370,000   | $0.16       | $47,253,100   |
| Tronix (TRX)          | $3,730,000,000   | $0.04       | $147,424,000  |
| IOTA (IOT)            | $2,835,120,000   | $1.02       | $32,376,100   |
| VeChain (VEN)         | $2,637,710,000   | $2.64       | $2,074,730    |
| Monero (XMR)          | $2,259,840,000   | $138.94     | $24,778,600   |
| NEO (NEO)             | $2,178,150,000   | $33.51      | $54,293,100   |
| Kin (KIN)             | $2,043,890,000   | $0.00       | $203,122      |
| Dash (DASH)           | $1,962,500,000   | $238.71     | $63,416,800   |

Source: CCN.com, 2018, Cryptocurrency market capitalizations. Available at https://www.ccn.com/marketcap/.
financial transactions and provides further insights into a coming FinTech revolution.

Intermediation is a fundamental component of finance as intermediation serves many critical interrelated purposes such as asset aggregation, market making, risk management and information clearing (Lin, 2016). For more than 100 years, we have shared the view that traditional financial intermediaries effectuate the primary functions of finance and create efficiencies. In the absence of bankers, most individuals and businesses would likely have to expend much more transaction costs. In recent years, new technologies and regulation reforms have transformed the financial industry. For a long time, the purpose of financial intermediation was to reduce costs and risks. However, the 2007/2009 financial crisis severely shook the brand image of traditional financial intermediaries, especially banks. Today, more people seek to bypass traditional financial markets to obtain lower costs, fewer restrictions and more efficiency. Driven by technological developments and new regulatory initiatives, customers in many financial services areas have shifted their mindset regarding who has the resources and legitimacy to provide financial services, challenging the role of financial intermediaries in favour of FinTech innovations.

A review of crowdfunding research suggests that this FinTech innovation does not eliminate the need for financial intermediaries; rather, it creates a substitution of traditional intermediaries. Current crowdfunding research concentrates on the determinants of crowdfunding success and the dynamic behaviours of investors using empirical approaches. The findings reinforce existing theories derived from long-standing traditional intermediaries and thus fail to contradict these theories. Although crowdfunding is believed to be an alternative financial investment instrument without standard financial intermediaries, we lack sufficient research to examine how this key feature of crowdfunding makes this FinTech innovation fundamentally different. Crowdfunding platforms do not eliminate the need for intermediaries; rather, these platforms are regarded as less regulated new intermediaries. In reality, a traditional bank provides a loan to a borrower, and the platform then provides a note to the lender. Following this, investment banks create a platform to enable the fundraiser to obtain funds from possible funders/investors. The foundations of this peer-to-peer platform and traditional banking intermediaries are therefore almost the same, if not identical.

Compared to traditional banks, one of the main advantages of crowdfunding is that it has fewer regulation requirements and therefore fewer transaction costs. Nevertheless, this is based on an ex ante perspective as we do not have ex post research to examine whether this belief is true or not. In addition, even if transaction costs can be reduced by crowdfunding platforms marginally, this does not suggest that crowdfunding platforms are a more ‘efficient’ way to aggregate and reallocate capital compared with traditional financial intermediation, as we do not have any research examining this issue yet either.

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Furthermore, current research on crowdfunding suggests that asymmetric information problems persist and are inherent in crowdfunding platforms. This implies that the need for intermediation still exists in crowdfunding innovation.

Therefore, while at the superficial level crowdfunding avoids the use of traditional financial intermediaries to generate funds, the main objectives of financial intermediation persist in this FinTech innovation. Crowdfunding platforms substitute for traditional financial intermediaries and thus serve as a new form of intermediary.

A review of ‘blockchain’ research suggests that true disintermediation might be possible in some finance areas but not all. The core of blockchain technology is that it enables people to reach a consensus in a decentralised way. It breaks the old paradigm of requiring trusted centralised third parties to dictate the validity of a transaction. This has historically been the major role of banks (traditional financial intermediaries). Blockchain could disintermediate banks by offering trust in a decentralised way. However, this does not suggest the traditional intermediaries will be eliminated by this emerging technology, as building systemic trust in transactions is not the only role that intermediaries play. On the other hand, blockchain can also be used by banks to reinvent (i) their processes and (ii) the products they offer. Blockchain can eliminate the necessity of intermediation in some areas, bring new forms of intermediation and, at the same time, reduce the layers of traditional intermediation.

Bitcoin, for example, has eliminated the classic intermediary of central banks. In lieu of intermediated governance, Bitcoin holders govern themselves through a publicly available blockchain ledger that manages large sums of money and millions of users. However, Bitcoin is not yet a major currency. When Bitcoin holders want to convert their cryptocurrencies into fiat currencies, exchange needs to occur, and thus, there is a need for third-party platforms to allow such a conversion. Before suspension of trading and bankruptcy in February 2014, Mt. Gox was the largest Bitcoin exchange platform, handling 70 percent of global Bitcoin transactions in 2013. Mt. Gox was a new intermediary and it dominated the early development of Bitcoin. Without this intermediary, people cannot move value from Bitcoin to fiat currencies and Bitcoin will have huge difficulties to interface with the rest of the world. That is to say, despite Bitcoin’s disintermediation from conventional financial infrastructure, it is still important to build up a new infrastructure with intermediation to allow the conversion between Bitcoin and fiat currencies to occur.

ICO (‘initial coin offering’, also known as a token sale) is another example that traditional intermediaries may be eliminated or reshaped in fundraising. Following the disruptive crowdfunding and blockchain technology, ICO rapidly surged in 2017. An ICO can be viewed as a joint application of crowdfunding and blockchain innovations. It is a form of crowdfunding, except it uses the blockchain technology to verify transactions. An ICO works

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12 Wikipedia, 2018, Mt. Gox. Available at https://en.wikipedia.org/wiki/Mt._Gox
similarly to an initial public offering (IPO). However, instead of offering shares in a company, a firm offers digital units of value called ‘tokens’ to public. Tokens traded in an ICO can be cryptocurrencies such as Bitcoin and others, or a token can be created on top of a blockchain and governed by a smart contract. Tokens do not represent ownership in the company that created them, nor are they considered securities in many countries. In an ICO, the investor would buy the token and the company would use that money to complete the project or portion of the project, which is based on the token itself. If the creation is successful in market, the token increases in value. Traditionally, start-ups raised capital through venture capitals (VCs). As financial intermediaries, venture capitalists take on the risk of financing risky start-ups in the hopes that some of the firms they support will become successful. When a VC invests in a start-up, they are looking for a possible successful IPO, merger or acquisition so they can exit and deliver returns to VCs’ investors. However, ICO investors bypass the traditional VC financial intermediaries to invest directly on start-ups and early investors can choose when to exit on companies through token trading. Moreover, blockchain tokens are scarce, global, liquid and tradable, making them especially appealing to global investors (Coinbase, 2016 and Massey et al., 2017). This new method of fundraising has existed for only a couple of years, and it has already enabled entrepreneurs and innovators to raise billions of dollars from global investors. Based on CoinSchedule website’s statistics, globally, in 2016, ICO raised around $95 million, and the following year, the ICOs raised more than $3.72 billion. For the first 6 months in 2018, more than $16 billion has been raised through ICO. In comparison, the traditional venture capital industry invests an average of $30 billion each year.

Another example is that blockchain can also help banks to reduce the layers of intermediation to improve the payment process. To date, the average bank global transfer takes ~3 days to be settled. This length of time is driven by the need for funds to (usually) flow through a number of intermediaries—corresponding banks and custodial services—before finally landing at their destination. The actual balances also need to be reconciled via a complex network of financial intermediaries. A blockchain could improve this process. By having a distributed ledger with a history of transactions that is visible and transparent to all relevant parties, banks could avoid having to use a third party to reconcile and settle transactions. This interbank blockchain can reduce the layers of intermediaries and therefore speed up the process and reduce associated costs. In a paper penned by Santander InnoVentures, it is estimated that this could save between $15 and $20 billion per annum by 2022 (Anthemis 2015). The awareness of the technology’s potential has been growing rapidly, and this prompts financial institutions to explore the emerging opportunities. For instance, 10 major world stock exchanges including London Stock Exchange, CME, Deutsche Börse,

13 CoinSchedule is an online website that provides ICO statistics. Data are retrieved on 10 August 2018 from https://www.coinschedule.com/stats.html?year=2017

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NYSE and Nasdaq have been working towards the application of blockchain technology in payments systems (Rizzo, 2016). According to World Economic Forum (2016), 80 percent of banks have declared the willingness to initiate blockchain technology projects by the end of 2017. This trend suggests that by reducing the layers of intermediaries and therefore the transaction cost, some of the traditional financial intermediaries can be more efficient and more transparent, which in turn will remain persistent in finance.

Findings from the review show that FinTech research is fragmented and our understanding of FinTech applications is still very limited. With the rapid growth of FinTech, we are currently witnessing the evolution of financial intermediation, with traditional intermediaries adopting new techniques and new intermediaries beginning to emerge. These traditional and emergent intermediaries are either competing or cooperating. Industrial practices are moving much faster than our academic understanding, with new phenomena that cannot be fully explained by existing studies. We are blueprinting a new era for the financial industry, but we have very limited research to support us in doing so. There is a range of unsolved puzzles that urgently need to be addressed. For instance, in the case of crowdfunding, existing studies fail to address whether and to what extent peer-to-peer platforms can really differentiate themselves from traditional funding channels. One of the main issues that persist in peer-to-peer platforms is information asymmetry; it would be very interesting to see how we might adopt the blockchain innovation in peer-to-peer platforms to mitigate this information asymmetry problem.

In the case of Bitcoin, a very interesting and important area of future study is the role of the miner and their strategic behaviour in mining competition. As discussed, Bitcoin has a high level of reliance on miners. These miners validate every Bitcoin transaction, they build and store all the blocks, and they reach a consensus on which blocks to include in the blockchain. In return, they are awarded with Bitcoins and transaction fees. In doing so, to some extent miners function as a new intermediary, similar to the role of a traditional bank. Retrospectively, it might be worthwhile to compare miners with the origin of a central bank and its development (such as the Bank of England). Prospectively, it would be interesting to examine the strategic behaviours and decisions of miners. Bitcoin decentralisation is achieved without a centralised authority by means of weighting miners’ costs (hardware costs and operating costs such as electricity bills and cooling systems) and rewards. As such, an examination of this equilibrium is warranted.

FinTech covers digital innovations and technology-enabled business model innovations in the financial sector. The scope of this review is limited to crowdfunding and blockchain only. It does not suggest only crowdfunding and blockchains are disrupting the existing finance intermediation. Rather, other FinTech innovations that are not covered in this paper are also (may be) disrupting financial intermediation. Mobile payment is an innovation that is not included in review, but it is disrupting the traditional role of banks in the
payments process, particularly in emerging markets. Mobile payment is an electronic wallet service which allows users to store, send and receive money using their mobile phone, providing a gateway to financial inclusion. It is already popular in Asia (e.g., Japan, Korea and China) and parts of Africa (e.g., Kenya, Tanzania and Uganda). The latest GSMA report, ‘The 2017 State of the Industry Report on Mobile Money’, shows that in 2017, the mobile payment industry processed transactions worth US$1 billion dollars a day, generating direct revenues of over US$2.4 billion. Mobile money is reaching scale all over the world, and it is affecting the traditional banks’ ability to generate revenue through credit and debit cards. Research on mobile money is fragmented but shows its potential great impact on the economic outcomes in developing countries and the disruptive nature of this innovation. By examining the rapid growth of mobile money in Africa, Aker (2010) and Aker and Mbiti (2010) suggest that mobile money systems offer new opportunities for distributing cash transfers and can affect economic outcomes in developing countries. In addition, using Kenya’s data, Jack and Suri (2014) provide empirical evidence that mobile money has had a significant impact on risk sharing attributable to the reduction in transaction costs (the costs of transferring resources between individuals). Artificial intelligence (AI), machine learnings and robot-advisor that are not covered are also expected to disrupt the financial intermediaries. These technologies are the catalyst of new innovative products emerging in the financial markets, and they may form new forms of financial intermediaries or provide access to direct channels to investors and customers, thus bypassing traditional intermediaries. Artificial intelligence involves creating machines that teach themselves using logic. These ‘intelligent’ machines use machine learning and deep learning, giving the technology the ability to improve tasks and to perform tasks. AI makes possible advanced analytical tools, and this technology is being used and explored in financial services. For example, insurance providers are using AI to streamline process flows and fight fraud, some banks are using chatbots to improve customer experience, and some robot advisers are using AI solutions as part of their digital robot solution. In the future, new forms of financial intermediaries might be replaced by AI agencies and robot-advisors. The need for traditional banks may be changed, and some bank scenarios may be disintermediated.

A more fundamental area of future research therefore is the role of financial intermediaries and how this role might be changed. As previously discussed, although being disrupted by FinTech, intermediaries remain persistent in finance. However, we expect to see competition and cooperation among traditional and new intermediaries and we urgently need to examine and explain these phenomena to provide guidance to all participants such as incumbents, new entries and regulators. An essential economic role of an intermediary is to resolve the conflicting preferences of surplus units and deficit units, and thus encourage both savings and productive capital investment. Intermediaries perform a range of functions such as economies of scale, risk
management, asset aggregation and information clearing. It is worthwhile to examine whether, how and to what extent these functions of financial intermediation might be affected by FinTech innovations. For instance, in the past, traditional financial intermediaries have gained considerable economies of scale due to their size and the volume of business transacted. They also have obtained cost advantages through effective knowledge management and the accumulation of financial, economic and legal expertise. Powerful intermediaries often impose monopoly and generate outsized benefit for themselves, and their monopolistic position is an obstacle for improving products, increasing efficiency and bettering consumer experience. Research has suggested that the current financial system is rather inefficient: the unit cost of financial intermediation has declined only marginally since the 2009 global financial crisis (see Bazot, 2017 in Europe and Philippon, 2016 in the United States). FinTech innovations are threatening the traditional role of financial intermediaries as most FinTech innovations appear to be led by technology companies rather than by banks. Comparing with highly regulated banks, these star-up FinTech new entries are not held back by existing systems and they are less or even not regulated. Therefore, financial markets have become more competitive than ever, and we might expect in a more competitive market that financial intermediaries will pass on more efficiency gains to customers in the form of reduced interest margins and fees. For the future research, it is worthwhile to examine how incumbents respond to these challenges and whether and to what extent the FinTech new entries affect the unit cost of financial intermediation. Risk management is another promising future research area. Given FinTech innovations are disrupting financial services, the nature and scope of financial intermediaries’ risks as traditionally understood may be changed significantly over time and we might also need to identify the new and additional risks while the growth of FinTech innovations.

Conclusion

This review and discussion are intended to provide deeper understanding of FinTech and its impact on the financial industry. Current research is decentralised and not systematic; given the nature of FinTech and its influences, more cross-disciplinary studies utilising technology, economics and psychology are required to examine unaddressed puzzles.

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Appendix

**Blockchain Mechanism**

Blockchain is a distributed ledger which records information or transactions in a decentralised way. This ledger is formed by blocks of data on a chain. Each block contains data/information (i.e. groups of transaction in Bitcoin’s case), hash, and hash of previous blocks. Each block includes a reference to the block that came before it. This lineage of blocks is the basis of blockchains built with hash pointers. There is not a master database that is controlled by a centralised authority; instead, every node in Blockchain updates information independently, with the most popular record the de facto official record on the ledger in lieu of a master copy (Bitcoin n.d., Wikipedia. n.d.).

Several components work together to render blockchain incredibly transparent and secure in a decentralised way. First, data in a blockchain are
protected by hash. A hash is a long string of alphanumeric data, which is created by encrypting the data within the block based on a pre-designed cryptographic algorithm. If data in the blockchain are altered, the hash will change accordingly. This would invalidate the block, as each block also contains the hash of the previous block. Therefore, one incorrect hash in the chain will cause all future hashes to become invalid. For example, Bitcoin relies on several well-known cryptographic algorithms: SHA-256, RIPEMD-160 and Elliptic Curve Digital Signature Algorithm (ECDSA). Both SHA-256 and RIPEMD-160 are used in the creation of Bitcoin addresses. Elliptic Curve Digital Signature Algorithm (ECDSA) is used to generate a Bitcoin’s signature. SHA-256 is also used as the proof-of-work algorithm (further discussed in the following paragraph) (Bitcoinwiki. n.d., IWAR n.d.).

Second, in addition to protecting data, consensus among nodes is achieved through a specific type of consensus algorithm. This protocol enables nodes in the Blockchain network to work together to update the ledger in a secure way. The consensus algorithm ensures that through decentralisation, the next block to be added onto the chain is the one and only version of the truth in the system. The first blockchain consensus protocol is ‘proof-of-work (PoW)’. Bitcoin PoW requires that each node that wants to add a new block into the existing blockchain (also known as miners) must solve a hash puzzle that is based on the SHA-256 cryptographic algorithm. The miner that finds the solution can then confirm the transactions and add a new block onto the chain. In return, the winning miner receives Bitcoin as a reward. With a cryptographic hash, a huge amount of computational effort is required to find this solution and the reward is generous (1BTC = AUD 10,107.00 as of 3 June 2018). This reward system incentivises miners to generate the right solution and ensures the network is secured.

In addition to the consensus algorithm, each block that is added to the blockchain must follow a certain set of consensus rules. For example, Bitcoin’s consensus rules include no double-spends and correctly formatted transactions and blocks. When a new block attempts to be added, its PoW must be verified by each node in the network and all other consensus rules must be followed as well. The network must reach a consensus (51 percent) that the new block is valid. The combination of the PoW consensus algorithm and the consensus rules produces a decentralised yet reliable network. It also is important to note that besides PoW, other consensus algorithms such as proof-of-stake (PoS) and delegated proof-of-stake (DPoS) are also used in blockchain applications.