Statement before the House Committee on Small Business
On "Building Blocks of Change: The Benefits of Blockchain Technology for Small Businesses"

Understanding Blockchains and Their Benefits for Small Business

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Executive Summary

Blockchain is a data structure that facilitates the operation of widely distributed digital ledgers. It contains records of recently occurring events or transactions. "Blocks" are pages in the ledger. They are strung together using cryptography, which fixes them in order and prevents changes to earlier blocks. Peer-to-peer creation and distribution of blocks results in a widely distributed, reliable accounting of whatever a given blockchain is meant to record.

Internet-native recordkeeping on blockchains may have important consequences. Blockchains may allow many organizations and organizational processes to be replaced with software, similarly to how email superseded postal mail for distribution of written messages. Blockchain systems may streamline and improve business processes and help create new business lines and categories. These benefits may particularly aid small businesses.

As the community around a given blockchain grows larger, the ability to trust contributors generally falls, so it becomes more advantageous to secure such blockchains using cryptocurrency. A cryptocurrency ecosystem can set up virtuous incentives that make various forms of misuse and abuse costly and unlikely. The original global public blockchain is the Bitcoin blockchain, of course, which is a ledger recording transactions in the original cryptocurrency.

A notable dimension of blockchain technology is the possibility that the entries contained in blocks can be executable computer code themselves. The "Ethereum" blockchain is the leading example of a system that allows instructions in computer code, called "smart contracts," to be automatically processed once secured in a blockchain.

There are three advantages of blockchain I can identify for small business: First, simple efficiencies may produce lower costs for small businesses. Second, blockchains may allow for diversified and open market structures that support more niches and specialties.

Finally, blockchains may reduce the competitive advantage that large businesses have in the world of data. Large companies have the resources and heft to set data standards for their industries. These standards may advantage these large businesses. And, of course, they have access to more data about markets, products, customers, and so on. Blockchains can bring large communities together to create data commons—unowned, non-proprietary stores of data. Blockchain projects are more likely to have data structures that serve all use cases, and blockchains may give small businesses access to data they did not have previously. This would give them opportunities to deploy advanced analytics and make other uses of data that are now reserved to only bigger businesses now.

Chairwoman Velázquez, Ranking Member Chabot, and members of the committee,

Thank you for the opportunity to testify today on the benefits of blockchain technology for small business. My name is Jim Harper, and I am a visiting fellow at the American Enterprise Institute, a public policy think tank dedicated to defending human dignity, expanding human potential, and building a freer and safer world. I am also a senior research scholar at the University of Arizona James E. Rogers College of Law, where I focus on the intersection between privacy and technology.

I have been a student of blockchain and cryptocurrency for many years. I first discovered Bitcoin and began dabbling with it in 2011. After two years of study, I wrote my first tentative piece about it in 2013.[1] As Global Policy Counsel with the Bitcoin Foundation in 2014, I worked with technical, business, and legal leaders to explain and advance this very interesting technology among various audiences. The "crypto" world has gotten much more complicated since then, but the basics of the technology and its potential are unchanged.

In my testimony today I will try to detail in non-technical terms how blockchains work and how cryptocurrency ecosystems can secure them. I will also observe how blockchain technology may benefit small business. First, the simple efficiencies that blockchain systems may produce will lower costs for small businesses. Second, blockchains may allow for diversified and open market structures that support more niches and specialties. Finally, blockchains may reduce the competitive advantage that large businesses have in the world of data.

This technology is complicated and its full meaning for society is hard to predict. In many ways, blockchain and cryptocurrency do not fit into familiar legal and economic categories. I believe the easiest entrée to them, though, is through familiar concepts such as email.

What Blockchains Are and What They Do

When email was invented, it was certainly nice that the name its inventors settled on was indeed "email."[2] That name signaled to non-technical people that a familiar process was being extended into the electronic and digital realm. Ordinary people could understand the basic idea that email was an electronic—or "e"—version of a highly familiar messaging system, postal mail. Email now has billions of users around the world.

Blockchain does not introduce itself in so friendly a way. That strange new word, "blockchain," makes the technology a little bit forbidding. It might be easier to think of blockchain as "e-

[1] Jim Harper, "What is the Value of Bitcoin?," Cato at Liberty blog, April 5, 2013, https://www.cato.org/blog/what-value-bitcoin.

[2] Email was invented over a long time, through a variety of technologies. *See*, Phrasee, "A Brief History of Email: Dedicated to Ray Tomlinson," March 10, 2016, https://phrasee.co/a-brief-history-of-email/.

ledger" technology. Blockchain is an Internet-based record-keeping technology that captures events and transactions in chronological order, like a ledger.

A "block" is a page in a ledger. The contents of a block may be any kind of entry and there may be any number of entries in a block. Those things are all defined in the software written for any given blockchain. Entries may update material in earlier blocks, but earlier blocks do not get changed. Added to the ledger from time to time as prescribed in the software, blocks are linked in a way that fixes them in order and that largely prevents tampering with earlier blocks. (I discuss how encryption does this below.) Block after block linked together form a chain of blocks, or blockchain.

It is an essential custom that blocks are added by propagating them across a peer-to-peer network of nodes. Each node independently verifies that the blocks and their contents are valid according to the terms defined in the software. The rules for data synchronization among nodes are often called the "consensus algorithm." Thus, a blockchain becomes a widely held repository of information. Blockchains create the potential for collectively controlled global data repositories that have impressive capabilities, but the community of participants and the terms of participation in a blockchain project can be defined by the leaders of more modest projects.

There is much more to it, of course, but that is the essence of the blockchain data structure and the peer-to-peer system that supports the creation and distribution of blocks and blockchains. It is a technology for operating a widely distributed e-ledger. Distributed ledger technology has interesting consequences, much as email did in its time.

Replacing Organizations and Organizational Functions with Software

Email did not replace postal mail entirely, of course, but the essence of mail, person-to-person communication, is now provided by software on the Internet as much as it is provided by a central organization such as the US Postal Service. That small structural change has some important consequences. It is cheaper, easier, and faster to send an email, obviously. There is also no longer a single institution through which our written communications pass. The power of that institution and some risks of relying on it are reduced, while other institutions and the risks of relying on them may have grown.

Blockchain is similarly structured—or de-structured, if you will. There are different ways of administering blockchains, but in the classic open public blockchain, there is no single organization that maintains the ledger. Rather, anyone can publish material to the system of peer-to-peer nodes for inclusion in the blockchain. If the material fits the parameters dictated by the ledger's software, it is included in a block that is added to the blockchain.

There is no "ledger service provider." There is no one organization that controls all the data, though there might be an organization or consortium that leads the blockchain project. This

makes for greater openness and accessibility in blockchain data and less reliance on single, large companies or institutions. Blockchain may flatten out the power hierarchies that data and data standards can otherwise create. In other words, blockchain-based systems can reduce some advantages that larger businesses enjoy and disadvantages that small businesses suffer.

Hungry? Blockchain Fixes This

A 2019 article by Michael Castillo in *Forbes* illustrates how blockchain can improve business processes with particular reference to small businesses—in this case small beef producers.

"The provenance of the food on your plate matters," Castillo writes, "and if a blockchain can give you details on the French farmer who grew your tomatoes or provide a glimpse of the prairie grasses that went into your rib eye, it just might make your meal taste sweeter—and command a higher price. There are also important health and safety reasons for tracking food via blockchain. Food-borne illnesses make thousands sick every year and cost businesses an estimated $90 billion in lost revenue."[3]

We have benefitted greatly from large-scale food production and distribution. But that system requires commoditization: standardized production and distribution of foodstuffs, including beef. Producers in such a system find that there are few quality-grades and few opportunities to distinguish their products. The opportunities for up-scale production in the beef example are limited to such things as "grass-fed," a blunt category which requires, simply, grass feeding.

Blockchain tracking allows for specialization and thus higher earnings. A rancher in Wyoming can produce animals that are better fed or better treated than others and get paid more for that beef by consumers who are able to see and appreciate its provenance. The system Castillo writes about is called BeefChain.[4]

The other major benefit of blockchain tracking in this application is that contaminated products can be eliminated from the food supply more precisely and quickly. If some food is bad, all product in a large lot does not have to be thrown out—and all producers do not have to take a loss. This helps small producers more as they will tend to have thinner reserves and credit lines and thus less capacity to bear losses.

It is not a given that blockchain or the BeefChain project are the best or most efficient way to achieve these ends. There is a good argument that an ordinary database system will serve applications like these. When leaders of a small consortium of beef producers give out permissions to operate nodes and add to their blockchain, they are extending trust to one

[3] Michael Castillo, "Blockchain's Movable Feast: How The Tech Is Changing Food Supply Chains," Forbes.com, January 8, 2019, https://www.forbes.com/sites/michaeldelcastillo/2019/01/08/blockchains-moveable-feast-how-the-tech-is-changing-the-way-we-eat-2/#7053872e17f3.
[4] *See* BeefChain.com web site, https://beefchain.com/.

another—sensibly. If they trust each other enough to run a blockchain together, they can just as well agree on running a plain vanilla database. There are a good number of people who salivate at the chance to debunk blockchain hype on this basis, and they are right to do so in many cases.[5]

That way of administering a blockchain is often referred to as "permissioned" because an authority of some kind gives out permission to contribute data and run nodes. The administrator must trust users, and users must trust the administrator. That's fine for many applications.

Below, though, I will discuss a wholly fictional blockchain project to illustrate more technical details of blockchain while showing how a blockchain can be secured for use among larger groups that are not necessarily able to trust one another. The bigger the circle of participation, the stronger the case for using a blockchain and for securing it using a cryptocurrency ecosystem.

Taking Flight with the "Air Travel Blockchain"

To illustrate how a blockchain might bring a community of strangers together to record events, imagine a blockchain project dedicated to recording the movements of airplanes around the world. With wide enough participation, it could act as an interesting catalog of global trade and commerce separate from government and corporate information channels. It could open new windows onto clandestine travel, for example, which is an interesting topic to some researchers.[6]

Figure 1. The Air Travel Blockchain might reveal flights traveling this suspicious route.

Hobbyists and professionals across the globe might participate in the Air Travel Blockchain by publishing their sightings of planes using blockchain software, written for the purpose by

[5] Pun intended. *See, e.g.*, Jill Carlson, "Trust No One. Not Even a Blockchain.," Slate, January 25, 2020, https://slate.com/technology/2020/01/blockchain-trust-response-essay.html.

[6] *See*, Sam Raphael et al., "Tracking Rendition Aircraft as a Way to Understand CIA Secret Detention and Torture in Europe," The International Journal of Human Rights (2015).

motivated coders and dedicated to open-access use. Participants would contribute information in a format dictated by the software. Let us say the required format includes precise specifications for: time and date, the airport code, each plane's tail number, and an identifier for the person or entity adding the report.

To submit a report to the blockchain, the report's author publishes it for dissemination across the peer-to-peer network. The report is collected by nodes, which examine reports as they come in and confirm that they conform to the standards of a report, including a valid time and date, valid airport codes, and valid tail numbers.

The nodes may de-duplicate multiple reports of the same plane in the same place. They may also validate the meaning of the data by checking to see that the same airplane is not reported in two different places at once, for example, or that sightings are not back-dated or post-dated.

To help ensure in-person sightings, they may check that the same author is not reporting from multiple locations at the same time. When a conflict or inconsistency exists among reports, they may flag reports to indicate potential or likely inaccuracies.

Every ten minutes, one of the nodes bundles together the most recent valid reports as a block. To establish sequence among blocks, the header of each block contains a unique cryptographic hash produced from the reports in that block and the hash published in the header of the previous block. Because it hashes the hash in the previous block, the new block could not exist before the previous block existed.

When a node publishes a block to the network, the other nodes validate the block by replicating the hash in the block's header. If they find it valid, they accept the new block and store it as the latest addition to the ledger.

Now there is a data set that anyone can draw from to gather the movement of planes around the world, to check open observations of air travel against the reports of governments and

CRYPTOGRAPHIC HASHING

A cryptographic hash is produced when data, such as a file or password, is scrambled to produce a value of uniform length called a checksum. The exact same data run twice through the same hashing algorithm will always produce the same checksum. But even the smallest change to the data will produce a dramatically different checksum. A good algorithm makes it effectively impossible to calculate the original data from the checksum.

Hashing allows for proof that computer programs or other data have not been altered since they left the control of the publisher. Hashing allows web sites to confirm that they are seeing their users' passwords even though they do not store copies of them. Instead of keeping passwords, they store hashes and compare hashes of incoming passwords to the stored hashes.

In blockchains, hashing proves that the content of a block is unchanged. By hashing hashes from previous blocks, blockchains prove the order in which blocks were created.

corporations, and so on. It is the product of a very rudimentary blockchain, and it illustrates a utility of the blockchain data structure.

Securing Blockchains with Cryptocurrency

The "Air Travel Blockchain" is only a rough sketch, and it is at risk from various forms of attack. For example, there is little reason not to file false reports. Anyone wanting to monkey-wrench the system could easily do so by "spamming" the blockchain. Also, there is little incentive to maintain node.

There are ways to create virtuous incentives that counter these threats and make the system more reliable using cryptocurrency.

The specification discussed above said that the author of reports would include an identifier. Let us make that identifier the public key in a public-private key pair. Public keys are used as cryptocurrency wallets.

When the author of a report submits it to the network, it also posts a small "bond" guaranteeing the veracity of the report. This takes the form of a certain small amount of cryptocurrency sent by the wallet to the address of a wallet dedicated to support of the system. The requirement for posting a bond makes it expensive to spam the blockchain. When a node confirms a report, it might be allocated some of the cryptocurrency that the author posted as bond, and some of the bond might be returned to the author's wallet. This system can reduce errant reports by declining to return funds to authors of inaccurate reports.

PUBLIC KEY CRYPTOGRAPHY

Public key cryptography is a technique for communicating secret information on open communications channels. Asymmetric key algorithms allow the creation of an encryption key, which can be made public, and a decryption key, which must be kept private. It is impossible without stupendously huge computing power to calculate the private key from the public one.

The sender of a message will use the recipient's public key to encrypt the communication. Provided the private key is kept private, the recipient alone can decipher the message using the private key.

Public key encryption is used to control the transfer of cryptocurrencies. Cryptocurrency holdings are recorded in terms of their association with a public key, which is called a "wallet." Transfer of any unit of cryptocurrency can only be initiated by someone who knows the private key associated with that wallet.

Meanwhile, the blocks themselves could be encrypted such that they could only be decrypted by the payment of a certain reasonable amount of cryptocurrency to the wallet that supports the project. Those payments could be distributed among the nodes and the authors of reports such that a reasonable fee for accessing the data pays everyone a little bit for making accurate reports and collecting those reports in timely blocks.

We have now tightened up the security of this blockchain project to limit inaccurate reports and create incentives for creating blocks. But this sketch of a blockchain system for capturing records of airplanes at airports is still woefully insufficient. There would have to be some very careful tuning to make sure that false reports are scrubbed (their "bonds" forfeited) and that only a minimum of true reports suffer that fate. The economics of the payment system would have to be tuned to reward nodes and authors of reports in the right amounts. But we have a sense of how a blockchain works, and how it can be designed to bring strangers together into an essentially leaderless data-collection enterprise.

In a truly leaderless enterprise, of course, the software on which the blockchain runs is open source. The parameters of reports and the economics of the system are decided by the community of coders and users when they write and adopt the software that they prefer. The dynamics of governance in open public blockchains are interesting and challenging.[7]

Bitcoin and "Proof of Work"

The original open public blockchain, of course, is the Bitcoin blockchain.[8] It is a ledger that records the transfer of units of value, called bitcoins. It is "fueled" and secured by an award of bitcoins to the creators of blocks, as well as per-transaction payments that users offer to these "miners" when they publish their Bitcoin transactions.

That award going to Bitcoin miners solves another problem in blockchains: Which node should get credit for creating the authoritative block? And which block should the other nodes build on?

Bitcoin addresses this question by creating an artificial difficulty around creating blocks. In Bitcoin and many other cryptocurrencies, a block is "found" through a lottery-like contest having to do with the hashes that go in block headers.

Most hashes have a roughly even distribution of characters, but the rules of Bitcoin specify that a valid hash must have a certain number of leading zeroes (e.g., 000000000000000000000d19d8ce9a0fe3ca22b1886ce55b39c14bc1a9ea54232). A hash with this peculiar characteristic is very hard to produce. Miners search for a satisfactory hash by adding random character strings (called "nonces") and hashing them with the block's contents and the prior block's hash. When a nonce is found that produces enough leading zeroes, a valid block has been produced, and the contest has a winner. The miner publishes the block, including the nonce, to show that the work of discovery has been done. That system is called "Proof of Work."

[7] For a snapshot into open blockchain governance at an interesting juncture in Bitcoin's history, *see* Jim Harper, "A Bitcoin Constitutional Amendment," Cato at Liberty blog (Aug. 19, 2015) https://www.cato.org/blog/bitcoin-constitutional-amendment-0.

[8] *See* Satoshi Nakamoto, "Bitcoin: A Peer-to-Peer Electronic Cash System," https://bitcoin.org/bitcoin.pdf.

Across the Bitcoin network, miners currently do this hashing exercise at a rate of over one hundred million trillion hashes per second.[9] Bitcoin's software adjusts the number of leading zeros that is required, and thus the difficulty of finding a block, so that the mining community finds blocks about every ten minutes.

Rarely are two blocks created near one another in time. When they are, a continuation of the contest is to see which block has additional blocks built on top of it. The ultimate victor is the block and the version of the chain with the most "hash power" behind it.

Bitcoin is a highly developed blockchain, with an intricate system of incentives to secure what is a very valuable ledger indeed: an accounting of billions of dollars-worth of cryptocurrency. Not all blockchains need to be quite so intricate or highly developed. But there is another type of blockchain that is important to understand, exemplified by the Ethereum blockchain.

"Smart Contracts"

A notable dimension of blockchain as an "e-ledger" technology is the possibility that ledger entries themselves can be executable computer code. Ethereum is a prominent blockchain that competes with Bitcoin for primacy in the blockchain and cryptocurrency world because it supports code and serves as a platform upon which to develop applications. The nodes on this type of blockchain not only record ledger entries; they also execute the instructions embedded in the entries to produce the results encoded by their authors.

On open public blockchains such as Ethereum, the code is essentially secure and unchangeable. The execution of the code cannot be stopped, not by any natural disaster or loss of power, not by theft or vandalism, and not by any court injunction, theft, or seizure of computers.

USING SMART CONTRACTS

Say a farmer wants to insure against the crop losses that are predictable from bad weather during the harvest month. She and an insurer can record a "smart contract" on the Ethereum blockchain that will make a payout of a certain amount to the farmer if defined bad weather conditions, such as freezing temperatures or heavy rainfall, exist during the harvest period they define. They must define an "oracle," of course, to supply the weather data. If the "contract" is coded correctly, the farmer and insurer will both get the benefit of their bargain automatically based on the weather that later occurs.

Coding smart contracts correctly is an important challenge. One of the most notorious early smart contracts was called "The DAO"—short for "distributed autonomous organization." It was to be a venture capital fund existing only as code. This gave it the interesting properties of having no corporate form and no susceptibility to any government's regulations or controls.

Unfortunately for the project's participants, errors in the code allowed some participants to drain the project of contributed funds. Ultimately, the Ethereum community decided to "unwind" their blockchain to restore Ether to its holders prior to the attack on The DAO. This was controversial, as an important dimension of public blockchains is their immutability.

[9] *See* Blockchain.com, "Hash Rate" web page, https://www.blockchain.com/charts/hash-rate.

The upshot is an unbreakable platform for the execution of "smart contracts." If an arrangement can be reduced to code, any deal that two parties want to make can be posted on the Ethereum blockchain and made a bullet-proof commitment. Ethereum nodes will execute the code and deliver the results required by its terms.

The term "smart contract" is a slight misnomer. A true legal contract is a promise made in exchange for something of value. Agreeing to participate in a smart contract may involve an exchange of promises, but smart contract code itself does not involve any promises. When smart contract code is published to a blockchain, the results follow the terms of the code. They do not turn on the promised actions or inactions of the parties.

The Benefits of Blockchains for Small Business

With the mechanics of blockchains and cryptocurrency in hand, it is possible to observe some strengths they have that may particularly benefit small business.

Efficiency

The first benefit of blockchains, evident from the discussion above, is simple efficiency. Efficient systems benefit all, of course, but small businesses arguably benefit more from a given unit of efficiency gain.

Small businesses do not have the economies of scale that large ones have, so an inefficient process is proportionally costlier to small businesses than to large ones. Take automobile titling, an example inspired by one of my co-panelists today. A large enterprise may be able to dedicate a full-time staffer to the intricacies of titling from state to state. In a smaller enterprise, someone without expertise may have to spend a disproportionate amount of his or her time on the problem, time that would be better spent on more productive work. If titling is taken care of with a clean software interface on top of a blockchain recordkeeping system, this will do a good turn to the smaller businesses by taking away a pain-point.

Diversified and Open Market Structures

The BeefChain example and another of my co-panelists today inspire the point that blockchains may alter market structures favorably for small business. As noted above, beef production has been largely a commodity business. Ranchers have been limited to producing whatever the feedlots and processors will support. But now blockchain-based provenance tracking can allow for the sale of specialty products in national markets. That is a huge boon to small, niche producers, to say nothing of consumers nationwide, who now may enjoy a proliferation of choices to enjoy.

In a similar way, FileCoin opens up to small competitors a market that is currently quite limited. Cloud storage is a commodity business dominated by a few of the largest tech companies. At the same time, there are computers and servers throughout the country and world with vast amounts of unused storage space. That space may be rented out using the FileCoin system. FileCoin may bring into use tens or hundreds of millions—perhaps billions—of dollars-worth of capital that is now sitting idle. Small businesses may benefit by putting their capital to use, and they also may benefit as buyers of storage because they may have more options, plus price competition that lowers their costs.

Reduced Competitive Advantage

The final benefit to small business I can identify is slightly more speculative and diffuse, but I think it is real. That is the potential that blockchain applications may reduce the competitive advantage that big companies enjoy from setting data standards and collecting data. Blockchain may allow all in a community of interest—big firms and small—to take advantage of data they produce collaboratively.

As noted above, blockchain is traditionally used peer-to-peer. Indeed, it has essentially no value if not used peer-to-peer. By nature, then, contributors of data are also given access to data. That means that data stores are not just owned by the leading firms in a given field. They are a shared resource for all in that community of interest.

Using a data commons—shared data—produced via blockchain projects, small businesses may be able to apply advanced analytics, artificial intelligence, machine learning, or whatever technique they please to generate new information, ideas, and innovations. Data will not just be the province of big companies. In this way, blockchain may contribute to more vibrant, competitive, and inclusive markets.

To illustrate the status quo and the possibilities, think of four concentric circles that roughly describe data-using communities from small to large.

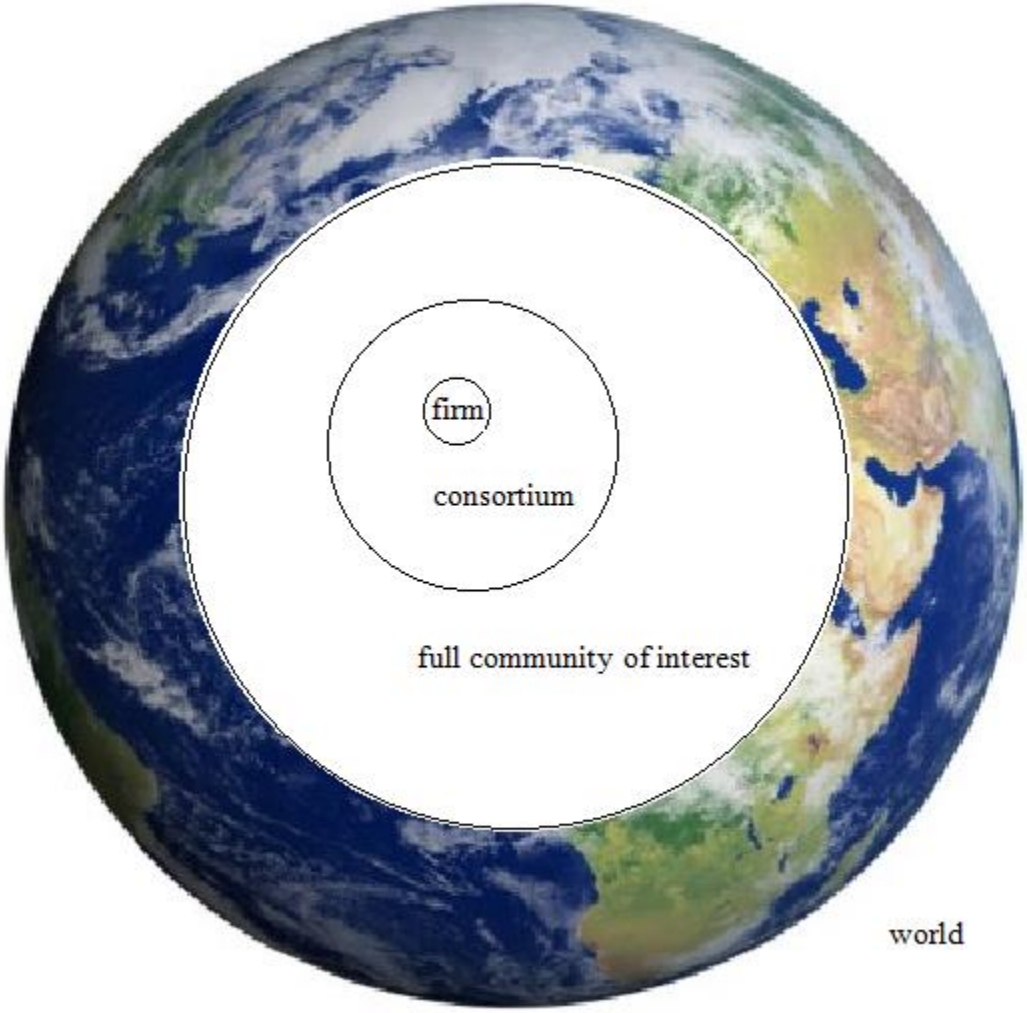
- The first and smallest community is the firm. Inside a business organization, data standards are set by fiat according to the use cases that best fit that firm. Data is shared according to those standards throughout that enterprise. This is the status quo in many industries today.

- The second, larger community is the consortium. That is the group of like-minded or allied industry actors with the resources to participate in standards-setting. Their participation ensures that the standards meet their use cases. Each collects and uses data internally according to the standards, and they sometimes share or trade data for mutual advantage. Small businesses, generally on the outside of this community, may use the data standards, of necessity, and may benefit from general efficiencies standards create.

But they are largely contributors of data to their larger counterparts, and they do not have as much access to data. This status quo data dynamic obviously favors bigger businesses.

- Lacking a better phrase, I will call the third, yet larger community the "full community of interest." A blockchain project devised to gather supply chain data, air travel data, or what-have-you from every relevant actor will be more likely to incorporate the interests of all, including small businesses. Their data structures are more likely to accommodate all use cases because that makes participation attractive. The offer to all actors in a given field or industry is: "You contribute your data, and you will get access to the data pool."

Figure 2. Visualization of data-using communities (not to scale).



Foresighted large players may lead such projects involving the full community of interest because they recognize that a data commons can vitalize an entire industry. What they

might lose in advantage over other industry players, they will more than make up in leading a bigger industry. Or such projects may start with small businesses that strengthen their hands by creating a data commons. One can imagine this kind of development happening in the beef example, where an entire high-margin category of meat production and distribution could come into existence.

- The fourth community is the entire world. Global participation among strangers requires the elegant economic systems that cryptocurrencies facilitate. This is the possibility with cryptocurrency-secured blockchains like Bitcoin and Ethereum, which make possible Internet-native value transfer, decentralized finance, and many other fascinating and powerful applications, including FileCoin.

People with global ambitions for blockchain and cryptocurrency sometimes deride simple blockchain applications. Sometimes they are right, because some things proposed for blockchains would be better done with traditional databases and power dynamics. But there is potential in the blockchain data structure—given its crucial peer-to-peer production—to change power dynamics for the better, making industries more diverse, competitive, and friendlier to small business. This is all a bit forward-thinking and speculative, but imagination, technological innovation, and the will to read through a very long congressional testimony can sometimes pay dividends.