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DECENTRALISED GOVERNANCE THROUGH BLOCKCHAIN

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ABSTRACT

This paper explores the application of blockchain technology to decentralised governance. More specifically, it examines the potential of blockchain in creating self-governing ecosystems that help manage shared resources effectively. The paper uses the late Nobel laureate Elinor Ostrom's model of decentralised governance to prove that effective resource management can be undertaken through a system that facilitates and rewards cooperation, as well as punishes parties that violate key principles and laws. This can be achieved without the overriding authority of the state imposing its will on the participants of that said ecosystem. Blockchain is presented as a transformative mediating platform that enables players within a given system to function without the fear of being undercut or cheated. Blockchain has the potential to revolutionise the way nations, societies, and industries engage with each other. As the 21st century progresses, adopting blockchain will go a long way in aiding Singapore's digital transformation and supplementing its goal of becoming the digital hub of Southeast Asia.

1. INTRODUCTION

James Madison, often known as the “founding father” of the US Constitution, once remarked that if men were angels, governments would not be required. This principle forms the basis of modern statecraft. In a world of nation-states, the role of government has become crucial for development and stability. To this end, laws are created to facilitate exchange between human beings as well as ensure their proper conduct with one another. Without laws, rules or regulations, the state would descend into anarchy. Hence, modern states, particularly developed ones, have strong institutions that guarantee rule of law. Equal treatment before the law enshrines trust in the government. It also inspires confidence amongst a state’s citizenry. This is further cemented by the state’s commitment to protecting the lives and property of its people. The combination of these factors allows people to go about their daily activities safe in the knowledge that they are under no threat from internal and external dangers.

In the 21st century, governance mechanisms have been placed under immense strain by the forces of nationalism and deglobalisation. The addition of technology to the equation destabilises things further. For a time, digitalisation was thought of as a solution to the problems of censorship and bureaucratisation. Technology would not only make information easily available, but also enable the state to expedite certain processes. While great strides have been made in the utilisation of technology for things like online transactions and information-sharing, certain problems have also arisen. The vices of human nature are now being translated to the digital space. The human tendency to gain an advantage at the expense of others has never dissipated.

Rather, it has been rejuvenated by the sudden availability of technology. As such, digital fraud has become of particular concern. Technology has now become a vehicle for con artists and scammers to prey on the vulnerable. This is due to the sometimes nebulous and uncontrollable nature of the Internet. A state can try to curb these practices through proper safeguards. However, by and large, it may not be able to identify the culprits responsible for robbing people of their life savings for

instance. The anonymity of the Internet has emboldened the worst excesses of man and given unscrupulous individuals the means to cover their tracks.

However, just as technology has accentuated certain problems, it can also resolve them. In this vein, blockchain technology has the potential to change the way people deal with one another. The inherently transparent nature of this technology allows stakeholders to precisely track the status of their assets and determine if they have been tampered with.

This paper will employ a qualitative and quantitative approach to the application of blockchain to decentralised governance in Singapore. It will start off by fleshing out the theoretical framework of Elinor Ostrom's model of decentralised governance that effective resource distribution is possible in a finite world. This can be achieved through a self-contained system that regulates resource consumption by blunting the greedy impulses of individuals without the need for state intervention. Blockchain will be tested against Ostrom's principles through an assessment of its use across countries and industries. The paper will conclude by exploring how blockchain can help policymakers, public and private sector stakeholders forge a new digital future based on transparency, cooperation and collective action.

Rather than suppress people's tendency to outcompete one another, blockchain will determine proper resource distribution in a system of self-regulation among stakeholders, that can redirect that human competitiveness towards productive and positive purposes without direct intervention by the state.

2. OSTROM'S INSTITUTIONAL ANALYSIS AND DEVELOPMENT MODEL IN BLOCKCHAIN

2.1 Resource Distribution in a Finite World

Elinor Ostrom's model of Institutional Analysis and Development (IAD) has redefined the study of effective resource distribution (Ostrom, 2010). Traditionally, resource distribution has been analysed within the context of population studies, where Malthusian principles have dominated. Proponents of Malthus have argued that it is not possible to drive towards infinite growth when resources are finite. These were reiterated in Garett Hardin's 1968 article, "The Tragedy of the Commons", which echoed Malthus' point that a population grows geometrically or exponentially, while food production can only grow linearly (Hardin, 1968, p. 1243). Hardin argued that population growth must eventually hit zero; that it was mathematically impossible to maximise the growth of two variables at one time.

In essence, Hardin urged humanity to abandon the need to reproduce liberally as the outcome would be the destruction of the commons, defined as natural resources that were accessible to all human beings like air, water, and land (p. 1248). Sooner or later, those resources would run out as each person behaved in a self-interested fashion, grabbing as much as they wanted for themselves without any concern for the long-term viability of the commons. Using the example of overgrazing by cattle on a plot of land, Hardin demonstrated that there were natural limits to the Earth's resources (p. 1244). Due to this, limitless consumption was not the ideal scenario. Rather, people had to be told to limit the number of children they had or stop reproducing altogether in order to preserve the commons for posterity.

2.2 On the Shoulders of Giants

In the digital age, the scarcity of resources in the virtual space has stirred up much debate, with doubt being cast on the ability of more efficient technology to reduce scarcity, and thereby, diminish intense competition for those said resources (Kostakis & Roos, 2018). In this regard, the IAD model is crucial as it adds another angle to the blockchain debate, which has been propelled by decades of

technological innovation seeking to improve digital transparency and robustness. This is best reflected by the origins of the idea of digital tokens or ledgers.

Contrary to popular belief, digital tokens or ledgers were not conceived by founder of Bitcoin, Satoshi Nakamoto.[1] Indeed, his 2008 White Paper was one of the early examples of the technicalities of blockchain being fleshed out (Nakamoto, 2008). Readers were able to see how a blockchain network would work structurally and were introduced to ideas such as time stamps and proof-of-work (p. 3). However, Nakamoto was not conceptualising something completely new. Rather, he was drawing on works produced by earlier writers.

Chief amongst these was a lesser-known article written by Stuart Haber and W. Scott Stornetta in 1991 titled, “How to Time-Stamp a Digital Document”. It was published in the *Journal of Cryptology* and introduced the idea of time-stamping digital documents so that users knew when information was created or last changed. The theory was that such a system would resolve intellectual property issues such as patents so that creators would have undeniable proof of ownership (Haber & Stornetta, 1991, p. 99). This could be applied to other fields where documents or data was involved.

The article aimed to resolve technical issues regarding time-stamping by proposing mathematical solutions to problems such as privacy, bandwidth and storage, incompetence (i.e. document corruption), and trust (p. 101). Haber and Stornetta introduced potential improvements such as hash functions (p. 101–102) and digital signatures (p. 102), as well as linking (p. 103) and distributed trust (p. 105) schemes. They also acknowledged trade-offs in the two schemes and encouraged further development in this space.

A trained programmer or computer scientist would understand the terms and mathematics in the paper as opposed to non-experts. However, the key thing to note is that Haber and Stornetta were two of the first few people to conceive a

[1] Satoshi Nakamoto is a pseudonym.

system of distributed information that could be altered and verified. Since each change would be recorded on the chain, one could look out for fraud or deception due to the way time-stamped information would be presented. While there were issues with the execution of schemes like linking and distributed trust, they could be modified further. Technological development would also help with these as fresh ideas came to the fore.

Haber and Stornetta's work paved the way for Bitcoin as the technological revolution accelerated throughout the 1990s and early 2000s. Nakamoto citied their works and acknowledged their contribution to the evolution of blockchain. Bitcoin was a realisation of the themes Haber and Stornetta had synthesised. It was the natural manifestation of nearly 20 years of theoretical and technological progress in the field.

In recent years, cryptocurrency has come to dominate all discourse on digital tokens and currencies. This is due to the potentially lucrative nature of crypto tokens, with users raking in gargantuan profits through token trading. However, the collapse of crypto exchanges like FTX has dealt crypto enthusiasts and proponents a harsh dose of reality. The inherently unstable and opaque nature of centralised crypto exchanges has revealed inherent weaknesses in unpegged tokens (Woo & R, 2023). This suspicion is now extending to stablecoins, where tokens are tethered to real world items like gold or actual money.

However, the narrative must shift away from crypto. Blockchain technology is far too adaptable to be shoehorned within a crypto context. Doing so would be a great disservice to decades of invaluable work on the subject. In this vein, the IAD framework is a natural fit for the use of blockchain in information-sharing, data transfers and document verification.

2.3 Why Ostrom?

Ostrom's IAD model provides an alternative understanding of resource management and how common-pool resources (CPRs) can be distributed without the fear of overuse. This is best characterised by Ostrom's synthesis of polycentric systems of organisation, where multiple players interact to make and enforce rules within a specific area or location (Ostrom, 2010, p. 641). This could occur between government bodies and private actors. Polycentric systems allow for independent decision-making, where norms, conventions and mechanisms are created by stakeholders so that effective cooperation and conflict resolution can take place (p. 643). These are best encapsulated by Ostrom's eight parameters.

Figure 1: Ostrom's Parameters

1. Cleary Defined Community Boundaries
2. Congruence Between Local Rules, Needs and Conditions of Common Goods
3. Ensure Participation in Modifying the Rules
4. Monitoring
5. Graduated Sanctions for Rule Violations
6. Dispute Resolution Mechanisms
7. Local Enforcement of Local Rules
8. Multiple Layers of Nested Enterprises

(Ostrom, 2010, p. 653)

The Eight Parameters Defined:

1. **Cleary Defined Community Boundaries**: The boundaries that define the rights of access and privileges within the system.
2. **Congruence Between Local Rules, Needs and Conditions of Common Goods**: The basis of the rules that govern the behaviour of the participants in the system. This may change based on local conditions.
3. **Ensure Participation in Modifying the Rules:** Actors that participate in the system are allowed to modify the rules they will be following.

4. **Monitoring:** Chosen actors in the system will monitor the behaviour of other actors as a form of accountability.
5. **Graduated Sanctions for Rule Violations:** If an actor violates certain rules, it will be sanctioned by other actors that find its behaviour unacceptable. This is to occur with incrementally harsh levels of punishment for repeat offences.
6. **Dispute Resolution Mechanisms:** Low-cost dispute resolution mechanisms that are open to all actors.
7. **Local Enforcement of Local Rules**: Rules are enforced in the system with the oversight of higher authorities.
8. **Multiple Layers of Nested Enterprises:** The layers of a system that address issues that may affect resource-distribution.

The eight parameters are general guidelines but can be modified to suit the scope of the field or industry they are employed in. They also allow polycentric systems to be self-governing.

Decisions are undertaken by actors within them according to pre-established rules and regulations. They work together for the common good and share resources according to the needs of the stakeholders within them. Any actor that violates these rules, like hording those resources, will be alienated by other players and expelled from the system. This is so as the other stakeholders stand to gain tremendously from “win-win” collaboration as opposed to the unequal outcomes of a “winner-takes-all” mentality.

As a result, Ostrom’s theory counters the narrative that individuals are doomed to a brutish race towards securing as much as of the resources they can if they are never sure when these will run out or if they will ever prevail again to have a share of them. Instead, according to Ostrom’s model, a system of stakeholder engagement can repel the worst impulses of human beings by creating ecosystems of accountability.

This is not a unique concept. Since the inception of modern anthropology, ethnographers have studied various indigenous tribes and their ability to sustain their populations through effective resource management (Johnsen, 2010). This

usually takes the form of practices in reciprocity — like the gift-giving *potlatch* by indigenous peoples of the Pacific Northwest Coast of Canada and the United States, which served to promote social cohesion and competition that enhanced social prestige within predefined boundaries (p. 43). This concept can be applied to the implementation of polycentric systems. Although the world of Pacific Northwest Coastal indigenous tribes is far removed from our highly digitalised and technologically sophisticated society, the principles they employ are fundamentally the same.

One example of this is the formation of Commons-Based Peer Production (CBPP) communities. These are made up individuals who cooperate with one another to produce shared resources without a hierarchical organisation (Rozas et al., 2021, p. 2).

As a result, the IAD model is not suggesting anything new. Rather, it taps into concepts people have been familiar with for thousands of years. The key differences are the technological considerations and scalability.

2.4 Two Approaches

Discussions surrounding blockchain adopt two approaches to the matter — technological determinism and market-driven values, and criticisms of the ideals undergirding the technology (Rozas et al., 2021, p. 3).

Proponents of the former often have an idealistic view of blockchain, believing that technology solves all problems. As a result, they tend to ignore the complex and multifaceted nature of human social organisation. They emphasise its potential to completely eliminate hierarchies when it comes to decision-making processes. These determinists also assume that decentralisation automatically distributes power evenly across the system without acknowledging that issues like the formation of oligarchies, can arise (Rozas et al., 2021).

Human beings tend to react very differently to mathematical models and lines of code. One cannot predict how individuals would behave if they were given access to blockchain or any other piece of technology for that matter. For example, it was thought the internet would lead to a new age of enlightenment as information could no longer be controlled or censured by malicious actors (Schaub, 2023). The assumption was that the availability of information would enhance human intelligence and learning. As it turned out, the internet would not only distribute human knowledge but ignorance as well, with misinformation and falsehoods being endemic in the digital age (Granados, 2023).

In contrast, advocates of the second, more critical approach argue that decentralisation is unwise and that there must be some central authority that keeps a lid on things. They criticise the deterministic viewpoint and argue that centralisation is vital to democratic governance. Often, they dismiss or ignore the potential of CBPPs that function without the need for a central authority. While this approach is sound and logical given the damage unregulated markets have done to the world economy in the 21st century, it completely dismisses the potential for self-regulation offered by blockchain. In such a scenario, the transformative power of blockchain is curtailed as it is subordinated to traditional central institutions (Rozas et al., 2021).

Both schools of thought are on extreme ends of the spectrum. However, some of the arguments raised by both are valid. Hence, the IAD model is useful in forging a compromise so that blockchain can be used as a vehicle of transformation.

2.5 The IAD Model in Blockchain

As a response, David Rozas, Antonia Tenorio-Fornes, Silvia Diaz-Molina, and Samer Hassan have explored the adoption of the IAD model to blockchain by reworking Ostrom’s principles into how a blockchain network is designed (Rozas et al., 2021, p. 5–10).

Specifically, these are the notions of immutability, transparency, persistency, resilience, and openness (p. 2). Hence, their six principles are:

1. **Tokenisation**: The process of transforming the rights to perform an action on an asset into transferrable data on the blockchain.
2. **Self-Enforcement and Formalisation of Rules**: The enforcement of rules and graduated punishment for any violation of those rules.
3. **Autonomous Automisation:** The use of Decentralised Autonomous Organisation (DAO) codes to automate decentralised processes that cannot be shut down by viruses, malicious parties or censorship.
4. **Decentralisation of Power over the Infrastructure**: The decentralisation of control on the blockchain which allows stakeholders to claim shared ownership of technological resources.
5. **Increasing Transparency**: The openness of organisational or transactional processes.
6. **Codification of Trust**: The processes and practices that inspire confidence in the blockchain amongst stakeholders.

These newly worked principles reiterate the fact that blockchain itself is not the goal. Rather, it is meant to facilitate better social organisation and governance so that human society can be transformed. Hence, any use of blockchain ought to be considered if it can benefit existing communities or create new ones.

Decentralised governance is a relatively new concept and requires more time to mature. Blockchain can help realise this, but the process will be slow and gradual, and it may sometimes need the tutelage or backstop of risk management by a central authority.

Furthermore, self-governing ecosystems may have to be constantly monitored so that the same issues that plague traditional systems or organisations — like bureaucratic red tape and the monopolisation of resources — do not occur. Hence, some form of centralisation will be required for the foreseeable future. By addressing the issues raised in the two camps of response to blockchain, the IAD model is a way out of the impasse.

2.6 Trust vs Efficiency: A Dilemma Resolved?

The blockchain principles that have been explored in the previous section are geared towards increasing the efficiency of digital transactions. This is a point that is repeatedly expressed by blockchain practitioners. However, there is healthy scepticism regarding the fool-proof nature of blockchain due to the controversies it has been involved in in recent years. The more famous incidents have been in the realm of cryptocurrency, where the crashes of crypto exchanges such as FTX have made headlines which have been catastrophic, resulted in the loss of billions of dollars' worth of investor funds (Berwick, 2022).

As a result, blockchain's reputation and its trustworthiness has taken a hit. If crypto has created an amorphous and volatile market where clients' investments are not guaranteed, what does that say about blockchain itself? However, it must be said that the sins of cryptocurrency advocates like Sam Bankman-Fried cannot be pinned on blockchain itself. In fact, the collapse of FTX and other crypto crashes are related to more conventional market failures — the opaqueness of these exchanges and platforms that exacerbated a "black box" type of environment where the risks associated with crypto were ignored or sidelined. The truth of the matter is that blockchain is merely a tool that can be used in myriad ways depending on the industry and application. The failure of the crypto space does not indicate a failure of the technology on a whole.

Ultimately, the debate surrounding blockchain pertains to the notion of trust and whether it can still be maintained in a system geared towards increasing the efficiency of transactions. It also involves the nature of information asymmetry where one party possesses more information about something than the other. Trust is easy to build if there is a history of repeated transactions between various players. However, information asymmetry still exists between buyers and sellers of goods, with the latter having more information about these products than the former.

What guarantees proper cooperation and the integrity of these transactions is the reputation of each stakeholder. This explains why people would be more inclined to

trust their friends and neighbours more than complete strangers as they simply know them better. This also shows why banks are trusted third parties for financial transactions as they adhere to strict regulations and safeguards that protect people's assets, thereby guaranteeing people's livelihoods.

In the "wild, wild, west" of the digital space, players may not be afforded such luxury. Investors using FTX were at the mercy of the exchange as they had no idea that their money was being used without their consent for risky investments (Cohen & Godoy, 2023).

What is theoretical may not necessarily run as intended when implemented. There is the gap between theory and application. As such, a more efficient system may not necessarily increase trust as it is designed with inherent flaws that instead, reduce it such that the hypothesised systems, when implemented, may possess huge flaws (Meyers & Keymolen, 2023). Hence, the idea that blockchain solves everything under the sun may be a fallacy (Foote, 2018). Implementation and motive will make all the difference.

The upside of blockchain is that trust is inherently baked into the system. It is an inextricable part of blockchain that cannot be decoupled from efficiency. As such, the issue of trust is already provided for and addressed as every transaction between the various stakeholders is recorded on the chain. It need not be based on direct interactions and transactions among stakeholders. This reduces the information asymmetry that exists between individuals and equalises the nature of these interactions and transactions.

It also increases their transparency and verifies the identities of the people participating in them. If everyone can see what, when and how something is transacted, as well as who is performing the act, people will have greater confidence in their actions. As such, suspicions surrounding blockchain will be reduced as parties to these transactions have direct access to the blockchain rather than through nebulous intermediaries as has been the case with the crypto-exchanges

referred to earlier. This helps realise the “win-win” philosophy stated earlier in this paper. In essence, blockchain is programmed to be truly unbreakable, make up for the lack of initial trust among parties working or sharing resources for the first time, and offers the scalability of the networks and transactions.

As such, trade-offs do not have to be considered when it comes to trust and efficiency as both are guaranteed by blockchain. With trust and efficiency already being implicit in blockchain, implementation becomes a matter of how it is done and what can be done to improve it. This is to be illustrated with cases across a range of industries, with focus on some of the issues that have been raised in this paper thus far.

3. NOTABLE EXAMPLES OF BLOCKCHAIN

Blockchain has been adopted for a variety of industrial and governmental applications across the world. These initiatives are applied in very specific spaces such as finance and cybersecurity. Also, current media coverage and literature tend to pay outsized attention to blockchain's role in an increasingly competitive geopolitical environment. Hence, measures employed by the likes of the United States and China to widen their lead in high-technology sectors dominate discourse on blockchain development. As such, the narrative surrounding blockchain has become intertwined with what great powers are doing with the technology. Such a narrow focus underplays the transformative potential of blockchain.

Instead, the authors of this paper call for a broader exploration of the blockchain revolution that is taking place. There are examples of the use of blockchain in unconventional ways to transform local communities. This section illustrates how blockchain has been used for community transformation, citizenship participation and empowerment to complement and understanding of the landscape. It also ties into the question of governance — how communities can organise themselves effectively to govern themselves and the use of their shared resources.

These cases suggest how blockchain can potentially afford a more sensitive, sustainable and collaborative way to mobilise those finite resources for the common good. This is to help us consider fresh approaches to ground-up governance systems that enable citizens to work towards that common good in Singapore.

3.1 Sweden

Blockchain Application: Property Transactions and Transfer of Land Titles

In most developed countries, property rights are of great concern to governments and citizens alike. As such, the need to verify documents and transactions pertaining to land ownership is significant. In this vein, Sweden has promoted the use of Distributed Ledger Technologies (DLTs) for property transactions and the transfer

of land titles. This is being done through various private sector players like ChromaWay. ChromaWay is a blockchain technology company that was founded in 2014. Its stated aim is to revolutionise the processes of decentralised property transactions to make them more transparent and efficient (Konashevych, 2020). It has developed a plethora of blockchain tools that have been customised for different countries and sectors. Most notably, it has done work in the land administration sector.

One example of this is its digital messages application Esplix. Esplix was created in 2019 as a prototype for a system that allowed users to use its database as a consensus mechanism. It is a "proof-of-concept" exercise around smart contracts for all phases of property sales that can be downloaded on mobile phones and used by people looking to buy or sell property (Bennett et al., 2021). This draws together key stakeholders such as the buyer, seller, buyer's bank, seller's bank, property agent, and land registry such that every time a piece of land or property is traded, digital signatures of the various parties are recorded on the blockchain. The banks involved and the land registry will have to sign-off on key documents once they have received transaction sums as a mark of their approval. Only parties to the contract are privy to the data transacted. As such, the contract is fully executed only when all the requisite data and signing requirements are satisfied.

In 2016, the Swedish government announced a partnership with ChromaWay, consulting firm Kairos Future, and telecommunications service provider Telia to put the country's land registry on the blockchain (Chavez-Dreyfuss, 2016). The digitalisation of Sweden's land registry is a clear example of Stockholm seeking to expedite property transaction processes. There is a clear need for this given how current processes take weeks or months to complete in the existing system. They also only involve the land registry late in the process. In addition to this, they are still mostly paper-based. Signed documents continue to be sent by regular email and require a manual identity check (Bennett et al., 2021). Hence, it was envisaged that blockchain would reduce problems like complexity, duration, duplication and physical documents that were involved in the existing system.

While the use of proof-of-concept tools is relatively new and requires more observation, early signs have been encouraging. Some benefits include a marked reduction in the number of tedious steps required for property transactions, greater transparency in the process for all parties to a property transaction, the accessibility of information regarding the status of a transaction at any given time, and a cheaper distribution of the standard property transfer protocol using a smart contract.

However, there are some challenges; for instance, Swedish law does not allow the use of electronic signatures for property transactions. Hence, the scalability of "proof-of-concept" to the national level is hampered (Bennett et al., 2021).

Legislative, regulatory and administrative processes would have to be modified so that smart contracts can be used for land transactions. The idea is not to completely do away with centralised authority, although this would require a significant overhaul of current business practices. In addition to this, only the state is truly capable of protecting property rights and is accepted as such. Hence, a hybrid "proof-of-concept" model where land registry agencies and private blockchain players work together, is considered the way to go.

The use of smart contracts will have to take place within already established legal spaces. Laws like the United States' Uniform Electronic Signatures Act and Electronic Signature in Global and National Commerce Act show that this is possible. Locally, Singapore's very own Electronic Transactions Act stipulates that electronic signatures are valid under Singapore law for most contractual documents (IMDA, n.d.).

As such, the changes seen in the land administration sector in Sweden possess great potential and have a great bearing on the development of blockchain in the property space.

3.2 Switzerland

Blockchain Application: Identity Verification for Voting

The use of digital signatures has also been used in voting data management, with the concept of decentralised voting being explored. This is of particular importance to the ideas of democratic participation in countries like Switzerland, where the desire to hold clean elections permeates the decisions of local authorities and citizens alike.

The use of blockchain for voting purposes is another prime example of “Proof-Of-Concept”. Many types of electronic voting (e-voting) systems have been proposed (Sahib & Al-Shamery, 2021). However, they all share a set of common concerns. For starters, data authenticity is guaranteed through security measures that prevent votes from being changed or moved. Voting data is stored across multiple nodes to stop hackers from destroying the data should they hack one or several of them. Furthermore, a distributed system increases stability as data is more spread out, thereby making it harder to be compromised. In addition to this, tasks could be reassigned from overloaded to idle nodes, reducing processing problems on the blockchain and preventing a power outage. Importantly, multiple stakeholders such as accredited institutions would be evaluating the votes cast and checking their validity. This would prevent malicious players, like corrupt governments, from forging vote shares.

Paper ballots also limit information due to physical constraints, and are untraceable once placed into a box or sent by email. Voters do not usually know if their votes have been counted. However, a voting system based on blockchain would inform voters if their votes have been recorded and send them confirmation notifications. Such a system is open-sourced and allows any person or institution to audit the data. In doing so, the perennial issue of data leaks or breaches from centralised servers would be resolved. Open-source software also allows peer reviews by developers to test and constantly improve its security features.

On an operational level, e-voting allows states and governments to disseminate information to participants and generate polling results within minutes. This in turn would save time and manpower costs. It would also engage more people through an instant and secure way to vote regardless of their location. E-voting does not reveal personal information, allows voters to alter their votes at any time during polling, yet anonymously validates the legitimacy of participants by an external system with every user having the power to verify their vote, and prevents data manipulation via security encryption (Sahib & Al-Shamery, 2021).

The application of blockchain in the e-voting space is being explored by Switzerland. The City of Zug in central Switzerland issuing digital IDs to residents on 15 November 2017. This was followed by a successful consultative test voting exercise between 25 June and 1 July 2018 using the city's eID system that had been set up in November 2016. Voters were able to vote through their smartphones by downloading an open-source application called E-Voting. The voting questions were entered into the system, and the results were non-binding. In the event, 72 out of a total of 240 people who could register took part (Swissinfo.ch, 2018).

As per the voting process, voters were given uPort digital IDs from the authorities and relevant information regarding the round of polling. The registrar created a set of questions and choices on the blockchain. This was followed by the appointment of the voting executors, nominees and voting committee. A voter could then log into a voting portal that generated public and private keys. The former was sent to a nominee together with a request for a new ballot. The latter was stored in the user's private wallet.

The public key allowed a voter to prove their identity on the blockchain; their answers were associated with their ID without their answers or identity being revealed. This was followed by a nominee authenticating the voter through their digital ID and giving them an individual ballot. Their private key allowed them to sign their ballot to prove that it belonged to them.

Once voting closed, the committee retrieved the anonymous and encrypted ballots from the blockchain to verify all digital signatures. The results were then calculated and submitted to the blockchain. Once this was done, any participant could verify the results using the committee's public key. A voter could use their public key to check if their own vote had been counted. As a result, no one could decrypt individual data. Voters were also assured that the results were and could not be corrupted (Sahib & Al-Shamery, 2021).

The city of Zug later conducted an online survey of 95 residents with digital IDs to capture their feedback. More than three quarters of those surveyed welcomed e-voting and 21 per cent believed blockchain could make electronic voting more robust. Only 2 per cent were opposed to the introduction of e-voting. While most participants approved of it, some were still sceptical. Many were also of the opinion that the city should provide an option to vote by mail.

The survey results showed general satisfaction with the test vote but revealed that improvements could be made to smoothen the voting process. Some voters also found it impossible to vote with their digital IDs due to technical difficulties. However, the individual nature of the process was perceived positively by participants. They also thought the process was simple and easy to understand. However, they stressed that the private digital ID mechanisms could be improved upon.

Furthermore, participants argued that the media did not adequately report on the voting process, producing a lack of awareness that resulted in a lower voter turnout. Some people did not even know about the vote or heard about it only at the very last minute. This was exacerbated by the inability of the uPort app to notify digital ID owners that a vote was imminent (Sahib & Al-Shamery, 2021).

Despite these issues, it was generally accepted that the exercise was a success and bolstered the idea that blockchain could be used to strengthen citizenship participation. However, the technology had to be refined before blockchain voting could be implemented on a nationwide.

3.3 The Netherlands

Blockchain Application: Pension and Benefit Management

The application of digital ledgers in the property sector is another interesting adaptation of blockchain. This versatility has also been explored in the field of pension management, where retirement support has gained greater scrutiny. This is a very real concern given how many developed countries are struggling with ageing populations. Furthermore, declining birth rates will cause present tax bases to shrink, increasing pressure on states to find other sources of fund to address the needs of their elderly citizens.

The problems facing retirees in developed countries are multifaceted and diverse. However, a common reality is that many retirees have insufficient savings for their retirement, often eroded by the net effect of inflation. Hence, the goal of any pension fund is to ensure that workers have enough financial support in their old age by providing returns that are higher than the average rate of inflation, whatever that is projected to be. Unfortunately, government institutions and markets have experienced a loss of trust in recent years, due to the complicated and opaque nature of the pension products being offered. Pensioners often find themselves at the mercy of dodgy management practices as well. These factors make it hard for retirees to truly reap the rewards of their hard work when they most need it (Clacher et al., 2018).

In countries like the Netherlands, pension systems lack communication and interoperability of data. These can reduce the speed at which benefit payments are made, resulting in extra costs and mistakes. This is made worse by the fact that updating applications for such benefit payments can take months and require physical notices to be sent to the relevant tax agencies. This is where blockchain can smoothen these processes. It can also prevent errors in the payment of these social benefits. The technology could also give pensioners more control over their money and greater accessibility to retirement plans (Komorowski et al., 2021).

In 2017, Dutch investment companies APG and PGGM announced that they were testing a blockchain-based pension management system that would help make pension payments simpler and more efficient. The prototype was described as a pension administration system shared by multiple parties and stakeholders. Employers, pension funds and regulators could view and update information according to pre-defined network rules. The data stored was secure and would allow pensioners to view how much funds they had amassed. The system was described as more secure and cheaper than existing ones. It must be noted that APG and PGGM did not state a target date by which it would be launched and used to manage pension operations (Reuters, 2017).

While the technology is still raw, governments are thinking of ways to reform their own pension systems — and certainly in ways that provide their account holders a greater level of transparency if not sense of agency around the management of their pensions. As such, pension management is another avenue of opportunity for blockchain to showcase its utility.

3.4 Singapore

Blockchain Application: Electronic Medical Records, Health Monitoring, and Supply Chain Management

Singapore is regarded as a nation that seeks to successfully adopt emerging technologies to complete its own digitalisation aims. In this regard, blockchain is increasingly becoming adopted in many fields like healthcare and medical supply chains. More specifically, the use of blockchain in the healthcare sector has exploded because of the potential benefits it can afford to institutions and patients. These include using ledger technology to ensure that medical records are preserved and transferred securely, medical supply chains are managed properly, and that doctors and researchers have wide access to the genetic profiles of people (Ng & Ting, 2021).

Usually, access to such data is heavily restricted in order to protect patients' privacy and information rights. However, as stated earlier in other cases, blockchain can expedite the process whilst maintaining a robust security framework that prevents the leaking of personal and medical data. This would be mutually beneficial to both healthcare professionals and their patients. Furthermore, blockchain can give patients direct control over their own medical records, and facilitate direct information transfer between patients and insurance firms or healthcare providers. In addition to this, hospitals would be able to track transactions and transfers regarding medicines, as well as critical bio-materials, yet in ways that cannot be compromised by malicious actors (Ng & Ting, 2021).

One key example of this is the creation of digital wallets in the form of the "Digital Health Passport" during the COVID-19 pandemic. SGInnovate, a government-owned investment firm, and a local start-up, Accredify, collaborated to develop a better way to manage medical records. Development on the application began in May 2020 and was completed in September 2020. The application was promoted as a programme that stored the personal medical documents of users for convenient access and verification. It digitised documents such as COVID-19 discharge memos and swab memos. It also refined the workflow for healthcare service providers (Yu, 2020).

In the following year, 2021, the government unveiled HealthCerts, a set of open-source digital standards used for the issuing of digital COVID-19 test result certificates. This could be used by travellers for cross-border COVID-19 status verification when they travelled to other countries. In more practical terms, it would speed up the immigration process for them at local and foreign checkpoints by rapidly confirming their COVID-19 status. Travellers who underwent a pre-departure test would receive their results in the form of digital certificates. These could be attachments or URL links to the actual certificate (Chiang, 2021). Travellers would then have to upload their certificates on notarise.gov.sg, a website that allowed the Ministry of Health to endorse locally-issued certificates that would be recognised in

Singapore and overseas. These could then be used as proof of their eligibility to travel.

These examples showcase the effect blockchain has had in Singapore's healthcare sector. There are more plans to expand the use of blockchain in this area as the technology continues making inroads. The clear utility of blockchain in healthcare points to yet another application of the technology in ways that improve people's lives and institutional efficiency in managing health data.

4. CONCLUSION

This paper has attempted to apply an anthropological understanding of resource management, and political theory, to the study of a piece of technology that has the potential to remake human digital interaction.

It started with an analysis of Ostrom's solution to the problem of finite resources by delving into the IAD framework. IAD principles were then adapted to blockchain in accordance with certain attributes such as tokenisation and DAOs. Examples of these adaptations in countries such as Sweden, Switzerland, the Netherlands, and finally Singapore were used to explore the utility of blockchain to decentralised governance.

Researchers in this field are constantly breaking new ground. Their work is of great political and societal significance due to the increasingly digitalised nature of the world. As such, policymakers must continue to keep abreast of developments in the space. Furthermore, the study of decentralised governance is a complementary task. Programmers and developers are always concerned about pushing the technology to its limits. However, they may not necessarily pay attention to the impact or consequences this may have on society and polity; of how human beings have to live their lives.

It is hoped the paper presented showcases how a consciousness of the potential and current impact of blockchain technology that allows for efficient, transparent, distributed data and power-sharing processes can plug that gap in knowledge and imagination. The technology can be improved and mobilised to enable new forms of decentralised governance that takes decision-making, especially on the management of finite resources, closer to the ground. Ideally, there will be no need to have these processes and decisions reduced either to the lowest common denominator, in binary formats, or in win-lose outcomes. Blockchain can then be a boon to society as it blurs the lines between the governing and governed hopefully to good effect — that the processes of self-organisation result in more sustainable, more responsive and responsible outcomes to benefit the country and the globe.

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