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Blockchain's potential to resolve institutional inefficiencies?

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1 Introduction

In 2008, Satoshi Nakamoto published on the Internet the paper "Bitcoin: A peer-to-peer electronic cash system" that introduced one of the most secure protocols in the open web (Nakamoto, 2008). The protocol, termed blockchain, distributes the point of failure across a network of different nodes, which are devices connected to the network, and provides the nodes with incentives to keep the system secure. As of 2019, Bitcoin has reached a market capitalization of USD62 billion with over 200,000 transactions per day without a single hacking incident of the underlying technology (Blockchain.com, 2019; CoinMarketCap, 2019). The blockchain protocol has also been used by a large number of entrepreneurs and traditional incumbents, such as governments and global financial institutions, to provide secure processes in the digital world. As a result, the blockchain industry has grown at an outstanding pace in the past two years. As we can see in Figure 16.1, both traditional investors, such as venture capitalists and angel investors, and crypto-enthusiasts have invested large amounts of money through equity funding rounds and initial coin offerings (ICOs), which are a new type of fundraising system enabled by blockchain (CB Insights, 2018; Coinschedule, 2018).

Figure 16.1 illustrates the recent growth of blockchain technology through recent investments. Equity funding investments were obtained from CBInsights (2018), and ICO amounts were obtained from Coinschedule (2018).

The recent growth motivates us to investigate the potential impact of blockchain on institutions. Keeping this goal in mind, we first provide a brief explanation of blockchain, followed by how it relates to the emergence of trust in institutions. We then discuss three case scenarios in which blockchain can be applied to reduce certain institutional inefficiencies. Finally, we venture into a discussion of the conceivable benefits of a nation implementing blockchain technology.

1.1 A brief explanation of blockchain

Blockchain is, above all, a security protocol that provides an irreversible proof of a transaction conducted on a digital network. The network is governed by nodes that decide to approve a state transition based on predefined rules. In the case of

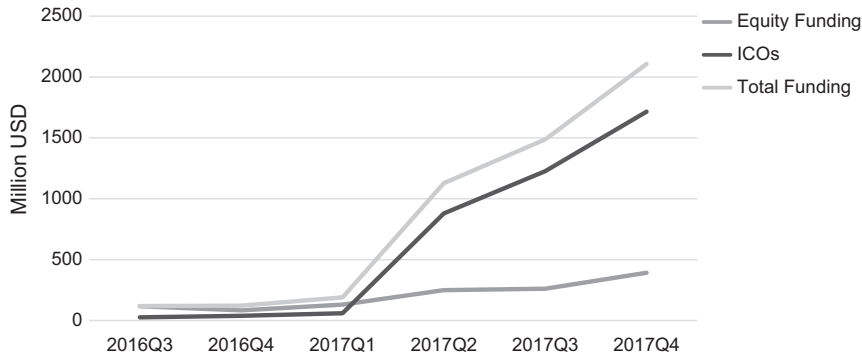

Figure 16.1 Blockchain investments

digital currencies, the network decides to approve a transaction by looking at the sender's transaction history. For instance, if Bob[1] wants to send 5 BTC to another party, the network reviews the amount of BTC sent and received over Bob's life-cycle. If Bob received 10 BTC and only spent 5 BTC, the network approves it. If Bob received 8 BTC and spent 5 BTC, the network rejects it.

Another application of blockchain technology is smart contracts. With a smart contract, two or more parties agree on a series of predefined rules, which can be anything explicitly written in code, and the network approves the state transition depending on whether those predefined rules have been fulfilled. For instance, if Bob wants to buy a USD500 computer from Alice for delivery by UPS, they would both agree on defining a smart contract that has the following steps:[2]

1 A contract account is created.
2 Bob sends USD500 to the contract account.
3 Alice sends the UPS tracking number to the contract account.
4 If:
    a UPS uploads in its tracking system that Bob has received the goods,
        i The contract account releases the money to Alice.
    b UPS does not upload in their tracking system that Bob has received the goods,
        i The contract account releases the money back to Bob or, if Alice disputes it, a predefined court of preference decides where the money goes.[3]

Each step of the contract is completed after the majority of nodes approve that the condition is fulfilled. For instance, if Alice does not send a UPS tracking number or Bob does not receive the computer, the money will never be released to Alice. This process can be now performed at a near-zero cost through the blockchain

instead of being performed through a trusted central party (e.g., a financial firm) in exchange for a small fee.

Blockchains can be divided into two types: private and public blockchains:

- Private blockchains have a finite set of trusted private nodes. Security is based on the private nodes not colluding to change the system as well as the difficulty of hacking the majority of them simultaneously.
- Public blockchains have a potentially infinite set of nontrusted public nodes that are motivated through a set of incentives. For example, public nodes have the option to "mine" blocks in exchange for cryptocurrencies. The cryptocurrencies that the miners receive can be either created by increasing the money supply or provided by the sender as transaction fees.

With the blockchain, and particularly smart contracts, code is "law" and anything that can be written in explicit code is possible (Moreno Puertas and Teigland, 2018). The resulting security that arises from distributing the decision-making process, which approves or rejects a state transition, is thus the most important feature of blockchain.

Although blockchain seems new, the protocol is based on the same principle that generated credible governments in the late 17th century – that of the distribution of power, which we discuss below.

1.2 The emergence of trust in political institutions

In the early 17th century, the world was heavily reliant on centralized powers. Spain and France, the main superpowers, were governed by absolute monarchs, and both countries aimed to impose a strict Catholic regime around the world. Nevertheless, Britain was becoming increasingly aligned with the Protestant reform, which resulted in the Anglo-Spanish war (1585–1604).

Soon after the Spanish Armada was defeated in 1588, Britain decided to further sponsor its mercantile operations across the world in order to ensure survival. The expansion was eventually successful and resulted in the bourgeoisie class gaining economic power (Motley, 1892; Simon, 2017; Ulm, 2004).

In the 17th century, Britain was involved in numerous wars, and its expenditures far exceeded its revenues. In order to keep financing its government, the Crown had to negotiate new sources of revenues, such as custom taxes and "forced loans," with the bourgeoisie class represented in the Parliament. In exchange for money, the Parliament requested the king to respect private property rights and cease monopolistic practices. However, the king had a tendency not to honor his promises and dissolve the Parliament if needed. Consequently, the emergent bourgeoisie class united to defeat the king. Over the century, through a series of civil wars culminating in the Glorious Revolution (1688), the bourgeoisie was able to establish politically aligned institutions (North and Weingast, 1989).

The new political institutions, as represented in the Parliament and independent courts, consisted of a diverse group of people. The distribution of power ensured

that no group had too much power, thereby generating stability, as Douglass C. North, a 1993 co-recipient of the Nobel prize in economics, and Barry R. Weinstein (1989, p. 818) stated in the following:

> The new constitutional settlement endowed several actors with veto power, and thus created the beginnings of a division or separation of powers. Supplying private benefits at public expense now required the cooperation of the Crown, Parliament, and the court. . . . The institutional and political changes significantly raised the predictability of the government . . . [and] the government's ability to tap the resources of society increased.

As a result, the British government established credible property rights, became financially solvent, and increased borrowing to unprecedented levels. For instance, from 1630 to 1688, the British government ran on average a total debt (obtained mostly through forced loans) of GBP1 million and had multiple defaults. In 1697, nine years after the Glorious Revolution, the British government raised its debt to GBP16.7 million (40 percent of GNP) without a significant increase in inflation. The ability to raise government debt allowed Britain to obtain enough resources to fight France in the Nine Years' War (1689–1697) and emerge as a superpower. Furthermore, with an independent judicial system and a strong parliament, the bourgeoisie class not only started to trust the government but also perpetuated the development of private debt markets (North and Weingast, 1989). Credit started to take a greater role in the economy as borrowers were able to put their guaranteed assets as collateral and lenders trusted their ability to claim them without government intermediation. Consequently, Britain experienced a financial revolution and a booming economy, acquiring global hegemony.

The distribution of power, which shifted the necessary trust from the king (central party) to the system (distributed parties) played a key role in this transition, as it enabled the British government to make credible promises, raise substantial amounts of debt, and develop its capital markets (North and Weingast, 1989). Today, almost every developed nation has implemented a similar system in order to foster economic growth and financial markets.

Blockchain is the enlargement of the already developed system present in modern economies to the open web. Blockchain brings different stakeholders into the equation and shifts trust from the centralized party to the distributed system. The protocol emerged as a solution to a series of failed attempts to create a new digital currency. Bitcoin, the first successful cryptocurrency, manages to stay resilient by providing incentives to users to participate in the decision-making process (Georgios, 2017). Today, the blockchain industry has evolved with many different types of governance, and the common denominator among them is, similarly to developed institutions, a distribution of power.

In the next sections, we are interested in how blockchain can diminish institutional inefficiencies that arise from centralized political elites. Nonetheless, in order to understand its potential impact, we must first understand why certain

political elites are reluctant to distribute their power given its economic advantages and the consequences of a centralized government.

2 Centralization of power

Acemoglu, Johnson and Robinson (2005) argue that conflict of interest among various interest groups is the main cause that prevents central governments from implementing institutions that promote economic growth. Although a plausible solution to this is to negotiate the distribution of benefits among different groups (see Acemoglu's (2003) discussion on the political Coase theorem), the centralization of power incentivizes the political elites to choose institutions that satisfy their self-interests and do not constrain their future actions. Consequently, the decisions made by the government are not binding. This lack of commitment prevents groups from engaging in effective bargaining, thereby inhibiting improvements to the overall well-being of the country's citizens. Acemoglu, Johnson and Robinson (2005) discuss two main commitment problems: 1) political losers and 2) hold-ups.

2.1 Political losers

In many countries with centralized governments, the political elite obtains rents, incomes, and privileges through their power. For that reason, they evaluate every potential change based on its political consequences. This prevents them from promoting institutions that provide power to other groups, regardless of potential economic benefits. As we saw above in the financial revolution, Britain's support for mercantile expansion ended eventually with a ruling bourgeois class (North and Weingast, 1989).

This was also seen during the industrial revolution. As workers started to organize and demand rights in Britain, political elites in nearby countries, such as Russia and the Austro-Hungarian Empire, opposed building railways to prevent similar potential tumults. It was only after certain military defeats that they decided to engage in full-scale industrialization (Acemoglu, Johnson and Robinson, 2005).

2.2 Hold-ups

In hold-ups, there are two groups: the political elite and the investor who has no political power. The investor offers the political elite to make an investment in exchange for future returns.

- In ex-ante negotiations, both parties have bargaining power and are incentivized to cooperate. The political elite gains from the investment and the investor gains from the future returns.
- However, in ex-post negotiations, only the political elite has bargaining power. The investor has already made a sunk investment and depends on the political elite to enforce property rights and provide them with the returns.

This problem has occurred many times throughout history. It is important to notice, as we explained in the financial revolution, that it was only after the merchant class obtained enough power that they were able to challenge the king and protect property rights (Acemoglu, Johnson and Robinson, 2005; North and Weingast, 1989). Furthermore, on many occasions, countries experience regime changes and the new political elites are not incentivized to honor any previous deals.

Except in rare cases of benevolent dictators, the distribution of power has thus been essential to promote the right economic institutions through effective bargaining. For that reason, a large part of the world, in which power tends to be concentrated, suffers from not having the desirable institutions, thereby depriving it of investment and long-term planning.

Nevertheless, with the emergence of the Internet, the world is becoming more digitalized and interconnected. Consequently, new opportunities are emerging to provide people from distant places with the right instruments to blossom in an ever-increasing digital world. Blockchain, with its security, is able to fill some of the gaps that arise from centralized governments by taking advantage of a global network to provide value-related services.

3 The trust revolution

In this section, we will focus on blockchain's potential to preserve private property and diminish the inefficiencies that arise from centralized political elites. We have divided this section into three parts: 1) digital currencies, 2) contracts and digital courts, and 3) tangible property rights.

3.1 Digital currencies

One of the main functions of a government is to establish a credible monetary system that enables its citizens to exchange goods and services. In most developed countries, the government sets up an independent central bank that is in charge of the money supply, thereby ensuring relatively stable exchange rates and price levels (e.g., EUR, USD) and, sometimes, other objectives such as high employment (e.g., USA). The central bank's independence is necessary in order to prevent governments from using their power to satisfy their short-term self-interests at the expense of their citizens' well-being.

However, in many less-developed countries with centralized power, the government has significant influence on the central bank, which results in a hold-up problem. In ex-ante negotiations, centralized governments promise to have the right monetary policies to encourage investments. However, once investments are made, the political elite has the power to print more money than expected in order to fund expenses and decrease debt.

This results in large price fluctuations and uncertainty that prevents households and firms from accurately forecasting future outcomes, such as cash payments (Poole and Wheelock, 2008; Barnes, Boyd and Smith, 1999; Tommasi, 1994). Furthermore, on many occasions, governments peg their national currencies at

unrealistic fixed exchange rates, further hindering trade with other countries. As a result, black markets emerge for other stable currencies, which citizens buy at a premium (Investopedia, 2013).

Digital currencies transmitted through the blockchain have the potential to provide citizens with the opportunity to avoid the drawbacks from unreliable central banks. In this area "stablecoins," which are considered the "holy grail of cryptocurrencies," are of particular use. Stablecoins can be divided into two different types:

- Those that represent stable assets stored in a private location, for example, Tether (USD), DigiX (gold)
- Those that use a set of incentives to ensure price stability, for example, Maker and Havven

Stablecoins allow citizens to have easier access to parallel currency markets through the open web. For instance, lower-income countries receive large inflows of USD and EUR through remittances. These remittances tend to be expensive (on average a 7.13 percent transaction fee) and are converted through the official exchange rate, which reduces substantially the amount of money received (The World Bank Group, 2018; Beck and Martínez Pería, 2011). Eventually, it would be expected that parallel markets based on stablecoins would emerge to provide better mediums of exchange for local citizens. This would provide greater bargaining power, as citizens would have an alternative option to inefficient monetary policies.

3.2 Contracts and digital courts

An independent judicial system is essential to ensure that contracts, which are agreements between two or more parties, are enforced in accordance with the law (Merriam-Webster, 2018; Courts and Tribunals Judiciary, 2016). The foundations for the independence of the judicial system were laid out after the Glorious Revolution in 1688, which was discussed above with the financial revolution (Section 1.2). This system increased the level of cooperation in society, as people could rely on an independent judicial system to settle civil cases. This resulted in an economic boom, and other countries started to mimic the system. Today, most developed nations have a relatively independent judicial system.

However, this is not the case for many lower-income countries. Although a strong independent court system provides clear economic benefits (Keefer and Knack, 1997), many countries with centralized power structures are reluctant to set independent judicial bodies. This is an example of the political loser problem described earlier (Section 2.2). Political elites perceive an independent judicial system as a potential threat to their power and decide to enact suboptimal institutions to prevent it.

Blockchain has the potential to mitigate the problems that arise from dependent judicial systems through smart contracts. Smart contracts, as explained above,

are programmable contracts that are self-enforced through a distributed network. With a smart contract, different parties agree on a set of predefined rules and the global node community accepts or rejects the state transition based on whether the predefined requirements have been fulfilled.

Currently, entrepreneurs are launching platforms that enable digital courts and provide clauses in case of disagreement. Digital courts are decided by the players within the networks and, usually, based on reputation.[4] For instance, in Section 3.1, we explained the process of buying a computer through a smart contract. The fifth step contains an "else" function that allows, in the case of dispute, a court of preference to decide where the money will be moved. Once the court makes a decision, the global node community will move the digital currency to the desired destination.

In the blockchain world, digital courts are being promoted as parts of larger ecosystems that provide a digital landscape for individuals. Examples of such a system are 1) the Aragon Network and 2) Pangea. A brief explanation of both systems is included in the Appendix.

Smart contracts provide contract enforceability, and digital courts have rights over digital currencies. This diminishes, but does not eliminate, the need for a central party to supervise many commercial activities and enables cooperation among untrusted parties. Once again, the benefit of smart contracts and digital courts is that they provide alternatives to inefficient institutions. Unreliable courts prevent cooperation among untrusted parties, as they fear unjust verdicts in case of disputes. In the blockchain world, people can be assured that a contract will not be enacted if certain conditions have not been fulfilled and that any dispute will be solved in a digital court, which incentivizes cooperation among untrusted parties. For example, funds will not be moved unless the contract conditions are fulfilled, and, in the case of disputes, the funds will be dependent on the digital court's decision.

3.3 Tangible property rights

Property rights, which are a shared belief, have played a prominent role in the development of human civilization by promoting cooperation among humans. Nonetheless, for the vast majority of human history, this shared belief depended on a central party, which resulted in high volatility as the self-interests of the central party shifted over time. For instance, in medieval times, kings secured property rights for their people on many occasions but then later expropriated property if needed without a valid reason in the eyes of the common people (Acemoglu, Johnson and Robinson, 2005). The resulting volatility harmed cooperation, as people were never fully guaranteed that their property belonged to them. Only after a system of checks and balances was implemented, in which every decision required the approval of different independent bodies, did the financial industry emerge (North and Weingast, 1989). This system originated in the Netherlands and Britain and expanded across the current developed world.

Yet, in countries with centralized power, the political elite still decides what can be expropriated. The resulting outcome is a hold-up problem. In the ex-ante situation, political institutions promise private property rights to encourage investment and stability. However, in the ex-post position, they have the ultimate power to expropriate assets when needed. This potential lack of commitment is accounted by investors and reduces their incentive to invest.

The blockchain may help to mitigate these problems by ensuring an adequate recording of every movement in a common distributed ledger. In the ex-ante situation, when both parties have bargaining power, the investor can require the use of blockchain technology in order to make an irreversible proof of every state movement, from any communication to payments. In the ex-post state, the centralized power will still have the power to expropriate, but the victim has an irreversible proof of every step conducted beforehand. This increases the likelihood of the victim recuperating their assets, as they have enough evidence to claim them in international courts or in future stable regimes.

However, the potential effect of blockchain technology on tangible property rights is not as high as in digital currencies and smart contracts. The reason is that tangible products, such as houses, cannot be physically moved through the open web, and their protection still relies on the government. Nonetheless, in the long term, the blockchain may help to reduce the incentives from central governments to expropriate, as they will always be accountable for their behavior.

4 The hypothetical blockchain nation: going back to first principles

In the previous sections, we have discussed the potential benefits of blockchain technology for currencies, contracts, and property rights. Each of these concepts is actually imaginary, or rather, an abstract idea provided by institutions to promote cooperation among ourselves (Soto, 2000).

- Currencies were created as an abstract medium of exchange that, compared to bartering, enhanced trade. Over time, currencies evolved from mint coins to bank notes to further increase the exchange of goods and services.
- Contracts originated as a set of promises and responsibilities attested by a group of witnesses. The enforcement of the contract tended to depend on centralized figures of power until the late 17th century, when courts started to become increasingly independent.
- Property rights were created as a framework to allocate resources. For most parts of human history, their allocation depended on the entities that had political power. In the late 17th century, property rights evolved into fully guaranteed rights. The ability of citizens to exercise those rights enabled the development of the financial industry and long periods of economic growth.

Each of those abstract ideas requires trust in order to function properly. To maintain trust, governments have distributed power among a diverse group, ensuring

that no person or entity has enough power to modify the pre-established concept (e.g., currencies, contracts, property rights). The resulting trust has allowed citizens to convert fixed assets into abstract forms and transact them at a low cost. For example, we can observe this abstraction when a company raises equity in exchange for US dollars:

- US dollars are an abstract concept that depends on an independent central bank, whose chairman is chosen by the president (executive power) and confirmed by the Senate (legislative power).
- The process of raising equity is done through a contract that is based on current laws (legislative power), which are enforced by the president (executive power) and in cases of dispute, judged by the courts (judicial power).
- The outcome, a stock, is a type of property right, which is protected by the executive, legislative power, and judicial power.

As we can see, each abstract concept depends on an agreement by a diverse group of people. Today, the total value of all stocks in all companies globally amounts to around USD80 trillion. These assets in their abstract form are constantly transacted in an imaginary financial world, which offers low transaction costs and results in an efficient allocation of capital.

This distribution of power, which guarantees trust, is also the basis of blockchain technology. Nonetheless, the abstract concept does not need to fully depend on the trust provided by an institution, which may or may not decide to distribute power, but on the trust provided by a global distributed network through the open web.

Having the aforementioned government services, relying on the open web can substantially diminish transaction and information costs, potentially resulting in another financial revolution. This would have an even greater impact in the developing world, as institutions have not yet managed to provide the trust needed to fully benefit from abstracting assets.

We can already see this disruption through the rise of initial coin offerings. Although studies have shown that more than 80 percent of ICOs are scams (Kelso, 2018), they have provided a clear medium of exchange between an abstract idea, usually represented in the form of a whitepaper, and an abstract digital currency. Since 2017, ICOs overtook venture capital funding, which is the traditional method for exchanging currencies for ideas, to blockchain startups by over 3.5 times, from USD1.3 billion to USD4.5 billion, respectively (Rowley, 2018). One of the main reasons behind this disruption is that digital currencies allow any person from anywhere to invest in an idea presented in the open web.

We can imagine a similar disruption occurring in the developing world if a government, or an independent society, decides to fully implement blockchain technology. For instance, imagine a hypothetical nation called SatoshiLand. SatoshiLand has implemented blockchain from the ground up:

- Every property is registered in the public ledger.
- Every property and currency movement needs to be accepted by the global set of nodes and is published in the public ledger.

- Smart contracts regulate most contractual relations between different parties and have clauses that, in case of disagreements, allow a digital court chosen by the network to resolve the disputes based on available data.

SatoshiLand would provide international investors an irreversible proof of every transaction conducted. This would substantially reduce scams, given the recent success of behavioral analysis in fraud prevention. A firm may be able to bribe an auditor, but it is unlikely that it can mimic the behavior of a business, in terms of transactions and properties, over many years. Investors would also be able to transfer funds almost instantly from anywhere and monitor how the firm uses their funds.

For example, suppose that an imaginary firm in SatoshiLand wants to raise money from an international lender to increase its shoe production. In the current world, the lender would charge a high premium, as it experiences information asymmetries and mistrusts the local legal system. In SatoshiLand, the international lender would have access to the inflows and outflows of the company over the past years. This information could not be forged and would be extremely expensive to mimic. Furthermore, the investor could arrange a contractual agreement through the blockchain that specifies how the money is spent and adds clauses in case of dispute, which would allow a digital court to redistribute the remaining digital currency if the borrower is at fault. The result would be 1) a lower risk rate and 2) a larger supply of funds through the international sphere. Overall, international lenders would be able to accurately forecast risk and improve substantially the efficient allocation of capital, which would result in higher economic growth.

Furthermore, citizens would be able to engage in global savings schemes due to the free flow of capital. Economic literature emphasizes how people can maximize their utility by smoothing their consumption over their life cycle using financial instruments. Yet, a large portion of the world does not have access to these financial instruments. If they experience unexpected events, they have to reduce their consumption or rely on informal high interest rate networks (Kast and Pomeranz, 2014). Kast and Pomeranz (2014) showed that access to formal savings reduces substantially reliance on informal credit networks, thereby improving the welfare of the poor. With stable digital currencies, lower-income people would be able to access international saving schemes through the open web and increase their consumption smoothing. This enables them to be self-insured regardless of local government policies.

Finally, diminishing information asymmetries could also reduce government fraud and increase government efficiency. Several studies have shown that people are reluctant to pay higher taxes when their governments cannot be held accountable (Glaser and Hildreth, 1999; Ortega, Ronconi and Sanguinetti, 2016). This means that people who may want more government services are voting for budget reductions due to a lack of trust. In SatoshiLand, since every government expenditure post has a digital trace accessible in the open web, citizens would be able to audit their governments and vote accordingly. In the long term, we would expect a more effective government that matches citizens' preferences. Given that the willingness to pay taxes increases with government efficiency and accountability, we expect a greater role of the government under this potential scenario.

Although the implementation of this type of digital nation seems far off, countries are already starting to use the blockchain for 1) registering properties and mortgage deeds, 2) increasing transparency, and 3) transacting digital currencies.

In our theoretical framework, the institutional spillovers arose from those nations that were able to adapt best to the emerging conditions. Blockchain technology enables a new type of irreversible digital trace that provides an unprecedented level of accurate information to both international investors and citizens. This would provide firms and citizens with access to international financial markets and governments with a greater source of revenues, potentially resulting in another financial revolution.

5 Conclusion

The distribution of power among a diverse group of people has formed the basis of credible governments and enables the emergence of financial markets. Blockchain brings this distribution of power to the digital landscape and creates trust in the open web. The benefits from this newly developed trust are still unclear. However, we see a tremendous potential in the developing world, as it enables their citizens to 1) access international financial resources and 2) provide an irreversible digital trace of their actions, which substantially mitigates information asymmetries. Nonetheless, our model is still in its nascent stage and has not discussed potential drawbacks (e.g., privacy concern) or the possible solutions to those concerns (e.g., zero knowledge proof or the decentralizing privacy model). We encourage future work in those areas and an empirical approach to measure the outcome of blockchain projects in developing countries. Our objective is not to justify our theory but to bring it as a starting point to discuss the potential benefit of blockchain technology in the institutional landscape.

Appendix

Aragon Network

The Aragon Network is a decentralized autonomous organization and a blockchain-based ecosystem where companies, investors, and entrepreneurs can securely transact and enforce smart contracts. The Aragon Network aims to provide a hybrid between smart contracts and real-world business applications using a decentralized court system called the Aragon Network Jurisdiction (ANJ). Any person with an Aragon token (ANT) can create a bond, which is a call for arbitration. The judges are drawn from a sample of people/entities who also posted a bond. If the person/entity selected decides to not participate, it will be penalized.

The selected judges will then look at ANJ and at organization-specific rules to state a verdict. If all the judges have a unanimous vote, they all receive back the bond, which was created in order to request an arbitration. If the vote is not unanimous, the verdict that had the most votes will be chosen. The judges that voted for the verdict that had the minority of votes will be penalized. This aims to create a dynamic judicial court that is based on incentives.

The agent, if not satisfied, can request an upgrade to a marketplace in which all judges can participate. Finally, if the user is still not satisfied, they can take the case to the "Supreme Court," which is composed of nine judges chosen by the whole Aragon network.

If the judges feel that the user has not posted enough information to make a case, the judges have the right to dismiss it. However, if the user requests an upgrade and the case is then approved by a higher hierarchy, the low-tier judges will be penalized. This provides the incentive that 1) people spend time on giving a detailed and understandable case and 2) if judges decide to slack off, they will be penalized (Cuende and Izquierdo, 2017).

BitNation

BitNation is a global free market for governance services based on the Pangea Jurisdiction. The Pangea Jurisdiction is decentralized software that allows citizens to conduct peer-to-peer (P2P) arbitration and create nations. The whole system is based on irreversible reputation, which is gained through feedback similar to the Uber and Airbnb rating systems.

Citizens are encouraged to develop smart contracts, reach agreements, and solve disputes through the Pangea Arbitration Token (PAT). The PAT contains both nontradable and tradable tokens.

Nontradable tokens serve to build reputation and are rewarded based on performance metrics (rated by AI) and user satisfaction (rated by other humans). There are three types of nontradable tokens:

- POA (Proof of Agreement): Given to users and arbitrators based on performance criteria with smart contract creation and execution.
- POC (Proof of Collective): Given to nations, user groups, and governance services based on users' satisfaction with collective contract creation and execution.
- PON (Proof of Nomic): Given to contracts, laws, and legal codes based on user satisfaction.

Tradable tokens (PATs) serve to pay for 1) arbitrators, judges, and juries and to 2) timestamping and executing smart contracts. PATs are rewarded to founders and contributors (32 percent), external stakeholders through a token sale (34 percent), and those who maintain high reputation scores (34 percent). A total of 42 billion tokens will be released through different stages (Tempelhof et al., 2017).

Notes

1 In reality, "Bob" is a public key.
2 This process is simplified to provide a clear explanation of the protocol.
3 Courts are a relatively new concept in the blockchain landscape. They are explained in detail in Section 3.2.
4 In the appendix, we have included two blockchain platforms that exemplify how courts are composed.

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