

BLOCKCHAIN AND CENTRAL BANKING:

an investigation into distributed ledger
technology and central bank digital currency

Australian Institute for Business and Economics

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Create change

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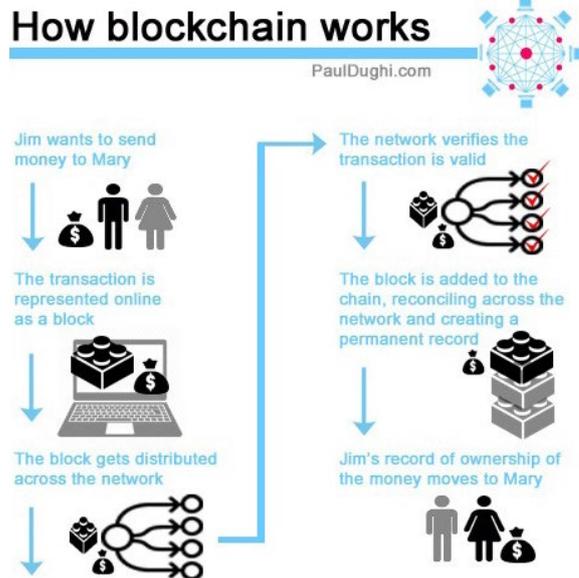
Fundamentals of Blockchain

Blockchain Technology

In response to the Global Financial Crisis (GFC) of 2008, a paper was released anonymously under the pseudonym of Satoshi Nakamoto detailing a peer-to-peer electronic cash system¹. The paper was brought into reality the following year in the form of Bitcoin which began to gain traction and public attention, ultimately encapsulated by a market peak at the end of 2017 of \$19600USD². Since then, blockchain technology has attracted the interests of economies globally for its broad set of applications and disruptive capabilities.

To begin, it's important to understand the fundamental difference between blockchain and cryptocurrency. Blockchain allows the operation of a "trustless", peer-to-peer (P2P) transaction system, where cryptocurrency is just one of many possible transferrable products³. These transfers are made possible through the distributed ledger technology (DLT) which allows transactions to be "distributed" across a network⁴. Ultimately, this allows blockchain to operate as a distributed database which synchronises across a network without the need for a centralised administrator.

Figure 1:



Source: PaulDughi.com

Figure 1 details the process of blockchain technology is broadly explained through this infographic which explains how transactions occur across "nodes" (i.e. Computers)⁵. Note that the transaction can be based on any information, from money (as depicted) through to contacts or securities.

1 Nakamoto, Satoshi (2008) Bitcoin: A Peer-to-Peer Electronic Cash System bitcoin.org <https://bitcoin.org/bitcoin.pdf>
 2 Richards, Tony (2018) Cryptocurrencies and Distributed ledger technology Reserve Bank of Australia (RBA) <https://www.rba.gov.au/speeches/2018/sp-so-2018-06-26.html>
 3 Plansky, John; O'Donnell, Tim; Richards, Kimberly (2016) A Strategist's Guide to Blockchain Strategy+Business <https://www.strategy-business.com/article/A-Strategists-Guide-to-Blockchain>
 4 Investopedia (2018) Distributed Ledgers Investopedia <https://www.investopedia.com/terms/d/distributed-ledgers.asp>
 5 Dughi, Paul (2018) A Simple Explanation of how Blockchain Works The Mission <https://medium.com/the-mission/a-simple-explanation-on-how-blockchain-works-e52f75da6e9a>



Blockchain is considered to be secure as all transfers within the network must be verified by multiple nodes of the network, after which they are permanently added to the blockchain⁶. Further, after a block is added to a blockchain, it can only be altered if over half of the computing power within the network agree it should be changed – a difficult feat⁷. This also explains why the technology is considered to be “trustless”; whereas transfers between individuals are usually facilitated by some centralised body (think financial transactions and financial institutions, or even Gmail and Google), the nature of a P2P system is such that it does not require a centralised body, and therefore does not require trust in any institution, only the system by which it fundamentally operates⁸.

Cryptocurrency

Cryptocurrencies are built upon blockchain technology, and thus are similarly decentralised and secure. They are stored in digital wallets which can only be accessed by a user with the appropriate “key” or password. The main differences between cryptocurrencies come within the validation phase which determines cryptocurrency supply and blockchain management. In general, the underlying systems of cryptocurrency will reward “miners” who confirm transactions with currency, however, it is worth noting that there are a wide range of different systems for authenticating transactions. Two examples are the proof of work and the proof of stake schemes, where the former rewards the individual or group who completes the final part of a complex problem, and the latter rewards each contributor proportionally to their contributions. It should be noted that these are not inherent to blockchain technology. Some cryptocurrencies place a cap on the total amount of currency, while others take a more inflationary stance. A good comparison here is between Bitcoin and Ethereum, perhaps the two most popular currencies where Bitcoin has a quantity cap of 21 million which is reached by increasing the supply as a reward to Bitcoin miners, Ethereum increases its supply by 2% each year⁹, where the additional supply is allocated to so-called “stakers” who provide their own currency as collateral in the case of false transactions¹⁰. This illustrates the flexibility of the technology – it can be moulded to suit different goals and ends.

6 PwC (2018) Making sense of Bitcoin, Cryptocurrency and Blockchain PwC United States <https://www.pwc.com/us/en/industries/financial-services/fintech/bitcoin-blockchain-cryptocurrency.html>

7 7. Investopedia (2018) 51% Attack Investopedia <https://www.investopedia.com/terms/1/51-attack.asp>

8 Malanov, Alexey (2017) Six Myths about Blockchain and Bitcoin: Debunking the Effectiveness of the Technology Kaspersky Lab <https://www.kaspersky.com/blog/Bitcoin-blockchain-issues/18019/>

9 Though this 2% increase is capped at 18 million per year, meaning the currency will inflate by less than 2% after reaching a total volume of 900 million.

10 Bayless, Evan (2018) Programmatic Monetary Policy: Blockchain as Central Bank Hackernoon <https://hackernoon.com/programmatic-monetary-policy-blockchain-as-central-bank-fa787b51ef8a>

Applications of Blockchain

Though this report specifically discusses blockchain in central banking operations, this is far from the only significant use of the technology. Indeed, this technology has plenty of applications across the entire global economy. Perhaps the most apparent applications of blockchain is as a cost-saving measure. The ability to validate transactions without intermediaries has the potential to create massive amounts of redundancies in the financial sector, possibly leading to significant structural unemployment. This will further be improved by smart contracts, an application of blockchain technology which “automatically implements the terms of an agreement between parties” and may improve efficiencies in everything from the insurance industry to the health industry¹¹. This technological disruption of intermediaries has the potential to ripple through all sectors of the economy.

The technology is also secure in that transactions are validated and then permanently saved to the blockchain, which can then be audited, thereby allowing it to double as a method of accountability. This can again be strengthened with smart contracts which could be implemented to ensure businesses are acting within regulations.

Table 1: Blockchain and its applications across industries

Industry	Blockchain-based applications
Financial services	<ul style="list-style-type: none"> International payments in a faster, cheaper, and more secure way with lower counterparty risk¹⁷ Registry for better Know Your Customer (KYC) checks and compliance¹⁸ Trade finance blockchain platform to improve and accelerate the financing of international trade
Health care	<ul style="list-style-type: none"> Ability to share clinical trial launches and enrollments in real time to better match patients and prevent double enrollments Smart contracts to connect different parties—such as providers, insurers, vendors, and auditors—and automate transactions¹⁹
Public sector	<ul style="list-style-type: none"> Registry to manage the digital identity of people and the ownership and transaction information on different assets such as real property and vehicles to increase efficiency and reduce fraud²⁰ Enhanced security and transparency of voting in public election²¹
Energy and resources	<ul style="list-style-type: none"> Smart contracts for more efficient and faster execution of energy trades and payments²² Managing and recording oil and gas transactions and connecting suppliers, shippers, contractors, and authorities via blockchain to improve supply chain processes²³
Technology, media, and telecom	<ul style="list-style-type: none"> Storing cryptographic hash of original music, linked to digital identities of owners, and using smart contracts to facilitate compensation for music²⁴ Supporting data storage and interaction among a large number of IoT devices in a cryptographic format to help mitigate security concerns²⁵
Consumer and industrial products	<ul style="list-style-type: none"> Better management of loyalty points programs in retail and travel and hospitality²⁶ Streamlining the vehicle buying and leasing process with less documentation and automated payments²⁷ Enhanced supply chain management, especially traceability across products from its inception at manufacturer to usage by end customer²⁸

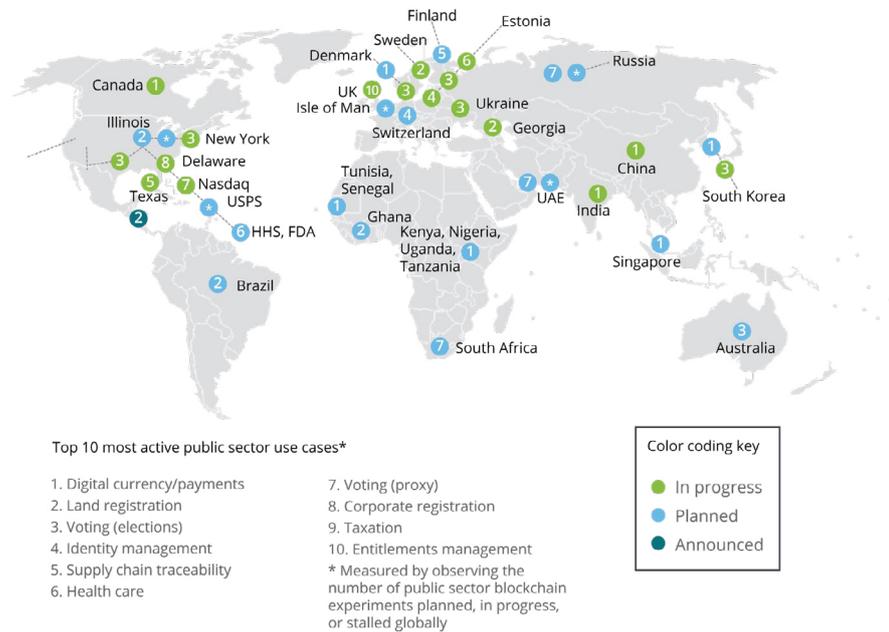
Source: Deloitte Insights

Table 1 lists some further applications of blockchain technology¹².

¹¹ Schatsky, David (2016) Getting Smart about Smart Contracts Deloitte <https://www2.deloitte.com/us/en/pages/finance/articles/cfo-insights-getting-smart-contracts.html>

¹² Iscini, Eric; Cotteleer, Mark; Holdowsky, Jonathan (2018) Blockchain: A Technical Primer Deloitte Insights <https://www2.deloitte.com/insights/us/en/topics/emerging-technologies/blockchain-technical-primer.html?d=us:2em:3na:4di4436:5awa:6di:062818:summer2018&sfid=00310000032TqhGQAS>

Figure 2: Blockchain in the public sector, as of March 2017



Source: Deloitte; Fletcher School at Tufts University

Figure 2 provides a brief overview of some applications being implemented globally by governments¹³.

While one of the big draws of blockchain has been its decentralised nature, it may be the case that it will be best implemented in complex, centralised institutional bodies; the use of permissioned blockchains where only certain individuals and groups can contribute to the blockchain as opposed to public blockchains like those found in cryptocurrencies like Bitcoin. One reason for this is that it allows for a greater degree of anonymity. Whilst blockchain technology does not require an individual to be transparent with their identity, any transactions they make within the chain is attached to their electronic address, meaning they are acting with pseudonymity rather than anonymity because if an individual's identity is connected with their electronic address, their entire history of transactions can be found through the blockchain¹⁴. If this is held only by government, or only by banks, then similar anonymity will exist to today based upon the current operations of these institutions, though potentially with a more secure and efficient system.

Another issue is the size of the blockchain itself which increases with every transaction. In a public blockchain, this must be downloaded by at least some users at no benefit to themselves¹⁵, while others can 'piggyback' off of them, only using the server and not contributing to the system itself. As a blockchain increases in size, it will be less and less accessible for more and more users, whereas this is not as much of an issue for institutions which could adapt to this constraint.

Ultimately, it is clear that blockchain can have large impacts upon industries throughout the economy. From here, the paper will focus on the applications of blockchain technology on central banks.

¹³ Borak, Masha (2018) China's Government is Harnessing its data to make Blockchain-Based Identity a Reality Technode <https://technode.com/2018/07/02/chinese-government-blockchain>

¹⁴ Emerging Technology from the arXiv (2017) Bitcoin Transactions Aren't as Anonymous as Everyone Hoped MIT Technology Review <https://www.technologyreview.com/s/608716/Bitcoin-transactions-arent-as-anonymous-as-everyone-hoped>

¹⁵ A reward system could be implemented to encourage users to download the blockchain, however this will also increase transaction costs.

Political Landscape - A Summary of Central Bank Thinking

Central Banks

Before discussing blockchain in relation to central banking operations, it is essential first to understand how central banks currently operate. The role of central banks is not entirely consistent across nations, however in the context of Australia, the duty of the Reserve Bank of Australia (RBA) is “to contribute to the stability of the currency, full employment, and the economic prosperity of the Australian people”¹⁶. It achieves this through the setting of a medium-term cash rate to meet the inflation target of 2-3%, as well as through facilitation of the financial system and the payments system and distribution of banknotes¹⁷. The cash rate is determined through Open Market Operations in which the RBA purchases varying quantities of assets like government bonds from banks in exchange for exchange settlement funds¹⁸. Financial stability is ensured alongside other government agencies who mitigate and step in when there are disturbances in the financial system, and the RBA works to maintain efficiency and competition in the payments system¹⁹.

Central Banks and Blockchain

While central banks around the world have thus far primarily withheld from implementing blockchain technology in their operations, there has been significant interest as to its potential applications to the role of central banks, whether it be through the implementation of DLT, or specifically cryptocurrencies.

While many central banks are aware of the current technological constraints of cryptocurrency and its applications, there is a consensus that DLT may have a future in central banking operations. This is perhaps best highlighted by the collaboration between the Bank of Japan and the European Central Bank to investigate the potential implications of the technology²⁰. Thus far, they have conducted two stages of research. One into the use of DLT in transaction settlement systems as a comparison to real-time gross settlement systems²¹, and another into the use of DLT in the transfer and settlement of securities²². Both presented promising results, with system resilience and performance being sighted as benefits the technology holds over current technologies, however with the acknowledgement that further testing of the technology would be required before wider-scale application.

Some banks are weighing up the costs and benefits of implementing blockchain-based currencies. This is seen through the Central Bank of the Netherlands who

¹⁶ Reserve Bank of Australia (RBA) (2018) About the RBA RBA <https://www.rba.gov.au/about-rba/>

¹⁷ Reserve Bank of Australia (RBA) (2018) About the RBA RBA <https://www.rba.gov.au/about-rba/>

¹⁸ Reserve Bank of Australia (RBA) (2018) Domestic Market Operations RBA <https://www.rba.gov.au/mkt-operations/dom-mkt-oper.html>

¹⁹ Reserve Bank of Australia (RBA) (2018) About the RBA RBA <https://www.rba.gov.au/about-rba/>

²⁰ European Central Bank; Bank of Japan (2017) Payment Systems: Liquidity Saving Mechanisms in a Distributed Ledger Environment STELLA

²¹ European Central Bank; Bank of Japan (2017) Payment Systems: Liquidity Saving Mechanisms in a Distributed Ledger Environment STELLA https://www.ecb.europa.eu/pub/pdf/other/ecb.stella_project_report_september_2017.pdf

²² European Central Bank; Bank of Japan (2018) Securities Settlement Systems: Delivery-Versus-Payment in a Distributed Ledger Environment http://www.boj.or.jp/en/announcements/release_2018/data/rel180327a1.pdf



created a cryptocurrency called DNBcoin to be used internally for testing²³. Additionally, as a country standing at the vanguard of the decline of physical currency, Sweden's central bank (Riksbank) is considering the benefits and disadvantages of implementing an e-krona to continue to provide citizens with access to a central bank currency²⁴.

Another example is China is currently in the process of introducing a government-controlled cryptocurrency²⁵. Over the last four years, the use of cash has declined dramatically, being replaced by online transactions which grew in usage by 113.4% in just the first quarter of 2017, and gross merchandise volume of online payments being 50 times greater than that of the United States²⁶. This has opened up the gateway for a national cryptocurrency to be implemented; in an increasing absence of physical cash, China is seeking to provide an alternative without altering the roles of the central bank and commercial banks²⁷.

RBA and Blockchain

In the context of Australia, the RBA has discussed the possibilities of blockchain. In a speech presented by the Governor of the RBA, Phillip Lowe, a range of blockchain topics were discussed, from Central Bank Digital Currency (CBDC) to be operated either with electronic wallets or via mainstream and accessible exchange settlement accounts with the RBA, through to DLT in comparison to the recently implemented New Payments Platform (NPP) which is a new transaction system shared by Australian banks²⁸.

The most significant argument for CBDC the RBA is currently taking into account is the reduction in the “electronic fingerprint” of the individual since the institution could produce the technology such that it would be entirely anonymous (as physical cash is), or at worst so that only they could track usage, thus assisting with investigations into fraud and illegal activity²⁹. At its worst, it could lead to bank runs due to the ease of transferring funds online from one account to another as opposed to the effort of an individual withdrawing all cash in their accounts³⁰.

23 Ozelli, Selva (2018) Upbeat Dutch Blockchain and Crypto Action Agenda Coin Telegraph <https://cointelegraph.com/news/upbeat-dutch-blockchain-and-crypto-action-agenda>

24 Riksbank (2018) E-Krona Riksbank <https://www.riksbank.se/en-gb/financial-stability/payments/e-krona/>

25 Leng, Sydney; Lu, Xie (2018) China is Open to Idea of a Digital Currency, as long as it's 'Efficient and Safe' South China Morning Post <https://www.scmp.com/news/china/economy/article/2136551/china-open-idea-digital-currency-long-its-efficient-and-safe>

26 iResearch (2017) The GMV of China's Third-Party Mobile Payment Shot Up 113.4% in Q1 2017 iResearch Global http://www.iresearchchina.com/content/details7_34723.html

27 Leng, Sydney; Lu, Xie (2018) China is Open to Idea of a Digital Currency, as long as it's 'Efficient and Safe' South China Morning Post <https://www.scmp.com/news/china/economy/article/2136551/china-open-idea-digital-currency-long-its-efficient-and-safe>

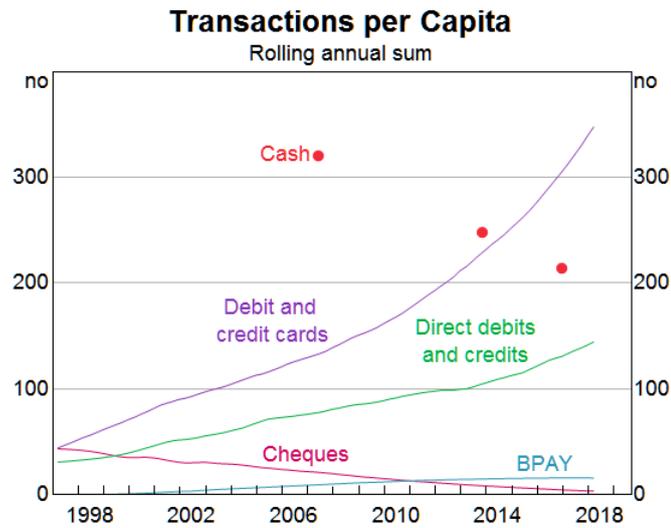
28 Lowe, Phillip (2017) eAUD? Reserve Bank of Australia <https://www.rba.gov.au/speeches/2017/sp-gov-2017-12-13.html>

29 Lowe, Phillip (2017) eAUD? Reserve Bank of Australia <https://www.rba.gov.au/speeches/2017/sp-gov-2017-12-13.html>

30 Lowe, Phillip (2017) eAUD? Reserve Bank of Australia <https://www.rba.gov.au/speeches/2017/sp-gov-2017-12-13.html>

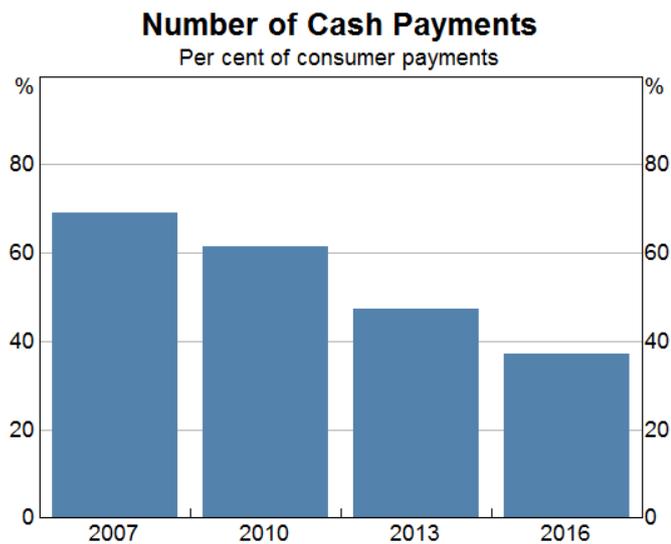
Regardless, the point was made that cash is still used often, if at a declining rate, and thus there is not currently a significant need to consider the prospects of an alternative seriously, and especially considering the recent implementation of the NPP it may be difficult to justify a new system which would produce marginal improvements³¹. Ultimately, the RBA remains cautious of cryptocurrency technology as is the case with many other central banks, appearing particularly critical of Bitcoin, however, is interested in the possibilities blockchain technology might provide into the future.

Figure 3:



Source: ABS; AusPayNet; BPAY; Colmar Brunton; Ipsos; RBA; Roy Morgan Research

Figure 4:



Source: RBA calculations, based on data from Colmar Brunton, Ipsos and Roy Morgan Research

Figures 3 and 4 demonstrate the decline in cash usage and increase in digital transaction methods in Australia³².

31 Reserve Bank of Australia (RBA) (2018) Launch of the New Payments Platform RBA <https://www.rba.gov.au/media-releases/2018/mr-18-02.html>

32 Richards, Tony (2018) Cryptocurrencies and Distributed ledger technology Reserve Bank of Australia <https://www.rba.gov.au/speeches/2018/sp-so-2018-06-26.html>



Applications of Blockchain to Central Bank Operations

Now that an outline of the underlying technology has been presented and there has been a discussion of the current views held of central banks internationally and domestically, this final section will present an in-depth analysis of the major applications blockchain could have upon central banking operations. The topics which will be discussed focus upon the potential of DLT, as well as the properties and consequences of a Central Bank Digital Currency.

Distributed Ledger Technology

The Current State of Transfer Settlement Systems

To consider the effects of DLT, current payment systems must first be understood. Real-time gross settlement (RTGS) systems are used by central banks to settle credits and debits to exchange settlement accounts; accounts held by financial institutions with the central bank. Countries tend to use different types of RTGS, where Australia's is called the Reserve Bank Information and Transfer System (RITS).³³ The New Payments Platform (NPP) operates within the RITS, and is an innovation implemented in February 2018 allowing for fast transfers any time or day of the year.³⁴ In the finance industry, DLT has already been implemented for cost-saving, efficiency, speed, and entirely new systems to work around regulations, all of which have gone on to cause central banks to ask whether or not DLT could be implemented to provide improved RTGS systems³⁵. Consequently, it may be the case that central banks should wait to see whether or not DLT is worth implementing, or whether the market will organise itself efficiently.

The Position of Banks

Currently, central banks do not see DLT as a viable technology in replacing the current payments systems which deal with a high volume of transactions. The Bank of Japan, European Central Bank, as well as the Bank of Canada have all declared that DLT cannot replace payments systems at its current level of development³⁶. The Federal Reserve is researching DLT and cryptocurrencies to understand how they can improve the US payment system, and other central banks like the Royal Bank of Scotland and the Monetary Authority of Singapore have built proof-of-concept DLT-based prototype systems³⁷.

³³ Reserve Bank of Australia (RBA) (2018) About RITS RBA <http://www.rba.gov.au/payments-and-infrastructure/rits/about.html>

³⁴ Reserve Bank of Australia (RBA) (2018) About RITS RBA <http://www.rba.gov.au/payments-and-infrastructure/rits/about.html>

³⁵ Del Rio, Cesar Augusto (2017) Use of Distributed ledger technology by Central Banks Enfoque UTE 8(5): 2

³⁶ Del Rio, Cesar Augusto (2017) Use of Distributed ledger technology by Central Banks Enfoque UTE 8(5): 2

³⁷ Del Rio, Cesar Augusto (2017) Use of Distributed ledger technology by Central Banks Enfoque UTE 8(5): 2

Table 2:

Adoption Status	Number	Percentage excluding central banks with no information
Not interested	0	0%
Open to it	8	24%
Studying it	13	38%
Experimenting	13	38%
Pilot	0	0%
Operational	0	0%.
Total	0	100%

Source: Del Rio, Cesar Augusto

Table 2 shows what stage central banks are at in researching and developing DLT technology. It is worth mentioning that only 34 central banks provided responses in this study³⁸.

Current Technological Barriers

The main limitation of DLT is the time the technology takes to settle transactions is not yet capable of surpassing current central banking operations³⁹. Additionally, it is not clear that the cryptographic tools used to secure the technology will continue to be as secure as technology continues to improve – it could be that improvements in computing power (such as quantum computing) will weaken the ability of this system, though it could equally allow the technology to improve in complexity⁴⁰. Further, there are questions of whether or not DLT can scale to match the current quantity of transactions per second, with Bitcoin at its peak completing 4.5 transactions per second, whilst Visa Net has a theoretical cap of 65000⁴¹. This being said, Ripple, another cryptocurrency, consistently completes 1500 transactions per second and claims to be scalable to handle similar quantities to visa⁴². These are just some of the issues the technology faces, with others including questions of costs, transparency, and how widely the network can be adopted⁴³. Ultimately, time will tell whether or not these issues are solved to a level of sufficiency which makes DLT better than current RTGS systems. This is a key question into the future; under what circumstances DTL will be faster and cheaper than RTGS systems?

Central Bank Digital Currency

The other blockchain application discussed in this paper is of Central Bank Digital Currency (CBDC). This will be discussed in terms of the characteristics of CBDC, followed by an analysis of how and why it could be implemented. There are two things to consider before beginning the discussion, being in relation to Open Market

38 The central banks include those from: Argentina, Australia, Austria, Belgium, Brazil, Canada, Chile, China, Czech Republic, Denmark, Estonia, Finland, France, Germany, Iceland, India, Ireland, Japan, South Korea, Netherlands, New Zealand, Norway, Poland, Russia, Slovenia, South Africa, Spain, Sweden, Switzerland, United Kingdom, United States, European Union, Bank of International Settlements.

39 European Central Bank; Bank of Japan (2017) Payment Systems: Liquidity Saving Mechanisms in a Distributed Ledger Environment STELLA

40 Del Rio, Cesar Augusto (2017) Use of Distributed ledger technology by Central Banks Enfoque UTE 8(5): 4

41 Richards, Tony (2018) Cryptocurrencies and Distributed ledger technology Reserve Bank of Australia <https://www.rba.gov.au/speeches/2018/sp-so-2018-06-26.html>

42 Ripple (2018) XRP: The Digital Asset of Payments Ripple <https://ripple.com/xrp>

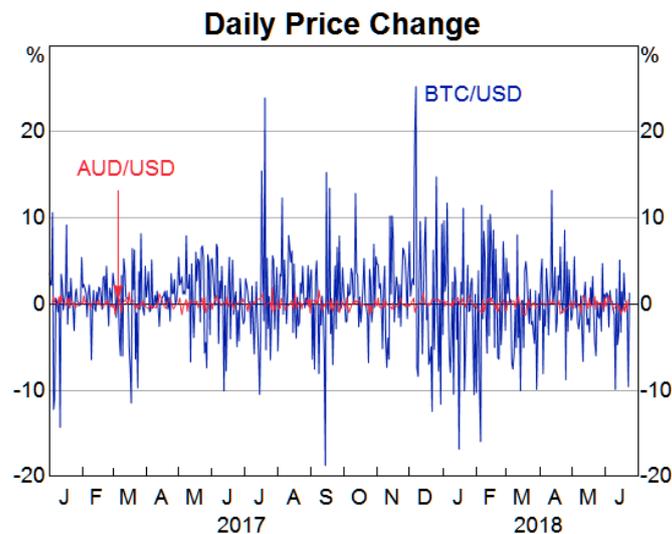
43 Del Rio, Cesar Augusto (2017) Use of Distributed ledger technology by Central Banks Enfoque UTE 8(5): 8-9

Operations (OMO), as well as an assumption about the digital currency. Were it the case that this technology was only implemented for transactions between the central bank and financial institutions usually participating in OMO, there does not seem to be much benefit in switching from the current system to a digital currency due to the NPP which already allows for fast and efficient transfers⁴⁴. Therefore, this section will focus upon the consequences of a CBDC accessible by individuals, not just financial institutions. Further, considering the decreased usage of physical cash discussed earlier, this topic adopts the assumption that CBDC replaces physical cash to adequately examine the consequences of the technology, an assumption which may prove true in the medium-to-long run.

A Unit of Account and a Medium of Exchange

While contemporary digital currencies tend to fluctuate in value significantly, this is largely considered to be due to the fact that they are rarely used as currency (amongst other reasons), and are instead generally treated as investments⁴⁵. Therefore, this is not a fear with a CBDC as it will essentially operate the same way in the economy as money does currently, therefore indicating that it can act as both a unit of account and as a medium of exchange⁴⁶. The currency can additionally act as a store of value however, this can be operated in a variety of strategies.

Figure 5:



Source: Coinmarketcap.com; RBA

Figure 5 compares the volatility of bitcoin compared to the AUD. Volatility in a digital currency is not inherent to the currency as much as how it's used. Where standard currency is continuously transferred to determine its value, many cryptocurrencies akin to Bitcoin are held as assets rather than currencies, meaning they are not traded in such density that a consistent value can be reached⁴⁷.

A Store of Value

CBDC could be implemented in three primary methods to facilitate the currency as a store of value, attaching the currency with a nominal value, a real value, or as an interest-bearing currency. With a nominal value the CBDC would operate identically

44 Lowe, Phillip (2017) eAUD? Reserve Bank of Australia <https://www.rba.gov.au/speeches/2017/sp-gov-2017-12-13.html>
 45 Richards, Tony (2018) Cryptocurrencies and Distributed ledger technology Reserve Bank of Australia <https://www.rba.gov.au/speeches/2018/sp-so-2018-06-26.html>
 46 Bordo, Michael D. and Levin, Andrew T. (2017) Central Bank Digital Currency and the Future of Monetary Policy National Bureau of Economic Research, Working Paper 23711: 5-8
 47 Richards, Tony (2018) Cryptocurrencies and Distributed ledger technology Reserve Bank of Australia <https://www.rba.gov.au/speeches/2018/sp-so-2018-06-26.html>



to physical cash, however in an online format⁴⁸. Attaching a real value would cause the funds to fluctuate with the price level, while an interest-bearing currency would do exactly as its name implies, whether the rate is positive or negative⁴⁹. The consequences of these systems will be discussed in relation to their potential applications, being through decentralised digital wallets akin to prominent cryptocurrencies, as well as about changes in the role of central banks and monetary policy.

Digital Wallets

The first method by which CBDC could be implemented is through digital wallets. As this would be a sovereign currency, the wallet function would still be facilitated by the central bank or financial institutions rather than the decentralised system currently implemented by most cryptocurrencies. Whether the central bank or financial institutions provide it then comes down to a question lies deep in economic thought, being whether or not banks should be able to roll-out their currency, or if a nation's currency should be backed fundamentally by a central bank. The Austrian school of economics has long-held the view that governments distort economies through the manipulation of the money supply so that they would stand in support of the privately issued fiat currency⁵⁰. However, economic recessions and depressions can lead to banks collapsing, and when these banks hold currency of individuals, said individuals could lose everything they own⁵¹. This is rectified by central banks which can either collateralise privately issued fiat currency or create their own currency as it, alongside regulation of how the currency can be used, reduces the freedom of banks to lend money. This operates as a safety net for consumers, making cash risk-free because of the government guarantee. Therefore, under these circumstances, the central bank would be the provider of the digital currency, or it would collateralise the currency for financial stability. The RBA has contemplated this option and found that due to the costs of backing or fully collateralising privately issued fiat money, the best way to implement this technology would be as CBDC⁵². Consequently, digital wallets could essentially operate as central bank accounts.

48 Bordo, Michael D. and Levin, Andrew T. (2017) Central Bank Digital Currency and the Future of Monetary Policy National Bureau of Economic Research, Working Paper 23711: 10

49 Bordo, Michael D. and Levin, Andrew T. (2017) Central Bank Digital Currency and the Future of Monetary Policy National Bureau of Economic Research, Working Paper 23711: 11-13

50 Rothbard, Murray N. (2012) The Austrian Theory of Money Mises Institute <https://mises.org/library/austrian-theory-money>

51 Note that the Austrian school of economics claims that without government intervention, market corrections will be far less often and less devastating (Rothbard, Murray N. (2012) The Austrian Theory of Money Mises Institute), however even if this is true, simply shifting to a privately issued currency system would not remove government intervention.

52 Lowe, Phillip (2017) eAUD? Reserve Bank of Australia <https://www.rba.gov.au/speeches/2017/sp-gov-2017-12-13.html>

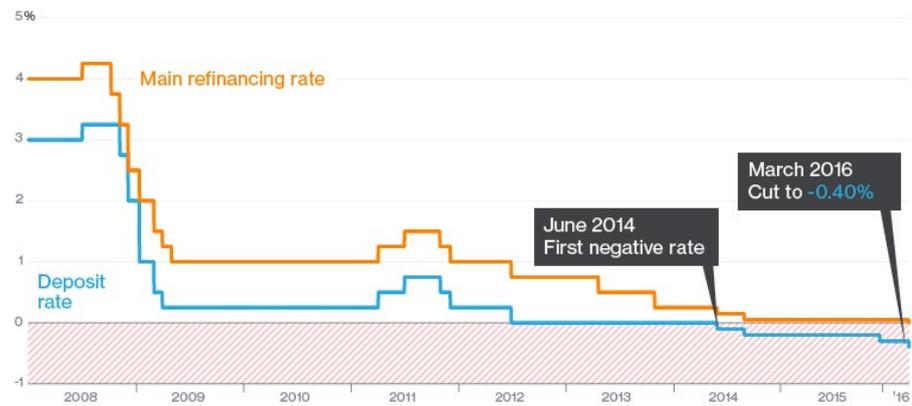
Implications of the Types of CBDC

A nominally-based CBDC would cause individuals in an economy to operate similarly to how they operate now, being incentivised to invest their funds rather than hold onto them as they deteriorate in value with inflation as is currently the case with cash. However, this would uphold the current zero-lower bound as individuals would have no trouble transferring funds from a bank account to their central bank account, meaning interest rates at and below zero would have the same impact upon consumer behaviour. In times of economic stress, this would place a heavier emphasis on unconventional monetary policy (such as quantitative easing).

Figure 6:

Europe Dives Below Zero

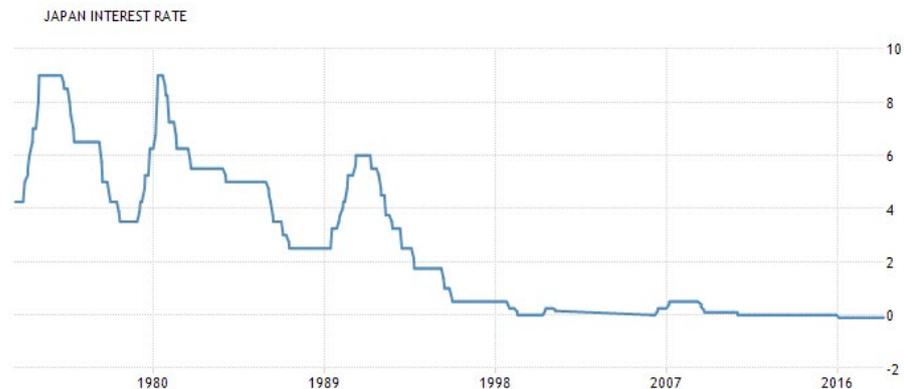
European Central Bank rates



Source: European Central Bank

The zero-lower bound exists when the cash rate is 0%. The European Central Bank reached this level trying to stimulate its economy to recover from the GFC, and consequently, the interest rate of the deposit facility has become negative⁵³. A nominally-based CBDC would experience this same zero-lower bound.

Figure 7:



Source: Tradingeconomics.com; Bank of Japan

The Bank of Japan has set its cash rate at -0.1%, below the zero-lower bound⁵⁴.

53 Randow, Jana and Kennedy, Simon (2017) Negative Interest Rates Bloomberg <https://www.bloomberg.com/quicktake/negative-interest-rates>

54 Trading Economics (2018) Japan Interest Rate Trading Economics <https://tradingeconomics.com/japan/interest-rate>



A currency valued in real terms would place a heavier restriction upon monetary policy as individuals and institutions would shift their funds into CBDC when real interest levels fall below zero⁵⁵. At the time of this paper, the Australian cash rate sits at 1.5% and inflation at 1.9%, indicating that the real cash rate is -0.4%⁵⁶. Where this sort of CBDC in existence now, monetary policy would currently be set below the zero-lower bound, demonstrating how this would only further restrict the power of monetary policy.

Finally, an interest-bearing currency could mitigate the need for unconventional monetary policy. By attaching the monetary policy cash rate or deposit rate⁵⁷ to the CBDC, the zero-lower bound will no longer exist as the CBDC will also be attached to an interest rate⁵⁸. However, it could also affect investments and fiscal policy funding as it would come out as a competitor to government bonds as a risk-free asset. The interest rate would set a yield floor, meaning the yield bids for government bonds would always tend to be higher than said interest rates. The increased yields may be accompanied by a crowding-out effect where demand for government bonds decrease in the private sector, but increase from the RBA as it expands its balance sheet to facilitate the increased liabilities from its commercial accounts⁵⁹.

55 Bordo, Michael D. and Levin, Andrew T. (2017) Central Bank Digital Currency and the Future of Monetary Policy National Bureau of Economic Research, Working Paper 23711: 11

56 Reserve Bank of Australia (RBA) (2018) <http://www.rba.gov.au/>

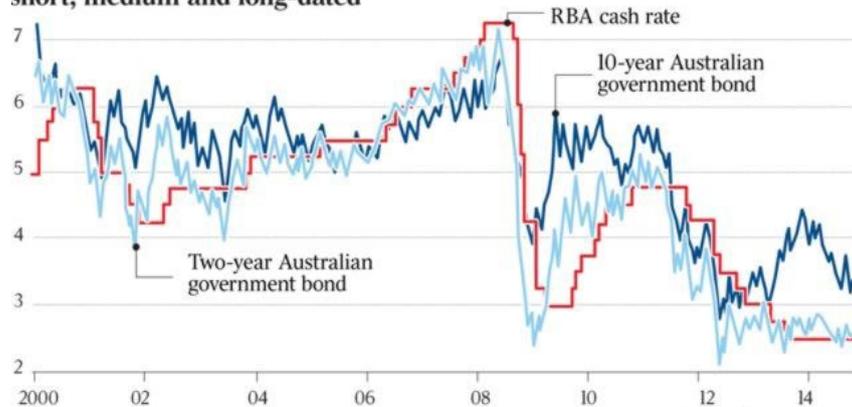
57 In Australia, the deposit rate is 0.25 percentage points below the cash rate, and is a restriction to guarantee the inter-bank trading rate does not fall significantly below the cash rate.

58 Bordo, Michael D. and Levin, Andrew T. (2017) Central Bank Digital Currency and the Future of Monetary Policy National Bureau of Economic Research, Working Paper 23711: 13

59 Committee on Payments and Market Infrastructure, Markets Committee (2018) Central Bank Digital Currencies Bank for International Settlements: 13 <https://www.bis.org/cpmi/publ/d174.pdf>

Figure 8:

**Our three key interest rates:
short, medium and long-dated**



Source: Bloomberg; Altius

Figure 8 demonstrates how closely government bonds are linked to the cash rate. Note that two-year bonds often fall below the cash rate.

In general, all these applications of CBDC share the fact that bank runs would occur much more efficiently – the difficulty of transferring funds electronically pales in comparison to the difficulty of withdrawing an entire bank account into cash. However, these could potentially be overcome by restricting the use of a central bank account. One potential strategy for this is to limit the amount of money that can be held in an account. A policy such as this one could distinguish between individuals and businesses, allowing some flexibility in how the limit could be implemented, whether through a specified limit (say, \$50000), or a sum proportional to total assets, which may, for example, be of assistance to investment funds. These restrictions could be implemented by government legislation, or perhaps as an extension of monetary policy. The latter possibility could be used as a soft stimulus technique, allowing the RBA to inject liquidity into markets (even if it's just banks) as a form of monetary policy by reducing the amount of CBDC able to be held. Such activities come at the expense of the central bank's reputation due to constraining how individuals allocate their funds. This is one example of how the issue of bank runs could be addressed.

Implementation of CBDC

While Phillip Lowe has claimed that the RBA is not looking to enter the commercial banking market, and considering the potential risks and lack of certainty around this new technology, there is a question of whether or not there is a case for CBDC at this time. However, aside from the improved efficiencies of blockchain technology, there are potential social and market benefits to be considered, including consumer control over their data, as well as a shakeup of commercial banking.

One of the most enticing elements of blockchain technology is the potential for individuals to gain control over their data. Currently, firms can use whatever data they can collect, however, blockchain could make this impossible without the permissions of individuals. By providing CBDC, even if the government chose to make the currency traceable in-house, the “electronic fingerprint” of individuals could be reduced⁶⁰. Therefore, one reason this technology could be implemented is to improve the privacy of individuals.

60 Lowe, Phillip (2017) eAUD? Reserve Bank of Australia <https://www.rba.gov.au/speeches/2017/sp-gov-2017-12-13.html>

In the aftermath of the GFC, new policies and regulations were implemented in financial sectors globally, with Australian bank bonds and deposits being guaranteed⁶¹. Further in response to the GFC, the international regulatory framework, Basel III, is in the process of being fully implemented with the goal of promoting stability across the financial system⁶². These policies and regulations make it increasingly difficult for banks to fail, even if it means they operate at what may be considered a less efficient manner, indicating a low level of risk. However, in the context of the big four banks in Australia, profits in the 2017 financial year ranged from \$6.6 billion to \$9.8 billion after tax⁶³, while interest rates in their savings accounts operate at approximately 2.5% returns⁶⁴.

To see why this may be a problem, the basic operations of banks should be understood. Banks require funds from individuals to run their operations, and these funds can come from shareholders or from savers who deposit money with them in savings accounts. This money is then used to make investments through the likes of loans and mortgages. The relationship here is that savings rates must be sufficiently lower than the average rate of return on their investments such that a profit is made and the bank continues to operate. Further, a portion of profits is redistributed to shareholders. In 2017, the average portion of profits amongst the big four banks was 75.2%⁶⁵.

Perhaps these profits will be disrupted given the ongoing royal commission into banking and the activities it has exposed, or perhaps the royal commission will cause governments to consider options which could shake-up the financial sector. These options may seek to reduce profits through tighter regulation, or maybe they will seek instead to redistribute the profits more towards the savers than the investors given the low-risk nature of banking.

Banks would inevitably experience a disruption were the central bank to allow individuals to open an account with them. If the central bank were to offer an interest rate at the cash rate or deposit rate, individuals might shift their funds from their commercial bank accounts, whether it be for a more appealing interest rate, or simply for the security it provides. This initial shift could pressure banks to increase interest rates in order to recuperate the funds they lose to the central bank accounts, thereby driving interest rates up to a more competitive level. At the time of this paper, this is not an unreasonable assumption; the savings accounts of three of the four big banks currently start at approximately 2.5%, however, revert to 0.5% after three to five months⁶⁶. Ultimately, this could cause a decrease in profits, and consequently a reduction of shareholder returns.

61 Australian bank deposit accounts are guaranteed to a capacity of \$250000. Australian Securities & Investments Commission (2018) Banking Australian Government <https://www.moneysmart.gov.au/managing-your-money/banking>

62 Basel Committee on Banking Supervision (2017) Basel III: International Regulatory Framework for Banks Bank for International Settlements <https://www.bis.org/bcb/basel3.htm>

63 KPMG (2017) Major Australian Banks: Full Year 2017 Results Analysis KPMG: 5 <https://home.kpmg.com/content/dam/kpmg/au/pdf/2017/major-australian-banks-full-year-2017-results-analysis.pdf>

64 Finder (2018) Compare Bank Accounts from Australia's Big Four Banks Hive Empire Pty Ltd <https://www.finder.com.au/savings-accounts/big-four-banks>

65 KPMG (2017) Major Australian Banks: Full Year 2017 Results Analysis KPMG: 6 <https://home.kpmg.com/content/dam/kpmg/au/pdf/2017/major-australian-banks-full-year-2017-results-analysis.pdf>

66 66. It should be noted there is a lot of variability amongst banks in general. Slightly higher interest rates can be found, though with higher minimum deposits. Finder (2018) Compare Bank Accounts from Australia's Big Four Banks Hive Empire Pty Ltd <https://www.finder.com.au/savings-accounts/big-four-banks>

This paper has discussed blockchain and its applications to central banking operations. It began by outlining the technology of blockchain and briefly discussing its broader applications, followed by an examination of the current international perspective of central banks and blockchain technology. It then went on to discuss two of the key applications considered by central banks, being distributed ledger technology and sovereign cryptocurrencies under the label of Central Bank Digital Currency.

Ultimately, should there be sufficient restraints placed upon access to CBDC, introducing the technology could produce significant benefit to central banks in their conduct on monetary policy and their maintenance of their respective economies. This is because it only provides a broader toolset from which they can draw from, allowing them to set an interest rate on the currency which could either be somehow linked to the cash rate or left at zero. By linking the interest rate to the cash rate (whether through the deposit rate or some new mechanism), monetary policy would no longer be constrained by the zero-lower bound, increasing its effectiveness.

Further, the current political climate could facilitate the implementation of the new technology. The GFC has caused banks to be even more heavily regulated to ensure their strength as institutions, causing them to become very low risk institutions. This, hand-in-hand with the royal commission into banking, could be grounds for a disruption in the banking sector, encouraging a shift in returns from shareholders to savers. This is a shift which could occur given the implementation of CBDC.

Additionally, CBDC could be simply observed as an upgraded form of currency, a concept of which few will argue that government should not be a part of. Given that central banks already distribute bank notes and are the institutions who control the monetary supply, providing CBDC as simply the next evolution of the technology is a reasonable premise.

However, given the technological constraints currently existing in the underlying distributed ledger technology, it is difficult to make a recommendation for the implementation of CBDC at this time. With questions ranging from the security of the technology all the way through to its scalability, there is currently too much uncertainty for full-scale implementation. This being said, the widely held interest in DLT by markets and central banks globally is encouraging, and it may not be too much longer before it becomes a more realistic possibility. At the very least, the RBA should consider experimental research programs to test the implementation of the technology.

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