Blockchain: ***Revolutionizing the Global Supply Chain by Building Trust and Transparency***

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Operations Analysis

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Introduction

The history of Supply Chain Management has evolved since its' roots in the early 1900s. From improving labor processes of basic material handling and freight transportation, to more sophisticated approaches of balancing cost and efficiency trade-offs, the concept of a supply chain is no longer siloed. It requires integration of supplier-customer relationships, process synchronization, and data harmonization in a complex, dynamic network that is susceptible to vulnerabilities in a global environment. Critical processes to this relationship include real-time communication, collaboration, trust, and transparency that yield mutually beneficial outcomes and competitive advantage. In today's world, there is a growing prevalence in leading firms advancing toward the adoption, development and implementation of Blockchain technology as a backbone of business operations.

This case dives a bit deeper into Blockchain, a novel technology with the strong potential to revolutionize the Global Supply Chain. The goal of this analysis is to discuss: 1) the key technical and economic aspects of Blockchain, 2) the current Blockchain innovators, barriers, and obstacles to Marketplace acceptance, 3) the business case for Blockchain, and 4) future applications and implications of Blockchain technology.

Technical and Economic Aspects of Blockchain

Blockchain technology is the culmination of a decade's work by "an elite group of computer scientists, cryptographers, and mathematicians" (Gupta, 2017). It aims to solve the inherent complexity of diverse global supply chain relationships using an incorruptible distributed digital ledger of transactions that can be programmed to record anything of value. Blockchain is a distributed public or private consensus system processed by mining

(verification), whereby every participant can view a database history of critical record keeping items in a digital cryptocurrency, the historical records of which are incapable of being falsified after the event is closed. For more information on how the Blockchain technology works and its intended outcome, we can turn to the following words of Shireesh Apte and Nikolai Petrovsky[1] as expressed in a recent editorial:

> The first party to a transaction initiates the process by creating a block. This block is verified by multiple computers distributed around the net. The verified block then becomes the starting point for a chain of blocks as the contents are passed from party to party which is stored across the net in multiple copies thereby creating an indestructible single unique record including its whole transactional history. This effectively creates an accounting ledger that can never later be changed or falsified given that this could only be done by changing or falsifying every single copy of the ledger distributed across the net, which would be effectively impossible (Apte & Petrovsky, 2016).

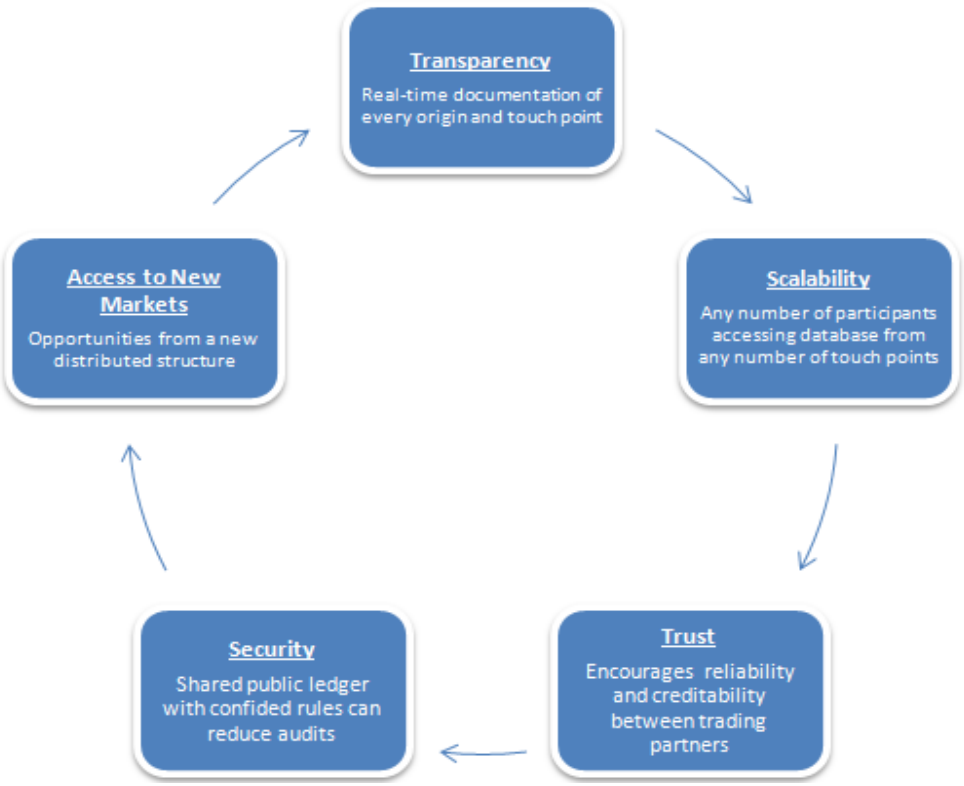
In the context of Supply Chain Operations, the technology can integrate the functions of Order Fulfillment, Distribution, and payment of intermediate goods as they move through nodes of production, shipping, and delivery and as title to them passes between different owners. This can give businesses increased flexibility "to find markets and price risk, by capturing the value that they have invested in the process at any point along the chain" (Casey, Wong, 2017).

As described in Figure 1 below, using a Blockchain further facilitates real-time granular visibility, insures trust, and enforces security using a chronological order of transactions verified

[1] Shireesh Apte is a member of the Editorial Board of the Journal of Excipients and Food Chemicals. Nikolai Petrovsky is a member of the Department of Endocrinology, Flinders University, Bedford Park, Adelaide, Australia.

by unique spendable crypto digital currency, like bitcoin. Every touch point in the Supply Chain will be accessible to yield improved forecasting and reduce bottlenecks. Other benefits include supplier reliability where economic trust is built in digital currency-backed transactions, scalability, faster payment processing without transaction fees, lower costs of goods, reduction in lead times, and opportunities to trade within a new, distributed system.

Figure 1: Blockchain Supply Chain Benefit Assessment



The use of Blockchain presents the opportunity for any private or public company or government agency to set up a trusted internet-based network upon which the members to that network may share information, knowing that the information 1) is only visible to the other members of the network and 2) is never alterable once entered (Miller, 2017).

Leading Blockchain Innovators

As is the case with anything new and yet unproven, adoption of technological advancements happens at different rates and to somewhat varying degrees. Many firms that would stand to benefit most from the adoption of a Blockchain infrastructure, like banks, by nature tend to err on the side of caution. The fact of the matter with new technology is no one wants to be last, but at the same time, it can be viewed as such a dauntingly risky undertaking that not many major players want to be first either (Bertrand, 2016). At this point, let us consider some of the happenings at firms which we believe to be some of the 'movers and shakers' in the Blockchain arena. These Blockchain innovators include Ernst & Young, Walmart, Maersk, and IBM.

Leading the way in many respects, IBM has been a pioneer in developing various applications of the Blockchain technology. The company believes nearly all transactional businesses could benefit from Blockchain in one form or another in the coming years. Although Blockchain first took hold in the financial industry, IBM and others strongly expect it to have a sweeping impact in supply chain management, healthcare, insurance, government, industrial, retail and entertainment (Miller, 2017). IBM has invested substantially in The Hyperledger Project, which it co-founded. This project is a Linux Foundation open-source program and collaborative effort focused in particular on *permissioned*[2] Blockchains and the collective effort to advance the technology. To date, IBM has donated over 44,000 lines of code, 35 researchers and developers, and 100 architects to the project, all in the well-intentioned and optimistic outlook that in doing so it can help make the Blockchain technology business-ready (IBM

[2] A Blockchain can either be permissioned (private) or permissionless (public). For more information, please see the Glossary of Terms in the Appendix.

Corporation, 2017).

In addition to IBM's work towards developing code, the firm has also launched services including providing an environment for companies to test and improve their own Blockchain networks and infrastructure. Essentially, IBM is attempting to offer a first of its kind Blockchain-as-a-service model, whereby the commercial deployment of their software offering enables firms to build a permissioned Blockchain network and in much quicker a time than ever before (Miller, 2017). In Blockchain's bright future, IBM sees the potential for improvements in the exchange of information, interaction of systems, and innovation of processes. It is anticipated that all of this will lead to a sharp reduction in frictions, and as a result, advancements in efficiency and reductions of costs (Brakeville & Perepa, 2016).

Maersk one of the world's more prominent shipping and transportation firms, announced in March 2017 that it would be pairing up with IBM to digitize, manage and track shipping transactions using Blockchain technology. The technology developed conjointly by the two companies is expected to be made available to the rest of the ocean shipping industry later this year. This is a breakthrough in ocean logistics because historically there has been lack of visibility and data accuracy in tracking shipments and managing risk disruptions. Their project intends to track the tens of millions of transactions involving shipping containers globally spanning the entire supply chain from start to finish. The companies expect the collaboration to save billions of dollars in the coming years. Both companies plan to work directly with a network of shippers, freight forwarders, ocean carriers, ports and customs authorities to build the new global trade digitization product (Chavez-Dreyfuss, 2017). Clearly, Maersk stands out as a current groundbreaker for incorporating the use of Blockchain in the global logistics industry to better the shipping and tracking processes involved.

Walmart has been an innovator in its use of ERP and its highly integrated Retail Link system for interfacing with its suppliers. Similarly, the retail giant intends to be a leader in the Blockchain space as well. The firm announced in December 2016 it would begin use of Blockchain technology to track and trace through its supply chain the pork sourced from China and fresh produce in the United States. The company expects this effort will help reduce delays and errors resulting in more efficient and streamlined operations. The collaboration is between IBM, Tsinghau University in Beijing, and Walmart. The group intends to test the effectiveness and determine scalability in the months and years ahead. Potential benefits include increased transparency and efficiency in supply chain record keeping and in turn improved safety standards (Prisco, 2016).

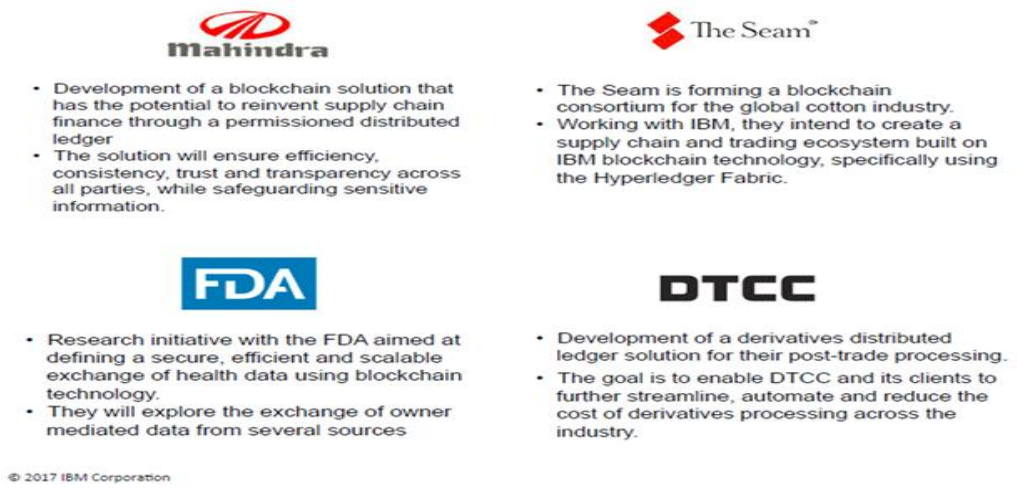
The focus on safety standards is arguably the most notable aspect of Walmart's work, as it is not necessarily a direct benefit which one would commonly anticipate of Blockchain usage in the supply chain. However, Walmart is confident that its use of Blockchain technology will lead to better control in food sourcing, ultimately diminishing risk of contamination. Even in the event of contamination, the greater controls and visibility offered by Blockchain enable the contamination to be traced to the source for proper corrective actions, with the possibility even for preventative actions to protect against the potential for future disaster scenarios in the firm's food supply (IBM Corporation, 2017). The Walmart project will run on transactional security and authentication technology developed by Tsinghau University, and Walmart plans to leverage this infrastructure for their tracking purposes. "China's rapid economic growth has led to massive opportunities for innovation, but it has also presented quality of life challenges, including helping to assure that food sold is safe to eat," said Tsinghau professor Chai Yueting from the National Engineering Laboratory for E-Commerce Technologies. He also noted, "We

believe the work with IBM and Walmart can serve as a global model for others to follow and replicate" (Prisco, 2016). There is much potential for increased tracking and traceability, and with more successful use cases like that of Walmart, higher safety standards may soon be realized through the use of Blockchain in supply chains.

Ernst and Young is another premier firm which has allocated significant resources toward the development of Blockchain, primarily through the Bitcoin cryptocurrency. The company has provided secure digital wallets to all its employees in Switzerland and has also enabled its clients to purchase and sell Bitcoins as well as pay in Bitcoin for services provided by the firm. This is in contrast to the other three "Big Four" accounting firms who are dedicating their focus on "permissioned" or private Blockchains. Although very much an area of widespread interest, permissioned Blockchains have yet to truly prove commercial viability; yet this technology has generated considerable investment from companies all around the world, as well as venture capital firms, in recent years (Young, 2016). Ernst and Young has been an early adopter of Bitcoin, and in doing so, an early champion of Blockchain technology overall. It will be interesting to see how decisions on permissible versus non-permissible networks will play out in the years ahead, as well as to see who tomorrow's true winners and losers will be as a result of today's actions (or lack thereof).

Shown in Figure 2 below are some other examples of other key work to date in the Blockchain space, outlined by IBM, from their unique perspective as a proponent and developer of the Blockchain as a service offering and as a facilitator of several key Blockchain consortiums and forums.

Figure 2: Other considerable movers and shakers in Blockchain



Barriers and Obstacles to Marketplace Acceptance

Similar to any emerging technology, Blockchain technology will have to overcome hurdles in order for it to see widespread adoption and to eventually become a mainstay within global supply chain operations. These hurdles, described below in Figure 3, include but are not limited to the three major aspects of legal oversight, governance, and integration with already established supply chain management system infrastructure.

Figure 3: Blockchain Barriers to Marketplace Acceptance

As Blockchain technology becomes more mainstream, laws governing its use will not have precedent in the court systems - Blockchain laws will be crafted from a clean slate. This means that the new laws created may pose an additional obstacle for users of Blockchain technology, requiring them to be able to adapt and adjust their operations to fit within those laws. According to Kiviat (2015), the regulations surrounding virtual technology like Blockchain do not yet exist. Federal agencies like the US Treasury and the Internal Revenue Service, among others, have offered to assist in creating regulations to protect the integrity of the technology and also to protect those entities using it to conduct trade. One part of the US Treasury, the Financial Crimes Enforcement Network (FinCen), is the organization that has set up regulations to comply with both the Bank Secrecy Act (BSA) and Anti-Money Laundering (AML) requirements (Mills, Wang, et. al, 2016). One of FinCen's main goals is to set up the virtual network with regulations that closely resemble that of physical currency of trade. This is because the current laws, regulations, and governance of payment networks were established for conventional financial markets; there are no existing equivalents for any specific form of virtual or electronic financial markets like those which would be driven by Blockchain (Mills, Wang, et. al, 2016).

As companies look to incorporate Blockchain technology into their operations because they want more transparency, lower transaction costs, and an overall quicker operation, they will need to also have strong risk and fraud units to monitor transactions and file Suspicious Activity Reports (SARs) with the US Treasury, and they will also need Risk and Compliance departments to ensure that their operations are falling in line with guidelines that are currently in place and guidelines will which change as the technology matures. Lastly, a company's legal department is going to need to be able to understand cryptocurrency, the way Blockchain transactions are kept

secured. The number of lawyers with this knowledge is currently limited (Earls, 2016), and that limitation could be the hurdle that many companies cannot overcome.

Another hurdle that supply chain companies will encounter when looking to utilize Blockchain technology is how to incorporate the technology into their operations. An investor in Blockchain, William Mougayar was quoted in Alan Earls (2016) describing, "In theory, this (Blockchain technology) all makes sense, but supply chains are very hard to change and adapt." Mr. Mougayar's quote is referencing the complexity of the supply chain systems that companies spend years perfecting (or at least attempting to perfect). Adding a brand-new technology to an existing supply chain system is undoubtedly an expensive and timely undertaking. From first-hand experience, there may often be need to decommission legacy systems which will be outright replaced by Blockchain, but in many cases, this would occur only after both coexist for a time. In Information Technology, it is common for there to be a period during which this system redundancy exists. Although more costly for a time, keeping the old system live alongside the new protects against failure of the new to deliver as expected.

Besides these redundancy costs and efforts, there are also those which directly relate to the overall integration efforts of standing up a new Blockchain technology. Integration, enabling one system to connect others for the purpose of creating a broader network or ecosystem for data exchange, is typically one of the most costly business-as-usual activities in IT departments. A related hurdle is the fact that Blockchain is generally not a stand-alone system, but a sub-system which would need to act as a component of an enterprise's broader information system. There is a ton of time and manpower dedicated to these integration efforts. First, the import of historical transactions into the new system must occur, and with Blockchain this this a very complicated task given the secure cryptographic hash encryption techniques it employs. There are then

multiple phases of testing to connect the new system to the organization's legacy systems, since the success of interfaces typically hinges on details going down to every last segment of coded information in the message protocols which the systems will use to communicate. Integrating a new system like Blockchain will be no easy feat (Wang, Chen & Xu, 2016).

On top of simply adding the new technology to operations, what risks will now be encountered as a result? Supply chains operate in a 24x7, 365-day environment. Before adopting and implementing a new technology like Blockchain, a company must understand what operational and financial risks they will be accepting by doing so. While these hurdles may seem to be insurmountable, those companies which exercise due diligence and understand the risks and rewards of Blockchain technology will ultimately be successful in realizing all of the benefits of the marketplace of tomorrow.

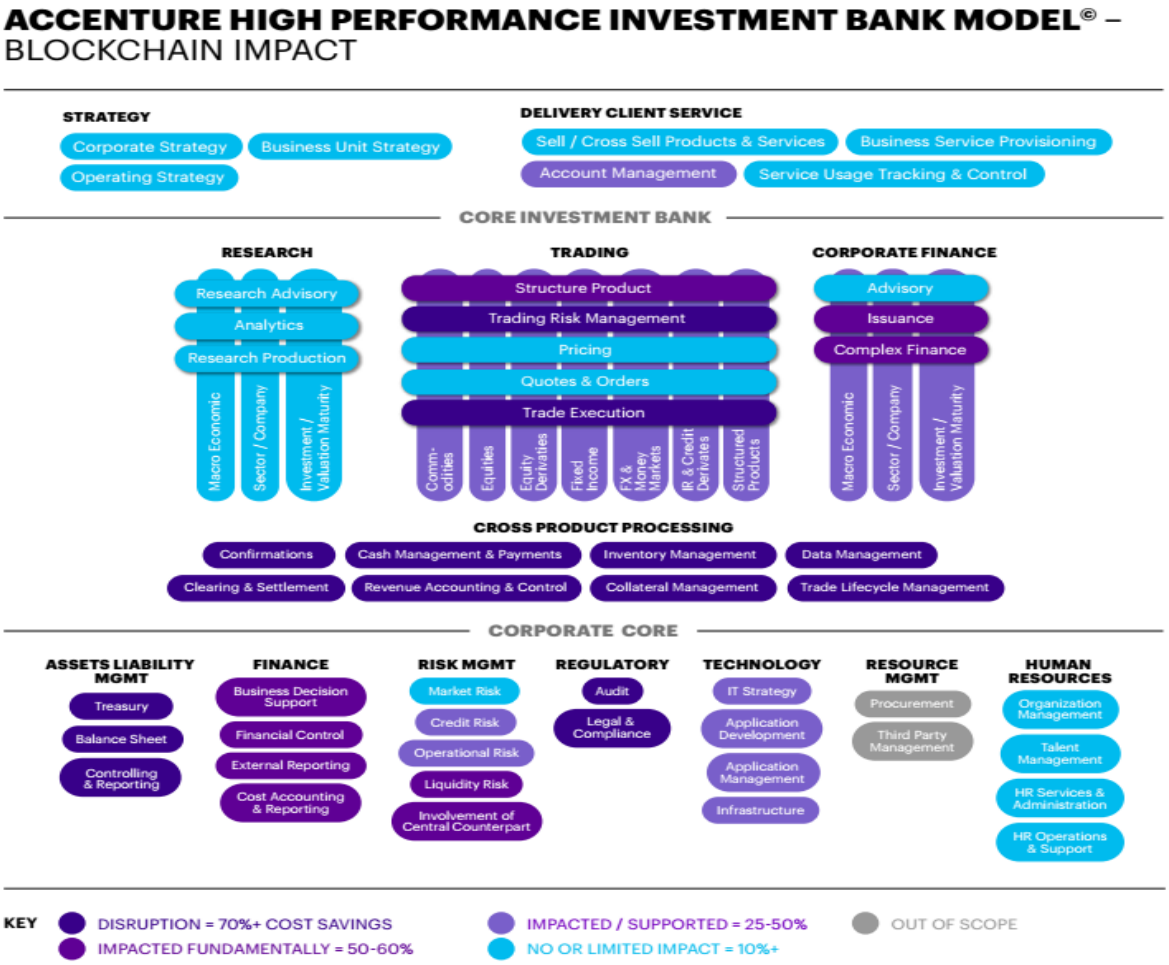
The Business Case for Blockchain

Many subject matter experts are placing emphasis on two main areas of business for which Blockchain technology is most fitting: financial services (e.g. trade finance and investment banking) and supply chain (e.g. transaction services and traceability). Blockchain is such a nascent technology that it is extremely difficult to construct a quantifiable metric based business case without first-hand experience with it. The technology is still widely being developed and piloted as a proof of concept, and it has not yet been widely implemented. Therefore, this case will aim to provide a macro-level business case view of Blockchain technology's potential.

Large consultancy firms are best positioned for thorough, unbiased analysis, and recent years have seen a heavy influx of research reports published by such firms. These reports aim to explore the value, or lack thereof, for Blockchain technology adoption and usage across varying

business areas. Accenture recently conducted reported on one such study. The firm partnered with capital markets benchmarking firm, McLagan, to analyze Blockchain use in investment banking. Accenture used 50 operational costs from McLagan's comprehensive benchmarking of the largest investment banks in the world and weighed that against the proprietary high performance investment bank models it has developed to clearly map out those areas of the business which would be most heavily impacted by Blockchain technology. The below Figure 4 is a complete diagram of the exercise findings. Key highlights include potential for 30-50% cost savings on compliance activities, 50% cost savings on both centralized operations and business operations in general, and most notably, 70% cost savings on central finance reporting. The firm concluded that on average, there is the potential for 30% overall annual savings for those enterprises that adopt Blockchain technology (Accenture, 2017).

Figure 4: Results from Accenture-McLagan study on Blockchain in Investment Banking

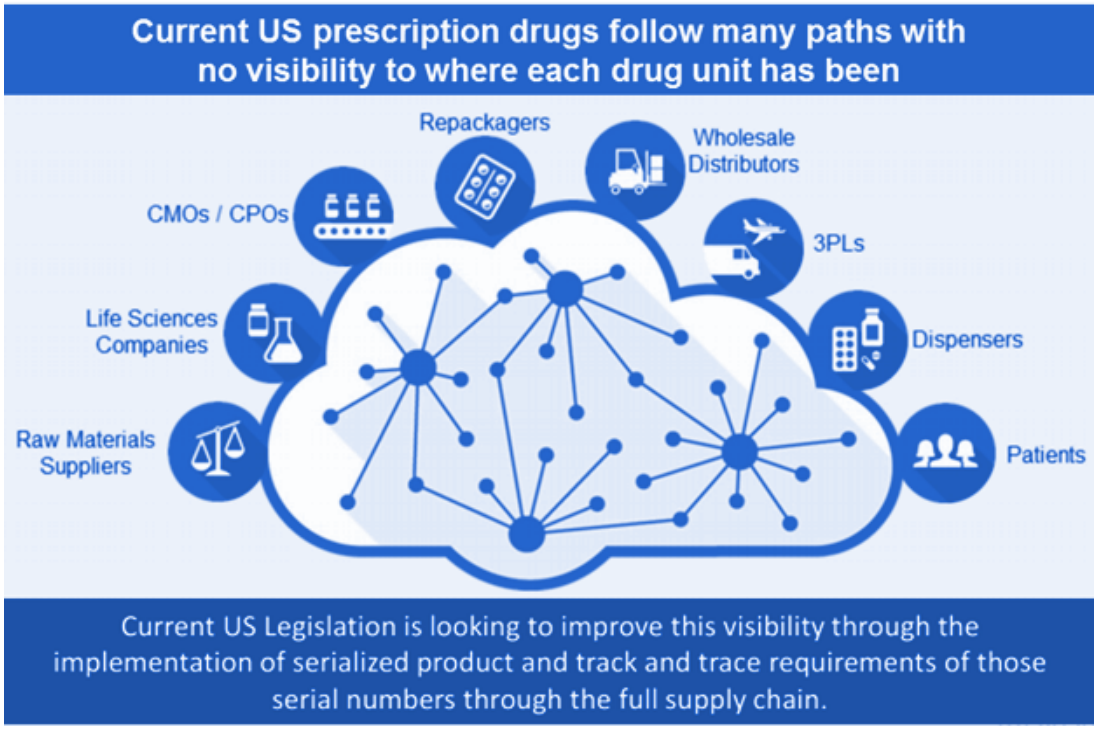


(Accenture, 2017)

A second major business case for Blockchain technology can be made for use in supply chain as a means to identify a track all assets throughout the supply chain. From first-hand experience, this is especially true in the Pharmaceutical industry, where we currently see a heavy influx of new laws enacted by the governing bodies of large and small markets across the globe. These laws are requiring the more stringent serialization (labeling), tracking, and traceability of pharma product in an effort to cut down on supply chain leakage and counterfeit product, while improving the abilities manufacturers have to make clean and educated recalls of product when

needed (Krause, et al., 2016). Figure 5 below further demonstrates the current problem statement for the US Drug Supply Chain Security Act (DSCSA) legislation in particular.

Figure 5: Drug tracking problem statement via US supply chain and DSCSA law



(Somerville & Garvin, 2016)

The track and trace needed for prescription drugs, in order for companies to meet the requirements of the DSCSA law, is just beginning to be piloted by firms across the supply network (manufacturers, wholesalers, retailers and third party packaging and logistics firms). The law has a need for an 'interoperable system' to handle the data, and it is the thoughts of some specialists that Blockchain technology is the answer. Due to Blockchains being an immutable chain of transactions, each product serial number can be completely and securely tracked so as to disallow any drugs from entering the system (and therefore supply chain) without having originated from the designated manufacturers (Somerville & Garvin, 2016).

The secure exchange of information from one party to the next through the chain of custody in the supply network is exactly that pharmaceutical companies struggle with most in

moving towards compliance with the DSCSA law. Most firms have an enterprise resource planning (ERP) system, like SAP, which holds all the information it is necessary to capture and pass along downstream. However, efforts must be made to ensure the firm's enterprise system can compile the information in formats which are ingestible by all those supply chain parties' systems to which it must send the information (from its central repository, or system of record). Often around the Pharma industry, the systems of record are provided by third party vendors, further complicating matters.

From experience, it sometimes takes weeks or months to to connect, test, and then go live with those B2B[3] interface connections, only after ensuring all data requirements for both compliance and operational purposes are included in the various messaging protocols employed for a firm to communicate with its myriad of trade partners. Whole divisions of business units within an organization are dedicated to efforts of the like. The last large benefit to using Blockchain for asset tracking purposes is that the technology would act as one central record and source of truth, providing a common hub with which all firms can communicate to pull or push information for secure keeping. This would eliminate the needs for such vast efforts to be placed into setting up countless interfaces across supply chain partners' various internal systems. Overall, successfully bringing Blockchain into the solution for DSCSA drug tracking compliance can provide the pharmaceutical industry with a more wieldy, more secure, and yet less expensive approach to meeting the requirements of the law.

[3] Business-to-business, also known as e-business; here with reference to the exchange of information, but also commonly stated with reference to exchange of products or services

Future Applications & Implications of Blockchain Technology

We believe the current state of Blockchain shows tremendous potential but is not yet ready for mass usage. Both design and codebases are still being refined constantly, and there are no other established applications beside crypto-currency. We simply can not tell if the bandwidth exists for Blockchain to scale, nor can we predict whether enough of a mass of adopters will come forward to ensure the network is wide enough to realize all the potential Blockchain offers. We believe that ultimately global trade will evolve into a battle of supply chains, where efficiency, block chain optimization, and innovative financing will yield best in breed organizations. As blockchain gains momentum, "there will be real-time visibility, reduced complexities, improved accuracy and efficiency in the system, which in turn will help reduce costs and enhance trust. Its usefulness will not be limited to shippers or customers but will extend to lowering trade barriers, especially for developing nations which are not able to participate in global trade owing to cost considerations" (Bajpai, 2017). Overall, "when adopted at scale, the solution has the potential to save the industry billions of dollars and benefit global trade and the world economy" (Bajpai, 2017).

Unfortunately, many organizations rely heavily on extended terms (DPO) and financing to float logistics and operations costs. It has become an accepted business practice for larger companies to extend terms to free-up cash flow. If blockchain backed by crypto currency becomes the norm, many organizations may suffer cash flow issues, simply unable to pay for transactions real-time and thereby unable to compete. While currency inflation and deflation rates become more difficult to leverage, allowing for a more fair trading environment, we question if Blockchain somehow contributes to a de-evolution of sorts, where "the iron law oligarchy" will inevitably surface. The golden rule which states "those who have the gold, rule"

seems probable as access to working capital will become necessary in a more transparent environment.

However, the tremendous benefits gained using Blockchain technology should not be overshadowed by the potential risks. Possibilities for usage across various segments of the global economy are listed in Table 1 below (Brakeville & Perepa, 2016). For example, smart contracts can be used for transactions to exchange money, property, shares, or anything of value where blockchain defines the rules and penalties of the contract and automatically enforce those obligations, including expiration dates and validity. Additionally, blockchain can be integrated in the Internet of Things device management, voting confidence, and P2P insurance. All of these applications of blockchain are already being vetted and show favorable results.

Table 1: Blockchain Usage Examples by Industry Segment

Industry Segment	**Uses for Blockchain**
Government	• Voting • Taxes • Tender processes
Industrial	• Manufacturing processes • Internet of Things (IoT) device management
Financial Services	• Foreign exchange • Corporate debt / bonds • Trading platforms • Payment remittance
Insurance	• Claims processing • P2P insurance • Ownership titles • Sales and underwriting
Retail	• Loyalty points • Identity management • Trusting industry • Capital asset management • Letters of credit

Healthcare	• Electronic medical records • Seed vault backup • Virus banks • Health research commons • Doctor-vendor RFP services and assurance contracts

Conclusion

In the era of globalization, companies must think beyond themselves to achieve goals to minimize production costs and achieve economies of scale. In developing a competitive global multi-tiered supply chain, it is vital that organizations recognize that they "no longer compete as stand-alone entities," but in an era of "network competition where the prizes go to organizations who can better structure, co-ordinate and manage the relationships with their partners in a network committed to closer relationships with their final customers" (Christopher, 2011).

Unless closely following the latest news and developments in the Blockchain sphere, one may be blissfully unaware of the explosive growth these technologies have experienced in the past several years, as well as the vast involvement of big name firms across nearly all global industry segments. Considerable amounts of time, capital, and labor are continuously invested into Blockchain technology development and adoption efforts. It appears that there is no longer a matter of whether blockchain will revolutionize the transactional transfer of value, assets, information and goods and services; rather, it is a simple question of when this will take shape.

Despite considerable progress displayed by these early explorers and adopters, the fact of the matter is that the technology is still in its infancy, especially in terms of bringing it to scale enough for widespread corporate industry use. Challenges include regulation, investment in infrastructure and compatibility for those entities still using outdated, legacy systems and processing mechanisms. As other proponents of the technology suggest, we too believe change

will be rapid in terms of development, and eventually its use in business supply chains will be prevalent once Blockchain adoption gains true momentum. “Blockchain is challenging industry players to fundamentally reimagine their data sharing processes. There is no turning back” (Accenture, 2017). The technology is likely to garner increasing attention as a superior alternative to traditional forms of transactional information exchange and record keeping, and it will one day capture considerable market share as the benefits become more apparent and the overall concepts continually proofed. As this case and its underlying research suggest, that day is very near.

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Appendix A: Glossary of Terms

- **Asset**: Anything that can be owned or controlled to produce value.
- **Blockchain**: A shared ledger distributed across a business network. Business transactions are permanently recorded in append-only blocks to the ledger.
- **Consensus**: among nodes ensures that these shared ledgers are exact copies and lowers risk of fraudulent transactions, because tampering would have to occur across many places at the same time.
- **Cryptocurrency**: a digital currency in which encryption techniques are used to regulate the generation of the units of currency and to verify the transfer of funds, operating independently of a central bank. digital asset designed to work as a medium of exchange using cryptography to secure the transactions and to control the creation of additional units of the currency
- **Cryptographic hashes**: such as the SHA256 computational algorithm, produce a fixed-size, unique hash value, known as a digest, from variable-sized transaction input.
- **Digital signatures**: ensure that the receiver receives the transactions without intermediate parties modifying or forging the contents of transactions, while also ensuring the transactions originated from senders (signed with private keys) and not imposters.
- **Node**: Each copy of the ledger operated by a participant in the blockchain network.
- **Permissioned**: networks are limited to participants within a given network. Participants are allowed to view only transactions relevant to them. The Hyperledger Project (Linux Foundation open-source) was founded to support the development of permissioned blockchains.

- **Permissionless**: networks are open to any participant and transactions are verified against the pre-existing rules of the network. Any participant can view transactions on the ledger, even if participants are anonymous. Bitcoin is the most familiar example of a permissionless network.
- **Smart contracts**: programs running directly on the replicated network. Smart contracts encode a business rule, or contract, in a programmable language onto the blockchain and are enforced by all the participants in the network.
- **Transaction**: Asset transfer onto or off of the ledger.