Cryptonetworks

THE INCENTIVE-BASED ECONOMICS OF BLOCKCHAIN

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Abstract

Blockchain technology has the novel ability to 'create' trust in a decentralised environment. With this technology, third-parties and middlemen are no longer necessary to enforce transactions. Instead, blockchain uses decentralised consensus protocols and embedded logic to enforce contracts. The applications of blockchain are vast and include cryptonetworks, the culmination of blockchain and crypto tokens. Cryptonetworks can have an impact on the business models of firms, both in terms of cost structure and value creation. By blending the functionality of centralised platforms with the community-orientated nature of the original open protocols of the internet, cryptonetworks enable value creation to be correctly assigned to the actual content creators through tokens. The work of Ronald Coase illustrated the need for firms to overcome the transaction costs of operating within the market. Cryptonetworks, however, provide an alternative 'middle ground' option to the firm and the market, allowing both to benefit from reduced transaction costs and incentive maximisation of the market. In addition, the implementation of economics in today's cryptonetworks, often referred to as 'cryptoeconomics', remains conventional and conservative, placing a limit on the potential of cryptonetworks. By revaluating and reconstructing today's value measurement criteria, cryptonetworks have the potential to move beyond a single 'Hayekian price' and instead incorporate multiple other indexes that better measure and capture value creation as it pertains to wider social issues of production, distribution, and consumption of goods and services. Finally, this thesis incorporates a case study on the MakerDAO stablecoin as a practical illustration of a cryptonetwork.

Table of Contents

1 Introduction

Blockchain is a distributed ledger technology (DLT) that stores and sequentially links groups of transactions (known as 'blocks') using cryptography (Crosby et al., 2016; Angelis & Ribeiro da Silva, 2019). The real innovation introduced by blockchain is that no single organisation or individual owns the blockchain. Instead, it is 'owned' by a distributed peer-to-peer network, provides redundancies of the data stored in the blockchain, and uses a consensus protocol to ensure that past transactions cannot be tampered with. The most well-known use case of blockchain has been cryptocurrencies, most notably Bitcoin. The technology, however, offers far greater prospects for any transactions requiring authentication (Nowiński & Kozma, 2017). As such, the focus of this study is not cryptocurrencies but another implementation of blockchain: cryptonetworks. At a high-level, a cryptonetwork is a blockchain-powered network that utilises tokens as the network's 'currency' or utility function (Oliveira et al., 2018; Lee, 2019; Tönnissen, Beinke & Teuteberg, 2020) and is governed by rules to create a secure, trustworthy, and ultimately valuable system for all participants. The rules of a cryptonetwork are hardcoded into its respective blockchain protocol. The principles of cryptoeconomics are then used to design the rules and incentives of the network. Cryptoeconomics is the culmination of cryptography, token design, and economic incentives. The development of cryptonetworks is an exciting endeavour that could potentially disrupt today's closed (centralised) platforms and their underlying business models (Lee, 2019; Prewett, Prescott & Phillips, 2020). The disruptive potential of cryptonetworks lies in the creation of open platforms that harness communities of developers and users who benefit from the growth of the network.

This study has two research questions:

RQ 1: What impact can cryptonetworks have on existing business models of firms, both in terms of cost structure and in terms of value creation?

This study advances the thesis that cryptonetworks represent the most ambitious and promising attempt to disrupt existing business models of firms. Implications for the way firms operate and are governed are profound. The argument advanced here is that cryptonetworks share properties of both the market and firm, and that cryptonetworks accordingly provide a 'middle ground' alternative that overcomes the firm's transaction cost benefits while maintaining the incentivisation mechanisms of the market (Coase, 1937, 2013; Wang, 2018; Lee, 2019). In doing so, cryptonetworks would represent a fundamental change in the cost structure of firms. In addition, by blending the functionality of centralised platforms with the community-orientated nature of the original open protocols of the internet, cryptonetworks enable value creation to be correctly assigned to the actual content creators through tokens.

RQ 2: Do cryptonetworks enable new measurement tools such as to redefine the nature of value creation?

The use of economic theories within blockchain-enabled applications such as cryptonetworks is referred to as cryptoeconomics. Current cryptoeconomic literature provides a conventional and conservative evaluation of the underlying economics. However, the strict restriction of cryptoeconomics to orthodox economics limits the potential of cryptoeconomics and thus of cryptonetworks. Cryptoeconomics focuses on designing cryptonetworks with incentives applicable to 'rational' actors. The opportunity cost is the forgone utility of tokens beyond their use in incentivisation mechanisms. In the 1940s, the argument for 'the market' stood as a strong alternative to 1940s central planning. Today though, this argument is not as strong. Advancements in big data and blockchain enable access to mass amounts of data that can be processed using existing computational power. Thus, the desire and need to simplify and reduce complex variables to a single 'Hayekian price' no longer exists. As such, by creating new measurement tools, cryptoeconomics looks to provide opportunities to redefine and capture value.

In **Chapter 2** of this thesis, a primer to blockchain technology is provided. Additionally, the circumstances leading to the invention of blockchain technology are discussed, as are the reasons why its real potential is the creation of trust. Lastly, there is a brief discussion of the types of blockchains, consensus protocols and the various industry applications of the technology. Cryptonetworks and their potential impact on business models are introduced in **Chapter 3**, both in terms of cost structure and value. In **Chapter 4**, an exploratory framework on the potential of cryptoeconomics is offered. It is argued that cryptonetworks offer the opportunity to rethink and reconstruct the way value is perceived and indeed measured in today's economies. The cryptonetwork MakerDAO is discussed in **Chapter 5** and is used as a practical illustration of a cryptonetwork. Finally, concluding remarks and future research areas are provided in **Chapter 6**.

Material and methods

This is a conceptual research paper which consists of a literature examination to offer a primer on blockchain technology. The contributions of this paper include looking at the history of the technology and how it functions, as well as, outlining the different types of blockchains and their relevant applications. The central research questions are then to understand the potential impact of the technology on a firm's business model both in terms of cost structure and value creation measurement tools. The objective is to provide some definition on the topic as it pertains to economics. A case study is then used to illustrate one application of the technology.

The research was conducted using desk research of current business press papers, professional reports, company web pages and blog posts concerning blockchain technology. Secondary sources were screened using the UCT Primo service as well as the Web of Science database. A combination of various terms was used including "*blockchain*", "*cryptonetworks*", "*tokens*" and "*cryptoeconomics*". The number of results varied greatly, with the highest number of results showing for "*blockchain*" whilst only a few to no results for *"cryptonetworks", "tokens"* and *"cryptoeconomics"*. This can be interpreted to the novelty of the topic addressed in this thesis. As a consequence, certain 'grey literature' in the form of blog entries and news articles were used, both of which fall outside of the classical source for scientific publications. Wherever possible, more verifiable sources such as journal articles, professional research institutions and working papers were used. To conclude, this paper should be considered as a conceptual paper where literature review and desk research leads to the development of theoretical propositions.

2 Understanding the technology

2.1 Before blockchain

Before the advent of blockchain technology, creating and enforcing trust between transacting parties always required a third-party such as a bank. To understand how blockchain creates trust, it is important to examine the current system of accounting and its origins as, at its core, blockchain is simply a new form of ledger-keeping. The current form of ledger-keeping, known as the double-entry bookkeeping method, is a 14th-century product of Luca Pacioli, a Franciscan friar and mathematician (Yamey, 2005; Smith, 2013). It enabled the use of Arabic numerals, allowed merchants to reliably keep records, and gave bankers the ability to act as middlemen in the international payment system (Lee, 2013). However, the impact of the double-entry system was greater than simply laying down the foundations of modern finance as it also influenced the culture of finance (Lee, 2013; Coate & Mitschow, 2018). Pacioli believed his method to be more than just an accounting tool, viewing it also as a moral obligation (Coate & Mitschow, 2018). The concept of moral obligation is inherent in the double-entry system as it requires that any inflow have an equal outflow, i.e., a debit (asset) for a credit (liability), thereby achieving balance between the values (Pacioli & Cripps, 1994). Over the following centuries, clean books became a sign of honesty, further entrenching the banker's role as a payment intermediary and increasing the circulation of money (Lee, 2013).

Although in many cases intermediaries do remain effective and honest at supplying the correct information, in practice, the double-entry system still falls victim to fraud. There are also many instances where honesty cannot be assumed and where inducements may exist for intermediaries to supply an ineffective service or to act dishonestly. Dishonesty may be voluntary if the intermediary is intentionally untruthful, such as the case of Cambridge Analytica[1] accessing data from Facebook (Schyff, Flowerday & Furnell, 2020), or may be unintentional, such as when the network owned by the intermediary is breached, as was the case with Yahoo, Sony, and JP Morgan Chase (Sloane, 2011; Telang, 2015). Moreover, even when data and verification processes remain intact, financial middlemen are considered indispensable, turning intermediaries into gatekeepers (Huang, Li & Shi, 2020).

Blockchain's real potential is that it enables a drastic reduction in the cost of forming trust using a new decentralised accounting method (Nowiński & Kozma, 2017; Liu, Wu & Xu, 2019; Sinha, 2020). By extension, blockchain allows for the creation of new types and structures of economic organisations (Casey & Vigna, 2018; Lee, 2019; Weking et al., 2020). A new bookkeeping standard may appear to be

[1] A firm that was affiliated with the 2017 Trump Presidency Campaign and which collected personal data from millions of Facebook users, raising questions about cybersecurity, big data, and user privacy.

dull and of limited significance, yet for thousands of years, ledgers have formed the bedrock of western civilisation (Mukhametzyanov, Nugaev & Muhametzyanova, 2017). Western society functions on trusting the claims of others as to what they own, what they are owed, and what they owe. This trust can only be achieved using a system that is accepted by everyone to keep track of transactions. This system, for centuries, has been the double-entry method.

2.2 Blockchain's beginnings

On 31 October 2008, a paper authored by Satoshi Nakamoto and titled *'Bitcoin: A Peer-to-Peer Electronic Cash System'* was posted to a cryptography mailing list (Nakamoto, 2008a). The paper proposed methods of using peer-to-peer technology to create *'a system for electronic transactions without relying on trust'* (Nakamoto, 2008b). On 3 January 2009, the Bitcoin protocol was released and the genesis block of bitcoin (block number 0) was mined by Satoshi Nakamoto himself. Although Satoshi did not coin the term 'blockchain', its principles (discussed in the next section) were laid out in this 2008 paper.

Bitcoin's popularity started to increase after 2011, when Silk Road, the Bitcoin-powered black marketplace for illegal drugs was exposed (Barratt et al., 2016; Krugman, 2018; Jawaheri et al., 2020). Two years later, Bitcoin's market capitalisation had exceeded $1 billion (CoinMarketCap, 2018). Notably, the second largest blockchain platform that operates today, Ethereum, was launched in 2013 (Buterin, 2013). Unlike Bitcoin which only records currency transactions, Ethereum also allows computer programs called smart contracts to be recorded on the blockchain (Buterin, 2013). Smart contracts are self-executing computer code that enables complex operations using tokens to be conducted (Xu & Zou, 2020). What makes these contracts 'smart' is not that they are automated, but that they are carried out on a decentralised blockchain network, assuring all transacting parties that the contract will be completed without the need of an intermediary (Macrinici, Cartofeanu & Gao, 2018; Angelis & Ribeiro da Silva, 2019). Blockchain's popularity continued to increase as shown by Gartner's 2016 hype curve which saw blockchain near the top on the curve, placing it in the "peak of inflated expectations" category (Gartner, 2016). By 2017, Gartner placed blockchain in its 'Top ten strategic technology trends' (Gartner, 2017). The result was excitement as well as misconceptions, charged opinions and confusion regarding the technology.

2.3 Deciphering blockchain

Blockchains are a network of physical computers that all work together to form a single virtual computer. The gain from blockchains, unlike a traditional computer, is that they produce trust through cryptographic rules. Each 'block' in the blockchain has three primary inputs: data, the current hash, and the previous hash (Morkunas, Paschen & Boon, 2019; Bamakan, Motavali & Babaei Bondarti, 2020). A hash acts the fingerprint for each block assigning a unique identifier number. The hash is calculated based on mathematical rules using the data inside the block. The block also contains the hash of the previous block, acting as the linkage between each block. Any changes to the block will change the hash number. Therefore, any attempted changes to the data inside a block will prove invalid as the hash numbers will no longer match (Zheng et al., 2017). Multiple transactions are then stored together per block, up to a certain size, and chained together, hence the term blockchain, using cryptographic locks, all of which are an outcome of the consensus protocol (Crosby et al., 2016; Alvseike et al., 2017; Kakushadze & Russo, 2018). If set up correctly, the result is an immutable, shared record of the truth that cannot be erased (Crosby et al., 2016; Casey & Vigna, 2018).

At its core, a blockchain is a distributed database of records, transactions or digital events that been concluded and shared amongst participants (Angelis & Ribeiro da Silva, 2019). For the first time, blockchain allows unconnected people to transact safely and securely without the need for a third party to verify the transaction (Cai et al., 2019). It performs this function by being a public, permanent, append-only, and distributed ledger (Mike Orcutt, 2018; Angelis & Ribeiro da Silva, 2019). These terms are further defined below:

- **Public**: blockchains are accessible to anyone, meaning the database forms part of public information.
- **Permanent**: It is almost impossible to tamper with data encoded in a blockchain, assuming the latter has been correctly set up.
- **Append-only**: Previous transactions cannot be amended in a blockchain, only new ones can be added.
- **Distributed**: No single entity owns or controls a public blockchain. Instead, a network of computers maintains and secures the database, and each participant or 'node' stores a copy.
- **Ledger**: At its core, a blockchain is a new type of ledger. For example, Bitcoin's blockchain tracks bitcoin currency balances.

Blockchain may be an answer to the early 1980s computer science problem known as the *Byzantine Generals Problem* (Lamport, Shostak & Pease, 1982), which concerned how consensus between distributed digital networks could be reached securely without involving a central authority (Wright &

De Filippi, 2015; Kuo et al., 2020; Sheikh et al., 2020). Historically, there have been three different approaches to answering this question (Mike Orcutt, 2018):

- **Enforcement (past)**: The threat of force was used to enforce early exchanges of value in civilizations.
- **Institutions (present)**: Central authorities such as governments and banks emerged, facilitating organised outsourced trust (assuming these authorities could be trusted).
- **Networks (future):** Powered by blockchain, trust is distributed by a network of computers that can automate trust in a way previously impossible. These networks may also be thought of as 'decentralised' institutions.

Therefore, what makes blockchain unique as a ledger is that instead of the ledger being managed and stored by a single centralised institution, such as a bank or government department, multiple copies exist on multiple independent computers within a decentralised network. No single entity on the network controls the ledger. All computers on the network may propose changes to the ledger. However, these changes are only accepted into the ledger according to strict rules determined by the 'consensus protocol'. The consensus protocol is a cryptographic algorithm that requires a majority vote from all computers on the network before any changes can be made to the ledger (Bamakan, Motavali & Babaei Bondarti, 2020). Once a majority has been agreed for any changes, the copies of the ledger stored on each computer are updated simultaneously.

The consensus protocol differs between today's largest blockchains. Bitcoin and Ethereum use Proof of Work (PoW), Ripple uses Practical Byzantine Fault Tolerance (PBFT) and EOS uses Delegated Proof of Stake (DPoS). PBFT and DPoS were developed to overcome PoW's shortcomings (Lee, 2019). However, each consensus protocol still has trade-offs, something that is referred to as the 'impossibility trinity'. That is, currently, no blockchain can ensure correctness, decentralisation and cost-efficiency at the same time (Abadi & Brunnermeier, 2018).

- **Proof of Work (PoW)** is the original consensus protocol proposed by Nakamoto (2008a). This method requires a complex and computationally demanding mathematical puzzle (known as a nonce) to be solved resulting in the block's hash (Salimitari & Chatterjee, 2018). Advantages of PoW is its highly secure and decentralised nature. Its disadvantages, however, is the high energy requirement (O'Dwyer & Malone, 2014; de Vries, 2018; Bondarev, 2020; Das & Dutta, 2020), low throughput and transaction speed (Milutinovic et al., 2016; Xu & Zou, 2020), and that it requires special hardware to run (Zheng et al., 2017; Alsunaidi & Alhaidari, 2019). The scalability of PoW over large networks is also of concern (Croman et al., 2016; Poon & Dryja, 2016; Prewett, Prescott & Phillips, 2020). Progress is being made in improving scalability within PoW networks, however, it remains a work in progress (O'Leary, 2017; Zheng et al., 2017). Potential solutions include the use of off-chain (outside the blockchain network) and on-chain methods (Bano, Al-Bassam & Danezis, 2017).

- **Practical Byzantine Fault Tolerance (PBFT)** requires all nodes to participate in the voting process of adding new blocks. Consensus is achieved when two-thirds of the nodes agree on the block. PBFT requires that a minimum of four nodes must be in agreement, meaning an individual malicious node will automatically be rejected (Lee, 2019). As such, consensus is agreed faster and more efficiently compared to PoW (Salimitari & Chatterjee, 2018). PBFT's advantages are, therefore, its energy efficiency and high throughput. Its disadvantages are its lack of scalability and the requirement for all nodes to vote, which introduces potential delays in transactions.
- **The Delegated Proof of Stake (DPoS)** method was proposed by Larimer (2014). It builds upon the Proof of Stake (PoS) method where the creator of a new block is chosen randomly based on the size of their stake in the network and age of their stake. DPoS improves on PoS by introducing the use of representatives in the voting process to validate blocks (Bashir, 2017). The number of representatives is limited to ensure that the network is efficient. The advantages are energy efficiency, scalability and low transaction costs. The disadvantage of this method is its semi-centralised structure (Salimitari & Chatterjee, 2018), however there are governance mechanisms in place that allow nodes to correct for mistakes or delays made by representatives (Zheng et al., 2017). Nevertheless, DPoS is more suitable in private blockchains.

Korpela, Hallikas & Dahlberg (2017) classify blockchain into three categories: public, private and consortium blockchains. The three types of blockchains tend to reach consensus in different ways. For example, public blockchains require all nodes to participate. Public blockchains are the focus of discussion in this study. Private and consortium blockchains, however, can reach consensus by only using a select number of nodes.

- **Public blockchains** are permissionless and decentralised blockchains whereby all participants can participate and access the information stored on the network. Bitcoin and Ethereum are both examples. Public blockchains are viewed as the most secure due to the decentralised consensus amongst all nodes. Consensus protocols used on public blockchains include PoW and PoS.
- **Consortium blockchains** or federated blockchains allow all participants to access the information on the network however any changes or additions are decided by a select group of nodes. Consortium blockchains are common in the banking sector (Dib et al., 2018). The

idea is to distribute decision power amongst a few participants instead of in a single authority to help make unbiased decisions. Some examples include B3i[2] (Insurance), EWF[3] (Energy) and R3[4] (Banking).

- **Private blockchains** are permissioned blockchains in which information is only accessible for pre-selected participants and changes can also only be made by an authorised group. Private blockchains are centralised in the sense that a single authority determines consensus. It is for this reason that private blockchains are often rather referred to as 'Distributed Ledgers' as they do not share the core decentralised principles of blockchains (Morkunas, Paschen & Boon, 2019). The primary motivation for private blockchains are situations where corporates are concerned about giving competitors visibility over their transactions (O'Leary, 2017).

2.4 Applications of blockchain

The development of blockchain can be characterised by the following four stages (Swan, 2015; Leon Zhao, Fan & Yan, 2017; Angelis & Ribeiro da Silva, 2019):

- **Blockchain 1.0**: focused on financial transactions. Cryptocurrencies were the primary focal point, with applications in digital payments systems such as remittances and currency transfer. The best-known example is Bitcoin. Such cryptocurrencies have experienced high volatility in their prices, limiting their effectiveness as payment tools (Xu & Zou, 2020).
- **Blockchain 2.0**: builds on Blockchain 1.0 and adds elements such as privacy, smart contracts and non-native tokens. Ethereum is the most well-known example.
- **Blockchain 3.0**: refers to digital society and incorporates decentralized applications (dApp) (Lee, 2019). These apps share the same properties as blockchains and have a built-in incentivization mechanism (Raval, 2016). The objective was to offer applications that look and feel like today's web apps, but that would be powered by decentralised cryptonetworks instead of individual company servers.

The potential of blockchain has received significant attention, however, the actual applications are still being tested and developed (Angelis & Ribeiro da Silva, 2019). A review of recent research reveals four fields of focus. First is financial services (Underwood, 2016), particularly in relation to banking, auditing and accounting (Wang & Kogan, 2018; Liu, Wu & Xu, 2019; Tan & Low, 2019; Sinha, 2020). By

[2] See: https://b3i.tech/home.html
[3] See: https://www.energyweb.org/
[4] See: https://www.r3.com/

not requiring a trusted intermediary, firms can significantly lower transaction costs (Nowiński & Kozma, 2017). Cross border payments are also able to benefit from the short transaction time and without needing to charge a currency conversion fee (Weking et al., 2020).

Second, research efforts have focused on the supply chain. Reyna et al. (2018) believe that blockchain's impact on the supply chain shows the most potential value outside of financial applications of the technology. A ledger powered by blockchain would enable all members of a supply chain to track, trace and identify any object moving through the supply chain (Grewal, Motyka & Levy, 2018; Xu et al., 2018; Min, 2019). The transparent, verifiable, and shared nature of a blockchain ledger would help eliminate redundancies in the supply chain and enable the use of connected devices (Christidis & Devetsikiotis, 2016; Zhang et al., 2020)

Third, relates to blockchain and multi-sided marketplaces (Glaser, 2017). In these marketplaces, a trusted intermediary is ordinarily needed to ensure fair and honest transactions can occur (Hein et al., 2019). This includes platform intermediaries such as Google, Amazon or Apple (Hein et al., 2019). Blockchain, however, removes the need for an intermediary through a decentralised consensus protocol (Ying, Jia & Du, 2018). These technology changes are driving disintermediation (Xu et al., 2018) and decentralisation (Swan, 2017). At the same time, low efficiency and high transaction costs could become a thing of the past (Ying, Jia & Du, 2018).

Fourth, there has been a concerted research effort into the social welfare benefits of blockchain (Jiao et al., 2017; Li et al., 2018). The decentralised nature of blockchain can allow for the automation, conclusion and enforcement of contracting services (Cong & He, 2019). Any market participant can prove their *legitimacy* and conduct transactions without information asymmetry (Xu & Zou, 2020). Examples of this include the voting system (Kshetri & Voas, 2018) and within the healthcare system (Mettler, 2016; Drosatos & Kaldoudi, 2019), including sharing and storing patient data (Smith & Dhillon, 2017; Swan, 2017).

Chapter 2 highlighted the mechanisms through which blockchains 'create' trust and indeed the importance of trust creation. Reliance on systems such as the double-entry accounting method and the expectation that centralised institutions will remain honest has proved an expensive assumption, especially in recent years. This is what makes the prospect of blockchain so attractive. For the first time, trust can be created in a decentralised environment. Furthermore, by leveraging cryptography, blockchains can prevent any alterations to transactions while avoiding the issues of centralised ownership. However, as a new technology, blockchain will require further innovation to overcome performance and scalability issues, as indicated by the trade-offs of the different types of blockchains and consensus protocols. The technology, though, is still in its early years and is certain to experience significant changes in the future (Sinha, 2020). Advancements in the technology are already evident by the introduction of new consensus protocols which look to correct for the shortfalls of Proof of Work. Recent research efforts indicate a focus on tackling the technical properties of blockchain (Nakamoto, 2008a; Eyal & Sirer, 2018; Wang & Kogan, 2018) or investigating the possible benefits of the technology for various industries, including financial services, supply chains, multi-sided marketplaces and healthcare (Dai & Vasarhelyi, 2017; Kshetri & Voas, 2018; Radanović & Likić, 2018). However, research on the impact of blockchain on firms' business models remains relatively thin. A discussion on the impact of blockchain on the business models of firms follows in **Chapter 3**.

3 Introducing cryptonetworks

In **Chapter 2**, the origins of blockchain, its potential advantages, and the way the technology functions were outlined. Here, we examine one of the key applications of blockchain technology: cryptonetworks. Cryptonetworks (or token economies/ecosystems), such as the Ethereum platform, are created through the combination of blockchain technology and tokens (**Figure 2** below). Tokens are distinct virtual 'currency' tokens that exist on their own blockchain (e.g., ETH on Ethereum). More precisely, tokens are a fungible and tradable asset or utility function that can be found on a blockchain network.

Figure 2: Cryptonetworks: blockchain and tokens

The pre-blockchain internet connected providers of information with consumers who used it. The blockchain-based internet, however, looks to create an internet that prioritises the sharing of value created by its users, and in turn, the reshaping business models through transparency and authenticity (Tapscott & Tapscott, 2016). Business models are a *"description and architecture of how a firm creates, delivers, and captures value"* (Teece, 2010; Weking et al., 2020). Cryptonetworks have the potential to reshuffle economic activities, reduce transaction costs and significantly strengthen the trust between actors in an ecosystem (Weking et al., 2020). Cryptonetworks and the underlying blockchain technology could bring about significant changes to business models of today enabling new products and services (Lansiti & Lakhani, 2017; Angelis & Ribeiro da Silva, 2019; Morkunas, Paschen & Boon, 2019; Tönnissen, Beinke & Teuteberg, 2020).

3.1 Cryptonetworks impact on business models

Central to the operating structure of a firm is its business model. The power of technology to alter business models is historically evident (Teece, 2010) and plays an important role in developing competitive advantage (Chesbrough, 2010; Baden-Fuller & Haefliger, 2013). In particular, it is interesting to discuss cost structure in the context of business models and how this may be disrupted. The cost structure of a firm *"describes all costs incurred to operate a business model"* (Osterwalder &

Pigneur, 2013:40). In the financial services sector alone, PwC estimates the cost savings as a result of blockchain to be between $15-20 billion by 2022 (Di Gregorio, 2017).

Historically, the pipeline business model has been the model of choice for the largest companies in the world. In this model, a company purchases raw material, use the materials to build products, and then sells the products to its customers (Tönnissen, Beinke & Teuteberg, 2020). In the pipeline model, value creation occurs internally and between firms (Jacobides, Cennamo & Gawer, 2018). However, the digital transformation of the global economy has brought new business models to the forefront. Namely, the platform business model where value is realised through the creations of the community in the ecosystem. Such platforms are on the rise and their prevalence is expected to continue to grow (Han, Martinez & Neely, 2018; Lamarre & May, 2018). Today seven of the 12 biggest companies operate as a platform: Apple, Alphabet (Google), Microsoft, Amazon, Alibaba, Tencent and to some degree, Facebook (Evans & Schmalensee, 2016; McKinsey, 2020). Smedlund et al. (2018) believe that these platform business models have radically altered our economy and possibly even society.

Cryptonetworks look to build upon, disrupt (Morkunas, Paschen & Boon, 2019; Prewett, Prescott & Phillips, 2020; Tönnissen, Beinke & Teuteberg, 2020; Weking et al., 2020) and potentially form entirely new business models (Lansiti & Lakhani, 2017; Kshetri & Voas, 2018; Lacity, 2018; Wang & Kogan, 2018). Blockchain offers several benefits over traditional models depending on its implementation (Wörner et al., 2016; Nowiński & Kozma, 2017; Subramanian, 2017). These include transaction cost reductions as a result of disintermediation (Xu et al., 2017; Ying, Jia & Du, 2018; Cai et al., 2019), speedier transactions (Underwood, 2016), improved tractability and verification of records (Morkunas, Paschen & Boon, 2019). Assets are also able to be authenticated without the need for an intermediary (Nowiński & Kozma, 2017).

All transactions are encrypted and in combination with decentralisation, blockchains provide security whilst ensuring participants can trust each other (Underwood, 2016; Zhu & Zhou, 2016). This means that ownership can be transferred without the need for an intermediary (Morkunas, Paschen & Boon, 2019). Ownership is reflected through tokens, which act as a value unit in the ecosystem *"to self-govern its business model, and empower its users to interact with its products, while facilitating the distribution and sharing of rewards and benefits to all of its stakeholders"* (Mougayar, 2017). The transfer of tokens between network participants corresponds to the transfer of property rights (Xu & Zou, 2020). Tokens also offer three unique features in the formation of an ecosystem (Oliveira et al., 2018). First, tokens enable the transfer of value between ecosystem participants and can be divided into small numbers (Pilkington, 2016; Dai & Vasarhelyi, 2017). Second, tokens act as an incentivisation mechanism (Wenger, 2016; Subramanian, 2017). Third, tokens enable networks effects to be reached in the ecosystem which is needed to reach a critical mass of users (Rouviere, 2016; Wenger, 2016; Chen, 2018; Oliveira et al., 2018). Interestingly, blockchain's impact may also extend beyond well-established models into industries that struggle with structural issues. An example is the real estate industry where illiquidity in the market acts as a structural bottleneck. Illiquidity is the result of two primary reasons: lack of trust and long closing times (Nowiński & Kozma, 2017), both of which blockchain has the potential to address. To better understand the advantages that cryptonetworks have over firms and their existing business models, an exploration of transaction cost theory is needed.

3.2 Transaction cost theory: the firm and the market

In the pivotal paper *The Nature of the Firm*, Coase laid the foundations of an entirely new branch of microeconomics known as the 'theory of the firm', winning him the 1991 Nobel Prize in Economic Sciences (Coase, 1937). *The Nature of the Firm* was written in response to economic theory practitioners at the time who, according to Coase, lacked a clear understanding of its assumptions. Coase believed that understanding a theory's underlying assumptions was not only important to avoid misunderstandings, but also to allow its valid selection above competing assumptions. In particular, the meaning of the word 'firm' in the field of economics may differ from its meaning in everyday use. Various interpretations of 'firm' resulted from economic analysis starting with an individual firm and not the entire industry. Coase, therefore, aimed to define the 'firm' in the real world using the idea of substitution at the margin.

In search of the definition of a firm, Coase first questioned the definition of the economic system. One view is that the economic system is coordinated by the price mechanism, with society thus considered not an organisation but an organism (Salter, 1921; Hayek, 1933). The economic system, therefore 'works itself' by functioning automatically without external intervention. Individuals still exercise some degree of planning by choosing between alternatives, but the direction of resources is directly dependent on the price mechanism. However, the economic system described by Salter is incomplete as economic theory implies that the allocation of factors of production between different uses is determined by the price mechanism. Thus, if the price of factor A becomes higher in use case X than that in Y, factor A will shift from Y to X. In the real world, however, the price mechanism is not always enough to coordinate factors of production, as a worker may move from department X to Y not because of a change in relative price, but because he is ordered to do so. In response to this, Marshall proposed organisation as the fourth factor of production representing coordination via such orders

(Marshall, 1890), Clark introduced the entrepreneur to explain coordination via orders (Clark, 1928), and Knight suggested the role of the manager to coordinate workers via orders (Knight, 1921).

Therefore, outside of firms, prices dictate production decisions and coordination occurs through a sequence of transactions in the *market*. However, when operating inside a *firm*, market transactions are replaced by entrepreneur-dictated production decisions. It is therefore clear that the market and the firm offer alternative production co-ordinating options. However, from the perspective of Salter, the price mechanism (market) is all that is needed for production, thus calling into question the need for the firm.

Coase argued that firms were needed over the market because of the costs of the price mechanism, and listed three specific types of transaction costs. First, there is a cost in determining (discovering) the relevant prices of production (Kaldor, 1933) and although such costs are not eliminated entirely within the firm, they are reduced. Second, costs exist in negotiating and concluding contracts needed for each transaction occurring in the market (Usher, 1920). As with discovery costs, negotiating costs are reduced but not entirely eliminated within firms. Third, firms allow for the creation and correct enforcement of long-term contracts, which may be desirable to those looking to avoid the costs of negotiating and enforcing a series of short-term contracts. Therefore, the firm is only more efficient than the market if the transaction costs entailed in obtaining factors of production are lower cost than those entailed in the acquisition of the same factors of production in the market. If the entrepreneur of the firm is unsuccessful, transacting participants are always able to revert back to the market. However, operating a firm at costs lower than those of the market cannot be guaranteed and therefore, without the uncertainty of the extent of transaction costs, the firm would not exist (Coase, 1937).

Considering this, Coase (1937:386-405) described three types of costs that are incurred when transacting with an external party on the open market:

1. **Search and information costs**: finding the lowest priced supplier for a job
2. **Bargaining and decision costs**: negotiating an agreement with the desired supplier
3. **Policing and enforcement costs**: ensuring the job completed by the supplier is of agreed-upon quality

These market transactions are reduced by the firm in the following ways:

1. **Search costs**: there is a greater flow of information within firms and the entrepreneur is better equipped to know the price of production (cost of assigning employees or suppliers to a task)

2. **Bargaining costs**: employees (suppliers) are already under contract and the entrepreneur, therefore, does not need to formally negotiate each task but can instead directly give orders
3. **Enforcement costs**: the threat of demotion, lower bonuses, and job loss ensures that employees (suppliers) follow orders and complete the job to sufficient quality

Moreover, firms are incentivised to 'internalise' transactions to remove any uncertainties over price and quality (Hennart, 1986; Love, 1997; Kaplan, 2012). For example, a beer company who owns its breweries, public houses, and suppliers may protect itself from any issues associated with sourcing the cheapest prices and negotiating contracts with suppliers and retailers, and in addition, the firm may enforce internal quality controls.

Two final factors may further impact transaction costs:

- **Bounded rationality**: individuals have finite decision-making power because of the cognitive restrictions of the human mind, time constraints, and the information available regarding the decision. It is for this reason that contracts are incomplete by nature and are filled with exceptions, requiring a judicial system to settle any disputes (Xu & Zou, 2020). However, bounded rationality does not apply only to individuals but also to firms. Firms may select prices and product characteristics with the intention of exploiting certain behavioural biases (Ellison, 2006), including hyperbolic discounting (DellaVigna & Malmendier, 2004; Della Vigna & Malmendier, 2006), loss aversion (Heidhues & Koszegi, 2004), and fairness (Rotemberg, 2011).
- **Opportunism**: individuals tend to act in their own best interests, thus introducing additional uncertainty in dealings between transacting parties (Nooteboom, 1996).

The severity of bounded rationality and opportunism will inform a firm on whether to expand internally (via vertical integration) or to transact with external parties (via the market), often known as the 'make-or-buy decision' (Jauch & Wilson, 1979). This is dependent on the following variables (Williamson, 1973, 1975):

- **Frequency***:* the greater the frequency of transactions, the greater the costs of operating via the market (because of constant negotiation, bargaining, and search costs)
- **Uncertainty**: the longer the contract, the greater the uncertainty
- **Asset specificity**: the degree to which an asset can be used for multiple purposes (i.e., its fungibility). The less specific the asset is, the fewer transactions required.

The trade-off between the transaction cost efficiency of the firm and the incentive maximisation (more efficient resource allocation) of the market is expressed graphically in **Figure 3** on page 22. This trade-off is linear and inversely related, and a transaction may therefore either benefit from reduced transactions costs using a firm or increased incentives using the market, but not both.

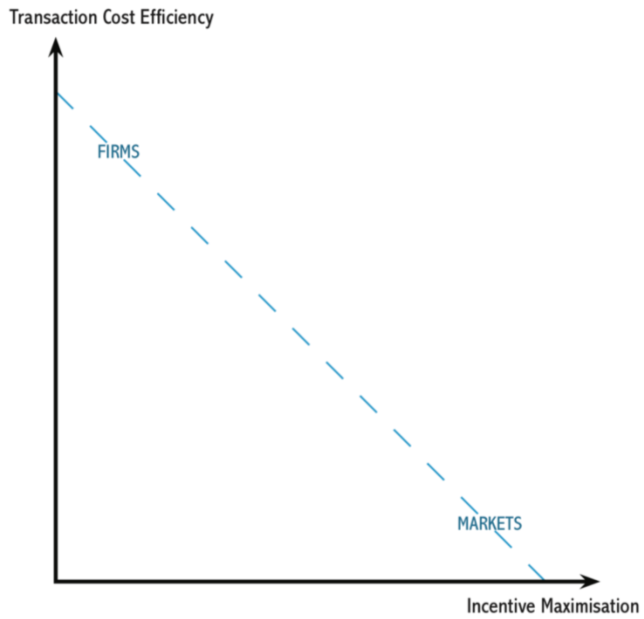

Figure 3: Trade-off between transaction costs and incentive maximisation between the firm and market (*source: Wang, 2018*)

Thus far, our discussion on transaction costs has remained limited to exogenous transactions costs, or costs that are incurred by the firm in engaging with parties or acquiring products and services outside the firm. The alternative is the acquisition of the same products and services *within* the firm, resulting in endogenous transaction costs.

Transaction costs are internal to a firm when transactions occur between departments or business units within the same firm, and which are headed by directors or managers. The same concepts of bounded rationality and opportunism also motivate any decision made by directors and managers. Therefore, by once again applying Williamson's economic formula on calculating behaviour surrounding decisions, this time in the context of endogenous transactions costs, the following questions are of relevance:

- **Frequency**: is dishonest behaviour commonplace within the firm's culture?
- **Uncertainty**: how likely is the manager to be caught for dishonest behaviour?
- **Asset specificity**: how much will the manager gain from a decision?

The level of monitoring and enforcement needed on a firm's management will vary according to the answers provided to the above questions. Naturally and as with exogenous transactions, any form of opportunistic behaviour within a firm will also have negative consequences on its financing and strategy (Kaplan, 2012). Thus, firms are motivated to put governance and monitoring controls in place to minimise the costs of bounded rationality and opportunism, thereby limiting the frequency, uncertainty, and asset specificity of internal transactions.

Alchian & Demsetz (1972) built on the idea of monitoring the costs of a firm and highlighted the necessity of monitoring costs within team environments. For instance, assume Firm A comprises three teams, each working on a separate project. Despite working on different projects, the three teams are likely to require similar, shared inputs to complete each of their projects, including technology infrastructure such as internet access and printing services and areas such as boardrooms for the team to meet and brainstorm. Without monitoring, one team could prevent the other two from using the meeting rooms by using these for the full working day. Therefore, when shared inputs are needed, the firm should ensure the most efficient arrangement for all teams to access the internet, printers, and meeting rooms.

3.3 Cryptonetworks – enabling new cost structures

Cryptonetworks may be thought of as a bridge between the market and the firm. Although cryptonetworks are not suitable for all situations, they supply an alternative that pushes out the trade-off boundary between transaction costs and incentives (**Figure 3** – pg22). When cryptonetworks are considered, the trade-off relationship shifts from a linear graph to a concave curve (**Figure 4** – pg24) as, like markets, cryptonetworks allow participants to conduct economic activities without a central decision-maker via economic incentivisation mechanisms (O'Leary, 2017; Angelis & Ribeiro da Silva, 2019). And like the firm, cryptonetworks also reduce transaction costs (Nowiński & Kozma, 2017; Angelis & Ribeiro da Silva, 2019; Cai et al., 2019; Weking et al., 2020). The concave shape therefore represents increased opportunity costs for firms and markets with cryptonetworks providing a middle ground. Thus, cryptonetworks can mitigate transaction costs while maintaining the incentive mechanisms of the market – changing the cost structure of firms.

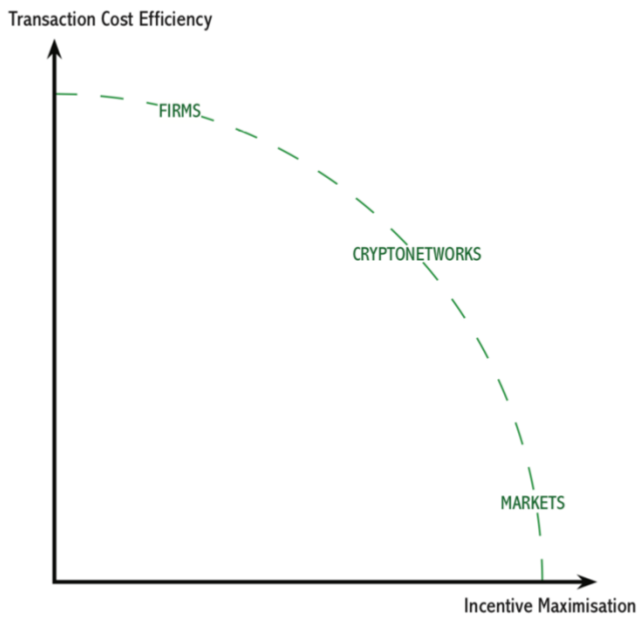

Figure 4: Improved trade-off between transaction costs and incentive maximisation associated with cryptonetworks (*source: Wang, 2018*)

Cryptonetworks distort the line between the market and the firm by lowering all three categories of transaction costs, according to Coase, in the following ways:

1. **Search and information costs**

Blockchain technology enables cryptonetworks to reduce search and information costs via simplified information exchange (public domain) and trust (consensus protocols) (Morkunas, Paschen & Boon, 2019). This information, which is forever stored in a publicly accessible, auditable, and immutable ledger, reduces information asymmetry (Xu & Zou, 2020) and enables easier and cheaper transactions as parties are confident in the accuracy of the information accessed. Also, because of their structure, cryptonetworks inherently benefit from network effects and network economies, and each network participant benefits from additional participants joining the network (Rouviere, 2016; Wenger, 2016; Chen, 2018; Oliveira et al., 2018), thus increasing the demand for the cryptonetworks' native token and causing its value to increase (Wenger, 2016; Chen, 2018; Wang, 2018).

Taiwanese start-up *BioIPSeeds*[5] is a blockchain-based peer-to-peer platform for Biomedical IP sharing. The company helps researchers freely exchange ideas. Researchers can upload their IP summary (research idea) to find research and funding partners. The platform secures and notarises any sensitive

[5] See: https://www.ipseeds.net/en/

data through blockchain. If a research partner is found, information can only be shared using the platform's encryption and decryption processes and all transactions are securely recorded in the blockchain (Lee, 2019).

2. Bargaining and decision costs

Bargaining is the process of discovering price, or what each participant is willing to pay (WTP) and willing to accept (WTA) (Condorelli, 2013). Because there are multiple participants and information is imperfect and asymmetric (one party is often better informed than the other), bargaining is a costly and time-consuming process that is replete with miscommunications (Julius & DiGiovanni Jr, 2016). Cryptonetworks streamline discovery (Morkunas, Paschen & Boon, 2019) and improve operational efficiencies (Nowiński & Kozma, 2017; Weking et al., 2020; Xu & Zou, 2020) by using open-source software (terms are open and known by all), open data, and auction techniques that further eliminate information asymmetry. Cryptonetworks also remove manual processes, shorten authorisation holds and therefore increase transaction speeds (Morkunas, Paschen & Boon, 2019). In the case of private blockchains, transaction speeds are decreased to microseconds (IBM, 2018).

Walmart in partnership with IBM launched a blockchain-enabled food tracing system to improve food security. This system reduced the time needed to trace food from its origin from seven days to a few seconds; allowing Walmart to recall products quickly (Morkunas, Paschen & Boon, 2019).

3. Policing and enforcement costs

Traditionally, contracts have been enforced by laws of contract, which may be national or multilateral. In the case of cryptonetworks, decentralised consensus protocols, which are not limited to national borders, and embedded logic are used to enforce contracts. Cryptonetworks connect consumers, suppliers and all other market participants directly, reducing errors and conflicts in contracts through smart contracts (Lee, 2019).

The *SyncFab platform*[6] links buyers and manufacturers in the original equipment manufacturer (OEM) parts procurement process. SyncFab reduces the time and costs of sourcing OEM parts; the platform also enforces anti-counterfeit measures, recalls and automated settlement.

[6] See: https://syncfab.com/

Finally, the last two factors that can further alter transaction costs and the implications of cryptonetworks are:

- **Bounded rationality**: Although cognitive and time limitations still exist in the context of cryptonetworks, information availability and reliability are significantly greater than on the market because of the transparent and immutable nature of blockchain transactions (Xu & Zou, 2020). Similarly, individual biases such as hyperbolic discounting, loss aversion, and fairness still exist, but their impact on transaction costs are reduced in the context of cryptonetworks.
- **Opportunism**: Because ownership of the cryptonetwork is shared via the use of the native network token, individuals are jointly incentivised to increase the value of the network (Wenger, 2016; Burniske, 2018). Therefore, uncertainty in dealings between transacting parties is also substantially reduced in comparison to that in the market.

Cryptonetworks also have an impact on the variables that influence bounded rationality and opportunism, specifically:

- **Frequency***:* Although the frequency of transactions in cryptonetworks may be high, the cost of these transactions is mitigated by removing the need for constant negotiations, bargaining, and search efforts, as transactions are cryptographically enforced and transparent.
- **Uncertainty**: Because transactions are cryptographically enforced, the length of a contract within a cryptonetwork does not result in greater uncertainty. The length of the contract could be two weeks or two years and both would be enforceable with equal levels of certainty. Due to cryptography, transacting parties can rely on the absolute enforceable nature of cryptonetwork contracts regardless of the contract length.
- **Asset specificity**: Except for a few cryptonetworks, most tokens are designed to be fungible, so that the same token may be used for any type of transaction. For example, the ETH token can be used for any type of transaction on the Ethereum platform, including payments and governance votes.[7] Furthermore, one token may be exchanged for another (e.g., BTC for ETH) to enable the seamless interoperability of different network tokens. Finally, tokens are infinitely divisible and can be 'broken down' to smaller fractions, thus highlighting their extremely low asset specificity.

[7] It should be noted that certain cryptonetworks have a separate governance token. However, the interchangeability of the governance token and use of the 'standard' token is possible through a single transaction request.

3.4 Why decentralisation is needed

Cryptonetworks will not always represent the optimal option in response to all cost inefficiencies; they are best suited to services that excel in decentralised environments (Nowiński & Kozma, 2017; Burniske, 2018) as only these can provide the adequate organisation and alignment of incentives for network participants. Without decentralisation, actors in a network may be tempted to engage in opportunistic behaviour mentioned above. Decentralised environments, however, align incentives so that all participants may benefit from increased network value (Rouviere, 2016; Wenger, 2016; Chen, 2018; Oliveira et al., 2018), thus reducing opportunistic tendencies.

The advantage of decentralisation becomes apparent when comparing the cost of using the current system of ensuring trust. An excellent example is that of the Lehman Brothers, who in 2007 recorded record profits, all of which had been fully audited by Ernst & Young (Wiggins, Bennett & Metrick, 2014; Calida & Katina, 2015). Nine months later, however, came the largest financial economic crisis in 80 years, forcing the 158-year-old company to file for bankruptcy (Katina et al., 2019). Evidently, the records of the years before the collapse had not been correct. Upon further investigation, it was discovered that the Lehman Brothers were not the only guilty party, with banks in the United States and Europe also being forced to pay billion-dollar fines to settle the costs of producing inflated balance sheets (Casey & Vigna, 2018).

The 2008 economic crash is an extreme example of the cost of trust, or lack thereof (Calida & Katina, 2015; Katina et al., 2019). But it is not the only example, as other areas of our economy exist purely to create trust in current records. Accountancy is one example of a profession solely dedicated to creating trust in external records. The job of accountants is to reconcile firm ledgers and their expertise is only needed as business counterparts do not inherently trust each other's ledgers. The current job of accountants is therefore expensive and time-consuming but is a necessity.

The cost of trust is also evidenced by what the current centralised system prevents. Companies such as Google, Facebook, and Amazon have used economies of scale and network effects to create monopolies (Chen, 2018; Dixon, 2018; Cowen, 2019). These networks have provided billions of users access to powerful, free technologies at the cost of massive monopolised user data silos. The cost of companies building massive user data silos goes beyond just privacy concerns. The true costs are revealed by analysing the lifecycle of centralised platforms (**Figure 6** below) and the problematic patterns that exist during this lifecycle.

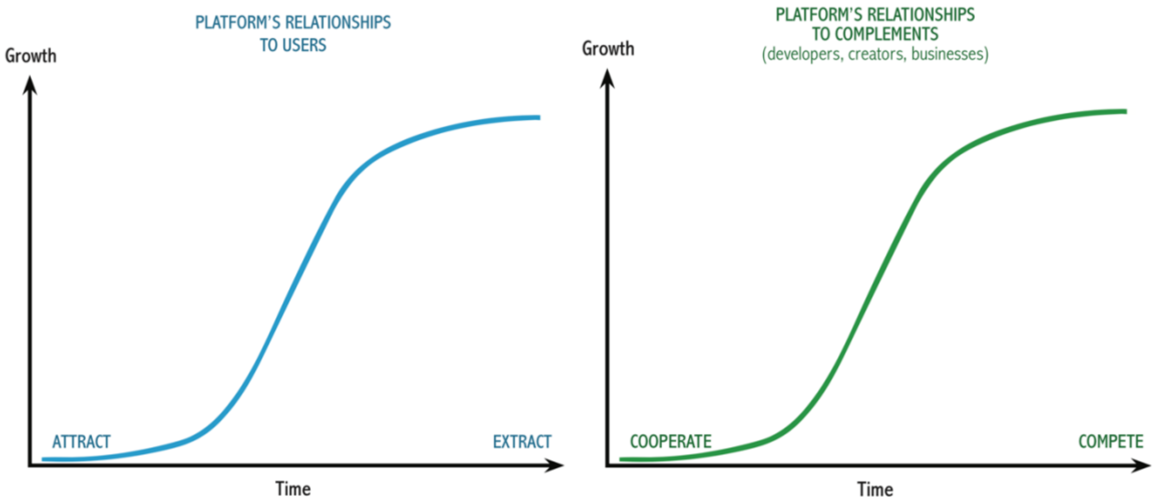

Figure 6: Centralised network shifts in power structures in relation to network growth (*source: Dixon, 2018*)

At the start of a centralised platform's lifecycle, its priority is to attract users and third parties, including developers and businesses (Dixon, 2018), and this is associated with network effects (Chen, 2018). The more users a network comprises, the more useful the network becomes for other users and developers alike, thus increasing its overall value (Rouviere, 2016; Wenger, 2016; Chen, 2018; Oliveira et al., 2018). As network adoption increases, the platform's influence over these new users and third parties also rises **(Figure 6** above**)**. Until this stage, the relationship between the centralised platform and its network participants is a positive-sum game as neither the platform nor the participants benefit at the expense of the other. Therefore, during its infancy, a platform such as a social media network requires additional users and developers to grow, thus benefiting the owners of the platform (via increased revenues), network users (via the use of the platform's services), and developers (via revenue generated by reaching new users) (Wenger, 2016; Chen, 2018; Wang, 2018).

However, the relationship between the platform and its participants changes to a zero-sum game once the top of the S-curve shown above in **Figure 6** is reached. As at this point, the platform has gained enough users and developers for it to render impractical the use of alternative platforms supplying similar services. Users are essentially 'locked-in' to the network as all social peers use the same platform, and developers are similarly 'locked-in' as the users of their apps are on the platform. Examples of such cases include Facebook, LinkedIn, WhatsApp, and Instagram. Therefore, the platform no longer has to explicitly attract additional participants as network effects have become so strong that new participants join spontaneously. Thus, further growth of the platform is achieved by extracting data from users and competing with platform complements over users and profits (Dixon, 2018). Therefore, instead of benefiting from network effects, the platform now exploits these effects.

Examples of network pairs having made this transition include Facebook and Zynga (BBC News, 2012), Google and Yelp (Smith, 2012), Microsoft and Netscape (Stern, 1997), and Twitter and its third-party clients (Newton, 2018). These platforms (Facebook, Google, Microsoft, and Twitter) initially attracted third-party developers (Zynga, Yelp, Netscape, and Twitter third-party developers) who built apps to make use of each platform's user base. However, once the platforms had grown large enough, these third-party developers were no longer *complements* to the platforms but instead *competitors* who were taking potential profits and users away from the platform. Because the platforms have absolute control over user access, they were able to change platform rules without consideration for the participants. This results in platforms developing or buying solutions previously offered in-house by third-parties and removing the original creators from their networks.

The third-party transition from cooperation to competition has been described as a '*bait-and-switch*' (Dixon, 2018). As a result, *"...over time, the best entrepreneurs, developers, and investors have become wary of building on top of centralised platforms"* (Dixon, 2018). For network users, the transition involves the surrender of privacy and data, with security breaches also becoming a later risk. Exploitation by centralised parties is a dysfunctional rent-seeking behaviour that occurs when trust is manufactured politically (Tullock, 1967).

The shift away from placing trust in open internet protocols began in the mid-2000s, when trust moved from open protocols to centralised companies. Companies such as Facebook, Google, and Twitter have built platforms and services that exceed the functionality of open protocols, migrating users to these superior platforms. However, the code of these platforms is proprietary and the power structure allows owners to make absolute decisions. Some additional examples of this control power include granting or denying user access to platforms (e.g., Google and Yelp, or Facebook and Zynga), search result rankings (Google), and revenue generation by network creators (YouTube). Such decisions are critical in determining the value that network participants may gain from partaking in the platform.

In contrast, cryptonetworks make use of two mechanisms to remain neutral throughout their growth and consequently do not experience the same bait-and-switch tactics as centralised platforms. The first mechanism is enforcing and storing the contract between the cryptonetwork and its participants in open-source code as trust is decentralised and manufactured cryptographically rather than politically (Nowiński & Kozma, 2017; Bamakan, Motavali & Babaei Bondarti, 2020). Secondly, a 'voice' and 'exit' mechanism is applied. Participants are given a voice (power) through the network's governance structure through the implementation of tokens (Oliveira et al., 2018; Katina et al., 2019). This may be on-chain (on the blockchain itself via the consensus protocol) or off-chain. Furthermore, in extreme scenarios, participants may exit the network through forking.[8] The political economy of a cryptonetwork may therefore be thought of as private order competitive federalism (Tiebout, 1956), as it enables free entry into and exit out of multiple networks, comparable to 'voting with one's feet' (Davidson, De Filippi & Potts, 2016). This allows for the removal of rent-seeking behaviour by decentralising network rule control. MacDonald (2015) referred to this shift in power as '*crypto secession*'.

Chapter 3 has introduced the concept of cryptonetworks, which are created through the combination of blockchain technology and tokens. Cryptonetworks look to build upon, disrupt and potentially form entirely new business models by blending the functionality of centralised platforms with the community-orientated nature of the original open protocols of the internet. Cryptonetworks operate under a meritocratic framework in which participants interact through pure economic incentives instead of orders. Any orders are enforced without the need of a third party by using the embedded logic programmed in the networks' consensus protocol. By leveraging economic incentives and decentralised enforcement, cryptonetworks act as a bridge between the market and the firm. Although cryptonetworks are not suitable for all situations, they supply an alternative that pushes out the trade-off boundary between transaction costs and incentive maximisation (**Figure 3** – pg22). When cryptonetworks are considered, the trade-off relationship shifts from a linear graph to a concave curve (**Figure 4** – pg24) as, like markets, cryptonetworks allow participants to conduct economic activities without a central decision-maker via economic incentivisation mechanisms. And like the firm, cryptonetworks also reduce transaction costs. Cryptonetworks also enable value creation to be correctly assigned to the actual content creators through tokens. A discussion on decentralisation showed decentralisation is needed to combat the negative behaviours of centralised networks which turn from a positive-sum game to zero-sum game once adoption has reached a critical level (**Figure 6** – pg26). This often comes at the expense of network participants who are left with no option but to comply with the new rules. These participants include those that originally contributed to the initial value of the network's growth. In contrast, cryptonetworks of today remain neutral throughout their growth and reward participants for their contributions through tokens. Future implementations of cryptonetworks, however, could extend this value creation framework even further. An exploratory framework for extending how value could be captured and measured is discussed next in **Chapter 4**.

[8] There are two types of forks: hard and soft. A soft fork only requires a majority of the miners to agree on the new rules, while a hard fork requires all nodes to upgrade and agree on the new version. Hard forks can result in separate 'chains' of the same network if participants do not agree on proposed changes.

4 Cryptoeconomics – opportunities for value creation

Economic theories used within blockchain-enabled applications such as cryptonetworks are referred to as '*cryptoeconomics' or 'tokenomics'* which is used to build token economies (Oliveira et al., 2018; Berg, 2019). Evaluation of the growing literature on cryptoeconomics reveals a prevailing theme: the underlying economic concepts are curiously conventional and conservative. The application of such orthodox and overly-narrow economic frameworks limits the potential of cryptoeconomics and cryptographically enabled, distributed economic-social systems that could permit drastically different politics and economics in the future (Bryan et al., 2018). This simple system perspective fails to consider the wider organisational, policy and social influences of blockchain (Katina et al., 2019).

The limitations incurred by applying orthodox economics to cryptoeconomics has two implications for the role of tokens. First, with regard to money, tokens offer an additional unit of account (Conley, 2017) as well as a means of exchange (Evans, 2014; Pilkington, 2016). Second, with regard to ownership, tokens allow people to take risks collectively rather than individually. In this chapter, we first describe the different schools of economics and their implications for cryptoeconomics and then discuss the idea of calculating 'fundamental value' in the context of cryptonetworks within the different framings of economic schools. The objective is to demonstrate that reframing economic theories may fundamentally alter the application of cryptoeconomics, and as a consequence, empower future token economies into a new economic paradigm of value capture and creation (Tapscott & Tapscott, 2016; Berg, 2019; Lee, 2019).

4.1 The role of economics in cryptoeconomics

Economics as a discipline is both vast and highly contested. Today, the dominant discourse in economics is 'neoclassical', as described in Jevons's *Theory of Political Economy* (Jevons, 1888), Menger's *Principles of Economics* (Menger, 1976), and Walras's *Elements of Pure Economics* (Walras, 1874). Although economic discourse has evolved since the 18th and 19th centuries, the neoclassical economic school remains dominant. The neoclassical school has faced challenges since its beginnings from both the right-wing in the form of libertarianism (Hayek) and the left (Keynesianism and Marxism). It is thus unsurprising that even economists disagree about what constitutes the discipline of economics. Here, we discuss two definitions of economics that have completely different implications for an understanding of cryptoeconomics. The first states economics as *"the science which studies human behaviour as a relationship between ends and scarce means which have alternative uses"* (Scoon, 1943). This definition alludes to the determination of price and decision-making processes of individuals and firms. 'Alternative uses' suggests utility optimisation, a concept that is largely addressed in microeconomics (the inner workings of individual markets) rather than in macroeconomics (the interaction of all markets as a unit).

An alternative definition states that *"economics is the social science that deals with the production, distribution and consumption of goods and services"* (Zambelli, 2013). This definition implies a wider social context than the first. More specifically, the second definition is not restricted to the idea of individual optimisation or the inner workings of the market, and a focus is placed on the collective rather than the individual. The second definition therefore implies that the economic system and other more social aspects of life are intertwined. In contrast, the first definition highlights the determination of price and decision-making processes by assuming individuals are independent rational actors (Levin, Milgrom & Rangel, 2004). Contemporary economics includes game-theory strategic rationality as well as 'systematic irrationality' or behavioural economics (Kahneman & Tversky, 1979; Tversky & Kahneman, 1992). Through this evolution, economics has become an increasingly mathematical and model-based discipline (Bryan et al., 2018).

Both definitions of economics have implications for the formation of cryptonetworks. When designing cryptonetworks, it is vital to simultaneously recognise the evolution of economic activity allocation (definition 1) and the power of mathematical modelling (definition 2). The cryptonetwork that has come closest to simultaneously recognising both definitions in its inner workings is Ethereum. Buterin provided a definition of cryptoeconomics that is consistent with definition 1: "*Build systems that have certain desired properties; use cryptography to prove properties about messages that happened in the past; use economic incentives defined inside the system to encourage desired properties to hold into the future*" (Buterin, 2017).

Conversely, one of Ethereum's lead developers Vlad Zamfir defined cryptoeconomics in a way that best fits definition 2: "*A formal discipline that studies protocols that govern the production, distribution, and consumption of goods and services in a decentralized digital economy. Cryptoeconomics is a practical science that focuses on the design and characterization of these protocols*" (Zamfir, 2015).

However, in practice, working definitions of cryptoeconomics have largely been closer to the first definition. Sometimes referred to as 'token engineering', the scope of cryptoeconomics here focuses on designing cryptonetworks with incentives applicable to rational actors. The opportunity cost of limiting cryptoeconomics to the first definition is ignoring the potential of tokens beyond their use as incentives. More specifically, the sole use of cryptoeconomics to lower transactions costs and create economic incentives that ensure optimal behaviour from rational network participants may lead to the disregard of wider social issues of production, distribution, and consumption of goods and services.

4.1.1 Current working definitions of cryptoeconomics

There is limited consistency with regard to the working definitions of cryptoeconomics. Almost all sources start by breaking the term down into two parts: *cryptography* and *economics*. However, analysis of these two components is not always equal and the definition of the cryptography component is often far more detailed and precise than that of its counterpart: "*Cryptoeconomics comes from two words: Cryptography and Economics. People tend to forget the "economics" part of this equation and that is the part that gives the blockchain its unique capabilities [...] Like with any solid economic system, there should be incentives and rewards for people to get work done, similarly, there should be a punishment system for miners who do not act ethically or do not do a good job. We will see how the blockchain incorporates all these basic economic fundamentals*" (Blockgeeks, 2017), and "*Cryptoeconomics [...] combines cryptography and economics in order to create huge decentralized peer-to-peer network. On the one side, the cryptography is what makes the peer-2-peer network secure, and on the other side, the economics is what motivates the people to participate in the network, because it gives the blockchain its unique characteristics*" (Energy Premier, 2018).

The limited framing of economics is perhaps a consequence of the paucity of persons highly qualified in both cryptography and economics. Szabo[9] stated that '*an economist or programmer who hasn't studied much computer science, including cryptography, but guesses about it, cannot design or build a long-term successful cryptocurrency. A computer scientist and programmer who hasn't studied much economics, but applies common sense, can*' (Szabo, 2018). However, although the first part of this statement is arguably correct, the latter is not. It is incorrect to believe that one can create anything new from common sense, as one is only able to repeat what is already known. Moreover, if the economy functioned via common sense, it would more closely resemble a computer and would follow power structures perfectly. Economists, however, treat the issue of power (politics), its control mechanisms, and its players as crucial concerns that are neither static nor prescribed and are otherwise known as the political economy (Smith, 1776; Mill, 1848).

Formally trained economists who do not have the necessary computer science knowledge are just as susceptible to misspecification. The MIT Cryptoeconomics Lab[10] defined cryptoeconomics accordingly: "*the paper focuses on two key costs that are affected by blockchain technology: the cost of verification,*

[9] Nick Szabo is a computer scientist and cryptographer known for his research in digital contracts and currency.
[10] See: https://ce.mit.edu/

and the cost of networking. For markets to thrive, participants need to be able to efficiently verify and audit transaction attributes, including the credentials and reputation of the parties involved, the characteristics of the goods and services exchanged, future events that have implications for contractual arrangements, etc." (Catalini & Gans, 2016). The cryptoeconomics team at the University of Berkeley provided similar perspectives on the scope of cryptoeconomics: "*Although Bitcoin's protocol is often explained from a technological point of view, in this series, I will convey the incentives existing at every level that allow for its various comprising parties to interact with cohesion and security. This study of the incentives that secure blockchain systems is known as cryptoeconomics*" (Koticha, 2018). The purpose of including these two definitions is not to critique their contributions as both papers achieve their outcomes of explaining what the authors view regarding the extent of the involvement of economics in cryptoeconomics. Instead, we argue that by limiting the idea of cryptoeconomics to such framings, cryptoeconomics will be restricted *only* to the optimisation of individual transaction costs and incentives. Accordingly, these analytical cryptoeconomic frameworks do not apply to larger matters of production, distribution, and consumption of goods and services (Bryan et al., 2018).

4.1.2 A Hayekian perspective

A subset of the blockchain community may be content with limiting the definition and function of cryptoeconomics to that of the reduction of transactions costs and the provision of individual incentives. Indeed, those who view the interaction of individuals and markets as both efficient and 'correct' will be particularly drawn to maintaining the current cryptoeconomics framework. Adopting an approach to economics that is aligned with that of Hayek would see cryptoeconomics maintain its current scope. Hayek was a strong believer in the ability of markets and prices to transmit information, positing that these create spontaneous self-organisation (Hayek, 1945, 2002). He was also an advocate for limiting the role of the government solely to the provision of law and order, a restricted menu of public goods and monetary policy. In *The Denationalization of Money*, Hayek argued against government intervention and for the use of private, competitively driven currencies in the following extracts: "*... but I do not think it an exaggeration to say that history is largely a history of inflation, and usually of inflations engineered by governments and for the gain of governments*..." (Hayek, 1976:34), and "*We indeed begin to see how completely different an economic landscape the free issue of competitive currencies would produce when we realise that under such a system what is known today as monetary policy would neither be needed nor even possible. The issuing banks, guided solely by their striving for gain, would thereby serve the public interest better than any institution has ever done or could do that supposedly aimed at it*" (Hayek, 1976:101).

This Hayekian perspective may exist in the interpretation of cryptoeconomics within cryptonetworks by the blockchain community. This perspective is perhaps unsurprising considering the attitude of 'decentralisation above all else' adopted by cryptocurrencies such as Bitcoin (Song, 2018; Barhydt, 2019; Schneider, 2019). It is understandable then that parts of Hayek's ideas resonate with the blockchain community, particularly those relative to individuals and incentives which align with blockchain's decentralised philosophy.

However, a closer inspection of Hayek's workings reveals that not all such ideas align with those of the blockchain community. Although Hayek was against the Keynesian proposal for government-backed money, he did not believe in the free issuance of money. Instead, Hayek thought that the quantity and value of money issued should be determined by growth in the 'real economy'. For example, during the post-WWII global monetary system debates, Hayek proposed a system that would be supported by a reserve of basic commodities (e.g. wood, coal, and wheat): "*the basic idea is that currency should be issued solely in exchange against a fixed combination of warehouse warrants for a number of storable raw commodities, and be redeemable in the same 'commodity unit'*" (Hayek, 1943:179). This idea of linking the real economy with money is largely ignored by cryptocurrency advocates who often push for non-state currencies without material support.

Neoclassical economics provides an alternative approach based on optimisation, transaction costs, and incentives, while also recognising that markets are limited in their scope. More specifically, neoclassical economics argues that there are two broad situations in which markets are limited:

1. **Imperfect markets***:* situations where firms can achieve return over and above the norm. Historically, this term has been used to describe the inefficiencies of oligopolies and monopolies. More recently, the term 'imperfect markets' also implies the issue of asymmetrical information, a situation in which one of the transacting parties has more complete information about the transaction than the other party.
2. **Market failure***:* a result of the market's inability to effectively allocate prices, as external benefits and costs (externalities) are not borne by individual producers. Neoclassical economists believe that government intervention is required to overcome these market failures.

Finally, economics is arguably '*performative*', in that economic models make the world, but they do not describe it (Mackenzie, 2006) with economics working under 'ought' rather than 'are' statements. Recognising this perspective is imperative for the full realisation of the potential of cryptoeconomics. More precisely, under a 'radical' framing (i.e., beyond the strict constraints of orthodox economic beliefs such as neoclassicism), cryptoeconomics could create entirely new ways of designing economies. Similarly, recognising the complexity of social and economic dynamics in token design is essential, as it must consider the social and formal technical underpinning of cryptoeconomics as equal. However, if token design remains limited to 'ought' systems, its social aspects will be understated and undervalued, likely leading to failures in the system's governance structures (Bryan et al., 2018).

In the following section, we discuss the realisation of the full potential of cryptoeconomics. First, we argue that tokens should be treated as a means of exchange (transaction perspective) (Evans, 2014; Pilkington, 2016) as well as a new unit of account (production and distribution perspective) (Conley, 2017).

4.1.3 Tokens: a dual-use case argument

According to the first definition of economics, which highlights optimisation, incentives, and transaction costs, tokens are conceived strictly as a *means of exchange* (Evans, 2014; Pilkington, 2016). However, under the perspective of the second definition, the significance of tokens shifts beyond their use as a means of exchange to represent a new *unit of account* (Conley, 2017). The second definition suggests that tokens provide a new unit and mechanism for measuring economy size. More specifically, the first definition is only concerned with items of the economy that can be measured using market calculus. However, the second definition encompasses the measurement of 'production' and 'consumption', a far less precise question with no absolute answer.

The limitations of the first definition's measurement criteria are well established. The exclusion of economic activities that result in products that are not marketed and therefore have no market price, such as household production, the informal sector, and subsistence production, is a well-known limitation of the traditional gross domestic product (GDP) function (Ironmonger, 2000). This exclusion is a result of the complexity of specifying a market price for items such as household production, or that of correctly pricing externalities such as pollution. Early responses to these limitations included measurement concepts such as 'triple-bottom-line reporting' (Slaper & Hall, 2011) and 'ethical investing' (Hudson, 2005). However, these measurement criteria suffer from the same limitations: they are solely profit-centric. Tokens open the opportunity to re-evaluate this measurement issue. As a *means of exchange*, tokens facilitate new ways of trading (Evans, 2014; Pilkington, 2016). As a *unit of account*, they enable new means of measuring output, or what is valuable and how it is produced (Conley, 2017).

The first challenge in discovering new ways of trading and measurement via cryptoeconomics is opening a dialogue regarding the definition of 'production' and 'consumption'. These discussions include determining how to incorporate the production of previously excluded items such as social, political, aesthetic, organisational, and environmental interactions. Crucially, new measurement criteria should be socially useful and indeed socially validated measures. The first implication is that production value cannot be reduced to the single measure of monetary price, which should instead be treated as one of many measurement indexes. Other indexes will need to be developed following the social quantification of other goods, services, and intangibles.

In cryptoeconomics, the question of what to measure and how is a critical question. Mainstream economics and accounting recognise the extreme difficulty of measuring intangible assets (Corrado, Hulten & Sichel, 2009; Jeny, 2015). Although it is relatively easy to measure the value of assets such as equipment and land, measuring that of intangible assets such as intellectual property (IP) and brands is far more complex. The history of financial economics provides some insight into the difficulties surrounding the measurement of intangible assets.

In financial economics, every company has a 'fundamental value'. Also known as the company's 'intrinsic value', it is the perceived value of a company and includes both tangible and intangible assets, using fundamental analysis (Mohanram, Saiy & Vyas, 2018). Unlike more traditional valuation techniques, fundamental value posits that a company can be valued outside of what the market price states and therefore also has an intrinsic value. This concept is most often applied by value investors who look beyond pure market-based measurement techniques (Gottwald, 2012; Amiri, Ravanpaknodezh & Jelodari, 2016). The resulting 'fundamental' value of a company may or may not be equal to its market value. Fundamental value analysis was especially popular in the 1980s during private equity buyouts, which were based on the idea that a company was worth more when broken up into 'parts' and sold as a going concern (Acharya, Franks & Servaes, 2007; Blundell-Wignall, 2007). Since the 1980s, measuring the value of a company has become an increasingly challenging task after changes in capital accumulation and the rise of 'intangible capital' (Montes, 2010).

Intangible capital refers to investments resulting in the growth of a company that leverages intangible assets (Montes, 2010). Intangible capital is not new, but its use remained relatively limited pre-1990s and it was simply categorised as 'goodwill'. Today however, the intangible capital of the largest companies cannot be ignored as it makes up the majority of their value. For example, 62%, 88%, and 95% of the enterprise value of Apple, Microsoft, and Amazon is made up of intangible assets, respectively (Brand Finance Institute, 2017). Such a radical increase in the importance of intangible capital may have resulted in a shift in the determination of new valuation criteria. However, it has not.

Measurement techniques from the 1980s are still applied, resulting in a measurement crisis (Montes, 2010; Bryan et al., 2018). The major assets of today's biggest companies no longer include those that have expiry dates and replacement costs, such as machinery, but are instead intangibles such as IP, information, brand, and reputation that do not have predefined expiry dates or replacement costs, and are often unique with no direct substitutes, thus making valuation extremely difficult.

Intangible capital on company balance sheets are currently priced as *call options* (the sale of intangible assets to shareholders at a projected future of the intangible value). Call options are a type of derivative whose price reflects the exposure risk on the value of intangible capital (Bryan & Rafferty, 2006; Rafferty & Bryan, 2008). The issue of the measurement of intrinsic value is circumvented using this accounting technique. The conventional accounting framework needs updating and this was attempted by Baruch Lev, a New York University accounting professor and leading accounting expert on intangible assets, and Feng Gu, a prominent US-based accountant. According to Lev and Gu, the use of accounting information such as net income and return on equity in explaining stock prices is no longer appropriate (Lev & Gu, 2016). This is associated with poor accounting standards for IP and in particular the measurement of research and development (Lev & Gu, 2016). This is unsurprising considering that the current framework was designed during a period of manufacturing that provided clear definitions of machinery, labour, and ownership and during which social impacts were strictly understood as profit, interest, rent, and wages.

Similar to that in the largest companies of today, the majority of assets in cryptoeconomics are also intangible, and the issue of measuring intangible assets is one that cryptonetworks share with conventional firms that comprise considerable IP. However, unlike conventional markets, valuation techniques for crypto markets are still being tested and defined and may well move beyond conventional accounting categories. Token valuation techniques must be developed in a way that specifically addresses the contributions of intangible capital to correctly measure and incorporate other contributions to societal growth. Considering that gamification is built into cryptonetworks via economic incentives using tokens, the most significant challenges faced in the development of crypto valuation frameworks are measuring required indexes and preventing participants from abusing the system's gamification mechanisms. Although it is not within the purpose of this paper, early attempts at crypto token valuation have shown to be exploratory and have their limitations. It would therefore appear that just like mainstream accounting, cryptoaccounting does not yet possess the necessary tools to accurately measure intrinsic crypto token value.

4.2 Information, knowledge, and tokens

Price, as we know it today, is the condensation of multiple determinations. The market processes all types of information and creates knowledge, resulting in spontaneous order: "*The most significant fact about this system is the economy of knowledge with which it operates, or how little the individual participants need to know in order to be able to take the right action. In abbreviated form, by a kind of symbol, only the most essential information is passed on, and passed on only to those concerned. It is more than a metaphor to describe the price system as a kind of machinery for registering change, or a system of telecommunications which enables individual producers to watch merely the movement of a few pointers, as an engineer might watch the hands of a few dials, in order to adjust their activities to changes of which they never know more than is reflected in the price movement*" (Hayek, 1945:526-527).

In the 1940s, the argument for 'the market' stood as a strong alternative to central planning. Nearly 80 years have passed since then and this argument is no longer relevant. Today, to learn about individual decisions, we have access to 'big data' and already have the computational power to process these data almost instantly. Thus, the desire and indeed the need to simplify and reduce complex variables (such as individual decisions) to a single 'price' no longer exists. Decentralised decision-making in cryptonetworks does not require formulating decisions solely through market prices (discussed in **Chapter 3**). Thus, the powerful potential of cryptonetworks is to challenge the very idea of the Hayekian price as the desired outcome of markets (Bryan et al., 2018).

In *The Use of Knowledge in Society,* Hayek argued that price encapsulates a complex set of information, creating knowledge for society, and that price enables a simple representation of that complexity (Hayek, 1945). Blockchain and more specifically tokens introduce fundamentally new ways of handling such complex information and measure value. To update this argument for a 21st-century context, it is helpful to reframe Hayek's argument in relation to *risk* and *derivatives*. Two aspects should be highlighted:

- Through the use of big data and blockchain, the information that makes up 'knowledge' as we know it today can be 'divided' into core elements that Hayek believed were too complicated to separate. Therefore, knowledge can be viewed as an artificial asset or a product of informational data points.
- Price itself is a derivative of the underlying elements of information it is said to combine. In the context of Hayek's *The Price System as a Mechanism for Using Knowledge*, 'price' is

actually the strike price[11] on the option of the artificial asset known as knowledge (Hayek, 1945; Bryan et al., 2018).

Therefore, if 'price' as viewed by Hayek is the condensation of multiple elements of information, what are these key elements for which price represents the risk (exposure) of a derivative? Once these elements are defined, the next questions would be: how important is each element *beyond* underpinning price? Can any of the elements be used in their own context as knowledge or as indicators for the market? For clarity, it is important to understand the implication of Keynesian and Hayekian discourses. With regard to Hayek, if the information making up price can be disentangled, the goal of using this information is challenged to consider other measures outside that of a single price. This discussion reveals entirely new social measurements with an economy. However, for Keynes, markets will not tend towards the stability of full employment and thus it is up to nation states to govern the national economy. Paramount to this is the idea that the state must tightly control and define its own financial system (Keynes, 1936). In *The General Theory of Employment, Interest and Money*, Keynes argues that the economic characteristics of money are not what makes it unique: "*the money-rate of interest—we may remind the reader—is nothing more than the percentage excess of a sum of money contracted for forward delivery, e.g. a year hence, over what we may call the "spot" or cash price of the sum thus contracted for forward delivery [...] Thus for every durable commodity we have a rate of interest in terms of itself,—a wheat-rate of interest, a copper-rate of interest, a house-rate of interest, even a steel-plant-rate of interest [...] Money is the greatest of the own-rates of interest (as we may call them) which rules the roost*" (Keynes, 1936:141).

Keynes describes money as the 'greatest of the own-rates of interest' for four reasons: (1) money itself does not produce any use value (such as copper or wheat) and so it remains exclusively as 'money', (2) the issuance of money has no wastage, (3) it is the most liquid of assets, and (4) its quantity is controlled. There are two points to note with regard to Keynes' observations on money. First, the four reasons proposed by Keynes to form the 'greatness' of state-operated money are not as convincing today, as all financial derivatives are as liquid and fungible as state money, and tokens are not confined to any one nation. Second, the language used by Keynes is now applied to financial derivatives in relation to the rate of interest: interest is the derivative of money. For the author, money is unquestionably state money. In this context, tokens are then an option on state money, representing the right to 'sell out' (de-risk) from the state's unit of account (Bryan et al., 2018).

[11] 'A strike price is the price at which a derivative contract can be bought or sold (exercised)' (Calin, Chang & Alshamary, 2012).

Therefore, if money is a derivative of risk to the state, what are tokens a derivative of? And what alternative economic and social organisation structures exist?

To expand on these two divergences on contemporary economic thought, price must be redefined. Price is no more than an index that measures *relative* values between products and over time (Fetter, 1912). Today though, price is treated by society as the absolute social measure of value. This social measure is the central idea behind the trust placed in a fiat monetary system. However, history has shown that this absolute measure is a social construct and that it can be changed, for example during the switch from the French Franc to the Euro in 2002 (European Commission, 2019) or the change in the British pound decimal system (Freeman, 2011). The very idea of tokens or cryptocurrencies is in stark contrast to the use of one absolute social measure (price). Therefore, why is price is treated as the only benchmark index for value? Why not use a social or environmental impact index instead? It is argued that price is reflective of the social and cultural values of a capitalist society (Bryan et al., 2018) and that by treating price as a sole valuation benchmark, two assumptions are made: (1) producing for the market is more valuable than producing for direct consumption as consumption generates no price (e.g., farming one's own food), and (2) profit is embedded within price. These assumptions make sense within a capitalist society as they capture what is valued by such societies. The use of GDP as the only valuation measure has been criticised as it does not reflect the costs imposed on the environment of production and consumption and excludes any consideration of environmental costs (Nordhaus & Kokkelenberg, 1999; Muller, Mendelsohn & Nordhaus, 2011; Muller, 2014; Chowdhury & Islam, 2017). Furthermore, GDP is not reflective of actual measures that reflect life satisfaction (Oswald, 1997; Abdallah, Thompson & Marks, 2008; Cassandra, 2010; Berkeley Economic Review, 2018). However, a discussion of the correct indexes for use is outside the scope of this paper. Rather, we highlight that any potential alternative index to GDP should provide a measurable underpinning of the social organisations of today.

4.3 Reframing value through cryptonetworks

Today, in the context of business models, value creation can be described as the "*the processes and activities, resources and capabilities, and their orchestration in the firm*" (Weking et al., 2020). Value creation is the product of a firm's revenue and cost structure which ultimately determines how a firm makes money (Frankenberger, Weiblen & Gassmann, 2014; Gassmann, Frankenberger & Sauer, 2017). **Chapter 3** has already discussed how cryptonetworks can alter the cost structure of firms as well as correctly reward value creation to the actual content producers through tokens (Lee, 2019). In that discussion, value creation was viewed in terms of its potential as revenue and profit. The discussion below, however, is an exploratory framework on how value creation within cryptonetworks could be reconfigured to usher in a new economic paradigm on what value creation is (Tapscott & Tapscott, 2016; Lee, 2019). And in doing so, capture the wider social value of production, distribution, and consumption of goods and services.

In an economy that does not consider profit as its sole objective, entirely new measurement methods will need to be developed, as even combining GDP frameworks with qualifiers (e.g., pricing environmental impact) would still fall under a profit-centric framing. Therefore, adding qualifiers will only result in the need to justify the lack of profit in the name of unmeasurable social improvements. Under a framework that treats profit as the key measure of value, any non-profit-generating indexes are viewed as 'trade-offs'. The objective should be to frame these not as trade-offs but as another means of conducting economic activity. However, achieving this would require abandoning profit as the singular goal, a difficult undertaking.

Adapting a view from Hayek provides a starting point for the formulation of these updated valuation measurement techniques, with the use of tokens as the unit of account (Conley, 2017). Hayekian price may be referred to as the 'profit price' reflecting a profit-centric perspective on value. Cryptoeconomics, however, provides new tools to measure both present and future value forms, allowing the incorporation of intangible forms of value. As discussed earlier, 'profit price' is not equipped to accurately measure future (intangible) value, calling for the development of new measurement techniques. Using knowledge as an example, determining how, where, and when 'profit price' gains its value highlights its limitations as a value-capturing index. Knowledge is a key component of a firm in creating a sustainable competitive advantage (Jana, 2016). The value obtained from knowledge accrues in three ways: (1) when it is adopted, repeated, shared, or copied in multiple ways, reflecting the inherent collective and social nature of knowledge, (2) when it interpreted, accepted, and thus invested in, and (3) when the creators of knowledge share in its gains and risk and continuously update it. These three key features of knowledge encompass precisely what Hayekian 'profit price' value is unable to accurately reflect. Capturing value in line with these three points requires an entirely new grammar. In this new grammar, value accrues through: (1) adopting, repeating and sharing multiple use cases (as opposed to the restriction of proprietary ownership, such as IP rights), (2) having multiple owners, interpretations, and versions (as opposed to keeping the source code private, e.g., the Microsoft Windows operating system vs the open-source Linux operating system), and (3) collective self-regulation, governance, and organisation (as opposed to singular organisational control, such as today's centralised firms).

A more suitable index could be a ‘social’ index/price that would capture the new forms of value listed here. Under a Hayekian framework, calculating a social index is almost impossible, requiring a monumental cultural shift in social as well as economic norms. The shift would mean economic production for value and not profit. However, producing for value is arguably no less logical than producing for profit and this is where tokens offer a unique value proposition. Tokens allow for experimentation in developing a social index of price by testing multiple valuation indexes that express different social priorities, in the same way that profit price expresses the priorities of capitalism.

Calculating ‘fundamental value’ in the context of cryptoeconomics is paramount as it is the first indication of good governance (Katina et al., 2019). Fundamental value provides the framework to determine whether an issued token fulfils its posited production. Thus, there must be an unmistakable relationship between token issuance and production output. Past views of fundamental value are not applicable in their unaltered states as the traditional perception of fundamental value refers to some ‘intrinsic’ or ‘underlying’ value existing outside of the market. Smith referred to this as a ‘natural price’ (Smith, 1776), while Marx viewed fundamental value as ‘socially necessary labour time’ (Marx, 1875). The accountancy profession believes in the fundamental, long-term productive value of corporate assets (Gottwald, 2012). Intangible capital falls outside the scope of each of these examples of fundamental value measurement, thus leading to problems as the prevalence of intangible capital is rising rapidly.

In conclusion, a shift in measurement methods is needed as the nature of capital is evolving from the tangible to the intangible. Over the last six decades, financial markets have displayed similar shifts in the way value is measured as the nature of capital has changed. Fundamental value techniques have shifted away from *stock measures* (labour hours, machinery, and physical factories) to *flow measures*, or as measures existing *at a point of time outside the market* (stock) towards new ways of measuring activities *over time within markets* (flow). This flow approach to fundamental value echoes the interoperable nature of transactions on a blockchain, signifying the need for a new fundamental value framing that aligns with the free-flowing nature of economic activities within cryptonetworks.

5 Case study: MakerDAO

So far, we have defined blockchain, its use cases, limitations, and potential (**Chapter 2**), and discussed cryptonetworks as one of the implementations of blockchain technology (**Chapter 3**). We proposed that cryptonetworks provide a balance between the market and firm, thus reducing transaction costs while maximising incentives for individuals. The purpose of the current chapter is to use MakerDAO as a case study to supply a practical illustration of cryptonetwork. MakerDAO was chosen as it directly relates to the reduction of transaction costs and the benefits of decentralised platforms. The Maker platform also incorporates other intriguing economic mechanisms to align incentives between network participants and maintain the stability of the network token DAI. Lastly, MakerDAO is a stablecoin blockchain which has been seeing an increasing amount of interest as they look to address the price volatilities of cryptocurrencies (Xu & Zou, 2020). Global stable coins have the potential to promote financial inclusion and improve cross-border payments as well as the international monetary system (Xu & Zou, 2020).

5.1 The MakerDAO platform

MakerDAO is a cryptonetwork that provides access to decentralised collateralised financial instruments[12] that are linked to the USD. The Maker network incentivises collective behaviour and participation in the network and reflects both the current and future price of its network token. MakerDAO is made up of two components: Maker, a decentralised autonomous organisation (DAO), and DAI, a stablecoin managed by Maker. A DAO may be defined as '*the most complex form of a smart contract, where the bylaws of the decentralized organization are embedded into the code of the smart contract, using complex token governance rules*' (Hsieh et al., 2018; BlockchainHub, 2019). Stablecoins are new cryptocurrencies whose value is pegged to another asset, which may be a fiat currency such as the USD, another cryptocurrency, precious metals, or some combination of all three (Senner & Sornette, 2019). In addition, Maker manages the MKR token, which is used for governance over the network (Maker, 2017).

The Maker platform allows ETH holders to collateralise their ETH in return for DAI-denoted loans through a system known as collateralised debt positions (CDPs). DAI is a decentralised USD-soft pegged[13] stablecoin (1 DAI~$1). CDPs are smart contracts that lock ETH as collateral which is only returned when the DAI is repaid. When ETH is locked up in a CDP, it becomes 'wrapped ETH' (WETH)

[12] '*a contract that gives rise to a financial asset of one entity and a financial liability or equity instrument of another entity*' (IAS, 2019)
[13] A soft peg describes a currency that keeps its value stable (within a certain margin) against a reserve currency.

and is tradeable. All WETH is then consolidated into Maker's pooled ETH (PETH), which contains all collateralised ETH within the Maker system (Maker, 2017). DAI loan owners may use their loans in numerous ways, including for hedging, crypto trading, and transfers. However, the Maker system specifies that a CDP must maintain a minimum 150% collateralisation ratio or risk liquidation. This is to protect the CDP from any sharp price movements in ETH. Currently, Maker only supports ETH as collateral although there are plans to extend this to a multi-collateral system with other cryptocurrencies (Maker, 2017; MakerDAO, 2018a, 2019a).

5.1.1 CDP mechanisms

CDPs are the source of any DAI that is loaned out by the Maker system (BitPR, 2019). Users may decide on the amount of ETH to lock up in a CDP in return for DAI. When a user decides to close out their loan, a stability fee must be paid in MKR along with the owed DAI. This stability fee has recently increased to lower the total supply of DAI and return its value to $1, and is currently 19.5% (Kim, 2019a). DAI has struggled to maintain its soft peg since February 2019 with the market price falling as low as $0.95, and a supply decrease was required. To the relief of the Maker platform, recent DAI price trends suggest that the fee increase is working (Kim, 2019b). Although 19.5% is high, it is expected to be a temporary measure only until DAI price stabilises adequately (BitPR, 2019).

MKR tokens are paid to close out a loan and stability fees are burned (destroyed) to reduce the MKR supply in the hope of increasing the value of remaining MKR tokens, *ceteris paribus*. DAI's stability is underpinned by the notion of over-collateralisation, implying that the total amount of ETH collateral locked up must be at least 150% of the DAI borrowed (i.e., to loan out $100 DAI, $150 ETH must be locked up as collateral). This collateral will remain locked up in the CDP until the loan is paid back in full, including the outstanding DAI and stability fees.

5.2 The MKR token

MKR is the Maker ecosystem's native ERC-20 token[14] and is its governance and profit-accumulating token, which is also burned to cover stability fees. MKR tokens represent the holder's governance rights and holders may use MKR to vote for changes to the functioning of the Maker platform (e.g., an increase in stability fees). Any modifications to the internal governance variables of the Maker platform are suggested through *active proposals*. Active proposals are smart contracts for which MKR

[14] An ERC-20 token is the technical standard token on Ethereum used for all smart contracts on the Ethereum blockchain that follow a common list of rules (Reiff, 2019).

token-holders may vote through community voting and are designed to self-execute approved modifications to the Maker platform. Other examples of parameters that can be altered through active proposals are liquidation ratios, penalty ratios, debt ceiling (maximum amount of debt allowed in a single CDP), and stability fees (i.e., interest on PETH). MKR holders must also vote to choose which Oracles the Maker platform should trust to supply the data feeds for DAI. MakerDAO defines Oracles as: '*Ethereum accounts (either contracts or users) selected to provide price feeds into various components of Maker Platform*' (Maker, 2017). Oracles are essential as they provide the real-time information used by Maker to determine the market price of DAI and to trigger liquidations of CDPs.

In addition, MKR acts as a backup in the case of DAI insolvency, which would most likely be caused by a black swan event such as a substantial and unanticipated drop in ETH price. In this situation, MKR tokens could be sold to cover unpaid DAI loans and prevent the DAI price (value) from crashing. MakerDAO also creates and sells new MKR tokens on the open market to support DAI by recapitalising when needed. Such actions incentivise good governance from MKR token-holders as they would otherwise be called upon to protect DAI from insolvency.

5.2.1 Use cases of DAI

DAI loans differ from traditional bank loans as they do not require a middleman, thus making such loans accessible to more people and allowing lower transaction fees for borrowers (BitPR, 2019). Furthermore, as DAI is a stablecoin, price volatility is reduced. A few use cases for DAI are discussed here.

Leverage and hedging

As ETH is the only accepted collateral, DAI is particularly useful for ETH holders. For instance, if an ETH holder wished to increase their ETH exposure but did not want to use USD or another fiat currency, the user could open a CDP, collateralise their ETH, receive DAI as a loan in return, and use the DAI to buy more ETH. This is referred to as *decentralised leverage* (BitPR, 2019). Importantly though, users are not restricted to using DAI to only buy ETH but may also buy other cryptocurrencies. In addition, DAI can be used by users to hedge their crypto position during times of market volatility when ETH holders may want to temporarily move out their ETH holdings without selling them.

Making payments or savings

DAI may also be used by users wanting to pay one another in cryptocurrency but who are afraid of the price volatility of other cryptocurrencies. In addition to making payments, Maker is in the process of adding a DAI savings rate (DSR), through which DAI holders will be paid interest provided they lock up their DAI in a DSR smart contract (MakerDAO, 2018b). Maker plans to launch DSR alongside multi-collateral DAI (BitPR, 2019).

Decentralised apps (DApps) have built upon Maker to enable payment and saving functionalities, including InstaDApp[15] and Bloqboard.[16] InstaDApp is a decentralised bank that aims to simplify banking activities such as making transactions and applying or paying back loans. Currently, InstaDApp has 8 291 ETH locked up as collateral (approximately $2 million). Bloqboard uses smart contracts to enable peer-to-peer borrowing and lending, and an estimated $150 000 in loans has already been processed through this platform.

International transfers

Users may also use DAI as a global store of value and medium of exchange. DAI may be transferred without the concern of price volatility present with most cryptocurrencies as it is a stablecoin pegged to the USD and is therefore insulated from crypto market fluctuations. This feature is particularly useful in countries that have high inflation rates, such as Nigeria, Venezuela, and Argentina (Renner & Doya, 2018; Johnson, 2019; Reuters, 2019). Residents in such countries may use DAI to protect their savings and move funds freely around the world.

5.2.2 Buying DAI

The official way of obtaining DAI is by opening a CDP (**Figure 7** below) as follows:

1. The user must decide how much ETH is to be used as collateral.
2. A CDP is opened and ETH from the user's wallet is locked up.
3. In return, DAI is generated.
4. DAI can then be used by the users in any way (e.g., to trade or lend).
5. Once a user decides to pay back their loan, the original DAI amount is paid back along with the stability fees denoted by MKR tokens (MKR tokens are accessible through several crypto exchanges including Coinbase and Cex.io).
6. The CDP is closed and the MKR tokens used as the stability fee payment are burned (destroyed).
7. Finally, the user's original ETH collateral amount is returned to their wallet.

[15] See: https://instadapp.io
[16] See: https://bloqboard.com

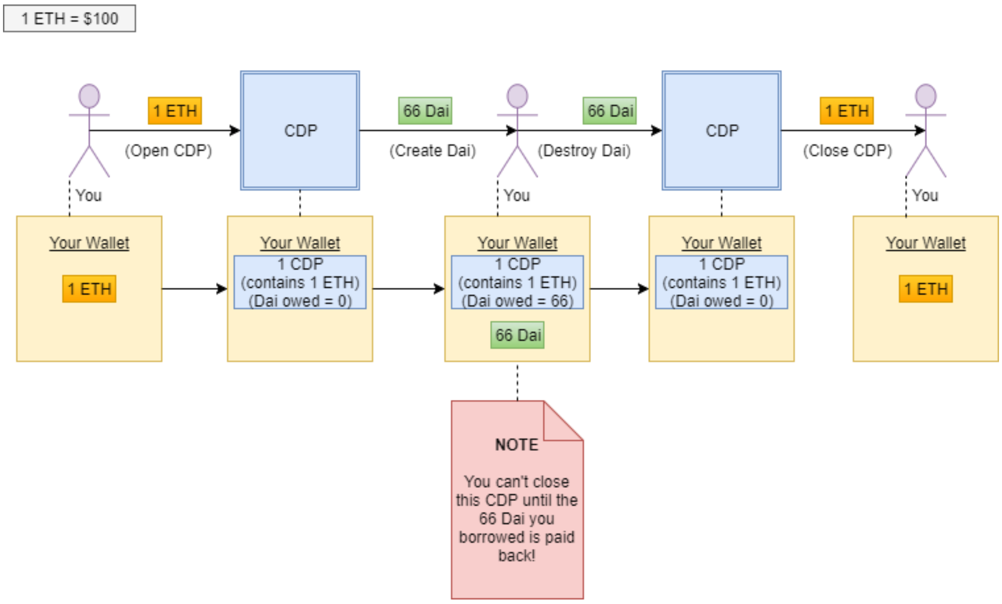

Figure 7: DAI buying process (*source: DiPrisco, 2017*)

Users that wish to open a CDP can do so directly through the Maker website, which guides users through the process and offers management tools including repayment and loan liquidation terms. Alternatively, DAI can also be acquired through direct transfers (receiving DAI as payment from someone directly to your wallet) or exchanges (either via centralised or decentralised exchanges such as Coinbase or OasisDEX).

5.3 The risks of DAI

5.3.1 Loan risks

As is the case with any loan, being under-collateralised or unable to reimburse the loan places the original capital at risk. In the case of DAI, a collateralisation ratio of 150% is needed as a minimum. If this ratio decreases below 150%, the CDP will be liquidated by MakerDAO and the loan owners will lose their collateral. However, liquidation resulting from under-collateralisation is the worst-case scenario and can be prevented. The collateralisation ratio may fall below 150% as a result of movements in the ETH price (BitPR, 2019) and, as shown in **Figure 8** below, a recent drop in the price of ETH (orange line) caused the price of DAI (green line) to rise above $1. This is because DAI holders either moved additional ETH into their CDPs to prevent liquidation or new CDPs were opened by those looking to protect themselves against ETH price movements. The price of DAI has since returned to $1.

Figure 8: Prices of DAI and ETH (*source: CoinMarketCap, 2019*)

5.3.2 USD peg risks

The prices of DAI and its USD peg over the month of April to May 2019 are shown in **Figure 9**. As seen in **Figure 8**, DAI has previously traded both below and above its $1 peg. At the time of writing, DAI was trading at $0.99 (CoinMarketCap, 2019). A break from its peg represents a risk to DAI holders and the stability fee has therefore increased to return DAI to its $1 peg by reducing its supply.

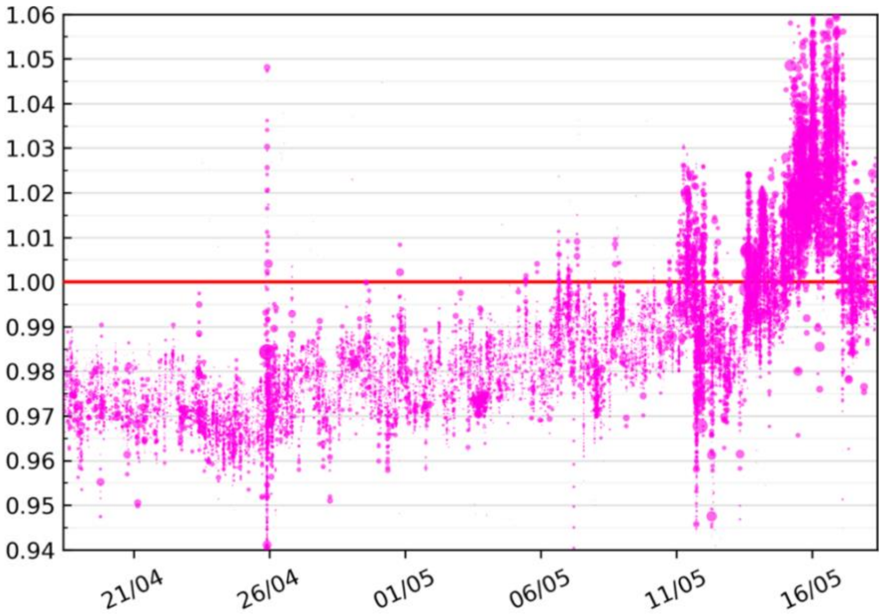

Figure 9: 30-Day price movement of DAI vs USD soft-peg (*source: MakerDAO, 2019b*)

5.4 Key statistics for MakerDAO

Below are some key figures of the Maker platform to illustrate its current state (data retrieved 25 May 2019).

Market position:

- Maker makes up approximately 90% of all USD locked up in decentralised finance projects (Shaughnessy, Demarco & Lulla, 2019).
- Approximately 1.7 million ETH is held in CDPs, making up 1.6% of all ETH supply (McDonald, 2019).

User growth rates:

- The Maker platform has experienced an average active user growth rate of 20% per month (MakerDAO, 2019b), indicating a growing demand for DAI.

Trading statistics:

- MKR is trading at $679.79 with a market cap of $679 793 190 (CoinMarketCap, 2019)
- There are 12 179 unique addresses that hold MKR tokens (Etherscan, 2019)
- The system collateralisation ratio is currently at 539.10% and is considered safe (McDonald, 2019)
- The total DAI supply is 82 349 535 with 24 196 DAI token-holders (McDonald, 2019)

5.5 Challenges faced by the Maker platform

Here, we discuss the two most significant challenges faced by the Maker platform. As this platform was only launched at the end of 2017, many of these challenges may be overcome as the platform matures.

5.5.1 Scalability and stability

DAI has set a debt ceiling of $100 million and at the time of writing, 82 million DAI had been issued, thus representing 80% of the ceiling. Maker has intentionally set this limit on DAI's debt to ensure that the system grows at a healthy rate while still 'proving' itself in the market (BitPR, 2019), for example by demonstrating price stability at its $1 peg or having the capacity to absorb any cryptocurrency market shocks, although neither has yet been proved. By restricting its debt ceiling, Maker may minimise the risks to DAI but must trade-off scalability. DAI's scale is most noticeable when comparing with the market cap for all major stablecoins, which is currently $3.892 billion (Messari, 2019). DAI is thus the fifth largest stablecoin, encompassing approximately 2% of the total stablecoin market (Messari, 2019). Over-collateralisation also presents a concern to DAI's scalability as not every ETH holder will have enough ETH to over-collateralise and meet the requirements of opening CDPs of any meaningful size. Maker will continue to trade-off between scalability and stability, thus putting a cap on the value users may derive from the platform, at least until the Maker system can handle the added pressures of a higher debt ceiling.

5.5.2 Low trading volume

Considering MKR's role within the Maker platform, it is concerning that the 24-h trading volume may fluctuate from $588 000 to $9 303 000 on any day. These fluctuations are significant and even at $9 million, the trading volume is significantly lower than the MKR total market cap of $679 million. Therefore, such low trading volumes could potentially create liquidity and systematic risks for MKR token-holders (BitPR, 2019). Moreover, the liquidity risk for MKR holders may be exacerbated by a crypto bear market.

5.6 The potential of MakerDAO

Unlike other major stablecoin platforms, MakerDAO's governance is exclusively maintained by MKR token-holders. The Maker platform therefore presents an intriguing model for truly decentralised financing. MakerDAO aims to bring independence and financial freedom to its users, remove reliance upon intermediaries in the financial system, and become a testbed for financial democratisation. The increasing digitalisation of financial activities coupled with a growing interest in blockchain technology promises an attractive future for Maker. Future features such as multi-collateralisation and saving rates will only add to Maker's value and potential use cases. Investors have taken note of this, with the well-known American venture capital fund Andreessen Horowitz investing $15 million into Maker in September 2018, providing Maker with enough capital to cover operating costs for the next three years (BitPR, 2019).

5.7 MakerDAO – lowering costs, creating value

It is now of interest to explicitly link the discussions from **Chapters 2** and **3** with the case study on MakerDAO. As per Coase's original theorem, there are three types of transaction costs that originate within the market and result in the need for the firm: information costs, bargaining and decision costs, and policing and enforcement costs (Coase, 1937). In **Chapter 3,** we discussed how cryptonetworks reduce such transaction costs. Here, specific reference to the cryptonetwork MakerDAO will be made to illustrate the reduction of these transaction costs.

5.7.1 Transaction costs

The provision of financial loans is not new. Financial loans can be sourced from the market or firms. Therefore, to understand the way MakerDAO as a cryptonetwork fits into the discussion surrounding transaction costs, one first needs to define the market and the firm as alternative sources of loans. In the case of financing, the firm could be any bank (Nowiński & Kozma, 2017). The market, on the other hand, could be an individual with excess capital to loan out.

Today, to take out a loan at market interest rates or make a secured financial transfer, one almost always has to use the services of a bank (Capitec, 2019; Nedbank, 2019; Standard Bank, 2019). However, the use of banking services come at the cost of high transfer fees and interest rates, lengthy transfer times, and stringent application requirements (Caskey, 2002; Samuels, 2003; Ratha & Riedberg, 2005; Johnston & Morduch, 2008; Love, 2009; McKane, 2019). Therefore, banks essentially decide who has access to financing, leaving many people in developing countries unbanked and excluding them from 21st-century finance tools (World Bank Group, 2017). As such individuals do not have access to bank services, they are forced to find alternative solutions and may seek loans from informal sources such as loan sharks or family and friends. However, searching for loans from the market comes with the transaction costs defined by Coase. With regard to secured international transfers, a bank account is a prerequisite as is often the use of a SWIFT payment network[17] (McKinsey, 2018; World Economic Forum, 2018), although it is worth noting that e-wallets are beginning to show promise, albeit in a fragmented and underdeveloped market (Hughes & Lonie, 2007; Dennehy & Sammon, 2015). Similarly, transacting online or making secure international digital payments without a bank is extremely difficult (McKinsey & Company, 2018; World Economic Forum, 2018). According to Coase, searching for alternative solutions within the market is rendered unfeasible, or at the very least expensive in terms of money and time, because of the high transaction costs incurred (Coase, 1937). Even if a source is found, negotiating an attractive rate to borrow or transfer funds is costly and enforcing this deal without an overruling entity such as a bank is likely to be difficult.

The Maker platform seeks to solve these problems of availability and expense and thereby begin to bridge financial exclusion gaps in the following ways:

[17] The SWIFT international payment network is one of the largest financial payment systems globally.

- **Search and information costs**

Access to the MakerDAO platform and acquisition of DAI or MKR are neither prohibitive nor selective. Anyone who wishes to open a CDP can do so. Maker does not require a credit check, only that you have the ETH needed to collateralise any relevant CDPs. Users are then free to make international transfers or payments, instantly and while incurring a minimal fee. In other words, Maker improves decision-making power by significantly improving information asymmetry and giving all users equal access to the available information regarding price using its network Oracles. Moreover, users know that they can trust the accuracy of the transaction information because of the transparent and immutable nature of blockchain.

- **Bargaining and decision costs**

Because of Maker's decentralised nature, users do not need to negotiate rates when opening CDPs. Instead, users will pay the market rate of whatever the price of DAI is at the time and have access to instant liquidity that is ordinarily only offered by banks while also knowing that they are getting the best possible rate by the market. By definition, transacting in an open market means that users will only transact when their WTP and WTA are equal.

- **Policing and enforcement costs**

Maker uses smart contracts built upon blockchain, and consensus protocols are used to ensure enforcement of any loans, transfers, or payments made on the platform. There is no single entity that can choose to increase interest rates or liquidate loans. These rules are hardcoded and self-executed by the Maker platform, not individuals, meaning that there are no legal contracts are needed, thus reducing costs associated with both drawing up and enforcing such contracts.

As discussed in **Chapter 3**, there are two other factors that can further impact transaction costs, according to Williamson:

- **Bounded rationality**

Transacting on any cryptonetwork, including Maker, does not alter the cognitive limitations of individuals. It does however improve decision-making power by significantly reducing information asymmetry as all users on Maker have equal access to the available information via network Oracles, which are appointed by the majority of MKR token-holders and not by a single entity looking for self-benefit. Finally, because of the transparent and immutable nature of blockchain, all users can trust the information available.

- **Opportunism**

Although opportunism may never be completely avoided, it is drastically lowered on the Maker platform through the alignment of incentives such as the DAI and MKR tokens, through which all holders are encouraged to increase value. As token-holders have shared ownership, they are jointly incentivised to ensure good governance, as bad governance would likely harm the value of the Maker network, thus decreasing the value of their token holdings.

Furthermore, the severity of bounded rationality and opportunism is dependent on three variables. These variables may be considered both in terms of endogenous and exogenous costs (Williamson, 1973, 1975):

- **Frequency**

The impact of frequency on transaction costs is made redundant by the fact that there are no search or bargaining costs when transacting on the Maker platform. Therefore, the process and cost of transacting remain equal to the market rate of Maker regardless of the number of transactions performed.

- **Uncertainty**

Uncertainty is avoided on Maker through the use of smart contracts that are cryptographically enforced via the blockchain's consensus protocol. These smart contracts are hardcoded to self-execute pre-agreed actions as soon as the relevant conditions are met. There is no entity on the platform that can override the execution of a smart contract. The only exception is when the liquidation ratio of the CDP falls below the required 150% minimum collateral ratio. However, this is agreed upon when opening the smart contract and therefore forms part of the agreement.

- **Asset specificity**

DAI is a fungible token and all DAI tokens are therefore of equal value, regardless of when they were created. In addition, DAI is infinitely divisible, enhancing the token's usefulness for transactions of any size. The fact that DAI is both fungible and infinitely divisible means that asset specificity is no longer a significant issue.

5.8 Final remarks on MakerDAO

In **Chapter 4**, an exploratory framework on cryptoeconomics was discussed and the need for novel economic theory framing for cryptonetworks was highlighted. We posited that tokens may serve both as units of account and stores of value. Here, Maker or more specifically DAI and MKR were used to validate this argument as both tokens may act as units of account, stores of value, and means of payment. In addition, we highlighted the need for new measurement methods to calculate value in response to the rising importance of intangible capital. Here too, Maker illustrates this argument as the entire platform's value is derived from the utility of its two tokens DAI and MKR, which are classified as intangible capital (EY, 2018; PwC, 2018). Therefore, current measurement techniques cannot be used to value a cryptonetwork such as Maker, as its intangible nature renders the task impossible using conventional fundamental analyses. Finally, the fundamental value of the MKR token exclusively reflects the quality of governance of MakerDAO. The MKR token provides a good example of the use of fundamental value as a framework to test whether a token is fulfilling the production it posits to enable (i.e., governance of the Maker platform).

It is important to note that Maker forms part of only the first generation of cryptonetworks. It is therefore unsurprising that Maker's cryptoeconomic mechanisms focus on traditional 'token engineering', such as low transactions costs and the creation of economic incentives, to ensure optimal behaviour from network users. As blockchain technology matures, future forms of cryptonetworks will expand to address the wider social issues of production, distribution, and the consumption of goods and services.

6 Conclusion & future research areas

This study began by describing the technology of blockchain, which enables the novel creation of trust within a decentralised environment, and through which new industries will come into existence. Prior to blockchain technology, creating and enforcing trust between transacting parties always required a third-party such as a banking institution. Trust is vital to the development of several new activities and the transformation of existing activities. Blockchain technology provides answers to the age-old question also known as the *Byzantine Generals Problem*: how can we create trust between two or more parties to complete exchanges of something of value? This was first achieved using the threat of force, then via central institutions such as governments, and now through distributed cryptonetworks by way of decentralised consensus protocols.

Historically, the pipeline business model has been the model of choice for the largest companies in the world. However, the digital transformation of the global economy has brought new business models to the forefront. Namely, the platform business model where value is realised through the creations of the community in the ecosystem. Cryptonetworks look to build upon, disrupt and potentially form entirely new business models by blending the functionality of centralised platforms with the community-orientated nature of the original open protocols of the internet. In doing so, cryptonetworks enable value creation to be correctly assigned to the actual content creators through tokens.

In *The Nature of the Firm*, Coase questioned the need for the firm if markets could maximise incentives. He argued that when operating outside of firms, prices dictate production decisions, and coordination occurs through a sequence of transactions in the market. However, in a firm, market transactions are replaced by entrepreneur-dictated production decisions. Therefore, the market and firm simply offer alternative production co-ordinating options. The trade-off relationship between the firm and market is inverse and linear, and a transaction can either benefit from reduced transaction costs in the firm or incentive maximisation in the market, but not both. According to Coase, firms are needed because of the costs associated with using the market's price mechanism, also known as transaction costs.

Applying cryptonetworks to the theory of the firm introduces an alternative that bridges the gap or trade-off between the firm and the market. The trade-off relationship between the firm and the market is pushed outwards to produce a concave graph, representing a fundamental change in the cost structure of a firm. Like markets, cryptonetworks allow people to conduct economic activity without a central decision-maker through economic incentivisation mechanisms powered by tokens. Just like the firm, cryptonetworks also reduce transaction costs through cryptographically enforced transactions. More specifically, through blockchain technology, cryptonetworks reduce search and information costs by allowing information to flow in a trusted manner, through consensus protocols, and easily, as it is public. Bargaining costs are reduced through the streamlined discovery of cryptonetworks that use open-source software in which terms are known to all, open data, and auction techniques that further reduce information asymmetry. And instead of driving enforcement through a centralised firm, cryptonetworks use decentralised consensus protocols and embedded logic to enforce contracts.

Lastly, the decentralised nature of cryptonetworks combats the negative behaviours of centralised networks which have shown to turn from a positive-sum game to zero-sum game as adoption reaches a critical level. This switch comes at the expense of network participants who are left with no option but to comply with the new rules, including those who originally contributed to the initial value of the network's growth. In contrast, cryptonetworks remain neutral throughout their growth and reward participants for their contributions through tokens. However, cryptonetworks will not always be the best option for all services but rather only for those that excel in decentralised environments. This is because the organisation and alignment of incentives for network participants only perform as intended in decentralised environments.

The application of orthodox economics in the context of cryptonetworks, also known as cryptoeconomics, is rather conventional and conservative. Applying such theories limits the potential of cryptoeconomics and cryptographically enabled, distributed economic-social systems that could introduce drastically different politics and ways to capture and measure value. What is often referred to as 'token engineering' restricts the potential use of tokens, which may represent more than just an incentivisation mechanism. Today's measurement frameworks suffer from the inability to accurately measure economic activities that have no market price, such as household production, the informal sector, and subsistence production. This is a well-known limitation of the traditional GDP production function. In response to these limitations, measurement concepts such as 'triple-bottom-line reporting' and 'ethical investing' were introduced. However, these measurement criteria still only apply to a profit-centric measurement outcome.

Tokens provide an opportunity to re-evaluate this value creation measurement question. As a means of exchange, tokens facilitate new ways of trading and as a unit of account, they represent new means of measuring output. Production value cannot be reduced to the single measure of monetary price, which should instead be treated as one of many measurement indexes. In addition, token valuation techniques must be developed to address the contributions of intangible capital adequately, unlike conventional valuation techniques. The use of token price as the correct measure for the value of a crypto economy is also questionable. The Hayekian price is the condensation of multiple determinants of data that otherwise would be too complex to process. However, blockchain and more specifically tokens introduce fundamentally new ways of handling such complex information. Today, price is treated by society as the absolute social measure of value although a more suitable index would include a 'social' index/price that would capture new forms of value. Under a Hayekian framework, calculating a social index is almost impossible and would require a monumental cultural shift with regard to social as well as economic norms. The shift would imply economic production for value as opposed to profit. However, producing for value is arguably no less logical than producing for profit. Tokens offer a unique value proposition in situations of production for the sake of value and allow for experimentation in developing a social index of price, by testing multiple valuation indexes that express different social priorities, as profit price expresses the priorities of capitalism. Profit price is not made redundant, as monetary prices will always hold value within a capitalist society, but it is important to expand upon this by incorporating other socially quantifiable indexes that are valued equally and incorporate a holistic view that benefits society and not just a select few.

This study has shown that our understanding of blockchain remains ill-defined, unstructured and limited. In particular, token valuation models are still in the exploratory phase and each model has exhibited its limitations. The limited understanding provides fertile ground for further research. Moreover, further research could contribute to realising the full potential that tokens have to offer in measuring and capturing value. Research contributions are likely to come from a wide range of disciplines in addition to economics – from finance, computer science and philosophy, for example. As blockchain matures, so too will cryptonetworks. There is undoubtedly significant future potential for the development of blockchain for which will further expand the range of its applications.

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