NEW AMERICA

BLOCKCHAIN TRUST ACCELERATOR

SARA L. M. GOLDEN AND ALLISON PRICE

SUSTAINABLE SUPPLY CHAINS

Better Global Outcomes with Blockchain

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About the Authors

Sara L. M. Golden was a 2017 fellow with the Blockchain Trust Accelerator (BTA) at New America while completing her Master's degree in international law and economics at the Johns Hopkins School of Advanced International Studies. She has worked with community impact organizations, social enterprises, and labor unions on issues of women's economic empowerment at home and abroad. Sara currently works at Flexport, a shipping and logistics startup in San Francisco and in her free time, consults for nonprofits and blockchain-for-social-impact projects.

Allison Price is the executive director of the Blockchain Trust Accelerator (BTA), a project of New America. The BTA is committed to advancing blockchain technology through research and innovative pilot projects designed to address some of the world's most persistent challenges like transparency, identity and corruption. Prior to diving into the global blockchain community she served in senior public affairs positions with the Department of Justice and the Peace Corps. Price has also worked at the intersection of public policy and communications for Obama for America, the Center for American Progress, Gillibrand for Congress, and Stonebridge International. She earned degrees from the University of Pennsylvania and the London School of Economics.

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The Blockchain Trust Accelerator (BTA) is the world's leading platform for harnessing blockchain technology to solve social impact and governance challenges. Established in 2016, the BTA brings together governments, technologists, civil society organizations, and philanthropists to build blockchain pilots that benefit society. BTA projects and research help organizations increase accountability, ensure transparency, create opportunity, and build trust in core institutions. The BTA operates as a not-for-profit collaboration between New America, Rockefeller Foundation, The Bitfury Group, and the National Democratic Institute. The BTA is based in Washington, D.C. For more information on how blockchain can be harnessed for social good, please visit **www.trustaccelerator.org**.

What is Blockchain?

blockchain: [*blok-chayn*] [noun] is a distributed ledger technology that empowers anyone with an internet connection to transfer data and assets frictionlessly—anywhere, anytime, with unmatched security and integrity and without relying on a third party intermediary. The first blockchain was conceived in 2008, in the wake of the global financial crisis. It has never been hacked.

Sustainable Supply Chains: Better Global Outcomes with Blockchain

Contents

INTRODUCTION

Global supply chains are modern marvels, propelling trillions of dollars of commerce through the world economy. Unfortunately, they are also riddled with waste, fraud, inefficiencies, and human rights abuses. Some of the resulting failings have implications for society. For example, many producers (including smallholder farmers) do not receive fair prices for the value they create due to supply chain opacity and the costs imposed by unscrupulous intermediaries. In other cases, supply chain problems take a toll on company profits. Maintaining the bureaucratic paper trails required to manage modern supply chains costs billions of dollars annually. For consumers and retailers, the failings are so obvious that they have long been accepted as inevitable: when goods reach their final destinations, most buyers and sellers do not know the true origins of the manufactured products they have purchased.

Harnessed correctly, transparent supply chain solutions could provide consumers and other downstream participants with leverage to promote higher standards of responsibility and sustainability in sourcing and production. The same solutions could also help reward adherence to best practices among small producers and level the production playing field by providing information on pricing and market conditions. However, data silos, outdated enterprise tools, and a lack of transparency, accountability, and traceability all limit the extent to which current supply chain solutions can improve outcomes for people and the planet.[1]

Blockchain technology and decentralized applications are already taking the financial services sector by storm. The supply chain landscape is a likely target for a building wave of blockchain-based innovation that could address critical challenges affecting the field. A range of technology and supply chain companies such as Maersk, IBM, Oracle, and SAP are already developing blockchain-based supply chain management (SCM) software. Numerous pilot projects launched in 2017. If, as early results suggest, blockchain-based solutions reach scale over the next five years, they could deliver a transformation in global supply chain management.

Why blockchain for sustainable supply chains?

Blockchain is well-suited for use in supply chains in part because the technology has the potential to provide an unprecedented level of transparency. Blockchains are structured as a shared, decentralized database with immutable, encrypted copies of the information stored on every server or “node” in the network. Unlike traditional centralized databases, blockchain

systems validate entries or changes in the ledger through a cryptographic consensus mechanism, thereby circumventing the need for intermediaries. This enables otherwise trust-less parties, such as individuals and firms that do not know each other, to engage in near frictionless peer-to-peer transactions. Bitcoin and Ethereum are public permissionless blockchains that anyone with a computer can access. There are also private or layered blockchain structured applications that allow for varying levels of user access depending on how their governing protocols are designed. Companies are testing private blockchains for an array of purposes, including protecting intellectual property and other proprietary information.

Blockchain technology continues to emerge as the right solution to solve core problems in supply chain transparency. Supply chains are complex networks of distant, separate entities that exchange goods, payments, and data across a dynamic, continuously evolving landscape. The underlying architecture of blockchain technology has key structural similarities. Blockchains create decentralized networks that allow participants in the system to exchange data relatively seamlessly from anywhere in the world. The system records all transactions so that auditing can be automated and the cryptography used to validate transactions prevents double spending or confusion around the custody of goods and payment.[2] Information stored in public blockchains cannot be erased, and this permanence incentivizes good behavior by preserving evidence of any wrongdoing. Private sector supply chain startups and established industry players are beginning to utilize blockchain to optimize their value chains and free up working capital. These attributes should deliver dramatic improvements in inefficiency.

Blockchain solutions constitute the rare innovation that could provide both profits and social purpose. Regulators, social enterprises, and civil society organizations are poised to harness the transparency and accountability available through blockchain-based tools to help solve supply chain problems including dangerous labor conditions and environmentally destructive practices.

Blockchain is not a one-size-fits-all solution to the challenges of supply chain transparency, but it provides a key piece of the puzzle. Ethically-minded solutions could lead to greater accountability and responsibility around human rights and environmental impact, such as monitoring factory working conditions for modern day slavery or measuring diesel pollution of trucks at shipping ports.[3]

KEY CHALLENGES

Early attempts to deploy blockchain-based supply chain solutions have encountered an array of challenges. The four most significant questions around this use of the technology provide context for understanding the potential promise and limitations of pilot projects examined in this paper.

Some supply chains are not decentralized and are already trustworthy.

In these cases is a blockchain even necessary? The entire blockchain supply chain space is asking this question. Traditional corporate supply chain management may turn out not to be the best use case for a decentralized system like blockchain because companies are incentivized to manage their supply chains in a central network. Trust is built into the centralized web where producers and buyers depend on one another's honesty. The supply chain use cases that have been released to date since the onset of this research involve private blockchains with a central authority. Therefore, the only thing that is different between a highly encrypted distributed database and a blockchain-based tool is that blockchain provides added security with both cryptography and its decentralized network structure. However, in a supply chain where businesses require trust among participants, blockchain loses some of its value proposition beyond security.

Blockchain may not seem vital to securing a system, but it is the best available security solution for a peer-to-peer, distributed network—and this alone has significant benefits. Maersk, the shipping giant, manages about 18 percent of global container trade.[4] In June 2017, the company was targeted by Petya ransomware in a cyberattack. The company estimated that the attack, which was aimed at permanently destroying supply chain records, cost them $200-300 million.[5] The distributed network structure of blockchain is intrinsically better equipped to defend against such attacks. As a result, even centralized shipping companies like Maersk stand to benefit from applying a blockchain backbone to their existing digital supply chain and financial database systems. To date, the public blockchain that powers the Bitcoin blockchain has never been hacked or corrupted. Companies with serious data security risks may adopt blockchain solutions to strengthen their business and supply chain resilience.*

* For more information on why blockchain provides better security and infrastructure than a traditional, centralized, shared database, refer to Gideon Greenspan's 2015 blog post on MultiChain.com titled "Private blockchains are more than "just" shared databases."

The limitations of tracking technology.

In decentralized supply chains where actors lack trust in one another, such as in the tuna market or luxury goods sector, it may be difficult to deploy blockchain solutions that add substantial value over a heavily encrypted, centralized distributed database for supply chain traceability and proof of origin. This is not the fault of blockchain, but an obstacle across industries because there is not yet a foolproof digital tracking solution that enables downstream actors to trace the origin of physical goods from seed to sale. Gaps in traceability exist as a result of security risks with some advanced tracking tools used by blockchain systems, including RFID codes, biometrics, and DNA testing. RFID tags, NFC tags, and QR codes can be duplicated and placed onto counterfeits. Biometrics are controversial and can pose serious long-term risks if compromised. It is nearly impossible to disintermediate between chemical compounds in a plastic or oil processed mixtures without huge investments. Some advanced tracking companies that do not use blockchain are testing DNA based traceability tools, such as for cotton traceability in Uzbekistan.[6] However, due to the current gap in automating product component traceability, there is still a lack of trust in the system that relies on humans or sensors to enter data. In the following case studies, information is manually entered into the system and actors use discretion when validating information in a private-permissioned chain. Blockchain may make it significantly more complicated or expensive to engage in collusion or bad behavior, but it does not completely eliminate the potential for malfeasance.

This potential weakness suggests a key question to ask around blockchain-based solutions: What are the incentives for actors to engage in good behavior? How does the system reward good behavior on the part of farmers, processors, factory workers, truck drivers, and everyone else who touches the product, and punish supply chain participants for bad acts? Blockchain solutions are likely to be far more accurate than existing technologies employed by companies to trace their goods. However, the incentive question—which is crucial for scalability—remains unanswered.

Good data in, good data out. Bad data in, bad data out.

Accuracy is essential for supply chain transparency. The quality of data can determine the validity of judgments around sustainability and business operations. One wrong entry or assessment upstream in the system can turn into a fiasco downstream, such as a miscalculated lead time or an unexpected environmental disaster. If anything, the permanence and interconnectedness of blockchain solutions magnifies the importance of ensuring good data in the system. Mistakes have the potential to ripple more quickly and widely than in fragmented ecosystems. As mentioned above, developers of these tools must consider how to incentivize truth and accuracy when requiring manually entered data, such as when farmers are required to complete an onboarding form. It is important to determine whether system safeguards will be enough to prevent unscrupulous actors from injecting bad information into the system.

Scalability and the network effect.

Data platforms such as those outlined in this study become far more valuable when they are able to scale across an entire ecosystem. The full potential of decentralized applications will be difficult to gauge during pilot deployments, but it will ultimately have a large bearing on the project's success. If platforms cannot reach enough users, the benefits of blockchain are reduced.

CASE STUDIES

This paper examines three projects poised to harness blockchain technology along with other advances in tracking and supply chain management with the goal of promoting sustainable or ethical sourcing from seed to sale. It compares use cases that cover different parts of global supply chains, with a focus on corporate sustainability in agriculture, shipping and logistics, and manufactured goods. Two of the cases exemplify how blockchain is being leveraged for human rights and environmental sustainability. The other highlights how blockchain can be used for economic sustainability.

Agricultural Traceability and Farmer Empowerment with BanQu, Inc.

Problem: Upstream agricultural supply chains are prone to human rights abuses and unfair labor practices. From California's Central Valley—where farm workers are exposed to harmful pesticides—to Vietnam—where smallholder coffee farmers often receive unfair payment for their harvests—many small producers lose out on potential economic and social gains because of opaque, inefficient supply chains and institutional barriers to market access.

Solution: BanQu, Inc. is using a blockchain-based economic identity system to take on supply chain transparency.[7] The firm is closing the gap between farmers and the resources necessary to support sustainable livelihoods, particularly financial credit and market access, by linking farmers' personal economic identities to their land and assets as collateral. This solution also offers women and the unbanked greater access to the global economy. BanQu is currently deploying pilots for crops like cacao, coffee, and corn in countries such as Indonesia, Congo, and Colombia with the goal of supporting smallholder farmers and women.

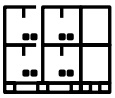
How it Works: BanQu's system is modeled on the community of farmers, input providers, and intermediaries that help bring goods to market. An unbanked farmer uses their mobile phone to create an online profile including personal and land information. That allows the farmer to have an economic identity linked to the modern economy, and then she or he can begin utilizing services on the BanQu network. A farmer's trusted network in BanQu's system includes other actors along their value chain and those network users validate entries into the system via consensus. A private key infrastructure gives users ownership over their own data so that no one else can alter or view their information without permissioned access.

The solution offers farmers the ability to build credit, qualify for crop insurance, and receive localized agricultural extension and crop

predictions by linking a farmer's land and produce data to its economic ID. It also provides traceability for assets such as a bag of coffee beans so that suppliers can track a commodity's journey on the way to market. In addition, both land and asset modules track quantity and quality measurements that are stored securely on the farmer's economic ID blockchain in a way that is only accessible with the farmer's unique private key.

Why Blockchain? In traditional supply chain management systems, especially in rural settings, trust is based on years or even generations of personal relationships, and dependent on intermediaries for inputs and access to markets. BanQu's solution codifies existing ties between farmers and buyers, but works to transfer power back to farmers by permanently recording all transactions in the chain. The decentralized technology allows farmers to own their own data and control who has access to the information with a private key. BanQu leverages the near-zero transaction cost of sharing data via blockchain and the potential of other advanced tracking technologies to make auditing increasingly automated.

Other Providers: BanQu is one of the first blockchain companies aimed specifically at providing financial services to the unbanked. Companies with similar services include uPort and Civic. However, all three companies have a different model. uPort and Civic are known for their digital identity solutions, but cater to more affluent, banked populations that are already involved in the formal economy. uPort is a multi-use self-sovereign identification system on the Ethereum blockchain. In addition to identity services such as secure digital contract signing, uPort's solution seems to be geared towards developers who want to build Ethereum contracts. Civic's main offering requires phones with biometric capability like an iPhone 5s or higher. BanQu is running pilots on so-called "dumb" phones, as well as smartphones, and is targeting historically underserved populations around the world. BanQu and uPort use public key infrastructures—the gold-standard for securely managing a distributed network of digital identities.



Shipping and Logistics with 300cubits

Problem: Every year, $23 billion is lost due to "booking shortfalls"—cargo space on ships that was either booked by suppliers and never filled or overbooked by carriers to prevent shortages.[8] The vast economic inefficiencies in the shipping industry are only one symptom of deeper dysfunction: Millions of shipping containers used in international trade are still tracked using paper.[9] The industry's antiquated recordkeeping increases risks of labor and human rights abuses, along with other illicit activity. Eventually, these business risks can contribute to expensive regulatory problems.

Solution: 300cubits is a Chinese startup working to solve this costly issue in ocean freight by creating a cryptocurrency token for the shipping industry.[10] They are tokenizing (linking a transaction to a cryptocurrency token) cargo reservations to incentivize suppliers to follow through with their booking and prevent overbooking by carriers. The goal of 300cubits is to rebuild trust between customers, container lines, freight forwarders, and cargo owners in order to stabilize the global shipping industry.

How it Works: 300cubits is a decentralized application built on the Ethereum network and comprises a smart contract builder, booking, marketplace, and credit agency modules. Their tokens are named TEUs—industry shorthand for the "Twenty-foot Equivalent Unit" of freight that can fit into a shipping container. After the initial sale, the company believes tokens will be valued at the price of standard shipping rates and become a price indicator for the industry.* Shippers purchase

* In August 2017, 300cubits launched their initial coin sale and soon after China temporary illegalized ICOs for Chinese nationals, while foreigners are still able to purchase tokens. The ban on Chinese ICO purchases does not change the scalable technology underlying 300cubits system.

a token online that monetizes a booking deposit in a shipping container. The tokens can either be redeemed as container space or traded on an online marketplace to other shippers who might need container space. The TEU blockchain ledger is used to track shippers' performance and provide credit ratings based on past reliability. 300cubits' solution offers support and interoperability for container lines that wish to apply TEU tokens on their proprietary platforms. 300cubits is slated to launch an alpha version of the booking module in January 2018.

Why Blockchain? Without blockchain, 300cubits would have to rely on less secure methods of cryptography and data transfer, and potentially rethink its entire business model. By tokenizing reservations, 300cubits has set out to free up working capital by creating a secondary market for reselling container reservations.

Other Providers: NYSHEX, or New York Shipping Exchange, has the same idea for the United States as 300cubits has for China.[11] NYSHEX aims to fix the carrier booking industry by preventing cargo overbooking and by cutting through the infamous general rate increases and peak season surcharges that can lead to wild fluctuations in shipping costs by offering immediate freight booking via a marketplace. The platform is partially funded by some of the largest carriers in the world, including Hapag-Lloyd and CMA CGM. Both NYSHEX and 300cubits have garnered attention in the supply chain technology world, and now their challenge is to convince other players in the 200-year-old industry to get onboard.

Manufactured Goods with Provenance

Problem: Consumers, buyers, and retailers rarely have a clear picture of the history and quality of materials used to produce clothes. Garment supply chains are particularly notorious for harboring labor and human rights abuses. In 2013, over 1,000 garment workers died when an unsafe, incorrectly permitted factory collapsed in Dhaka, Bangladesh. The facility supplied garments to leading global brands like Benetton, Carrefour, JCPenney, and Walmart.[12] Soon, consumers, regulators, and watchdog organizations may have far greater visibility into the inputs that comprise a garment, thanks to new solutions from organizations that are deploying blockchain technology for sustainable and ethical sourcing.

Solution: Provenance is a social enterprise whose mission is to create full transparency in consumer product supply chains in order to build trust between consumers and brands, and curb the negative impact of manufacturing on communities and the planet.[13] The London-based company is piloting their complete blockchain-based supply chain transparency system in partnership with Martine Jarlgaard, a London-based fashion designer.

Provenance's project brings transparency to garment supply chains with the goal of meeting growing consumer demand for traceable, ethical sourcing. While blockchain technology underlies Provenance's system, the company pairs their technology with other traceability tools, such as SourceMap's supply chain mapping platform.[14] By the time a finished garment reaches the end user, anyone can scan its embedded tag with their phone and view an interactive dashboard with details on the product's origins, costs per input, and any applicable certifications. The system is easily auditable due to the security and immutability of a blockchain backbone, which makes it possible to "inspect the uninterrupted chain of custody from the raw materials to the end of sale."[15] The solution provides a range of benefits for procurement professionals, corporate sustainability practitioners, policy makers, and consumers. Additionally, it can potentially be harnessed to address legal reporting requirements, public procurement regimes, or risk management issues.

How it Works: Provenance's solution, like BanQu's, is a systems approach that bridges several tools to trace the origin and movement of products. Each actor in a supply chain is considered a member of

> **Soon, consumers, regulators, and watchdog organizations may have greater visibility into inputs that comprise a garment, thanks to organizations deploying blockchain for sustainable and ethical sourcing.**

that chain's trusted network with controlled access to modules in the system. In order to control access for different security needs, Provenance uses Private Key Infrastructure that allows varying levels of access depending on the needs of the actor ranging from farmer to manufacturer to retailer to consumer.

Traditional supply chain management systems store data in centralized silos that cannot interact or communicate easily. Provenance uses blockchain's decentralized structure to replace siloed data storage. Their interopable network solution relies on transparency and traceability data tools including tamper evident seals, NFC tags, QR codes, 3D scanning, laser-engraved barcodes, and SourceMap's supply chain mapping software to generate a digital "passport" for goods. According to Provenance's white paper, the system logs the nature, quality, quantity, and ownership of all materials and consumables.[16] This information is visible on a dashboard that provides users with real-time visibility into the supply chain. Provenance interprets supply chain data to present a full picture of the garment's journey from seed to stitch. The solution has the potential to deliver a dramatic advance for consumers interested in using sustainable, ethically sourced supply chains. However, there is potential for even more transparency in the process. Currently, the app dashboard displays total labor cost, but not disaggregated labor costs to see how value is distributed throughout the supply chain. If consumers and watchdog organizations do not know how much money was spent per worker across the supply chain, it will be difficult to tell from looking at the dashboard if everyone involved in production was paid fairly.

Why Blockchain? Provenance uses blockchain technology to securely store and transfer the garment production data from tier to tier in the value chain. The blockchain backbone functions as a single platform to host interoperable tools or modules that attempt to cryptographically build trust between consumers and brands, and between supply chain parties. Provenance has published several other case studies that provide further information on their pilots.[17]

Other Providers: The supply chain traceability space has been one of the most active arenas for blockchain projects this year. Major blockchain players and traditional enterprise resource planning and supply chain management systems providers are putting blockchain supply chain solutions on the market, including Walmart teaming up with IBM to track food safety with blockchain. Oracle and SAP have products on the market that offer blockchain-based cloud management solutions for supply chains. The Linux Foundation's Hyperledger has an enterprise-grade blockchain, Sawtooth, which they plan to use in seafood supply chain traceability projects.[18] Other players to keep an eye on include TATA Trusts, the world's largest charitable endowment, which is building a solution for seafood sustainability;[19] Chronicled, whose platform brings together the Internet of Things, artificial intelligence, and blockchain to monitor refrigerated freight shipping and prevent the sale of counterfeit goods;[20] and Blockverify, which offers blockchain-based anti-counterfeiting tools.[21] Ultimately, standardization of processes across industries and borders will be vital to the sustainability and scalability of these blockchain supply chain solutions. There are a handful of coalitions working to build the necessary infrastructure for the future of blockchain supply chains including the Trusted IoT Alliance and the Sweetbridge Alliance.[22]

HOW TO APPLY THIS RESEARCH TO FUTURE BLOCKCHAIN-BASED SOLUTIONS

In addition to the challenges outlined above, there are three key lessons that emerged from this research to consider when contemplating a blockchain-based sustainable supply chain solution:

Supply chains can harness different types of blockchains.

Decisions on how to structure a blockchain-based supply chain system depend on the needs of the organization and its governance structure. While the three pilots highlighted in this paper use the Ethereum network, the most widely utilized blockchain-based supply chain management network, there are a variety of blockchain networks available for testing supply chain use cases. There is also the option of building a private chain. For example, IBM partnered with Maersk and PIL to test supply chain systems on the Hyperledger Fabric, an open-source blockchain network developed by IBM, which processes micro-payments more efficiently than the Ethereum and Bitcoin blockchains. Supply chain information could also be anchored to existing public blockchains using frameworks such as the Exonum platform developed by the Bitfury Group.[23]

Advancements in supply chain management should be coordinated and shared in order to scale impact.

Technological development is extremely fragmented because there are massive sub-industries involved in most global supply chains. Standardization and knowledge-sharing should be key priorities to help ensure that the sector does not become oversaturated with flawed pilot projects. Blockchain remains a nascent technology, and organizations looking to leverage blockchain applications have few resources available to guide their work. Despite a rapidly growing number of pilot projects, virtually no best or worst practices have been catalogued from these experiences. Knowledge sharing and standardization will become even more important as environmental- and human rights-oriented supply chain startups attempt to capture data on the environmental and social impact of different

solutions. In order to ensure that human rights and environmental considerations are integrated into future industry-wide blockchain developments, developers will need a clearer vision of how the ecosystem is evolving.

The transformation is coming—we just don't know when.

If blockchain solutions can scale sustainably and integrate other successful supply chain technologies, global markets might experience a sweeping transformation sooner than we think. Breakthrough innovations could emerge from a variety of actors: SkuChain, creator of one of the earliest applications of blockchain for supply chains;[24] Sweetbridge Alliance, which is creating new protocol layers for supply chain financial liquidity; and BASF, one of the world's largest manufacturers, who recently announced that they are testing blockchain "smart pallets" (cargo pallets with smart sensors that can communicate with computers via the Internet of Things), are four of the many firms in the sector that could deliver game-changing innovations.[25]

CONCLUSION

Despite some manageable challenges, supply chain applications of blockchain technology should provide producers and consumers with a significantly better way of doing business. Added security, accountability, and efficiency will help drive adoption of blockchain solutions. However, blockchain's biggest contribution to the global supply chain system may turn out to be the decentralized ownership of data. If broadly adopted with the right incentives for accurate data recording, the technology could help improve the balance of power in the global economy, giving small producers and consumers an added stake in ensuring sustainability and social responsibility. Along the way, the technology can help shippers, manufacturers, and other intermediaries deliver better results for people and the planet.

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Ashish Gadnis, email interview by the author, September 2017.

Ronen Kirsh (co-founder of Blockchain@Berkeley, Co-founder of Dekrypt Capital) in discussion with the author, October 17, 2017.

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