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BEYOND CRYPTOCURRENCIES: ECONOMIC AND LEGAL FACETS OF THE DISRUPTIVE POTENTIAL OF BLOCKCHAIN TECHNOLOGY

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Abstract: *While the most prominent applications are represented by virtual currencies (especially Bitcoin) and other financial technology solutions (FinTech), blockchain technology is a powerful new tool that has significant disruptive potential - both from economic and legal perspective. Not only private investors, but also governmental institutions focus their attention on this complex distributed ledger technology which is seen as a ground-breaking solution for long-standing problems in traditional highly centralised systems belonging to the public and private sector. However, blockchain technology faces some important challenges – mainly regarding scalability, privacy, regulatory uncertainties, business models and standardisation.*

Key words: *Blockchain Technology, FinTech, Distributed Ledger Technology, Smart Contracts, Blockchain Regulation.*

1. Introduction

The hype around crypto currencies like Bitcoin has somewhat faded in the aftermath of the latest significant value fluctuations of the most popular virtual currencies and the enforcement of new regulatory measures - therefore, the question arises: what will happen in the future with these new technologies?

The core technologies behind virtual currencies like Bitcoin and FinTech Solutions can be grouped under the concept of **blockchain-based Distributed Ledger Technology (DLT).**

Satoshi Nakamoto, the creator of Bitcoin, explained the technology in his 2008 white paper “Bitcoin: A Peer-to-Peer Electronic Cash System” as an “electronic payment system based on cryptographic proof instead of trust, allowing any two willing parties to transact directly with each other without the need for a trusted third party. Transactions that are computationally impractical to reverse would protect sellers from fraud, and routine escrow mechanisms could easily be implemented to protect buyers”. (Nakamoto, 2008)

According to the World Bank 2017 DLT report, although initially merely seen as the

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base technology of the virtual currency Bitcoin, Blockchain-based DLT “has a variety of potential applications beyond the narrow realm of digital currencies and cryptocurrencies”, and consequently, “DLT could have applications in cross-border payments, financial markets infrastructure in the securities markets, and in collateral registries”. (IBRD - World Bank, 2017)

Due to a series of important possible benefits over conventional centralized ledgers and shared ledgers (such as: “decentralization and disintermediation, greater transparency and easier auditability, gains in speed and efficiency, cost reductions, and automation and programmability”), the World Bank considers that future use cases of DLT will not be restricted to FinTech applications and will encompass “digital identity products (such as national ID, birth, marriage and death records) or build tamper-proof, decentralized records of flow of commodities and materials across a supply chain by using trusted stakeholders to validate flows and movements”. (IBRD - World Bank, 2017)

Moreover, Deloitte’s 2018 survey of more than one thousand blockchain-knowledgeable managers worldwide shows that “Blockchain is at an inflection point, with [...] momentum shifting from a focus on learning and exploring the potential of the technology to identifying and building practical business applications”.

The report also emphasizes an important managerial imperative of Blockchain-based DLT implementation: “This is a business model change where companies need to focus on more than just a solid proof of concept for implementation. Because blockchain, when properly implemented, should fundamentally change how a business operates, it impacts the entire organization, creating new tax and cyber implications along with a variety of governance and regulatory issues that need to be addressed”. (Deloitte, 2018)

2. Main Features of Blockchain Technology

According to the 2017 DLT report of the International Bank for Reconstruction and Development (IBRD - World Bank, 2017), we should differentiate between “Shared Ledgers” (SL), “Distributed Ledgers” (DL) and “Blockchain”: **Distributed Ledgers** represent a particular variety “of the broader category of ‘*shared ledgers*’ ”, while **Shared Ledgers** (basically described as “a shared record of data across different parties”), can embody “a *single ledger* with layered permissions or a *distributed ledger*, which consists of multiple ledgers maintained by a distributed network of nodes”.

In this context, the World Bank defines a **Blockchain** as “a particular type of data structure used in some distributed ledgers which stores and transmits data in packages called ‘*blocks’* that are connected to each other in a digital ‘*chain’* “ - utilizing “cryptographic and algorithmic methods to record and synchronize data across a network in an immutable manner” (IBRD - World Bank, 2017).

Another important international organisation - the GSMA (which advocates the interests of mobile operators globally, representing “more than 750 operators with over 350 companies in the broader mobile ecosystem, including handset and device makers, software companies, equipment providers and internet companies, as well as organisations in adjacent industry sectors” - according to the GSMA corporate website at www.gsma.com) considers a **Blockchain** to be “[...] a linear form of a distributed ledger composed of immutable blocks of data, each block containing a list of transactions and a unique reference to its predecessor block" - while "strong cryptographic techniques are employed to maintain integrity between each block and its predecessor", thus enabling everyone - having the proper permissions - to distribute and validate the Blockchain (GSMA, 2018 - "DLT, Blockchains and Identity 2018" report).

In its "DLT, Blockchains and Identity" 2018 report, the GSMA also classifies Blockchain types according to distinct permission models - as presented in Figure 1 and identifies the main characteristics that differentiate Blockchains from other Distributed Ledgers:

1. "*Cryptography*: a wide variety of cryptographic functions are used, including hashing algorithms;
2. *Peer to peer*: consist of a peer to peer discovery and synchronisation mechanism;
3. *Consensus*: algorithms that determine the sequence and validity of transactions;
4. *Ledger*: list of transactions that are bundled together in cryptographically linked blocks;
5. *Validity rules*: the network rule set determines what transactions are considered valid and how the ledger gets updated, etc.;
6. *Crypto economics*: a combination of cryptography and economics (game theory) that makes sure all actors in a decentralised system are incentivised to remain honest."

		Read	Write	Commit	Examples
Open	***Public permission-less***	Open to anyone	Anyone	Anyone	Open ecosystems, e.g. Bitcoin, Ethereum
Open	***Public permissioned***	Open to anyone	Authorised participants	All or subset of authorised participants	Open ecosystems, e.g.. Ripple, Sovrin
Closed	***Consortium***	Restricted to an authorised set of participants	Authorised participants	All or subset of authorised participants	Multiple companies within or across sectors Hyperledger or Corda
Closed	***Private permissioned ('enterprise')***	Fully private or restricted to a limited set of authorised nodes	Network operator only	Network operator only	Internal enterprise solutions within industries Ripple

Fig. 1. *Types of Blockchain – according to GSMA 2018*

(Source: "DLT, Blockchains and Identity - 2018" report)

Analogously, two broad categories of Blockchains can be found in the 2017 DLT report of the International Bank for Reconstruction and Development (IBRD - World Bank, 2017), which distinguishes between **Public (open) Blockchains** (like *Bitcoin* and *Ethereum)*, and **Permissioned Blockchains** (like *R3's Corda* and *Hyperledger Fabric*), further describing the main features of each category (by taking into account the following aspects: Central party, Access, Level of Trust, Openness, Security Speed, Identity, Consensus, Asset, Legal ownership) - as shown in Figure 2.

	'Public' (open) Blockchains	Permissioned Blockchains
Central party	No central owner or administrator	Has some degree of external administration or control
Access	Anyone can join	Only pre-selected participants can join the network
Level of Trust	Network members are not required to trust each other	Higher degree of trust among members required (as collaboration among members could alter the ledger)
Openness	Ledger is open & transparent - shared between all network members	Different degrees of openness and transparency of the ledger are possible
Security	Security through wide distribution in a large scale network	Security through access control combined with DLT in smaller scale networks
Speed	Slower transaction processing restricts transaction volume	Faster transaction processing allows for higher transaction volume
Identity	User identity anonymous or protected by pseudonyms	Identity verification typically required by owner/administrator
Consensus	Difficult proof-of-work required as consensus mechanism	Variety of consensus mechanisms possible (typically less difficult & less costly than proof-of-work in permissionless blockchains)
Asset	Typically: native cryptocurrencies. But implementations are possible where a token is used which can represent any asset.	Any asset
Legal ownership	Legal concerns over lack of ownership as no legal entity owns or controls the ledger	Greater legal clarity over ownership as owner/administrator is typically a legal entity
Examples	Bitcoin, Ethereum	R3's Corda, Hyperledger Fabric

Fig. 2. *Public (open) Blockchains and Permissioned Blockchains*

Source: *"Distributed Ledger Technology (DLT) and Blockchain" report - IBRD - World Bank, 2017)*

In the 2017 white paper of the International Development Research Centre (IDRC) entitled "Blockchain - Unpacking the disruptive potential of blockchain technology for human development", Zambrano identifies the following key players of Blockchain systems: "**Core developers** (have write access to the source code), **Full nodes** (have up-to-date copies of the blockchain, validate new blocks and propagate them across the network), **Miners** (are dedicated to running proof of work), **End users** (use the network to do their transactions by using client or wallet software), [and] **Service nodes** (such as wallets, storage, exchanges, and cloud services)". (Zambrano, 2017)

The functioning scheme of Blockchain technology is graphically represented in Figure 3 and the method how records or rows are interlinked is also explained: Every new element in the public database comes in the form of a "block of transactions" with a distinct identifier and it is interlinked with the previous one – therefore being "a child of the previous block thus creating a logical chain between blocks". Zambrano (2017) stresses that: "Each block unique identifier is used to generate the unique identifier of the next block. This creates a chain of linked blocks, or a blockchain, where changing the content or the order of the rows is virtually impossible. Any block is thus the mathematical child of the previous one. The only exception here is the so-called "genesis block," the first block or row in the data" (Zambrano, 2017).

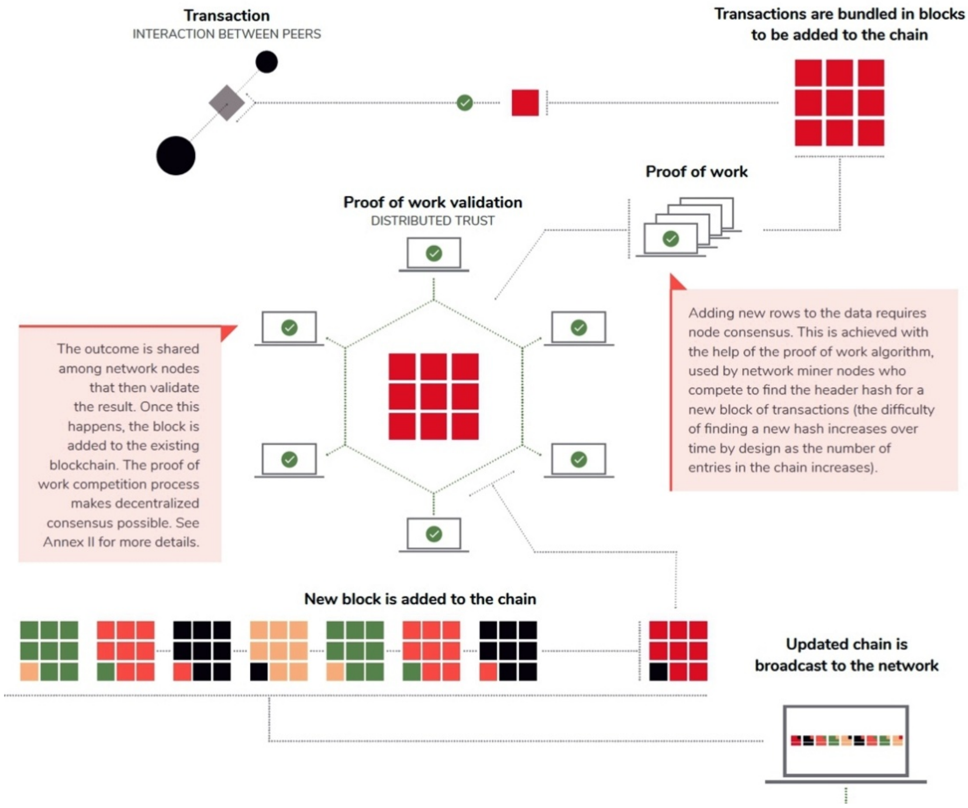

Fig. 3. *Functioning scheme of Blockchain technology (Source: Zambrano, 2017)*

3. Blockchain and DLT Applications - Economic and Legal Facets

According to Deloitte (2018), the story of Blockchain and DLT Applications could be heading for a happy ending - as the academic hypotheses of a few years ago are gradually becoming a reality and the surveyed executives "see great value in blockchain's potential to reinvent processes across the business value chain as more investment is made in identifying and developing a wider range of use cases".

3.1. Blockchain and DLT Applications with Disruptive Potential

In their 2017 Harvard Business Review article entitled "The Truth About Blockchain", professors Marco Iansiti and Karim R. Lakhani consider that some of the instabilities and inefficiencies generated by the international economic mechanism could be tackled through Blockchain technology (Iansiti and Lakhani, 2017):

"Contracts, transactions, and the records of them are among the defining structures in our economic, legal, and political systems. [...] And yet these critical tools and the bureaucracies formed to manage them have not kept up with the economy's digital transformation. They're like a rush-hour gridlock trapping a Formula 1 race car. In a digital world, the way we regulate and maintain administrative control has to change. [...] Blockchain promises to solve this problem. [...] Blockchain could slash the cost of

transactions and reshape the economy. [...] Transformative applications will also give rise to new platform-level players that will coordinate and govern the new ecosystems. These will be the Googles and Facebooks of the next generation."

Additionally, although Blockchain technology may not substitute the present market structure and system very quickly, according to a technology brief published by the National University of Singapore in 2018, it is important to analyse how, in the future, Blockchain technologies could enable transactions between untrusted parties eliminating the requirement of a central authority or certain intermediaries - with significant consequences:

"This could help accelerate the digital economy, which at present is encumbered by the current market system and needs a massive network of trusted third-party intermediaries, including financial institutions, law firms, regulatory bodies, etc. Bitcoin, as the first use case of blockchain technology, has given us a glimpse of a future with a decentralised global ledger. While the Internet has democratised information, blockchain could, in the future, democratise trust". (National University of Singapore, 2018)

Moreover, the newly developed **Smart Contracts** based on the Blockchain allow for the first time real P2P transactions without a middleman and have the potential to change many off the current traditional business and administrative processes from the ground up. Therefore, the most impacted by this revolution are banks, insurance companies and all those authorities that supply, archive, verify, authenticate, patent, and license information. Nevertheless, traditional distribution chains are also disrupted because the Blockchain has the potential to restructure traditional economic production and distribution chains, by eliminating the middlemen and intermediaries, while also allowing for significantly increased transparency. Furthermore, Blockchain could also become a base-technology solution for a new 4.0 level of the classic Industry, and - through their automated contract processing power - Smart Contracts based on Blockchain could represent an efficient solution in an Internet of Things (IoT) world, in which Machine-to-Machine communication and transaction are essential (Voshmgir, 2016).

Other authors also agree that, while executives in the financial services sector are leading the way in adopting Blockchain (Deloitte, 2018), there are an increasing number of emerging disruptors within each sector, challenging traditional business models with the use of Blockchain in various "non-monetary systems such as in online voting, decentralized messaging, distributed cloud storage systems, proof-of-location, healthcare" etc. (Mahdi and Maaruf, 2018).

Essentially, Blockchain is a complex ledger system, a multipurpose technology that "can record financial transactions, store medical records, or even track the flow of goods, information, and payments through a supply chain". Blockchain - combined with a solid use case - can operate as a type of "Trust-as-a-Service (TaaS) to ecosystem participants" (appearing to be the ideal "Trust Machine" paradigm). Fundamentally, "it's more of a business model enabler than a technology" (Deloitte, 2018).

In an IoT ecosystem, most of the communication is in the form of Machine-to-Machine (M2M) interactions. Thus, substantiating trust among the participating machines is a big challenge and Blockchain may function as a catalyst in this regard by allowing improved scalability, security, reliability (through eliminating the Single Point of Failure - SPF vulnerability) and privacy (by implementing hashing techniques) (Mahdi and Maaruf, 2018). Furthermore, the list in Figure 4 elaborated by IBRD - World Bank in 2017 offers a comprehensive overview of DLT Applications.

Overview of Potential DLT Applications (at varying stages of development)	
Financial Sector Applications	
Money & Payments	• Digital currencies • Payment authorization, clearance & settlement • International remittances and cross-border payments (alternative to correspondent banking) • Foreign exchange • Micropayments
Financial Services & Infrastructure (beyond payments)	• Capital markets: digital issuance, trading & settlements of securities • Commodities trading • Notarization services (e.g. for mortgages) • Collateral registries • Movable asset registries • Syndicated loans • Crowdfunding (as initial coin offerings) • Insurance (in combination with smart contracts) for automating insurance payouts and validation of occurrence of insured event
Collateral registries and ownership registers	• Land registries, property titles & other collateral registries
Internal systems of financial service providers	• Replacing internal ledgers maintained by large, multinational financial service providers that record information across different departments, subsidiaries, or geographies
DLT-based applications in other sectors	
Identity	• Digital identity platforms[22] • Storing personal records: birth, marriage & death certificates
Trade & Commerce	• Supply chain management (management of inventory and disputes) • Product provenance & authenticity (e.g. artworks, pharmaceuticals, diamonds) • Trade finance • Post-trade processing • Rewards & loyalty programs • Invoice management • Intellectual property registration • Internet of Things
Agriculture	• Financial services in the agricultural sector like insurance, crop finance and warehouse receipts • Provenance of cash crops • Safety net programs related to delivery of seeds, fertilizers and other agricultural inputs
Governance	• E-voting systems • E-Residence • Government record-keeping, e.g. criminal records • Reducing fraud and error in government payments • Reducing tax fraud • Protection of critical infrastructure against cyberattacks
Healthcare	• Electronic medical records
Humanitarian & Aid	• Tracking delivery & distribution of food, vaccinations, medications, etc. • Tracking distribution and expenditure of aid money

Fig. 4. *Overview of DLT Applications*

Source*: IBRD - World Bank, 2017 - "Distributed Ledger Technology - DLT and Blockchain")*

Lastly, in Figure 5, Hackius and Petersen (2017) reveal Blockchain's potential by examining the prospects of Blockchain for logistics and Supply Chain Management (SCM) through presenting four significant ideas as use case paradigms currently explored in both theory and practice, "out of a yet unmapped sea of opportunities":

1). *Ease Paperwork Processing* (e.g. substituting paper-based freight documents like the bill of lading); 2). *Identify Counterfeit Products* (e.g. counterfeit medicine); 3). *Facilitate Origin Tracking* (e.g. in the food supply chain); and 4). *Operate the Internet of Things* (e.g. about logistics objects' sensors and the status of a shipment).

Fig. 5. *Overview of SCM Use Case Exemplars (Source: Hackius and Petersen, 2017)*

3.2. Interactions of Blockchain and DLT Applications with Policy and Regulation

The findings of the 2016 "Distributed Ledger Technology: beyond block chain" report elaborated by the UK Government Chief Scientific Adviser Sir Mark Walport show that: "Both the legal and the digital spheres are governed by rules, but the nature of these rules is different. In a digital environment, both laws (legal code) and software/hardware (technical code) regulate activity. The impact of both must be considered in setting out regulations that cover distributed ledger systems." (Walport, 2016).

Additionally, according to the Law Society's Research Unit (2017), "blockchain-based currencies present many legal and regulatory challenges including consumer protection mechanisms, enforcement methods and possibilities for engaging in illegal activities such as tax evasion and the sale of unlawful goods", while the **fundamental legal concerns** are related mainly to: **data privacy**, **legal jurisdiction** (servers and the nodes can be located in multiple jurisdictions around the world, posing complex jurisdictional issues); **liability** (inability to control and stop the functioning of public blockchains); **legal status of Decentralised Autonomous Organisations** as entities (what legal status attaches to DAOs?); and the **legal enforceability of smart contracts** (e.g. concepts such as 'offer' and 'acceptance', 'certainty' and 'consideration', are unlikely to be relevant to many coded programmes - since smart contracts are pre-written computer codes).

Consequently, as a wide-ranging regulatory response to Blockchain (as a whole) does not exist yet, the OECD, in its report "Blockchain Technology and Corporate Governance Technology, Markets, Regulation and Corporate Governance" from 2018, stresses the need to adapt the traditional methods of regulation to the new digital realities:

"Since early 1990's, most jurisdictions have successfully digitalized their existing 'analogue' (paper based) processes and hence the term RegTech. Considering the big challenge posed by blockchain, this is no longer adequate and a new paradigm is called for. Regulators must now explore the possibility of using blockchain technology for their own purposes ('RegTech 2.0'), where monitoring and supervision of financial markets is done using blockchain-based platforms". (OECD, 2018)

For protecting broader social interests, regulators may want to collect taxes, prosecute crimes, and curtail the use of a distributed ledger for criminal activities, while making sure that the new system is resilient against systemic risks and market failure. This regulation can be implemented **through legal code** (e.g. enforcing legal obligations on owners of a *permissioned distributed ledger system* or regulating *an unpermissioned system* like Bitcoin by concentrating on regulating the businesses that transact with Bitcoin, such as exchanges and wallet providers - safeguarding compliance with anti-money laundering rules), or **through technical code** (encompassing software and protocols elaborated by the public sector) (Walport, 2016).

While the setting is multifarious and regulatory responses are often immature, it appears that **three types of regulatory positioning** can be identified (OECD, 2018):

- "Study-and-Wait-and-See (most regulators are in this position - trying to conceptualize and understand the potential foundational and transformational implications of blockchains for economies and societies)";

- "New legislation and regulation (e.g. France allows blockchain ledgers for crowdfunding records. Some states in the USA have enacted laws on smart contracts, blockchain-based digital signatures, and on blockchain ledgers as legal evidence.)";

- "Guidance and sandboxing (some jurisdictions [...] have chosen to provide regulatory guidance of how new technologies fit into existing legal frameworks and to provide sandboxing opportunities [...] a legally safe environment (often through some regulatory exemptions) for blockchain developers to test their products [...] implemented on a controlled scale for a limited period of time and under close supervision." - e.g. in Canada, UK, Australia, Singapore, Switzerland, and the EU).

The OECD study emphasises that one of the most important regulatory initiatives is led by the **International Organization for Standardization (ISO) -** through Standards Australia, which has set up a task force working on **internal blockchain standards** and also on **standards about the interoperability of separate blockchains** (within **ISO/TC 307** standard). Notwithstanding engineering specifications, standardization should cover three critical areas: **Terminology**; **Architecture** (especially regarding *protocols of data storage*, *data diffusion* and *access rights*, *consensus*, and *smart contract capabilities*); and **Governance** (i.e. procedures and rules on how a blockchain is initiated and managed; on "network membership, management of permissions, transaction validity, issuance of new assets and their tokenization, dispute resolution, software updates, regulatory reporting, and protection against cyber risks" etc.) (OECD, 2018).

4. Conclusion

Based on their core philosophy of distributed consensus, open source, transparency, and community, Blockchain and Distributed Ledger Technologies have the potential to be profoundly disruptive and represent a substantial challenge to existing business and governance models, spurring ground-breaking mutations in business structures, and even generating far reaching transformations in the way in which the economy and society itself is organised and governed.

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