Special Collection: Report on Blockchain for Societies.

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The Amsterdam Law Forum (ALF) has released in this edition a Special Collection titled Report on Blockchain for Societies, which has been edited by Dr Thibault Schrepel who is an Associate Professor at the Vrije Universiteit Amsterdam (VU) and PhD student in blockchain and antitrust Kirill Ryabtsev. This Report is composed of several contributions written by prominent scholars and practitioners in the area of blockchain technology, the Report discusses the application of blockchain governance to various legal fields such as data protection, regulation of luxurious goods industry, real estate, health and vaccines, and laws on nationality.

BLOCKCHAIN AND AI: AN (ALMOST) PERFECT LIAISON

A PRELIMINARY STUDY OF THE CIVIL RESPONSIBILITY REGIME

By: Benedetta Cappiello

INTRODUCTION

The rapid improvement and development of Distributed Ledger Technologies ("DLTs") and software or hardware of artificial intelligence (AI) are increasingly changing people's daily lives. Overall, the technological advent is deemed to be "disruptive" towards the old and traditional nation system, as conceived since the Peace of Westphalia; namely, the current spread of new technologies is leading towards a paradigm shift among all in the economic, social and for what it of interest for the present contribute, the legal. It thus requires a coherent change of approach at all levels of society.

Both DLTs and AI have put at stake at least the economic and the legislative sovereignty of the State; also, traditional legal concepts struggle against the (alleged) new ones, developed thanks to the new technologies. Reference is made, for instance, to the contract *vs.* the smart (legal) contract, the companies *vs.* the diffuse autonomous organizations (DAOs).

This entry intends to question what would happen if the two more challenging technologies, blockchains (one among the DLTs representation) and AI, were to be combined. The aim is to understand whether and how the said technologies can work together to improve each other while increasing society's well-being. In this respect, this entry will tackle both the technology (what blockchain and AI are, and how they work) and the legal consequences derived from their use. In this respect, two use cases will be presented. In detail, the expected regime of non-contractual liability, which shall apply to platforms/systems developed and deployed, combining a mix of blockchain and AI software will be scrutinized. A conclusion will then be attempted. Regarding the geographical area of interest, the entry will focus on the EU while being aware that the phenomenon under scrutiny has a transnational dimension.

TECHNOLOGICAL SIDE

The idea to combine blockchain technologies and artificial intelligence is grounded on

the assumption that, as said, both are leading to a radical shift in society. Given this, it is questionable whether a combination will boost their respective use while overcoming their shortcomings. A brief understanding of both technologies will help.

AI is used to automate tasks that normally require "*human intelligence*". AI technologies are not new, but today they have become highly sophisticated. As regards the state-of-the-art, two significant branches of AI can be distinguished. In the first one, real-world phenomena or processes are modeled (translated) in a form that computers can read and use. Thus, IT programmers will provide an AI software with rules mirroring the underlying logic and knowledge of the activity the programmers want to model and automate.

The second area is represented by the so-called machine learning software, which detects patterns in large amounts of data. These systems are programmed to understand whether a given data (such as an email) shall be in (desired) or out (spam). The system reaches this conclusion by analyzing given words/patterns it has learned to understand from an enormous amount of data. Accordingly, king/win/ and others lemma, along with ab email departure (such as Belarus), might prove that a given email has a higher chance of being spam. Accordingly, the more data an AI system has, the more it learns and elaborates them highly sophisticatedly. However, it does not guarantee their "quality" nor certify their provenance or immutability. The software can thus then get mistaken. Given these shortcomings, an AI machine learning system might be combined with blockchain technologies.

In a nutshell, blockchain is a digital ledger storing an impressive amount of data. The system is decentralized, immutable, and transparent. It has been changing the concept of trust: from third-party trust to technology trust. The data uploaded within the chain are "correct" from the technical side: they have not been duplicated or reused. However, the data are not necessarily true; the garbage in and garbage out paradigm is inherent to blockchain: a data stored in block is in fact immutable but if it mirrors an information which is untrue, the negative consequences will affect all the subsequent transactions.

Some blockchains rely only on endogenous data (party, token); thereby, the transaction occurs within the chain. Some others require an exogenous third party, an oracle, acting as a virtual agent, providing for the data, which triggers the required transaction. For instance, a swap contract (Bitcoin *versus* Euro) written as a smart contract in the blockchain might provide that the exchange will be made once the Euro has reached a given value in the Milan stock exchange. The contract is basic: if – then. However, it

requires data taken from outside the blockchain to be deployed. The contract abides by what the oracle states, and the parties, too, are indirectly bound.

This said, one might wonder whether the proposed integration of AI and blockchain might entrust the data provided by machine learning software: the algorithm developed within it might exploit the blockchain technologies to collect, store and use accurate and certified data.

TWO USE CASES

1. Fetch.ia is a native platform developed on blockchain and provides a series of different services in various fields of daily life (energy, supply chain, hotel agency, parking, energy consumption). For each field, an AI agent written with an algorithm of machine learning is deployed and increases its capabilities thank to the available amount of data at its disposal. In fact, the platform is open to all interested users who can enter in the P2P buying the FET token; once in, each user can share and get information in its field. In practice, once a transaction in a given field is required (say that a party is searching for a hotel room in a given place), providers and consumers *via* their AI agent (the interested party and the hotel owner) will be connected; the AI agent will then elaborate the information at its disposal – available within the blockchain – to get out of the transaction their respective optimum. This means that the two AI agents share the data stored in the platform (say the medium price for a hotel room; the amount of money the person involved wants to spend) and through the algorithm of machine learning they get the maximum output. Then a transaction on the blockchain is made, say the booking of the hotel.
2. Jur.io is a native blockchain platform providing three levels of dispute resolution: the first one implements "a smart arbitration" system based on legally binding procedures. For this level, the deployment of an AI system is under scrutiny, smoothing the task of data 'storing, reading, and elaborating. When a claim, all documents and attachments will be scrutinized and synthesized by AI software before reaching arbitrators 'attention.

   The other two layers work as ADR on a P2P platform; take for instance the case of a selling contract of minimum value, and having a transboundary nature; in case of breach of contract parties won't have interest to start a claim before a court or an arbitral tribunal; however, justice in the relationship can be ensured by other means. In this respect ODR first, and ADR on blockchain system now can offer a solution. In practice,

they feature a decentralized oracle-like voting system providing decisions in small/micro-claims (similar to contract agreement). This is possible by exploiting game theory and the Schelling focal point. The result will reflect the desirable solution; then, the algorithm of deep learning, linked to the platform, will help corroborate or not the solution. This means that the algorithm will elaborate the data stored in the platform (including for instance old decision) and it will tell whether or not the solution proposed is the "just solution". Those acting as arbitrators might rely on the oracle, which has a better and deeper understanding of the praxis in a specific field.

LEGAL CONSEQUENCES

All the above raises some legal consequences which need to be tackled with. Reference is made to the accountability and responsibility issue. The question arises because the oracle/AI Agent developed as an algorithm of machine learning might get wrong because of an original bias or a bug subsequently appeared. The negative consequences are borne by the parties (users and bystanders); however, the principle of *neminem ledere* which informs each legal system requires that, in case of damage, there should always be someone to be held liable. The spread of new technologies is putting at stake the regimes of civil liability (fault-based or risk based) currently available; namely, the question has become how to ascertain who is liable for what; the opacity of AI-systems – especially those engaging with machine learning techniques – can make it extremely difficult to identify who is in control and therefore responsible.

The current challenge for the legislator is to determine a clear legal framework able to, firstly, guarantee continued technological development and secondly, to be integrated with already binding sources of law. To reach this result, we assume that there is a human being behind each technological application who shall be held accountable and take responsibility for his/her wrongdoing (in programming or controlling a program). That said, it is of interest to scrutinize the most recent legislative proposal enacted within the EU.

The legislator has started to sketch normative provisions regarding blockchain technology, at least on some aspect of its deployment (crypto assets or cryptocurrencies). As for AI, its ethical, social, and legal aspects have been under deep scrutiny. The EP recently released a draft Regulation on AI enacting provision on civil responsibility of AI-Operators, distinguishing between AI-systems having high or low-risk impact. Given this, one might wonder whether the said EP proposal will apply to platforms developed

through both AI and blockchain once enacted as a Regulation. Mainly, reference is made to the provisions enacted for AI systems having a low-risk impact. For those, the EP draft introduces a fault-based system according to which the AI operators will be held accountable for their wrongdoing (only a few exemptions are provided). In the case of the P2P platform linked to AI (Oracle /agent), the operator allegedly accountable is the individual/company that has developed and is controlling the algorithm; besides, it might be held accountable (joint responsibility) the operator having deployed the P2P platform.

Moreover, the combination of AI and Blockchain technologies might make it easier to apply the EU Regulation on general data protection. The data controller and the data processors might be easily found where there is an AI system developed to store and use the data. Unlike blockchain, AI does not guarantee the anonymity of its users and its developers.

PRELIMINARY CONCLUSION

The entry has shown that new technologies such as blockchain and AI can be integrated exploiting the best each one can offer. As shown, the reliability linked to a blockchain platform (in terms of data storage and data control) can ensure that an AI-system linked to the platform will provide its algorithm of machine learning with data which can be trusted because they are immutable and transparent. The output so reached by the AI algorithm increases the confidence of parties involved; the medical sector is the one which could exploit the best from the said technologies integration (think about data triggered out of clinical trial, then stored in a blockchain platform and re-elaborated by an AI algorithm to provide, among all, a diagnosis).

That said, the entry has also shown that there is legal effect liked to new technologies development and use which need to be tackled with; technologies run faster than legislators at all levels; as seen, currently there have been very few normative attempts to enact provisions defining a regime of responsibility for both blockchain platforms and blockchain operators. Conversely, legislators have drafted provisions on AI ethical and, also and foremost, responsible development and use. Accordingly, the proposal to apply these letters to a platform which combines AI and blockchain technologies will help confer legal certainty upon users; this will cover the normative on civil liability within blockchain operators currently lay. Accordingly, the anthropocentric approach distinguishing AI shall somehow be favored and applied for blockchain platforms. This

will, in turn, positively impact society: it will raise the confidence in the technology while better protecting users, acting as producers or consumers.

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MAKING LUXURY LAST FOREVER: THE USE OF BLOCKCHAIN IN DIAMONDS, ARTWORKS, PRECIOUS METALS, AND WINES INDUSTRIES

By: Bruno Vieira

INTRODUCTION

Diamonds and valuable gemstones trade can sometimes play a central role in financing wars and coups.[1] The diamond industry also provides poor working conditions, frequently using child labor[2], and the mining process of diamonds also raises concerns about environmental issues. Not only diamonds but also luxury goods such as artworks, precious metals, and wines frequently have to protect their product from mislabeling, counterfeit, and smuggling.[3] Blockchain can help track the diamond transformation process to its origins and help luxury good producers identify, protect, and track their products to minimize counterfeit and smuggling.

From a legal standpoint, the initiatives presented in this report can use blockchain in the diamond industry to help improve labor conditions in diamond and precious metals mining and avoid the financing of civil wars in third-world countries, promoting human rights like the right to life, liberty, and security. In the luxury goods industries, the projects can help the efficient and effective enforcement of intellectual property rights and protect consumers from defective products.

WHAT ARE THE SERVICES?

TrustChain, Everledger, and Tracr use blockchain to track, trace, and certify the authenticity of luxury goods like diamonds, artworks, precious metals, and wines from their extraction, manufacture, and retail.

TrustChain is a consortium led by IBM with diamond and jewelry companies to provide the final customer perennial blockchain digital record of all transactions made within the consortium. The consortium includes parties from the entire diamond supply chain: gem supplier, precious metals supplier, refinery, and jewelry retailer and manufacturer. Each part adds its activity into the blockchain before a new transaction with the next agent in the supply chain. The blockchain stores information such as the diamond's mine of origin, the provenience of the precious metals used in the

[1] See J. H. Sherman, 'Profit vs. Peace: The Clandestine Diamond Economy of Angola' (2000) 53(2) Journal of International Affairs 699-719; see also J. Mhandu and S. S. Mugambiwa, 'The Role of Diamonds in Financing and Perpetuating Civil Wars on the African Continent' 11(4) African Journal of Development Studies 267-284.
[2] See F. P. Miller, A. F. Vandome, and J. McBrewster, Child labour in the diamond industry (VDM Publishing 2010).
[3] See M. Varela, P. Lopes, and R. Mendes, 'Luxury brand consumption and counterfeiting: A case study of the Portuguese market' (2021) 17(3) Innovative Marketing 45-55; see also A. Maria Pinto Da Cunha Brandão and M. Gadekar 'The Counterfeit Market and the Luxury Goods' (2020) IntechOpen.

jewelry, diamond and jewelry characteristics, and every transaction made within the consortium, from the diamond supplier to the final consumer.

The **Everledger** Platform uses blockchain to certify the origin, ownership, and characteristic of different high-valued products such as artwork, diamonds, gemstones, and wine. Everledger teamed up with experts from diverse fields to guarantee and certify the provenance and genuineness of goods. The platform relies on other technologies alongside blockchain to provide provenance records, product condition, chain-of-custody, and characteristics. The platform registers every property change on the supply chain in a private blockchain. To the Wine and Spirit Industry, Everledger also adds to the blockchain information like anti-tamper bottle closure QRcode, NFC or RFID, bottle location, and temperature. It stores similar data to certify luxury goods' origin, characteristics, and ownership. Due to the wide range of goods certified by Everledger, they insert specific data about the asset into a block. This data can be a QRcode, NFC or RFID, bottle temperature, asset location, or ownership.

Tracr uses blockchain to store the diamond industry's digital assets, such as diamond origin, authenticity, and 3d scanning information, allowing for the transfer of diamonds and their digital assets with the trust of a valid transaction. Tracr assures diamonds' provenance, traceability, and authenticity from its extraction through verified sources to the retailers. Tracr allegedly also relies on artificial intelligence to determine the chain-of-custody the diamonds go through in the supply chain. Besides the 3d scanning info, Tracr also stores information as diamond 4C, i.e., Color, Clarity, Cut, and Carat Weight and its photo. In that way, Tracr adds to the block rough, split, or polished diamond's 4C, provenance, shape, or measures. It also uses blockchain to certify the source and characteristics of diamond jewelry. Each node on the Tracr blockchain is either a miner, a manufacturer, a wholesaler, or a retailer. Each node adds information into the blockchain about the diamond after adding value to it. They then transfer the diamond to the next node until the final transaction with the end consumer.

The services' main proposal is to record all sorts of transactions within its scope into the blockchain in a way it is possible to track, trace, and audit a product throughout its supply chain. Every gem transformation, i.e., cut, refinery, or jewelry design, is a transaction inserted into a block.

HOW DO THEY REINFORCE TRUST BETWEEN PRIVATE CITIZENS?

Companies like Tracr TrustChain seek to increase the trust in the diamond industry by first using gems mined from verified sources. Later, with blockchain, they track every stage of gem transformation until the hands of end customers. The possible tracking feature of blockchain allows all the chain-of-custody of the precious stones to have reliable information about all the transactions

throughout the value chain. Every nod then has the security of not working with conflict or unreliable resources.

Tracr and TrustChain aim to increase trust among the diamond and jewelry industry value chains, up to the end consumer. The services rely on different methods to guarantee that the asset and its transfer are authentic or from reliable sources. Trustchain, e.g., initially only uses diamonds from mines in Australia and Canada, certifying that their rough gems are from reliable sources. Tracr uses diamonds from verified sources, and 3d scans those diamonds to guarantee their authenticity throughout the chain. They allegedly also use artificial intelligence to add another layer of authenticity to their diamonds.

Everledger provides authenticity and traceability to the diamond industry and various industries, like wine, artwork, insurance, and luxury goods. Everledger services go way beyond blockchain, providing anti-tamper bottle closure, artwork digital fingerprints, or intelligent labels to their customers. All the information, however, is stored in the blockchain. To increase the trust in the assets traded through its platform, Everledger relies on experts from various fields to attest, standardize and certify that the goods are genuine and from a reliable source. Everledger's solution helps increase transparency between traders in the art industry, avoiding smuggling and counterfeit.

Everledger increases trust in the industry by providing anti-tamper bottle closure identified by QRcode, NFC, or RFID. By scanning the bottle label, the service offers secure sources, like landing pages, where the provenance history of that specific wine or spirit is available and validated by every node in the blockchain.

The main idea in all the services is to guarantee that every nod or consumer has a permanent record of all the previous transactions added to the chain. All the services try to increase the trust among the value chain and the end consumer. Only reliable and verified sources trade the goods from their origins to the final consumer. They allow that every node that buys, retails, transforms, or adds value to the product has a record of the previous transactions within the blockchain.

Even though the services allegedly use only reliable sources, diamonds still come from disputable origins. Nonetheless, from the technological perspective, none of the services addresses known flaws of blockchain. The lack of scalability might not be an issue for small consortiums. Still, scalability is needed in industries with large-scale production, like wine or garments, where billions of transactions happen every year. Due to the low throughput in blockchain, the services might not work accordingly in some industries. Furthermore, all the services add a large amount of information to the block. The ample storage of data can be costly and deepen the scalability problem. TrustChain, Tracr, and Everledger are significant initiatives to increase trust among private agents, but the issues mentioned must be addressed to keep the services viable and profitable.

DATA TOKENIZATION: TOWARDS TRUSTED DATA MARKETS

By: Carlos Muñoz Ferrandis

INTRODUCTION

According to the European Commission, from 2020 to 2025, the data market will reach 82.5 billion euros in the EU27. The latter is defined as the market where digital data is exchanged as products or services derived from raw data (European Commission, 'The European Data Market Monitoring Tool', 2020). Despite the foreseen EU data market growth and consolidation, there is currently a conundrum related to data ownership rights and their protection, pertaining to non-personal and personal data. Blockchain, and corollary to its tokenization, have risen as possible technical solutions to the current legal uncertainty around data ownership and its protection.

According to the OECD, asset tokenization is the process of representation of pre-existing real assets on a ledger by linking the economic value and rights derived from these assets into digital tokens created on the blockchain. Current initiatives around the tokenization of data target a considerable challenge: to enable what cannot be enabled by technical means by existing legal frameworks – i.e., technically-enabled data property.

Under these circumstances, how can data tokenization provide trust to the different economic actors of a data market?

DATA TOKENIZATION APPLIED IN PRACTICE

Kneron, Ocean Protocol, and Datum provide data tokenization services through their marketplaces. Data tokens enable customers to both securely monetize and access data.

The three companies leverage blockchain capabilities for secure data storage. For instance, a customer can store his/her personal or non-personal data in an immutable, encrypted, and flexible way by choosing to which extent third parties can access the encrypted information. When it comes to decentralization, Datum implements the concept of 'Storage Nodes.' These provide computing power and storage capacity in a decentralized way thanks to a blockchain database - e.g., BigChainDB - which provides global storage capabilities for the submitted data.

With regards to data tokenization, these companies can convert the stored data into a digital asset that the customer will manage within the platform. They enable the creation of ownership rights on data by technical means – i.e., data tokens. As an example, in Ocean's platform, data tokens can (and are not limited to) give either perpetual or time-bound access to a dataset. Moreover, the latter can

also provide either static or dynamic access to a dataset – i.e., access to a single file or a constant data stream.

Data tokenization is placed at the center of a multi-sided market model. Taking a simplified approach, on one side, data holders submit data to get it firstly encrypted and stored in the blockchain. Subsequently, data tokens giving access to the encrypted dataset will be issued for the data holder to trade with them and monetize his/her data. On the other side, the storage nodes are rewarded via tokens (or fee-based models) to store data submitted by data holders. Finally, another angle of the model integrates data consumers interested in getting access to specific types of datasets. The user will then receive an access or purchase request from the data consumer, either proposing some terms or abiding by existing ones implemented by a smart contract linked to the token. For instance, the user will receive DAT tokens as payment within the Datum platform, and the decryption key will be sent to the data consumer.

HOW DOES DATA TOKENIZATION IMPACT TRUST?

To extract the full benefits derived from data tokenization, it is crucial to secure trust among the economic actors willing to operate in the data marketplace. To this end, security, privacy, user's control, flexibility, and monetization incentives are the baseline upon which trust is built-in data tokenization platforms.

Security is provided by combining encryption mechanisms, decentralized data storage, and data immutability by implementing tamper-proof protocols. As a result, and by providing the user with the possibility for data anonymization, the user is given full control over his/her encrypted data and is free to use it as s/he pleases. Once the data is stored, encrypted, anonymized, and related data tokens are issued, both data protection and data ownership are enabled by technical means.

Technical control over the data provides the user with more asset flexibility on-chain than off-chain. The user will be able to prevent unauthorized use of his/her data by third parties, s/he will be able to trace who is accessing or requesting access to his/her dataset, and moreover, s/he will be free to choose how to transact with his/her data. Thus, s/he enjoys his/her freedom of contract, which has not been the case when subject to 'take-it-or-leave-it' agreements imposed by dominant data aggregators – i.e., user-centric approach.

From the side of data consumers looking to access specific datasets, the latter are incentivized by lower transaction costs resulting from the elimination of the intermediary – i.e., the data broker. With regards to companies collecting data from their users, data tokenization might provide them with the opportunity to design new economic incentives for the users of their platforms to consciously share their data. This new data collection model differs from the established one focused on platform access

in exchange of personal data. However, from an operational perspective, it remains to be assessed whether the benefits promised by data tokenization might overcome the switching costs of these companies' well established internal data collection processes. Although both models might not be mutually exclusive.

However, even though trusted data monetization might well be the epitome of a data-driven economy, the latter does not come without limits.

Data quality is a concern that might come up when assessing data tokenization. How can the blockchain platform provider and 3rd parties willing to access the data assess the quality of submitted data? Two leading foreground solutions might be explored:

(i) Legally binding platform governance mechanisms where the data holder will be ultimately responsible for the quality of the submitted data;

(ii) for non-personal data, the intervention of regulated, automated entities (e.g., oracles as data curators) in charge of attesting certain data features, such as accuracy.

Both suggestions might risk impacting users' flexibility and control over their data while imposing consumer safeguards. Hence, internal governance mechanisms might be needed to secure economic actors' trust. Trust cannot rely on a 'one-way-street' definition benefiting one side of the platform (data holders). Trust as a core standard in the blockchain realm should be secured for every economic actor in the platform, thus including due consumer safeguards to balance the economic interests in blockchain-enabled data platforms.

Other limitations which are not specific to data tokenization, and are present in blockchain settings in general, are: (i) security-related concerns when it comes to potential risks of data breaks, as Ocean Protocol clearly states in its terms of use (clause 3.6); (ii) the lacking potential of cross-chain interoperability, enabling data tokens from different data platforms to be exchanged – i.e., cross-platform data transactions.

CONCLUDING REMARKS

Data tokenization provides users with the necessary technical features to own and secure their data and thus be able to monetize it in several ways. Blockchain, therefore, provides data holders with a technical architecture protecting the content, identifying its owner, and enabling the latter to trace his data usage by 3rd parties.

Nonetheless, the above-discussed solutions might still be limited when providing efficient consumer safeguards regarding data quality, and broadly, to protect platform users from potential cybersecurity threats. Nonetheless, data tokenization has an immense potential to keep empowering the next generation of prosumers by enabling users to exploit the full benefits of trusted data ownership, thus creating new markets and new economic actors.

Upcoming legislative proposals such as the Data Governance Act, on the one hand, and new regulatory tools such as sandboxes – e.g., AI Act's data protection sandbox, might potentially have a beneficial role in future data trading markets, and more specifically, in data tokenization marketplaces. Nonetheless, the latter will have to be paired with solid platform governance practices from the providers of these services, in order to secure data protection, veracity and quality, being core incentives for data trading.

BLOCKCHAIN IN THE MINING AND METALS INDUSTRY: PERSPECTIVES AND LEGAL IMPLICATIONS

By: Gabriel Luchetti

INTRODUCTION

The sustainable development of the mineral industry is directly proportionate to the consolidation of the regulatory framework upon which transactions and investments are implemented. This is particularly true for the mining and metals industry segment, where investments are inherently risky and long-term, consequently making the legal system an important variable within risk allocation. Moreover, the overall industry demand is shifting towards more sustainable and responsible projects, which is further requiring companies and governments to improve monitoring and enforcement of environmental, social and governance standards throughout mineral extractive chains.

Because of the randomness of geological occurrences, mineral deposits will often be located in underdeveloped legal systems, as mining investors will face a dilemma regarding whether to decline the investment opportunity or internalize the legal risks and proceed with the new ventures.

According to a comprehensive study that examined different types of legal regimes governing mining projects in 18 countries around the world[4], in most jurisdictions, natural resources are owned by the state and a right to explore and exploit (i.e., a "**mineral right**") is typically granted to private companies. The study highlights two primary systems under which states grant mineral rights, being: **(i)** licensing system[5], which is typical in well-developed mining jurisdictions; and **(ii)** contract-based system[6], which is more commonly observed in emerging jurisdictions.[7]

Therefore, in order to attract investments to the mining sector, governments must act in accordance with established statutes (or contracts) and must not create regulatory distortions that harms security of tenure[8]. Private mining entrepreneurs, in turn, must not only trust the government, but also allocate

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4 David Kienzler and others, 'Natural Resource Contracts as a Tool for Managing the Mining Sector' (2015) 21 Columbia Center on Sustainable Investment Staff Publications.

5 A generally applicable legal framework that fully governs the rights and obligations of the state and private entities and with very little room for negotiation of key provisions relating to the mineral right. This system has the benefits of reducing opportunities for corruption and information asymmetries; whereas improving public oversight and security of tenure (see Footnote #5).

6 Individually negotiated agreements providing for the key provisions of the mineral right, which regularly ends up with poorly negotiated terms that confer limited benefits to the country and local communities. For this reason, the study also identified a trend away from negotiated agréments and towards legislated terms to govern the rights and obligations of the parties in a mining project.

7 Kienzler and others (n 1).

8 Meaning the legal certainty of the mineral title's management ownership. If one government could simply expropriate mining titles, there would be little ex ante incentives for mining entrepreneurs to invest in such jurisdiction. On the other hand, if the criteria for cancellation and maintenance of mineral titles are clear and predictable, entrepreneurs may feel safer to invest.

several risks inherent to the mining business itself, particularly those related to compliance with ESG Standards – as a breach along the extraction chain (child labor or environmental crimes, for instance) can undermine the whole operation. Thus, the success of the industry varies as a function of **trust** in both licensing and contract-based systems.[9]

More recently, blockchain technology has emerged as a valuable tool for enhancing the trust factor within the mining and metals industry. Depending on the design of applications built on top of the blockchain, the technology has the potential to improve governments' ability to manage and grant mineral rights by deploying smart contracts within blockchain-based platforms. Blockchain may also improve market players' ability to monitor compliance with regulatory and environmental standards throughout extraction chains, as well as to further escalate trade, thus improving the trust factor within the industry.

Due to the incipient development of blockchain technology, especially in the mining business, its legal boundaries are not yet established, as there is great uncertainty regarding the legal validity and the enforcement of legal rules in blockchain-based ecosystems. It follows that new legal rules will most likely have to be implemented as the technology consolidates, so as to ensure a legal framework that favors innovation without surrender of adequate regulatory principles.

In the following topics, this paper will address three use cases for blockchain technology in the mining and metals industry, which have been briefly introduced above, namely: **(i)** blockchain-based smart-contracts to grant and manage mineral rights; **(ii)** blockchain as a tracking platform to monitor and enforce compliance with ESG standards throughout extractive chains; and **(iii)** blockchain as a transactional platform for business-to-business mineral commodities trade. The following topics also address the legal implications arising from such scenarios.

BLOCKCHAIN-BASED SMART CONTRACTS TO GRANT AND MANAGE MINERAL RIGHTS

The first use case for blockchain technology in the mining and metals industry relates to the deployment of blockchain-based smart contracts to grant and manage mineral rights, particularly in emerging jurisdictions still managing mineral rights through negotiated agreements (see footnote 3).

According to a report prepared by the prepared by the Columbia Center on Sustainable Development per request of the German's Federal Ministry for Economic Cooperation and Development[10], "*[o]ne*

[9] Historically, both governments and private market players have carried out significant legislative efforts to design legal rules that enhance trust. Some examples include (i) the Kimberly Process for certifying diamonds; (ii) the OECD Due Diligence Guidance for Responsible Supply Chains of Minerals from Conflict-Affected and High-Risk Areas; (iii) Section 1,502 of the United States Dodd-Frank Act; and (iv) the European Union's conflict minerals regulation, which came into force on 1 January 2021.

[10] Kienzler and others (n 1).

of the biggest criticisms of negotiating agreements is that it gives significant discretion to a small number of people, often with little to no oversight, public consultation, or transparency. Given the financial potential and economic value of mining agreements, discretion without proper accountability can create serious risks of corruption." The report follows that the issues arising from the contract-based system "*have contributed to the global trend away from negotiated mining contracts towards legislated terms to govern the rights and obligations of the parties in a mining project*."

Also, according to the report, the transition from the contract-based to the licensing system transition can be slow and difficult due to the natural slowness of legislative processes, which is the reason why the report suggests the adoption of **model mining agreements**[11] providing for the boundaries of negotiable and non-negotiable terms to facilitate the transition between the two regimes.

In this regard, blockchain can be a convenient tool as the underlying platform upon which model mining agreements are implemented and enforced via smart contracts – contractual arrangements that facilitate replication whereas preventing content distortion of the base model.

In order to implement this structure, governments should deploy model mining agreements as smart contracts in blockchain platforms. Blockchain technology would then facilitate public oversight and consultation to the terms of the agreements, fostering transparency and increasing reputational costs that would discourage the provision of wrongful terms and conditions. This could potentially narrow the risk for corruption and undue influence on developing mining jurisdictions.

Furthermore, a framework in which the governance terms of mineral rights are transparent and easy to monitor should considerably improve security of tenure in underdeveloped jurisdictions, to the extent that it would reduce the subjective aspect on the negotiation (and, mainly, cancellation) of mining agreements. This would enhance investor protection, enabling a reliable and predictable legal framework for carrying out mining investments while underdeveloped jurisdictions shift towards license-based systems.

Yet, it is important to address an apparent contradiction between blockchain's essence of decentralization and its use by governments, which are centralized institutions by definition.

For that matter, complete decentralization of the mineral rights management system is a suboptimal structure, in the sense that governments would not admit the unrestricted exploration and exploitation of mineral deposits which, as previously mentioned, are property of the state. Therefore, one should consider a design tradeoff in order to implement the blockchain as the underlying technology to grant

[11] According to the report, "[t]he model is similar to a form contract in that it provides the general structure of the agreement and most terms, all of which are non-negotiable, while including carefully delimited areas that are open for negotiation, such as royalty rates within a certain range and community development and work commitments. It strengthens the government's position by narrowing the focus of negotiations".

and manage mineral rights – some degree of government control is imperative to the platforms' governance rules, as well as mitigation measures with respect to encryption and user identification.

Therefore, the success of this scope of blockchain use case heavily depends to the governance and design of the smart contracts to be deployed. Here lies the importance of the legal system to embrace the technology.

As a key legal implication, mining jurisdictions will need to design legal rules that provide legal certainty for model mining agreements deployed into blockchain platforms – that is, legal rules that assure contract sanctity. In addition, there is also an institutional challenge of understanding the dynamics of blockchain technology, which can be a challenge especially for underdeveloped jurisdictions. Therefore, it is also necessary that public servants are qualified to understand the blockchain framework and adopt an approach that embraces and incentives innovation, rather than handling technological innovations with mistrust and skepticism.

At the time of writing, no governments using blockchain to manage mining rights have been identified. If, on the one hand, this hinders concrete analysis about the legal implications of the technology in the mining sector, on the other, it introduces a research agenda that will be relevant to develop the appropriate legal boundaries to ensure that blockchain technology will be implemented efficiently, without prejudice to adequate regulatory standards to the mining and metals industry.

BLOCKCHAIN PLATFORMS TO MONITOR AND ENFORCE ESG STANDARDS

A second use case for blockchain technology in the mining industry relates to blockchain as a platform for tracking mineral supply chains, especially in high-risk areas (i.e., conflict minerals[12]).

Several jurisdictions have been enacting legislation to prevent the exploitation of conflict minerals to fund illicit activities. The legislative efforts also aim to improve compliance with ESG standards throughout mineral supply chains, e.g., preventing child labor, environmental crimes, and corruption.

In this context, blockchain technology can be implemented as a platform for mining companies to track their extraction processes, from the mining pits to end-user, to ensure that the operation is not funding illicit activities and/or is ESG compliant. The ideas in this scope of application include private blockchain consortia involving all market players (i.e., mining companies, investors, traders, and so on). In this case, each node (i.e., market player) would be responsible for inputting data into the

[12] According to the European Union, in politically unstable areas, the minerals trade can be used to finance armed groups, fuel forced labor and other human rights abuses, and support corruption and money laundering. These so-called 'conflict minerals' such as tin, tungsten, tantalum and gold, also referred to as 3TG, can be used in everyday products such as mobile phones and cars or in jewelry. It is difficult for consumers to know if a product they have bought is funding violence, human rights abuses or other crimes overseas.

blockchain, which would then be validated by specific nodes (in case of a private blockchain) or by the remaining nodes (in case of a public blockchain). In both cases, however, it is important to note that blockchain itself would not grant the validity of the data. The technology would have to be combined with traditional due diligence methods (such as the OECD Guidance) to ensure that the information mined into the platform is truthful.

The Responsible Sourcing Blockchain Network is a great example of a platform that tracks conflict minerals' supply chains, built on IBM's blockchain. The platform aims at providing an immutable audit trail that documents proof of initial ethical production of raw material and its maintenance from mine to end manufacturer. It also aims at providing decentralized control, so no single entity can corrupt the process, thus promoting trust, while enabling platform users to share proof of fact while protecting confidential and competitive-sensitive data. Lowering costs through digitalization is also a goal.

Another great initiative that illustrates this use case is 'Minespider', a company that deploys blockchain protocols for responsible mineral sourcing. The application offers transparency and traceability at every stage of the supply chain, addressing the conflict minerals issue and reducing monitoring and due diligence costs while improving security.

Another use case is 'Tracr', which uses blockchain to store the diamond industry's digital assets, such as origin and authenticity and 3D scanning data, allowing for the transfer of digital resources with the trust of a valid transaction.

As mentioned, blockchain's aspects of immutability, transparency, and security may be harnessed by mining entrepreneurs to reduce due diligence costs and improve compliance with binding legislations, such as the recently enacted European Union Conflict Minerals' Regulation. Nonetheless, in this scope of application, the technology is not sufficient by itself to ensure the trustfulness of the data inputted into the platforms. Traditional due diligence methods would complement the company's operations alongside blockchain to create a valid and reliable tracking system.

As key legal implications, one should anticipate potential antitrust issues arising from the exchange of competitively sensitive information between members of the blockchain, as well as the facilitation of collusive/exclusionary practices from dominant market players operating in the blockchain.

Environmental authorities should also participate in the development of blockchain technology by mining entrepreneurs, as it may facilitate monitoring of compliance with environmental requirements laid out by licensing and inspection agencies.

TRADING MINERALS AND COMMODITIES IN BLOCKCHAIN PLATFORMS

The third use case of blockchain application in the mining industry relates to a transactional platform for business-to-business commodity trade.

Trading on top of blockchain platforms may turn out to be convenient as the technology may facilitate **(i)** selling mineral products to local and export markets; **(ii)** obtaining payment in a freely convertible currency and to convert that currency into the currency which was initially invested (at an adequate conversion rate); and **(iii)** the ability to service loans and to repatriate profits and capital − three cornerstones of an investment-friendly regulatory framework as proposed by Pritchard.

One use case is Atomyze − a tokenization platform for commodities trading. The marketplace aims at connecting investors, financial service professionals, and commercial users of metals and other commodities. The goal is to modernize commodities trading and investment, improve supply chain contracts' management and create real access and liquidity for market participants. Blockchain technology builds trust between the extractive chain and manages several smart contracts, thus increasing the number of transactions in the industry.

As large corporations are further reporting sales being carried out on the blockchain,[13] key legal implications relate to implementing a legal framework that protects transactions held in blockchain platforms, as well as monitoring and inhibiting anticompetitive practices by dominant market players operating in blockchain platforms.

[13] Brazil's Vale conducts first iron ore sale via blockchain. Available at: Reuters Staff, 'Brazil's Vale conducts first iron ore sale via blockchain' (Reuters, 3 September 2020) https://www.reuters.com/article/vale-sa-blockchain-idUSS0N2FM032 accessed 9 June 2022.

CENTRAL BANK DIGITAL CURRENCIES: REINFORCING PUBLIC TRUST

By: Hatim Hussain

INTRODUCTION

The advent of distributed ledger technologies has ushered an ongoing financial system reform that will potentially revamp the monetary and payment systems worldwide. At the forefront of this change has been *central bank digital currencies.* Two years after China laid down the regulatory framework for its central bank digital currency (CBDC), it launched a pilot of digital yuan a few months back.[14] With many equity and debt securities already existing only in digital form, CBDC projects have been implemented in Cambodia,[15] Bahamas,[16] and the Eastern Caribbean Central Bank,[17] with larger central banks such as the Swedish Riksbank,[18] European Central Bank,[19] German's Bundesbank,[20] and the Bank of England[21] is also exploring its use case.

A Central Bank Digital Currency (CBDC) is an electronic form of central bank money that could be used (i) by institutions for improved settlement and payments in financial markets (wholesale CBDC) or (ii) by households and businesses to make payments and store value, creating new opportunities for payments and the Central Bank to maintain monetary and financial stability (direct/hybrid CBDCs). Simply put, CBDC's give individuals access to central bank account and can operate either as a traditional bank account, or in a tokenised form on a blockchain.

Historically, payment systems for centuries have followed a two-tiered system, where the public has accounts with commercial banks used to make payments and withdraw cash, and commercial banks have accounts with the central bank. Technological innovations – such as credit/debit cards,

[14] Frank Tang, 'China moves to legalise digital yuan and ban competitors with new draft law' (*South China Morning Post*, 27 October 2020) https://www.scmp.com/economy/china-economy/article/3107119/china-moves-legalise-digital-yuan-and-ban-competitors-new accessed 9 June 2020; Reuters, 'China central bank launches digital yuan wallet apps for Android, iOS' (Reuters, 6 January 2022) https://www.reuters.com/markets/currencies/china-cbank-launches-digital-yuan-wallet-apps-android-ios-2022-01-04/ accessed 9 June 2022;

[15] Alice Shen, 'Cambodia officially launches quasi-CBDC' (*Central Banking Institute,* 2 November 2020) https://www.centralbanking.com/fintech/cbdc/7705396/cambodia-officially-launches-quasi-cbdc accessed 9 June 2022.

[16] Vipin Bharathan, 'Central Bank Digital Currency: The First Nationwide CBDC In The World Has Been Launched By The Bahamas' (*Forbes*, 21 October 2020) https://www.forbes.com/sites/vipinbharathan/2020/10/21/central-bank-digital-currency-the-first-nationwide-cbdc-in-the-world-has-been-launched-by-the-bahamas/?sh=e50db8e506eb accessed 9 June 2022.

[17] ECCB, 'ECCB Digital EC Currency Pilot' (*ECCB*, 12 March 2019) https://www.eccb-centralbank.org/p/about-the-project#:~:text=The%2520Eastern%2520Caribbean%2520Central%2520Bank,of%2520the%2520EC%2520dollar%2520%252D%2520DCash accessed 9 June 2022

[18] Swedish Riksbank, 'The Riksbank's e-krona project: Report 1' (2017) Swedish Riksbank.

[19] Martin Arnold, 'ECB confident it can overcome challenges to create a digital euro' (*Financial Times*, 22 October 2020) https://www.ft.com/content/b6f0c233-0b35-45d1-896f-1c6599558d9b accessed 9 June 2022.

[20] Jens Weidmann, 'On the future of money and payments' (*Deutsche Bundesbank*, 11 September 2020) https://www.bundesbank.de/en/press/speeches/on-the-future-of-money-and-payments-843720 accessed 9 June 2022.

[21] Bank of England, 'Central Bank Digital Currency: Opportunities, challenges and design' (2020) Bank of England Discussion Paper.

electronic transfers, small technologies, etc. – are ultimately cleared through this two-tiered payment system. However, unlike past innovations, token-based payment systems such as those based on distributed ledger technologies (DLT) pose a new and potentially radical challenge to existing financial structures. While it resolves high intermediation costs and increases efficiency of payments, inherent issues such as financial stability, data protection, privacy, and operational risks also arise.

It is also essential to understand three central bank digital currencies models to determine various policy considerations attached to them. *First,* indirect CBDCs allow the customer to hold a claim on an intermediary bank, while the central bank controls wholesale accounts such as those of the intermediary. In this model, digital tokens are issued by the commercial bank which also handles KYC requirements, including those pertaining to suspicious transaction reporting, identification and customer due diligence. Here, the data of the consumer is stored by the financial intermediary who is responsible for the safety and privacy of customer information (in a same way as cryptocurrency exchanges currently store data).

Whereas, in a direct CBDC, everyone holds an account with the central bank, which issues the digital currency and manages the permissioned system to clear transactions. While the central bank can enlist intermediaries to do initial KYC, the central bank owns customer data on transactions. *Finally,* in a hybrid CBDC, the private intermediary plays a larger role in transactions. In this model, the central bank issues a digital token in place of cash, and depositors can withdraw digital tokens from their accounts with the intermediary.

Primarily, central banks primarily have two motivations for CBDCs: (a) decline of cash as a means of payment and (b) financial stability. Other factors leading to increased interest in CBDCs include payments efficiency (both domestically and cross-border), financial inclusion, and safety.

BENEFITS OF CBDCS

Central bank digital currencies offer three key advantages in reinforcing public trust: (i) anonymity, (ii) account control, and (iii) opportunity for innovation. *First,* a crucial aspect of CBDCs operation is its controllable anonymity – transactions through a DLT based digital currency are not anonymous but use a pseudonym mechanism that discloses transaction data in full scale to PBoC as a sole third party. This allows the central bank to keep track of personal data of the consumers while maintaining anonymity at the user level.

Second, CBDCs employs a command and control-style architecture in which the regulators can unilaterally freeze users' funds, stop the flow of money, or control accounts directly and instantaneously. This allows greater control over illicit flows of money and reinforces regulatory control through money laundering and terrorist financing mechanisms.

Third, CBDCs also lay the groundwork for digital wallets that users can link to conventional bank accounts. The characterization of CBDCs as property even allows the general public to apply for digital wallets without opening a bank account (but potentially, with strict balance limits). As a result, issuing central bank digital currencies can extend financial services in poor, remote, and underbanked areas and improve financial inclusion. For instance, in China, the e-CNY support for smart contracts has led to new financial instruments, such as uncollateralized flash loans (automatically approved loans) and the rise of decentralized financing (DeFi) mechanisms.

Advantages	**Disadvantages**
Increasing efficiency & security of payments	Transaction monitoring is not typically the role of central banks
• Making central bank money available to all	1. Increased political influence over the economy
Strengthening the resilience of retail payments	Reduced role for commercial banks and increased authority of central banks (centralisation of authority)
• Disintermediating commercial banks and reducing their level of control	Small numbers of proven use cases to date
• Facilitating new monetary policy measures, such as use of negative interest rates	Complex to implement technically
2. Detecting and discouraging illicit transactions	

In the current banking system, three types of monies exist: a *central bank paper currency* issued in the form of small-denominated paper bills by the central bank, *private bank digital currency* provided by private banks in the form of demand deposit liabilities and *privately issued digital currencies* issued by private entities. In comparison with PIDCs, a CBDC has a clear benefit in combining some of the benefits of digital currency to complement existing fiat-money whilst also having the support of existing financial system and the ability to shape regulation. A CBDC offers in digital form the unique advantages of central bank money: settlement finality, liquidity, and integrity.

In this respect, two further distinctions can be made: wholesale CBDCs and retail CBDCs. While wholesale CBDCs build on the current two-tier structure (which places the central bank at the

foundation of the payment system while assigning customer-facing activities to PSPs) and are intended for the settlement of interbank transfers and related wholesale transactions, retail CBDCs are a more far-reaching innovation that modifies the conventional two-tier monetary system by making CBDC available to the general public.

In effect, wholesale CBDCs can make central bank money programmable, to support automation and mitigate risks. Besides, wholesale CBDCs are implemented on new technology stacks which enables them to be designed with international standards in mind to support interoperability.

Let us now consider how CBDCs provide utility in operation. As the Chinese experiment with e-CNY has revealed, It China's CBDC does not change the existing money in circulation or create competition with commercial banks. Rather, it leverages the two-tiered system (discussed above) to keep existing monetary policy transmission as it is, thereby preventing any negative impact on how the real economy operates. It also prevents disintermediation by settling into the existing financial system and by retaining the role of intermediaries. Finally, the model is extremely cost effective, improves money circulation, and enhances user-friendliness of payment services. On the legal front, the draft regulatory framework grants e-CNY the status of a legal tender and categorises it as a property bound by Chinese property law.[22] Digital yuan is also subject to existing anti-money laundering and counter-terrorist financing regulations. It places high fiscal penalties for those attempting to make or sell digital tokens that replaces RMB in circulation.[23]

Three salient features of e-CNY, based on PBoC's 80+ patent filings include: (i) anonymity, (ii) account control and (iii) opportunity for innovation.[24] *First,* a crucial aspect of e-CNY's operation is its controllable anonymity − transactions through China's CBDC are not anonymous, but use a pseudonym mechanism that discloses transaction data in full scale to PBoC as a sole third party. This allows the central bank to keep track of personal data of the consumers while maintaining anonymity at user level.

Second, the Chinese CBDC employs a command and control-style architecture in which the regulators can unilaterally freeze users' funds, stop the flow of money or control accounts directly and instantaneously. *Third,* e-CNY also lay the groundwork for digital wallets that a user can link to conventional bank accounts. The characterisation of e-CNY as property even allows the general public to apply for digital wallets without opening a bank account (but with strict balance limits). As

[22] The People's Bank of China, 'Notice of the People's Bank of China on Public Comments on the Law of the People's Republic of China on the People's Bank of China (Revised Draft for Comments)', (*The People's Bank of China*, 23 October 2020) http://www.pbc.gov.cn/goutongjiaoliu/113456/113469/4115077/index.html accessed 9 June 2022.
[23] YICAI, 'The central bank solicits public opinions on the Law of the People's Republic of China on the People's Bank of China' (*YICAI*, 23 October 2020) https://www.yicai.com/news/100810505.html accessed 9 June 2022.
[24] Perianne Boring and Marc Kaufman, 'Blockchain: The Breakthrough Technology of the Decade and How China Is Leading the Way – An Industry White Paper' (2020) Chamber of Digital Commerce.

a result, issuance of e-CNY can extend financial services in poor, remote and underbanked areas and improve financial inclusion. An e-CNY support for smart contracts may led to emergence of new financial instruments, such as flash loans (automatically approved loans).

Among other considerations, two other benefits of the CBDCs stand out from a public good perspective. First, it enhances payment systems rather than replacing them. Second, it promotes significant financial inclusion.

MAJOR CHALLENGES:

Technological innovation is a double-edged sword. While the Chinese CBDC framework presents numerous opportunities, there are also profound associated risks such as consumer protection, adequacy of existing legal frameworks, monetary policy implications, potential for illicit activities and financial instability. This has been evident since the invention of bitcoin in 2009, as well as with the emergence of stablecoins such as Facebook's Libra – raising questions about the readiness of current financial systems to adopt these technologies.[25] Evidently, half-baked innovations could be destructive, CBDCs should therefore map coverage of all critical standards, including investor protection rules, principles for financial market infrastructure and legality. The Chinese CBDC falls severely short of this threshold. There are many concerns, but I delve into two key aspects in detail: (A) privacy and (B) identity verification.

Privacy: Permission-less cryptocurrencies such as Bitcoin were designed specifically to *not* be controlled by the state. On that basis, use of CBDC requires additional regulatory and compliance support. With controllable anonymity features in a CBDC, while built-in compliance rules may help in detecting criminal activities such as terrorist financing, tax evasion or money laundering, it also lays the foundations for large-scale abuse and human rights violations, enabling the government (and potentially private operators like banks) to track individuals with an unprecedented level of granularity. Specifically, two types of privacy considerations arise:

1. Identity Privacy: the practice of using *pseudonyms* (ex: S. Nakamoto ='1234', with 1234 being the pseudonym) rather than persistent identifiers to provide anonymity in a CBDC is a fragile design. In case of Bitcoin, the pseudonym (also called address) is the hash of the public key, which does not reveal any information about the user to whom it is tied. However, pseudonyms can leak information about actual participants in the transaction in two ways: (i) hackers can cluster pseudonyms together to identify them according to common transaction patterns and tagging addresses with real world owners (websites such as WalletExplorer

[25] Financial Times, 'Federal Reserve sets out regulatory challenges facing Facebook's Libra' (*Financial Times*, 16 October 2019) https://www.ft.com/content/ef650f9a-f052-11e9-ad1e-4367d8281195 accessed 9 June 2022.

already offer these solutions,[26] for bitcoin network) and (ii) by exploiting the underlying communication network infrastructure i.e. the Internet (for instance, when a user initiates a transaction involving CBDC, they must send a message over the internet to the central bank. An attacker with access to internet infrastructure may identify the point of origination i.e. the IP address and link it to a person's hardware).

2. Transaction privacy: in a CBDC, input data beyond identity privacy (such as transaction amounts) are stored on-chain and entrusted to validator (ex. central bank) who can decrypt confidential data. Placing complete trust in a central bank to protect privacy, however, involves a trade-off – a single breach of the permissioned ledger can expose the identities and financial histories of millions of users at once (an example of this is the Equifax data breach,[27] which affected nearly half of the US adult population. Centralisation of data in case of the CBDC thus creates complex privacy considerations.

A typical consequence of privacy is also incidence of fraud. An identity thief could be a hacker in an 'X' country not subject to compulsion under the laws of CBDC's jurisdiction. In case of fraud, CBDC's administrators must be capable of modifying the transaction (or reverse/alter it) in accordance with legal system of the country to ensure justice to the aggrieved. There is also a need to verify when the transaction should be modified, so an infrastructure which interfaces with agents capable of giving trusted instructions for modification is essential. In its current form, the irreversible character of cryptocurrency transactions makes the recourse path impossible. Besides, a dispute resolution mechanism to settle litigations requires evidence (such as IP address of the thief, history of attempted transactions etc.). Given the pseudo-anonymous nature of CBDCs, the authorities may be unable to capture these details. This conflict with judicial mechanisms is a major drawback of a CBDC.

It is also not clear that a CBDC based on public blockchain can ever ensure compliance with GDPR disclosure limitation and rectification rules. Achieving a solution that combines privacy with performance, trust and easy adoption is difficult. For a CBDC, the challenge is not whether technological building blocks for such designs exist (they do) but to build them into operational, secure and privacy-preserving systems.

Digital Identity Verification: Decentralised cryptocurrencies are inherently designed to avoid identification, through use of cryptographic public and private keys. This raises a key question for CBDCs as identity checking or 'Know Your Customer' (KYC) is necessary to facilitate payment transactions. A CBDC adopts the same approach as Financial Intelligence Units do in case of

[26] WalletExplorer, 'Bitcoin block explorer with address grouping and wallet labeling' (WalletExplorer, 2022) https://www.walletexplorer.com accessed 9 June 2022.
[27] Hal Berghel, 'Equifax and the Latest Round of Identity Theft Roulette' (2017) Computer 72.

cryptocurrency exchanges for AML purposes – delegate identity checking to commercial banks. However, this puts payment systems at great risk because they are exposed to security attacks. Just as cryptocurrency exchanges have been hacked consistently in the past,[28] it is possible for commercial banks to be compromised, severely affecting financial stability. Any potential attack on commercial banks does not only affect financial system, but also risks identity theft of consumers.

Another question concerning identity verification for a CBDC is *how* a customer's identity is verified, especially in cases where a plethora of proxies are used by the users of CBDC. Few approaches to tackle this, and their trade-offs are:

- In-person checks: use of a government issued ID or passport to complete verification at branch office,
- Online checks: video identification services (this approach has the same issues that absence of identity layer on internet raises),
- Use of weak digital identity proxies: such as email, phone no., IP address or CAPTCHA (all of these can be faked, however),
- Biometrics: use of biometrics for CBDC verification raises profound security and privacy issues (ex: India's Aadhaar[29]) especially when used for identity features (in this case, a central bank not only records biometrics, but also has to compare with biometrics of all others, which requires data to be centralised and stored with the central bank, and thus, providing a single point of compromise),
- Self-sovereign identities: this approach involves users collecting digital attestations of identity from an institution so as to reproduce the same when demanded. Self-sovereign identities may form a viable identity basis for CBDCs but are currently immature given their low acceptance rates.

Beyond privacy and identity issues, several other concerns abound. Central banks are usually lenders of the last resort, use of CBDC thus greatly enlarges the commercial footprint of PBoC, extending (to some extent) the role of central bank in financial intermediation. This way, a CBDC also goes against the objectives of digital currency's decentralised nature (increasing both political and economic power of government).

[28] IDEX, 'A Complete List of Cryptocurrency Exchange Hacks [Updated]' (IDEX, 17 July 2020) https://blog.idex.io/all-posts/a-complete-list-of-cryptocurrency-exchange-hacks-updated accessed 9 June 2022.
[29] Subhashis Banerjee and Subodh Sharma, 'Privacy Concerns with Aadhaar' (2019) 62(11) Communications of the ACM 80.

The other major challenge with a CBDC is the usability of wallets, particularly *key management.* Since the inception of Bitcoin, more than 4 million (~25% of total) bitcoins have disappeared forever.[30] Daunting key management has led to emergence of custodial services such as Coinbase,[31] paradoxically centralising systems originally meant for decentralisation. The need for financial intermediaries such as custodial services also go contrary to the goal of financial inclusion of the CBDC. It begs the question: if CBDC still requires intermediaries, how is it different from traditional fiat currency operating in the market currently?

POLICY CONSIDERATIONS

The risk of CBDCs is complex, requiring several technological, legal, and financial considerations. A key decision thus remains to analyse if CBDC create more problems than it solves. Even with the desire to encourage new technologies, allowing large scale payments to be made through vehicles which are (a) excessively costly to audit (due to associated technical and operational costs) and (b) which requires a new regulatory framework, is quite risky.

Policy responses can be twofold. *First,* it is crucial to implement regulations to mitigate adverse effects of digital yuan, such as state-controlled data monopolisation. This should be done to resolve concerns around consumer consent, data ownership and data collection/dissemination procedures. *Second,* public sector should play an active role in providing core foundational infrastructure and encourage innovation to promote level playing field. Essentially, the role of central banks should not transform to being a monopolistic state bank, but retail payments/loans should be encouraged from private sector by setting up sandboxes/innovation offices. A good example is the evolution of internet, made possible by common adoption standards such as TCP/IP. In this regard, developing countries which lack legacy infrastructure are best placed to leapfrog existing payment architectures and associated vested interests (for instance, India's efforts to build digital infrastructure called 'IndiaStack'[32]).

Specifically, given that pseudonymous accounts only offer weak privacy (as explained above), retail CBDCs such as the digital yuan which maintain account balances on the ledger may reveal more information about individual transactions than existing systems do. Design considerations should therefore offer technical and legal confidentiality protections. Finally, since commercial banks are responsible for onboarding CBDC users in China, maintaining interoperability between financial intermediaries is essential. A public-private approach where WeChat and Alipay (two widely

[30] Jeff John Roberts and Nicolas Rapp, 'Exclusive: Nearly 4 Million Bitcoins Lost Forever, New Study Says' (*Fortune*, 25 November 2017) https://fortune.com/2017/11/25/lost-bitcoins/#:~:text=Exclusive%253A%2520Nearly%25204%2520Million%2520Bitcoins%2520Lost%2520Forever%252C%2520New%2520Study%2520Says&text=According%2520to%2520new%2520research%2520from,based%2520on%2520a%2520low%2520one accessed 9 June 2022.
[31] Coinbase, 'Jump start your crypto portfolio' (*Coinbase*, 2022) https://www.coinbase.com accessed 9 June 2022.
[32] IndiaStack, 'India Stack is' (*IndiaStack*, 2022) https://www.indiastack.org accessed 9 June 2022.

renowned payment systems in China) offer payment services backed by digital yuan may create problems as both are 'closed' systems not directly fungible with each other.[33]

CONCLUSIONS AND RECOMMENDATIONS

As experience with CBDC so far have proven, a libertarian view that private sector currencies could replace government currency is utterly naïve. While private sector innovates, in due time the government regulates and appropriates. Nevertheless, digital currencies are not hypothetical. Token based payment systems do exist and have enormous benefits, but also possess a radical potential for disruption to existing payment systems. Decisions taken by policymakers now could thus shape the global financial system for decades to come.

Given the above, central banks should play an active leadership role to develop operational /technical standards as well as public infrastructure for payments. Multiple payment alternatives should also be introduced to allow competition. At the same time, existing technologies should be implemented more widely. Regulators such as PBoC should factor concentration of risk, excessive government control and disintermediation before implementing any type of CBDC and provide a safety net to maintain integrity of financial systems. It will also be important to find a balance between protection of individual data and privacy versus government's imperative to collect data to enforce regulations and taxes. Perhaps most importantly, cross-border usage of CBDCs necessitates an international framework to govern data usage and exchange.

[33] Mohammad Musharraf, 'Digital yuan will work with WeChat and Alipay, says bank exec' (CoinTelegraph: The Future of Money, 26 October 2020) https://cointelegraph.com/news/digital-yuan-will-work-with-wechat-and-alipay-says-bank-exec accessed 9 June 2022.

BLOCKCHAIN PAYS ARTISTS MORE FAIRLY. WHO DOESN'T WANT THAT?

By: Johan Loo[34]

INTRODUCTION

Musicians in the current system are the major content creators and innovators, but are also the biggest losers, when it comes to being recognized for their work. Large market players such as the record label and production houses intervene between the artist and the end consumer to make the most out of the deal. In the name of production, platform, marketing, and advertisement costs, the record labels pull towards themselves a major part of the profits received, even though it was the artist that was responsible for the end product.[35] This article will discuss what impact blockchain can have on the music industry.

BLOCKCHAIN APPLICATIONS IN THE MUSIC INDUSTRY

1. Resonate: Stream-to-own

Resonate is a music streaming platform using blockchain technology to publish music, collect analytics and reimburse artists. Artists can publish their work and manage their royalties independently. Resonate is a stream-to-own model. Users pre-purchase credit and are allowed unlimited, ad-free streaming of the entire catalog. Each subsequent play of a song debits the user's account incrementally per play until the 9th play when the song becomes available to download. According to Resonate, artists can earn the same amount from 9 plays on Resonate as from 150 plays on Spotify.

For this reason, Resonate describes itself as "the ethical music streaming co-op." Listeners are charged less than the competition and only for what they actually listen to. Resonate doesn't transact in cryptocurrency. Artists are paid in fiat currency via Stripe.[36] The reason is that fiat-only transactions probably mean a greater reach. Cryptocurrency purists might avoid this platform due to the fact that fiat currency and Stripe's payment gateway are involved.[37]

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[34] Author works as a tax advisor at Taxand Netherlands B.V. The author has no conflicts of interest to declare.

[35] Reverse Acid Research, 'Ujo as a Platform for Music Revamping – An Innovation Review' (*Medium*, 13 February 2019) https://medium.com/@reverseacid/ujo-as-a-platform-for-music-revamping-an-innovation-review-53185bf3d19f; See also S. Carretta, 'Blockchain challenges to copyright. Revamping the online music industry' (2019) Stockholm University 9-11.

[36] Stripe offers payment processing software and application programming interfaces for e-commerce websites and mobile applications. See stripe.com.

[37] Resonate, 'Blockchain music streaming platform' (*Johnbartmann*, 17 October 2018) and Resonate, 'Play fair. The community-owned music network' (Resonate, 2022) https://resonate.is accessed 9 June 2022.

2. UJO: Put the artist on top of the chain

UJO is a platform that uses the Ethereum blockchain as the substrate for innovation by empowering artists. UJO digitizes its music rights and metadata and shares this information in an open environment. This will enable new applications, products, and services to license their catalogs. Artists are then paid directly with minimal friction. UJO can rewire the music industry, better serving the needs of artists and fans while also enabling entrepreneurs and engineers, through the blockchain, to build products and services. UJO assures immediate royalty payments and ensures complete transparency. This is possible due to smart contracts that simplify all the backend technical processes, allowing creators to use it without any technical expertise. The UJO platform, with all its decentralized capabilities and end-to-end market connections, puts the artist on the top of the chain rather than the bottom, which could become an incubator for the production of improved content for the public. With all the responsibilities transferred from the middlemen to the creator, customizing the platform becomes possible where artists can tailor it as per their needs.[38]

3. OPUS: Fair share

OPUS is a decentralized music-sharing platform that leverages blockchain technology to guarantee fair compensation for artists, transparent and reliable payment rules, and extensive music content stored by the community. OPUS introduces its digital token (OPT) for payments and revenue management for artists and fans. These tokens give artists new possibilities in the music industry: artists can decide how to split revenues between band members and for each song separately, share their own revenue with the fans, which can support their favorite artists or purchase extra content. Leveraging the speed and redundancy of a decentralized and immutable file storage technology - IPFS (Interplanetary File System), OPUS can scale and deliver thousands of tracks per second in a very decentralized manner. This is achieved by encrypting music tracks on the go and storing the encrypted music files permanently on the IPFS swarm. The smart contract on the blockchain collects hashes of the statistics of the played songs which are the basis for revenue calculations for each artist. This data is publicly available, and its immutability can be checked by comparing hashes.[39]

[38] Reverse Acid Research (n 2).

[39] Bokang Jia, Chenhao Xu, and Mateusz Mach, 'Decentralized music distribution using InterPlanetary File Systems (IPFS) on the blockchain: White Paper' (2018) OPUS Stream Limited and Opus, 'Blockchain music streaming platform' (*Johnbartmann*, 26 February 2019) https://johnbartmann.com/blockchain/opus-blockchain-music-streaming-platform/ accessed 9 June 2022.

Conceivably, more frequent use of a composition could be charged differently from a sparing user, in contrast with existing models which do not allow for such dynamic pricing. This leads to more flexible pricing and revenue optimization for the authors. Similarly, artists could be paid much quicker than with prevalent systems which have inordinate delays in artists' payments. While blockchain is unlikely to change the ludicrous fact that artists are paid last since all parties would share the same ledger, the time it takes for artists to get paid would likely decline drastically. Blockchain could also foster a generation of new music business models wherein consumers could also become promoters. Conceivably, blockchain could offer monetary rewards (in the form of micropayments) to avid listeners who also zealously promote their favorite music. Such models will likely be a net positive for the music industry since the revenue generated by repurposing fans as promoters will likely outweigh the incentives provided to such fans for their service. Metadata embedded into every piece of recorded music could include terms of use and contact details for the copyright holders, making it far easier to locate the owners of a piece of recorded music and obtain a license to use it.[40]

CHALLENGES TO ADOPT BLOCKCHAIN IN THE MUSIC INDUSTRY

There are also challenges with blockchain adoption. Think of significant difficulties regarding the lack of guidelines, legislation, or case law for using the blockchain in the music industry. The music industry also has to comply with EU directives like the GDPR. When data is recorded on the blockchain ledger, the GDPR rules become more complex since the technology is designed to prohibit retroactive changes of the blockchain ledger. This is directly at odds with the GDPR allowing individuals the right to ask for their data to be deleted.[41]

Like other technological disruptions, disintermediation occurs. When the blockchain is widely adopted, the role of labels and others could be diminished. With the rise of smart contracts and micropayment, disintermediation could be seen as a threat by the established players in the music industry.

Also, mass adoption is necessary to make blockchain successful in the music industry. Network effects make a product or currency more useful as more people join the network, like blockchain.[42] Users must overcome some barriers to use the blockchain platform. Some blockchain

[40] I. de Leon and R. Gupta, 'The impact of Digital Innovation and Blockchain on the Music Industry' (2017) Inter-American Development Bank 22.
[41] PwC, 'First streaming, Now blockchain: An analysis of risks and opportunities of blockchain technology in the music industry' (2019) PwC.
[42] Paid Network, 'The Network Effect and Why it is Vital to Blockchain Ecosystems' (*Medium*, 1 July 2021) https://paidnetwork.medium.com/the-network-effect-and-why-it-is-vital-to-blockchain-ecosystems-82a3314eb525 accessed 9 June 2022.

use cases require cryptocurrency or a crypto wallet to register. If you want to listen to music, a user must download and install a crypto wallet app as a gateway to blockchain apps. After a crypto wallet is installed, you have to buy cryptocurrency like Ethereum to proceed with the payment through the platform. For experienced users who already have cryptocurrency, these steps shouldn't lead to many problems. But for beginners, this could lead to serious barriers. These barriers could easily be overcome if the platform makes sure that the users are guided through all the required steps.[43]

LEGAL IMPLICATIONS

Companies that wish to use or exploit musical works that they do not control, must obtain a specific license for the specific use of both compositions, and sounds recordings from all rights holders. It is often difficult to determine what license is needed (e.g., public performance, synchronization, master use, etc.) and where to obtain the license (e.g., performance rights organization, label, publisher, artist, etc.). The lack of a centralized database that employs one standard to identify ownership of musical works further complicates this issue.[44]

CONCLUSION

The future of music is still not entirely clear, but blockchain has the potential to impact the music industry drastically. Artists would be able to get their fair share of compensation through blockchain without middlemen taking a share of the compensation. Further development of blockchain should determine whether blockchain becomes the norm in the music industry, considering the challenges and legal implications.

[43] 'Are blockchain-powered music streaming platforms the next Spotify?' (*Ledger*, 23 July 2020) https://www.ledger.com/are-blockchain-powered-music-streaming-platforms-the-next-spotify accessed 9 June 2022.
[44] James G. Gatto and Alexandra L. Bear, 'Overview of Legal Issues with Blockchain for the Music Industry' (2018) Sheppard Mullin.

MEDICAL RECORDS ARE SHARED MORE EFFICIENTLY THROUGH BLOCKCHAIN TECHNOLOGY

By: Johan Loo[45]

INTRODUCTION

Acquiring and storing patient information imposes high costs on biomedical research centers and private businesses, slowing down the pace of new discoveries, all in a sector where identity theft and privacy breaches are widespread. This is not surprising as the current IT landscape remains a set of local data repositories, mostly managed by hospitals. They often lack the skills, experience, and capital to establish appropriate defenses.[46] This article will discuss what impact blockchain can have on the healthcare industry.

BLOCKCHAIN APPLICATIONS IN THE HEALTHCARE INDUSTRY

1. UNLock: proof of corona testing, immunity, and vaccination

The consortium 'uNLock' is developing an open source, non-profit application that allows for proof of corona-testing, vaccination, and immunity with 100% certainty. This application protects the privacy of its users.[47] A person can securely store and share digital documents from various public institutions with the unlock app. Think of demonstrating your state of health at the airport or when entering nursing homes as visitors or care staff. This app was created in response to COVID-19. This is not a tracking app to track COVID-19 patients and people who came in contact with a COVID-19 patient. This app is meant for entering certain public places. Public places are places where many vulnerable people are working or living. Using this solution, society can better protect at-risk groups within a trusted environment. It significantly reduces the risk of infections and allows residents to regain controlled access to friends and family.[48]

[45] Author works as a tax advisor at Taxand Netherlands B.V. The author has no conflicts of interest to declare.
[46] My Health My Data, 'Why MHMD' (*MHMD*, 2022) http://www.myhealthmydata.eu/why-mhmd/ accessed 9 June 2022.
[47] K. van Kranenburg and S. Sanders, 'Consortium uNLock presenteert privacyproof corona-applicatie', https://cms.law/nl/nld/news-information/consortium-unlock-presenteert-privacyproof-corona-applicatie (*CMS*, 16 April 2020) accessed 9 June 2022.
[48] The Unlock app is no longer used by the Dutch Ministry of Health. P. Olsthoorn, 'Fieldlab zet Unlock-app buiten de deur' (*AG Connect*, 17 May 2021) https://www.agconnect.nl/artikel/fieldlab-zet-unlock-app-buiten-de-deur accessed 9 June 2022.

2. MyHealthMyData: sharing sensitive data through blockchain

MyHealthMyData (MHMD) aims to fundamentally change the way sensitive data is shared. MHMD is intended to become an actual information marketplace based on new mechanisms of trust and direct, value-based relationships between EU citizens, hospitals, research centers, and businesses. One of their objectives is implementing the personal data account, a personal cloud allowing data subjects direct access to their entire clinical data from any personal device through the blockchain.

Nowadays, it is not easy to access its medical data and transfer it to other medical professionals as a data subject. To transfer its medical record from one medical professional to another (or between medical professionals like pharmacies), the data subject has to sign paperwork to make sure data can be transferred between these medical professionals. MHMD allows data subjects to enable or revoke data access for specific purposes. This increases trust in the medical data field. In the case of MHMD, the platform allows the data access to hospitals, research centers, pharmaceutical and others. Here, a blockchain platform is being used as a decentralized system for controlling, monitoring, and enforcing the GDPR guidelines during the data sharing lifecycle.[49]

3. My Zorg Log: control over one's own care and data

My Zorg Log[50] is a working prototype in which clients, care providers, and families keep a digital logbook together. They have access to up-to-date information at all times. The user decides for himself who gets access to his data. This gives him greater control over his own care and data. During the trial, maternity nurses and young mothers kept time records with My Care Log on a smartphone. This ensured that the registered hours were irrefutably recorded and immediately visible to the parties involved in maternity care. The mother had real-time insight into the outstanding number of maternity care hours. The check on maternity care hours provided was shifted with the blockchain to the source: the mother. This means that retrospective monitoring is no longer necessary. Blockchain can be of added value to the exchange of data in healthcare in realizing an up-to-date and unambiguous picture for all parties involved. Various pilot projects have demonstrated this, a number of working applications, and the practical trial of blockchain in maternity care.[51]

[49] Aurelie Bayle and others, 'When Blockchain Meets the Right to Be Forgotten: Technology versus Law in the Healthcare Industry' (2018) EEE/WIC/ACM International Conference on Web Intelligence.
[50] Idius Felix and others, 'Rapportage: Praktijkproef blockchain kraamzorg met Mijn Zorg Log' (2018) Zorginstituut Nederland.
[51] E. Piller and I. Felix, 'Blockchain in de zorg: organisatorisch vraagstuk en mensenwerk' (2019) 4 ICT&Health 12.

HOW BLOCKCHAIN CAN ENFORCE TRUST IN THE HEALTHCARE INDUSTRY

Blockchain technology can facilitate the transition from institution-driven interoperability to patient-centered interoperability. Blockchain technology allows patients to assign access rules for their medical data, for example, permitting specific researchers to access parts of their data for a fixed period. With blockchain technology, patients can automatically connect to other hospitals and collect their medical data.[52] And some important information (like drug prescription) can be published in a public blockchain.

Nowadays, there is a fragmented application landscape with different portals of different healthcare providers. The future is a personal health record, to which the patient has access and shares the data with the various participants (healthcare providers). After, for example, the general practitioners have added data to the file, it will be copied to all blockchain participants. In this way, all participants have an up-to-date synchronized file.[53]

Another critical topic is the digital rights aspect of patients. 93% of the survey participants valued control over their data as highly relevant. Digital identity requires interoperability of user's identity across multiple locations, user's consent, and true user control to create user autonomy. The legal requirements, such as compliance with data protection laws, like GDPR, could be directly encoded into smart contracts and thus be automatically enforced by the network. As a result, citizens, private and public institutions can interact decentralized and trusted.[54]

CHALLENGES TO ADOPT BLOCKCHAIN IN THE HEALTHCARE INDUSTRY

But there are also some challenges. It would take a significant cultural shift in the health care sector. Currently, many doctors are still stuck on paper. So, getting them to go from paper records to electronic healthcare records using blockchain is a big ask. For example, doctors like leaving questions blank, a required field in technology makes this habit hard to break. Also, blockchain is a decentralized system and, therefore, hard to implement. Healthcare physician providers and insurance payers are all over the board regarding how different entities handle records. Without a streamlined system, it would be challenging to pull all these entities together to adopt blockchain technology. Unfortunately, if any are resistant and do not adopt it, it reduces the usefulness of the entire system.

Some players in the healthcare chain are not willing to share information. A classic example of this is how insurance payers and hospitals actively try not to share data. It is a competitive advantage for

[52] Hyung-Jin Yoon, 'Blockchain Technology and Healthcare' (2019) Healthc Inform Res 59.
[53] M&I Partners, 'Let's talk about blockchain' (*M&I Partners*, 31 August 2017) https://mxi.nl/kennis/120/lets-talk-about-blockchain accessed 9 June 2022.
[54] P. Sandner, 'Blockchain in healthcare' (*Medium*, 19 May 2020) https://philippsandner.medium.com/blockchain-in-healthcare-fbbd2989a9dc accessed 9 June 2022.

hospitals to keep cost data to themselves. If they are forced to share with insurance companies, they might get different rates for different patients.

As we know, changes in healthcare systems are a heated debate, and a technology change would take a dedicated focus from the Health and Human Services Administration. Their focus changes every time a new government is sworn in. Also, nothing has been proven yet. Healthcare leaders would not adopt blockchain technology until they see a confirmed use case.[55]

Another challenge is speed and scalability. Transaction processing speed is expected to be only a few hundredths of the conventional way, such as credit cards. Considering that the number of transactions in the healthcare sector is enormous, the blockchain is not ready to process thousands of transactions per minute.[56]

LEGAL IMPLICATIONS

There seem to be at least two areas in which the GDPR still does not offer enough clarity about how real-world blockchain applications for the health sector should be developed:

(1) anonymization of personal data (e.g., which techniques are sufficient to anonymize personal data to the point where the resulting output can potentially be stored in a blockchain), and

(2) GDPR rights conflicts (e.g., how to rectify or remove personal data that are recorded in a blockchain that is immutable by nature, or who is responsible for requesting and managing the "freely, specific, informed, and unambiguous" consent from a data subject, especially if the data controller is not specified).[57]

A regulatory sandbox would be a practical outcome to identify and address these legal problems.

CONCLUSION

Blockchain is a growing technology for application in the healthcare industry that comes with several legal implications and practical challenges. Nevertheless, blockchain has the potential to change the healthcare industry for the benefit of the patients.

[55] David Chou, '6 challenges to healthcare blockchain adoption' (Childrensmercy, 4 January 2018) https://news.childrensmercy.org/6-challenges-to-healthcare-blockchain-adoption/ accessed 9 June 2022.
[56] Yoon (n 8).
[57] Anton Hasselgren and others, 'GDPR Compliance for Blockchain Applications in Healthcare' (2020) Cornel University; Cornelius C. Agbo, Qusay H. Mahmoud and J. Mikael Eklund, 'Blockchain Technology in Healthcare: A Systematic Review' (2019) 7(2) Healthcare 56; Rania El-Gazzar and Karen Stendal, 'Blockchain in Health Care: Hope or Hype?' (2020) 22(7) Journal of medical Internet research.

BLOCKCHAIN IS CHANGING THE ART INDUSTRY FOR GOOD

By: Johan Loo[58]

INTRODUCTION

Authenticity and provenance are two of the biggest issues that the art world faces. Provenance and authenticity are the main determinants of any artwork's value. Every other concern is secondary if the art sector is unable to rule out a forged piece or a piece that could have been looted from its rightful owner. Currently, it has been impossible to have complete confidence about these aspects for many artworks.[59] This article will discuss what impact blockchain can have on the art industry.

BLOCKCHAIN APPLICATIONS IN THE ART INDUSTRY

1. Verisart: proving authenticity and provenance

Verisart is the world's leading platform to certify and verify artworks and collectibles using the blockchain. Verisart has provided contemporary artists with an easy way to generate permanent certificates of authenticity and reduce the scope for fraudulent activity in the art industry. Verisart combines museum certification standards, distributed ledger technology, and image recognition to its provenance and registry services.[60] Records on Verisart are encrypted and timestamped. Certificates can be managed, shared, or transferred at any time. Verisart is focused on perhaps the most commonplace struggle artists of our time face - proving authenticity and provenance. Verisart aims to increase trust and liquidity in the global art market by bringing transparency and uniformity to the certification and verification of artworks and collectibles.[61]

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58 Author works as a tax advisor at Taxand Netherlands B.V. The author has no conflicts of interest to declare.

59 Alleywatch, 'This NYC startup has created the Art registry built on blockchain to bring trust to the art market' (*Alleywatch*, 2022) https://www.alleywatch.com/2018/12/artory-art-registry-built-on-blockchain-trust-art-market/ accessed 9 June 2022.

60 Shraddha Nair, 'What is blockchain certification, crypto art, and why should you care?' (*Stirworld*, 16 December 2020) https://www.stirworld.com/see-features-what-is-blockchain-certification-crypto-art-and-why-should-you-care accessed 9 June 2022.

61 Mike Butcher, 'Verisart plans to use the blockchain to verify the authenticity of artworks' (*Techcrunch*, 7 July 2015) https://techcrunch.com/2015/07/07/verisart-plans-to-use-the-blockchain-to-verify-the-authencity-of-artworks/?guccounter=1&guce_referrer=aHR0cHM6Ly93d3cuZ29vZ2xlLmNvbS8&guce_referrer_sig=AQAAAL1NyvGxGjn1CEHtLEVQ8ofezbbyKyBR_b8B782EziztV72FecOC2wR--JWBPDpmTTTyl6OSJnvyeyCyCUoBA4xq9AKefvWHm0_Z2O-CyESYgESyrlP2C_Ld36V3fR1Mh1KmtNQtpjdtlYc4r4PYwLbOPsNfGiKRda6Gg-xHhVKr accessed 9 June 2022.

2. Artory: blockchain registry for art

Artory[62] uses the blockchain to be the industry's first object-oriented database for the art and collectibles market. This blockchain registry, already being adopted by key players in the art world like Christie's,[63] digitally memorizes the stories, histories, provenance, and archival material. Furthermore, the platform allows collectors and buyers to remain completely anonymous. Artory creates a secure, digital record of transactions by leveraging blockchain technology to record significant events. Artory's goal is to build confidence in an artwork's ongoing provenance and provide greater efficiency in its eventual resale. In sum, Artory provides a digital registry of verified information about artworks and other high-end collectibles.[64]

For first-time buyers and experienced collectors alike, Artory provides the reassurance that they are dealing with a vetted seller. Also, Artory assures that there will be an immutable record of the transaction, and that they will receive a certificate of sale from an independent third party. These assurances encourage users to buy and sell with confidence.[65]

3. SuperRare: marketplace to buy and sell art

SuperRare[66] is an online platform for buying and selling digital art.[67] On SuperRare, each artwork is authentically created by an artist in the network and tokenized as a crypto-collectible digital item that you can own and trade. Digital art found on SuperRare functions the same way as traditional artwork in an auction house. On the SuperRare platform, artists create a piece of art and tokenize it, linking the art with a token.

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[62] Alleywatch (n 2).

[63] Artory, 'Our Story' (*Artory*, 2022) https://www.artory.com/our-story/ accessed 9 June 2022; Christies, 'Press release: Major Collection of the Fall Auction Season to be Recorded with Blockchain Technology' (*Christies*, 11 October 2018) https://www.christies.com/about-us/press-archive/details?PressReleaseID=9160&lid=1 accessed 9 June 2022.

[64] V.L. Hendrickson, 'Artory announces partnerships to help protect digital art' (*Barrons*, 2 August 2019) https://www.barrons.com/articles/artory-announces-partnerships-to-help-protect-digital-art-01564779212 accessed 9 June 2022.

[65] 'Artory launches the World's first publicly available art and collectibles registry on the blockchain' (*Businesswire*, 15 November 2018) https://www.businesswire.com/news/home/20181115005195/en/Artory-Launches-the-World's-First-Publicly-Available-Art-and-Collectibles-Registry-on-the-Blockchain accessed 9 June 2022.

[66] SuperRare, 'Frequently Asked Questions' (*SuperRare*, 2022) https://superrare.co/about accessed 9 June 2022; Ki Chong Tran, 'What is SuperRare?' (*Decrypt*, 26 March 2020) https://decrypt.co/resources/what-is-superrare-3-minute-guide-explained-art-collectible accessed 9 June 2022.

[67] Alison DeNisco Rayome, 'Collect digital art on this platform to display in your home, or in VR' (*Cnet*, 25 September 2020) https://www.cnet.com/culture/collect-digital-art-on-this-platform-to-display-in-your-home-or-in-vr/ accessed 9 June 2022.

HOW BLOCKCHAIN CAN ENFORCE TRUST IN THE ART INDUSTRY

Blockchain creates a system for adequately vetting, permanently memorizing and expertly protecting transaction data while simultaneously allowing the data's owner to stay anonymous if he/she wishes. This is also why blockchain is an excellent opportunity for owners of artwork. The artwork owner always gets his or her fair share for his work if sold. Smart contracts achieve this. Indeed, thanks to smart contracts, collectors can buy and trade artworks with royalties going back to the creator directly.

As for the legal sector, the art industry consults middlemen to ensure certain documents or artwork are authentic. For art, more art sales are moving online. There will be an increasing demand for certificates of authenticity and the need to perform real-time verification of provenance. The blockchain allows potential buyers to verify the chain of title in a work without relying on any single node of verification.[68]

Because the art industry relies on middlemen, this will be expensive for the owner and inefficient. With blockchain, the owner of artwork has control over his or her portfolio while selling his artwork directly to the buyer. This is cost-efficient, and the buyer is certain that the artwork is authentic because of the blockchain characteristics.

Artists using one of the above-mentioned blockchain services are using it because they help them with paperwork, which can now be executed more quickly. They also ensure every update to that certificate is brought together. In the past, there had often been different information silos between the paper certificate, the provenance, the object's story, the authority, the registry. Blockchain pulls together the certificate, origin, and registry.

Verisart does not verify the authenticity of the work itself because Verisart would have to come into contact with that artwork. Verisart (and the other blockchain services mentioned above) verifies who the issuer of the certificate is - the artist or appointed representative of that artist. If a person is creating an artwork and that person is not the artist, that person cannot create the certificate of authenticity. The person is making a certified record, which basically means that that person has a claim of this work in terms of recording it. But this does not mean much in Verisart's system unless someone else agrees with that claim.[69] This sums up how the blockchain helps art owners enforce trust in the art industry. By not verifying the authenticity of artwork, it could compromise the use of applications such as Verisart. Artists would then no longer want to use Verisart (or a similar application) if anyone can create a certified record and claim the ownership of the artwork.[70]

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[68] Butcher (n 4).
[69] Nair (n 3).
[70] Verisart recently faced criticism for failing to prevent incorrect data being recorded on their platform. See A. Hunton, 'The drivers behind the push for blockchain. Blockchain is the solution to the art market's key issues – lack of

CHALLENGES TO ADOPT BLOCKCHAIN IN THE ART INDUSTRY

The biggest challenge to blockchain adoption in the art industry is that the end-user is frequently asked to understand blockchain to use a blockchain-based product.[71] Many are worried that blockchain could open the gates for forgeries, lead to inconsistencies in stored data, and cause scalability and performance issues. Furthermore, a lack of regulatory oversight regarding blockchain technology has become a significant roadblock for mass adoption. Art market participants must be cautious about engaging with newly adopted blockchain-based platforms and technologies, considering that private companies are still experimenting with this technology. Even if an artwork boasts a flawless provenance on the blockchain, it needs an equally secure mechanism for keeping the blockchain connected to the artwork itself in the physical world. Otherwise, a fraudster could detach one from the other and "verify" a fake by tying the forgery to a legitimate (block)chain of title.

The viability of the blockchain project depends on buyers demonstrating that they are willing to pay a premium for data integrity. Suppose the industry produces a robust title registry for artworks, and the database's existence doesn't fail to motivate a significant number of new buyers to enter the market. In that case, the value proposition of a blockchain title registry will increase and thrive.[72]

LEGAL IMPLICATIONS

A legal issue concerns the lack of a control mechanism. Whereas the immutability of blockchains might have an important impact on the traceability and transparency of (digital) artworks, there is no guarantee that the authenticity or provenance or alleged authorship are actually true.

If a judge observes an unlawfulness or an incorrectness of information – for instance if the rights are actually expired or if the claimed rights are false – the data within an artwork need to be changed. Also, when an author decides to make some adaptations to its work, or if the financial value of it changes drastically, the information needs to be modified. But it can't be modified because the immutability of data is one of the key characteristics of blockchain.[73]

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transparency, regulation and traceability' (*Omnia*, 8 September 2018) https://omniaglobal.com/news/the-drivers-behind-the-push-for-blockchain accessed 9 June 2022.

[71] See also: M. Kochetkova, 'Blockchain in the art market: opportunities and challenges' (2020) LAB University of Applied Sciences 25-35.

[72] Tim Schneider, 'Cryptocurrencies, explained: how blockchain technology could solve 3 big problems plaguing the art industry' (*Artnet News*, 22 March 2018) https://news.artnet.com/art-world/cryptocurrencies-explained-part-three-1248863 accessed 9 June 2022.

[73] Laurens Kasteleijn, 'Legal considerations concerning digital artworks – challenges and opportunities' (*Art Law Services*, 17 March 2021) https://www.artlawservices.com/post/legal-considerations-concerning-digital-artworks-challenges-and-opportunities accessed 9 June 2022.

CONCLUSION

Blockchain has the potential for a wide range of applications across a wide range of industries like the art industry. The wider adoption of blockchain in the art industry can help the artist to find a new niche or audience. Blockchain could be a real game-changer in the art industry if the legal implications and other challenges are addressed.

BLOCKCHAIN: THE FUTURE OF LITIGATION AND CONTRACTS

By: Johan Loo[74]

INTRODUCTION

In the current situation, trust is created by intermediaries. Think of lawyers who draw up contracts. Or think of a government official, a notary, or a witness. Besides, the legal industry as a whole is already one of the most expensive in relation to the needs of enterprises and professionals, and year after year, the existing legal frameworks become more complicated. This article will discuss what impact blockchain can have on the legal industry.

BLOCKCHAIN APPLICATIONS IN THE LEGAL INDUSTRY

1. Jur.io: Contracts and dispute resolution on the blockchain

Jur.io is a blockchain service where one can quickly open a dispute and get a fair resolution. With Jur.io, users can record agreements while being provided with unbiased, swift, and affordable resolutions for disputes over any kind and size of agreement globally. With Jur.io, users can create legally binding agreements on the blockchain quickly. The user can also choose a template that fits the user's needs. These templates are drafted by experts. Besides, a fundamental issue lies at the root of the disputes: contract preparation. The contract industry has become unsustainable for private parties. Lawyers always work many hours on contracts to prevent any possible dispute. This results in many billable hours that the client has to pay, without absolute certainty that the dispute with the negotiating counter-party will be prevented. The agreements may still be violated or not adequately performed. According to jur.io, the solution is to redesign the entire tree of business transactions from the roots, i.e., from contracts.[75]

2. Acronis Notary: Adding an extra layer of confidence

Acronis Notary is also a blockchain service in the legal sector. Acronis Notary adds an extra level of confidence to the authenticity of the user's personal and business data. In the future, the user may want to simply reassure itself that a file the user previously stored or backed up has remained unchanged. Or the user may have a file (or someone may be presented with a file) that needs to be

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[74] Author works as a tax advisor at Taxand Netherlands B.V. The author has no conflicts of interest to declare.

[75] Jur, 'White Paper 3: The Open Justice Platform and the Justice Problem in the Pandemic' (*Jur*, 25 March 2021) https://jur.io/blog/tag/white-paper/ accessed 9 June 2022; Jur, 'Jur – A legal blockchain solution designed to simplify, optimize and automate legal disputes and business transactions on the internet' (*Medium*, 2022) https://medium.com/@JurOfficial accessed 9 June 2022.

validated by confirming it is authentic and unchanged from its backup or the moment the user received a file. Common potential uses include property records, court documents, and long-term archives that could be subject to legal or tax audits. This blockchain service focuses on the need to verify the authenticity of documents. Besides legal or tax audits, the logistic sector and, for example, bills (paid), can use this blockchain service to make sure the document is authentic and not tampered with.[76]

3. Silent Notary: Authenticate certain events

Silent Notary is an ecosystem that develops around smart contracts, ensuring the evidence of existence and permanence of certain events. This blockchain service does not differ from the previous two blockchain services. Like the blockchain services above, Silent Notary ensures certain events are authenticated. Code text, picture, story, music, etc. Any intellectual property item, represented in digital format, is subject to legal protection. Silent Notary cannot replace a patent solicitor, but it helps to prove precedence in the case of a dispute. Verbal agreements are very hard to prove in court. With Silent Notary, a person can record an audio file that will be authenticated.[77]

HOW BLOCKCHAIN CAN ENFORCE TRUST IN THE LEGAL INDUSTRY

By verifying a document or contract on the blockchain, the parties obtain a timestamp, and can no longer change the document's content. If one of the parties tries to modify the contract, this is impossible. In addition, the blockchain ensures that the content of the document has not changed compared to when it was drawn up. Should the document have changed, the content of the document will be null and void.

Parties who enter into an agreement can, using smart contracts, determine for themselves in the contract how it will be implemented between the (contracting) parties. Another significant advantage of the blockchain is that drawing up and executing the agreement is faster and more efficient. There are also fewer costs involved. Besides costs, blockchain also reduces time by increasing management efficiency and facilitates access, as the whole procedure is entirely online.[78] However, it is not only in the case of contracts and other types of documents that the blockchain can generate confidence. This can also be done through, for example, photographs, intellectual property, and e-mails sent. Trust in this context means that the owner of these matters is certain that they belong to him because they are

[76] Acronis, 'Technology Notary' (*Acronis*, 2022) https://www.acronis.com/en-eu/technology/blockchain-notary/ accessed 9 June 2022.
[77] The SilentNotary team, 'Silent Notary Whitepaper' (2022) Silent Notary.
[78] See also: Consensys, 'What are the benefits of blockchain in the Legal industry?' (*Consensys*, 2022) https://consensys.net/blockchain-use-cases/law/ accessed 9 June 2022.

stored on the blockchain with a certain timestamp. If someone imitates the owner's product, the owner can raise this by claiming that he or she was the first. The blockchain contains information about the owner's work which allows him or her to prove that the work was originally his. These aspects enforce trust in the blockchain system as opposed to classic intermediaries.[79]

CHALLENGES TO ADOPT BLOCKCHAIN IN THE LEGAL INDUSTRY

Blockchain can cross jurisdictional boundaries as the nodes on a blockchain can be located anywhere in the world. This can pose a number of complex jurisdictional issues which require careful consideration concerning the relevant contractual relationships. The principles of contracts and title differ across jurisdictions, and therefore identifying the appropriate governing law is essential. The difference in the governing law could be subject to further dispute between the parties, leading to more administrative costs.

Besides jurisdictional boundaries, the relationship between privacy and transparency could be a significant challenge. Once data is stored, it cannot be altered (at least, not easily). This clearly has implications for data privacy, particularly where the relevant data is personal data or metadata sufficient to reveal someone's personal (or business) details that parties have laid out in the contract(s). The unique transparency of transactions on the blockchain is not easily compatible with the privacy needs of contracting parties. In some cases, it is not in parties' interest that certain information is accessible for everyone. To prevent this, solutions to design privacy-protecting blockchains yet need to be found. This could include limiting who can join the blockchain network to 'trusted' nodes. By making the blockchain more privacy-proof, parties do not have to fear that confidential (business or personal) information is (publicly) accessible.[80]

LEGAL IMPLICATIONS

Blockchain technology offers many possibilities, but it is not a miracle solution. Critics will mention that control measures are still needed to ensure that, for example, the agreement concluded through a smart contract is in line with local law and case law. A regulatory sandbox could be a good way to test how, for example, agreements created by smart contracts work out in practice.

[79] See also: Jillian Ada Burrows, 'Does Blockchain generate trust?' (*Medium*, 16 January 2018) https://medium.com/jill-burrows/does-blockchain-generate-trust-5e96148ae597 accessed 9 June 2022.
[80] John McKinlay and others, 'Blockchain: background, challenges and legal issues' (*DLA Piper*, 2 February 2018) https://www.dlapiper.com/en/uk/insights/publications/2017/06/blockchain-background-challenges-legal-issues/ accessed 9 June 2022.

CONCLUSION

In this article, I discussed a number of blockchain applications in the legal industry. My article shows that blockchain can have a big impact on the legal sector in the future. But before blockchain is the norm in the legal industry, there are challenges to overcome.

BLOCKCHAIN MODERNIZES REAL ESTATE TRANSACTIONS

By: Johan Loo[81]

INTRODUCTION

The process of buying, selling, and valuing real estate is quite opaque. For many, it is difficult to access the true value of a property and understand the intricacies of the housing market. Also, many transactions are still paper-based and involve several parties, leading to decreasing transparency and increasing costs. The untransparent nature of real estate transactions allows activities such as money laundering to exist. This issue coincides with the low degree of digitization concerning land and ownership registries, of which some are still paper based. Therefore, these can still be lost, destroyed, falsified, or easily manipulated.[82] This article will discuss what impact blockchain can have on the real estate industry.

BLOCKCHAIN APPLICATIONS IN THE REAL ESTATE INDUSTRY

1. Propy: platform to manage transactions

The Propy platform brings parties together to manage transactions virtually. That said, the intuitive interface makes it simple to configure permissions. For example, a buyer can provide his or her agent with personal financial details without the seller seeing these details. Later, when the buyer is ready to tender an offer, he or she can do so directly through the platform.[83] With Propy, you can receive offers from your website or MLS listing while getting an instant email and a text notification with a summary of the terms. You can keep track of all offers and navigate them with confidence in one spot. Instantly accept, decline, or counteroffers. Propy is automating the closing process for all participants involved.[84]

2. Streetwire: tokenizing real estate

Streetwire is a blockchain-based data platform for real estate transactions. The company develops decentralized solutions for tokenizing real estate assets-enabled transactions. The company leverages blockchain and smart contract technologies to enable real estate data producers (such as brokers,

[81] Author works as a tax advisor at Taxand Netherlands B.V. The author has no conflicts of interest to declare.
[82] Jan Breker, 'Blockchain in Real Estate' (*Lisk*, 4 August 2020) https://lisk.com/blog/research/blockchain-real-estate accessed 9 June 2022.
[83] Propy, 'We make buying and selling homes faster, easier, and more secure' (*Propy*, 2022) propy.com accessed 9 June 2022.
[84] Ibid.

appraisers, lawyers, etc.) to exchange and monetize information directly without working through intermediaries.[85] In doing so, the company can return the value of their data to the people and organizations that have produced it.

StreetWire's decentralized network is built using blockchain technology to service the $217 trillion global real estate market. The transformation of this industry begins with timely and accurate data - StreetWire is building that solution.[86]

3. Ubitquity: provides an immutable record of ownership

Ubitquity, a blockchain-secured platform for real estate recordkeeping, offers a simple user experience for securely recording, tracking property deeds and land records. The company haspartnered with academia, municipalities, and title companies.[87] Ubitquity offers a simple user experience for securely recording and tracking property with the Blockchain-as-a-Service (BaaS) blockchain platform, ecosystem, and API called "unanimity". Ubitquity helps title companies, municipalities, and custom clients benefit from a clean record of ownership, thereby reducing future title search time and increasing confidence/transparency. In short, Ubitquity is a leading, modern software platform that provides an immutable record of ownership history for all parties involved through a simple, customizable, and accurate distributed ledger system.[88]

HOW BLOCKCHAIN CAN ENFORCE TRUST IN THE REAL ESTATE INDUSTRY

One of the most significant impacts of blockchain on commercial real estate would be a smoother, faster contract management process that expedites deals. With smart contracts, every part of a lease or sale agreement is automated, and payments are received instantly – even outside of business hours.

Blockchain would make it possible to create, authenticate and audit contracts in real-time, across the world, and without intervention from a middleman. Smart contracts have instructions rooted in the transaction so that payment can only be taken as long as the instructions are fulfilled, providing complete transparency to all parties and reducing the likelihood of payment disputes. Smart contracts would also speed up pre-lease due diligence. Blockchain technology can help verify identities, making

[85] Tracxn, 'Streetwire' (*Tracxn*, 2022) https://tracxn.com/d/companies/streetwire.net accessed 9 June 2022.
[86] Streetwire, 'Streetwire Blockchain network to Revolutionize real estate transactions' (*Cision PR Newswire*, 18 April 2018) https://www.prnewswire.com/news-releases/streetwire-blockchain-network-to-revolutionize-real-estate-transactions-300632453.html accessed 9 June 2022.
[87] Ubitquity LLC, 'Ubitquity, the first blockchain secured platform for real estate recordkeeping, announces historic pilot with a land records bureau in Brazil' (*Medium*, 5 April 2017) https://ubitquity.medium.com/ubitquity-the-first-blockchain-secured-platform-for-real-estate-recordkeeping-announces-historic-46c2b0d9f895 accessed 9 June 2022.
[88] Ubitquity, 'One Block At A Time: The Leading Blockchain Company for Real Estate, Title, and Escrow' (*Ubitquity*, 2022) https://ubitquity.io accessed 9 June 2022.

the background check process faster. Parties involved in a contract can access it with a personal digital key, arguably reducing the likelihood of fraud.[89]

Cutting out the intermediaries will result in buyers and sellers getting more out of their money as they save on commissions and fees charged by these intermediaries. This makes the process much quicker as the back-and-forth between these middlemen gets cut.

The transparency associated with a decentralized network can also trim down costs associated with real estate transactions. Beyond the savings made by cutting out intermediaries' professional fees and commissions, there are other costs such as inspection costs, registration fees, loan fees, and taxes associated with real estate.[90]

Property management is highly complex, with many stakeholders involved — including landlords, property managers, tenants, and vendors. Most properties are currently managed either offline through manual paperwork or through multiple software programs that generally do not integrate well. Using a single decentralized application that uses blockchain-backed smart contracts, the entire property management process – from signing lease agreements to managing cash flow to filing maintenance requests – can be conducted securely and transparently.[91]

Blockchain technology enables new ways to invest in real estate, which benefits companies and individuals. New business models lower the barriers to real estate investing for individuals and allow companies to raise funding more easily for projects. Blockchain allows individuals and companies to purchase and trade only fractions of a real estate (tokenization), and in turn, enables fast and easy transactions of ownership. This creates liquidity and ultimately makes the real estate industry more accessible.[92]

The introduction of blockchain in real estate will also lead to a simplified administrative process and reduced processing time for all institutions involved. This way, the need to double-check and verify one client's information by multiple institutions will no longer be necessary. With the implementation of the blockchain, all the parties will be able to communicate directly and efficiently by accessing the client's information. Thus, once one party has approved, the other can immediately process the necessary documentation concerning the real estate without restarting the same background check.[93]

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[89] JLL, 'How blockchain is reshaping the real estate industry' (*JLL*, 12 March 2018) https://www.jll.it/it/tendenze-e-ricerca/investitori/how-blockchain-is-reshaping-the-real-estate-industry accessed 9 June 2022; Alt. Estate, 'Blockchain in real estate: potential and real benefits' (*Medium*, 18 January 2019) https://medium.com/@Alt.Estate/blockchain-in-real-estate-potential-and-real-benefits-3fa434eec089 accessed 9 June 2022.

[90] Joe Liebkind, 'How blockchain technology is changing real estate' (*Investopedia*, 22 March 2020) https://www.investopedia.com/news/how-blockchain-technology-changing-real-estate/ accessed 9 June 2022.

[91] CBS Insights, 'How Blockchain Technology Could Disrupt Real Estate' (*CBS Insights*, 21 February 2019) cbinsights.com/research/blockchain-real-estate-disruption/#challenges accessed 9 June 2022.

[92] Breker (n 2).

[93] Alt. Estate (n 9).

CHALLENGES TO ADOPT BLOCKCHAIN IN THE REAL ESTATE INDUSTRY

What are the challenges for blockchain adoption? There will probably be resistance from traditional professions affected by blockchain technology. In this case, it will be real estate agents. Real estate players traditionally dominate the real estate sector.[94] It should also be noted that – according to Perrin Quarshie, CEO and founder of Realblocks - real estate is an industry that relies on a traditional way of doing things. Therefore, it's imperative to show the value of blockchain to be adopted in the mainstream.[95]

Another challenge that real estate companies face while embracing blockchain is cross-chain interoperability. Various blockchains exist in the digital market, many of which cannot connect or work together. This lack of interoperability makes it tough for real estate companies to simultaneously use different data available on a public and private Ethereum blockchain and streamline their processes.[96] Networks such as Cosmos and Polkadot have emerged as leading examples of blockchain interoperability. Recently, Cosmos has rolled out the Inter Blockchain Communication protocol. This protocol ease inter-blockchain communication and inter chain messaging.[97] This should enable many different blockchains to communicate and interact with each other.

LEGAL IMPLICATIONS

a. *Control of the legality and effectiveness of the contract*: Lawyers and notaries ensure that a real estate transaction is concluded in accordance with the legal requirements, and they inform the purchaser about previous encumbrances and rights of the property. Blockchain can neither inform in the same way about the consequences of a certain transaction nor carry out a previous check of the legal requirements by itself.

b. *Co-ownership and property rights*: Co-ownership with different shares, the right to build, the right to use, temporal ownership or shared ownership are all challenging to translate into blockchain code and can pose a problem if they are not addressed properly.

c. *Reverse transactions*: When it comes to real estate there is an enormous need for reversibility of transactions. In case of illegal activities, operational errors, or breach of a contract, property

[94] Ibid.
[95] Sam Mire, 'What Are The Challenges To Blockchain Adoption In Real Estate? 12 Experts Share Their Insights' *Disruptor Daily*, 18 May 2019) https://www.disruptordaily.com/blockchain-adoption-challenges-real-estate/ accessed 9 June 2022.
[96] Chirag, 'How adoption of blockchain in real estate changing the scenario?' (*Appinventiv*, 30 March 2022) https://appinventiv.com/blog/blockchain-taking-real-estate-next-level/ accessed 9 June 2022.
[97] Pragya Soni, 'All About Blockchain Interoperability in 2022' (*Analyticssteps*, 10 October 2021) https://www.analyticssteps.com/blogs/all-about-blockchain-interoperability-2022 accessed 9 June 2022.

rights might need to be revoked. While the blockchain is mainly irreversible, the legislation stipulates the reversibility of transactions or changes of the property.[98]

CONCLUSION

The potential of blockchain in the real estate sector is big, provided a clear regulatory framework is in place. But for the (mass) adoption of blockchain in the real estate sector, there are still challenges that need to be overcome, such as interoperability. If blockchain keeps developing in the real estate sector, the future of real estate transactions could look very different in a few years.

[98] Lexcellence, 'Legal obstacles to mass blockchain adoption in the real estate industry' (*Lexcellence*, 2022) lexcellence.com accessed 9 June 2022; Rosa M. Garcia-Teruel, 'Legal challenges and opportunities of blockchain technology in the real estate sector' (2020) 12(2) Journal of Property, Planning and Environmental Law 129-145.

HOW BLOCKCHAIN TECHNOLOGY ENABLES CITIZEN PARTICIPATION AND ANTI-CORRUPTION IN GOVERNMENT SERVICES

By: Jorge Pomareda

INTRODUCTION

With time, the failures of the democratic system, represented by the lack of representativeness, trust in the political class, and corruption, have become evident[99]. These anomalies have been causing significant social and economic damage in the world[100]. An increasingly digital and online world has stimulated the demand from citizens for the State to provide its traditional services and develop its activities in a more efficient, transparent, and dynamic way. Blockchain technology can satisfy these needs by allowing citizens to become actively involved in the delivery of government services and activities.

Through decentralized citizen participation within public and permissionless blockchain, centralized state power and potential corruption are reduced as its decentralized architecture eliminates single-points-of-failure, the entries of transactions are confirmed by a consensus of nodes and are immutable, and the open nature of these transactions creates transparency for everyone, achieving an absolute liberation of state power to fulfill their needs.

PUBLIC SERVICES AND BLOCKCHAIN

a. Public procurement

Smart Tender and Transparency Project are projects linked to public procurement, an activity carried out to date in a unidirectional manner by the State. Transparency Project is a project designed within the Programa de Alimentación Escolar (PAE)[101] to procure food for schoolchildren in Colombia. It uses a PoC (proof of concept) software within the public permissionless Ethereum blockchain.

Transparency Project makes the entire public procurement procedure transparent and auditable by any interested party, getting the seller to be chosen by an efficient procedure and under the

[99] For a broader perspective on the erosion of trust in politicians and democratic institutions *see* A Braun,'Blockchain—The Savior of Democracy?' in D. Feldner (ed) *Redesigning Organizations* (Springer 2020) 240-243.

[100] To understand the magnitude of the costs that corruption imposes on government, citizens and businesses see Rajni Bajpai and Bernard Myers, 'Enhancing Government Effectiveness and Transparency: The Fight Against Corruption' (2020) World Bank 153-157.

[101] The Programa de Alimentación Escolar provides a food supplement to Colombian children and adolescents to contribute to the permanence of students in the school system. For more information *see*: Gov.Co, 'Unidad Administrativa Especial De Alimentación Escolar' (Gov.Co, 2022) https://www.alimentosparaaprender.gov.co/ accessed 9 June 2022.

public control of citizens[102].

Smart Tender is a project under the National Digital Strategy and the Ministry of Public Administration (Mexico) initiative. Smart Tender makes use of the public and permissionless Ethereum blockchain and, together with the smart contract, seeks not only the online audit of the public procurement process but active participation through a voting mechanism that involves citizens, government, and certain evaluators. Under various incentives, Smart Tender ensures that the selection of the winning bidder is the one that generates the most significant benefit, providing the choice of the most suitable bidder, efficiently and reducing the waste of money in corruption[103].

b. Urban development process

And there are other interesting projects in the space. BBBlockchain is one of them. It allows decentralizing decision-making regarding a given municipality's planning and urban design. BBBlockchain is an application anchored in the public and permissionless Ethereum blockchain through which the active participation of all the sectors involved is possible. BBBlockchain uses public and permissionless Ethereum infrastructure and smart contracts to carry out the entire urban development process.

BBBlockchain embraces different levels of participation, from the information storage of, for example, the urban development project, through the participation workshop, to the issuance of tokens to enable a decentralized voting mechanism where parties participate by casting their vote without the need to trust each other and achieving true empowerment in citizen decision making[104].

c. Resolution of legal claims

Finally, Kleros is a decentralized application built on the Ethereum blockchain. It allows resolving those conflicts of interest that arose in the online world, which would otherwise be resolved under the traditional model, generating cost overruns, jurisdictional disputes, bureaucracy, and potential corruption. Kleros allows the parties to agree and decide to establish their obligations within a smart contract that will enable resolving disputes that arise with them, establishing a jury that will behave according to economic incentives.

Under a scheme of game theory and SchellingCoin, Kleros allows the members of the jury, without

[102] World Economic Forum, 'Exploring Blockchain Technology for Government Transparency: Blockchain-Based Public Procurement to Reduce Corruption (2020) World Economic Forum 21-23.

[103] Secretaría de la Función Pública and others, 'Blockchain HACKMX' (2017) Mexico: Presidencia de la República.

[104] Robert Muth and others, '*BBBlockchain: Blockchain-based Participation in Urban Development'* (2019) 15th International Conference on eScience (eScience) 321-330.

the need to know or trust each other, to achieve an honest and coherent solution to obtain a financial reward[105].

HOW BLOCKCHAIN TECHNOLOGY ENABLES CITIZENS PARTICIPATION

To sump up, Transparency Project represents a level of participation called "partnership," in which citizens and the State share not only information but also the planning of public procurement. Smart Tender is a manifestation of "delegation of power" in which citizens achieve a dominant position in decision-making through a voting mechanism in public tenders. BBBlockchain, on the other hand, consecrates the so-called "citizen control," where neighbors organize themselves without the need for intermediaries and decide the manner of urban development of the neighborhood to which they belong together with the corresponding authority and the private sector in a horizontal and decentralized way. Finally, Kleros allows such an essential government service as justice to be placed in the hands of private individuals for the sake of the values of neoliberal politics and individualism, with emphasis on personal responsibility, self-promotion, self-government, and control over one's destiny. In this way, Kleros represents a complement to the traditional legal system, as it is in charge of administering justice within the Web3 even being accepted as legally valid in courts[106].

On the other hand, citizens' distrust in the State's services stems from the corruption perceived in public officials' actions. Every public contract, every transfer of money from the public treasury, and any private sector approach to public officials (judges, mayors, etc.) is under suspicion of corruption. Blockchain technology allows any information stored in the blocks to be audited, any transfer of money to be traceable, and personal interaction between citizens and public officials to be reduced more and more.

Blockchain technology allows many services provided exclusively by the State to be redesigned, questioning the need, usefulness, and power of a State increasingly perceived as corrupt and indifferent to its citizens' real needs. The projects and applications presented here are based on a decentralized, transparent, auditable, peer-to-peer scheme, motivating participation (at various levels), control, audit, and total liberation from centralized and coercive power.

LEGAL IMPLICATIONS AND PROPOSAL

All the aforementioned projects run the risk of not having sufficient legal and technological structure

[105] Clement Lesaege, Federico Ast, and William George, 'Kleros: Short Paper v1.0.7' (2019) Kleros.

[106] See Kleros, 'Kleros as Valid Arbitration in Mexico' (*YouTube*, 25 October 2021) https://www.youtube.com/watch?v=JDu8S9zLhHM&ab_channel=Kleros accessed 9 June 2022.

to allow them to be carried out on a large scale and benefit the entire population.

It is important to raise the need to create a technological sandbox based on blockchain where the different state entities in charge of providing public services participate; take a representative sample of the beneficiary population; invite stakeholders such as universities and regulators, and finally make a public and general call to all those interested in applying blockchain technology in the solution for the provision of public services, in a controlled environment.

State entities should indicate those public services subject to digital transformation through blockchain technology.

A representative sample of the population who will be asked for their authorization to participate in the sandbox platform should be considered. This population should be selected according to the need in solving their problems related to the provision of public services and the number of them.

Interested participants will operate in a controlled environment. The sandbox platform will allow them to acquire knowledge and the validation of experimental applications, as well as the introduction of innovative applications that may even allow another way of providing a certain public service.

Finally, the participation of stakeholders is also fundamental. Universities and regulators should be involved from the initial stages within the sandbox platform as it will allow them to understand all the legal implications of providing public services with the use of blockchain technology such as privacy, jurisdiction, civil liability, among other legal issues.

CONCLUSIONS

As Werbach (2018) points out, "the main elements of the Leviathan trust architecture that people see are bureaucratic rules for participation and dispute resolution"[107] reflected in the inefficient, unidirectional, and costly services provided by the State. Blockchain technology is shown as a new trust architecture relegating intermediaries (State and its officials).

However, although blockchain technology is based on a neutral cryptographic code that allows a decentralized consensus on a large scale, it is important to note that blockchain technology is not the solution to all the ills of the public sector as it is still at an early stage; also, blockchain technology still faces several problems such as its technological complexity that goes hand in hand with resistance in its adoption, its linkage to make illegal payments, the difficulty of writing less deterministic smart contracts and the ever present theoretical possibility that the blockchain could

[107] Kevin Werbach, *The Blockchain and the new architecture of trust* (The MIT Press 2018) 27

be hacked. Notwithstanding, blockchain technology offers advantages that allow the State to plan, organize, direct and execute various government services, reducing information asymmetry, transaction costs, opportunism, rent-seeking and corruption in the delivery of government services.

DISCLAIMER

Any cryptocurrency, token or project mentioned in this document are for informational purposes only and do not constitute financial, investment, or other advice.

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BUILDING & TRUST IN INTERNATIONAL TRADE AND SUPPLY CHAINS

By: Juan Rodrigo

INTRODUCTION

While the world has experienced since 1990s progressive liberalization, which has facilitated international trade, exporters and importers still face red tape resulting from fragmented regulation and frauds and scams that might hinder them from engaging in international trade.

In response to these challenges, the private sector has begun embracing emerging technologies, including blockchain-based solutions. Blockchain's characteristics – immutability, decentralization, and transparency- allow blockchain-based solutions to bring trust, efficiency, and security to international trade. Following the above, four blockchain applications that have been implemented are reviewed to expose how blockchain-based solutions are bringing trust to international trade.

ORESOURCE

From 1 January 2020, importers of minerals and metals into the European Union have to comply with the recent EU–Conflict Minerals Regulation. This regulation, which covers the importation of tin, tantalum, tungsten, and gold, intends to prevent the financing of armed groups and the use of forced labor in the extraction of these minerals and metals. In particular, EU companies must ensure that their importations come from responsible smelters and refiners only.[108] For these reasons, smelters and refiners are deemed to carry out supply chain due diligence for meeting regulatory requirements.

In response to these new regulatory requirements, **OreSource** is offering blockchain-based digital certificates that help importers comply with their new legal obligations. Smelters and refiners are required to upload the data required by the regulation to a public blockchain protocol where it is stored. Then, as a QR code is associated with an invoice or a shipment, EU importers will have all the information they need to ensure that the minerals and metals come from a trustworthy source.[109]

[108] European Commission, 'EU Reaches Landmark Agreement on Conflict Minerals Regulation' (*European Commission*, 22 November 2016) https://ec.europa.eu/commission/presscorner/detail/en/IP_16_3931 accessed 9 June 2022.
[109] Mining Review Africa, 'Minespider partners with LuNa Smelter to pilot blockchain tool in Rwanda' (*Mining Review Africa*, 18 November 2020) https://www.miningreview.com/east-africa/minespider-partners-with-luna-smelter-to-pilot-blockchain-tool-in-rwanda/ accessed 9 June 2022.

E- CERTIFICATE OF ORIGIN ("ECO")

In international trade, the rules of origin are the criteria defined by jurisdictions to determine the national source of a product.[110] Governments use these rules of origin to grant imported products access to preferential tariffs and quotas. In 2018, the Singapore Chamber of commerce developed the first e-Certificate of Origin platform. The platform host information using a distributed ledger system, allowing authentication and access to digital certificates of origin that certifies a product's national origin. Behind this, **eCOs** are affixed to QR codes that enable verifying these certificates efficiently, reducing manual paperwork.[111]

BLOCKCHAIN LETTER-OF-CREDIT TRANSACTION

The letter of credit is one of the most widely used payment methods in cross-border transactions due to its security. Particularly, letters of credit provide the beneficiary with assurance to both parties that the terms and conditions of the agreement will be honored. Sellers are assured that they will receive payment for their merchandise. Buyers are guaranteed to receive the goods under the agreed conditions, by evaluating documents (such as invoices, shipping documents, insurance documents, certificates of origin, quality, weight, etc.). In 2020, **HSBC** reported the first cross-border blockchain transaction in Bangladesh. This transaction reduced the transaction time from 5-10 days to just 24 hours.[112]

BITCANNA

As some jurisdictions have legalized the use of recreational and medical cannabis, Bitcanna has begun developing a platform for offering a transparent supply chain for marijuana. **Bitcanna** implemented a decentralized payment system that allows consumers to purchase cannabis. Consumers and suppliers to connect directly, removing the need for financial middlemen. Additionally, it enables users to trace the production, sale, and distribution of cannabis products, as well as unaltered rating systems to the **Bitcanna** users.[113]

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[110] World Trade Organization, 'Technical information on the rules of origin' (*World Trade Organization*, 2022) https://www.wto.org/english/tratop_e/roi_e/roi_info_e.htm accessed 9 June 2022.

[111] Singapore International Chamber of Commerce, 'Singapore International Chamber of Commerce and vCargo Cloud Launch World's First Blockchain-Based e- Certificate of Origin ("eCO")' (2018) SICC.

[112] HSBC, 'HSBC drives Bangladesh's first cross border blockchain transaction' (*HSBC News Release*, 31 October 2020) https://www.scribd.com/document/482649761/HSBC-PR accessed 9 June 2022.

[113] Bitcanna, Bitcanna Whitepaper V.1.2' (*bitcanna.io*, 2022) https://www.bitcanna.io/wp-content/uploads/2019/09/BitCannaWhitePaper_versionMaltav3.pdf accessed 9 June 2022.

BRINGING TRUST FOR INTERNATIONAL TRADE

There is a consensus on the importance of trust for trade. While trust between trading partners is fundamental, according to Kumar et al. (1998), building trust can be expensive, as both importers and exporters have incentives to not trust each other due to existing information asymmetries. These blockchain-solutions could reinforce trust in the international supply chains by mitigating information asymmetries. This is said as blockchain-based solutions allow all those involved in trade transactions to access a single source of reliable, transparent, and collaborative information.

In this sense, as Loebbecke et al. (2018) stress, blockchain technology could facilitate without demanding a prior trusting relationship. This is the case of users of **OreSource** that while allowing importers to know whether an imported mineral or metal complies with the regulation, it could also provide final consumers reliable information that their purchase is not supporting forced labor or financing armed groups. In this same direction, the transparency and traceability of **Bitcanna** allow final consumers to integrate the recorded information such as quality, reputation among others, in their purchasing decision of cannabis products. The same goes with the **e-Certificate of Origin,** as with these digital certificates, customs authorities will be able to trace the origin of goods for imposing or not preferential tariffs. Moreover, as a growing number of consumers are concerned about the origin of the products they consume, an **e-Certificate of Origin** could limit false or misleading designation of origin of goods.

Moreover, blockchain letter-of-credit transactions could also enhance trust in improving the efficiency of international trade. This is said as by having using the automated electronic submission of documents in cross border transactions both importer and exporter will know that in case of fraud or when the agreed terms are not met, they would not incur in extra cost associated with enforcement or arbitration and time delays (Tapscott, 2017)

Despite the potential of these blockchains to build trust in international trade, the impact on international trade could be limited given not only their early stage of development but also because these solutions are scattered and not widely used. In the presentation of these blockchain applications, it was not found that they solve the interoperability and scalability problems that have hindered the expansion of blockchains.

While some jurisdictions have already implemented regulatory sandboxes to encourage the growth of blockchain in the fintech sector, in order to foster the adoption of this technology in the area of international trade a transnational regulatory approach is needed. A potential transnational regulatory approach could be a **"blockhain regulatory sandbox model for trade"**. This model could integrate the blockchain standards developed by the ITU and ISO and include among other provisions a reciprocity provision that enables sandbox participants to operate in other jurisdictions

that have joined the **"blockhain regulatory sandbox model for trade"**. As The World Trade Organization is the most prominent international organization in international trade, this organization can be the global forum to discuss and develop a blockchain as a way to achieve a regulatory convergence in blockchain for trade.

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BLOCKCHAIN TECHNOLOGY AND THE GENERAL DATA PROTECTION REGULATION: AN INEVITABLE CONFLICT?

By: Pedro García de Pesquera Villagrán

INTRODUCTION

In May 2017, The Economist newspaper referred to data as the "new oil"[114]. However, the stark difference between oil and data is that the product of oil does not generate more oil. In contrast, the Internet of Things is generating new data permanently, including self-driving cars, drones and wearable technology, to name a few. Moreover, the amount of data in the world is rapidly increasing. According to the most recent report from MIT, it is estimated that 20% of the world's data has been collected in the past couple of years[115]. This is why data has become the new valuable asset of companies, especially the so-called tech giants, and why it can be considered the new gold. As a result, new ways of influencing people have developed.

The modus operandi of today's internet giants including Google, Facebook, Twitter, Uber, and Airbnb all have one thing in common: they rely on users' contributions to generate value within their platforms. This value is, of course, their data[116]. Thus, the current data driven economy aims for centralizing services throughout these new digital intermediaries, which present a clear tendency not only to capitalism, but also to network effects[117].

Because of the unprecedented advancement of Blockchain technology, on 14th April 2016, the EU agreed to introduce the GDPR in order to substitute the obsolete Directive 95/46/EC66. The regulation aims to give citizens back control of their personal data and create a high, uniform level of data protection across the EU[118].

Blockchain can be thought of as a development environment, technology or data base of decentralized applications that take place on a database. Its main goal is to ensure secure and public accounting for

[114] Leaders, 'The world's most valuable resource is no longer oil, but data. The data economy demands a new approach to antitrust rules' (*The Economist*, 11 May 2017) https://www.economist.com/news/leaders/21721656-data-economy-demands-new-approach-antitrust-rules-worlds-most-valuable-resource accessed 9 June 2022.

[115] Guy Zyskind, Oz Nathan, and Alex Pentland, 'Decentralizing Privacy: Using Blockchain to Protect Personal Data' (2015) IEEE Security and Privacy Workshops 180.

[116] Primavera De Filippi, 'What Blockchain meansforthe Sharing Economy' (*Harvard Business Review*, 15 March 2017) https://hbr.org/2017/03/what-blockchain-means-for-the-sharing-economy?referral=03759&cm_vc=rr_item_page.bottom accessed 9 June 2022.

[117] Primavera de Filippi and Smari Mccarthy, 'Cloud Computing: Centralization and Data Sovereignty' (2012) 3(2) European Journal of Law and Technology 33, 66; Directive 95/46/EC of the European Parliament and of the Council of 24 October 1995 on the protection of individuals with regard to the processing of personal data and on the free movement of such data OJ L 281 [1995].

[118] European Parliament, 'Data protection reform - Parliament approves new rules fit for the digital era' (*Owes: European Parliament*, 14 April 2016) http://www.europarl.europa.eu/news/en/press-room/20160407IPR21776/data-protection-reform-parliament-approves-new-rules-fit-for-the-digital-era accessed 9 June 2022.

transactions, and its most famous feature is that the system can use its resources to self-finance its operations. That, in turn, allows the creation of companies or groups of digital bodies with a very developed sense of democracy. The users who make up these companies or groups are responsible for the ownership of their own data[119].

Regarding the interplay of Blockchain and the GDPR technology Blockchain is no longer just about cryptocurrencies and is now about the possibilities the technology offers. Many companies and projects worldwide are already implementing it in their everyday affairs despite the technology being incipient. The common belief is that Blockchain and its decentralized nature contribute to ensuring individuals' privacy. Indeed, rather than relying on the coordination activities of a centralized authority, Blockchain operates through a decentralized public ledger which is regulated exclusively by code and algorithmic rules[120].

The proposition of Blockchain technology and data decentralization gives the ledger the specific features as data storage, controller, or transferor. These attributions may on the one hand benefit an individual's data protection rights, but, on the other hand, it may raise concerns when meeting privacy law requirements, especially those protected by the GDPR.

Regarding the most controversial right outlined in the GDPR with Blockchain technology, the right to erasure, or right to be forgotten. According to article 17 of the GDPR, "a data subject should have the right to have personal data concerning him or her rectified and a right to be forgotten". This means the data controller shall have the obligation to erase personal data without undue delay when conditions of article 17.1 are met:

- The personal data is no longer necessary for the purposes they were collected or otherwise processed.
- The data subject withdraws consent on which the processing is based or where there is no other ground for processing.
- The data subject objects to the processing and no overriding legitimate grounds for processing.
- The data has been unlawfully processed.

Thus, the right to be forgotten empowers any person to correct or delete their personal

data if it is no longer necessary for the purposes collected.

Because of the immutability and transparency features presented by Blockchain, it is almost impossible to erase or change the data once it is introduced in the block and added to the chain.

[119] Joaquín López Lérida and José Juan Mora Pérez, *La economía de Blockchain Los modelos de negocio de la nueva web* Kolokium (Kolokium 2016) 32.
[120] De Filippi (n 3).

Therefore, from a transaction record management point of view, the immutability characteristic is very appealing; however, from a data protection point of view, any personal data stored must be capable of being updated and corrected and this is where the scope of the right to be forgotten and Blockchain technology may not be aligned. But on the other hand, "the right to the protection of personal data is not an absolute right; it must be considered in relation to its function in society and be balanced against other fundamental rights, in accordance with the principle of proportionality".

Therefore, the ledger's Public Key and personal data disclosed in the nodes might not comply with article 17 of the GDPR. Moreover, article 17.2 empowers a data subject to request the data controller to erase the data, considering the technology available and the cost of implementation121. At this point and because the regulation does not give the exact definition of erasure, technical alternatives have been proposed to ensure that Blockchain complies with the GDPR.

Several solutions have been proposed to ensure Blockchain complies with the GDPR around the issue of personal data disclosure and Public Keys, although, to date, none are definitive solutions, just mere experiments or proposals. "encryption alternatives", is the most radical, but very straightforward: not to introduce a user's personal data on a Blockchain. However, this drastically reduces the usefulness of Blockchain for any public application, such as, health record tracking, social media, reputation reporting systems associated with online sales, and identity systems such as an international passport[121].

Because of the nature of Blockchain, similar to the first option, a second simple and popular possibility has been presented: to store personal data in an off-chain database and store a reference to this data and other metadata Blockchain with a hash.

Following this proposal, a similar project for data storage are the so-called "sidechains". Sidechains can be considered parallel Blockchains that sit alongside the main Blockchain serving several users. In this alternative, the degree of confidentiality and privacy provided for transactions depends on what technology the sidechain uses - public or private[122].

The final solution in this first category is cryptographic hashing. The idea being that when personal data must be removed to comply with GDPR requirements, the hash corresponding to each unit of personal data will be stored in the Blockchain. Still, the unit itself will remain stored in a common external database. So, when the data controller removes data from the external database, there is correspondence with the hash in the Blockchain and therefore the information is unreachable.

Other alternatives such as "alternative cryptocurrencies", might be the ones to attract the most support as it is the solution with the most similarity to an existing Blockchain, but which complies with

[121] Chain Frong, 'Blockchain and the GDPR' (2017) Chain Frong.
[122] Winston Maxwell and John Salmon, 'A guide to Blockchain and data protection' Hogan Lovells.

the regulation. In this regard, cryptocurrencies such as Zcash[123], Monero[124] and others that might adhere to the regulation.

Since article 17 of the GDPR does not provide the exact definition of "erasure" there can be some room for interpretation on whether it means absolute deletion. Therefore, although alternatives have been proposed for acting not only in accordance the right to erasure, but with EU data protection law, whether these solutions comply with the right to be forgotten and other substantive rights of the regulation remains to be seen and would need to be analyzed case-by-case by technology developers or legal authorities.

[123] Bit2Me Academy, 'What is Zcash (ZEC)?' (*Bit2Me Academy*, 2022) https://academy.bit2me.com/que-es-zcash-zec-criptomoneda/ accessed 9 June 2022.
[124] Bit2Me Academy, 'What is Monero (XMR)?' (*Bit2Me Academy*, 2022) https://academy.bit2me.com/que-es-monero-xmr-criptomoneda/ accessed 9 June 2022.

BLOCKCHAIN-BASED FORECASTING MARKETS

By: Rutger van Bergem[125]

THE CONCEPT OF FORECASTING MARKETS

Forecasting markets are mechanisms that participants can use to get accurate answers to potentially important questions. For instance, people can be allowed to bet on the probability of an event occurring (the likelihood of a "Russian invasion of Ukraine before 2023[126]), or even on the probability of events occurring conditional on some other events ("The share price of company X will have increased 10% at the end of the next financial quarter if the current CEO is fired").

Two types of forecasting markets exist[127]; betting and prediction markets. The first type is markets that are open to the public, where everybody in the world can answer a question. The second type exists within an organization or a firm. The second type of market focuses on topics of interest to a specific organization X, such as whether firing the CEO can increase company X's share price. The latter type functions with participants from within the organization involved.

The key difference between prediction markets and betting markets is that prediction markets have a particular market maker – as opposed to betting markets - who wants a certain question answered and is willing to incentivize market participants. Indeed, market participants must be motivated to join a particular prediction market and pay attention. Money is a good incentive, but other motivators such as status and reputation as a good forecaster can be sufficient for participants to care.

Prediction of betting markets have shown to be more accurate forecasting methods, such as opinion polling or expert opinion, in forecasting election results or essential events related to corporate internal performance[128]. In short, the value for society from the use of forecasting markets lies in its ability to produce prices that contain valuable information regarding the expectations that have about important future events[129].

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[126] The forecasting market for this proposition is up at the time of writing at Metaculus, see Metaculus, 'Russian Invasion of Ukraine Before 2023' (*Metaculus*, 2022) https://www.metaculus.com/questions/8898/russian-invasion-of-ukraine-before-2023/ accessed 4 February 2022.

[127] Sintetia, 'Robin Hanson: In depth Interview on Prediction Markets' (*Sintetia*, 28 April 2014) https://www.sintetia.com/robin-hanson-full-interview-about-prediction-markets/ (accessed 7 April 2021).

[128] Adam Ozimek, 'The Regulation and Value of Prediction Markets' (2014) Mercatus Center Working Paper.

[129] J. Brito, H. B. Shadab, and A. Castillo, 'Bitcoin Financial Regulation: Securities, Derivatives, Prediction Markets, and Gambling' (2014) 16(1) STLR.

FORECASTING MARKETS USING BLOCKCHAIN INFRASTRUCTURE

Prediction and betting markets also exist on blockchains[130]. Augur[131] was developed in 2014 by the Forecast Foundation. Another comparable example of a forecasting market, using Ethereum as the platform of their services, is Gnosis[132]. These operational blockchain-based forecasting markets have mostly similar functionalities: They are open source and do not prevent any user from investing in any forecasting event of their choice, nor do they prevent anyone from creating a market for others to bet on (censorship resistance). The markets are resolved by what are called oracles that can determine whether a particular event - underlying a market- has occurred or not. To be sure, oracles[133] are not the data source itself that finalizes the market outcome but rather the querying, verification, and authentication layer that relays the necessary data. The oracle aims to resolve a forecasting market truthfully.

In the context of blockchain based forecasting markets the question is how to determine whether a specific event occurred at the expiration time when there is no broker or no form of central authority? After all, a centralized oracle in the form of a third-party website or feed seems to contradict, at least partially, the use of blockchain as the forecasting market infrastructure layer. Indeed, a third party would be in control of resolving the market - such a market could be vulnerable to cheating or other forms of opportunistic behavior from the third party controlling or outsiders compromising the oracle. The answer to the oracle problem is addressed differently for by aforementioned examples; Augur and Gnosis[134].

ADDRESSING THE ORACLE PROBLEM

Gnosis, in contrast to Augur, allows markets creators to choose between the usage of a decentralized or a centralized oracle. A centralized oracle uses a single source of data to resolve the market. A decentralized oracle in contrast, either used as the initial prediction market resolver or dispute resolution mechanism, financially incentivizes to report truthfully on relevant events. So-called reporters stake valuable crypto tokens to back an event outcome at the moment of market resolution. In case of correct reporting, they will receive a small compensation above their returned stake. The reporter's stake will be confiscated in case of untruthful reporting or other cheating behavior.

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[130] Emil Froberg, Gustav Ingre, and Simon Knudsen,'Blockchain and Prediction Markets' (2018) Inom Examensarbete Teknik.

[131] Augur can be accessed here, Augur, 'Augur: Your global, no-limit betting platform' (*Augur*, 2022) https://augur.net/ (accessed 4 February 2022).

[132] Gnosis can be accessed here, Gnosis, 'Gnosis' (*Gnosis*, 2022) https://gnosis.io/ (accessed 4 February 2022).

[133] Vallery Mou, 'Blockchain Oracles Explained' (*Binance Academy*, 22 January 2020) https://academy.binance.com/en/articles/blockchain-oracles-explained, (accessed 7 April 2021).

[134] Froberg, Ingre, and Knudsen (n 6).

Decentralized oracles query multiple data sources to validate the accuracy of the event data. The final verdict on the truthfulness of the data is done by estimating the degree of consensus backing certain event data. Augur's oracle arrives at consensus by counting reporter token votes and providing an incentive for truthful reporting. The staked crypto-tokens of reporters that do not conform with the consensus are distributed among the reporters who voted according to the consensus. Gnosis's decentralized oracle is slightly different and arrives at consensus by backing the event outcome with the most crypto-token value staked in its favor, regardless of the number of votes.

SOME ADVANTAGES OF BLOCKCHAIN BASED FORECASTING MARKETS

The question is why the blockchain-based forecasting markets might offer better tools than their centralized counterparts. As already mentioned, centralized forecasting markets might limit the types of market they are willing to list. The limitations in the offerings can be the results of regulatory restrictions or the forecasting market's reluctance to host certain markets. In principle, the decentralized alternative is permissionless from the point of view of the market maker and participants[135]. Besides, no single authority or malicious actor can easily shut the operations down, making the forecasting service resistant to censorship, barring off course the possibility of a hacker exploiting coding mistakes in the underlying smart contracts for example. Moreover, the cost of using decentralized alternatives can ultimately be lower given the absence of much of the overhead required to run the centralized alternative.

HURDLES TO BE OVERCOME

A big hurdle for blockchain-based forecasting markets are scalability issues associated with public blockchain infrastructures. Low transaction speeds and or high underlying blockchain transaction fees can result in lower than optimal market liquidity required for forecasting market accurateness. Another hurdle for wide spread implementation, is the regulatory uncertainty surrounding the legal status of forecasting markets[136]. Although blockchain based applications rely mostly not on legal rules but rather on technology, the possibility of legal enforcement could add to the trust level provided by

[135] Permissionlessness can be argued to have negative effects in terms of allowing the creation of repugnant markets where for example, markets in people's lives can be created (an example market; "Jeff Bezos is alive at the end of 2021". A small chance of dying implies a huge upside for the users that bet "yes" with obvious repugnant implied incentives for those betters.

[136] 'Polymarket' got fined $1.4 million by the Consumer Futures Trading Commission and was ordered to cease operation in the United States. US law considers unlicensed prediction markets to be illegal akin to gambling and illegal futures trading; see: Cheyenne Ligon, 'Polymarket Introduces New Information Markets After CFTC Fine, but Not for US Traders' (*Coindesk Business*, 24 January 2022) https://www.coindesk.com/business/2022/01/24/polymarket-relaunches-site-after-cftc-shutdown-but-not-for-us-traders/ accessed 9 June 2022.

blockchain based applications. The possible desirability of stopping blockchain based forecasting markets rests on underlying errors in smart contracts or oracles, or perhaps are related to the repugnancy of a particular forecasting market. A promising way of testing the possible societal implications of blockchain based forecasting markets is to offer legal comfort zones, such as sandboxes, in exchange for legal privileges for fledgling forecasting market platforms[137]. Failing to do so, will inevitably lead blockchain based forecasting markets to fully decentralize and thus escape regulatory scrutiny altogether, thereby limiting its potential use to a select few crypto natives who are able to navigate the crypto wild west. The downside off course is that the potential societal benefits of the use of forecasting markets are expected to be limited.

[137] Thibault Schrepel, 'Smart Contracts and the Digital Single Market Through the Lens of a 'Law + Technology' Approach, (2021) European Commission.

BLOCKCHAIN APPLICATION IN HEALTHCARE:

THE EXAMPLE OF FARMATRUST, MEDICALCHAIN AND E-HCERT

By: Sven Rojnić

In the following article, I will be discussing the application of blockchain-based services in the healthcare sector.

FarmaTrust [138] is a global service that provides provenance tracking for the elimination of counterfeit drugs, automation of various pharmaceutical industry processes, and customer data insights. Its blockchain-based system ensures data integrity and uses artificial intelligence and big data analysis to provide security to pharmaceutical companies, governments, regulators, and private citizens. FarmaTrust also uses smart contracts for automatic payments, regulatory reporting, tax compliance, and law enforcement notifications, which creates significant cost savings. Their digital solutions and services create efficiencies, accountability, and transparency for supply chains. They ease the burden of compliance requirements, reduce costs and eliminate counterfeit or substandard products. Finally, they make immutable and incorruptible records to ensure data integrity and full auditability.

FarmaTrust has specialized in specific services, starting with the integration of pharmaceutical supply chain management systems, from the point of manufacture to the point of consumption, utilizing blockchain technologies combined with the internet of things (IoT) and artificial intelligence (AI) services. They provide data insights to assist in finding efficiencies, better planning, focused production runs, transparency, and visibility of the complete supply chain. Great effort is also put into the clinical trials sector. Lastly, one of the greatest achievements has been made by providing more efficient and secure processes for personalized medicine, particularly for cell and gene therapy.

Medicalchain[139] is a decentralized platform that enables secure, fast, and transparent exchange and medical data usage. The goal is to put the patient in control of their medical data, giving them the power of sharing their records with desired organizations, institutions, and medical professionals. Fragmented patient records create inefficiencies and inaccuracies across the diversified healthcare system. Medicalchain uses blockchain technology to securely manage health records for a collaborative, smart approach to healthcare. It aims to integrate and facilitate many aspects of healthcare.

[138] See *FarmaTrust,* 'Digitising and Innovating the Pharmaceutical and Healthcare Business' (*FarmaTrust*, 2022) https://www.farmatrust.com accessed 9 June 2022.

[139] See MedicalChain, 'Own Your Health' (*MedicalChain*, 2022) https://medicalchain.com/en accessed 9 June 2022.

Pharmaceutical and Research Companies do not have to approach hospitals or clinics for information. Through Medicalchain they can access an accurate and up-to-date database of patients who have opted into being contacted by researchers. Following up patients is simplified with a dynamic health record that stays with the patient. Patients can grant access to their electronic health records to other users and revoke access by setting up a time-limited gateway, thereby improving their experience and guaranteeing data security. Medical insurance companies benefit from cutting out the middle man and receiving prompt, validated health information directly from patients, allowing them to access their accurate records in a cost and time-efficient way. Patients can communicate directly with doctors and share their health records for online consultations, while doctors can document the consultations directly onto the patient's health record. Giving the patients a possibility of direct, regular, and exclusive access to their health records empowers them to receive the best possible care.

E-Hcert[140] is a healthcare wallet that provides an authentic solution based on the VeChainThor blockchain for laboratory test results and vaccination certificates. It represents a new category of healthcare record systems that combines interoperability, immutability, traceability, and compliance. The E-Hcert app reduces the data storage costs, facilitates the digital transformation of healthcare, and rapidly provides secure and legit access to patient's information. It is designed to ease the management of large amounts of data produced by hospital laboratories daily. It substantially shortens patients' waiting time between taking the tests and receiving the results. The hospital does not have to contact the patient and deliver physical test results while the patient does not need a hard copy of the results, notably reducing costs and saving time.

On top of that, all the information stored and shared this way is GDPR compliant. The E-Hcert app provides a digital wallet for all the lab test results and vaccination certificates, enabling users to completely control their profile and medical records. Patient's medical records are being encrypted and uploaded onto the VeChainThor blockchain, yet only the patient, with his private key, has the possibility of accessing and further sharing them. For everyone else, they remain practically inaccessible without user's permission. Interoperability applies to all the hospitals, institutions, and patients that use the E-Hcert app. A patient can decide to share those data with any doctor at any time, which simplifies communication, reduces the costs of useless and repeated diagnostics, and improves the effectiveness of healthcare treatments.

The three services explained above are trying to solve some of the most challenging issues in the healthcare sector. Those issues have become even more prominent and urged to solve since the breakout of the Covid-19 pandemic. Despite the differences between the US and the EU healthcare systems, those problems remain common to all of them. Medical institutions – not only from the US

[140] See E-HCert, 'E-HCert, the Healthcare Wallet' (*E-HCert*, 2022) https://e-hcert.com accessed 9 June 2022.

and the EU, but the whole world likewise – are facing and trying to solve them. The Covid-19 vaccine race has probably been one of the biggest, most intensive, and financially most challenging global projects in the history of humankind. In that respect, benefits from services like the FarmaTrust, Medicalchain, and E-Hcert are more than obvious.

Blockchain-based systems with their encrypted, immutable, and incorruptible records ensure data integrity and full auditability, therefore eliminating suspicious activities and fraudulent players from the game. The vaccine development and distribution process could be faster, cheaper, more transparent, and safer. Pharmaceutical and research companies do not have to approach hospitals or clinics for information but could instead access accurate and up-to-date blockchain-based databases of patients. Patients would have control over their medical records through their digital wallets. Such wallets enable the patients to have the exclusive access to the lab test results and vaccination certificates, while giving them possibility of sharing their records with desired institutions and doctors.

The interconnection of all subjects in a healthcare sector inevitably improves patients' position. They can receive the service faster, with lower costs. The same applies to the medical system itself – it becomes more rational. Reduction of the cost of physical data and documents storage, and elimination of unnecessary and useless repeated diagnostics, significantly improves the effectiveness of the healthcare treatments. All of those improvements enhance the economical aspect by reducing the costs and step by step improve the quality of life. Shorter time between testing and receiving results generates less stress. Giving the patients a possibility of direct, regular, and exclusive access to their health records empowers them to receive the best possible care. Furthermore, data privacy is also of great importance, and blockchain-based services are perfect tools to grant users maximum autonomy and sovereignty over their data.

However, despite all the benefits, there is still a long way to go before broader adoption of blockchain technology in the healthcare sphere. Firstly, for more than obvious reasons, public blockchains or – from the perspective of blockchain advocates – the (only) real blockchains, are completely inappropriate in healthcare, thus the private or permissioned blockchains remain the only applicable option. Secondly, such technology is still relatively new and there are therefore many doubts and unknowns, additionally emphasized by lack of technical skills. Thirdly, there are big costs for adopting such technologies and introducing new applications, along with all the technical, security, and interoperability issues. Lastly but equally important, there are the upcoming regulation issues. For a big and inert systems like healthcare, every substantial change generates a high risk of possible procedural mistake or technical error. In healthcare particularly, those risks can result in fatal consequences and shall therefore be avoided or reduced to minimum. Nevertheless, in the long run –

once all the obstacles are overcome – the benefits that emerge from the use of blockchain technology are more than obvious.

Legal regulation of blockchain technology in healthcare shall not be an insuperable challenge. Regulation shall be minimal and provide a legal frame for the use of such technology, without restraining technology's potential and mitigating broad range of advantages it offers. Like in many other situations, not every new technical discovery or new technology requires a new law or set of laws. Very often, they can simply fall under the interpretation of an existing law using deduction or analogy. Numerous and up-to-date laws and regulations such as internet and data security laws, health laws, GDPR, etc., can all be applied to the use of blockchain technology in healthcare. Permissioned system of a private blockchain, based on the special permission of a controlling body, being that a national or supranational (e.g. EU) regulator, along with the aforementioned existing laws, offer a sufficient and reliable legal frame.

BLOCKCHAIN TECHNOLOGY IS MAKING ITS WAY INTO PUBLIC SERVICES: THE EXAMPLES FROM GEORGIA AND ESTONIA

By: Sven Rojnić

In the following article, I will be discussing how blockchain technology can impact the quality of public services.

In 2016, the Republic of Georgia had teamed up with Bitfury blockchain company and a renowned Peruvian economist Hernando de Soto to launch a blockchain-based land registry pilot project[141]. The goal was to strengthen the property owners' rights, enhance citizens' trust in government and reinforce data security, which is possible to achieve due to the main blockchain features: immutability and auditability. Timestamping feature integrated into the land registry provides citizens with digital certificates of their assets backed with a cryptographic proof called hash. The hash is published to the blockchain, enabling the document owners to prove their legitimate ownership of the property by showing their timestamp. The timestamp cannot be altered. Therefore, the information about a property title cannot be altered either because any such attempt would be publicly visible to everyone on the blockchain network. This makes a blockchain-based land registry transparent and corruption-proof.

Estonia is a fascinating example of the country that has, in only two decades, transitioned from an ex-socialist country to the most advanced digital society in the world. E-Estonia[142] is a comprehensive project run by the Estonian government to facilitate citizens' interactions with the state through electronic solutions. 99% of governmental services are online, creating a society with more transparency, trust, and efficiency. It all started in 1994 by creating a national information policy. From that point, every year, new projects were introduced like e-banking, m-parking, e-id, digital signature, i-voting, or e-health, to name some of them.

On top of that, certain features like blockchain technology or government artificial intelligence (AI) strategies have considerably impacted on a global scale. Estonians have an electronic ID card to more easily access public services. They can use it to sign documents, file tax forms, pay parking, transfer money and even start a company. Another service that has greatly impacted is the e-ambulance app that allows medical personnel immediate access to patients' medical records and is likewise used for

[141] See National Agency of Public Registry, 'Land Registration Reform' (*National Agency of Public Registry*, 2022) https://napr.gov.ge accessed 9 June 2022; BitfuryExonum, 'Improving the security of a government land registry' (*BitfuryExonum*, 2022) https://exonum.com/story-georgia accessed 9 June 2022.

[142] See E-Estonia, 'We have built a digital society and we can show you how' (*E-Estonia*, 2022) https://e-estonia.com accessed 9 June 2022.

telemedicine. Estonian example shows that blockchain technology can make a significant impact by literally saving lives, apart from saving money and time. However, blockchain technology has so far most commonly been used for security and data integrity.[143]

Another futuristic Estonian project is e-residency[144]. Starting from 2014, Estonia became the first country to introduce a transnational digital identity available to anyone in the world, a step that the Estonian government explains as "moving towards the idea of a country without borders". E-residency enables digital entrepreneurs interested in administering a location-independent business to start and manage an EU-based company online. The whole process is managed online through a modern, intuitive, and straightforward interface, which enables its users to register quickly and efficiently and start a business in no time with minimal costs. Non-residents (now e-residents) who work as digital nomads, freelancers, or simply want to open a startup company can apply to have a smart ID card issued by the state. It provides the same access to Estonia's various electronic services that a physical resident would be given. The card is protected with a PIN code that allows e-residents to register a company over the internet, digitally sign documents, exchange encrypted documents, find tax accountants, legal consultants, payment providers, etc. The list goes on, and other services gradually become available as the scheme is expanded. However, while e-residency provides access to these services, it is not related to citizenship. Therefore, it does not grant the right to enter or reside in Estonia physically, nor the ability to use the smart ID card as physical identification or as a travel document.Public services have been a domain with the most frequent interaction between governments and private entities, both natural and legal persons. Traditionally, this type of service and interaction was presumably upheld for citizens and foreigners living within the country's jurisdiction. On the other side, the Estonian e-residency project is backed by the idea of *a country without borders*. It therefore stands out as one of the examples that can challenge such traditional policies and slowly re-shape them by fading out the current boundaries. Once again, this process has been backed by the blockchain technology, which has been used to ensure the secure use of sensitive data.[145]

There are many blockchain-based use cases that can be implemented in the public services that could generate many positive effects. It's impossible to indicate all of them in a short article, but the most obvious ones that emerge from the use cases aforesaid shall be pointed out. Public services generally require many public officials, thus creating an inert administrative apparatus that often becomes its *raison d'être*. Even setting aside that such apparatus generates immense expenses, it often conducts

[143] See GovChain, 'Estonia' (*GovChain*, 2022) https://govchain.world/estonia/ accessed 9 June 2022.

[144] See Republic of Estonia: E-Residency, 'The New Digital Nation' (*Republic of Estonia: E-Residency*, 2022) https://e-resident.gov.ee accessed 9 June 2022.

[145] See Daniela Godoy, 'e-Residency joins forces with the UN to empower entrepreneurs in the developing world' (*E-Estonia*, 15 September 2017) https://e-estonia.com/e-residency-joins-forces-with-the-un-to-empower-entrepreneurs-in-the-developing-world/ accessed 9 June 2022.

purely automatic and routine tasks, causing severe inefficiencies. Both the issues could quickly be resolved with blockchain-based applications. Being time and cost-saving is only a top layer of easily visible benefits. Blockchain technology could potentially disrupt public services on a larger scale.

Starting a business in Estonia could be useful for internet entrepreneurs in emerging markets who don't usually have access to an online payment provider. The same applies to startups from developing and less-developed countries that suffer from financial and technical limitations. In general, blockchain-based services and blockhain-supported technology could give the people from those countries an opportunity equal to those from developed countries, that would otherwise be inaccessible[146]. Having a possibility of paying with cryptocurrencies instead of national currencies, having access to blockchain-based (mobile) financial services instead of traditional banking institutions, or using blockchain-based food supply chain management, to name some of many.

Another example is a blockchain-based land registry that could allow billions of people who currently do not have a possibility to legally register their property, to successfully do so. Such registries preclude the need for physical storing and risk of destroying, thus losing all data. In addition, blockchain-based land registries ensure a level of security that guarantees to eliminate frauds and adequately protect such a capital property like a house or land. Blockchain technology seems to possess a tremendous potential to impact public services in general. It can enhance transparency and trust in public services, hence in government. Some of its features justify the impression of building a corruption-proof system. A question is: is there a political will to make it?

The above examples from Estonia or Georgia could serve as a basis for a pilot project that could be used for the implementation on a supranational level. For example the EU. A few neigbouring countries or coutries with intense economic and social interaction could team up to create a regulatory sandbox. Implementing e-health, e-ambulance or e-residency ideas on a supranational level could result in many benefits. The benefits that Estonian citizens enjoy in their country could be used by a much broader number of people. The advantages that the people from developing and less developed country enjoy in Estonia, could be now used in all the EU countries by having access to their e-services. On top of that, the Estonian example shows that the blockchain technology itself does not neccesserily interfere with the existing laws and might not require any specific regulation.[147]

[146] See Energypedia, 'Blockchain Opportunities for Social Impact in Developing Countries' (*Energypedia*, 2022) https://energypedia.info/wiki/Blockchain_Opportunities_for_Social_Impact_in_Developing_Countries accessed 9 June 2022.

[147] See GovChain (n 3).

A CASE FOR BLOCKCHAIN-BASED VOTING APPLICATIONS TO REINFORCE PUBLIC TRUST IN ELECTIONS

By: Thymo P.J. Burgemeester

INTRODUCTORY COMMENTS

This short article will cover four blockchain-based applications in the voting space. By discussing these applications in the context of recent developments regarding major political elections, this article sets out to illustrate how blockchain-based applications can improve the 'traditional voting process' and potentially reinforce public trust in the outcome of political elections.

BLOCKCHAIN-BASED APPLICATION THAT CAN REINFORCE TRUST IN THE VOTING PROCESS

Due to the unique technical capabilities and characteristics of blockchain-based applications – including its decentralized nature, the privacy it can offer to its users, and its technical immutability - they have the potential to improve various aspects of 'the traditional voting process.'[148] Utilizing blockchain-based voting applications can offer concrete remedies to concerns that some might have with the traditional voting process and is thereby very likely to increase *trust* in the validity and outcome of a vote.

> **Quick technical recap** | In short, blockchain-based applications are generally speaking characterized by their *decentralized*, *encrypted* and *immutable* nature. Furthermore, blockchain technology allows users to be 'pseudonymous,' thereby shielding one's personal identity from the outside world, while – depending on the way in which the software is designed – making it possible to trace one's 'pseudonymous identity' back to a 'real identity', e.g. when required for verification purposes. These characteristics make that blockchain technology is very well suited to accommodate processes where transparency, reliability, verification, accuracy, and privacy are key.

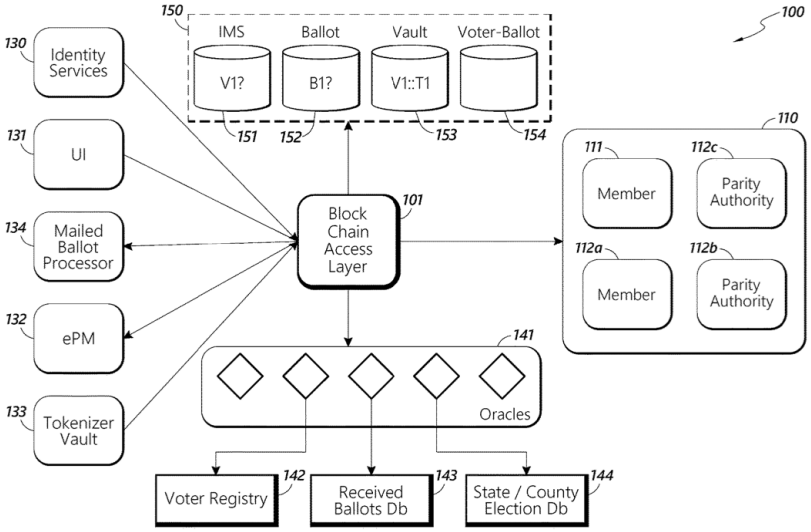
The following examples illustrate what blockchain-based voting applications can look like in practice and underline how blockchain-based applications can be used to optimize the voting process.

[148] Where ballots are being cast physically (on a designated location) and subsequently predominantly counted by hand.

U.S. Postal Service's Secure voting system | On February 7th, 2020, the U.S. Postal Service (**USPS**) filed a patent application in the U.S. for their *Secure voting system,* which is based on blockchain technology.[149] In their application, the USPS fittingly states:

> *"(...) those holding elections wish to be able to ensure that election results actually correspond to the votes that were cast. In some embodiments, a blockchain allows the tracking of the various types of necessary data in a way that is secure and allows other to easily confirm that data has not been altered."*

The USPS explains how voting systems can benefit from the combination of mail services and the security that blockchain offers to provide a reliable voting system.[150] In short, the way this system would work is that a registered voter receives a (Q.R.) code in the mail that is used to confirm one's identity and the correct ballot information before one can cast a vote. Their vote will be automatically be stored and registered on a distributed ledger in a blockchain, ensuring transparency, reliability and allowing for accurate verification.[151] The application adds that the system is designed to separate voters' identification form the casted votes, to ensure complete anonymity. [152]



A visualization of what the system would look like[153]

[149] U.S. Patent Application No. US 2020/0258338 A1 (publicised Aug. 13, 2020).
[150] Ibid.
[151] Ibid.
[152] Ibid.
[153] Ibid.

Test case for electronic voting based on blockchain technology in Zug, Zwitserland | In 2018, the city of Zug (Switzerland) offered its citizens the option to vote on topics through a blockchain-based e-voting platform, developed by Luxoft (a Swiss software company), in collaboration with Hochschule Luzern's Blockchain lab and the city of Zug.[154] Local authorities hailed the e-voting trial as a success, and results of the small-scale survey carried out by the city of Zug showed that its residents welcome the use of e-voting in the city.[155]

On a more technical level | Luxoft states the following in a press release regarding the platform:

"Luxoft built the permissioned blockchain-based solution e-Vote, including the platform itself, software, and algorithms on Hyperledger Fabric. This was then integrated with Zug's Ethereum-based digital I.D. registration application, enabled by uPort, to allow residents to cast votes on the blockchain. The solution uses an innovative encryption technology that on the one hand anonymizes the votes and on the other hand allows tamper-proof tally and secure audit."[156]

"By distributing the data into three different data centers, security and data loss risks are distributed geographically, making the system more robust."

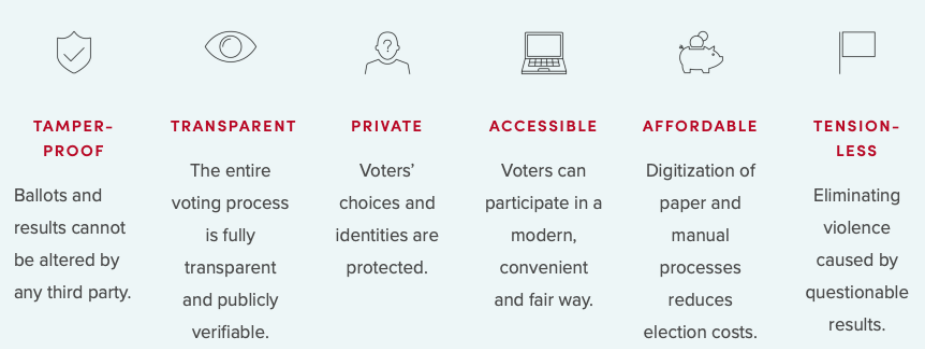
Agora voting | Agora is a private corporation whose core business revolves around services tailored to organizations with large-scale voting needs.[157] According to their website, Agora's systems are built on top of a custom blockchain and provide a *"trustless, digital and decentralized method of generating cryptographically secure records, which also preserve the anonymity of participants while remaining open to public inspection. Applied to voting, blockchain ensures that votes are recorded accurately, transparently, permanently and*

[154] Luxoft, 'Report on Switzerland's First Blockchain-Based Vote Reveals Citizens Want More e-voting' *(Luxoft,* 30 November 2018) https://www.luxoft.com/pr/report-on-switzerlands-first-blockchainbased-vote-reveals-citizens-want-more-evoting/ accessed 9 one 2022.
[155] Id; Swissinfo, 'Switzerland's first municipal blockchain vote hailed a success' *(Swissinfo*, 2 July 2018) https://www.swissinfo.ch/eng/crypto-valley-_-switzerland-s-first-municipal-blockchain-vote-hailed-a-success/44230928 accessed 9 June 2022.
[156] Luxoft, 'Luxoft's E-Voting Platform Enables First Consultative Vote based on Blockchain in Switzerland' (*Luxoft*, 25 June 2018) https://www.luxoft.com/pr/luxofts-evoting-platform-enables-first-consultative-vote-based-on-blockchain-in-switzerland accessed 9 June 2022.
[157] Agora, 'What is Agora' (*Agora*, 2022) https://www.agora.vote/about accessed 9 June 2022.

securely".[158] Agora's system has been used to pilot the national government vote in Sierra Leone d.d. March 2018, where their protocol was used to record votes from a sample of polling stations on their blockchain ledger. According to Agora, the pilot was very successful, and using their software; they were able to provide reliable election results days ahead of the manual tally process.[159]

> **On a more technical level** | In order to maintain a high level of security while allowing anyone, anywhere to verify election results, Agora's system combines cryptography with two layers of participatory consensus security infrastructure. [160] They use a hybrid permission/permission-less model – used by a 'global community of node operators' – who are incentivized to verify election results by a token mechanism.[161]

Therefore, according to Agora, their system is an improvement to 'traditional voting' and is considered to be:



[162]

Ballotchain | Ballotchain uses blockchain technology to allow for an online vote with 'the same guarantees of a public election.'[163] According to Ballotchain, their software can be used to facilitate an online voting system that can be accessed from basically all personal-usage devices connected to

[158] Id; for more about the technical specifications of Agora and what their services entail, see: Agora, 'Bringing our voting systems into the 21st century, Whitepaper Version 0.2' (2015) Agora.
[159] Agora (n 10); Agora, 'Blockchain is the key technology which unlocks Agora's mission of spreading secure and transparent elections around the world' (Agora, 2022) https://www.agora.vote/technology accessed 9 June 2022.
[160] Ibid.
[161] Ibid.
[162] Agora, 'Bringing voting systems into the digital age' (*Agora*, 2022) https://www.agora.vote accessed 9 June 2022.
[163] Reply, 'Ballotchain' (*Reply*, 2022) https://www.reply.com/en/content/ballotchain accessed 9 June 2022.

the internet and offers: '(I) secure and anonymous votes, which can be verified at any moment; (II) impossibility to vote twice or to commit electoral fraud; and (III) low operational costs.[164]

SOCIETAL CONTEXT

Especially during the past year, the voting process in political elections across both the European Union (**E.U.**) and the United States of America (**U.S.**) have been subjected to a high level of criticism and public scrutiny. A significant point of concern for many was the introduction of 'new ways to vote' in major political elections, prompted by the consequences of the outbreak of the coronavirus SARS-CoV-2 (**COVID-19**) and the subsequent pandemic.[165]

> Examples include the recent Presidential election in the U.S. and the parliamentary election in the Netherlands. In their respective elections during the COVID-19 pandemic, both countries introduced the option to cast a vote by 'mail-in voting.' While in both countries, mail-in voting has proven to be an effective solution, many claimed that mail-in voting is a major concern for the legitimacy of elections, and those opposing this method have even gone as far as to link mail-in voting to voter fraud.[166]

> However, it is important to emphatically remark that there has been no legitimate, verifiable evidence whatsoever to substantiate claims amounting to 'general widespread voting fraud' in both the U.S. and the Netherlands. Neither is there any sound evidence showing the illegitimacy of mail-in voting. When challenged in legal procedures, courts in both the U.S. and the Netherlands have upheld its legality.[167]

However, despite the lack of evidence to substantiate the aforementioned claims, the unprecedented events of last year have laid bare how citizens can sometimes *perceive* the voting process as opaque and even unreliable.

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[164] Ibid.

[165] See: Yochai Benkler and others, 'Mail-In Voter Fraud: Anatomy of a Disinformation Campaign (2020) 6 Berkman Center Research Publication.

[166] Ibid.

[167] Case C-09-606858 -KG ZA 21-104 *Vereniging Partij voor de Dieren v de Staat der Nederlanden* ECLI:NL:RBDHA:2021:1305 [2021]; see also Sam Levine, 'US supreme court deals setback to Republicans over mail-in voting in key states' (*The Guardian*, 29 October 2020) https://www.theguardian.com/us-news/2020/oct/28/pennsylvania-elections-ballot-extension-supreme-court accessed 9 June 2022.

SUMMARY OF THE POTENTIAL OF BLOCKCHAIN-BASED VOTING APPLICATIONS

Based on the cases discussed in this article, one could argue that that blockchain-based voting applications have the potential to remedy (often unfounded) concerns that exist with regards to the transparency and reliability of traditional voting, including those concerning mail-in ballots and can therefore help to reinforce public trust in voting processes, for instance in political elections. As set out above, blockchain-based voting applications can be designed in a way that is: (I) tamper-proof; (II) transparent; (III) safeguarding voter privacy; (IV) easily accessible; (V) affordable; (VI) decentralized; and (VII) more robust than the traditional voting process.

LEGAL IMPLICATIONS

Substantial changes to the voting process, including alteration of the voting system, should be vetted, and tested carefully prior to real-world implementation. In order to achieve the desired result and enhance public trust in voting, the system designed to do so should not only be technically solid but also designed to functions in a real-world-setting, accounting for human emotion and interaction. This means that, next to being tamperproof and transparent, the system should be designed in a way that exudes confidence in its well-functioning and is able to remove skepticism, as a prerequisite to real-world-success. It should be able to earn the trust of those that understand the ins and outs of the underlying technology, as much as from the people who don't.

Therefore, the testing and optimization of the system, should include interaction with a broad variety of real people, in a real-world setting. One might trust a system in a lab environment, but what does it take to get one to believe (new) technology when a democratic vote is on the line? A good way to get a grasp on how this can be achieved and where potential bottlenecks are, is the creation a regulatory sandbox. This way, actual people can use a (draft) version of the application in real-world-conditions. The output of this trial will be invaluable to the optimization of the application and a suitable way to introduce the concept to the public, that one might one day be using it.

CONCLUDING REMARKS

While more research is necessary to identify the concrete upsides and drawbacks of specific blockchain-based voting applications, the above shows that these applications have great potential. Furthermore, more research is required to determine how this application could impact public trust regarding elections. That being said, the advantages that blockchain-based voting applications offer compared to traditional voting systems and procedures appear to be well suited to enhance transparency and reliability and could potentially be more cost-effective.

HEALTH PASSPORTS ON BLOCKCHAIN

By: Vassupradha Rengarajan

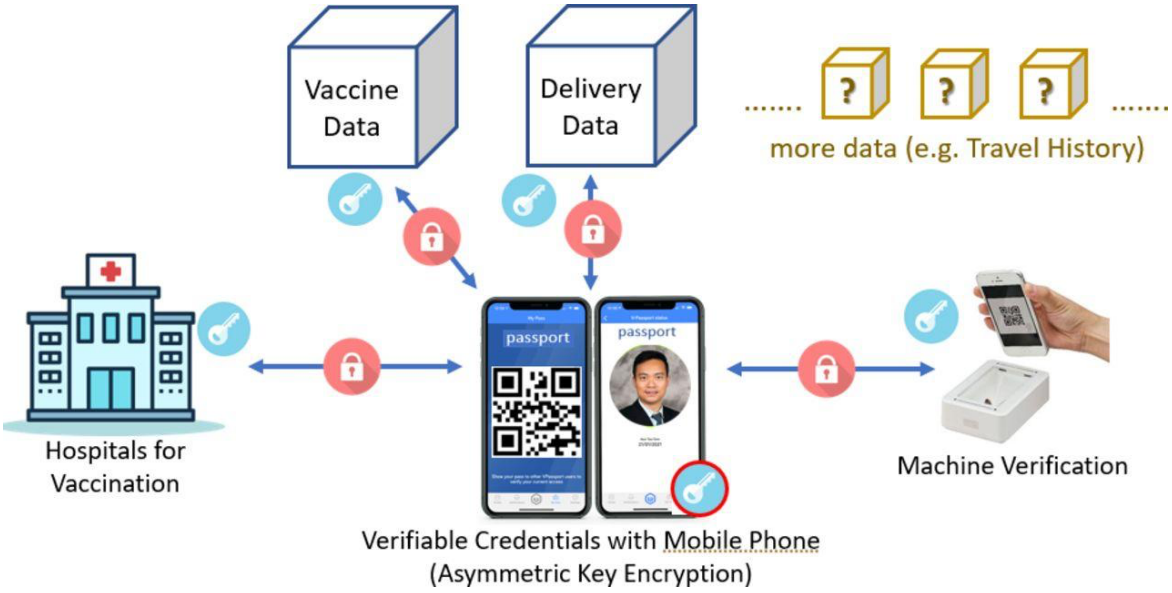
WHAT IS A HEALTH PASSPORT AND HOW BLOCKCHAIN IS RELEVANT?

The COVID-19 has affected various sectors globally, travel being an important one. The decision to travel is not an easy one to make, and the decision to allow people to travel has become even more difficult for the governments and tourism and travel-related industries around the world. To make traveling safer and curtail the spread of COVID-19, various countries have adopted safety guidelines and precautionary rules, such as requiring compulsory negative test results for COVID-19 before boarding the flights and requiring proof of vaccination before allowing people to travel. These concerns have been handled not only by the respective governments but also by the industries mainly related to tourism and travel.

To make the implementation of such rules easier and to ensure the safety and security of the people, various organizations have been coming up with different ideas, and the 'Health Passport' is an interesting one amongst them. Some also call them 'Vaccine Passport', but the term 'Health Passport' has a broader connotation, discussed later in this article. The most important aspect of these Health Passports is the majority of them are built digitally on the blockchain technology. It is mostly developed as an application or a digital certification that contains the health records, mainly the COVID-19 records of the individuals. Blockchain uses a distributed ledger system called Distributed Ledger Technology (DLT) to keep the records within the chain. The ledger itself isn't centralized but distributed to all the computers. Meaning, we need the same and accurate signature/ credential to access the records via blockchain. If a new version, different than what is tracked in the DLT is introduced in the system, it will be rejected as the signatures will not match, thereby will preventing manipulation of records.

The figure below published by BMJ Journal in the article titled "The way forward after COVID-19 vaccination: vaccine passports with blockchain to protect personal privacy"[168] is helpful to understand the application of blockchain over Health Passports.

[168] Kelvin K F Tsoi and others, 'The way forward after COVID-19 vaccination: vaccine passports with blockchain to protect personal privacy' (2021) 7 BMJ Innovations 337-341.



PROMINENT CASES OF BLOCKCHAIN-BASED HEALTH PASSPORTS

1) Singapore the forerunner and its DHP:

Singapore was one of the first countries to test the concept of Health Passport on blockchain technology successfully. Government-owned investment firm SGInnovate [169] and local startup Accredify jointly developed the "Digital Health Passport (DHP)" in September 2020 to support medical records management. Work on the application began in May 2020 during the height of the global pandemic, when SGInnovate roped in Accredify to join the project.[170] Following the pilot's success in July 2020, DHP began to be extended to the travel industry to help facilitate checks and verifications on the health status of travelers as borders gradually reopen. DHP is also part of a trial by the Singapore Airlines to validate travelers' medical records to facilitate the return to air travel. Clinics in Kuala Lumpur and Jakarta will issue digital test result certificates that travelers can use to progress through immigration checkpoints seamlessly. DHP will also allow people to prove their compliance with the entry requirements for large venues and events. Simon Gordon, Deputy Director — Venture Building, SGInnovate added that "there are many challenges related to data interoperability in healthcare completely unrelated to COVID-19 as well. We have already been approached by stakeholders about a number of specific pain points that they believe we can help with."

[169] SGInnovate, 'A Digital Health Passport for Travelling in a Post-COVID-19 World' (SGInnovate, 13 January 2021) https://www.sginnovate.com/blog/digital-health-passport-travelling-post-covid-19-world accessed 9 June 2022.
[170] Eileen Yu, 'Singapore touts blockchain use in COVID-19 data management' (*ZDNet*, 30 September 2020) https://www.zdnet.com/article/singapore-touts-blockchain-use-in-covid-19-data-management/ accessed 9 June 2022.

2) ICC AOKpass on the Ethereum permissionless blockchain:

In May 2020, the International Chamber of Commerce (ICC) launched "ICC AOKpass"[171], a digital health pass supported by International SOS, allowing users to safely present medical records to border authorities and government administrations without compromising their personal medical data. ICC AOKpass has been piloted by Alitalia, Air Caraïbes, Air France, Etihad Airlines, French Bee, Singapore's Immigration and Checkpoints Authority, and Girona in Catalonia, Spain. ICC AOKpass uses distributed ledger technology based on the Ethereum permissionless blockchain. The difference between permissioned and permissionless blockchain is that a permissioned blockchain requires user approval to join and is generally used for enterprise purposes, whereas a permissionless blockchain is used for public purposes that require less transparency and control[172]. The AOKpass platform also employs hashing and encryption algorithms to protect user data and maintain system security.

3) The Excelsior Pass:

Another interesting case of blockchain use is the "Digital Health Pass[173]", built on IBM Blockchain and is described as a way for organizations to verify health credentials for employees, customers, and visitors entering their site based on the criteria specified by the organization. New York and IBM launched the COVID-19 pilot Digital Health Pass, calling it "Excelsior Pass" in March 2021. Privacy is central to the solution, and the digital wallet can allow individuals to maintain control of their personal health information and share it in a secure, verifiable, and trusted way. Individuals can share their health passes to return to the activities and things they love without requiring exposure to the underlying personal data used to generate the credential.

4) Travel Pass for the international travel:

In December 2020, the International Air Transport Association (IATA) announced that it is developing a new digital health credential solution that can reopen international travel and replace compulsory quarantine measures. IATA "Travel Pass[174]" is a mobile application based on decentralized block chain technology, which will help people travel with ease while meeting any government requirements for COVID-19 tests or vaccines. The IATA Travel Pass has four open and

[171] Aokpass, 'A secure way to present medical information' (*Aokpass*, 2022) https://www.aokpass.com/ accessed 9 June 2022.
[172] Jake Frankenfield, 'Permissioned Blockchain' (*Investopedia*, 24 January 2022) https://www.investopedia.com/terms/p/permissioned-blockchains.asp accessed 9 June 2022.
[173] IBM, 'IBM Digital Health Pass' (*IBM*, 2022) https://www.ibm.com/products/digital-health-pass accessed 9 June 2022.
[174] IAA, 'IATA Travel Pass Initiative' (*IATA*, 2022) https://www.iata.org/en/programs/passenger/travel-pass/ accessed 9 June 2022.

interoperable modules that create the end-to-end solution. IATA Travel Pass incorporates; 1) Global registry of health requirements 2) Global registry of testing/vaccination centers 3) Lab App, and 4) Contactless Travel App.

5) South Korea's COOV:

South Korea announced in April 2021 about their plan of introducing "Vaccine Passport" or "Green Pass" built on blockchain technology. It has been noted[175] that Korea's Green Passport is being donated by Blockchain Labs, which developed the InfraBlockchain, a Korean enterprise blockchain solution. Korea launched the COOV app, deriving its name from the phrase "COVID overcome". The app is now used in the "Living with COVID" campaign. Korea Disease Control and Prevention Agency (KDCA) published about COOV in their website[176] and stated that, "Countries around the world are actively discussing the needs for, and trying to implement vaccine passports. However, if each country develops its own system, the lack of interoperability among those systems will inevitably prevent their uses abroad. To address the lack of standardized system, Blockchain Labs Inc. have developed PASS INFRA, a global vaccination verification and management solution, and are providing it to all governments and organizations for free. Starting with South Korea's COOV, PASS INFRA is being provided to the Linux Foundation and numerous other countries".

HEALTH PASSPORTS ON NON-BLOCKCHAIN PLATFORMS

In addition to these blockchain-based Health Passports, there are other solutions such as CommonPass[177], CoronaPass[178], Israel's Green Pass[179], EU's Digital Health Certificate[180], and so on, developed on non-blockchain technologies. The benefits of a blockchain-based system for maintaining health care records are manifold: records are stored in a distributed way (they are public and easily verifiable across non-affiliated provider organizations), there is no centralized owner or hub for a hacker to corrupt or breach, data is updated and always available whereas data from disparate

[175] Ledger Insights, 'Korea to launch blockchain-based vaccine certificate this month' (*Ledger Insights*, 1 April 2021) https://www.ledgerinsights.com/korea-to-launch-blockchain-based-vaccine-certificate/ accessed 9 June 2022.
[176] NCV, 'PASS INFRA: A Global Vaccination Verification & Management Solution' (*NCV*, 2022) https://ncv.kdca.go.kr/menu.es?mid=a12509000000 accessed 9 June 2022.
[177] CommonPass, 'CommonPass' (*CommonPass*, 2022) https://commonpass.org/ accessed 9 June 2022.
[178] CoronaPass, 'Protecting lives and livelihoods' (CoronaPass, 2022) https://www.coronapass.org/home accessed 9 June 2022.
[179] Israel Ministry of Health, 'Green Pass' (*Israel Ministry of Health*, 2022) https://corona.health.gov.il/en/directives/green-pass-info/ accessed 9 June 2022.
[180] European Commission, 'Questions and Answers – Digital Green Certificate' https://ec.europa.eu/commission/presscorner/detail/en/qanda_21_1187 accessed 9 June 2022.

sources is brought together in a single and unified data repository[181]. But it is also to be considered that blockchain was designed for transactions, not data, so sending it tends to eat up a ton of bandwidth. That means it's slow, possibly limiting its use for emergency services[182].

LEGAL COMPLICATIONS

It is well known the blockchain presents challenges to the existing and legal regulatory framework. Mainly, the issue of privacy and blockchain technology has been widely debated. Even though the countries have made drastic improvement in formulating legal and regulatory policies around the blockchain, the existing framework still looks inadequate to protect 'data' in the world of blockchain. The original purpose of blockchain was to facilitate peer-to-peer transactions without the need of a central party. In a permissionless public blockchain system, no single party takes responsibility for the availability or security of a particular blockchain network, and all users of the system may have access to the data on the network. These attributes conflict with the thrust of privacy laws, which require the party controlling personal data of an individual to safeguard the security and privacy of that data on behalf of the individual or "data subject".[183] In order to have efficient legal protection around the blockchain based Health Passports, and to make it easier for the regulators, the technology leaders along the governments should start employing the blockchain technology for public purposes such as Health Passports, and should provide proof of concept indicating the scalability of these projects.

THE GOOD NEWS

On a general note, to digital health passports, the solution may be ineffective globally as there is a considerable population that still does not own a smartphone[184]. But the good thing is, the numbers are continually growing. The governments and technology companies need to be more responsible in providing a safe and sound system to maintain authentic health records. With proper plan and execution, and with the support of global technology leaders, blockchain technology could be an efficient solution as they provide scalable and tamper-proof global electronic record system.

With particular regard to the Vaccine Passports, countries worldwide need to arrive at a standardized vaccine administration and records management rules for digitalization to be effective. Blockchain-

[181] Wunderman Thompson, 'Health' (Wunderman Thompson, 2022) https://www.wundermanthompson.com/expertise/health accessed 9 June 2022.
[182] LexisNexis Risk Solutions, 'The blockchain story is still being written: White Paper' (2018) LexisNexis Healthcare.
[183] John Salmon and Gordon Myers, 'Blockchain and Associated Legal Issues for Emerging Markets' (2019) EMCompass.
[184] Laura Silver, 'Smartphone Ownership Is Growing Rapidly Around the World, but Not Always Equally' (*Pew Research Center*, 5 February 2019) https://www.pewresearch.org/global/2019/02/05/smartphone-ownership-is-growing-rapidly-around-the-world-but-not-always-equally/ accessed 9 June 2022.

based Vaccine Passports could be a great start for maintaining health records securely, resulting in a drastic reduction in cases of breach of Personally Identifiable Information (PII) and Protected Health Information (PHI). These Vaccine Passports could potentially lay a longstanding road to Health Passports. Blockchain-based Health Passports could facilitate the individuals and healthcare organizations to maintain, access, and utilize health care records to gain and provide uninterrupted medical services worldwide.

NOT SO GOOD NEWS

Although these solutions are revolutionary, data sharing guidelines and procedures must be exhibited for blockchain solutions in healthcare to go mainstream[185]. Unfortunately, the healthcare industry could be reluctant to innovate. Findings from Deloitte's 2020 Global Blockchain Survey[186] indicate that out of 1,488 senior executives, 63% view digital identity as "very important". However, only 9% saw the use of digital identity progressing in the healthcare industry.

FINALLY, SOME HOPE

As Drew Ehlers, the global futurist, and the global general manager of SmartPack, Office of the CTO at Zebra Technologies stated,[187] "If we want to open the world economy and enable everyone to move forward with their lives, including consumers who don't have access to mobile technology, we must work together to stand up this technology framework."

Even though there are many concerns to be addressed for using blockchain technology in building Health Passports, it is a great solution to address the existing privacy issues in health records. With more discussions in the global arena and necessary support from the governments, there is no doubt that the increase in blockchain-based health passports will revolutionize the concept of digital health records around the globe.

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[185] Rachel Wolfson, 'Safe and Sound: Blockchain-Backed Digital Identity in the Post-Coronavirus Era' (*CoinTelegraph*, 24 June 2020) https://cointelegraph.com/news/safe-and-sound-blockchain-backed-digital-identity-in-the-post-coronavirus-era accessed 9 June 2022.

[186] Deloitte Insights, 'Deloitte's 2020 Global Blockchain Survey: From Promise to Reality' (2020) Deloitte Development.

[187] Drew Ehlers, 'Is Blockchain the Answer for COVID Vaccine Passports?' (*Government Technology,* 31 March 2021) https://www.govtech.com/opinion/Is-Blockchain-the-Answer-for-COVID-Vaccine-Passports.html accessed 9 June 2022.