With a little help from the miners: Distributed Ledger Technology and Market Disintermediation

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Abstract

Value chain disintermediation has been one of the most important effects of the early years of the Internet and e-commerce, especially in information services. In this paper, we posit that the advent of cryptocurrencies (such as Bitcoin) and distributed ledger technologies (also known as blockchains) will enable a new era of e-commerce, also conducted between machines (M2M commerce), and a fresh wave of value chain disintermediation, this time removing trusted third parties from electronic value chains. Using a shared ledger, kept in synchronization across institutions for transaction verification, will give rise to new forms of distributed applications and business models, including nano-payments, distributed services and proof-of-existence. Coupled with other technological advances, such as the Internet of Things (IoT) and artificial intelligence (AI), blockchains can ultimately lead to a new era of commerce between distributed autonomous corporations that exist only on the cloud. However, because the distributed ledger is a novel and disruptive technology, achieving the above is subject to overcoming the barriers that still inhibit its mass adoption and further exploitation.

Keywords: blockchain; distributed ledger technology; disruptive technology; disintermediation; distributed autonomous corporations; smart contracts

Structured Abstract

- Purpose: The purpose of this paper is to argue for the role of the blockchain, i.e., distributed ledger technology, in building innovative business models, including machine money, autonomous economic agents and decentralised organisations.
- Design/methodology/approach: The paper is conceptual/argumentative. As such, it draws on research on (e-) commerce, theories of markets, disruptive innovation and extant studies and conceptual work at the intersection of cryptocurrencies, M2M commerce and the internet of things.
- Findings: We highlight three application areas for blockchains, whereby they can function as applications, can help develop autonomous economic agents, and can lead the development of decentralised autonomous corporations. With regards to the question of market dis-intermediation, we suggest that, rather than complete disintermediation, the most probable scenario is that of new types of intermediaries finding previously unthinkable roles to play in mediating blockchain-based economic transactions. With regards to the inhibitors that slow down the technology's adoption and, therefore, the development of new business applications, we posit that these relate mainly to the inherent risk of the technology, infrastructure requirements, scepticism of early decision makers and the lack of required new skills and competencies.
- Originality/value: We examine how new forms of digital money and technologies embedding trust in decentralized networks will alter markets and commerce, at a time when many regulatory issues remain unresolved; in doing so, we focus on how blockchain-enabled technologies can be used to enable and further develop decentralized trusted peer-to-peer transaction ledger systems and applications and lead to sustainable business models.

Introduction

The role of a market lies in bringing together and matching buyers and sellers, facilitating transactions and providing the necessary institutional infrastructure, whereby the first two functions are supported by intermediaries, and the latter by the government (Bakos, 1998). Along these lines, transacting within a market means, among other things, that the buyer is exchanging something for something else, at a fixed or arranged price, that both parties agree to the terms of the exchange and that the exchange can be monitored and documented (Fligstein & Calder, 2015), e.g., that there exists a ledger of transactions.

Today, buyers typically use fiat (state- or central bank-issued) currency to buy products or services. Such transactions may be cash-based or cashless, meaning that buyers may use debit and credit cards, or conclude their transactions through third-party applications, such as PayPal, Apple Pay or Google Wallet. In all cases, there is money involved, with a sovereign issuing the currency in which transactions are finally settled. Further, no matter how the transaction is actually concluded (cash or cashless), there is some sort of documentation, as the supplier can either provide a receipt for the exchange of cash for goods, or the card issuer, the escrow service or other intermediary keep track of the cashless transaction.

Within this context, one cannot but take note of the disruptive technology of cryptocurrencies that have led to the production and active use of money that are algorithmically generated through a decentralized process. This process entails that 'miners', i.e., the members of a peer-to-peer network, process transactions with the use of specialised software and hardware. In return for their services, the network rewards them with newly generated cryptocurrencies. The arrival of cryptocurrencies has already made strides in many different fields and the financial industry is already seeing some of the effects and engaging with the technology. For example, several banks, such as HSBC (2016) and RBS (Creer et al., 2016), have started developing proof-of-concepts and central banks are exploring regulatory issues (e.g., European Central Bank, 2012).

It is thus timely to examine how this form of new digital money will alter markets and commerce. In this paper, we posit that cryptocurrencies and the underlying technologies that make cryptocurrency-based transactions possible, such as the distributed ledger technology (also known as blockchain), will lead to the development of new business models. Coupled with the advent of the Internet of Things (IoT), we consider that these technologies will help develop previously unthinkable applications, including even organisations without human workers, where all business is conducted by and between distributed network-connected machines or blockchain-based smart contracts. If implemented at scale, such actors will enter the economic arena as independent agents engaging in Machine to Machine (M2M) transactions, gradually leading to a new wave of market disintermediation akin to that witnessed in the early years of e-commerce.

The paper is structured as follows. In the next section, we discuss the nature of cryptocurrencies and that of the digital ledger technology to show how they can act together as the equivalents of traditional money and ledgers. Next, we identify possible applications of the distributed ledger and how market disintermediation will (and will not) happen in such applications. Following, we discuss possible inhibitors that can slow down the full adoption of the distributed ledger technology for everyday commercial applications. The paper concludes with remarks regarding threats and opportunities, as well as ethical considerations.

The Elements of Commerce

While the concept of commerce originally referred to the interaction of two or more parties coming together for the exchange of e.g., ideas (Barnett, 2012), today it has come to refer to the exchange of commodities, either for other commodities or for money. In this sense, the main elements of commerce would be the existence of a buyer and a seller, the need for a particular product or service, an agreement between the parties regarding the value of that product or service and an agreement on the medium used for the exchange, i.e., how much money the product is worth and in what currency the buyer is going to pay for it. Gradually, third parties started mediating interactions between buyers and sellers; as markets started getting bigger and more complex, intermediaries took up the role of matching buyers with sellers, making the exchange of information regarding products and services easier, and supporting payment and transaction processes, whereby the involved parties trust the intermediary with, e.g., the settlement stage (Bakos, 1998). While intermediaries also play a strong role in e-commerce, there is also room for market disintermediation due to decreasing search and transaction costs (Giaglis, Klein, & O'Keefe, 2002).

In this respect, we consider that cryptocurrencies, such as Bitcoin, together with its underlying technology, like the blockchain, and blockchain-based applications, like smart contracts, all combine to introduce a strong aspect of further decentralization and disintermediation. As such, they can accelerate the move toward ubiquitous commerce; they provide the means for businesses to develop new products and services, and at the same time, lay the foundation for the development of new types of businesses, i.e., fully decentralized and autonomous corporations (DACs). Within this context, we posit that there will be little room for transaction intermediaries, at least in their existing form and nature.

In what follows, we describe in more detail how the main elements of commerce have changed through the aforementioned technologies in order to explicate how commerce itself is shifting. These matters are discussed in tandem with how these changes make possible new business application areas.

Are cryptocurrencies money?

There are two main theories of money today, commodity theories and claim theories (Bryan & Rafferty, 2007). Both deal with the nature of money, its source of power and its role within society, directly or indirectly. Unsurprisingly, these theories derive from and are frequently discussed within the fields of economics and social theory (Lawson, 2016).

Commodity theories see money as being valuable because money in itself is a valuable commodity, for example a precious metal, or even work labour (Hampton, 2013). According to claim (or credit) theories, something is exchanged for credit, whereby the value of credit is not linked to another commodity, but on the value assigned to it by the creditor (Innes, 1913). In this case, money is valuable because institutions (e.g., a state), surround that money with assurances of trust, acceptance and stability, and its power emerges from the fact that the state "determines what will be accepted in payment as taxes" (Bryan & Rafferty, 2007, p. 148). As such, the creditor, i.e., banks and states take focal role by issuing and controlling money.

A discussion on the nature of money involves what functions money needs to fulfil in order to be considered as such. Historically money has acted as a medium of exchange, a unit of account and store of value. Lawson (2016) argues that, like everything else, money is socially positioned, and that anything that can be a reliable and transferable form of value while fulfilling the previously described functions, can act as money. Indeed, Bryan and Rafferty (2007), arguing for the role of derivatives as money, underline that the definition of money has to be flexible because the number of things that can essentially act as money has thus far proven to be endless.

Cryptocurrencies, like Bitcoin, Ether, and Litecoin, are a form of digital currency made possible by cryptography. Encryption techniques are used to issue the units of the currency and to verify the transfer between parties, entirely independently from central banks, states or other intermediaries. In this sense, they are completely decentralized (Böhme, Christin, Edelman, & Moore, 2015) and near anonymous (Meiklejohn et al., 2016). Because coin production is algorithm-based, there is a fixed supply of cryptocurrencies and a transparent creation policy. In addition, because the entire process is based on distributed computers and because some cryptocurrencies are stored in offline devices (e.g., external hard drives) that may be destroyed over time, some of the cryptocurrencies that were once in circulation have already been lost or more will be lost in the coming years (Sauer, 2016).

Recent studies have focused on whether cryptocurrencies, and Bitcoin in particular, can in fact be considered money or represent value. Cheah and Fry (2015) argue that, much like other fiat currencies, Bitcoin, too, needs to provide a level of confidence to its users, be a unit of account, and have value in order to be seen as money. In their study, they conclude that Bitcoin exhibits none of fiat money's characteristics due to significant fluctuations in its price, that it is vulnerable to speculative bubbles and that its fundamental value is zero. Legal-wise, the question of whether cryptocurrencies are money remains unanswered, as there are different court rulings across different countries. In the Netherlands, for example, in a 2014 court case the ruling was that Bitcoin is more of "a commodity-like medium of exchange" rather than typical money, as it couldn't at the time fit any of the known definitions of money (Ramasastry, 2014). In September 2016, a Federal court in New York decided that Bitcoins are indeed money because "[they] can be accepted as a payment for goods and services or bought directly from an exchange with a bank account. They therefore function as pecuniary resources and are used as a medium of exchange and a means of payment" (Fortune, 2016). Another important thing worth mentioning is that the UK government recognised Bitcoin as a form of digital cash in one of its reports regarding cryptocurrencies (Government Office for Science, 2016) and that Japan has recently accepted it as a legal payment method (Garber, 2017).

Going back to the functions of money, we consider that cryptocurrencies, regardless of the exact type, exhibit some of the characteristics of regular money. They are a *medium of exchange* because cryptocurrencies can provide a measure of value, and, because they are recognised and accepted for transactions, they are being exchanged for goods and services and have eliminated the need for barter. They act as *a unit of account*, and as with regular money, their exchange rate fluctuates depending on inflation/deflation and supply and demand, as cryptocurrencies can be exchanged for other currencies, such as dollars, euros etc. Therefore, inflation and deflation do hamper cryptocurrencies' ability to store value, but this holds true for all currencies; we thus see no difference between cryptocurrencies and fiat money along this function. They act as *store of value* because once created, cryptocurrencies are then verified and ultimately transferred to their owners' digital wallets, where they can be stored until exchanged. Further, the value stored is portable, is divisible into nano-units, and identifiable (all peers of the network can attest to the production and transfer of that particular coin and no other). Finally, they can be used for settling a debt (*form of payment or standard of deferred payment),* as they are used for payments, although still not widely.

The differences we detect between cryptocurrencies and fiat money is that the former are independent from a central bank, a sovereign or an institution, being produced and handled by a distributed network of peers. As money is created and used by societies, it is considered a social institution; therefore, it needs to adapt to the context and "the character of the times", which includes any technological advances (European Central Bank, 2012, p. 10). Cryptocurrencies may "fall short of the legal concept of currency or money" and may not be able to "completely fulfil the three economic roles associated with money" (IMF, 2016, p. 16), however they are actively used as money more and more. As such, they inescapably have a place within contemporary markets and we consider that they can ultimately substitute or complement fiat money, at least to some extent.

Documenting Transactions in a Distributed Ledger

While cryptocurrencies constitute an important technological advancement themselves, we consider the distributed ledger technology (DLT), also known as blockchain, that underlies their existence more significant because it holds greater potential to disrupt business and commerce areas beyond money. Traditional ledgers are paper-based or digital files that help with documenting transactions, such as accounts paid, outstanding balances, etc. DLT creates online, distributed and publicly available ledgers that are updated by every node of a peer-to-peer (P2P) network. This is based on the consensus of the nodes, with the use of a proof-of-work or similar consensus algorithm, and without the mediation of a trusted third party. This means that the nodes, i.e., the peers or the miners, agree which 'block' should be added next on the 'chain', forming eventually the blockchain.

Distributed ledgers are secured through public key cryptography. Transactions refer to hashes of the public keys of the peers involved in them and are cryptographically signed by the sender. Further, each transaction is referenced on the blockchain and time-stamped, therefore no coin can be transferred twice and the transaction with the earliest time-stamp is considered the valid one in case of grievance (Papp, 2015). In other words, once a transaction has taken place, there is evidence and the necessary safeguards that the specific digital 'coins' and no other have been transferred, and therefore cannot be used again, even momentarily for other transfers (Dierksmeier & Seele, 2016). As a result, the overall infrastructure is more secure compared to other types of digital transfers (Hari & Lakshman, 2016).

Along these lines, the importance of DLT is that the business logic (i.e., the rules) can be set at the level of each individual transaction (Government Office for Science, 2016); this being distributed across several geographically dispersed locations and shared among different participants, all of whom have access to an identical copy of the ledger, means that improper use of the ledger can be detected by any of the peers. In other words, DLT helps in developing trust between otherwise unknown and untrusted peers. It further means that, as DLT operates in a similar fashion to traditional ledgers, together with cryptocurrencies it can be used for settlements. As a result, escrow services, credit card issuers etc. are no longer relevant for the secure flow of money, because DLT introduces a form of digital, collective bookkeeping (Westphal, 2015).

Notwithstanding, thanks to DLT, smart contracts, i.e., code, embedded on the blockchain, can be executed according to rules predefined and programmed within them. The concept behind this is that the smart contract self-executes if and when pre-programmed conditions are met (Kosten, 2015); therefore, a smart contract may control the timing of a transaction, the permissions of an account or the lifecycle of a document, among others. While they are not ordinary contracts, they act us such by enforcing the conditions under which an action should take place, and reinforcing a trust environment within which parties may transact without the reassurances of intermediaries.

Distributed Ledger Technology and New Business Applications

We posit that DLT is set to disrupt the way commerce is conducted today. The technology allows for transactions to be carried out using programmable money, verified and validated by the consensus of a peer-to-peer network, and for software to proceed with initiating such transactions (monetary or otherwise) without human mediation. All these take place in a distributed, decentralised fashion, where transactions cannot be intercepted, forbidden or modified by any one state or financial institution, in a fully anonymous manner; this means that ownership of any amount of cryptocurrencies can't be connected to any one individual, transactions can't be traced back to parties involved. Most importantly, this suggests that trust to the currency is embedded within it, rather than ensured by an issuing body. In other words, the technology distils trust across each and every node of the network by design. The end result is that one can create a strong 'accounting' system, free of its weak points, i.e., sin of commission, sin of deletion, sin of omission (Mainelli & Smith, 2015), as the network is enriched "with the desired mix of transparency and anonymity, and a ledger of records history which cannot be changed or altered" (Kosten, 2015, p. 13).

Using cryptocurrencies instead of fiat money, coupled with DLT and smart contracts can and has already changed the nature of money and commerce. Within traditional commerce environments, the market comprises of the buyer, the seller and the intermediary. In the early days of electronic markets, studies suggested that this setting would change and that intermediaries would be removed from the market, as the very structure of e-commerce left little room for them: both buyers and sellers were experiencing lower costs, and the market were allowing them to transact directly with one another. Yet, fast forward some years later, intermediaries succeeded in providing value-adding functions that could not be easily replaced (Giaglis et al., 2002). With the advent of cryptocurrency technologies, we see new opportunities along the dimension of disintermediation. What we witness is that we are being led to disintermediation of payment systems, where there are almost no costs involved for concluding a given transaction. For the first time, there are the conditions for buyers and sellers to communicate directly, and transact safely and securely without a third party needed to establish a secure communication between the two. Gradually, the decentralised nature of these technologies will mean that, those functioning today as intermediaries may see their role shrinking considerably. Chief among them would be banking institutions, states and, generally, the heads of hierarchically-driven organisational systems (Government Office for Science, 2016).

However, we don't consider full disintermediation to be a possible scenario, as this would require businesses to operate their own DLT. Rather, it is likely that this will lead to new roles for intermediaries. Presently, DLT is an attractive technological solution when the requirements include proof of ownership, trade ability, and trust among the participating actors with the aim to achieve real time transactions, increased reliability and resilience to external threats. As a result, we consider that intermediaries may still have a role to play within a blockchain-enabled environment. Building on Giaglis et al. (Giaglis et al., 2002), we foresee three different outcomes:

- The *disintermediation* outcome, where existing intermediaries will be driven out of value chains, just like intermediaries were driven out of supply chains due to e-commerce. Blockchains will create an Internet of Trust, where traditional trusted third parties (such as governments, banks, lawyers, notary services, etc.) will see their role diminish in blockchain-backed commercial transactions.
- The *reintermediation* outcome, whereby existing intermediaries will attempt to build on their experience, expertise and market positioning in an attempt to find new business opportunities to remain relevant. For example, banks could substitute their existing processes for tracking mortgage payments and concluding cross-borders and cross-bank payments, with blockchain-based processes.
- The *cybermediation* outcome, with new intermediaries will enter the market, offering previously unthinkable services to transacting parties in DLT networks. This may refer to intermediaries acting as DLT service providers (Manning, Sutton, & Zhu, 2016), offering Blockchain as a Service (BaaS). For the recipients of such a service, the benefits would be similar to those of cloud computing, whereby the burden of the infrastructure and maintenance are taken up by the provider, thus allowing the customer to focus on its primary business activities.

Along these lines, we consider DLT to create numerous opportunities for the development of new application areas and business models, and we speculate that these underlying technologies are much more promising and disruptive in nature. In what follows, we discuss these in further detail.

Money as Application

Money can now have properties that can be stored within a smart contract. In our understanding, this opens up three different scenarios: a) there can be *application-specific money*, that can be used as credit or token within specific applications, b) money can have an expiration date or money may be governed by specific depreciation rules, and c) money can be used as *value tokens or rewards*.

Application-specific money, or *money-over-IP*, may be perhaps the most straightforward application, as in essence it entails the use of cryptocurrencies as actual money. Application-specific money can be used as tokens for concluding certain tasks, as for example sending and receiving e-mails over a network, conducting nano-payments and offering rewards for specific services (e.g., community service). Money-over-IP will be used to bypass traditional intermediaries. In the case of a business, money-over-IP brings down payment barriers and facilitates borderless commerce (Antonopoulos, 2016), whereby settlement can take place without commission fees and the risk of volatile exchange rates, as cryptocurrencies, such as bitcoin, are universal. In the case of individual users, we see cryptocurrencies as having great potential for the 'unbanked'. In many occasions, people are unable or unwilling to access the services of financial institutions (due to e.g., lack of acceptable credit history, lack of local branches, desire for independence). This essentially means that a proportion of individuals (approximately 11% in high income countries and 59% in developing countries in 2015 (CGAP, 2014)) don't own a bank account. Yet, in many countries, the unbanked leverage ICTs, such as smartphones, to send, receive and store money. M-Pesa, for example, allows users to access such services through text messaging in return for a small fee. This service could be made available over the Bitcoin network, as 'digital wallets' for mobile phones already offer these functionalities in real time, over a more secure network that is always available, with much lower fees (Darlington, 2014). The same scenario is applicable to expatriates and migrants for the purpose of international money transfers.

In the previous examples, there appears to be little to no room for an intermediary. Indeed, users are able to send and receive cryptocurrencies from one address to another without the need for the services of a third-party. Yet, many individuals, particularly those who are less technologically savvy, may see a benefit in accessing such financial services through an easier to understand interface, without getting into the particulars of cryptocurrency-based systems. Therefore, while an intermediary is not always essential, digital wallets can operate as the new intermediaries offering third-party support (cybermediation scenario).

Autonomous economic agents

Based on already available technology, it is possible to create autonomous economic agents who send and receive money-over-IP, i.e., application-specific money in the form of some cryptocurrency, for their transactions. Such autonomous economic agents may take the form of autonomous vehicles, independent certification agents (e.g. academic degrees, national IDs), or even simple computers. Within this context, the computer or the software essentially will own itself and will be able to bid for passengers, process one's file or bid for leasing processing power, respectively; in turn, their payment would be in cryptocurrencies, later spent on e.g., their maintenance (Aron, 2014) or simply handed over to their human owner.

In all cases, with the emergence of DLT and the advent of programmable money, there are now the necessary conditions to actually transact in nano-quantities of regular money. This means that new business models can be created around the emergence of new machine-to-machine (M2M) applications. For example, idle computers can be used within a network for machine learning purposes, by leasing over their processing power and the necessary resources and getting paid in cryptocurrencies. Based on blockchain principles, logistics may be revolutionised completely. The participants of a supply chain can leverage the distributed ledger for documenting transactions (monetary or not), movement of products and settle payments, with each participant having access to the same blockchain. Essentially, this would mean that all actors will be able to communicate with one another in real time, over a trusted network, having automated many parts of their processes, and experiencing lower costs.

We see further possibilities within this scenario. Within the realm of IoT, this new form of money, together with autonomous agents, opens up new streams of business. Everyday, more and more IT devices and household appliances come equipped with internet connectivity, sensors and actuators. These appliances and devices need to interact with each other and conduct transactions in order to be truly 'smart' and part of the IoT; in this scenario, as others have noted, a washing machine can start sourcing its detergent on its own, without its owner's intervention, and pay for it in cryptocurrencies (Stark, 2016). While this may be a fairly simplistic use scenario, it does point to other more sophisticated scenarios where Artificial Intelligence (AI) and the IoT can lead to even more innovative business models if enriched with the concept of DLT. For example, hailing a taxi can take the form of an auction where autonomous agents may proceed with the bid if certain conditions are met e.g., gas consumption is below certain level (Giaglis, 2015). In other words, DLT can support autonomous vehicles in becoming fully autonomous agents that are able to optimize their functionality by exchanging information among them (Gerla, Lee, Pau, & Lee, 2014), being vetted against predefined criteria and being equipped with a transaction mechanism for settlements. Within the logistics realm, where tracking informs many processes (e.g., recalls and payments), DLT can streamline the entire supply main and make it more responsive and cost-efficient. For example, upon the receipt of a shipment by the warehouse, a smart contract may be executed, initiating the payment process in real time, with all the necessary documentation being sent over a secure network to those involved.

In the previously discussed examples, we see reintermediation and cybermediation equally relevant and possible. With regards to traditional intermediaries, such as banks for example, we consider that they will expand their services portfolio to include blockchain-based applications for settling payments and that these will be successful by being able to capitalise on pre-existing trust-based relationships between them and logistics actors. Further, regulatory bodies and other governmental organisations will remain pertinent for the logistics field. However, their relationship with the involved actors can become more efficient; logistics businesses can build on smart contracts technology to automate their processes most affected by regulatory aspects, such as recalls, where traceability and tractability are of importance.

Decentralised Autonomous Corporations

Cryptocurrencies together with DLT and smart contracts provide the infrastructure for the development of corporations that are fully digital and distributed and, for the first time in history, even entirely autonomous. Cryptocurrencies provide the payment method for transactions, DLT provides verification and validation of these transactions, while smart contracts can be the mechanisms that trigger transactions, essentially setting the entire corporation in motion when certain conditions are met.

DACs aren't an entirely new concept; they first appeared on a conceptual level in 2011 (The Economist, 2014). However, coupled with other technological advancements, such as autonomous agents, the possible applications of DACs may be endless, as there can be "pre-programmed" businesses (Aron, 2014). For example, a DAC may be a digital land registry office, where the blockchain and autonomous agents substitute the notary. The Swedish government has already begun testing the application of DLT for this (Chavez-Dreyfuss, 2016). Since DLT is in essence a ledger of time-stamped transactions, it can be used for documenting property ownership at any given time, which is verified and validated by a network of trusted peers and is characterised by increased transparency, as the ledger itself is distributed, synchronised and available to thousands of computers. In a similar fashion, the Estonian government uses DLT for developing a Keyless Signature Infrastructure (KSI), which is secure and transparent and allows citizens to verify that all government records about them are accurate; because this infrastructure cannot be compromised, it means that the information can be successfully used for digital governance (Shukla, 2016).

Other benefits emerging from the application of DLT within the context of DACs is that because no signle peer can alter any transaction without other parties noticing, fraud can be avoided altogether. In addition, because DACs operate through autonomous agents, no single entity is entrusted with the management of the corporation. In other words, considering that when power is centralised, it allows for greater corruption, DACs may be seen as going against power accumulation, by providing a flat network for trusted application and transactions (Antonopoulos, 2016). We thus posit that DACs will introduce new ways of governing corporations that are flatter, less hierarchical and where the power structure is, too, decentralised and distributed across the many nodes of the network (Kypriotaki, Zamani, & Giaglis, 2015).

Factors that Inhibit Full Implementation

The success of disruptive technologies lies in that, among other things, they manage to introduce new business models and support new products and services that are significantly cheaper, better, convenient and more desirable than their predecessors (Kostoff, Boylan, & Simons, 2004). However, what needs to be stressed is that, for any technology to be considered successful, it needs to be fully developed and implemented, to get adopted beyond the confines of a niche group, and to be commercialised; in other words, the technology needs to move from the conceptual phase, or out of the research lab, and into actual use.

While cryptocurrencies and the supporting technologies are already in use by several businesses and individual users, the full impact of the blockchain has yet to reach the business world due to a series of factors that inhibit its wide adoption. In order to sketch out some these inhibitors, we adopt Assink's conceptual model of disruptive innovation inhibitors (Assink, 2006) and trace its dimensions against the distributed ledger technology.

Assink identifies five clusters of inhibitors that limit the full implementation and performance of disruptive innovations, that relate to adoption, mindset, risk, nascent and infrastructural barriers. On an abstract level, these inhibitors may be considered as pertinent and applicable to any new technology that is considered for adoption. In what follows, we discuss how these inhibitors affect the adoption of the blockchain technology.

Adoption Barriers

Within the cluster of adoption barriers, the main inhibitors have to do with pre-existing designs, and organizational inertia (Assink, 2006), which lead into unwillingness to change from the dominant paradigm (Herbig & Kramer, 1993). With regards to cryptocurrencies, DLT and smart contracts, all three of them were indeed developed so as to replace long established solutions; chief among them Bitcoin, with the dominant design being fiat currency. Specifically for large corporations, seeking to develop new use cases or improve existing ones through blockchain-based applications, they will need to do so by challenging, on the one hand, the status quo within them (because they will need to reengineer business processes, adopt different approaches for doing things and so on and do forth), while, on the other hand, seeking to cause minimal disruption on their day-to-day business. However, when there are existing technologies, e.g., electronic payments, credit cards, CHAPS payments, as alternatives, it is quite likely that organisations will be hesitant to do so. Indeed, while many large financial institutions have started engaging with the blockchain, they are still at the stage of discovering its possibilities and nurturing it into business propositions, having yet to enter the stage of commercialization, which requires organisational learning, unlearning and re-learning (Beck & Müller-Bloch, 2017). Generally, we consider that a cost-benefit analysis may support the decision-making process, through which organisations can make an informed decision as to whether substituting legacy payment systems with blockchain-enabled ones could be beneficial for their clients and themselves.

One more barrier that we see as belonging within this cluster is the usability, or lack thereof, of the technology. Conducting everyday transactions, and buying and selling cryptocurrencies is nowadays fairly straightforward. There are many different mobile applications, being a metaphor for the traditional wallet, and numerous exchange platforms exist, used by less and more experienced users. However, from the viewpoint of the average user, understanding the underlying structure and parsing the encryption principles that are useful for transacting safely and securely, is a very complicated task and limits the proliferation of the technology. On the one hand, using cryptocurrencies for paying at a regular point of sale may be simple, although not always as fast as using cash or credit cards (Lo & Wang, 2014). Further, not all transactions can mimic 'regular money'-like transactions; for example, while the buying process is more or less the same, getting a refund is entirely different. For the Bitcoin case, if a transaction has been broadcasted to the network, then by design it cannot be reversed unless the other party agrees to it. If transactions are conducted through escrow services, there is the chance to settle grievances through the escrow service, usually during the period over which funds are held by the escrow. Therefore, because the technology cannot mimic the full range of regular transactions, and because thus far, using it as an alternative for all transactions is not easier from using its predecessor, we posit that low usability levels have an impact on its adoption.

Mindset Barriers

While organisational learning is important, unlearning and relearning are also significant. These relate to how organisations and individuals break free from their own assumptions so as to identify the possibilities of the disruptive innovation and eventually reject old paradigms (Sinkula, 2002). It also highlights that organisations often hesitate to shift focus from their developed expertise, and concentrate on building new in fear of losing their competitive edge (Assink, 2006). Further, research suggests that the more radical the innovation, the greater the change is in the technology (Cabanes, Galy, Le Masson, & Weil, 2016); this means that the possibility of requiring new knowledge, new skills and competencies is higher.

Therefore, as a first step for the case of distributed ledger technology, organisations need to become more flexible, in the sense that they will need to start working on different areas that may be uncertain and often risky. While doing so, they have to assess whether they are short of the right talent for identifying use cases, developing prototypes and pilots and moving them to full development and commercialisation. In addition, as it happens with the blockchain technology, the necessary competencies are found at the crossroad of cryptography, finance, business process and information systems, which are rather difficult to be found in combination. As a result, organisations need to source new talent or identify existing from within them, whose skillset spans across these disciplines.

Further, we consider that the way through which organisations attempt to overcome mindset barriers will play a role in whether reintermediation or cybermediation occur. Assuming that traditional intermediaries lack the necessary set of competencies to compete within the blockchain field and fail to secure them, this will leave ample room for new players to enter the market by offering more competitive products and services. These may take the form of payment systems and third-party applications offering lower transaction fees for cross-border payments, more intuitive interfaces between client and provider, and so on. Similarly, if traditional intermediaries succeed in unlearning and relearning, they will be able to leverage their expertise and expand their portfolio of services so as to include blockchain-based offerings.

Risk Barriers

Disruptive innovations introduce high levels of uncertainty as they create, most often, areas and applications previously unknown and unforeseen. Such uncertainty creates a lot of risk for organisations, because organisations need to invest significant resources, both financial and human, in order to experiment with the technology and nurture their ideas. Further, they are not able to predict whether there will be a demand for the future products and services, whether these will be successful or better than their precursors, and, in the end, whether there will be a return on their investments (Assink, 2006).

In this respect, the blockchain technology presents quite a challenge for most organisations, irrespective of their particular profile. It comes with demands for new competencies, and new development methods, it is meant to be a substitute of several traditional alternatives, all of which have to be seamlessly integrated within the organisation and combined with pre-existing structures. At the same time, those working in the area need to find successful use cases, and get the buy-in of different divisions from within their organizations, so as to secure high-level support (be it financial or otherwise). As a rule of thumb, we consider that the risk barriers may be minimised if these new and old use cases can get leaner with the help of the blockchain rather than over the legacy system, i.e., they need to capitalise on the privacy and transparency offered by DLT, they require an increased level of trust among the nodes of the network and operate on the basis of proof of ownership, and where ownership is loosely interpreted into permission to create, store, edit data on the blockchain.

Nascent Barriers

Within the cluster of nascent barriers, Assink (2006) identified, among others, the lack of creativity and foresight, and the innovation process mismanagement as important inhibitors towards capitalizing on disruptive innovations. Lack of creativity relates to organisations, particularly large ones, being unable, or less prepared to support breakthrough ideas and individuals or teams to diversify on pre-existing solutions (Ahuja & Morris Lampert, 2001), which is nevertheless invaluable for developing and commercialising radically innovative products and services. Foresight is also necessary to predict what may create new markets or respond to needs that aren't yet fully formed. Development that responds to current needs rather than envisaged ones' (e.g., developing products based on focus groups and user studies) may be a barrier for innovation (Verganti, 2009), which can prove costly, particularly for high-tech businesses, who, as a result, may lose their market positioning (Christensen, 1997). Notwithstanding, management-related aspects are also crucial. Working with disruptive technologies requires the buy-in of key members from across the organisation, and from those responsible for allocating resources, be it financial, human, time or otherwise.

Along these lines, we consider that the single most important inhibitor for the adoption of the blockchain technology is the inability to effectively manage the innovation process, because on the one hand it brings together all other aspects of the nascent barriers cluster, while on the other, in order to be considered as innovating with the blockchain environment, a business will need to go beyond the mere replication of a legacy system using blockchain applications and tools. In Beck's and Muller-Bloch's study on an investment bank who is currently an incubator (Beck & Müller-Bloch, 2017), the innovation process was supported early on by senior executives, with an acute interest in the technology, who were encouraging and driving it across the organisation. The discovery stage, i.e., when the organisation begun identifying opportunities, was inspired by the need to solve problems that could not be solved with existing tools and led by enthusiasts, creative enough to see the applicability of the technology in a different area. All the while, management was aware of the uncertainty, the involved risks, and the possibility of not being able to extract value out of this endeavour; yet, financial resources were committed, external expertise was acquired, and stakeholders were involved so that use cases and reengineered business process remain relevant. Taken together, the organisation managed to create the appropriate environment for innovation and to move from the discovery to the incubation, and eventually to the acceleration stage.

Infrastructural Barriers

The infrastructural barrier aims to underline the lack of regulation, standards, processes, distributors, markets and the like, which are required to make the disruptive innovation a fully commercialised product (Assink, 2006; Walsh & Linton, 2000). This is particularly pertinent for blockchain-enabled technologies and applications.

The adoption of DLT is, almost by definition, not a single organisation's decision. Conversely, it takes a network of businesses to decide to cooperate on a blockchain-based infrastructure. Network effects and perceived compatibility (or lack thereof) with existing internal IT systems, may all play a role of inhibiting early adoption decisions by such networks or clusters of users. The lack of a genetic, interoperable infrastructure to support seamless DLT adoption at a cross-organizational setting will therefore be a significant barrier to early adoption of the technology and its applications. It is also probably the reason behind the current attempts of many large technology providers (such as IBM or Microsoft) and industry consortia (such as R3 in the financial services industry) to set up and provide a standard, interoperable set of infrastructure services to interested users.

Next, distributed ledgers may be permissionless or permissioned, or hybrid (Wust & Gervais, 2017). Being permissionless means that the blockchain is decentralised, anonymous, open to everyone and trust nests within the technology. The permissioned model is closed to outsiders, and monitored by the owner who grants access to participants based on their profile. In this scenario, trust develops as a result of the monitoring and emerges out of the owner. They are usually developed by organisations or consortia of organisations (hybrid); as a result, they serve a specific purpose and are governed by specific rules. Most importantly, they require significant funds for their development and for medium or small organisations may make no financial sense to invest in developing a private or hybrid blockchain of their own. However, this barrier may be overcome through third parties, whereby an intermediary can surface as blockchain provider for many smaller organisations, offering Blockchain as a Service (BaaS) as a hybrid solution, i.e., a partially decentralised blockchain, by creating economies of scale.

Conclusions

In this paper, we have examined how cryptocurrencies, distributed ledger technology and smart contracts can be combined to unleash a new era of commerce. As Worner et al. (2016) show, many companies leverage cryptocurrencies to innovate, and that in doing so, they manage to create new markets and/or remove central authorities from the equation. Other businesses are more focused on the distributed ledger technology, experimenting with proof-of-concepts or use cases, and are at the verge of moving to the acceleration stage, where a full business proposal gets drafted and exploitation activities begin (Beck & Müller-Bloch, 2017). Within this line of thought, we believe that the focus should be placed on how these technologies can be used to enable and further develop decentralized trusted peer-to-peer transaction ledger systems and applications (Giaglis & Kypriotaki, 2014), and lead to sustainable business models (Wörner et al., 2016).

However, for that to be possible, the technology needs to overcome a series of obstacles that prohibit its full commercialisation. As our analysis shows, there are adoption, mindset, risk, nascent and infrastructural barriers. These are not independent from each other, but rather interact and are interdependent for the most part. Blockchain technology requires that organisations come up with new ways of doing business and in doing so, they will need to consider abandoning old paradigms, possibly successful ones, and developing new competencies. To do so, it is necessary that senior management develops an understanding of DLT's possibilities and creates a supportive environment, where the innovation process may flourish.

Like all technological innovations, this comes, too, with opportunities and risks. What we have described in the previous sections fall within the category of Machine to Machine (M2M) and Human to Machine (H2M) commerce, where financial transactions are ultimately facilitated by the existence of digital money and ledgers. Such scenarios open up numerous possibilities and benefits; for example, a cryptocurrency payment system can be literally programmed, and it will be possible for computing devices to bid for each other services, through the use of smart contracts. This means that ultimately, computers can participate in auctions, whose outcome may be based on the most efficient allocation of resources, while DLT can provide for cryptographically-proven transactions and for maintaining the anonymity and the security of all parties.

With regards to the risks and other considerations, such as the ethical ones, for the time being financial institutions and governments appear to be in the process of devising ways of taking advantage of the DLT and considering ways of regulating its use (Subramanian & Chino, 2015). Given the near-zero transaction costs of cryptocurrency-based payment systems, existing business models are now being challenged and new opportunities emerge. The distributed nature of computers over networks that can communicate with each other and transact without the intervention of humans, and as technology advances each and every day, may create a future where humanless corporations can very well be a reality. As the members of the network can remain fully anonymous, without clear regulation that governs cryptocurrencies, cryptocurrency-based payment systems may be used, and are already being used, for criminal activities, such as money laundering. This further gives rise to ethical considerations and how this technology can be used for illegal activities (Dierksmeier & Seele, 2016; Hurlburt & Bojanova, 2014).

Another extension would be that, as these technologies bring forward the development of humanless corporations through DACs. DACs, in these scenarios, offer their services to other parties of the network, without the mediation of other human agents, but only autonomous agents are involved and in control of the interactions and transactions. This may sound dystopian, as it may be seen as emerging technologies, like DLT and the likes take over towards development and growth, with the ultimate purpose to increase efficiency (Atzori, 2015). We acknowledge the ethical and moral considerations behind the full deployment of cryptocurrency-based payment systems and the use of DLT for creating humanless corporations, whereby autonomous agents can substitute humans. However, we don't consider that this will necessarily lead to a dystopian future, as we see this to be dependent on the use context. While removing social interactions from some contexts, such as the educational or the health care one is certainly harmful, DACs and other rigid forms of transactions can be quite beneficial in financial contexts or where records, registers and voting procedures are required and have to be strictly monitored (Reijers & Coeckelbergh, 2016).

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