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What is digital currency?

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The financial industry is witnessing advances in financial technology and increasing consumer preferences towards online financial services. In this environment, central banks are considering their role as issuers of cash. This article addresses the primary question of what is digital currency. It does this by introducing a money tree classification that shows digital currencies include all forms of electronic money, and can be grouped depending on what type of technology they rely on and whether they can be traded for cash at par value. The article concludes with three observations on digital currencies.

1   Introduction

During the past decade there have been continuous developments in financial technology as consumers shift towards online and mobile financial services. Global interest in crypto-currencies increased rapidly during 2017 as the price of Bitcoin, a crypto-currency introduced in 2008, began to soar. While crypto-currencies and their underlying technologies seem new and mysterious, digital currencies themselves are not new. Money has been available electronically via the banking system for several decades. What is new, is the use of distributed ledger technology (DLT) in conjunction with cryptography for currencies and payments.[2] This technology, combined with the proliferation of smart phones, internet access and changing consumer expectations, has reinvigorated discussions on electronic forms of currencies. In this environment, central banks are considering their role of providing cash and in financial technology innovations. One question that central banks are asking

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1   The author would like to thank Jamie Culling, Christie Smith, Tom Smith and colleagues in the RBNZ for their contributions to this article.

2   A DLT is a ledger that is shared across a group of users.

themselves is whether they should issue a digital currency to the public and what such a currency might look like.[3]

This article describes digital currencies using a 'money tree' classification.[4] This classification then provides a base to consider what kind of digital currency a central bank could issue. However, this article does not prescribe a particular design for a digital currency issued by a central bank, nor whether a central bank should issue such a currency. Section 2 explains the concept of money and digital currency, before using the money tree to describe forms of digital currency. Section 3 explores digital currencies that use existing financial market infrastructure to transact. Section 4 explores crypto-currencies that use DLT and cryptography to transact. Section 5 concludes.

2   The money tree – understanding different forms of money

To understand digital currency it is helpful to revisit the concept of money. What is money? At its core, money is a token that can be used as a unit of account, medium of exchange and store of value. For example, New Zealand dollars are a form of money because:

- •   we write prices in terms of dollars (unit of account),
- •   we use dollars to buy goods or services (medium of exchange), and
- •   we build up savings in dollars (store of value).

Over the course of history the belief that various forms of money can be used as a unit of account, medium of exchange and store of value has been based on either the value of an asset underlying the money (i.e. gold), or trust in the money issuer (i.e. a bank), or both.

Today, central banks issue fiat currency (cash) on behalf of governments. Fiat currency is physical currency (notes and coins) and legal tender.[5] People trust fiat currency to the extent that they trust that the government will not go bankrupt and that the national economy will not collapse. People use fiat currency because it is a good unit of account, medium of exchange and store of value, and because it can be used to pay taxes.[6] In addition, people use fiat currency instead of notes issued by private institutions because most countries do not allow any other institution to issue notes and coins.[7] In New Zealand, the Reserve Bank is the only institution permitted to issue notes and coins.[8]

However, today money can also be issued in a digital form and there are no restrictions on who can issue digital currency. Similar to fiat currency, digital currency is a useful form of currency if it can be used as a unit

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3   This is the first article in a three-part series titled 'The central bank digital currency series'. The second article in the series, 'Decrypting the role of distributed ledger technology in payments processes' considers how distributed ledger technology could change the payments process. The third article in the series, 'Pros and cons of a central bank digital currency', provides a high-level introduction to the pros and cons of a central bank issuing a digital currency.

4   The terms money and currency are used interchangeably in this article.

5   If money is legal tender this means that it is legally recognised as a valid form of payment and represents a claim on the central bank or government (McBride, 2015).

6   The Chartalist theory of money describes that money derives its value from trust that the government that issued the money will not or cannot go bankrupt, see Rogoff (2016, p. 20), Kiyotaki and Wright (1989, p 943). In addition, Smith (1937, p 312), Bell (2001), and Knapp (1924) describe a monetary theory in which fiat currency is valued because it is required to pay taxes.

7   In some countries, such as Scotland and Northern Ireland, private financial institutions can issue physical currency. Scottish and Northern Ireland commercial bank notes are fully backed by ring-fenced assets of Bank of England banknotes and deposits.

8   Section 29 (1), RBNZ Act.

of account, medium of exchange and store of value. In addition, digital currency is trusted to the extent that users trust the person or institution that issued it and the economy that underpins it. However, there are two additional sources of trust in digital money that do not exist for fiat currency. The first is trust in the technology that underpins the digital currency (which ensures that money cannot be spent more than once); and the second is whether it can be easily exchanged for fiat currency.

Figure 1 uses 'a money tree' to organise digital currencies into categories. The first category in the money tree distinguishes between physical money and intangible forms of money. The second category in the money tree differentiates between the technologies that digital currencies use to transact. There are two forms of technology currently in use: conventional ledger technology; and DLT and cryptography. [9]

- Conventional ledger technology is a term describing the financial market infrastructure that we currently use to securely transact payments. This infrastructure is centralised and hierarchical, which means only trusted parties can initiate and settle payments to ensure that is not spent more than once and account balances are accurate.

- DLT and cryptography ensure that crypto-currencies cannot be spent more than once and that account balances are accurate. [10] DLT is a term that describes a ledger that records transactions and account balances, and that is shared over a network of computers.

Cryptography is a technique used to hide information that is transmitted over a public network. [11]

The third category in the money tree differentiates between digital currencies that are exchanged for cash at a fixed rate (i.e one-for-one) and those that are exchanged at a variable rate.
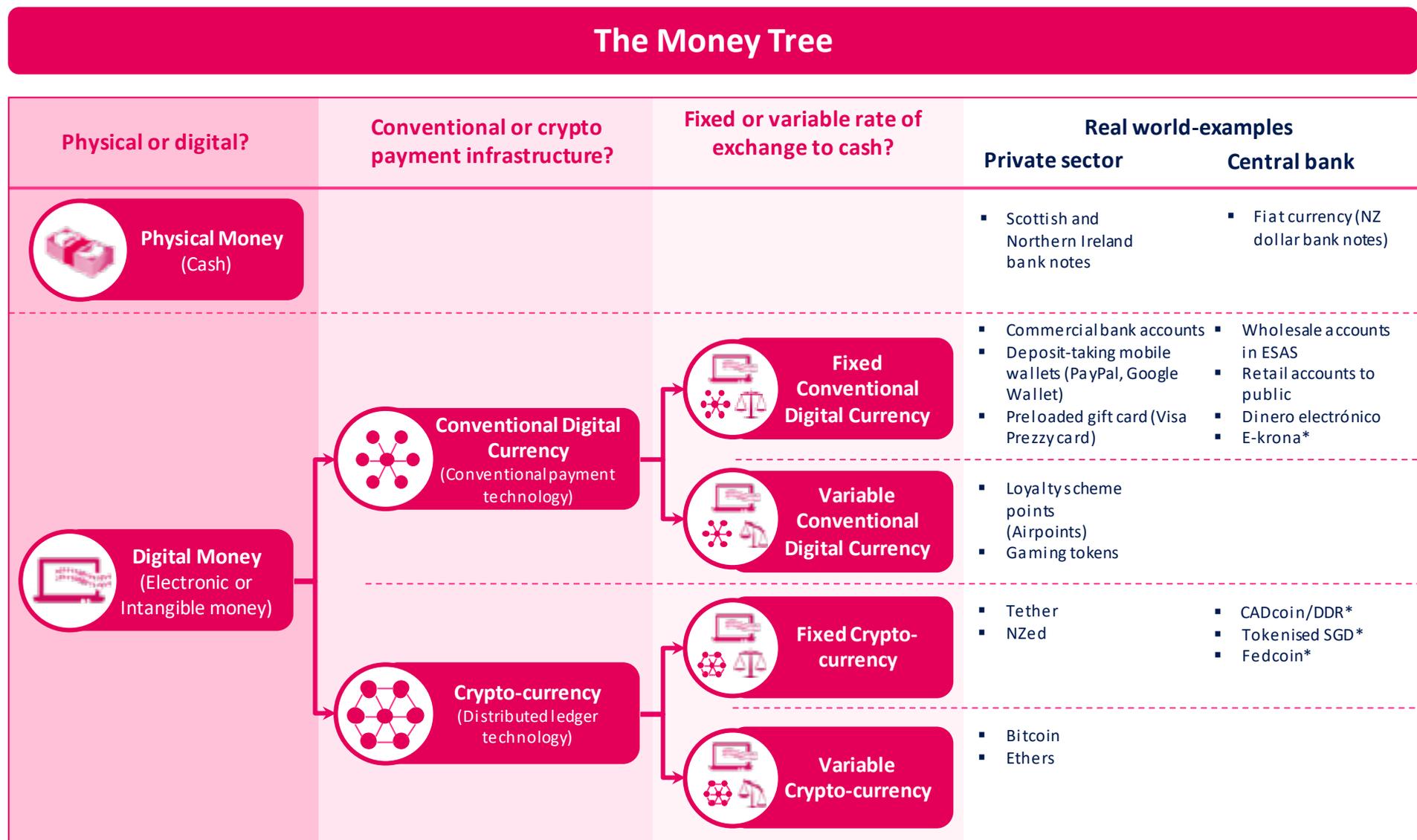
- A digital currency with a fixed exchange rate to cash represents a promise for that currency to be redeemed for bank notes and coins at par value at any time. This par value promise then creates an additional source of trust in this form of digital currency.

- A digital currency with a variable exchange rate to cash is trusted to the extent that people trust the institution that issued it, and the technology that it relies on. This form of currency is more independent from cash.

3 Conventional digital currencies

This section describes digital currencies that rely on conventional infrastructure. Within these currencies, it explores those that have a fixed exchange rate to cash, and those that have a variable exchange rate to

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9   It is also feasible that another form of centralised payment infrastructure could be built outside of the current system and so bypass it, but for the purposes of brevity this case is not described in this article.

10   CPMI (2017), Mills *et al* (2016).

11   Cryptography involves converting data into code for transmission over a public network, for example, by turning data text into coded text using an encryption algorithm. The two use cases for cryptography in crypto-currencies are hashing, and digital signatures. A hash takes any amount of data and represents it in a unique sequence of numbers and letters. If the data changes, the representative hash will also be changed. In this way, hashing can be used to verify data authenticity. Each transaction of crypto-currency is encrypted into a hash which cannot be reversed. Transfers of these coins are then authorised using digital signatures. Digital signatures are encrypted code that verify someone's unique identity and are used to validate ownership of crypto-currency for transactions. Similar to a hash, digital signature encryption cannot be reversed but is easy to verify. For more information see Nakamoto (2008) and Kumar and Smith (2017).

Figure 1
The money tree

The Money Tree

Physical or digital?	Conventional or crypto payment infrastructure?	Fixed or variable rate of exchange to cash?	Real world-examples	
			Private sector	**Central bank**
Physical Money (Cash)			▪ Scottish and Northern Ireland bank notes	▪ Fiat currency (NZ dollar bank notes)
Digital Money (Electronic or Intangible money)	**Conventional Digital Currency** (Conventional payment technology)	**Fixed Conventional Digital Currency**	▪ Commercial bank accounts ▪ Deposit-taking mobile wallets (PayPal, Google Wallet) ▪ Preloaded gift card (Visa Prezzy card)	▪ Wholesale accounts in ESAS ▪ Retail accounts to public ▪ Dinero electrónico ▪ E-krona*
		Variable Conventional Digital Currency	▪ Loyalty scheme points (Airpoints) ▪ Gaming tokens	
	Crypto-currency (Distributed ledger technology)	**Fixed Crypto-currency**	▪ Tether ▪ NZed	▪ CADcoin/DDR* ▪ Tokenised SGD* ▪ Fedcoin*
		Variable Crypto-currency	▪ Bitcoin ▪ Ethers	

Currencies that are still either conceptual or experimental.

cash. These are titled 'fixed conventional digital currency' and 'variable conventional digital currency' in the money tree (figure 1). These forms of digital currencies could be issued by the private sector or by central banks.

i   *Privately issued conventional digital currencies*

This section describes and gives examples of digital currencies that use conventional infrastructure and are issued by the private sector.

Fixed exchange rate to cash
Digital currencies with a fixed exchange rate to cash are the most common form of digital money and are widely used by most people in New Zealand. They include digital currency issued by commercial banks, such as the electronic currency held in a transactional bank account. Because this currency can be very easily converted to cash at par value (one-for-one), most people would not consider it to be a separate form of currency. Trust in digital currency issued by commercial banks is based on its par value exchange rate to cash as well as trust in the commercial bank that issued it.

Other examples of conventional digital currencies with par value exchange rate to cash are those issued by mobile wallets. Mobile wallets are accounts (either online, on a mobile phone application, or attached to a credit card) where users can store their credit or debit card details, or maintain a prepaid account. When a user uploads money into the wallet, the wallet then issues digital currency to their account. The user can make payments using the money stored in their account or with the cards that are linked to the account.[12] Examples of these wallets are PayPal, Western Union, Google Wallet, and Visa Money Transfer.

Variable exchange rate to cash
Conventional digital currencies with variable exchange rates to cash are less common but do exist. Trust in these forms of money are based on trust that the issuer of the currency will allow it to be exchanged for (desirable) goods or services at a reasonable exchange rate. One example is of this digital currency is reward points earned via loyalty schemes such as Airpoints (points earned through the Air New Zealand loyalty scheme). Airpoints can be redeemed for goods or services through the Airpoints store, or by using them to purchase Air New Zealand flights.[13] The exchange rate for Airpoints to fiat currency depends on how the issuer prices the goods and services that can be purchased with Airpoints.

Another example is in game currencies such as the currency in World of Warcraft. The owners of World of Warcraft do not allow the in-game currency to be purchased with fiat (or any other) currency, but a market still exists. The exchange rate on this underground market is determined by supply and demand dynamics and is extremely volatile.

ii   *Central bank-issued conventional digital currencies*

This section describes and gives examples of digital currencies that use conventional infrastructure and are issued by central banks.

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12   Some mobile wallets are open loop systems where payments can be made to any individual, and some are closed loop systems where payments can be made only to scheme participants.

13   www.airnewzealand.co.nz

Fixed exchange rate to cash

There are many examples or central banks issuing conventional digital money that can be exchanged with cash at par value. Central banks currently issue digital currency to commercial banks. For example, the Reserve Bank issues digital currency to commercial banks through the provision of money into each bank's account within the exchange settlement account system (ESAS).[14] This digital currency represents the commercial banks' holdings of cash, as well as each bank's holdings of money generated through its lending operations. Trust in digital currency issued by a central bank is based on the same fundamentals as trust in fiat currency because of the promise of par value convertibly to cash and the fact that the central bank issued it.

In the past, central banks have issued conventional digital currency to the public through government-owned postal banks. More recently, some South American and African central banks have issued digital currencies to the public using mobile wallets.[15]

In 2015, for example, Ecuador issued a mobile currency called dinero electrónico which is denominated in US dollars.[16] The initiative was motivated by the government's desire to provide low-cost mobile payments services to its people who do not have bank accounts. Consumers can open a dinero electrónico account using their national identification number and a mobile phone that has been activated by an authorised operator. Electronic payments can then be made without the internet or a bank account. Money is uploaded to the mobile wallet

through electronic transfers, or by depositing and uploading tangible currency at transaction centres. The dinero electrónico can be converted for fiat currency (US dollar) at par value. However, take-up rates of the dinero electrónico have been low as Ecuadoreans still prefer US dollars for everyday transactions.[17]

Another example of a conventional digital currency issued by a central bank is the proposal by Riksbank to issue an e-krona in Sweden.[18] The Riksbank is facing a situation of decreased availability of cash in bank branches and increased take-up of mobile payment technologies. Because of this, the Riksbank is concerned about its ability to promote a safe and efficient payment system and to provide Sweden with fiat currency. Therefore, it has proposed issuing a digital currency called e-krona to reduce concentration in the commercial banking system and to counter problems that could arise from reduced public access to its fiat currency. The Riksbank proposed two forms of e-krona. The first option is a register-based e-krona, where the Riksbank would hold deposit accounts of e-krona and users would access their e-krona holdings using cards, online applications or other payment service providers. The register-based e-krona is very similar to current commercial bank electronic money, but balances would be held by the Riksbank, not by commercial banks. The second option was a value-based e-krona which would be much like a preloaded gift card (such as a Visa Prezzy card). The e-krona would be stored on a card or application and would be lost if the card was lost as there would be no centralisation of deposits.

Variable exchange rate to cash

A central bank could issue a conventional digital currency with a variable exchange rate to cash, but this is a more abstract idea. There are

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14   ESAS is like the bank for commercial banks. For example, when commercial banks deposit physical currency within the RBNZ vaults, electronic currency is issued to their account in ESAS. Likewise when the RBNZ buys securities from commercial banks the payment will be issued electronically to their account within ESAS. See https://www.rbnz.govt.nz/markets-and-payments/esas/esas-rtgs-overview for a description of how the ESAS system works.

15   At the time of writing, countries that had issued mobile wallets included Ecuador, Uruguay, Venezuela, and Kenya.

16   Ecuador adopted the US dollar as its official currency in 2000. www.bce.fin.ec

17   Americas Market Intelligence (2016).

18   The Riksbank is Sweden's central bank.

currently no real-world examples of a central bank issuing a currency that would have a variable exchange rate with cash, but in principle it could be issued. The premise for such a currency is a situation where users believe that it is an imperfect substitute for cash so are willing to pay more (or less) to hold it compared to cash.[19] It would also require a central bank to not accept the digital currency at par value with cash. This form of digital currency could be used as an additional monetary policy tool by a central bank. In this case, a central bank could vary the supply of the digital currency relative to cash, depending on whether it wanted to encourage spending or saving.

4   Crypto-currencies

This section describes crypto-currencies that have a fixed exchange rate to cash and a variable exchange rate to cash. These forms of digital currencies are relatively new and less understood. These are titled 'fixed crypto-currency' and 'variable crypto-currency' in the money tree (figure 1).

i   Privately issued crypto-currencies

Crypto-currencies have been issued by private institutions. Bitcoin is the most well-known example of crypto-currency, but many other crypto-currencies are in circulation which transact over forms of distributed ledgers. These crypto-currencies are collectively referred to as 'Altcoin'. These currencies can have either a fixed exchange rate with cash, or variable exchange rates with cash.

Fixed exchange rate with cash
Crypto-currencies with fixed exchange rates are typically backed by a pool of assets (such as national currency[20]), which makes them more stable as a medium of exchange and store of value than crypto-currencies with a variable exchange rate to cash. For example, the Tether Platform issues three currencies and claims each is fully backed by national currencies. These are: USDT (backed by US dollars), EURT (backed by euros), and JPYT (backed by yen). In New Zealand, Cryptopia issues a crypto-currency called NZed which is backed by New Zealand dollars.[21] These currencies are trusted because of the technology they are based on and the fact they can be easily exchanged for cash.

Variable exchange rate with cash
As mentioned, crypto-currencies can also have variable exchange rates to cash. The best example of this digital currency is Bitcoin. Bitcoin's exchange rate to fiat currencies is influenced by changes in demand for bitcoins and a fixed supply of the bitcoins. Bitcoin's exchange rate has fluctuated dramatically since its implementation and particularly over the later part of 2017. Thus, Bitcoin has been behaving more like a speculative asset than a form of money.

Users of Bitcoin trust it due to the particular form of DLT it is based on called Blockchain. This technology relies on a distributed ledger and network of agents to validate transactions using a proof-of-work protocol

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19   Bjerg (2017).

20   This article refers to the combination of fiat currency and digital currency issued by commercial banks as 'national currency'.

21   Cryptopia is a Christchurch-based crypto-currency exchange.

that makes it very difficult to spend bitcoins more than once.[22] However, demand for Bitcoins appears to be driven by a belief that others will be prepared to buy bitcoins at higher and higher prices. Bitcoin's exchange rate fluctuations reduce its usefulness as a medium of exchange for real-world goods and services, and as a unit of account.[23] If Bitcoin cannot be used as a stable medium of exchange then it would not be a reliable form of money.

ii   Central bank-issued crypto-currencies

Central banks could also issue a crypto-currency, but at the time of writing there were no examples of a currency such as this being issued to the public. A crypto-currency issued by a central bank would likely have a fixed exchange rate with cash, but could also have a variable exchange rate with cash.

Fixed exchange rate with cash
A central bank could issue a crypto-currency that is traded at par value with fiat currency by ensuring that for each unit of crypto-currency issued into circulation, an equivalent unit of fiat currency is removed from circulation. This would control the supply of both forms of fiat currency to ensure a par exchange rate. Alternatively, the central bank could promise to always exchange one unit of crypto-currency for one unit of fiat currency.

No central bank has issued a crypto-currency. However, the Bank of Canada and Monetary Authority of Singapore have (separately) experimented with using a crypto-currency for interbank settlement in a test environment. The crypto-currencies in these test environments were backed by a pool of national currency to ensure a par value with cash.[24]

Koning (2016) and Andolfatto (2015) proposed a hypothetical crypto-currency that could be issued by a central bank to the public called Fedcoin. This crypto-currency would run on a blockchain and have a flexible supply. Each unit of national currency swapped for Fedcoin would be removed from the monetary base, and each unit of Fedcoin swapped for national currency would be removed from circulation. The authors say this would ensure a stable exchange rate between Fedcoin and cash.

Variable exchange rate with cash
Alternatively, a central bank could decide to issue a crypto-currency with a variable exchange rate to cash in the same way that it could issue a conventional digital currency with a variable exchange rate to cash. It may be more believable that users view a crypto-currency as an imperfect substitutes for cash (and even digital currency issued by commercial banks) because of the DLT and cryptography on which it transacts.[25]

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22   Proof of work in the Bitcoin-Blockchain involves producing a hash that represents an exact piece of information (such as transaction details). 'Miners' search for the proof-of-work hash using a computer to guess all possible combinations of numbers and letters that make up the hash. Thus, providing proof of work to validate a transaction is a costly exercise. Any member of the public can elect to become a miner by downloading the blockchain ledger. These miners are motivated to validate transactions with the promise of receiving a bitcoin payment after every accepted validation. For more information see Nakamoto (2008) and Kumar and Smith (2017).

23   Kumar and Smith (2017).

24   Deloitte and Monetary Authority of Singapore (2017), Monetary Authority of Singapore and the Association of Banks in Singapore (2017), Payments Canada et. Al (2017).

25   Barrdear and Kumhof (2016)

5 Conclusion

This article uses a money tree to explain what is meant by digital currency. The money tree classifies digital currency as all electronic forms of currency. However, this leaves us with a broad spectrum of currencies. The money tree then categorises digital currency further by separating currencies that use cryptography and DLT to transact, from those that use existing financial market infrastructure to transact. The third classification of digital currency separates currencies that are exchanged for cash at par value and those that are not.

Exploring digital currencies using the money tree classification leads to three observations.

1. Despite the recent attention to digital currencies, most forms of digital currencies are not new and are not significantly different from each other. Crypto-currencies with variable exchange rates to fiat currencies are the most novel digital currencies.

2. A central bank could issue either a conventional digital currency or a crypto-currency to the public. A central bank could also choose to issue a digital currency with a par value or variable exchange rate to cash. However, it is conceptually easier to image a central bank issuing a digital currency that trades at par value with cash.

3. Crypto-currencies have been issued by private institutions but not by central banks. It appears that crypto-currencies that have fixed exchange rates to fiat currencies are a better unit of account, medium of exchange and store of value than crypto-currencies which do not have fixed exchange rates to cash.

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Glossary

Altcoin: Collective term referring to crypto-currencies other than Bitcoin.

Bitcoin: A crypto-currency that uses Blockchain and proof-of-work validations. Several competing Bitcoin currencies each have Bitcoin in their name.

Blockchain: A distributed, open source, public and permissionless ledger. It is titled the Blockchain as the ledger consists of a chain of completed blocks of transactions.

Claim on the bank: For example, banknotes issued by a bank represent money that the bank owes the holder of the note.

Conventional ledger technology: This refers to existing financial market infrastructure, which uses a more typical hierarchical and centralised structure to ensure trust and security for transacting payments.

Crypto-currency: A digital currency that requires distributed ledger technology and encryption techniques to be transferred.

Cryptography (digital): Converting data into a code that cannot be deciphered by unintended recipients, e.g. for transmission over a public network.

Cyber-attack: An attack by malicious hackers to steal information from, or destroy, a computer network system.

Digital (electronic) currency: A broad term that captures all forms of money that are not physical.

Distributed: Shared across a group of entities.

Distributed ledger technology: A record of transactions or account balances that is shared across a group of entities.

Fiat currency: Physical forms of money that – a) a government issues and declares to be legal tender, and b) is not backed by a promise of convertibility into a tangible asset, such as gold.

Financial market infrastructure: Institutions that are responsible for processing payments.

Fixed conventional digital currency: Digital currency with a fixed exchange rate to national currency that relies on existing financial market infrastructure to transact.

Fixed crypto-currency: Crypto-currency that has a fixed exchange rate to fiat currency.

Fixed exchange rate: When the exchange rate between two currencies is held constant, often because the supply and demand dynamics are controlled.

Variable exchange rate: When the exchange rate between two currencies is variable depending on the supply and demand for each currency.

Legal tender: Coins or bank notes that are a legally valid offer of payment. This means it cannot legally be refused when offered as a settlement of a debt in the same currency.

Mining: The process by which transactions are verified and added to a distributed ledger.

Privately issued: (Currency that is) issued by a private entity or not a central bank or government.

Proof of stake: The validator of a transaction in a distributed ledger is chosen based on a combination of random selection, and coin holding characteristics (referred to as 'stake').

Proof of work: Proof of work in the Bitcoin-Blockchain is a string of numbers and letters (otherwise known as a 'hash') which represents an exact piece of information (such as transaction details). 'Miners' search for the proof of work hash using brute computer power. Thus, providing proof of work to validate a transaction is a costly exercise.

Validation: In a DLT transaction, validation is the process of ensuring that the funds are not being double spent and that ledger balances are accurate and true.

Variable conventional digital currency: Conventional digital currency with a flexible exchange rate to other currencies, including fiat currency.

Variable crypto-currency: Crypto-currency that has a flexible exchange rate to other currencies, including fiat currency.