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Research Article

Blockchain for decentralised rural development and governance

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ABSTRACT

Rural areas are steadily being marginalised in a global economy where 'core/periphery' models of development are dominant. To overcome this, rural areas have experimented with decentralised governance. However, this process is fraught with political, fiscal, and institutional difficulties. These often revolve around transparency and accountability issues and low participation rates. Blockchain technology could act as a social innovation to overcome issues in decentralised governance, and rural areas could even prove to be a fertile environment for future innovation. In this conceptual paper, the potential of blockchain technology is theoretically positioned in regional development discourses. After exploring how blockchain could be applied to rural governance and the barriers it needs to overcome to reach mass adoption, a new distributed model of governance is suggested.

1. Introduction

Rural development and the governance of these places is a matter that is constantly perplexing policy-makers; the issue is how to overcome uneven patterns of development [1,2] in regions with lower population densities and larger distances to markets. 'Core/periphery' models have dominated in regional development discourses [3,4], which focus attention and resources on developing 'core' areas (i.e., cities and innovation hotspots), with peripheral areas either being 'left behind' [5,6] or placed on the wrong side of trickle-down economics [7]. 'Core-periphery' logic still underlies current city-regions models of development [8] whereby the city supports the rural hinterlands. Consequentially, this has led to under-development in rural areas, and the desire to instead self-govern through decentralised forms of governance [9,10]. However, the process of decentralisation has historically been fraught with difficulties [11].

As will be explored in this paper, blockchain technology has the potential to become a new innovative mechanism for decentralised rural development and governance, and perhaps even prove a fertile environment for use-cases and innovation in this emerging industry "as the barriers to adoption are likely to be reduced and the social and economic drivers engender greater impetus for change" [12] (p.125). Blockchain technology "enables a network of participants that do not know or trust each other to agree on the state of a shared administration, without relying on human intervention, a central point of control, or regulatory supervision" [13] (p.21).

This conceptual paper aims to explore the following research question: Can blockchain technology help to overcome issues commonly associated with rural governance and development? It begins by presenting the dominant discourses in economic geography that have led rural areas to lag behind urban areas (Section 2). Following this, it explores how previous decentralised development and governance attempts have been unsuccessful (Section 3), somewhat due to the lack of appropriate mechanisms or tools to govern these initiatives. Next, in Section 4, the key characteristics of blockchain technology and use-cases for rural areas are presented. The role of blockchains in future governance systems is explored (Section 5) before considering the criticisms, limitations, and barriers to adoption (Section 6). A new model of distributed governance is proposed in the discussion (Section 7) before the conclusion provides a future research agenda and initial policy implications (Section 8).

Before continuing, it is necessary to define some of the key concepts in the paper: governance, decentralisation, and blockchain. Firstly, governance is defined as the institutional mechanisms that help two or more parties agree and enforce a decision by increasing both cooperation and coordination between them [14]. Mode 1 forms of governance are hierarchical, whereby decision-making resides at the top of a vertical hierarchy [15]. Mode 2 forms are considered more horizontal and include more actors (such as the private sector and civic society) in decision-making [15]. More recently, network-based (Mode 3) forms of governance have emerged, with power relations and decision-making being distributed across the network [15]. Mode 3 models are distinct

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from previous modes and require new technologies (such as blockchain technology) to facilitate them [16].

Secondly, decentralisation is a term that has multifarious meanings across different disciplines. In the development literature, decentralisation infers a process of devolution [17] whereby strategic decision-making and monetary budgets are transferred to regional governmental bodies. However, as this paper will explore, by using blockchain technology, it is perhaps better to reframe this as 'distributed' governance [18].

Lastly, blockchain is a new technology that operates a public ledger that is trustless, indisputable, and theoretically tamper-proof [19]. Blockchains have three key characteristics that separate them from other databases and ledgers, in that they are open, have a full and public history of transactions, and are operated through a cryptographic consensus protocol [20]. Further details about the features and operation of a blockchain are found in Sections 4 and 5.

2. Regional development and the geography of innovation

The geography of economic development is uneven, with some places prospering, whilst others are considered backwards [21], uncompetitive [22], peripheral [23], or 'left-behind' [5]. Policymakers and academics alike tend to consider rural areas to fall into these descriptions.

This polarising and centralising dynamic has developed over centuries [24] since the times of feudalism [25]. Marshall [26] suggested that economies developed faster and became more efficient when they specialised in one sector and co-located through agglomeration—producing economies of (increasing) scale, which has remained the dominant model to date. Co-locating businesses helps to reduce distances within supply chains, share expensive equipment, share human capital and exchange expertise—all creating competitive advantage [27]. Thus, physical proximity [28] between actors became a fascination for development policies [29], witnessed through the work on industrial districts [30] and clusters [31,32]. Cities and other urban locations, due to their higher levels of physical proximity, have became the prime loci of development [33].

As policy attention and monetary budgets were directed to the most competitive cities, the reverse occurred in many rural areas, which produced continuous marginalisation. Rural residents suffer from a lack of access to services, whether health care [34], infrastructures such as roads or water irrigation [35], broadband [36], public transport [37], business support [38], social care [39], child care [40] or access to mental health services [41], due to a 'rural premium' in delivery [42]. Combined with a growing elderly population in rural areas [43]—who rely on some of these services even more—the issue becomes even more pertinent.

These areas have witnessed mass out-migration of residents as the lure of the city grows, with its promises of employment, education, culture, amenities, and public services [44]. Losing young residents has resulted in a rural 'brain drain' [45] with remaining residents either ageing or lacking the skills (and means of obtaining them) to enter into new markets [46].

Innovation is also seen to have geographic (or territorial) characteristics [47]. Playing into development policy discourses, a 'core/periphery' model has also been followed when studying the geography of innovation [21], with rural areas largely disregarded [48].

Rural areas do not fit neatly into discourses of regional development or innovation policy and are therefore often disregarded or integrated into wider systems in a tokenistic way. Neglect from policymakers and regional development agencies has led to 'self-help' communities forming, who take ownership of their decision-making through more decentralised and participatory forms of governance and development [9,49].

3. Decentralised rural governance

Decentralised rural governance implies that central governments devolve decision-making and budgets to regional governments [17]. Strictly exogenous, 'top-down' and centralised approaches [50] from national governments do not account for (or ignore entirely) the differences in (and between) rural areas [51]. Policies are often designed by urban elites [52] who focus their attention on core areas [53]. When blanketly applied, these policies are dysfunctional or ineffective in rural areas and require 'rural proofing' [54]. Instead, 'bottom-up', decentralised and community-driven approaches are seen to be more beneficial by both policy-makers and academics, especially when facilitated and supported financially, institutionally and politically from above—known as neo-endogenous development [55,56]. This involves empowering rural communities to participate in the creation and implementation of development policies and to self-govern their own budgets, priorities, and services [9]. Participatory rural development has three aims: to allow communities to identify their needs and implement their own solutions to these; to raise the capacity of communities to participate; and to create a framework of cooperation between organisations [57].

In some cases, leaders make no attempt to develop rural areas, and it is instead left to Non-governmental Organisations (NGOs), who are typically volunteer groups with social aims [58]. These groups often have greater flexibility, but with limited funds and tend to focus on smaller local scales rather than regional scales.

In theory, decentralised rural governance gives rural areas the autonomy, ability, and resources to determine their own future success. However, whilst some efforts of decentralisation have achieved beneficial results [59], many more have been fraught with difficulties [60,61], with only tokenistic forms of participation achieved, such as consultation or placation [62].

Parker [49] suggested that there are political, institutional, and fiscal dimensions to decentralisation, where the neglect or ineffectiveness of one dimension can compromise the entire process. Perhaps "the most important and prudent [issue] is based on political transparency and accountability" [63] (p.133), with the decentralised process being susceptible to corruption and lobbying powers [11,64] (also known as 'elite capture' [65]), which has continuously hindered attempts at decentralised development [66]. Similarly, the process can actually reinforce existing power structures by further empowering local elites [67].

Fiscal dimensions revolve around the capacity of local governments and groups to raise capital (whether this is through taxation, grants, donations, or budgets allocated from central governments) and the accountability/transparency of these revenues. Rural areas are often poor and do not have the local resources available to them; therefore, they rely more on intergovernmental fiscal transfers or donations from elsewhere. The crux of the issue around financing a project appears to be a lack of an appropriate mechanism:

> "A fine balance must be found between designing a system of accountability that prevents severe fiscal imbalance, but at the same time does not place unnecessary restrictions on important local fiscal decision-making." [49] (p.29)

Institutional arrangements vary significantly between contexts, but a clear legal framework, an active civil society, the capacity to engage, and accountability are all important dimensions [49]. Information asymmetries are often cited as an institutional barrier, whereby decision-making mechanisms favour the opinions of (often small groups) of informed citizens [68]. Sometimes participatory approaches go against popular opinions, and citizens lose trust in the process [60], or there is a lack of trust that central governments will actually grant devolved decision-making [49]. Institutional accountability can involve "some system of sanctions that penalises institutions that fail to carry out their functions appropriately" [49] (p.35).

Even successful examples such as the LEADER approach of the European Union [69,70] (of which research is available from Spain [71], Romania [72], and many others) have suffered institutional issues. Local Action Groups (LAGs) were established to involve local groups and citizens in the decision-making process, initially to great success. However, and somewhat as a victim of its own success, the previously autonomous LAGs were integrated into local and regional public sector structures, diluting their power and removing public participation from decision-making [73].

The call for decentralised and participatory forms of rural governance was heeded in theory, yet in practice, these processes are often fraught with difficulties, "the real challenge is, therefore, to design appropriate forms of decentralisation that would help realise the promised benefits of decentralisation" [10] (p.438). It appears that there is a desire to implement decentralised rural governance, but to date, there has been a lack of appropriate tools or mechanisms to improve participation and to ensure transparency and trust in accountability, monitoring and evaluation. Blockchain technology could be this mechanism.

4. The potential of blockchain technology

Blockchain is a new technology that has the potential to have "radical" [74] (p.4) effects on society. Fundamentally, it is a 'chain' of data made of individual blocks that cannot be altered or removed when added into the sequence. An open ledger—"a distributed database comprising records of transactions that are shared among participating parties" [75] (p.2)—is held on every computer in the network, which makes the blockchain transparent and collectively verifiable. Every party has an identical copy of the ledger, so it cannot be altered or reversed without the consensus of the protocol. It is also impossible to alter or hide information added to the chain, which could be a valuable tool in fighting corruption [76–78] and transparency in election voting [79]. A cryptographic protocol often underlies a blockchain, which is a method to ensure the data inside a block are correct and keep the network secure. There are many protocols, for example, 'proof-of-work' [80], 'proof-of-stake' [81], and 'zero-knowledge-proof' [82].

A decentralised system offers many advantages over centralised approaches: it cannot fail if one party decides to stop validating data, it eradicates trust from the network, it ensures reliability of data, and it has high security [83].

Blockchain technology has evolved through three generations [84, 85]. First-generation chains offer a peer-to-peer transaction system, the most successful of which is Bitcoin [86]. These chains allow parties to transact in a secure, trustless, and permissionless manner through a system of wallet addresses. Second-generation chains bring additional functionality through two new innovations. Firstly, through smart contracts [87], which are autonomous contracts that are verified and executed on the blockchain. These allow for two parties to enter into a contractual agreement without having to trust each other. For example, the legal deeds for a house could be added into a contract that cannot be released to the buyer until the agreed amount of money is entered into the contract, which is then delivered to the seller. As smart contracts are automated and executed when the terms of the contract are met, there is no need for a central organisation to check and perform these tasks or offer custodial services [88]. Another innovation of second-generation blockchains is decentralised applications (DApps) [89]. These are software that provide tools, such as decentralised exchanges (for example, Uniswap [90]), collateralised loans (for example, Maker [91]), and marketplaces for artwork [92]. Third-generation blockchains are beginning to emerge that promise governance systems (which is of key interest to this paper), greater scalability and further utility [93], including providing digital identities [94]. As blockchain technology matures, it is proposed that the fourth-generation will incorporate artificial intelligence and algorithmic management [85].

Blockchain projects can incentivise participation and good practice through a range of tokenisation dynamics. Tokens (akin to coins) can be created [95]—commonly called 'cryptocurrencies'. Tokens can be 'fungible' (i.e., replaceable by another identical token) or 'non-fungible' (i.e., unique and not replaceable) [96]. Tokens can be earned (commonly through either 'mining', 'staking', or voting [97]), bought or sold, publicly on an exchange or privately through peer-to-peer transactions. But importantly, these tokens could have utility—for example, if you own a token, you could cast a vote in an election, gain entry to an event, or get exclusive access to new social media content. Unique Non-Fungible Tokens (NFTs) could represent ownership of a limited-edition product (like a certificate of ownership for a piece of art) [98].

The following will explore the current use cases of blockchain for rural areas.

Blockchain has a proven use-case as a currency and payment system. Many rural areas suffer from high levels of poverty, and residents lack access to financial systems (such as bank accounts, insurance policies, loans, etc.) [99,100], also known as 'the unbanked' [101]. In Africa, for example, unbanked levels are high, and multiple local currencies are suffering from inflation, yet mobile phone usage is relatively high. Therefore, using mobile phone call minutes as a form of currency has become commonplace [102]. Blockchain offers the opportunity to offer financial services without the need for a bank, known as decentralised finance (DeFi) [103]. Protocols already exist that offer loans, savings accounts, and insurance policies without the need for banks or brokers, with liquidity provided by the community [104]. Microfinance has proven incredibly beneficial to supporting start-up rural micro-businesses, which is well documented in Sri Lanka [105]. However, access to this is dependent on NGOs. A blockchain-based microfinance (DeFi) system could facilitate peer-to-peer microfinancing, where richer individuals from anywhere in the world can support a business in a developing country. Blockchain microfinance is becoming a reality through Decentralised Autonomous Organisations (see Section 5) [106].

Many rural residents in developing countries leave to find wages in more developed countries [107] or urban areas. Remittances are commonly the only method of sending money over borders; however, this is not as beneficial to alleviating poverty as development agencies first thought [108]. As of 2018, the average global fee charged for sending a remittance payment was over 10% [109]. This equated (in 2017) to US $30 billion of fees collected globally, the cost of which "is borne by the migrant senders and their family recipients, [but] there is a sense in which the burden also falls on poor countries as a whole" [110]. Blockchain systems such as Stellar [111] could reduce these costs radically and speed up sluggish transfer times. Hughes et al. [12] demonstrated the use-case for blockchain in helping to resolve issues resulting from the mass out-migration of rural residents in India towards cities.

Land registries (or lack of in many cases) need reforming. Exploring the role of blockchain in land-ownership and rentals is already underway, with Daniel and Ifejika Speranza [112] using the example of the informal land rental industry, the OECD offering three case studies of Georgia, Honduras, and Ghana [113] and the concept being theoretically applied to Serbia [114]. The need is particularly apparent in countries with no such form of the registry and where land disputes are frequent and sometimes violent, like in Afghanistan [115]. Graglia and Mellon [116] proposed a nine-fold typology of levels of blockchain integration in public land registries, ranging from no integration (most of the world) to recording land on a blockchain (e.g., in Brazil), recording progress of a transaction of land (e.g., in Sweden), escrowing facilities and moving the registry onto a blockchain (e.g., Georgia and the United Arab Emirates), through to disaggregated rights, fractional rights, peer-to-peer transactions, and interoperability (none of which is a current reality).

Rural areas are becoming increasingly marginalised with public services cut, leaving communities to source their own social innovations to deliver these services. One example of this is through decentralised energy systems [117–119], whereby communities operate their own (renewables) power grids [120,121]. The Energy Web Foundation is a project specialising in blockchain solutions for renewable energy grids [122]. However, decentralised microgrids are often plagued with logistical and trust issues around usage versus production. The blockchain could provide a transparent account of everyone's power usage and production if disputes occur. In effect, this is an example of overcoming a 'tragedy of the commons' scenario.

5. Governance and blockchain

Blockchain has been heralded as a technological solution for governance issues for some time now, with Atzori [123] in 2015 suggesting that the state is no longer necessary. However, using blockchains for governance is still an emerging concept that is at the forefront of third-generation thinking [124].

It is important to differentiate between the governance *of* the blockchain and the governance *by* the blockchain [125]. Governance *of* the blockchain refers to the internal capabilities blockchains have to decide on future software updates and changes to internal protocols [126] by asking community members to vote on proposals. Voting helps to reach an equitable consensus without alienating some members of the community, which can lead to contentious 'hard fork' events where a new chain is formed (witnessed to Bitcoin in 2017) [127]. 'On-chain', governance *of* the blockchain is an example of Mode 3 governance [15]. Examples of cryptocurrency blockchains that have functional 'on-chain' governance (self-executing according to the decision of the vote) include Cardano's Project Catalyst (where the community can vote on which projects to fund) [128], Cosmos's Tendermint protocol [129] and Tezos [130]. The governance *of* the blockchain has three dimensions: decision rights (who can make decisions), accountability (who is held accountable), and incentives (mechanisms to aid participation) [126].

Governance *by* the blockchain is when blockchain is implemented into real-world systems (such as supply chains or an electoral voting system) and is still in its infancy compared to the governance *of* the blockchain. What makes the concept of blockchain *by* governance so compelling is the ability to be transparent, tamper-proof, and trustless—all of which could make governance more open, accountable, and participatory. Blockchains could have three important functions in a governance system: tracking (of resources, contributions of community members and data); managing (decision-making and evaluating achievements); and negotiating (reaching consensus through voting mechanisms) [119]. Blockchains have been viewed as a way of facilitating greater cooperation and coordination in the governance process [131] by eradicating opportunistic behaviours and building trust between parties. They are predicted to have a strong replacing effect when transactions are explicit (i.e., easy to codify and often contractual), but with less of an effect when transactions are tacit (i.e., hard to codify) [131].

The principal mechanism of blockchain governance is Decentralised Autonomous Organisations (DAOs) [132], which were invented in blockchain's second-generation and maturing in functionality and viability in third-generation chains. DAOs are autonomous protocols which are programmed to follow a set of algorithmic rules (which cannot be altered) that track input data, execute smart contracts and administer voting. A case for applying DAOs to e-government has already been made to automate auditing, bidding for tenders, selecting tenders and issuing official documents (like driver licenses) [133]. Recently, DAOs have become very popular in cryptocurrency projects and have become more accessible through visual interfaces (which require no coding skills), such as DAO DAO [134].

If blockchain technology is adopted, future decentralised rural governance initiatives could avoid the pitfalls of previous attempts. Currently, "effective decision-making processes, in which local citizens can participate and for which decision-makers can be held accountable, are weak" [10] (p.423). A recent trend in decentralised governance is 'participatory planning' [135]—a means of empowering citizens in the decision-making process of future developments in their neighbourhoods. The real-life example of 'neighbourhood plans' in England [136] will be used to demonstrate how blockchain governance and DAOs could improve the process, which has often been described as 'toothless' [137]. Since 2010, England has been implementing a 'localism' agenda with the aim of reducing decision-making further to the local scale [138]. Neighbourhood plans were envisaged to be a participatory planning mechanism whereby neighbourhoods could decide on the number of new houses being built, where these would be, and at what price range. Several issues were encountered around the creation and implementation of the plans. Firstly, there were severe ranges of competence and capacity at the neighbourhood level to draw up a plan and ensure meaningful participation from citizens [139]. In some cases, the plans in fact contributed further to the uneven aspect of development by favouring communities with the capacity and time to prepare plans and participate in consultation—something that affluent communities are better at than poorer ones [140]. Secondly, conflicts occurred over complex issues that were hard to resolve (such as which sites to place new houses on), with the final decision being made by a planning official [141], which left some communities disenfranchised with the decision of the plan. Thirdly, plans lacked the legitimacy or legislative support to actually be implemented [142].

Blockchain technology could provide tracking, managing, and negotiating tools [119], which would not only make the process more transparent but also incentivise citizens to participate. A new participatory planning initiative could establish a DAO to govern the process. Neighbourhoods (or representatives of that community) could vote on various proposals the DAO puts forwards. For example: What type of development do you want in your neighbourhood? What are you not willing to have? Which public services do you require? Willingness-to-pay surveys, etc. Voting could also take place on a map, where neighbourhoods, streets, buildings, or vacant plots could be voted on for locations of new developments. Budgets could be proposed and voted on. The voting could be anonymous or public, depending on the sensitivity of the subject.

Public meetings could be held initially to discuss important proposals and set the overall strategy, but finer details could be voted on using a mobile application or similar. This avoids levels of bureaucracy that cause 'participant fatigue' (whereby participants become disenfranchised with the process, mainly due to excessive levels of bureaucracy) [143] and allows citizens to vote on proposals around their own schedules and commitments. All information needed to have an informed vote can also be provided through the application, allowing information asymmetries to be overcome.

The data collected could be used to settle or nuance conflicts between neighbourhoods, ensure representation of all interested parties, and be able to return to certain groups for further consultation (a strategy that has proven to increase the quality of participation and results [144]).

Blockchain could also bring fiscal accountability and transparency to these processes. Budgets allocated from central governments, local resources and donations could be entered into a smart contract at the start of the process and divided accordingly to the projects the community needs. The budget for a new road (for example) could be clearly defined, and then the search for a contractor would begin. The tendering process (which is particularly susceptible to corruption [145]) could be implemented and executed through the smart contract, ensuring the best value-for-money offer is contracted in a transparent and accountable way.

However, the example of using blockchain technology to improve participatory planning projects (and decentralised rural governance more widely) is still hypothetical due to (as we shall explore below) several limitations and a lack of adoption.

6. Limitations of blockchain

Despite the potential that blockchain has as a revolutionary technology, so far development and adoption have been slow [146]. On the development side, it is proving difficult to scale blockchains, and solutions have been lacking [147]. This is due to a blockchain requiring consensus between nodes and the ledger requiring constant updating. However, recent advances in 'zero-knowledge roll-ups' or sidechains might prove to be a solution to this issue [148], as they can move some transactions away from the main chain and validate them separately to reduce congestion. Another development issue is that some projects have been exploited or hacked [149], somewhat due to the complexity of programming a smart contract correctly. One solution to this is through a visual interface using a functional programming language (Cardano's Marlowe application, for example [150]).

Hughes et al. [12] suggested that there are several limitations that have stopped widespread adoption in the private sector, including a lack of privacy (important for businesses wanting to hide financial information), high costs, the security model (you cannot retrieve a wallet or reverse a transaction), latency (blockchains are not fast enough to process the number of transactions mass adoption would bring) and governance (in the sense that a central organisation cannot control the governance of the system). Businesses find it too expensive to move to a blockchain system and do not want to radically restructure their current structures and systems [85]. These are all valid limitations for businesses that have to consider their profitability, with blockchain currently proving too expensive and slow to justify moving towards. However, many of the limitations (for businesses) raised by Hughes could be considered irrelevant when considering governance systems; when making important decisions that require consensus, trust in the system, transparency and security are more important than speed and cost.

Regarding governance, there is currently a dearth of research concerned with this [126]; therefore, limitations and criticisms are still emerging. Major issues can be framed as “first mile, last mile” scenarios [16], where challenges emerge by overcoming initial barriers and then later in the refinement stage. As governance *by* the blockchain is still emerging, most issues revolve around overcoming the “first mile”. An obvious issue is getting those in power to relinquish control and adopt a new form of transparent and accountable governance. One major issue for governance *by* the blockchain is the difficulty in codifying complex and tacit decisions into a smart contract [16]. Simple votes (such as a ‘Yes’ or ‘No’ response) are easy to code, but decisions in the real world are often far more complex and nuanced than this, with negotiation required. Another limitation relates to the trustworthiness and accuracy of information being entered that is non-native to the blockchain [151], which would need independent validation from a third party, adding complexity and bureaucracy to the process.

7. Discussion

This paper presented why rural areas are often ignored in development policies and how previous attempts at devolving power to these places (through decentralised rural governance) have largely failed due to issues around a lack of transparency, legitimacy, and trust. Blockchain technology was presented as a potential solution, and use cases were applied to rural areas, including how DAOs could be used in rural governance. Limitations concerning the development and adoption of this new technology were also raised and discussed.

As there is a demand for decentralised solutions but a lack of available mechanisms, rural areas can be viewed as a unique scenario which appears to be a prime area for blockchain developers and researchers to apply governance *by* blockchain. However, these places also have additional institutional, social, economic, and political barriers [51], which may make the implementation of blockchain harder and present a set of real-world ‘first mile’ limitations. For example, rural areas tend to suffer from weak internet infrastructure [152], which is an obvious requirement for applying a digital form of governance. Rural areas also typically lack the capacity (compared to urban areas) to implement bottom-up initiatives and have overall lower average educational levels. Rural governance is often led by local elites who have power and wish to maintain decision-making, and in some cases, these local elites are also susceptible to corruption or acting in their own self-interest. The situation presents somewhat of a paradox, as rural areas could be considered a fertile environment to implement and test blockchain-based governance solutions, but it may prove even harder to overcome the ‘first mile’ in these places. Discourses in innovation theory suggest that new innovations can occur in extreme conditions [153], with rural areas sometimes considered as ‘extreme’ when compared to urban areas [48]. If governance *by* blockchain can be applied to an extreme rural area, in theory, it should then be easier to implement in an urban area.

Returning to the ‘core/periphery’ discourses of economic geography, which have resulted in uneven development, decentralised rural governance emerged as a potential solution, but most projects failed. With the tool of blockchain available in the future, new forms of rural governance could emerge.

Vergne [18] made a distinction between decentralised and distributed forms of organisations, focusing on digital platforms (such as Facebook or Uber). Decentralisation is related to the coordination of communication (centralised or decentralised), whereby unstructured data are collected and made understandable to help inform decision-making. Centralised coordination of communication implies that only a few individuals structure the data, whereas decentralised coordination involves more members contributing to reading and understanding the data. Distribution is related to decision-making (either concentrated or distributed), whereby in a concentrated system, a managerial hierarchy makes the decisions and in a distributed system, multiple individuals need to reach consensus on decisions. Vergne went on to propose four models of organisations (see Fig. 1). A Centralised-Concentrated (Ci-Co) model is a typical Mode 1 system, similar to that of a small business whereby the manager processes all information and makes all the decisions. A Centralised-Distributed (Ce-Di) model is where “[c]centralisation remains for communication and organisational strategy; yet decision-making—and trust—are distributed to manage complexity” [18] (p.8). A Decentralised-Concentrated (De-Co) model allows data processors to reach a consensus on the best strategy, which is then passed to a manager to make the final decision on—akin to a Mode 2 system. Lastly, a Decentralised-Distributed (De-Di) is where “trust is both distributed (i.e., any member can be a decision-maker) and decentralised (i.e., every member has equal access to data and information)” [18] (pp.8–9) and is representative of a Mode 3 model. These four models can also be applied to governance systems, whereby decentralisation relates to the coordination of strategy and resources, with distribution still relating to decision-making.

If blockchain is integrated into governance systems (to help overcome the common pitfalls associated with previous attempts at decentralised rural governance), more distributed models could emerge, which would be beneficial for rural development. A two-stage model involves a Ce-Di model governing at the national scale and a De-Di model governing at the regional scale (or in areas where NGOs voluntarily take a lead on rural development initiatives).

The national Ce-Di model would have two levels of DAOs operating (shown on the left of Fig. 2) between the national and regional scales and then the regional and neighbourhood/local scales. The aim is to truly distribute the decision-making process to rural areas; therefore, a series of regional DAOs would let neighbourhoods decide on their own local agendas and allow them to vote on proposals (which would be overseen by Regional Development Agencies or NGOs). These individual regional DAOs would adopt Di-De models (shown on the right of Fig. 2), which can ensure the participation of residents is open, transparent, and well-suited to negotiating conflicts to come to an equitable decision. The lines on the diagram indicate that neighbourhoods are interconnected and share information about voting proposals together (neighbourhoods in close proximity have more to consider together, as decisions could affect both), and then their votes are fed into the regional DAO.

A network of regional and neighbourhood DAOs would also provide the infrastructure and nodes for a national DAO, which would oversee the entire process and allocate budgets from central funds. The role of the national DAO is to monitor (the types of decisions being made and stakeholders involved), manage (by evaluating the effectiveness of decisions), and negotiate (future regional budgets, based on their evaluations). National governments can use the information provided to the DAO to strategically plan future directions and make transparent decisions about future budgets using machine learning where appropriate [18]. The idea of the national DAO is to ensure another layer of

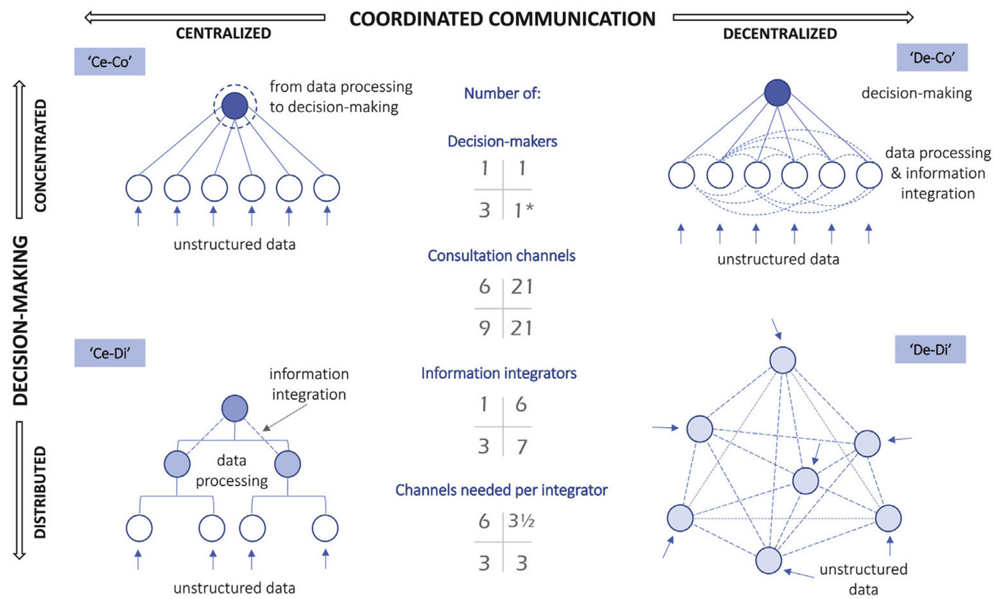

Fig. 1. The decentralisation and distribution of organisations [18].

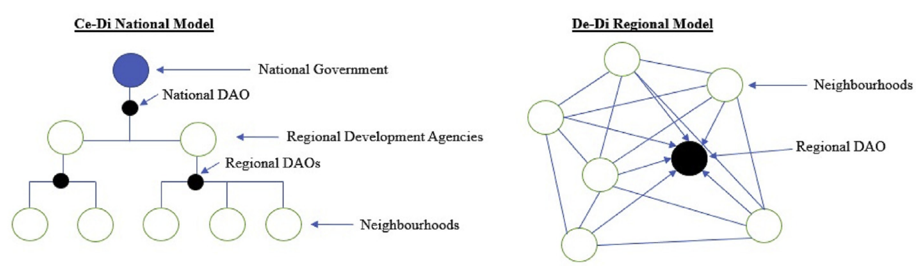

Fig. 2. Distributed rural governance models at the national and regional scales (adapted from Ref. [18] with permission). DAO: decentralised autonomous organisation; Ce-Di: centralised-distributed; De-Di: decentralised-distributed.

accountability and transparency occurs between the national and regional scales.

For now, the proposed model is only considered hypothetical, as we are still many years away from it ever becoming a reality, but it could be a useful framework for future research on blockchain-based rural governance projects (or experimentations). It does, however, remain grounded and realistic by recognising the role of central governments and some form of hierarchical power structure for strategic (national scale) direction. It does not intend to be a silver bullet which will completely eradicate the need for institutional arrangements to oversee governance in real-life scenarios. Before implementing the model, it is important to ensure that several criteria are met, some of which will be particularly challenging in rural areas in the first instance: sufficient digital infrastructure (in terms of hardware and a stable/fast internet connection), sufficient training for operators (whether this is an NGO or regional development agency), sufficient buy-in by the community (in terms of how to participate and why it is important) and sufficient buy-in from governments.

8. Conclusion

This paper asked whether blockchain technology can help to overcome issues associated with decentralised rural governance. It has also positioned blockchain's potential into academic discourse on rural development as a starting point for future debate. It is important to acknowledge that the process of adopting blockchain technology for rural development is a monumental task, which will no doubt begin with humble roots.

Blockchains have characteristics that make them particularly appealing to bringing greater transparency, trust, and validity to the decision-making process in rural areas, but major barriers in development and adoption are still present. Governance *of* the blockchain is rapidly being developed and implemented, but we are still some distance from governance *by* the blockchain becoming a reality. If barriers are overcome, then rural areas could in fact be a fertile environment to develop and test blockchain-based governance solutions using the Ce-Di and De-Di models. This paper has demonstrated that blockchain has characteristics that make it appealing for rural governance, but it has not considered how it could be implemented and importantly by who. In extreme cases where governments are not concerned with rural areas, NGOs are often tasked with rural development initiatives, many of which adopt bottom-up grassroots projects. It could be these scenarios and groups that adopt the first wave of governance *by* the blockchain projects in rural development. On the other side of the spectrum, it could be the most well-resourced and progressive governments that lead the way in blockchain adoption. The practical aspects of implementation are an area for future research to address.

Researchers from many disciplines across the social sciences could play an important role, and considerably more theoretical and empirical research is required. More theory building is required around the concept of distributed rural governance that this paper has introduced. Researchers could be involved in empirical action research projects, alongside practitioners and policy makers, to evaluate the effectiveness of blockchain-based interventions. The institutional role of NGOs and development agencies needs further investigation. Will these organisations become facilitators or barriers to technology? Research also needs to address whether blockchain helps increase participation and what issues there are around access (internet access and computer literacy being two obvious concerns).

If blockchain does achieve mass adoption, then there will be a new and heightened role for blockchain developers in policy initiatives, as bespoke DAOs and smart contracts will need to be built. Specialist interdisciplinary teams could be formed of developers, experts in economic development (who have a thorough understanding of the economic issues of rural areas), practitioners of participatory governance (who know how to educate and encourage citizens to participate), and evaluators (whether these are researchers or policy officials). In the short term, development agencies, policy makers, and regional/local governments could look to educate themselves on this technology and consider areas in their jurisdiction where experimentation is possible.

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