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Managing Complexity for Social Outcomes

A Behavior Perspective of the Blockchain:
Considerations for the Design and Testing of International Development Blockchain Interventions

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I have greatly enjoyed and benefited from discussions and collaborations with numerous colleagues in working to develop this paper. I firmly believe that the early thinking presented here could benefit from additional conversations. I invite all comments and questions at emergence.cooper@gmail.com

This paper is meant to be debunked, it is meant to generate conversation that will lead to an evidence base that provides actionable data that tests its assumptions and conclusions. This paper is meant to be a starting point for thinking about how the blockchain could be used in the international development space, its behavior change potential and the pathway to them. This paper is not a pure empirically driven argument, more than anything it is possibilities (using evidence and thinking we have from relevant experience) that need to be tested. The paper speaks mostly to new thinking around token design, token engineering and token economics for behavior change. It is hoped that the next steps could be a taxonomy of different blockchain applications, the problems they address, the behavior change they seek to leverage and the attributes of the system they interact with. From there the hope is that we can get to the relevant guidance and toolkits to design and evaluate the various types of blockchain based interventions.

We are approaching the time where the blockchain[1] will be a significant component of interventions aiming to achieve social impact in the developing world on a wide scale. Blockchain is being discussed as a disruptive technology, potentially creating a paradigm shift in social ecosystems at a time that international development interventions continue to build a poor track record of aid effectiveness, partly due to a poor understanding the ecosystems they operate in. Hence we have a limited amount of time to develop proper guidelines (to include

[1] In this paper, I use the phrase "blockchain" as a bit of a catch all. When I say "the blockchain" I am referring to all possible applications of the blockchain. If I am referring to a specific use of a specific blockchain I will caveat it as such or use the phrase "a blockchain".

ethics) for projects utilizing the blockchain before the pace and complexity of change leveraged by blockchain interventions overwhelm our ability to achieve targeted outcomes while "doing no harm".

This paper attempts to inform the early need for principles, guidelines and tools on designing and testing blockchain interventions in international development from a behavioral perspective. It focuses on the social outcomes of projects using the blockchain and not the performance of the technology itself. Meaning the focus here is on behavior change outcomes in the surrounding social ecosystem influenced by the introduction of a blockchain and not performance of the blockchain in terms of processing ledger transactions.[2]

In short, the blockchain facilitates decentralized self-organization around aligned interests and it is the effects of this organization on the immediate social ecosystem that need to be considered when designing and testing international development projects using the blockchain. While there is a lot to that statement it is also a summary of how this paper is organized in outlining:

- How the blockchain facilitates **self-organization** around social outcomes
- How social outcomes are currently pursued in international development
- Why the **decentralization** of the blockchain enables self organization for social outcomes
- What the influences are from the blockchain are on the immediate social **ecosystem**
- Implications for how projects that integrate the blockchain could be design and tested

The conclusion of the paper is grounded on four tenets that the blockchain could influence ecosystems by facilitating 1.) mutually beneficial relationships in a 2.) decentralized fashion where 3.) power is shifted from the center of the ecosystem to the 4.) hard to reach populations at the fringes of the ecosystem.

Opening Example

Imagine a rural-micro-grid where a rural population has no access to power due to their distance from the centralized grid that serves urban centers. The interests of the rural population are to gain access while the interests of the centralized utility may not include

[2] For a discussion of performance evaluation for blockchain technology, as opposed to evaluating social outcomes resulting from a project using the blockchain, see Hyperledger Blockchain Performance Metrics.

providing this access for a variety of reasons (financial sustainability, political pressures, etc.). Micro-grids are increasingly a preferred option amongst rural populations to gain access to electricity (sometimes even over access to the centralized grid) due to the transparency of having the micro-grid managed locally, lower costs and higher reliability of service.

Micro-grids result from a lack of aligned interests between producers (centralized providers) and users (rural populations) and the blockchain has already been used in managing the transactions of micro grids thus facilitating increased access to electricity to be self managed by those within the micro-grid network. Hence we have some empirical evidence of how the blockchain create efficiencies through decentralized and emergent management of resources to achieve a social outcome.

Many in the international development space currently design and measure interventions to build incentives and nudge behavior towards an outcome based on our understanding of the various actors in the social ecosystem and their respective interests. For example, some try and introduce policy and regulatory reforms within national regulatory regimes and utility management to incentivize or somehow nudge actions that would increase the access of rural populations to electricity, often with mixed success.

The blockchain could be a very helpful tool to attach rewards around social outcomes, like increasing access to electricity, without having to chart out the exact causal pathway to achieving those outcomes. In the case of micro-grids, a donor could fund the initial installation of meters, solar panels, etc. (perhaps through a loan that could be re-paid in an automated fashion using blockchain smart contracts that disperse payments based on the type of electricity consumed/produced). Then the management of the system (all the transactions involved with buying and selling power on the micro-grid) is done on a blockchain. The value add of the blockchain being that it offers a way for these transactions to be done in a transparent and automated fashion that does not need any authoritative/central actor (like a utility) for oversight, resulting in costs savings from not having to provide the resources to fund the authoritative/central actor and any loss of resources from corruption or mis-management.

Hence a formerly hard to reach population is now empowered to self manage its own electricity. The community is able to organize around its own interests and not the interests of the utility or political actors that constrained the expansion of the central grid in the first place. There is no need to "nudge" behavior or action, nor is the impact dependent on creating new incentives, the micro-grid managed on the blockchain is built on mutual interests hence why is has the potential to be a more efficient means of achieving the impact. While micro-grids have existed before the blockchain, the blockchain introduces the cost-savings required to make the

micro-grid a much more efficient, and thus feasible, option for increasing sustainable access to electricity.

This does not mean that the hard-learned lessons of behavioral economics, the importance of beneficiary mindsets and mechanisms of change (explained below) are ignored. It just means they are re-calibrated to focus on different types of decisions made by those within the blockchain ecosystem. For example, with the rural population now served by the blockchain based micro-grid, their mindsets and decision making towards the use of clean versus non-clean energy could be a factor in determining the pricing structures of the blockchain smart contracts that govern the micro-grid transactions. If there is a need for higher use of clean energy on the micro-grid, a responsible tariff schedule to incentivize the use of clean energy should still be based on things like affordability, competing priorities for household resources, etc.

Complexity and systems thinking have extremely valuable lessons to lend to the development of principles and guidelines for designing, testing and evaluating blockchain solutions. This is because the blockchain will create new dynamics within a social ecosystem that necessitate revisiting our old thinking and practices in order to stay ahead of the impending changes. In the micro-grid example, imagine the 2nd and 3rd order effects from scaled micro-grid solutions using the blockchain. In addition to the effects electrification has on the socio-economics of communities, such a solution creates new winners, losers, potential spoilers and possible significant disruption to social dynamics. The more local communities are able to self provide essential services like electricity, what is the effect on relationships/expectations with central governments? Do the mandates for public service providers change? Who "wins" and who "looses" authority, resources and credibility in such a scenario? What social dynamics are magnified and which are disrupted?

These questions still remain relevant in order to ensure "Do no Harm" principles in blockchain influenced social impact solutions. Hence Political Economy Analysis (PEA) (to include ethical considerations) will become increasingly critical during the design and early testing of these blockchain-based solutions.

"Nudging" Behavior in International Development

At present, most international development actors design, implement and evaluate interventions based on inputs leveraging a mechanism of change within the ecosystem they are operating in to bring about an outcome that enhances social welfare. In short, inputs are meant to "nudge" mechanisms of change and shift mindsets to bring about some type of

behavior change that leads to the outcome, what some call the Context-Mechanism-Outcome configuration. For example, a hand washing campaign produces marketing materials based on community norms around hygiene, a fertilizer program uses an understanding of farmer spending habits to try and incentivize buying fertilizer at certain times of the years. The 2015 World Development Report highlighted this approach.

However, the path of causation between the inputs and outcomes are rarely understood, if achieved at all, due to a lack of understanding of the mechanisms of change. These mechanisms of change are difficult to detect and the lack of understanding around them has created in-efficiencies in how we achieve impact. A potential of the blockchain is that impact can be achieved without having to completely understand these mechanisms as the blockchain could stimulate, in a more cost-effective manner, an "emerging" alignment of interests for positive social outcomes.

I say "emerging" on purpose because "emergence" is a Complexity Sciences term that describes the self-organizing ability of a system to synergize interests; meaning a system is "emergent" when it does not need an organizing authority to prescribe an optimal, or any, action. The action "emerges" from the system in an organic, self-organizing fashion. Going back to the micro-grid example, if a local community is able to buy and sell power in a peer to peer (household to household) manner, prices can fluctuate according to supply and demand (as opposed to a fixed pricing system demonstrated in most tariff schedules) which could lead to more responsible consumption.

Hence the mechanisms of change are not as critical in emergent systems because the system organizes around the appropriate mechanism for the specified outcome (this is an over simplification but it will do for our purposes here). This is not saying that self-organizing social change does not already happen, it happens all the time. But part of what makes the blockchain so significant is that it creates increasingly cost-effective ways for solutions to social problems to self-organize, it introduces new efficiencies by creating new possibilities for self-organization.

A micro-grid managed on a blockchain ledger using smart contracts can provide more timely data on consumption patterns at various prices in an automated fashion. In a micro-grid run on a blockchain, a distributed network of households could replace a centralized Utility and other gatekeepers that previously ran services, established prices, etc. Providers, whether it is a Utility and or individual household producers, and users could mutually own and maintain services that run on the blockchain. In return, they share the profits that the services generate,

thus facilitating alignment of interests around appropriate pricing, consumption, etc. As indicated in one of the first systematic reviews of blockchain applications in the energy sector,

> "Blockchains in local energy markets can incentivise end-consumer participation. As a result, consumers are exposed to the real cost of energy, which might result in more rational energy consumption or suitable price signals for demand response…. Until now, prosumers (consumers who also produce) have not had real access to the energy market, which remains a privileged playing field for the institutionalized energy suppliers due to high associated costs…..If prosumers are allowed to sell their surplus directly to other consumers without intermediaries, a potential for energy cost savings emerges for all stakeholders. Prosumers can derive greater benefits from their investment, as value remains within the micro-grid and local community. P2P trading in local energy market- places can provide socio-economic incentives that promote local renewable generation and therefore might form an alternative incentive for prospective prosumers. Consumers, who cannot afford investing in renewable generation, either due to capital funding or limited space, can buy certified green energy at a affordable prices. Emerging platforms indicate that there might be a market for matching consumers to renewable energy suppliers, such as in the case of Piclo and others. Often consumers are willing to pay a premium for buying green energy, however currently there is no guarantee about the origin of energy purchased and most likely the energy used by end consumer is still sourced by the closest fossil-fuel power plant."

This alignment of interests has already been assessed in real world examples like the Brooklyn microgrid project where prosumers can sell their energy surplus directly to their neighbors by use of Ethereum-based smart contracts. Energy surplus is measured by specially designed smart meters that can handle physical energy measurements and data, and sequentially transformed in equivalent energy tokens that can be traded in the local marketplace. Tokens indicate that a certain amount of energy was produced from the solar panels and can be transferred from a prosumer's smart meter wallet to end-consumers by use of blockchain technology. Tokens are deleted by the consumer's smart metering device, as purchased energy is used in the house. Microgrid users interact with the platform by specifying their individual price preferences in the form of willingness to pay or sell electricity. The platform can display location- specific and real-time energy prices. In the initial phase of the project, users manually trigger an agreement in the platform, whose terms are recorded in the blockchain. The ledger records contract terms, trans- acting parties, volumes of energy injected and consumed as measured by metering devices and crucially the chronological order of transac- tions. In addition, payments are automatically initiated by self-executed contracts. Every member of the community can have access to all historic transactions in the ledger and verify transactions for themselves.

In this example, the blockchain enabled alignment around true prices, willingness to pay, optimal use of resources and corresponding change in consumer/prosumer behavior. Up until now we have had to rely on very expensive practices like Willingness to Pay Surveys that offer up very limited data for decision making around tariffs for service delivery because we are not able to efficiently gather real-time empirical data. Hence something like the blockchain can alleviate the need for top-down driven decision making based on very limited and costly data and allowing for more de-centralized self-organization around social outcomes.

The in-efficiencies stemming from over prescribing causal pathways for social impact solutions has already been recognized, in the case of Utilities the inefficiencies around Tariff scheduling has been well documented. The increasing use of results based financing is indicative of this. Result based financing is where the input, outputs and strategy are loosely prescribed but the funder pays once results are achieved and validated. Often in these cases the funder does not care much about how results are achieved (outside of some established parameters like environmental or social protections), just that they are achieved. There is an almost acquiesce to the fact that foreknowledge of mechanisms of change is exceptionally difficult and perhaps it is more efficient to incentivize outcomes and then let the emergent ecosystem self-organize and learn how to best get there. The blockchain is now a part of that conversation.

From Ledgers to Ecosystems: The Decentralizing Effect of the Blockchain

The blockchain at its core is just a ledger. But to understand how this ledger can disrupt an ecosystem it is necessary to understand the role that ledgers play in social structures. The importance of ledgers can be demonstrated by quickly thinking about how they influence our everyday lives.

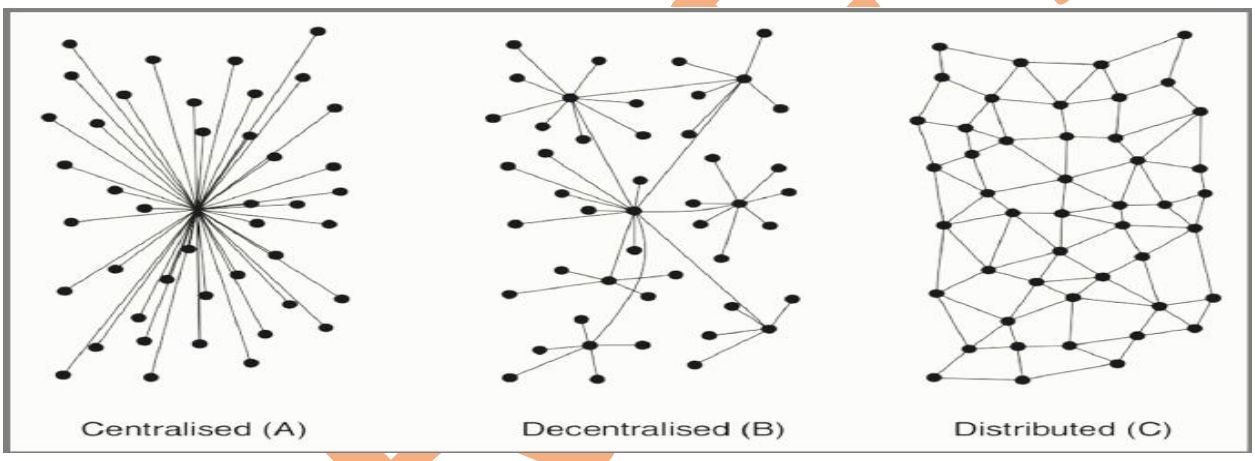
Why can banks be able to tell customers that even though they deposited their money into "their" account, they are not able to access those funds for several days? How is it possible that so many customers credit scores were damaged when Equifax (or the U.S. Federal Office of Personal Management) was hacked and the sensitive information of millions of accounts lost? How can so many public utilities in the developing world have massive amounts of corruption in their "public" financial management? Answer: because they have centralized control of the ledgers.

Your bank controls your funds (within parameters) because they control the ledger that your funds are on. Equifax was vulnerable to hacking because they control the ledger that contains all your sensitive information in a central location. Utilities can have rampant corruption by because when you control the ledger in a non-transparent, you can make the numbers say whatever you need them to say. This is not implying that there are no protocols to prevent all

this. Banks have regulations, Equifax has computer security systems, and public utilities have financial management protocols. But if these were as effective as they should be, we would not be having this conversation.

The point is that there is centralized control over these ledgers. That centralized control hampers transparency and the lack of transparency facilitates the problems alluded to above. What the blockchain does is decentralize control of the ledger to whatever degree is desired (it can be completely open or completely closed) so that the ill effects of centralized control are mitigated.

It looks something like this on a spectrum of levels of centralized control:



If we think about this from a complexity standpoint, the level of complexity increases as you move from centralized to distributed. This increase in complexity does not mean that there is a loss of efficiency in coordinating action though. Controlled economies are less efficient than market driven ones because of the emergent nature of open markets. Markets are systems that self-organize to figure out the most optimal way (alignment of synergies/interests) to produce, sell and buy widgets.

Centralized systems have "simpler" ecosystems because they are more predictable; have fewer moving parts, etc. I say "simpler" because there are many attributes of complexity and while centralized systems can be more complex on one attribute, generally they are simpler overall compared to more decentralized systems. Distributed systems have high levels of complexity but tend to organize themselves around mutually beneficial outcomes and membership in the

system tends to be more voluntary (because there is no centralized authority controlling/coercing/forcing entry and exit). Hence if one does not like the approach, values or outcomes preferred by others in the ecosystem, perhaps they can just leave it entirely and join one more in line with their preferences.

What the blockchain does is decentralize authority over the ledger but, as you can begin to see from the previous paragraphs, this has direct implications on the ecosystem around the ledger. To better understand what this means a quick outline of what an ecosystem is comprised of is necessary.

The Principles for Digital Development do an outstanding job of outlining the components of an ecosystem to help practitioners better understand the ecosystems in which they are working. These ecosystem components include:

- Users targeted by the intervention (beneficiaries)
- The community, culture and socio-economic context in which the beneficiaries/users live
- The market and technology environment
- The political landscape to include policies and regulations
- Active donors and projects in the same "space"

I would add to this a lesson from Outcome Mapping in that the ecosystem includes all those actors and things that somehow influence the outcomes of interest. International development interventions have had various scopes of aims, from integrating within an existing ecosystem (for example tariff reform) while others attempt to re-engineer an entire ecosystem (de-centralization and privatization reforms for example).

Ecosystems can be as abstract or as specific as needed depending on the design of the intervention. The same goes for type and level of complexity. Systems Thinking has provided some very valuable thinking about where the boundaries of ecosystems. This is important as the boundary defines the thresholds (who is in and who is out, winners/losers, etc.) and defines the scope for the intervention. Draw the boundaries too close and you may miss including a critical relationship that can facilitate the social outcome, too broad and it may dilute your effect.

The Blockchain Influenced Ecosystem: How Decentralizing Happens

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Understanding how blockchains can influence ecosystems is critical to integrate into the design, testing and evaluation of these blockchain solutions to avoid negative un-intended harm. These characteristics include:

- A diffusion of authority from the center of the ecosystem to the edges which;
- Alleviates the need for previous functions served by the center while;
- Creating new functions that serve the newly integrated beneficiaries at the edges resulting in;
- Expanded access for those at the edges and an overall more inclusive ecosystem.

These outcomes are targeted in current interventions attempting to facilitate and incentivize extension services amongst water/sanitation, electrical and financial providers for example. Within agriculture and other market systems, development workers spend scarce resources attempting to facilitate market linkages and incentivizing these linkages between global buyers and small-scale producers. A primary difficulty of these interventions has been to fix some type of market failure, where the market has not provided the most efficient solution, resulting in a net social loss. This failure sometimes results from a lack of alignment in interests, something that is not easily fixed by International Development interventions but could be addressed by a blockchain as alluded to before.

Part of this is due to a fundamental issue with more centralized ecosystems, they are not built upon aligned interests. The central actor can be predatory at worst or, even if benevolent, does not have the capacity to obtain optimal outcomes due to lack of knowledge about the necessary mechanisms of change. Hence the ability of the centralized actor, for example an international development donor, to align interests is severely hampered; otherwise command economies would be more prominent.

Centralized systems have problems delivering services to the fringes of their ecosystem, resulting in trickle-down relationships with the edges always being dependent upon the center. Hence we used an example of a micro-grid earlier, as they are seen as one of the more viable solutions to increasing access to electricity for rural populations far from city centered power services. Those closest to the center receive better services than those at the edges who are not economically worth serving within that specific ecosystem.

> "Centralized systems of organization for the recording and validation of assets have advantages, but they also have many limitations. Because they are centralized they create bottlenecks; there are a few people in the center trying to serve a large population. If the administration is well developed this can work to a certain degree; land registry in places like Germany and Singapore may work well but for most of the

> world it does not. In places like India or Africa centralized institutions are overwhelmed and under-resourced to provide for the mass of people and as a consequence, the majority of our global economy is undocumented and informal; not having access to legal rights, financial services etc." (Token Economics: Designing the New Digital Economy)

It is becoming clearer and clearer that there are hard limitations on the ability to achieve optimal social outcomes within such a centralized ecosystem, hence part of the solution lies in developing new ecosystems that align interests. As we seek to design and test new interventions using the blockchain, it could be that the primary question we ask is "how well are interest aligned?" as a leading/predictive indicator as to whether the outcome will be achieved.

It is this alignment of interests that facilitates the optimal outcomes we seek. We have seen this play out at a dizzying pace using the Internet to serve as the medium of coordination. This coordination is not achieved by a central coordinating authority, but through emergent patterns of actors seeking to act on their own interest by seeking to transact with others with whom they have aligned interests. The blockchain enhances the ability of these actors to find and transact with each other without that central actor coordinating action.

The alignment of interests in this ecosystem is done through tokens. Tokens are merely receipts; they designate ownership of some asset, physical or digital. Tokens are not coins in the form of a crypto currency, although they can be. I will not go into depth about tokens, how they work and the economics behind them but Complexity Labs has put out an excellent guide on Tokenomics that should be consulted for this purpose.

For our purposes here we just need to know that by functioning as both equity and currency the token can work to link the value of the ecosystem with the value that people exchange within that ecosystem or market. This closes the economic loop and aligns the interests of everybody in the organization.

Implications for Designing and Testing Blockchain Projects

We are early in the discovery process of thinking about and testing the potential of the blockchain in facilitating positive social impacts. We run the risk of being too dependent on the technology of blockchain driving outcomes instead of designing and testing around the interaction between the technology and the social ecosystem it is integrated into. In the case of micro-grids this interaction has already spurred serious research into the disruptive nature of blockchain on communities, utilities, local political leadership, etc. While this paper has been

general in scope there are some specific implications for how we could design and test blockchain application in international development projects, namely:

- *More uncertainty means more piloting and adaptive feedback loops*. There is a lot of uncertainty around applying blockchains in international development projects, this uncertainty is less around the interoperability with legacy technology systems and more around the 2nd and 3rd order effects of the blockchain on social ecosystems. This level of uncertainty necessitates smaller pilots to explore what the effects are through high frequency Monitoring, Evaluation and Learning (MEL) systems meant to map out these effects to inform subsequent adaptations and eventual scaling of the pilots. Blockchain applications that go to scale without relevant testing on the social eco-system will drastically increase the likelihood of failure and/or harmful effects.

- *MEL for self-organizing and emergent behavior as opposed to linear theories of change.* International development has made vast improvement in how projects are designed and evaluated using Theories of Change (ToC) that outline inputs, intermediate and longer term outcomes, often in very linear relationships but increasingly these ToC's used systems thinking to more accurately reflect non-linear relationships in the cause and effects that lead to ultimate outcomes. However, designing for, much less developing responsive MEL frameworks, for self-organizing and emergent behavior that does not follow such linear ToCs is something that will need to be improved. Greater integration of complexity monitoring and systems thinking will need to be integrated into more adaptive MEL frameworks.

- *Focusing on Ecosystems.* Because blockchain is a disruptive technology the cascading effects over time and across different ecosystem dimensions, it will be crucial to map out and then monitor for possible effects (both intended and un-intended) during piloting to build awareness of potential risks and downfalls. Better understanding of these ecosystems will be crucial since the level of disruption (positive or negative) the blockchain can stimulate will be high, thus the potential for negative un-intended consequences can significant.

Blockchain technology could follow the same laws of amplification that other technology based solutions have, meaning that the pre-existing social dynamics could be amplified with the application of a blockchain. Hence the need for carefully crafted pilots with iterative MEL feedback loops that build an understanding of the larger ecosystem and inform adaptation. The potential of blockchain as a disruptive technology can be for good or bad depending on the

thoughtfulness and learning involved with its early applications.