
# ANALYZING THE USE OF BLOCKCHAIN TO STORE CERTIFICATIONS AND IMPROVE EFFICIENCY IN STC


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## Abstract

The Testing, Inspection, and Certification (TIC) industry provides certifications consumers rely on to ensure goods are up to a certain standard. This project explores the implementation of a blockchain-based solution in STC to store certifications to mitigate certification fraud. This project also explores other alternatives such as creating better workflows for STC's certification service or an industry-wide solution to store certifications. We reviewed relevant literature and interviewed staff at STC and experts in blockchain technology. We investigated the benefits of blockchain in other industries and identified the costs of implementing blockchain in STC. Our research results led us to recommend against blockchain in STC in favor of a centralized database and recommend the creation of an industry-wide blockchain.

## What is the TIC Industry?

The Testing, Inspection, and Certification industry, better known by the acronym TIC, is an industry that provides conformity assessment services for certain products. This industry tests, inspects, and certifies products to make sure that they are up to different standards and regulations. This helps mitigate the selling of low-quality or potentially hazardous goods. It provides these quality and safety controls through product testing, supply chain certifications, industrial site inspections, and more.[1] Consumers rely upon this industry to know if a product is safe and what standards the products will meet. Businesses also rely upon this industry to ensure production is meeting their quality, as well as health and safety standards. Our sponsor, the Hong Kong Standards and Testing Centre (STC) is one such company providing accreditation services on a global scale through locations in Hong Kong, the USA, Germany, Mainland China, and more.

## Fraud in the TIC Industry

Currently, consumers must turn to the sellers of a product to get details on a certification and, in some cases, sellers may lie about certifications their product has. For example, in 2012, Hong Kong authorities caught a shipment of over 112 thousand glucose patches with false certification marks. These patches were found to be ineffective at providing glucose and would have compromised the health of those who rely on them.[2] By providing a trustworthy method to check the tests, inspections, and certifications performed on a product and supplying this information to consumers, STC can provide an easy way to verify certification authenticity and mitigate the problem of fraudulent sales.

Especially in the traditional Chinese medicine (TCM) industry, it is hard to prove that a seller's claims are legitimate, or that a product is authentic. Because the composition of many traditional Chinese medicines are complicated, the ingredients are often not easily identifiable through a consumer's senses.[3] Drugs that may be meant to help a patient may end up causing harm, or may have no effect at all. For this reason, the tests done by the TIC industry to verify claims made by a TCM provider and the contents of the medicine are important for consumers of this product. As of right now, however, most of the information that the consumer gets is directly from the seller of the product. This may lead to false or misleading advertising from the seller who is trying to make a profit.

## Blockchain Technology

Blockchain technology has the potential to revolutionize a multitude of industries on a global scale. By offering improvements in speed and automation, as well as reductions in costs and reliance on companies as a single point of trust, blockchain can fundamentally change how businesses manage data. The implementation of blockchain in various industries has the potential to not only benefit individual companies and organizations but also to promote inter-industry cooperation. A blockchain implementation may also address larger societal issues related to transparency and security.

In the TIC industry in Hong Kong, there is an opportunity for blockchain to add value

by increasing the trust consumers have in the evaluations companies such as STC provide. A single blockchain to store different tests and certifications across the entire TIC industry could improve customer experience and trust in the validity of certifications, as well as reduce certification fraud. As Hong Kong is a global center for trade, improving the networks of trust between all parties in Hong Kong has a direct effect on the global market, as the products they test, inspect, and certify are distributed worldwide.

The opportunity blockchain offers to STC is providing an optional package to its clients to store tests and certifications on the blockchain, making forging this information harder. This would increase consumers' trust in the client's products, giving them a competitive advantage over their competitors. By being one of the first TIC companies to provide such a package, STC would gain an advantage over its competitors, making them a more attractive option for potential clients. STC wants our team to investigate the costs and requirements of a pilot program for storing certifications of traditional Chinese medicine on the blockchain and how blockchain could make STC's processes more efficient in order to provide them with a final recommendation on using blockchain.

In order to achieve our goal, we needed to understand the ways blockchain can be implemented, how it had been successfully implemented in other businesses, and how it could suit STC's needs. While there is very little literature on the applications of blockchain in the TIC industry, there is research on implementations in other businesses and industries. Based on these studies, we decided to investigate implementing blockchain into STC's business.

## Data Storage

Data storage is the process by which a company will store relevant business information. This data can take any form from records of sales and analytics of different products to user information. The company can then use this information to make better-informed business decisions. Some data can also be mandated to be stored by governments and ruling bodies for compliance and auditing purposes. Stored records of company transactions, for example, could be required to be kept for a certain number of years for auditing purposes by entities such as tax services. Data storage itself can take many forms, ranging from physical copies to digital databases (and sometimes both forms). Current data storage techniques require that other businesses and consumers trust that a company's data storage is safe and reliable, with no way to prove it.

In today's world more than ever, data is being stored in internet-connected databases. As more of the world's data becomes accessible online, cyber-attacks have become increasingly frequent.[4] Such attacks can have millions of dollars in economic impact on companies and the economy as a whole. In fact, the data shown in Figure 1, compiled by Statista (2022), estimates that by 2027 the cost of cybercrime will top $23 trillion worldwide.[5]

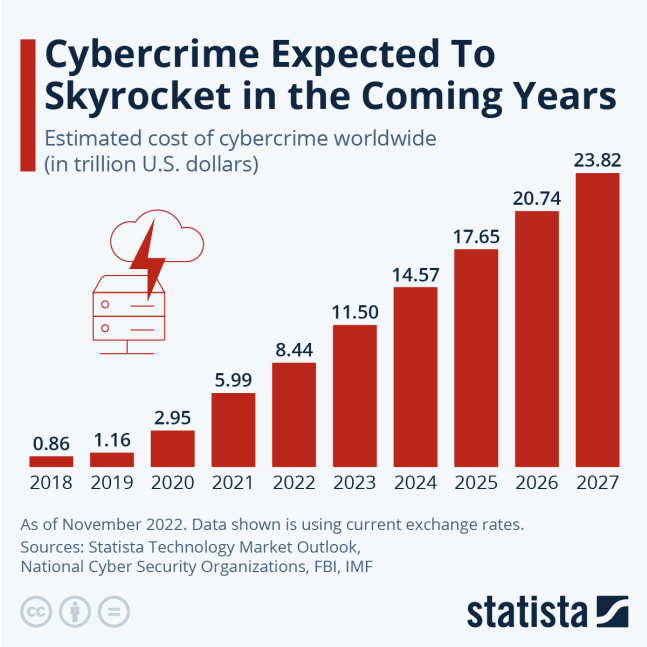


Figure 1: Cybercrime Cost Outlook 2018-2027[5]

The traditional method of data storage, a centralized database, is efficient, but provides a single point of failure in the case of any disasters, or entry for any bad actors, meaning that this form of storing data is potentially untrustworthy. A centralized database is a mode of data storage that is located, stored, and maintained in one location.[6] Centralized databases are not necessarily geographically centralized, but they are functionally centralized. This means that these databases can be accessed by interacting with one central system. These databases are generally accessed through a computer network, which gives access to all of the data in the database. In a centralized database, a central administrator has control over the database.

These databases offer an easy way to keep and manage relevant data, but users suffer when an error occurs, as a single error can block database activity on the whole network.[7] In this sense, it is possible for a centralized database to be rendered completely useless for everyone on the network for an extended period due to one error, which affects the reliability of the database. Because the centralized database runs off of one network, there are very high technical demands on the infrastructure. There needs to be enough bandwidth and computing power on the network to serve all of the requests in a timely manner. Since the entire database is hosted off of one system, it is this central system alone that has the authority to undertake these tasks. If this central system that serves all of the requests crashes, all of the users lose access to their data.

This centralized form of data storage also suffers from vulnerability if the administrator of the system is compromised.[8] If there is a breach in security due to unauthorized access, then it is possible for the entire database to be compromised. In any case, the possibility of a single malicious user gaining full control of the database is not a desired outcome. Because it is possible for modifications to be made to this data, it makes it more difficult to verify that this stored data is authentic.

A related issue is that the reliability of the database depends on the reliability of the group maintaining the database. In order for the data of a centralized database to be trustworthy, the group maintaining the database must also be trusted because they have full access and control over all the data. If the group is untrustworthy, then they can easily change items in the database to their liking causing considerable damage to those relying on that database.

Not only must a third party be trusted not to make intentional changes to the data, but they must also be trusted not to make unintentional changes to their data or input incorrect data. In the case that the third party in control of a centralized database does not provide correct data to their database, the data would also be untrust-

worthy. The owning party has complete control over who can add, delete or modify items in their database. In many cases, this results in a sort of "black box" for many users of the database, where they do not fully know what changes or additions are happening inside the database. Because of this lack of transparency, users of the database have no independent guarantee that the data they are being provided is reliable.

## What is Blockchain?

The first blockchain database was created in 2008 when a still unknown person going by the pseudonym Satoshi Nakamoto released a peer-to-peer version of electronic cash known as Bitcoin.[9] What made this new technology so special was its ability to allow payments to be made directly between interested parties without using any central third-party intermediary. To support this, Nakamoto also devised a ledger system, which acts as a systematic way of keeping track of records. He called this system "a chain of blocks"' which would later be dubbed "blockchain."

Blockchain provides a digital database of transactions. It differs from traditional database structures due to its decentralization.[8] Instead of all of the information being hosted on servers controlled by one entity, data on the blockchain is stored on individual computers and servers around the world. This is also known as a distributed ledger.

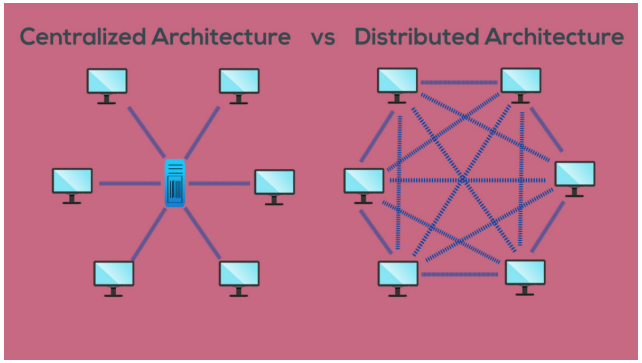


Figure 2: Centralized vs Distributed Architecture[10]

This distributed ledger is maintained and updated by a network of computers that serve to verify and approve transactions before they are added to the ledger. Once data, also known as a block, is added to the blockchain, it is immutable. This means it cannot be modified or deleted. There is always a record of a piece of data's entire history available.

A new blockchain-based technology, smart contracts, is used to automatically execute the details of an agreement when the conditions of that agreement are met. These contracts allow all participants to be immediately certain of the outcome of the contract, so there is no time loss in communication or actual fulfillment of the contract. In this way, smart contracts provide a guarantee for both parties that the contents of the contract will be fulfilled if the conditions are met, as well as manage the actual performance of the exchange.

As blockchain has evolved and been implemented in more industries, two main methods for implementing it have arisen, public and private blockchain.[11] In a public implementation, anyone can participate in the network by both reading and adding new blocks. Alternatively, in a private implementation, only prevalidated users are able to access the ledger to view or add to it.[12] A private blockchain offers more privacy to each transaction while also being easier to scale up, has higher security, lower costs, and can accommodate a higher rate of transactions at any given time.

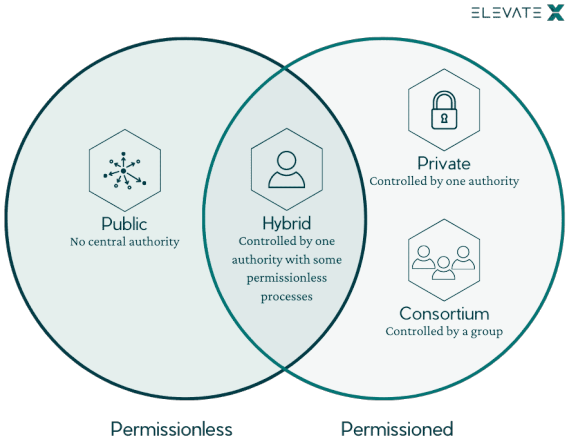


Figure 3: Different Kinds of Blockchain Access Schemes[13]

Since blockchain's emergence in 2008, there have been many efforts to apply this new technology to a wide range of areas. Blockchain provides a level of transparency and immutability where it is implemented. In many areas, blockchain has the potential to enhance business models as well as create entirely new businesses. An example of this is blockchain solutions in the financial industry, where blockchain has been used to "eliminate the need for reconciliation and intermediation and enable direct transactions between trading partners."[14] A public blockchain effectively eliminates the need for a third party to validate transactions. These new enhanced business models may become more prevalent as we explore the possibilities of using this new technology. Blockchain is able to eliminate these central intermediaries by providing trust between companies that these third parties once provided.

The goal of our project is to create a feasibility report on a method of blockchain to increase the authenticity of certifications for STC and the TIC industry as a whole. To do this, our team developed three objectives: to understand at a broad level how current business operations are handled in the TIC industry, to identify how blockchain could fulfill the needs and add value to this industry while functioning as a ledger, and to identify the requirements and challenges for STC to have a successful implementation of blockchain.

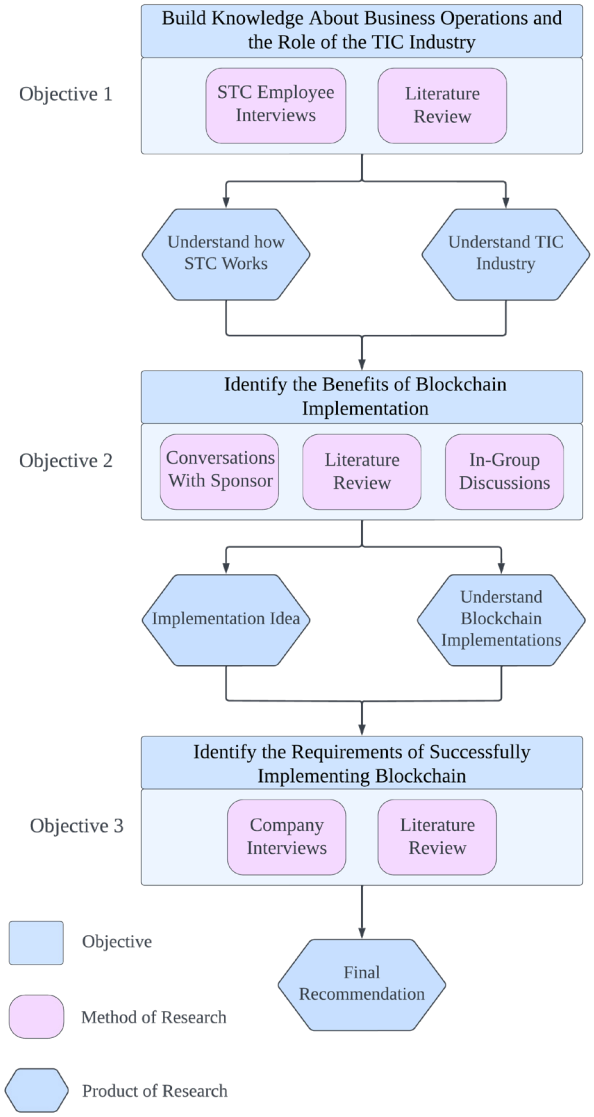


Figure 4: Project Objectives and Research Methods

## Objective 1: Build Knowledge About Business Operations and the Role of the TIC Industry

This objective focuses on building an understanding of the TIC community as a necessary background for deciding on implementation details and the feasibility of blockchain in this business space. We focused on investigating the services the TIC industry provides, the people who rely on the TIC industry, and the way that business operations are handled within TIC companies and STC. We wanted to learn where a blockchain implementation might be successfully implemented in the TIC industry by first understanding both the needs of the industry and the workings of potential sectors of the industry that may benefit from blockchain.

We used Google Scholar to search for information relevant to the importance of standards and testing and its practices, traditional Chinese medicine (TCM), and blockchain implementations in businesses. We found articles in journals such as *Policy Design and Practice* and *Technological Forecasting and Social Change*, as well as from international TIC associations. We also found relevant legislation on government regulations websites. We looked for information on how TIC business operations are handled and developed an understanding of how these operations work. This information gave us a deeper understanding of the needs of the industry by studying the systems currently in place.

We interviewed key personnel at STC such as Franki Lee, Director of Business Development and Compliance, Paul Lai, Dickson Mak, Joey Lau, Senior Manager of Chemical, Food and Pharmaceutical Products, Wai Leong, Supervisor of HKEMD, and Janet Wong, Assistant Manager of Sales and Marketing. Through these interviews, we learned about how STC handles client interactions, how departments collect and store data, each stage a product goes through when being tested by STC, and how inspections and certifications are handled.

## Objective 2: Identify the Benefits Of a Blockchain Implementation

The purpose of this objective is to understand how a blockchain ledger implementation has improved various other industries and how this could be applied to the TIC industry. This helped us understand to what extent blockchain would be beneficial to STC and allowed us to understand how a ledger implementation of blockchain could bring authenticity to the certification of goods. We focused on potential implementations in the traditional Chinese medicine (TCM) industry as a pilot program. Starting with an implementation on a smaller scale and with a high-value good allowed us to determine different potential strategies of implementation.

Our research consisted of searching technologically geared databases and through Google Scholar and WPI Gordon Library for implementations of blockchain ledgers as well as specific implementations of blockchain ledgers in other industries or businesses. We also reviewed journals such as *Business Horizons, the Journal of Cleaner Production, the Journal of Medical Internet Research, and Electronic Markets*. Through this research, we identified examples where blockchain as a ledger had been beneficial in other industries and determined the environment where these implementations of blockchain had the most impact. Once we de-

termined the environments in which blockchain ledgers had the most success, we then looked to see if the TIC industry has a similar environment where blockchain is applicable.

## Objective 3: Identify the Requirements of Successfully Implementing Blockchain

To identify the requirements for successful blockchain implementation, we interviewed Mavis Yik, a Project Manager from HerBChain, a company using blockchain to increase traceability in the traditional Chinese Medicine supply chain and Greg Solt, Director of Technology at DigiKerma and Senior Solutions Architect at Verizon. Through these interviews, we were able to acquire information about the implementation of blockchain in other industries, however, focusing specifically on the costs and requirements of blockchain. We asked questions related to the upfront and ongoing costs of a blockchain implementation, the manpower it requires to develop and maintain such an implementation, and through which sources this can be done. The research in the previous objective gave us a grounding in blockchain to understand the best ways it could fit into STC. Now that a specific use case for blockchain has been determined, we compared that specific type of implementation across multiple different industries to get an estimate of the requirements for implementing the technology. From these requirements, we gauged the challenges and costs of working with a partner to build STC a solution.

We conducted interviews with HerbChain and Verizon. Since these companies have implemented blockchain already, we wanted to understand the requirements of specific implementations. The benefit of these interviews over reading published studies in academic journals and trade publications is these companies gave us insight into the more practical challenges of implementing blockchain that might not have been published. These companies also had a better idea of the ongoing costs after implementation. For these interviews, we sent a list of interview questions to interviewees to allow them to gather information for the interview.

## Tests & Certifications are Administered in a Multi-Step Process

In STC, as in many TIC companies, products go through a process from receiving an inquiry from a manufacturer to producing a final certification. Although TIC companies follow the same general structure as can be seen in Figure 5, each company follows a slightly different process. In our interviews with Franki Lee, Director of Business Development and Compliance, and several department heads at STC, we were able to get an idea of the key processes that occur to allow STC to grant certifications.

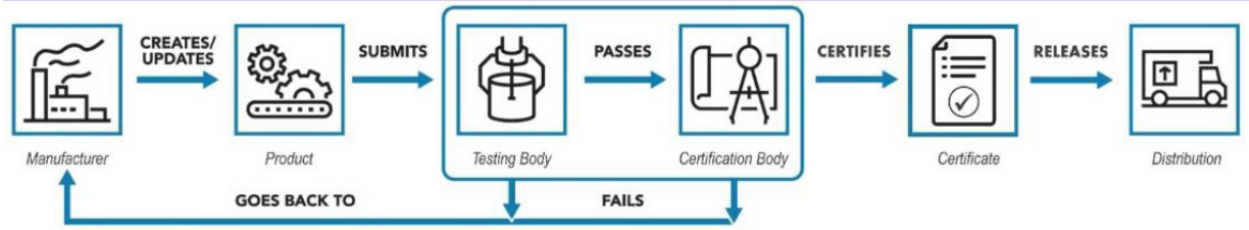


Figure 5: The Certification Process in the TIC Industry[15]

1. The customer sends an email to STC with an inquiry on whether STC is able to conduct tests on their product, as well as some initial product information. This information is usually a product description and a photo of the product.
2. The customer service team reviews this information and assesses whether STC can provide the testing and/or certification that the client desires, and responds accordingly.
3. If STC is able to provide these services, then the customer must fill out an application form to send back to STC.
4. This is received by STC and added to their Customer Relationship Management (CRM) system, and STC can prepare a quotation for the customer.
5. A formal quotation is then issued for the tests using a Laboratory Information Management System, which includes sample quantity, and turnaround time.
6. If this quotation is accepted by the customer, it is signed and sent back to STC. STC's customer service team will then arrange to have the necessary samples sent to STC for testing. These samples and the product information will then be passed to the lab team so they can prepare the tests, which depends on the nature of the product.
7. These samples will then be tested, with the results being recorded on paper. A final report is then prepared and approved by the customer service team. This report is reviewed by the technical manager of the lab as a final check, and then released to the customer via email.

If the product fails a test, the report will include the tests the product fails on. In the case that a customer requested a certification, and the product passes the required tests for the requested certification, then the report is used to prepare a certification for the customer. These final certifications are usually kept in a file system on a computer where the customer service team has access to pull them when requests are made for these certifications. More detailed recordings of the tests done, however, are sent in paper copy to an external warehouse.

## Blockchain Business Cases

For businesses to implement new technologies, there must be a clear role for the technology called a business case. There are three separate business cases where we have seen blockchain applied: enhancing value creation, strengthening an existing value ecosystem, or creating new value ecosystems.[16] Enhancing value creation refers to an individual company creating a new process with blockchain for its own internal use.[16] Such applications usually focus on either making the current process more efficient or increasing transparency of a process or of the lifecycle of an item. The Vanguard Group, a US-based investment advisor company, is a prime example of a company using blockchain to increase the efficiency of one of its operations. Vanguard has created a blockchain process to simplify and automate the process of sharing index data between providers and the market, thereby reducing errors related to index funds and reducing costs. In terms of using blockchain to increase transparency, the diamond company De Beers has created a blockchain platform that allows their diamonds to be tracked all the way

from the mine to the retail store. This allows them to assure customers that the diamonds were produced according to their ethical and sustainability standards as they have an immutable record of every place the diamond has been and how it was transferred. Both of these implementations have a clear business case. Vanguard uses blockchain to reduce errors and costs, and De Beers is able to sell more diamonds, as its customers can verify that their diamonds were produced ethically. In both cases, the implementation of blockchain allowed the corporation to create more profit, thus strengthening the business.

Strengthening an existing value ecosystem occurs when multiple organizations and companies come together in order to create a permissioned blockchain that would benefit the industry as a whole.[16] Such a blockchain eliminates unneeded back and forth between companies, speeding up transactions and easing transactions that happen across borders. In the finance industry, seven large European banks have created a consortium called Digital Trade Chain which aims to use a blockchain platform to increase efficiency for cross-border trade of medium-sized businesses. In such cases as this, an investment by multiple actors in the industry allows for an easier, faster, and cheaper process than the pre-blockchain approach.

Creating new value ecosystems comes from using blockchain technology to create brand-new industries.[16] These industries would not have been viable without the use of blockchain technology. One industry that has been revolutionized is the microinsurance industry. Several companies such as Etherisc provide microinsurance for farmers and based on weather data automatically payout claims for farmers in a decentralized manner. This lowers the insurance company's costs and increases the farmers' security. Without the blockchain to support this system, such an industry would struggle to exist. It would not be possible to profit on such small claims with the overhead of having to evaluate every claim manually. The decentralized automated method allows this new industry to grow and gives farmers more support and insurance companies a new revenue stream.

## BlockAudit: Use as an Audit Log

Another way we observed the way blockchain was implemented is as an audit log which, as opposed to the conventional implementation of logs, is more trustworthy and secure. Audit logs, or ledgers in business, allow businesses to keep track of sensitive data and any changes that occur to that data. A common use case of audit logs is for financial transactions, in which a company keeps its log of financial transactions on a secure audit log/ledger in order to keep track of the changes to the data for both internal uses and for complying with regulatory requirements. A common implementation of a business audit system would be an append-only device or Write Once Read Multiple optical device (WORD) which makes it so that under normal circumstances, data is not able to be edited – only added onto the blockchain.[17] Audit logs for businesses constitute a "point of trust" which makes them a target for malicious attacks on sensitive data. These attacks could lead to manipulated data and audit information that can impact a business's ability to operate or comply with regulations.[17]

Threats to a centralized auditing system can be categorized into two classes, a physical and a virtual attack. Physical attacks include gaining access to credentials, usernames, and passwords via social manipulation which allows for administrative access, while virtual means a remote attack during which an attacker takes advantage of system vulnerabilities to infiltrate and gain control over the database.[17]

Technologies such as *BlockAudit* (Figure 6) provide a solution to security problems by promising the security guarantees of the blockchain model and the "plug and play services to audit log applications."[17] This occurs by increasing the number of machines/points where a physical access attack could take place – meaning in order to change data one would have to gain access to credentials/databases in many data centers rather than just one – which also, in turn, increases the number of machines you would have to perform a physical access attack on substantially. The safety, reliability, and trust that blockchain offers in such an application to businesses makes it an appealing option for businesses looking for either a new system or looking to upgrade.

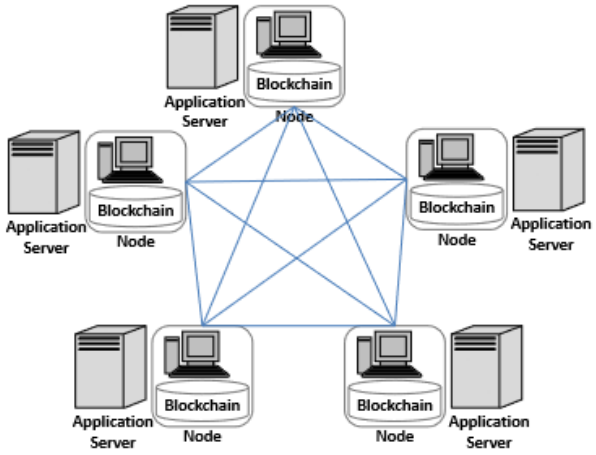


Figure 6: An Example of Nodes on a BlockAudit System[17]

## Vertrax: Use in a Supply Chain

Blockchain has been adopted as a system of managing supply chains. Supply chains are the concept of a system that begins with the producers of a product and ends with the consumers of a product that dictates and plans out all of the in-between steps to improve the visibility and controllability of the process.[18] Blockchain allows businesses to keep detailed records of their supply chain, and allows these businesses to easily notice any anomalies in their records. The existence of this data on a public blockchain also means that this data is publicly verifiable. This allows for greater trust between the public and the company implementing this technique, as the public now has a way of keeping these parties accountable through this immutable record.

Cui and Idota observe that companies delegate the management of their supply chain to their suppliers causing confusion about the supply chain's state.[18] This confusion causes reductions in the companies' control over the supply chain, lack of traceability of products, and susceptibility to counterfeiting. However, the authors also present smart contracts as a solution that allows easier and more trustworthy supply chain operations. They propose a blockchain that all parties in the supply chain are able to access and use in order to allow for a smoother, more controlled flow that can be easily examined at any point by the company without issues with data transparency.

Vertrax's case is an example of a successful implementation of blockchains in supply chains with business interoperability. Vertrax

used IBM's Blockchain Platform in order to manage its supply chain with the cooperation of its supplier.[19] Prior to implementing a blockchain system, Vertrax had a problem in its supply chain, as when something went wrong, Vertrax was unable to know exactly when and where this happened. Because its supply chain was so complicated, it was difficult to track down the specific fault that occurred, and they lost track of goods. Losing track of these goods would cause Vertrax to face delays on shipments and monetary losses due to being behind schedule or not fulfilling contracts. Such disruptions in the supply chain were a common enough occurrence that Vertrax decided to implement blockchain to try to fix its problems. The suppliers that Vertrax had were competitors with each other, but through trust in the security of blockchain, they were able to display their information to Vertrax. This information would consist of the amount of product being delivered, the time they would deliver it, and from where they would deliver it. These companies were able to provide this information in good faith without having to worry about competing businesses being able to see it. Implementing blockchain into their supply chain allowed Vertrax to keep track of their supply chain by mitigating ambiguity for both them and their suppliers and making sure that their product reached consumers while minimizing hiccups. Figure 7 shows an example of a blockchain-based traceability system similar to Vertrax's implemented by Dentsu.

## Use as a Shared Ledger

Another use of blockchain is in a collaborative manner with other businesses using shared ledgers. Shared ledgers can be created using blockchain between multiple parties to handle external processes that support their col-

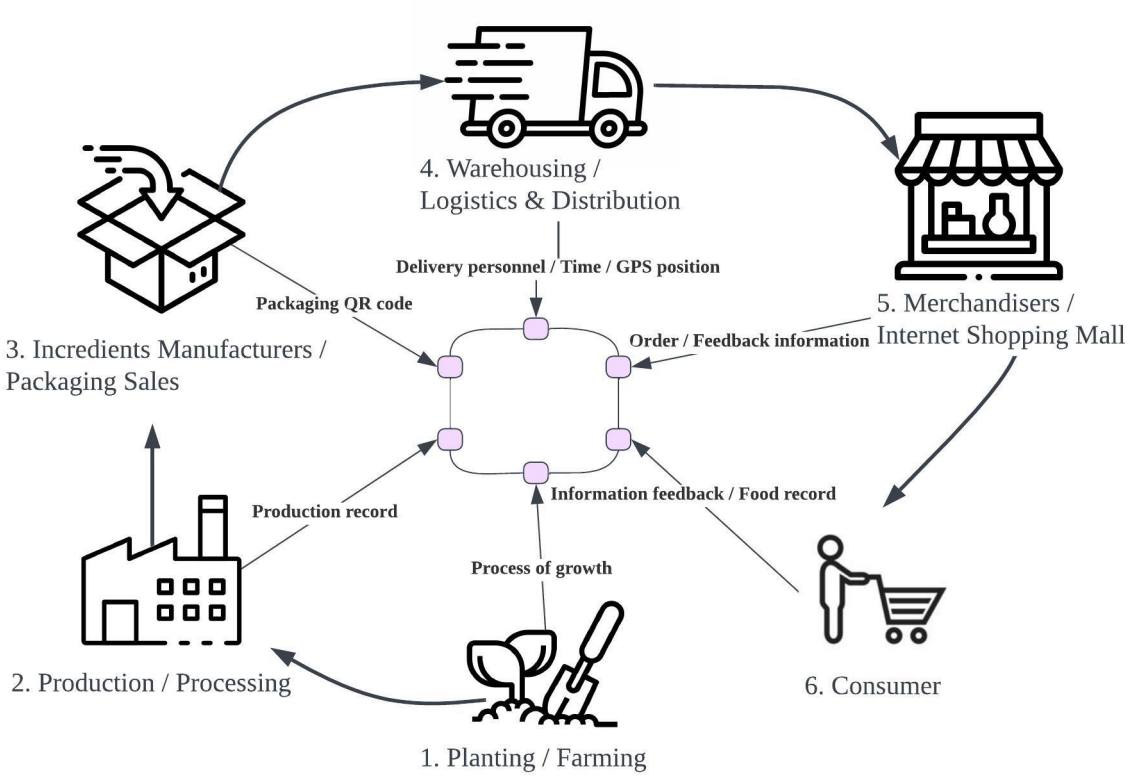


Figure 7: Dentsu's Blockchain-Based Supply Chain Traceability System[18]

laborative efforts. An example of a collaborative effort between two companies could be between a referrer and a fulfiller, such as between a travel agency and an airline where both the agency and the airline would normally have separate copies of transactions on both of their servers. This separation leads to the transaction not being properly synced across both servers at the time of the transaction, which can lead to confusion among collaborators.[20] In order to avoid the problem of unsynced data, blockchain could be used to create a shared ledger to make sure the data is synchronized across two parties. This can allow for better and easier collaboration between businesses by allowing both businesses to trust that their data is quickly synced between their servers.

## Blockchain is Most Effective in Three Environments

From implementation in multiple industries and applications, we compiled a list of the benefits and drawbacks of blockchain in general as shown in Figure 8. We have noticed, however, that these benefits and drawbacks rely heavily on the way blockchain is implemented, and the environment blockchain is implemented. Specifically, we noticed that the cases in which blockchain seems to work the best are in three environments. These environments are when blockchain is used:

1. In a process with a large number of steps.
2. To facilitate tracking of a good when it exchanges hands between parties.
3. As an intermediary between parties to facilitate trust and synchronicity of data.

Blockchain in supply chains, for example, embodies all three of these environments. A blockchain implementation is used to facilitate the many steps of the chain by keeping track of the product at each step. It is also used to facilitate the tracking of goods through the supply chain from the manufacturer to the transport company,

| Benefits | Drawbacks |
|---|---|
| • Protect a firm's business dealings | • Slow / Varied transaction speed |
| • Prevent theft and loss of data | • Lack of confidentiality in public solution |
| • Increase efficiency of internal processes | • Parties owning 51%+ of the blockchain can modify it |
| • Remove need for third parties | • New technology / possible unknowns in security |
| • Verification is from consensus of multiple parties | • More expensive than traditional storage techniques |
| • Facilitate trust between cooperating parties | |
| • Increased uptime due to many servers | |
| • Can be used to exchange digital assets | |
| • Can automate workflows | |

Figure 8: Aggregated Benefits and Drawbacks of Blockchain Implementations

to the seller. Lastly, it allows parties of the supply chain to share data such as when and where a product has been shipped securely, and allows the members of the blockchain to agree on this data. This is just one example, however, and other applications may only be similar to one of these environments. In cryptocurrency, for example, blockchain is only being used to facilitate the tracking of a good (the cryptocurrency) when it exchanges hands.

## Upfront and Ongoing Costs

To obtain estimates on both the upfront and ongoing cost of blockchain solutions we interviewed Greg Solt, Director of Technology at DigiKerma and Senior Solutions Architect at Verizon, as well as Mavis Yik from HerBChain, a Hong Kong company using blockchain to improve traceability in the traditional Chinese medicine supply chain.

When determining the monetary costs of a solution, both upfront and ongoing costs need to be taken into account. Upfront costs cover things such as hiring developers to create a solution and setting up an infrastructure that a solution can continue to run on. On the other hand, ongoing costs are the costs required to keep that solution running into the foreseeable future. These costs include ongoing server/storage costs, system maintenance, and system updates.

## Blockchain's Upfront Costs are Expensive

In terms of upfront costs for a blockchain solution, we obtained an estimate from Greg Solt. Most of the upfront costs in his experience were development costs, to build the software for the solution. He gave us an estimate of the cost to develop a blockchain solution similar to the certification storage system we proposed which was from HK$1.5 million to HK$2.5 million, or may even be upwards of HK$4 million to HK$5 million. This is more expensive than hiring engineers to develop a traditional solution due to blockchain being a newer field with fewer specialized experts. As such, developers who have learned how to use this new technology are able to charge a premium to develop it compared to traditional systems.

## Blockchain's Ongoing Costs are Also Expensive

The way that storage works in a blockchain solution is inherently different from traditional methods. In a blockchain solution, the ongoing costs of storing data are also different. The upkeep of blockchain solution software is much more expensive than traditional solution software. This is again due to the higher prices blockchain software developers charge to develop or maintain this newer technology. In terms of the prices of storing data using blockchain or more traditional methods, it is a little more complicated. Using either on-site or cloud storage, a traditional method is essentially set up to cost a certain amount of money per month or year per amount of storage that is being used. In the case of purchasing a server, a company would pay for the server itself, the upkeep of the server, electricity costs to run the server, and staff to manage the server. In this way, the server provides a certain amount of storage at a fixed rate that needs to be continually paid. Cloud storage works similarly to this, as a certain amount of storage is rented from the provider and paid on an ongoing

basis. In both cases, if payments stop, access to the data is lost. Here is how a blockchain solution differs. To store data on a blockchain, only a one-time fee is needed to permanently store data. The drawback, however, is that storing data is expensive. The one-time cost of storing data on the blockchain also changes depending on the token associated with the blockchain. This means depending on the value of, for example, 1 ETH, the cost of storing data on the Ethereum blockchain will change.

## Blockchain for STC in Theory

On the surface, blockchain seems as if it could be an excellent fit for STC. It would provide an immutable form of storage that would give consumers peace of mind knowing that the certification on products they buy is not falsified. Particularly in the TCM industry, where it can be difficult to know what is really in a product, having this publicly accessible and trustworthy certification data would put consumers at ease. Manufacturers would be willing to pay STC a premium for the service to have their product's data on the blockchain, as it would give them a competitive advantage in the market. In addition to increasing trust for consumers, and charging a premium from manufacturers, STC would be able to gain operational efficiencies by using smart contracts to automate parts of their processes and communication with their clients. Due to providing a valuable add-on package to their clients and automating parts of their workflow, blockchain seems like it would be a great fit for STC.

## Blockchain for STC in Practice

While blockchain as a decentralized storage system provides immutable data storage when one party, STC in this case, owns the whole chain and all of its nodes, that party can easily change the data on all nodes at once, rewriting the chain's history. This essentially gives a blockchain where a single entity controls the whole chain the same trustworthiness as a traditional database. Alternatively, if STC were to use a third party public blockchain to store their data, no one party would own the nodes, negating the issue of a single party having total control and being able to change the blockchain. However, if this were the case, STC would be unable to have any data on the chain they did not want to be exposed to the public. Since STC does not want to share all the details of a certification with the public, this could be problematic.

With regards to process efficiency enhancements provided by smart contracts, due to STC's current technology, it is more likely using blockchain would be an additional burden as opposed to improving their workflows. In STC's current workflows, all communication is done manually with their clients via email. When clients arrange to use STC's services, products are tracked through STC's Laboratory Information Management System (LIMS). While this system keeps track of at which step in the process a product is, all the data and tests done on a product or data collected for inspections of a factory is handwritten. This raw data is never stored digitally. When STC concludes its service, a report is manually written, looking at the papers containing the raw data. These final reports are sent to clients and stored on STC's server's file system as different folders for each client request. The raw data is then sent to an offsite warehouse for STC to retrieve in the future if

necessary. These raw data are not backed up or ever stored digitally. For blockchain to improve efficiency via smart contracts, it would need to be able to interact with STC's data and process, but as it stands, since those processes are manual, it cannot. Implementing smart contracts in STC would require a complete overhaul of how STC currently stores its data, moving them to a system that would be able to interact with smart contacts. This would also require redesigning their processes to involve storing their data digitally, retraining their employees on a new system, new software to enter data, and most likely purchasing new equipment.

The costs of blockchain would also be a barrier to the profitable implementation of blockchain for STC. Both the upfront costs of building the technology and the ongoing costs of maintaining and running the chain would be high. It is unclear if the premium a manufacturer would pay for the blockchain service would be able to support the initial and ongoing costs of implementing blockchain. Therefore, we recommend that STC should not implement blockchain to store certifications.

## The Same Benefits With Lesser Cost

While using blockchain internally might not be in the interests of STC, it is clear that there is still a benefit to having a publicly accessible records system for certification. Using a traditional database system, STC could still create a mechanism for consumers to access certification information. Even though this data is technically mutable compared to a decentralized blockchain solution, the software/application would look identical to the consumer. Since TIC companies are already trusted sources, whether the data is immutable or not poses less of an issue than in other scenarios. Based on this, STC can use a traditional database to increase trust in a similar manner to how they intended to use blockchain.

A traditional database would be much cheaper with both the initial implementation and ongoing costs. As traditional databases are a much more mature technology, there are many systems and services for creating and implementing databases for business in a cost-effective manner because the technology is better understood and developers are cheaper than blockchain developers. This comes with the benefit that the providers of these services have a lot of experience creating business solutions and are able to help smoothly transition customers. Additionally, as this technology is still much more used, providers benefit from the economies of scale that come with having a much larger user base, allowing them to offer cheaper storage rates than blockchain providers. This keeps on going and initial costs down as compared to a blockchain solution.

## An Opportunity in the TCM Supply Chain

During our research, we discovered another avenue for STC to implement blockchain in a capacity beyond simply storing certifications. During our interview with HerBChain, we discussed the possibility of a partnership between HerBChain and STC. HerBChain uses blockchain to improve the traceability of traditional Chinese medicine throughout its entire supply chain, including testing and certification. STC could partner with HerBChain to refer

customers to HerBChain or work directly with customers to integrate HerBChain into the customer's workflow. The way that blockchain is being used in this application is similar to the successful applications we have seen, and there is a potential for this technology to make an impact in the traditional Chinese medicine sector. While this business case does look promising, the specifics of the traditional Chinese medicine supply chain is out of the scope of our research for this project. We recommend more research into the TCM supply chain and the connections to testing and certification and a market analysis before recommending an HerBChain partnership.

## Blockchain Across the Entire TIC Industry

Another implementation of blockchain that we examined is a permissioned blockchain across the TIC industry. The permissions on the blockchain would be set so that participating TIC companies would add to the blockchain, but consumers would only be able to view the blockchain. This blockchain would also be viewable through an interface that would allow consumers to ensure a product certification is not falsified. Examples of potential interfaces would be NFC stickers, QR codes, websites, or mobile applications. QR codes or NFC stickers, for example, would be printed on certified products' packaging and would allow consumers to easily check the authenticity of any product's certification by scanning them.

If such an industry-wide TIC blockchain was created, it would be beneficial to participating TIC companies, participating manufacturers, and consumers of their goods. The increased trust and accessibility that the authentication service would provide would add value to the goods of participating manufacturers. For participating manufacturers, the added value to their goods would increase consumer interest and trust in their product, leading to a competitive advantage. Consumers would then also be able to directly check the collaborative industry blockchain instead of having to go through customer service representatives of separate TIC companies to authenticate a certification. Finally, the TIC companies in the blockchain would benefit by being able to add this service to the ones they offer to clients, meaning they would have a competitive advantage over other TIC companies which do not participate.

## Implementation Obstacles

This proposed solution takes advantage of having multiple parties in the blockchain which allows for trustworthiness and transparency between companies via a collaborative effort, where no one party can interfere with the other's data. The costs of the blockchain could also be shared among the participating companies meaning that the costs for participants could be much lower than a single-company solution.

There are multiple obstacles to a solution like this. One of these obstacles is that the TIC industry is a competitive market where there is little cooperation. From interviews with our sponsor, we realized many TIC companies provide similar services, leading to competition between them. Another of these obstacles is that participants of this industry-wide blockchain would need to agree on how the system should be created and maintained. The most likely option would be a split of initial and ongoing costs

between the participating companies, but there is also the problem of how a new company would join the blockchain, and what the costs allocated to them would be. A third obstacle is that there would need to be resources allocated internally to retrain employees of participating TIC companies to use this new system. However, during our interviews with STC, we were assured that internal processes are handled very similarly among TIC companies through the use of the LIMS system. If there is a training plan created, retraining would be able to occur relatively easily.

Despite the obstacles in the way of this implementation, the end result would be a beneficial use of blockchain to allow consumers to have greater trust in the products they buy and bring value to the TIC industry by enabling greater visibility of their services to the public and clientele. We recommend further research should be conducted into creating a broader TIC blockchain. This research should include:

- Market research.
    - This market research would need to include both other TIC companies and potential users of the final product.
- Consultation with relevant government and industry-wide bodies.
- How certifications can be linked to physical products (NFC sticker, QR code).
- Specific price estimations/quotes.

After further research into these areas, the implementation of an industry-wide blockchain solution would be able to bring immense value to consumers of any type of product.

# Endnotes


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