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# BLOCKCHAIN FOR TRADE:
## SELECT CASE STUDIES AND LESSONS LEARNED

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# ACKNOWLEDGEMENTS

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# ACRONYMS

| | |
|---|---|
| API | Application Programming Interface |
| CEO | Chief Executive Officer |
| COMESA | Common Market for Eastern and Southern Africa |
| DFTA | Digital Free Trade Area |
| DLT | Distributed Ledger Technology |
| DRC | Democratic Republic of the Congo |
| eB/L | Electronic Bill of Lading |
| GTCN | Global Trade Connectivity Network |
| GTD | Global Trade Digitization |
| GTR | Global Trade Review |
| HKMA | Hong Kong Monetary Authority |
| IBM | International Business Machines Corporation |
| ID | Identification |
| IDA | Info-communications Development Authority of Singapore |
| IoT | Internet of Things |
| IT | Information Technology |
| IUU | Illegal, Unreported, and Unregulated |
| LPFM II | Leadership in Public Financial Management II |
| MAS | Monetary Authority of Singapore |
| MSC | Marine Stewardship Council |
| MOU | Memorandum of Understanding |
| NFC | Near Field Communication |
| NGO | Non-governmental organization |
| NOAA | U.S. National Oceanic Atmospheric Administration |
| NTP | National Trade Platform |
| PDF | Portable Document Format |
| QR | Quick Response |
| RCI | Responsible Cobalt Initiative |
| RFID | Radio-Frequency Identification |
| RFP | Request for Proposal |
| SMS | Short Message Service |
| SQL | Structured Query Language |
| SUNAT | *Superintendencia Nacional de Aduanas y de Administración Tributaria* |
| SWIFT | Society for Worldwide Interbank Financial Telecommunication |
| UAE | United Arab Emirates |
| UK | United Kingdom |
| UN/EDIFACT | United Nations Rules for Electronic Data Interchange for Administration, Commerce and Transport |
| USAID | United States Agency for International Development |
| USAID/E3 | United States Agency for International Development Bureau for Economic Growth, Education and Environment |
| VUCE | *Ventanilla Única de Comercio Exterior* |
| XML | eXtensible Markup Language |

# GLOSSARY

*Consensus Mechanism* The participating nodes in the computer network either bid for an opportunity to validate (for a reward) or vote to validate the block of transactions. Any invalid transaction is not entered into the blockchain.

*Consortium Blockchains (or Federated Blockchains)* Blockchains operating under the leadership of a consortium or group. The consensus process is controlled by a pre-selected set of nodes.

*Digital Ledger* A database where transaction history is documented.

*Distributed Ledger* The multiple entities in the network co-manage the database. Each entity receives a copy of the ledger after every transaction and there is no central owner.

*Hash* A string of characters that represents a longer block of data often used to help identify or validate that block of data.

*Hashing (in the context of blockchain)* The process of producing a hash from a block of data representing multiple transactions.

*Permissioned Blockchain* Networks that use conditions to allow only a restricted set of users to act as nodes of the blockchain and have the capability to validate transactions.

*Permissionless Blockchain* Networks that allow anyone with internet access to become a node of the blockchain and have the capability to validate transactions.

*Private Blockchains* Networks which allow only a restricted set of users to access information on the blockchain.

*Public Blockchains* Networks which allow anyone with an internet connection to download the application and access information on the blockchain.

*Smart Contract* Code that executes when defined conditions are met, such as rules of ownership, transaction formats, and state transition functions.

# INTRODUCTION

Technology, when used appropriately, allows developing countries to leapfrog[1] the advancements in domestic and cross-border economic activity. However, technology should be able to leverage the existing capabilities in a developing country context. Otherwise, the costs related to building capabilities can far outweigh the opportunities presented by technology, thus making a technology solution infeasible to operate at scale.

This paper will analyze how one technology – blockchain – is increasingly being used to realize efficiencies in the conduct of international trade and assess whether the technology can be used in an international development context.

The paper begins with a simplistic but detailed explanation of blockchain technology (from a non-cryptocurrency context), its types, and its most common platforms. To understand the maturity of the technology with respect to application in trade, the paper analyzes the stages of implementation of various global examples of blockchain projects across four broad application categories: trade finance, supply chains, traceability, and other applications.

The paper then delves into case studies for each of the four application categories. The case studies not only evaluate the benefits of blockchain in each of those contexts but also look at several challenges and key considerations faced during implementation. Based on the case studies, the paper evaluates blockchain platforms over paper-based as well as centralized solutions both from cost/benefit as well as implementation standpoints.

The final section highlights the key aspects that need to be considered, with respect to blockchain implementation that can assist USAID in its programming for blockchain implementation.

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[1] Leapfrogging is the process of skipping a development stage usually through the advent of a new technology. Mobile technology is an example of a "leapfrog" technology which enabled developing countries to skip the fixed-line technology in their telecommunication development journey.

# BLOCKCHAIN: BACKGROUND

David Gerard, in his book *Attack of the 50 Foot Blockchain*, emphasizes that "Blockchain marketing claims are largely divorced from tawdry considerations of technical or economic feasibility, mathematical coherency or logical consistency. Normal people hear these nigh-magical claims, see obvious uses for them in their own business and are left with the impression 'blockchain' can get them these things. Some of the claims are sort of true in some sense, but most are completely fanciful."

Even some of the ardent blockchain technology supporters and implementers often agree that blockchain is not the most efficient platform. For example, Wave's CEO (one of Wave's project has been included as a case study in this white paper) Gadi Ruschin mentions "Blockchain is actually the most inefficient database other than a notebook. We believe blockchain should be used only when all other technologies have failed" (Legal Geek 2018).

However, that has not prevented many industry stakeholders from testing the technology while trying to solve some of the real issues faced in their respective industries. For example, in the trade and logistics ecosystem explored later in this report, more than 94 major organizations have signed up to participate in IBM and Maersk's TradeLens blockchain platform to digitize trade. Singapore and Hong Kong governments are partnering on a Trade Finance project built on a global blockchain-enabled platform that aims to be the global information highway for trade. The Korea Customs Service and Samsung have recently signed an MOU to use Samsung's blockchain as the backbone for its customs clearance system. Multiple successful pilots have traced food materials and minerals from origin all the way to the store via blockchain-enabled platforms.

## ENTERPRISE BLOCKCHAIN: BASIC PRINCIPLES

So, what really is blockchain technology and how is it useful for business? A detailed explanation about blockchain and its types, differences between blockchain and digital ledger technology, and applications across industries have been provided in the USAID's "Primer on Blockchain" (Nelson 2018).

This section aims to describe blockchain in very simplified terms that are relevant from an enterprise/non-cryptocurrency point of view.[2]

Blockchain is a technology to build and maintain a **digital ledger**, which is **distributed**, **tamper-evident** (sometimes described as "immutable," though this term is problematic), **validated,** and **secured**.

A **digital ledger** simply means a database where transaction history is documented. For example, a digital ledger in a supply chain would be a repository, that contains the records for transactions that occur between the importer, exporter, and all the intermediary entities to make a trade transaction possible. Digital ledgers are traditionally centralized and managed by a single administrator to bring

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[2] This paper uses blockchains and distributed ledger technologies synonymously for the sake of simplicity.

together the inputs from multiple entities. The different entities access the ledger through their own permission settings. However, such a ledger has a single point of failure (i.e., if the server carrying the information in a centralized ledger fails, then the entire system collapses – thus redundancies need to be built into such systems), is vulnerable to hacks, and requires trust that the system administrator will not misuse or modify any data-point without consent from the various stakeholders. This lack of trust in an agreed central administrator often restricts digitization of transactions that involve multiple entities.

An alternate option is that of a **distributed ledger**, where the multiple entities in the network co-manage the database. Each entity holds a copy of the ledger which they update after every transaction as there is no central owner. In this case, there is no single point of failure; manipulating data contained in the ledger is exponentially tougher as one needs to hack multiple ledgers; and since there is no central administrator, there is no central point that owns or controls the data.

However, this leads to certain complications, such as how does one ensure that all the ledgers (distributed among multiple stakeholders) match and are tamper-evident. This complication is averted through the concept of 'hashing.' In this process, multiple transactions are hashed and combined to form a block. This block is then passed through a unidirectional[3] algorithm to form a hash.[4] This hash is included in a data field within the next block of transactions. The resultant data in the next block (the block of transactions and the previous hash) is again hashed and the hash is added to the next block and so on. This forms a chain of blocks (and hence block-chain) connected through these hashes. The hashing algorithm is such that if there is even a slight change in the data within a particular block, the resultant hash is very different from the original one. If someone modifies an old transaction within a ledger, it leads to a cascading change in the hashes across the ledger making that ledger invalid. The hashing makes the ledger **tamper-evident** and thus "virtually immutable," though not in the absolute sense.[5] If a change has to be made to a particular transaction, it needs to be appended as a separate transaction on the ledger.

A distributed database without a central validator also leads to the complication of defining who validates the transactions according to a given set of rules (e.g., for a payment, an entity could "double spend" its money if no central authority tracks balances across the network. Data is validated in a blockchain through the application of a consensus mechanism. In many consensus mechanisms, the participating nodes in the network either compete for an opportunity to validate (for a reward – a process called "mining" in cryptocurrency context) or vote to validate the block of transactions. The validation is usually automated. Any invalid transaction is not entered into the blockchain, thus assuring the transactions entered are **valid** – in the sense that the transaction complies with the rules of the

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[3] In this context, a unidirectional algorithm is one where you can develop a `hash' from a block of data but one cannot retrieve the block of data by applying a reverse algorithm on the hash.

[4] A hash is a string of characters generated through the hashing algorithm that is unique to a block of data.

[5] See, for example: Gideon Greenspan, "The Blockchain Immutability Myth," MultiChain (May 2017), https://www.multichain.com/blog/2017/05/blockchain-immutability-myth/

network.  Being "valid" in this case might not necessarily mean that an underlying activity facilitated by the transaction is "valid."

Another element that is often used but is not a necessary condition in a blockchain network is the usage of digital signatures. A user can digitally sign documents or transactions that need authentication. For this, the user signs the document via their own private key, which can be authenticated by any recipient by using the user's public key.[6] This process of authentication ensures that the transactions are **secured** from bad actors impersonating valid accounts.[7] It is important to note that digital signatures can easily be incorporated in non-blockchain solutions as well.

## PUBLIC, CONSORTIUM AND PRIVATE BLOCKCHAIN

Blockchain networks can be categorized across two dimensions: 1) the category of entities who can download and access the application (public/ private), and 2) the category of entities who can validate transactions (permissionless/permissioned).

On the category of who can download and access the application, blockchain networks are of the following types (BlockchainHub 2018):

1. *Public Blockchains:* In a public blockchain, anyone in the world can send transactions through the network and expect to see them included in the blockchain if they are valid. Anyone can read transactions on the public block explorer. Transactions are transparent but anonymous. Examples of public blockchains include Bitcoin, Ethereum, Litecoin, and Dogecoin.
2. *Consortium Blockchains (or Federated Blockchains)/Private Blockchain:* Such blockchains operate under the leadership of a consortium or under one organization. To access the blockchain network, one has to be a part of the consortium/organization. Examples include Hyperledger, R3 Corda, EWF, B3i.

Blockchain networks that allow anyone with internet access to become a node of the blockchain are called **permissionless blockchains**. These nodes validate and enter new transactions into the distributed ledger. If the networks use certain conditions to restrict entry of users to acts as nodes of the blockchain, then they are called **permissioned blockchain**. Public blockchains are largely permissionless whereas consortium and private blockchains are largely permissioned (but this is not always the case). Figure 1 highlights different settings, such as Public to Private versus Permissioned to Permissionless.

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[6] In digital signatures, the private key is used to encrypt a hash of the document; the signature can be verified using the public key pair of the user that is publicly available to recover the hash. Public and Private key pair consist of two uniquely related cryptographic keys. Private key is confidentially held by its owner.

[7] Strategy and Research team within the Center for Digital Development at USAID recently published a report on digital identity which highlights this issue. The report is titled "Identity in a Digital Age: Infrastructure for Inclusive Development," https://www.usaid.gov/sites/default/files/documents/15396/IDENTITY_IN_A_DIGITAL_AGE.pdf

The term blockchain in the context of the permissioned private ledger is highly controversial and disputed as blockchain as developed for bitcoin was meant to be public. This is why the term 'distributed ledger technologies' (DLT) emerged as a more general term. However, this paper will use the term 'blockchain' interchangeably with 'distributed ledger technologies' for the sake of simplicity.

*Figure 1: Comparison of Various Blockchain Types*



Source: Nathan Associates, BlockchainHub 2018

## KEY ENTERPRISE BLOCKCHAIN PLATFORMS

In 2008, Satoshi Nakamoto, the preliminary writer/implementer on blockchain, initially designed the technology to solve the "double spending" problem in digital currencies. However, the original blockchain platform that powered bitcoin is constrained in that it was designed to serve one specific purpose: peer-to-peer electronic bitcoin payments. As such the bitcoin blockchain framework is not necessarily a suitable foundation for building other applications beyond the purpose of facilitating peer-to-peer electronic payments. This led to the emergence of other platforms that enable developers to build applications that can be adapted to different business/enterprise needs. Ethereum, Hyperledger, and R3 Corda are amongst the most popular and used blockchain platforms (Fersht 2018). Table A provides a summary of the three blockchain platforms.

## TABLE A – KEY BLOCKCHAIN PLATFORMS

| ETHEREUM | HYPERLEDGER FABRIC | R3 CORDA |
|---|---|---|
| Ethereum is an open public (permissionless) blockchain network. It offers a platform for developers to build and deploy a wide range of decentralized applications (Blockchain Review 2018). Ethereum addresses the limitations of scalability, scope, and cost of development time that a developer would face while developing an application over the bitcoin blockchain. To this end, Ethereum builds a foundational layer, which allows anyone to write their own rules (*smart contracts*) and create decentralized applications (*dapps*).<br><br>The programming language Solidity writes smart contracts and the Ethereum Virtual Machine powers them, runs them on time, and coordinates them with the network. Ether is the digital currency that platform clients pay to machines executing the requested operation (Ethereum 2018). Ether incentivizes developers to write quality applications and to ensure that the network runs smoothly.<br><br>The Ethereum Enterprise Alliance has more than 250 members, which include Fortune 500 enterprises, academics, and technology vendors. Since Ethereum requires consensus mechanisms such as proof-of-work, it is slower and energy-intensive. | Hyperledger is an open source collaborative effort created to advance cross-industry consortium blockchain (permissioned) technologies. It is a global collaboration that includes leaders in finance, banking, Internet of Things, supply chains, manufacturing, and Technology. The Linux Foundation hosts the Hyperledger initiative.<br><br>Hyperledger holds multiple differentiated frameworks such as "Indy," "Fabric," "Iroha," "Sawtooth," and "Burrow." Each framework provides unique features that are suitable in different application contexts. Hyperledger Fabric is a framework that has often been used in international trade transactions. This is because IBM led Hyperledger Fabric development and has been an organization leading the application of blockchain in trade.<br><br>Hyperledger Fabric acts as a foundation for developing applications or solutions with a modular architecture. Thus, the framework allows components such as consensus and membership services to be plug-and-play. Hyperledger Fabric also hosts a feature similar to Ethereum's smart contracts called "chaincode" that comprise the application logic of the system. | R3 Corda is also a permissioned consortium blockchain technology. However, unlike Hyperledger Fabric and Ethereum, R3 Corda was developed solely for the financial services industry. The primary goal of the platform is to eliminate the manual, time-consuming effort required to keep disparate ledgers between banks synchronized with each other. Other goals include enabling greater levels of code-sharing and reducing the cost of financial services for clients.<br><br>Corda acts a "global logical ledger" in which all economic actors can interact, allowing parties to record and manage agreements amongst themselves. In such a ledger, every entity sees the same data pertaining to them.<br><br>The R3 Corda architectural framework relies upon a nodal structure that is reliant on submodules called notaries who help maintain the validity of a network (consensus mechanism). Nodes are accompanied by relational databases[8] that are appended within the data-structures allowing for querying using Structured Query Language (SQL).[9] |

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[8] A relational database is a set of formally described tables from which data can be accessed or reassembled in different ways without having to reorganize the database tables. This is possible by linking tables using a primary key that identifies every record.

[9] SQL allows users to access and manipulate databases.

# BLOCKCHAIN APPLICATIONS IN TRADE

International trade requires several transactions (and corresponding movement of documents) between various actors that include exporters, importers, customs administrations, and other operators, such as banks, insurance companies, freight forwarders, shipping companies, and/or port operators. Developing countries, in the same way as developed countries, are processing higher levels of cross-border transactions (and thus documents) especially with the advent of e-commerce. The traditional systems are largely paper-based, which are administratively costly, prone to fraud, and inefficient with respect to time. It has been difficult to digitize the processes that facilitate trade (e.g., the paperwork required) especially because of the wide range of entities that need to be brought under a common platform.

Blockchain, due to its distributed architecture and tamper-evident design, seemingly presents an opportunity to rethink the processes that facilitate trade. Businesses of all sizes, information technology (IT) companies, and government organizations are beginning to collaborate on blockchain projects that aim to address some of these issues in global supply chains. This section provides an overview of the major blockchain-based trade initiatives across the world. The application areas range from trade financing to integrated supply chains to traceability of products to other blockchain platforms that combine blockchain with other technologies, such as Internet of Things (IoT) systems.

These projects are at varying implementation stages; the tables below classify the projects accordingly (see box). While most projects have occurred in more developed countries, developing countries such as the Colombia, the Common Market for Eastern and Southern Africa (COMESA), Costa Rica, Democratic Republic of the Congo (DRC), Indonesia, Malaysia, Peru, Rwanda, Seychelles, and Zambia, are also directly or indirectly considering, developing, or implementing blockchain projects.

Table 1 (in the Appendix) highlights 10 projects in the Trade Finance category, all

> **Implementation Stages**
>
> 1. **Concept:** Theoretical concept has been proposed.
>
> 2. **Pilot Currently Running:** Various stakeholders have been brought together to execute a pilot to test the concept for a one-off transaction.
>
> 3. **Pilot Completed:** The pilot has been completed and the stakeholders have gathered evidence from the pilot for the one-off transaction.
>
> 4. **Actively Scaling:** Post the success of the pilot, stakeholders are being brought together to adopt the technology to replace the existing system in a phased manner.
>
> 5. **Implemented at Scale and Is Operational:** The technology has replaced the existing system for all transactions and is being used on a day-to-day basis.

implemented in the past 2 years. Of these projects, none are implemented at scale and are operational. Few (3) have completed successful pilots and are actively in the process of scaling (including the we.trade platform, Infosys/Emirates NBD ICICI Bank collaboration, R3CEV). Most of the other projects have just completed pilots or are in the process of completing pilots.

Table 2 (in the Appendix) examines 8 projects in the Supply Chain Digitization category, which have been implemented over the course of the past 2 years. Of these projects, none are implemented on scale. However, IBM/Maersk's TradeLens platform is rapidly scaling (as we will see in the case study section). Most of the other projects are in the pilot stages only.

Table 3 (in the Appendix) highlights 10 projects in the Traceability category implemented in the past 2 years. Of these projects, none are implemented at scale. IBM's Food Trust initiative is scaling actively.

Some private blockchain solutions such as BanQu's project with Anheuser-Busch InBev and Everledger's diamond trace projects are also in the "actively scaling" stage.

Table 4 (in the Appendix) highlights 4 other projects which act either as a combination of the above application areas or serve as an independent application (e.g., trade insurance). Among these, again none are implemented at scale. Singapore/HongKong's GTCN platform (see case study on large scale roll out of implementation), and NTT DATA's projects with Tokio Marine and SkuChain are the most advanced projects in this category.

# CASE STUDIES

**SUPPLY CHAIN TRANSPARENCY: IBM AND MAERSK**

This case study examines the blockchain trade platform developed by technology company IBM and container shipping company Maersk and its application, including a recent pilot in Peru. An executive at IBM[10] provided insights on the TradeLens platform. From a user standpoint, an official from SUNAT – Peru's Customs administration – provided their experience of implementing the TradeLens platform for two routes: Callao – Amsterdam, Netherlands and Callao – Algeciras, Spain.

## CONTEXT

Traditionally, trade generates high volumes of paperwork. Supply chains and governments rely on the physical movement of such documents to provide security against illegal smuggling, counterfeit goods and in some cases, human-trafficking. Processing the documents and information for a container shipment is purported to cost more than twice the actual cost of transportation (IBM Blockchain 2017). A joint study conducted by IBM and Maersk found the following inefficiencies during their pilot projects (IBM 2018):

- A single shipment of avocados from Mombasa, Kenya to Rotterdam, Netherlands involves 30 actors/organizations, 100+ individuals and 200 information exchanges. Interactions between these actors involve time-consuming manual, paper-based processes. The information collected across organizational boundaries were inconsistent leading to blind spots throughout the supply chain. These blind spots include missing or incorrect paperwork across the supply chain with limited traceability. Peer-to-peer messaging was complex, cumbersome and costly. Risk assessments lacked sufficient detail and clearance processes were vulnerable to fraud.

- In another trade transaction over the same trade network[11], conventional flow of documents accompanying a shipment of flowers from Kenya to the Netherlands takes several days for the documents sent from the farm in Kenya to reach the authorities at Dutch customs. It is a cumbersome process and, according to a Maersk executive, "the average border-related administrative costs of trade are 21 percent of the total cost, compared to 8 percent for transportation."

- The same stands true for other trade networks too. Shipments from Central Europe to the United States were often delayed by four weeks due to a lack of transparency and delayed information exchange. Some of the issues that caused this delay included missing customs documents that prevented gate-in at arrival terminal; containers arrived on different mode causing complications for

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[10] Stewart Jeacocke, Customs Lead for IBM Government.

[11] Trade network means the network of all the entities that are involved in ensuring the movement of goods from the exporter to the importer (including regulatory agencies at both end).

receipt and pre-announcement to terminal was not updated in time; there were delays in filing due to miscommunication between exporter and customs over documentary requirements; containers missed the vessel due to late gate-in, visibility issues and communication delays; and limited visibility over transport plan issues meant that inland logistics providers were unable to carry cargo on the expected date.

## CONCEPT

IBM and Maersk aim to address these issues through a distributed permissioned platform called TradeLens (formerly Global Trade Digitization - GTD). The platform facilitates the exchange of event data and handling of document workflow within the supply chain ecosystem.

Using the platform, all the stakeholders can access documents in real time – though this feature is not unique to a blockchain-based system. Stakeholders digitally sign documents that they certify. These cryptographic signatures provide real-time authentication for the documents. These documents are entered into the blockchain (some directly by the stakeholders acting as nodes on the blockchain network; some indirectly via the stakeholders – see implementation section below). The combination of cryptographic authentication and the characteristic that a blockchain transaction cannot be modified seeks to resolve distrust among its various actors.

Since it is a distributed database, there is no need for different jurisdictions to agree on a centralized authority that controls the ledger.

### USING THE TRADELENS (GTD) PLATFORM
Figure 2 characterizes how a TradeLens platform operates with different stakeholders and the type of documents that usually form part of TradeLens Paperless Blockchain Network (Tan et al.).

*Figure 2: Interactions in TradeLens Platform*
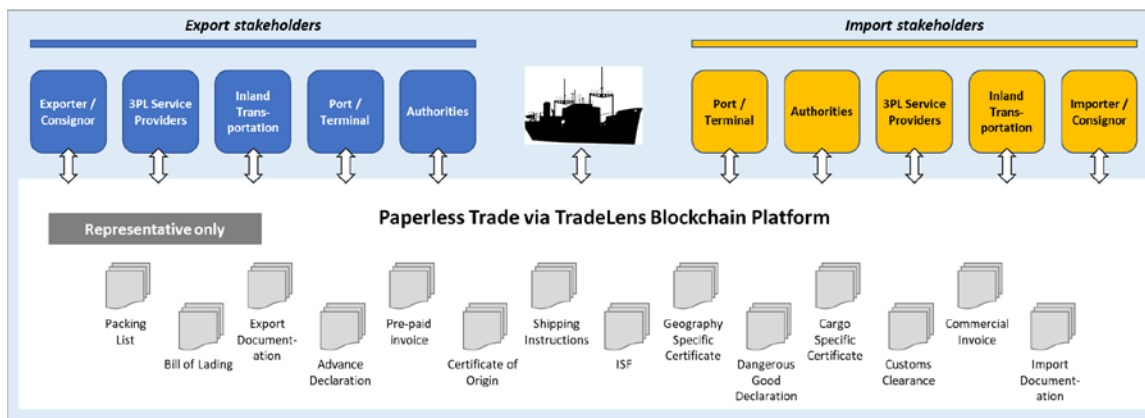


Source: Adaptation from IBM/Maersk CORE WP23 Presentation.

A few policy and regulatory concerns act as barriers for the adoption of TradeLens platform. This includes data privacy, data protection, data validation, dispute settlement, systems interoperability and integration, and the investment required.

### DATA PRIVACY

The TradeLens platform addresses data privacy with the use of a feature called "channels" in Hyperledger Fabric. When a user (e.g., exporter) initiates a shipment, the user also lists all the interested parties that need to access the data. Thus, for such a shipment, only the interested parties listed can access the specifics of the shipment. This essentially creates sub-networks for each transaction within the permissioned blockchain network for that trade network. For example, in a trade transaction involving a shipment of flowers from Mombasa to Rotterdam, only the relevant stakeholders will have access to information for that particular transaction. Other traders and logistics providers in the Mombasa-Rotterdam trade network who are registered on the TradeLens platform will not be able to access the information for that particular trade.

### DATA PROTECTION

The type of data determines the level of data protection within the platform. Users that upload the data onto the platform own the data. As the vast majority of the data uploaded is data that participants already share globally, the data is not subject to personal data protection regulations such as the European Union's General Data Protection Regulation (GDPR). However, commercial data, including proprietary information and invoices, may not necessarily be public and requires a layer of protection. TradeLens does not accept such data as-is on the blockchain but rather stores and shares that data separately. Instead, these sensitive documents are hashed and only the hash values of such documents are available publicly over the blockchain. These hash values can be used to trace but not retrieve the sensitive information. Similar arrangement has been followed in the case of implementation in Peru with SUNAT. The users that upload the data own the data. The information exchanged is, however, public. SUNAT does not include personal data or confidential commercial information in the TradeLens platform.

IBM and Maersk also hope, in the long term, to use the "channels" feature to keep certain classes of information within a country (data localization), as many countries continue to restrict cross-border exchange of and access to data.

### DATA VALIDATION

The platform does not prevent entry of incorrect information into the platform as there is no data validation mechanism at the nodes. Thus, if someone enters incorrect information at the initiation of a chain, the blockchain will "faithfully" enter it into the system and, thus, it does not prevent the issue of "garbage in, garbage out.[12]" However, blockchain allows for an "audit trail" and, therefore, one can track the origin of incorrect data entry once a fault is detected (while tracking errors is possible via other solutions too, the tamper-evident nature of the blockchain ledger makes the audit more trustworthy). This can prevent willful data corruption and enable post-fact assessment and targeted correction. In addition, if a government participates in the blockchain network (in the future) then they can be part of the consensus mechanism. The validation of transactions is done automatically according

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[12] This term is used to express the idea that in computing and other fields, incorrect or poor-quality input will produce faulty output. For example, if a user undervalues a commodity and enters incorrect information into the system, the incorrect information will remain in the system and any output derived using such inputs will be inaccurate.

to a 'chain-code/smart-contract' (which is the program that runs on top of the blockchain to implement business logic of how applications interact with the ledger). This will limit the incorrect information to be restricted to information that cannot be recognized as invalid by the automatic validation process.

*DIFFERENCE WITH OTHER CENTRALIZED TECHNOLOGIES*

How is the TradeLens platform different from a centralized ledger or database accessible to stakeholders via different permission rules? For one, a centralized database represents a single point of failure. The database is both vulnerable to attacks and poses a storage risk if redundancies are not in place. In addition, if entries are changed in the database (either by the attacker or by the system administrator), it is difficult to track changes made. With a blockchain platform, the database is distributed among its nodes (members), so attacking all the nodes at the same time is far more difficult than attacking a single node. Additionally, each block of transaction includes a hash of the previous block of transactions, thus forming a chain. If one entry is changed, the corresponding hashes after the changed transaction will differ from the original and, therefore, one can track where the change has been made instantaneously. Thus, a blockchain-enabled platform, such as TradeLens, is more secure than a centralized database operated by a system administrator.

*DISPUTE SETTLEMENT*

Another question on blockchain adoption is whether a dispute emerging from a transaction entered on the blockchain platform can be resolved within the existing legal systems both within and between countries. Gaps are very likely in this area, particularly in developing countries. However, these gaps are not specifically restricted to blockchains. For electronic single windows, for example, countries need to have laws and regulations that govern, among others, acceptance of electronic documents as equivalent to paper documents, archiving and retention of electronic documents, acceptance of electronic documents in judicial proceedings, electronic signatures, intellectual property rights of electronic data, liability for data loss or breach, and dispute settlement, including for cross-border exchange of data, Thus, Industry 4.0 technologies, including blockchain, compel countries to assess where their legal systems stand with respect to digital trade and e-commerce and ensure that any gaps are addressed soonest.

## IMPLEMENTATION EXPERIENCE

Implementation of TradeLens varies from country to country both based on the country context and the particular application (e.g., customs clearance, certificate of origin processing and exchange). Implementation is carried out in stages (see Table B).

**Table B – TradeLens Implementation Stages**

| Stage | IBM/Maersk Actions |
|---|---|
| 1st | Analyze the trade network or corridor in detail, including the context of host countries. |
| 2nd | Identify organizations at both ends of the trade network to engage. Broadly, there are three categories of organizations: importers and exporters; government authorities at both ends that are part of the regulatory framework; and the organizations that are part of the logistics chains (e.g., ports, logistics providers, ocean carriers). |
| 3rd | Communicate with organizations to receive buy-in to set forth an agreement between all parties. |
| 4th | Work within host countries ecosystems to agree on various information to capture and retrieve, as well as the governance mechanisms. This includes identifying and adopting the shared documents, approval processes, privacy and controls, and data retrieval procedures. |

| | |
|---|---|
| | Stages 1 to 4, to get enough stakeholders agreeing to participate, varies considerably but on an average takes about 3 months. |
| 5th | Send a team to the host countries to implement the solution. The fifth stage, on average, takes about 1.5 months before some quick wins based on the implementation can be observed. The steps include (as in the case of implementation in Peru) <br>     i.    Implementation of technological architecture <br>     ii.   Integration with existing platform and set up exchange of information <br>    iii.   Integrated testing <br>    iv.   Launch |
| 6th | Transfer the platform to the stakeholders (with assistance only as required) |

*IMPLEMENTATION COSTS*

Costs consist of implementation and maintenance costs. Implementation costs, mainly incurred by the network stakeholders in the fourth and fifth stages mentioned above, involves the cost of integrating the TradeLens with existing systems using APIs. Such integration requires participation of IT implementers within three to four organizations in a given country for a few weeks. On average, such implementation costs run between US $10,000 to $100,000. As far as ongoing costs are concerned, network clients pay to make use of TradeLens on a per transaction (container) basis. Network members (such as governments) receive access to the platform's data without needing to pay because they contribute significant amounts of data to the platform.

*TECHNICAL CHALLENGES*

IBM and Maersk have implemented this solution on a pilot basis in multiple jurisdictions. Implementation has faced certain challenges. On the technical front, the solution can help developing countries leapfrog their existing trade platforms. However, there is a certain minimum IT capability required to operate such a system. A first requirement is to have the capacity to run a node in the permissible blockchain. The capabilities required for running such a node are relatively standard IT skills. The organizations must have some basic pre-existing IT infrastructure (e.g., a dedicated pool of IT staff, a functioning IT system both at the front and the back-end that is capable of executing consensus algorithms), to ensure that capacity building exercise is not too steep.

*CAPABILITY CHALLENGES*

During implementation, IBM and Maersk realized that not every member in the ecosystem has the technical capability to run a node in the permissible blockchain (operated on the Hyperledger Fabric). Additionally, individual stakeholders in the ecosystem are used to their own systems to enter and retrieve information. Thus, the consortium only places certain members of the ecosystem on the nodes of the blockchain. Currently, these include IBM, Maersk and usually other ocean carriers (totaling between 10 and 15 members). The importers, exporters, government agencies, access the platform through an API where they can enter and retrieve information from the blockchain but only via the nodes operated by the blockchain members. The longer-term goal is to include stakeholders who are more core to the platform, such as the customs organizations, as members of the blockchain operating the node so that these core stakeholders can be a part of the consensus process that determines rights to the blockchain network.

In the context of SUNAT, there were many capability challenges primarily because of the lack of knowledge about blockchain across Peruvian organizations. IBM representatives from Holland and the

United States conducted multiple workshops in Peru (in English) describing the benefits of the TradeLens platform and on how to use it.

*INTEROPERABILITY CHALLENGES*

Another challenge is the systems' interoperability. By integrating existing IT systems in countries (e.g., an electronic single window) to the TradeLens platform, the solution requires minimal changes from the user's application interface perspective. For example, in Peru, SUNAT uses an external single window – VUCE Peru – for controls of restricted merchandise, payment of fees from other entities and maritime controls. In all implemented cases including Peru, the solution embeds with legacy systems. However, though connecting to the TradeLens platform has been easier across agencies, such as Customs, logistics providers, carriers, interoperability between these agencies remains a challenge due to very little standardization in data between agencies even within the same country (which is also a challenge for electronic single windows). For example, Customs, logistics providers, carriers use different data standards and TradeLens platform requires customization for each player to accommodate to the TradeLens' standard. TradeLens is actively working with the United Nations Rules for Electronic Data Interchange for Administration, Commerce, and Transport (UN/EDIFACT) to align itself according to global standards of data exchange and interoperability with the hope that governments and trading community will comply with those standards (UNECE 2018).

Another concern among IBM developers is that there will be a proliferation of DLTs and, thus, a trading community using a competing system to IBM/Maersk's may not be able to inter-operate with TradeLens, which could prevent, e.g., regional connectivity and sharing of cargo data across-borders. Thus, IBM is working with Hyperledger QUILT, a basic blockchain tool that offers interoperability between ledger systems, by implementing the inter-ledger protocol (also known as ILP) (Hyperledger 2018).

## IMPACT

According to IBM, TradeLens platform has already demonstrated impact (the impact emanates primarily due to digitization of trade processes – however, this digitization across the supply chain was made possible due to accessibility and security features of a blockchain platform), albeit on a pilot scale:

- TradeLens has reduced the transit time of a shipment of packaging materials to a production line in the United States by 40 percent.

- TradeLens helped reduce steps taken to answer basic operational questions, such as "where is my container," from 10 steps and five people to one step and one person.

- As part of the European Union Core research program, Dutch Customs used the additional data in TradeLens to improve their targeting processes. They used the data to avoid unnecessary inspections that they would have otherwise performed - a benefit to legitimate trade.

## RECEPTION AND OUTLOOK

The IBM and Maersk platform was operating in private beta from 2016. The platform moved to limited availability in mid-2018 with plans to move to general availability by the end of 2018 (when it would charge participants for using its platform). As of August 2018, 94 organizations have signed up to participate. These include, but are not limited to:

- **Port Operators:** PSA Singapore, International Container Terminal Services Inc, Patrick Terminals, Modern Terminals (Hong Kong), Port of Halifax, Port of Rotterdam, Port of Bilbao, PortConnect, and PortBase.
- **Terminal Operators** APM Terminals' Network and Holt Logistics (Port of Philadelphia).[13]
- **Global Container Carriers:** Maersk Line, Hamburg Süd, and Pacific International Lines (PIL).
- **Customs Authorities**: the Netherlands, Saudi Arabia, Singapore, Australia, and Peru.
- **Customs Brokers:** Ransa and Güler & Dinamik.
- **Beneficial cargo owners (BCOs)**: Torre Blanca / Camposol and Umit Bisiklet.
- **Freight Forwarders, Transportation and Logistics Companies**: Agility, CEVA Logistics, DAMCO, Kotahi, PLH Trucking Company, Ancotrans, and WorldWide Alliance.

In some countries, particularly ones without a functioning single window platform, the outlook is to take the core TradeLens platform and use it to implement a national single window as an extension to the platform.

## CHALLENGES IN DEVELOPING CONTEXT ADOPTION

There are certain pre-conditions for adopting the solution in a developing country context. The system can only be implemented in countries with a certain level of existing automated IT infrastructure. This is because TradeLens connects to and integrates those electronic systems. If there are no existing automated IT systems, setting up the entire digitization infrastructure becomes a very tough task. If there is an existing IT infrastructure, then there is also a dedicated IT capability that can help run the TradeLens platform with minimal additional costs. Internet connectivity, data storage and redundancy in case of failure, will also need to exist.

In the context of SUNAT, one of the primary pre-requisites was to have participation from the actors that historically generated the majority of information required on the TradeLens platform such as the shipping carriers, customs authorities, and so on. The next step was to ensure that there is adequate information flow on the platform, the resources to implement and manage the platform, and the sustained will among different players to do so. Implementation of such a platform, thus, requires both resources and commitment to be successful in a developing context. Thus, it is worth thinking about blockchain-based systems as a solution for supply chain digitization, only when the prominent actors, such as the shipping carriers and customs authorities, are ready for the same.

## TRACEABILITY: PROVENANCE IN INDONESIA

This case study will examine how a combination of mobile phones, blockchain technology, and smart tagging traced fish sustainably caught by fishermen in Indonesia to UK shops. Most of the information

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[13] Approximately 234 marine gateways worldwide that have or will be actively participating in TradeLens.

listed below is based on the case study published by Provenance on its website and inputs from Provenance CEO Jessi Baker (Provenance 2016).

## CONTEXT

A wide variety of fishing practices in the seafood industry is compromising the wellbeing of people, wildlife, and the environment all over the world (Future of Fish 2014). These include human right abuses; overfishing; fraud; and illegal, unreported, and unregulated (IUU) fishing practices. In some cases, as reported by the Guardian after a six-month investigation, slaves are forced to work for no pay for years at a time under the threat of extreme violence in Asia to produce seafood sold by major United States, British and other European retailers (Hodal et al. 2014).

Consequently, government agencies such as the U.S. National Oceanic Atmospheric Administration (NOAA) have increasingly implemented programs and measures for international fish brokers and importers to provide more robust paper trails for fish species vulnerable to IUU fishing and seafood fraud.[14] These trails are required to identify the origin and social standards of fish and seafood products to prove their compliance to regulations (e.g., no slavery, or no overfishing), and environmental standards, such as the Marine Stewardship Council (MSC) Fisheries Standard (MSC 2018). In addition, sustainably caught fish can also justify a market premium in some markets. For example, 72 percent of millennials in the UK are willing to pay more for products from companies committed to positive social and environmental impact (Michail 2016). Even in the United States, results from a poll showed that 80 percent of Americans who regularly eat fish say it is "important" or "very important" that the seafood they buy is caught using sustainable methods (Barclay 2013). From both a regulatory point of view and from a market premium point of view, it is essential to trace the chain of custody of a product from capture to the customer.

Multiple organizations are working to address this "traceability" challenge, including ThisFish. Figure 3 highlights its methodology on tracing a fish along the supply chain.

*Figure 3: ThisFish's Approach to Traceability (Source: Adapted from the image in ThisFish website)*



**Code the Catch**          **Upload Info**          **Handle + Ship**          **Trace to Discover**

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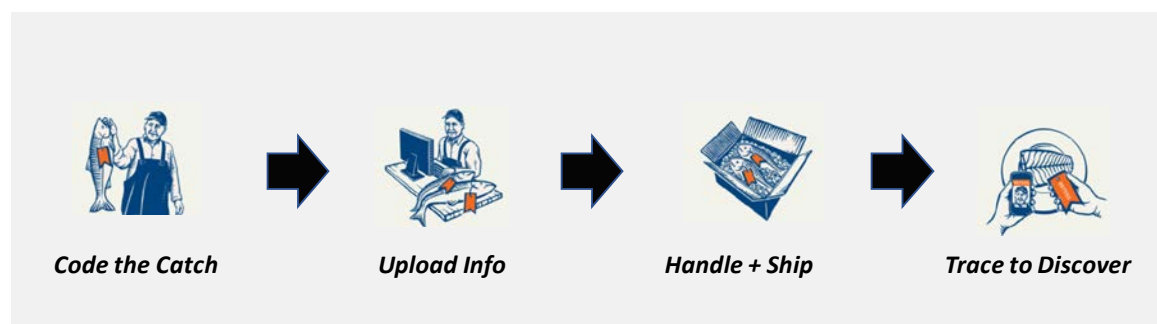
[14] In December 2016, NOAA established the Seafood Import Monitoring Program for reporting and recordkeeping of imports of certain seafood products. The program requirements are currently in effect for 11 "priority species." For more information, see https://www.fisheries.noaa.gov/national/international-affairs/seafood-import-monitoring-program.

However, with these systems, effective interoperability of data along the supply chain poses a significant technical challenge. In Figure 5 above, if there are additional actors in the supply chain, such as a factory to process the fish, one needs to transfer the data across multiple systems. This is achieved by generating and scanning Quick Response (QR) codes. However, there is a limitation in data capacity that a QR code can carry. The data can also be corrupted by any of those actors (e.g., some information about the fish can be added or deleted based on commercial attractiveness) and without a trusted database tracking the chain of custody, it is difficult to pinpoint where the data corruption occurred.

A centralized system, with a governing third party, is a potential solution. However, having a single organization responsible for ensuring transparency across the whole supply chain is both impractical and risky (unless the single organization is a large retailer/off-taker who can mandate the upstream partners to adopt a platform). Third parties like non-governmental organizations (NGOs) or industry associations rarely manage such projects. In addition, a centralized system can become a single point of weakness which would be a vulnerable target for bribery, social engineering or targeted hacking. Sharing the costs of set-up and operation of the centralized system is also difficult to apportion and agree on.

## CONCEPT

Provenance's blockchain solution is an attempt to develop an information system that is shared among all fishery supply chain stakeholders (fishermen, factories, certifiers, and consumers) without giving them or a third-party control over the database. Provenance builds an "audit layer" on top of the existing systems, such as the open source platform Tally-O.[15]

For its pilot, Provenance tested the platform for a tuna supply chain, which consists of three essential parts.

1. *From the sea to the factory:*

To be eligible to participate in the Provenance-validated chain of custody, the fishermen must be certified by local NGOs. The social and environmental conditions for the fisherman are verified by the NGOs, whose audit systems validate the fishing practices compliance to an external standard. The fishermen details are entered as blockchain addresses in the system and their mobile numbers noted. NGOs certify the fishermen via digital signatures on the Provenance blockchain. The digital certification process is crucial in the traceability exercise. In traditional systems, one would need to carry copies of these certificates physically across the supply chain to prove compliance with regulations. Adding these certificates to a digital platform enables one to track these records using a reference number. These certificates can be transferred via non-blockchain digital platforms too. However, a blockchain platform provides the assurance that these certificates have not been artificially added into the system at the later stages of the supply chain.

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[15] Tally-O is an open-source data management software to enable seafood processing companies to improve their internal traceability and production data recording.

There are multiple methodologies being followed to trace the fish to the first mile (from the sea to the factory).

- In some methodologies, an RFID tag is attached to the fish (with information inputted onto the blockchain at every stage) before converting it into a QR code at packaging (Visser and Hanich 2018). However, the process can be costly and complex when the whole fish is cut and distributed in packages.

- Provenance leverages other platforms, such as ThisFish's methodology of using plastic tags attached to the loins of the Tuna fish to provide the physical product with an ID.

In the Provenance concept, the certified fishermen then send simple SMS messages to register their catch on the blockchain. Accompanied by the unique IDs, the digital register is then transferred to the supplier along with the catch. The supplier enters their entry into the blockchain (adding other details including weight and type) via mobile phone and transfers the catch with the unique ID to the factory. Since the details are entered into the blockchain, the identity of the fisherman and the supplier are saved forever in the list of previous owners. An illustration of the process (Figure 4) and the interfaces (Figure 5) are highlighted below:

*Figure 4: Provenance case study: From the sea to the factory* (Source: *Provenance Website*[16])
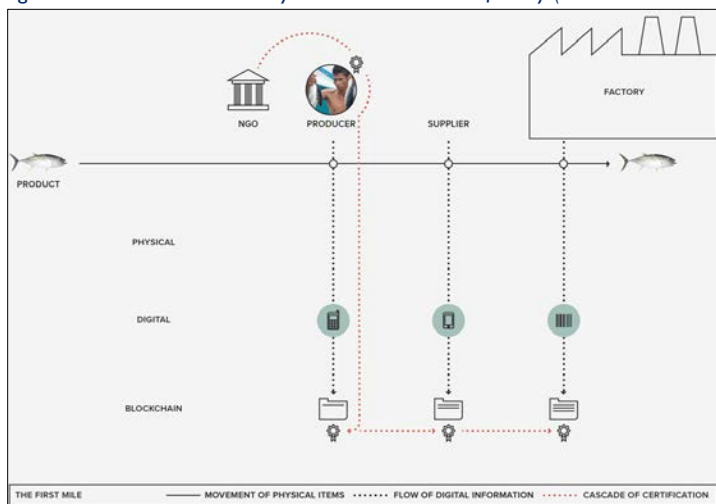
*Figure 5: Provenance case study: Interface* *(Source: Provenance Website)*



1. Registration of fisherman by NGO
2. Item attribute confirmation by NGO
3. Fisherman issues item
4. Fisherman transfers item to supplier
5. Supplier receives the item
6. Checking items on blockchain explorer
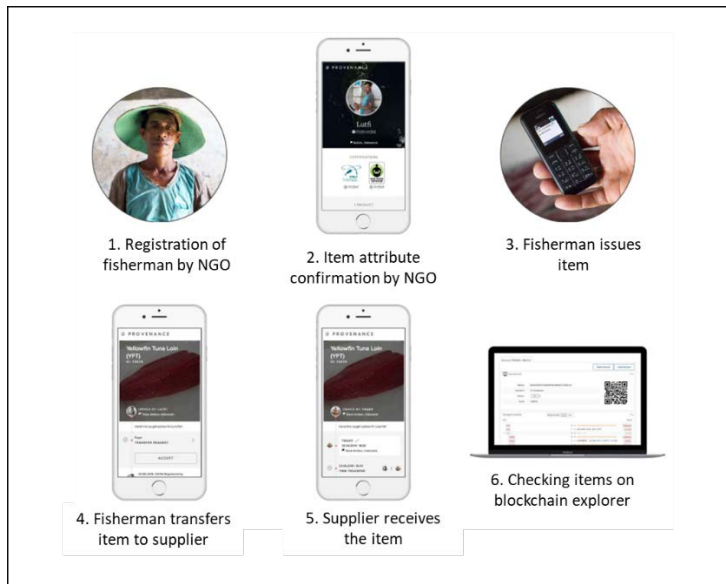
## 2. From the factory to the store or restaurant:

Once the product enters the factory, it goes through a series of processing steps (Figure 6). The operator at the factory registers the fish into the factory's IT system. The factory's IT system already uses software such as Tally – O (which does not work on blockchain). However, Tally-O's platforms are not able to capture data when interfaces change and thus there is a chance that the data re-entered can be tampered. Provenance's blockchain layer over the Tally-O ensures that the fish's history (including from certified fisherman to the factory and beyond) is tamper-evident as the product moves from one platform to the other.

*Figure 6: From the Factory to the store* *(Source: Provenance Website)*
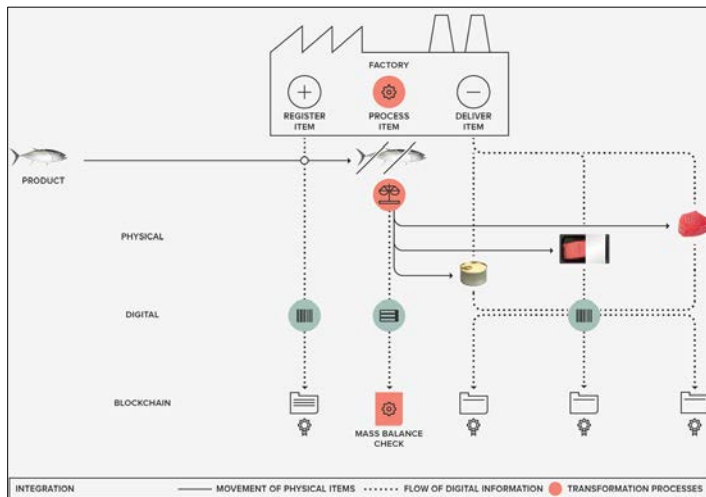


Once processed and registered, the fish can be transformed either as canned, or packaged. Each transformation is recorded into the blockchain. Tally-O uses mass balancing techniques to account for

the number of ingredients used in the transformation.[17] Thus, if a single fish is used to fill multiple cans, the ID of the fish is recorded for each can but with the accurate description of how the fish was split amongst the multiple cans. Once the transformation is completed, the identifier string in the form of a QR code is encoded in a label and attached to the physical product. This product is then exported and transported through the supply chain.

### 3. From the shop/restaurant to the consumer:

*Figure 7: From the Factory to the store* (Source: *Provenance Website)*
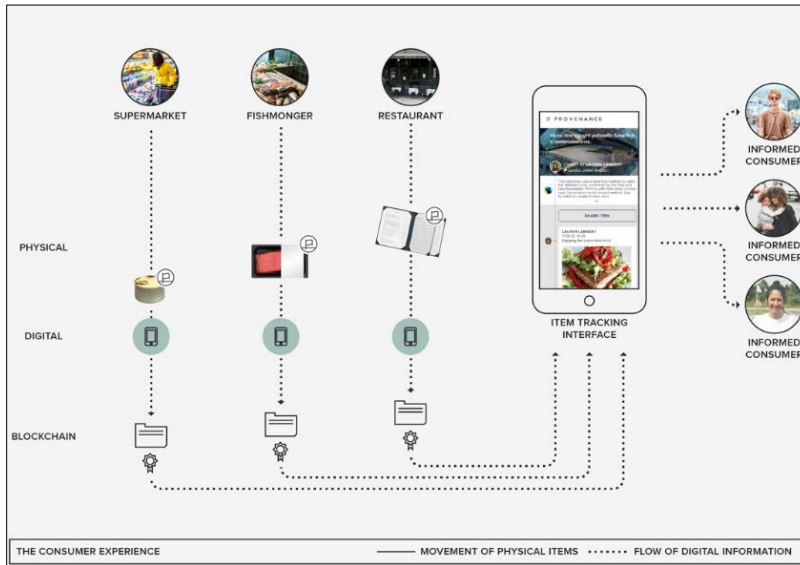


At the point of sale (the supermarket, fishmonger, or restaurant), the tag on the fish packaging can be read by a smartphone to inform the consumer of the entire journey the fish has made. Figure 7 above highlights the process and Figure 8 below highlights the user interface.

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[17] Mass balancing accounts for material entering and leaving a system (with outputs never exceeding inputs).
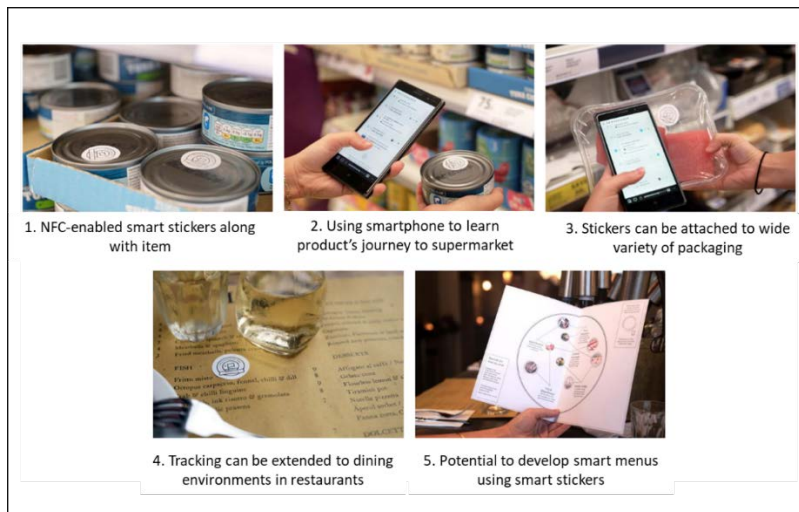
## IMPLEMENTATION EXPERIENCE

Provenance ran a pilot to successfully track fish in Indonesia between January and June of 2016, and reported the following challenges:

1. Provenance uses a public blockchain. This is to ensure that, unlike consortium blockchains, new stakeholders can be onboarded without changing the consensus mechanism. This also prevents collusion between the players, in case only a few players access the nodes of the blockchain, and keeps the supply chain data open source without linking to a proprietary system. However, public blockchains are usually slower, less scalable, and costlier to operate, and have fewer privacy options, as compared to a consortium blockchain.

2. Provenance acknowledges that the QR codes and near field communication (NFC) stickers that are used to link products to digital assets are easy to duplicate. Therefore, if at any point in the supply chain, a different fish with the duplicated QR code is entered into the system – it will undermine the validity of the physical product associated with the blockchain without indicating it in the register. Provenance indicated it is working on technologies (such as advanced NFC tags) which are very difficult to replicate.

Provenance is not willing to publicly share the information about who operates the nodes of their blockchain, their consensus mechanism (which could theoretically address challenge 2 highlighted above), or the costs of the system as they consider such information to be proprietary and confidential.

## RECEPTION AND OUTLOOK

The pilot did not move into mass adoption in the Indonesian fishing industry. However, the CEO of Provenance states that it paved the way for many initiatives in this space. As per Provenance, they are now working in Europe's fishing industry and that their approach has been adopted by over 10 enterprise clients including Unilever, Sainsbury's, and Co-op across many other food types.

## CHALLENGES IN DEVELOPING CONTEXT ADOPTION

Since the platform is on a public blockchain, there is a significant cost associated with scaling the solution. This is because of the costs associated with registering individual fishermen as addresses on blockchain. In addition, it is difficult to convince the various players in the fishing ecosystem to use and maintain a distributed ledger. Thus, scaling such a platform beyond high-value fishing seems far-fetched at this point.

Some of these challenges can be offset if multiple large buyers come together to introduce the technology across their supply chains. A similar exercise is being adopted in other food industries where a coalition of ten Foundation Partners comprised of both suppliers and retailers, which include Walmart, Kroger, Wegmans, Tyson Foods, Driscoll's, Nestlé, Unilever, Danone, McCormick, and Dole have come together to build a blockchain network that is interoperable and brings together the entire ecosystem.

## TRADE FINANCE: ABSA GROUP (BARCLAYS AFRICA) AND WAVE

This case study will examine how Absa Group (formerly Barclays Africa) and Wave (a blockchain start-up) piloted one of the first trade finance transactions using blockchain technology, facilitating a transfer between an Irish dairy cooperative and the Seychelles Trading Company. This case study is based on inputs from both senior executives in the Absa Group and Wave CEO.

## CONTEXT

Trade finance conventionally involves the back and forth exchange of documents across the supply chain. Figure 9 below highlights an example of a traditional trade finance process (simplified). The largely paper-based process takes several days to complete and is prone to several challenges. These include:

- Costs incurred due to manual labor (filling the forms and dispatching them across the process)
- Risk of human error
- Risk of fraud due to verification challenges
- Risk of processing delays
- Cost and time delays incurred in sending and receiving documents across multiple geographies
- Environmental benefits

Digitization of trade finance has become an appealing proposition both for reducing costs and for saving time. However, since trade happens across multiple national jurisdictions, it is difficult to for jurisdictions and the corresponding stakeholders to agree on a single centralized platform to handle data. This is mainly because stakeholders are unable to resolve questions regarding data ownership, storage, protection, and other aspects of data governance.

Blockchain provides a solution that can potentially mitigate these challenges. Being decentralized, and thus, without a central authority to control the process, blockchain solutions can reduce the entry barriers caused by the challenges above to digitize trade. In essence, blockchain solutions could potentially work in a similar way to paper-based transactions (where the documents travel across the supply chain) but with a layer of trust which is possible due to digital signatures and tamper-evident nature of the ledger.

Identifying the opportunity of emerging blockchain technology, Absa, Barclays Group and Wave launched a pilot in 2016 to test this hypothesis. The objective was to reduce the costs, time required, risk of fraud; and create efficiencies.

*Figure 9: Traditional Trade Finance Process*
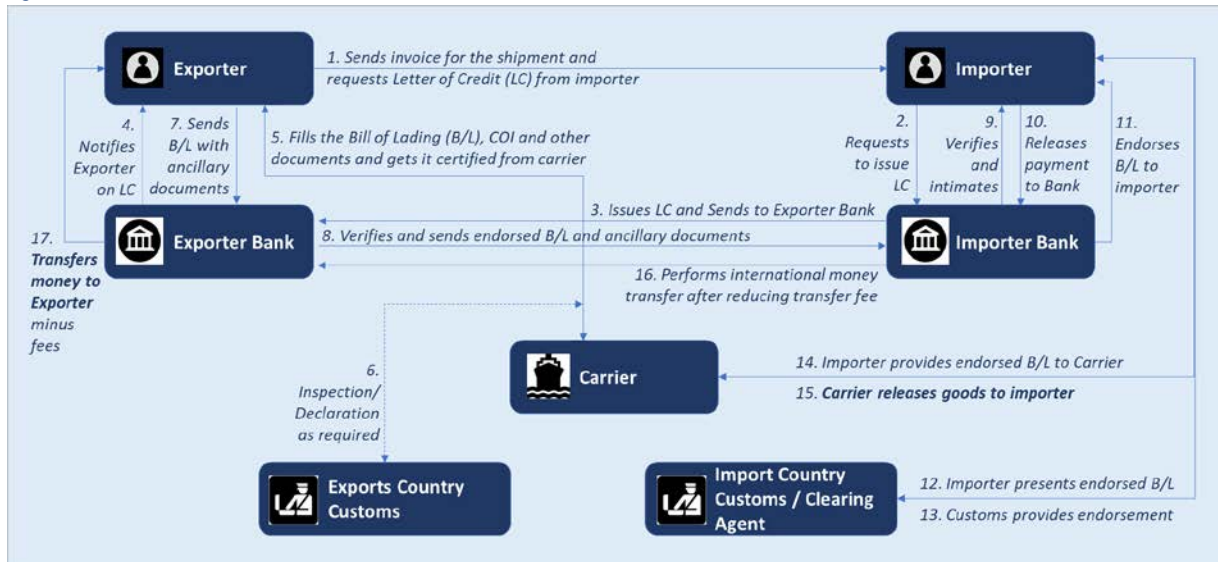


*Source: Nathan Associates, Absa Bank Report, WEF Report, BCG Report*

## CONCEPT

During the inception of the pilot, Wave developed a blockchain-enabled technology platform to digitize paper-based documents and allow different entities to provide a digital signature verifiable by the recipients. While digital signatures are common across many business transactions, the blockchain component enabled every transaction to be tokenized (hashed) and entered into the blockchain (the ledger is distributed among the various stakeholders), thus notifying the document holders of every step of process flow for a particular transaction.

The pilot only covered digitization of actions 5 to 13 of Figure 9, primarily digitizing the bill of lading and the conflict of interest forms.[18]

For the pilot, Absa, Barclays, and Wave used a permission-less blockchain ledger (created by using a fork on the bitcoin blockchain).[19] However, only the participants who acted as the various nodes of the blockchain accessed the ledger. The blockchain was kept permissionless to ensure that new participants
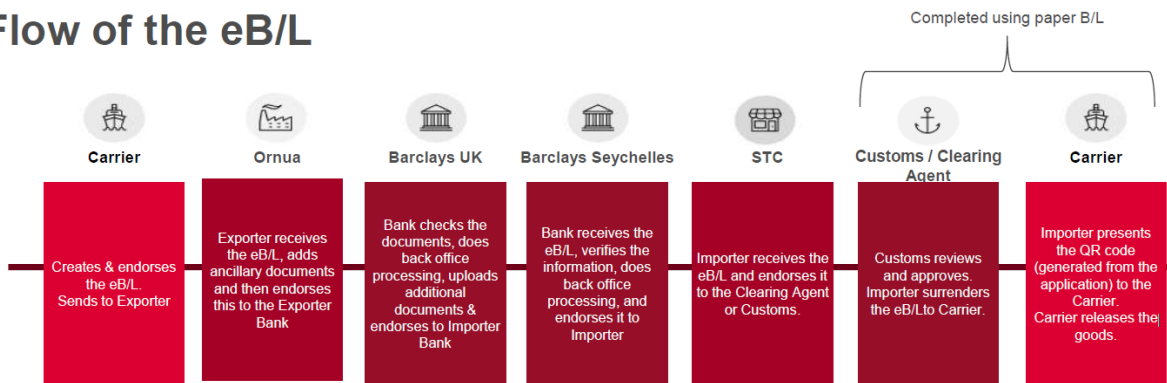
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[18] The Wave platform is agnostic to the type of document to be digitized and can conduct the same for letter of credit.

[19] Forking in blockchain happens when blockchain diverges into two potential paths, either with regards to networks transaction history or a new rule in deciding what makes a blockchain transaction valid.

can download the Wave app and be a blockchain node without the need for any permissions. Figure 10 highlights the concept.

*Figure 10: Absa Wave Blockchain Conceptual Flow*

## Flow of the eB/L

Completed using paper B/L

| Carrier | Ornua | Barclays UK | Barclays Seychelles | STC | Customs / Clearing Agent | Carrier |
|---|---|---|---|---|---|---|
| Creates & endorses the eB/L. Sends to Exporter | Exporter receives the eB/L, adds ancillary documents and then endorses this to the Exporter Bank | Bank checks the documents, does back office processing, uploads additional documents & endorses to Importer Bank | Bank receives the eB/L, verifies the information, does back office processing, and endorses it to Importer | Importer receives the eB/L and endorses it to the Clearing Agent or Customs. | Customs reviews and approves. Importer surrenders the eB/Lto Carrier. | Importer presents the QR code (generated from the application) to the Carrier. Carrier releases the goods. |

*Source: Absa Group*
*Note: Seychelles Trading Company (STC) – Sends an originally signed copy to the customs and keeps the ownership. When all approved STC surrenders the eB/L to the carrier and gets its goods.*

### STEPS FOR EXECUTING A TRADE FINANCE TRANSACTION OVER WAVE PLATFORM

The process involved installing Wave application on each stakeholder's computer. The Wave application is used as a stand-alone application that does not require any integration with the stakeholders' current systems. The application acts just like an email application in that the documents and files are sent on a peer-to-peer basis. The general process involves the carrier issuing a bill of lading and sends it to Wave in PDF format. This PDF replaces the paper documents and Wave enables adding to the document an electronic signature and endorsement procedures as if it was a paper bill of lading. The carrier digitally signs the electronic Bill of Lading (eB/L) and sends it on Wave to the exporter as shown in Figure 12. The ownership and endorsement chains are created on the blockchain and visible on the relevant documents. Thus, Wave both helps in transfer of digitally signed documents from one party to the other (and the corresponding verification) as well as tracing and notifying the stakeholders through the blockchain. Thus, this process mimics the trail of paper transactions but in a decentralized digital format.

### DATA PRIVACY AND PROTECTION

Data (documents like eB/L) is like an email, held individually by each participant. Wave only acts as an application, such as Microsoft Outlook or other email platforms that provides an interface. With respect to the blockchain ledger, it only includes information related to the documents – not the actual data – for each transaction including who owns or has the title to those documents. Thus, there are no separate data protection features enabled in the system. In addition, since the document transfer is peer-to-peer, and sensitive data is not accessible on the blockchain, and no separate privacy features are needed.

### DATA VALIDATION

The technology does not enable one to prevent wrong entry of data. However, since every document is digitally signed and verified, and the document flow can be traced on the blockchain, and the accountability increases. However, post-facto audits are required in such a case to identify these frauds so that the risk of fraud is reduced over the long-run.

### NEED FOR INTEGRATION WITH LEGACY SYSTEMS

*NEED FOR INTEGRATION WITH LEGACY SYSTEMS*

Since the version in use is a stand-alone application there is no need for integration with existing IT infrastructure (thus reducing primary implementation costs and challenges). On the other side, the user will have to use two applications. Future versions are planned to provide integration tools. If the application has to be integrated into the legacy system, then the concern of data protection rises back again.

In terms of interoperability with other systems, multiple players in the industry would need to consolidate their data structures to avoid "technology silos" and to be able to create a global network of the trade finance supply chain.

## IMPLEMENTATION EXPERIENCE

In 2016, Absa selected and successfully piloted a blockchain trade finance transaction of almost US $100,000 in cheese and butter between Irish agricultural food co-operative Ornua (formerly the Irish Dairy Board) and the Seychelles Trading Company.[20]

*IMPLEMENTATION STAGES*

Following internal discussions, Absa and Barclays contacted the two companies and provided a high-level overview of the pilot and both clients agreed to join. The two banks conducted additional outreach to other participants in the process, such as transport carrier Kuehne + Nagel and the Customs and tax authorities in Seychelles. The initial idea was to have the entire transaction process occurring digitally but as project owners approached the launch, the Customs Head at Seychelles resigned, and they had to conduct that end of the supply chain in paper (as highlighted in Figure 12 above). The implementation did not touch many regulatory topics except the question of whether the bill of lading would be electronic or paper-based at the customs-end. All the stakeholders participated in a few demos before the actual pilot. Once the carrier (Kuehne + Nagel) was decided and buy-in established, specific date and time for the trade transaction were ready from the legal, compliance and customs perspective. The first attempt was delayed, but the second attempt was successful and widely reported.

*IMPLEMENTATION TIMELINE*

The timeline for setting up such a platform for a trade network can take anywhere between 2 to 8 months, depending on the internal governance, and ensuring everyone is comfortable from a data protection and cybersecurity perspective. Executives at Absa Group and Wave believe that it would take even longer if they moved towards specific integration into the back-office system within banks. The current strategy for the Wave team is to work with the banks so that they are comfortable with the benefits of the platform before pushing towards a larger integration effort. While the benefits of the platform are shared by stakeholders in the trade finance ecosystem (including importers, exporters, and the corresponding banks), banks are the best positioned to act as champions to implement this solution for the benefit of their clients.

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[20] Both companies were clients of Barclays Africa.

### IMPLEMENTATION COSTS

The costs incurred by the team (Absa and Wave) for the proof of concept stage were only for travel and lodging in Seychelles. For the actual pilot, it cost around 50,000 Rand (US $3,500).

### GOVERNANCE CHALLENGES

The main challenge for the implementation of blockchain for most banks is that it will require scalability and industry-wide acceptance and take up. The focus of this pilot was predominantly on the Bill of Lading, and while the Freight Forwarder was comfortable to be part of this specific transaction, consideration will be needed to drive adoption across all critical stakeholders (regulator support is especially critical for the long-term) in the supply chain. This is critical to avoid breaks in the transaction that would revert the process into to a manual one, thus reducing the benefits.

Another challenge with respect to governance is related to the compliance requirements at banks. Banks must adhere to several regulations, and thus are not structured to be agile towards technologies like blockchain. For example, banks are required to set up complex legal contracts by regulatory authorities (e.g., compliance with data protection). Most start-ups, providing services to these banks with emerging technologies such as blockchain, will not have the legal resources to understand and comply with those contracts. Thus, there is a need to fast track some processes (by employing resources to circumvent the regulatory hurdles) or provide relevant legal support to the start-ups so that implementation can occur in a quicker period.

### CAPABILITY CHALLENGES

Since the pilot did not involve changing existing processes, the challenges from an end-user learning standpoint were low. All the stakeholders understood the functionality of the Wave platform with minimal to no training (a relatively simple guide with snapshots of the application was provided).

### TECHNICAL CHALLENGES

Basic internet connection is necessary for the implementation, but again was not a significant issue in this pilot.

### INTERBANK CHALLENGES

As the Absa Group at the time was part of Barclays Group, information sharing was easy.[21] If the pilot were to happen with different banks, there may have been a need to discuss the governance approach, including internal sign-off agreements on compliance and other legal issues. However, with respect to technology, the Wave application is agnostic to the base IT platform. The application can be downloaded at any bank and the trade finance transaction could involve different banks at the import and export location if there is buy-in.

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[21] Barclays Africa has now been spun off as Absa Group.

## IMPACT

According to the Absa Group (previously Barclays Africa) and Wave, the pilot displayed the following benefits:[22]

- Reduced the cost of end-to-end processing, including:
    - Issuing process
    - Transferring, authenticating, storing documents (±US $200 in courier fees)

- Reduced the time to complete end-to-end processing from ±10 days to 4 hours, including:
    - Issuing, endorsing, verifying, amending, sending a copy of eB/L
    - Receiving, locating, sending additional documents

- Reduced overall risk of end-to-end processing, including zero forgeries and zero disputes

- Reduced operational complexity and manual intervention through the supply chain and in the banking segment

- Provided a streamlined client experience for all parties (e.g., efficient transfer between counterparties and quicker back-end processing)

- Provided contingency for non-adoption (i.e., easy conversion to paper and XML format for SWIFT users)

- Solution received relevant support and buy-in from all stakeholders that were able to recognize the originality of an eB/L (as a proof that a live transaction can be carried over blockchain)

## RECEPTION AND OUTLOOK

The trade transaction over the blockchain platform received significant press attention in 2016, with multiple articles from top newspapers covering this transaction. In particular, Absa, Barclays, and Wave asserted that it was the first successful trade finance transaction conducted through blockchain.

However, the uptake since 2016 has not gone as planned. Absa Group states that this is largely due to administrative issues that stemmed with the split between Barclays and Absa Group and because of the complexities around getting a vast network of individuals and companies to collectively adopt this solution. Banks, in general, are still figuring out how to incorporate FinTech into their ecosystem, especially those that use new and emerging technology, as often the regulation around them is not clear. Other issues such as legal contracting (as highlighted in governance challenges) have slowed implementation with Wave.

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[22] The benefits are accrued primarily due to digitization of the flow of documents that accompany a trade finance deal. The digitization of the process across stakeholders, which was not possible before, was achieved in the pilot through the use of blockchain technology.

## CHALLENGES IN DEVELOPING CONTEXT ADOPTION

This solution needs basic internet connection similar to what is necessary for e-mail. However, the speed of the transaction will be dependent on the stability and speed of the internet. Developing countries that cannot provide stable internet across the different stakeholders in the supply chain will not be able to implement this solution successfully. Other challenges include governance and receiving buy-in from the several stakeholders in the supply chain. The stakeholders need to understand the economic, legal and security implications as well as the benefits of executing blockchain. In a developing country, this may be even more difficult if the political and bureaucratic establishments are suspicious of the impact and not transparent about their proceedings. For example, government organizations with embedded corruption might resist implementation of a digital solution that drives transparency (even though the solution might not immediately affect status quo in the short run). In addition, finding support for complying with banking regulations is a challenge a startup/or any mid-size organization will face.

According to Absa Group, the biggest opportunity for this platform appears to be in the supply chain finance space if the technology can reduce the cost and risk faced by banks in relation to the increasing cost of regulation and specifically financial crime, fraud, and anti-money laundering. This would need to be a joint effort between regulators, banks and the FinTech companies.

## TRADE PORTAL: SINGAPORE/HONG KONG

This case study explores Singapore and Hong Kong's proposed blockchain-enabled information highway that combines various application areas, such as trade digitization, trade finance, traceability, and insurance. This case study was prepared based on interviews with Singapore Customs, press releases and limited data that is publicly available about the project.

## CONTEXT

In October 2017, The Monetary Authority of Singapore (MAS) and the Hong Kong Monetary Authority (HKMA) signed an agreement to strengthen cooperation on fintech between the two economies and foster fintech development within the region (MAS 2017a). As part of the agreement, MAS and HKMA committed to working on a cross-border trade finance initiative that is DLT-based.

The Global Trade Connectivity Network (GTCN) is the joint innovation project that emerged from a cooperation agreement. The principal objective is to "build an information highway using DLT between the National Trade Platform (NTP) in Singapore and the Hong Kong Trade Finance Platform, which will make cross-border trade and financing cheaper, safer, and more efficient." (MAS 2017b) A joint working committee, comprising MAS, the HKMA, the NTP office of Singapore, and Hong Kong Interbank Clearing Limited, manages the project.

The longer-term objective is for the GTCN to serve as the trade platform connecting different trade functions and ecosystems around the world. GTCN stakeholders consider the trade finance project between Singapore and Hong Kong to be the first lane of the "global information highway" (a platform where trade-related information can be shared easily between different government jurisdictions). A fundamental assumption of this project is that there will be a proliferation of blockchain platforms

around the world and that GTCN will bring these different platforms together. Thus, interoperability between different blockchain platforms will serve as one of the key differentiators of GTCN.

## CONCEPT

GTCN is currently at a stage where the project is evaluating tenders from technology firms; the scope of the platform is therefore confidential. However, the platform has three broad objectives (Singapore Customs 2018):

1.  Establishing blockchain-enabled end-to-end digital connectivity in the international cross-industry trade ecosystems; collaborating with different trade platforms and participants while maintaining neutrality

2.  Enabling a common view for trusted cross-border trade while meeting privacy and data confidentiality requirements, benefiting all trade ecosystem participants

3.  Providing a platform as the foundation for developing innovative commercial applications to facilitate cross-border trade, leveraging on NTP capabilities

*Figure 11: GTCN Network*
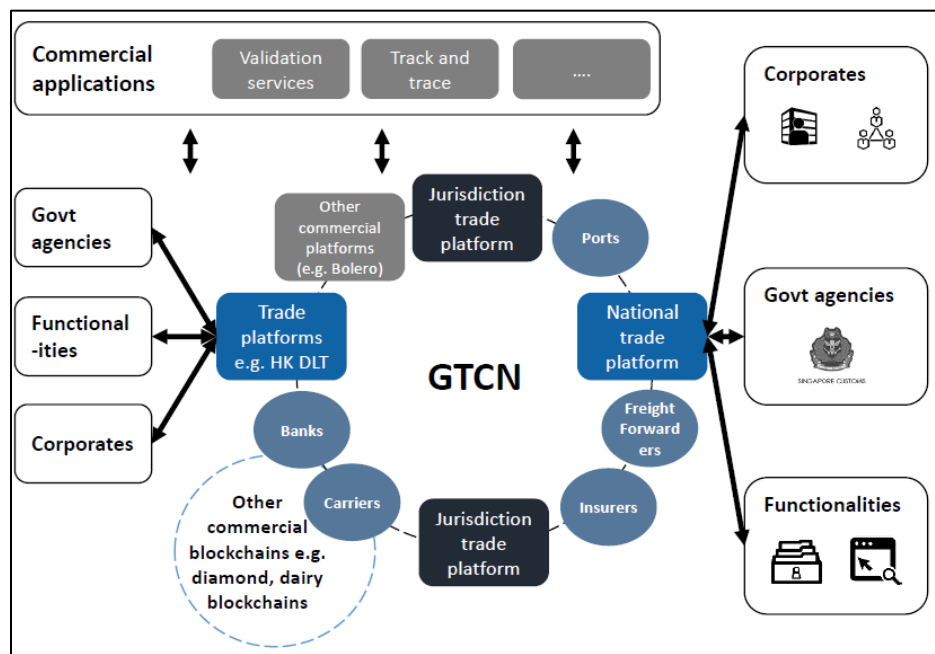


*Source: Singapore Customs 2018.*

Figure 11 highlights the overall vision for the GTCN project. According to the vision, there will be direct and indirect participants to the GTCN blockchain. Direct participants would include Singapore NTP, Hong Kong's Trade Finance platform, and, in the future, trade platforms from governments of other jurisdictions (countries and/or regions) as they implement projects. These direct participants would act as the permissible nodes of the blockchain. Indirect participants would be non-governmental supply chain players, such as the banks, carriers, insurers, freight forwarders, ports, and other commercial platforms. These indirect participants will access the blockchain nodes via the direct participants. In cases where blockchain networks are already set-up between various players in the

ecosystem (e.g., trade finance between Barclays and Wave), such networks can interface with GTCN through GTCN's interoperable platform to finalize customs requirements (in accordance to the respective government laws) and to connect with other networks and entities. GTCN will further allow the building of third-party commercial applications such as "track and trace"[23] and "validation services"[24] on top of the GTCN network.

In general, the GTCN would adhere to the following core principles (Singapore Customs 2018):

- **Connectivity:** A cross-border infrastructure that will connect various trade platforms (either government or commercial) and allow platform users to share data and electronic trade documents with users of other connected platforms.

- **Open Innovation:** A common set of APIs for interested parties to develop applications that allow users to interact with the GTCN. These commercial applications would leverage the connectivity and infrastructure provided by the GTCN to offer value-added services, such as duplicate financing checks and end-to-end digital trade financing flows.

- **Flexibility:** Ability to cater to multiple application areas (e.g. traceability, trade finance, etc.) within and across industries. The GTCN should be flexible enough for new functionality to be added to accommodate additional applications in later phases.

- **Scalability:** Ability to scale up to connect various trade platforms in the region. Starting from the initial connectivity between Hong Kong and Singapore, the GTCN should be able to accommodate connections with other trade platforms and process any interactions with the GTCN accordingly.

- **Trust:** Allow sharing of data and documents only in a protected and permissioned environment, to build trust in the GTCN ecosystem so that stakeholders are willing to transact digitally.

The final shape of the platform, including decisions on the underlying blockchain technology used (e.g., Hyperledger, Ethereum, R3 Corda) will depend on the design agreed between GTCN and the selected vendor.

*DATA STANDARDIZATION*

Data standardization has been one of the biggest challenges in accomplishing interoperability of automated systems. Entities use multiple data models/standards to maintain their respective databases, such as Universal Business Language (UBL 2.0), ebXML, and the UN/EDIFACT. Singapore's NTP platform uses an interoperability layer that can be leveraged for 'standards to standards' translation.[25] The layer allows NTP to interact with different platforms irrespective of the data standard being used. GTCN will most likely use a similar approach to data standardization.

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[23] In distribution and logistics of many types of products, track and trace concerns a process of determining the current and past locations (and other information) of a unique item or property.

[24] Validation services are applications validating the accuracy of data inputs.

[25] An automated process to translate data from one universal data standard to the other.

*DATA PRIVACY AND PROTECTION*

GTCN team places a high emphasis on data privacy and protection and thus the bidding parties will have to exhibit robust privacy and data protection methodologies to be eligible to build the platform. However, the details for the same are still confidential.

## IMPLEMENTATION EXPERIENCE

The heads of MAS and HKMA signed a Memorandum of Understanding (MOU) during a workshop at the 2017 Singapore FinTech Festival organized by MAS.

The Joint Working Committee for GTCN then held intensive discussions with banks in Singapore and in Hong Kong to understand the requirements for developing the system. A request for proposals (RFP) was released in early 2018 to select a technology provider to build and operate GTCN. The RFP was made available only to those providers who signed Non-Disclosure Agreements (ABS 2018). Currently, the committee is in the evaluation phase for selecting a vendor. Concurrently, the parties are working towards resolving governance issues surrounding implementation.

*CHALLENGES*

Challenges faced during GTCN implementation are similar to ones faced by other blockchain projects, e.g. governance, technology, regulatory, and capacity building. However, the primary challenge for GTCN is in making the platform relevant. This entails getting different parties to converge on the idea.

One of the challenges in convincing stakeholders is sensitizing them to the concept of blockchain and its benefits and GTCN is using a different approach in this regard. Instead of speaking about blockchain as an esoteric concept, GTCN officials focus on sharing applications and explaining the benefits that the stakeholders can derive by the platform in general with less emphasis on blockchain. Trade Finance was chosen as the first project to start GTCN, despite its broader objectives of developing a global information highway that can cater to multiple applications.

## RECEPTION AND OUTLOOK

GTCN is expected to go live by the second quarter of 2019, to connect with the targeted go-live dates of the Trade Finance Modules on the National Trade Platform in Singapore and the Hong Kong Trade Finance Platform.

## CHALLENGES IN DEVELOPING CONTEXT ADOPTION

GTCN provides an opportunity for several developing countries to accelerate their customs modernization efforts as developing countries can join the proposed platform and avail many of the services and networks that are already built into the platform. However, every country is at a different stage of readiness when it comes to adopting a platform such as GTCN and, specifically, to operate as one of the nodes of the blockchain. Thus, there is a need to map out a country across several parameters to understand its readiness to adopt the GTCN platform. Once the gaps are identified, then multiple cross-border capacity building projects can be leveraged to fill these gaps and facilitate the digitization of trade.

# INSIGHTS AND LESSONS LEARNED

The case studies in the previous section reveal both the benefits and challenges of blockchain technology when compared to other platforms (e.g., paper-based and centralized solutions). Figure 12 compares blockchain technology both with traditional/paper-based systems and with its primary alternative in digitization: a centralized solution operated by a third-party service provider.

*Figure 12: Comparative Analysis of Traditional Systems Vs Blockchain Vs Best Alternative on Benefits and Costs*

| Cost - Benefit Analysis | Traditional/Paper-based Description | Traditional Attractive? | Blockchain Technology Description | Blockchain Attractive? | Best Alternative in Digitization: Centralized Solution Description | Centralized Attractive? |
|---|---|---|---|---|---|---|
| Time Taken | The physical flow of documents, and populating and validating paper docs is very time consuming | 2 | Digitization minimizes physical flow of documents and allows for automation increasing efficiency | 8 | Is even faster than blockchain-based technologies as processing happens in a centralized ledger | 9 |
| Costs to Transact | Paper based systems incur logistics costs as well extensive labor costs. There are also human error costs | 2 | There are upfront implementation and maintenance costs but saves drastically on logistics and labor | 8 | Similar costs as blockchain but reliant on a single administrator | 7 |
| Risk of Fraud | Paper based forms can easily be manipulated and tracing back the point of fraud is difficult | 3 | Hashing and digital signatures ensures that there is traceability and authentication throughout | 9 | Central databases allow for traceability but one needs to trust the central administrator | 6 |
| Points of Failure | Due to its distributed nature, even if some nodes fail/are attacked, the entire system doesn't collapse | 7 | Being a hashed distributed ledger, it is tamper-proof and operates despite nodes failure/attacked | 7 | Being a centralized database, it has a single point of failure (but there are often redundancies) | 4 |
| Implementation Costs | Status Quo: So no incremental costs required for implementation | 9 | Installation, maintenance costs but also costs to build human capacity to run nodes across stakeholders | 3 | As compared to blockchain: similar installation, higher maintenance but lower capacity building costs | 4 |
| Data Privacy and Protection | Customs organizations can ensure privacy and protection of the paper documents | 7 | Some privacy with features such as Hyperledger "channels". Sensitive data is not entered into the system | 4 | Data privacy and protection is determined by the central provider (querying through data is possible) | 5 |

*Source: Nathan Associates Analysis*

The case for blockchain technology in comparison to traditional paper-based methods is that it reduces the time taken to transact as well as the costs for transaction, and prevents fraud much more effectively. However, implementation of blockchain will incur costs and it does not offer the same level of data privacy that paper-based methods can provide.

If one compares blockchain solutions to a centralized alternative, even though the centralized alternative is marginally better in performance on time, and may even be marginally cheaper, it requires participants to trust the central single administrator. The participants need to be confident that the central administrator will be honest (i.e., not manipulate entries themselves), reliable (i.e., provide redundancies to keep the system running even if some nodes fail), protected (i.e., prevent hacking and manipulation of the database), and secured (i.e., will not use or query the data without permission of users). Hashing transactions ensure that the database is tamper-evident[26] and, because the ledger is distributed, one

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[26] Hashing can also occur in centralized systems; however, the central administrator can theoretically still manipulate the database and re-hash to remove the evidence of tampering.

entity cannot single-handedly modify the whole database, which is still possible in a centralized solution even if the database uses the technique of hashing and creating a chain.

This need for trust acts as a significant barrier to stakeholder buy-in when it comes to implementation of centralized solutions. Figure 12 compares the implementation challenges between traditional system, blockchain solution and a centralized database solution.

*Figure 13: Comparative Analysis of Traditional Systems vs. Blockchain vs. Best Alternative on Implementation Challenges*

| Implementation Challenges | Traditional/Paper-based Description | Attractive? | Blockchain Technology Description | Attractive? | Best Alternative in Digitization: Centralized Solution Description | Attractive? |
|---|---|---|---|---|---|---|
| Stakeholder Buy-in | Status Quo: No need to receive buy-in to adopt a new system | 9 (High) | Easier to receive buy-in as no need to trust centralized administrator; but blockchain education needed | 7 (High) | Very difficult to get stakeholders in different jurisdictions agree on single admin controlling data | 2 (Low) |
| Ability to Scale | Paper based systems are easier to scale as investments for additional stakeholders is minimal | 8 (High) | One has to coordinate with multiple stakeholders and have them use/or integrate using API | 5 | Has similar problems as blockchain technology coupled by a lack of trust on a central admin | 4 |
| Technology Pre-requisite | Minimum technology pre-requisites as the documents are all paper based | 9 (High) | Need some basic IT infrastructure existing where blockchain can extract using API | 4 | Need basic IT infrastructure like internet. But a central admin may be able to develop systems | 5 |
| Human Resources Pre-requisite | Paper based would need training to detect frauds, but will not require technology training | 7 (High) | Doesn't require extensive UI training but training needed for IT system admins and on security | 3 | Stakeholders don't need to be trained on maintaining a blockchain network | 5 |
| Legal Pre-requisite | Legal systems need to be changed as most laws are made for paper based trade documentation | 9 (High) | Need legal changes in acceptance of electronic documents and understanding of blockchain | 5 | Same as blockchain technology minus the need for legal understanding of blockchains | 7 |
| Inter-operability | Interoperability between different organizations are difficult due to the manual processes involved | 4 | Interoperability can be achieved through the use of APIs; data standardization is an issue | 6 | Similar to blockchain solutions | 6 |

*Source: Nathan Associates Analysis*

Given the status quo, traditional systems face few implementation barriers. However, challenges in interoperability will continue to mount as trade volumes continue to increase.

Digitization, either via blockchain or a centralized cloud solution, will be a difficult proposition across implementation parameters, such as technology, human resources, legal frameworks, and scalability. However, if the decision for digitization is taken, then blockchain solution becomes more viable as stakeholders across multiple industries and jurisdictions will most likely not agree on one centralized administrator to manage all the data flow. For example, in the implementation of electronic single windows (eSW), non-customs government agencies fear that a customs-controlled centralized system will gradually take away their functions (i.e., all permits/licenses will get processed automatically – according to set rules within the eSW) and that they will lose their jobs/functions in the long run. This is a primary motivator that has driven stakeholders across the supply chain to agree on adopting blockchain's distributed ledger technology in trade.

When examining the specific applications, in addition to the general costs-benefits analysis and implementation challenges mentioned above, the below factors are important to consider:

*Supply Chain Digitization*

- The primary stakeholders that need to champion a blockchain initiative are either the major shipping carriers or customs organizations, as they generate the most data in the system.

- There is a need for IT management capacity to run the nodes of a blockchain network. In developing countries, this capacity is usually absent in the customs agencies. Thus, carriers like Maersk and IT system implementers like IBM have to lead the implementation and management of blockchain networks in the initial stages.

*Trade Finance*

- The primary stakeholders that need to champion a blockchain initiative are banks (preferably a consortium) supported by the respective government agencies.

- Banking regulations and their impact on start-ups are additional barriers for consideration.

*Traceability*

- Blockchain solutions can build trust in traceability of goods, which could increase food safety and risk mitigation (e.g., efficiently locating the source of a contamination outbreak in the food supply chain).

- Blockchain traceability solutions can be public or private.

  - **Provenance case study in Indonesia** was an example of a public network. Public networks can be expensive to initially implement and maintain because of costs incurred in registration, especially at the raw materials or products end of the supply chain, and cost to maintain it through consensus mechanisms. The uncertainty as to whether the market will bear the costs is a significant barrier to scaling.

  - **Anheuser-Busch InBev is tracing cassava from farmers in Zambia** using BanQu's blockchain platform. This is an example of a private blockchain network. In such cases, the supply chain is well defined and it is easier to bring the various stakeholders within a single decentralized platform. The champion for such a project would ultimately be the brand or the retailer, who would benefit from being able to determine the origin as well as better forecast risks.

# IMPLICATIONS FOR USAID

Blockchain solutions, as seen in the case studies and the analysis in this paper, have the potential to support digitization of cross-border customs procedures, trade finance, and traceability of the supply chain, among other things. Blockchain-led digitization can significantly reduce lead times, handling costs, and human errors. It can also reduce corruption given the traceable and tamper-evident nature of its ledger.

Blockchain technology, theoretically, could be more adept than traditional IT platforms at receiving buy-in for digitization among multiple stakeholders across different jurisdictions in the trade ecosystem. This emanates from blockchain's capability to provide accessibility (access in real time), security (via digital signatures), audit trail (via a tamper-evident ledger) and resilience (no single point of failure) to the ledger. Further, blockchain-led solutions do not need the stakeholders to trust a third-party to operate and manage its database as would be the case in centralized solutions.

At the same time, blockchain solutions require more time and effort to set up, especially to convince participants to join (despite the benefits mentioned above). This is largely due to the need to socialize the concept of blockchain from a non-cryptocurrency context, securing agreement to an application, conducting a pilot, monitoring and evaluating to improve the system, then scaling the solution. Most of the blockchain solutions currently operating are still at a 'pilot' or 'scaling' stages. Many providers have found it difficult to reach the 'active implementation' stage, largely due to the challenges in bringing different stakeholders together and the need for capacity building.

## COST PERSPECTIVE

Most of the solutions that are being piloted or implemented from a trade perspective use private or consortium blockchains, which do not require a resources-consuming consensus mechanism to validate transactions (unlike blockchain solutions used in cryptocurrencies that require extensive amount of resources such as electricity and computing power). Implementation costs, in the cases reviewed, are comparable (or slightly higher) to other IT solutions. Given that multiple stakeholders have to maintain the system (instead of a central third party), the cumulative operating costs (for the platform and the extra resources required) would likely be higher than centralized solutions.

## RECOMMENDATIONS

USAID should consider blockchain solutions as an alternative to other IT solutions, when reaching consensus among stakeholders or "lack of trust" in a system are the most significant impediments to digitization of processes that facilitate trade (or from realizing the benefits of digitization thereof). However, before deciding to invest in/implement blockchain solutions, stakeholders need to assess the potential implementation challenges and costs that such solutions entail.

In developing countries, the basic resources required to implement and maintain a technology are often unavailable. Blockchain solutions are no different. When evaluating whether or not to implement a blockchain solution, USAID and other implementers should understand the following pre-requisites for implementing a blockchain solution.

**Usability Standpoint:** For almost all application areas (except in traceability where the first mile can be connected over simple mobile phones), users need the necessary IT skills to operate the system. Since blockchain solutions sit beneath the application layer, stakeholders can continue using their traditional IT systems with minimal user-interface changes (or with a standalone application like in the case of Wave) and therefore may not require additional IT skills training. Another challenge to consider is that blockchain solutions do not completely prevent the phenomenon of "garbage in, garbage out" that plague various IT systems, although the audit trail increases the accountability for each actor entering information into the system. Thus, it is important to note that blockchains are not a substitute for good data entry practices especially in developing countries.

**Maintenance Standpoint:** Operating a blockchain node at the back-end (including providing computing power to validate transactions, set permissions) is relatively more complex. While most of the capabilities required are automated, basic IT infrastructure (including hardware, connectivity, and personnel) is necessary to operate a node on the blockchain. The level of infrastructure required will vary based on the type of blockchain used. In addition, personnel would need to be hired and/or trained to operate the node. USAID should ensure that such activities are a part of the capacity building exercise.

**Governance Standpoint:** For a consortium blockchain solution to work sustainably, the entities in the consortium, including government agencies, should be willing to agree to a governance framework to manage the blockchain network. This will include ownership, financial and technical commitment to operate and maintain the system, and commercial terms. In addition, implementation of such solutions may face opposition from certain actors, including politically strong entities, especially if the existing systems have elements of corruption that would be eliminated by the introduction of the new system. USAID would need to assess the winners and losers that will emanate from the blockchain solution and evaluate whether implementing such a solution will be feasible in the ecosystem. Often, to implement such a solution in a challenging context, one requires strong sponsors or champions willing to act as change agents and to lead others into adoption (like any major regulatory reform).

**Legal Standpoint:** Some blockchain solutions, as detailed in the case studies, require laws and / or regulations in a country to be changed in order to implement and use a blockchain solution. USAID would need to evaluate the legal framework that may need to be changed for a blockchain solution, including the effort that will be required to make such changes and whether such an effort can be commercially justified.

Once it is established that a blockchain solution may be the right solution, USAID can play a key role in ensuring that the enabling environment is conducive to the solution's uptake. The enabling environment can be built through a detailed change management exercise that would include both stakeholder management and capacity building to address the issues highlighted above.

APPLICATION AREAS FOR CONSIDERATION

USAID should consider the following application areas due to potential for impact in a developing country context and the value that these initiatives can bring to the consumers in the United States.

**Traceability pilots and projects:** Implementation of such solutions has the potential to help developing country exporters meet food safety requirements and sustainability standards of developed

country markets. Such solutions can also reduce fraud in the supply chain thus helping consumers in the developed markets be sure of the provenance (origin) of the products. This improvement in consumer experience can command a market premium, which can benefit each step of the supply chain. However, an evidence gap still exists in this regard. This is largely because we are reliant on fragmented information from third party accounts on the technology's capabilities. USAID should consider implementing proof-of-concepts/pilots of their own to reduce this evidence gap.

**Supply chain digitization (digitizing the processes that facilitate trade):** In developing countries which demonstrate a readiness from governments, and local trade communities for implementing blockchain solutions, USAID could support pilots on improving supply chain efficiencies. Specific regions of focus may include Southeast Asia and Asia Pacific, where blockchain discussions are more advanced.

## FRAMEWORK FOR DETERMINING THE APPLICABILITY OF BLOCKCHAIN

In determining whether or not to fund blockchain solutions in trade, USAID can ask the following questions:

**Table C – Questions for Determining Blockchain Applicability**

| | **Questions** | |
|---|---|---|
| I | Is there a case for digitization of trade facilitating processes? | What are efficiency gains both in time and cost that digitization of the specific supply chain in consideration will bring about in the short and long run? |
| | | Are there other gains such as in helping reduce fraud? |
| If **yes,** proceed to Question 2. If **no**, there is no need to consider a blockchain solution | | |
| 2 | Is blockchain the right solution for digitization? | Is there a fear that if digitization is carried out by a central administrator/third party, that the database may be compromised? |
| | | Is it necessary to protect the digitized trade data from hacks and manipulation? Can this be prevented better in blockchain than by a central administrator? |
| | | Is data privacy a significant concern? Are the major stakeholders satisfied with the privacy provided by blockchain solution? |
| If **yes,** proceed to Question 3. If **no**, assess alternative solutions. | | |
| 3 | Will implementation and ongoing maintenance be a significant challenge? | Which stakeholders should champion? Are they willing? |
| | | Does the solution need a consortium? What is their readiness for a blockchain solution? |
| | | Is there a basic IT infrastructure within the country that one can build on? What would be the cost to achieve the basic IT infrastructure needed for blockchain? |
| | | What are the data standards that are used within the trade network? Is it easily translatable? |
| | | What is the current situation of human resources capability? What are the capacity building exercises that are needed? Can the gap be filled? |
| | | What are requirements from a legal perspective? Is it possible to comply or change laws if needed? |
| | | Can this model be sustainable? Who will take-over the platform? Is there a business model that the entire value chain is interested in? |
| | | Are the costs to fill these gaps prohibitively high? |

| If **yes,** proceed to Question 4. If **no**, assess alternative solutions. | | |
|---|---|---|
| 4 | What should be the implementation plan? | Should it be a public or a private blockchain? What should be the governance of the blockchain |
| | | What is the vision, objectives, and functions of the blockchain network being planned? |
| | | Who should be the technology implementer and what will be their role subsequent to launch? |
| | | What is the project schedule and timelines, roles and responsibilities? |
| | | What are the key performance indicators and monitoring methodology? |

# APPENDIX

| TABLE 1 – TRADE FINANCE | | | |
|---|---|---|---|
| **Implementers** | **Activity** | **Stage** | **Links** |
| BBVA<br><br>Wave | In November 2017, BBVA Bank used Wave's blockchain technology for simplified tracking and document sharing for tuna shipments from Mexico to Spain. | 3 | USAID (2018)<br><br>BBVA (2017) |
| Absa Group<br><br>Wave | In September 2016, Absa Group (formerly Barclays Africa) partnered with Wave to complete the first blockchain-based trade-finance deal for a shipment of dairy products from Irish agricultural food co-operative Ornua to Seychelles | 3 | Reuters (2016) |
| Digital Trade Chain Consortium (we.trade) | In July 2018, the we.trade platform, established by Deutsche Bank, HSBC Bank, KBC Bank, Natixis, Nordea, Rabobank, Santander, Societe Generale and UniCredit, to address the expectations of their customers to simplify cross-border trade, went live and has reported 7 trade transactions completed by 10 companies on the platform across 5 countries. | 4 | we.trade (2018)<br><br>USAID (2018) |
| Infosys<br>Emirates NBD<br>ICICI Bank | In October 2016, using the EdgeVerve Blockchain Framework for Financial Services, the network was successfully piloted between Emirates NBD and ICICI on the UAE-India remittance corridor. The pilot achieved a near real-time transfer of invoices and purchase orders in a transparent and secure manner. In April 2018, ICICI announced it has successfully on-boarded over 250 corporations on its blockchain platform for domestic and international trade finance. | 4 | ICICI Bank (2018)<br><br>IFC (2017) |
| HSBC<br>ING Bank<br>Cargill | In May 2018, HSBC Bank announced that it has processed a letter of credit with ING Bank for an international soybean shipment. HSBC and Cargill completed the transaction, for a shipment of soybeans traveling from Argentina to Malaysia, via an R3 blockchain platform. | 3 | Supply Chain Dive (2018) |
| ING Bank<br>Société Générale<br>ABN AMRO | In January 2018, ING Bank, Société Générale, ABN AMRO Bank, and several other participants successfully traded a shipment of soybeans on their Ethereum-based Easy Trading Connect blockchain platform. In February 2017, the platform was also used on an oil cargo shipment containing African crude which was sold three times on its way to China and included traders, banks as well as an agent and an inspector, all performing their role in the transaction directly on the platform. | 3 | ING and Société Générale (2017) |
| AIG Inc.<br>TradeIX<br>Standard Chartered | In October 2017, AIG Inc. and TradeIX Limited announced the completion of a blockchain-enabled trade finance transaction for a global logistics company with financing provided by Standard Chartered. The transaction enabled the logistics company to help its customers extend their payment period whilst maintaining the company's receivables at current terms. In August 2018, Standard Chartered partnered with Siemens for blockchain-based smart guarantees in trade finance, using technology based on R3's Corda. | 3 | TradeIX (2017)<br><br>AIG (2017)<br><br>GTR (Aug. 2018) |
| Banking<br>Consortium R3CEV | In March 2016, R3 announced it had completed a trial involving 40 banks testing the use of blockchain solutions to facilitate the trading of debt instruments. A few premium banks left the consortium in November 2016. By April 2018, Corda had completed multiple live transactions. | 4 | Coindesk (Aug. 2016) |

| Bank of America Merill Lynch HSBC IDA | In August 2016, Bank of America Merrill Lynch, HSBC Bank, and the Info-communications Development Authority of Singapore (IDA) announced a prototype to replicate a letter of credit using blockchain technology. In February 2018, HSBC announced readiness to pilot the technology. | 2 | DHL (2018) IBM (2016) IFC (2017) GTR (Feb. 2018) |
|---|---|---|---|
| Mizuho Bank | In June 2017, Mizhuo Financial Group, Mizhuo Bank and Cognizant Japan, R3CEV LLC announced a joint project to analyze the results of actual trade transactions conducted using blockchain technology. The technology uses the R3 Corda platform. | 3 | Mizuho (2017) |

## TABLE 2 – SUPPLY CHAINS

| Implementers | Activity | Stage | Links |
|---|---|---|---|
| Maersk IBM | In August 2018, Maersk and IBM announced the creation of TradeLens - a blockchain-enabled shipping solution designed to digitize trade across the supply chain. IBM and Maersk also announced that 94 organizations are actively involved or have agreed to participate in the TradeLens platform built on open standards. Prior to this announcement, IBM and Maersk ran multiple pilots across the globe via TradeLens's predecessor (Global Trade Digitization Platform). | 4.5 | USAID (2018) DHL (2018) IBM (2017) WCO (2018) |
| Common Market for Eastern and Southern Africa (COMESA) | In January 2018, sixteen COMESA members, including the Burundi, Democratic Republic of the Congo, Egypt, Ethiopia, Kenya, Madagascar, Mauritius, Seychelles, Sudan, Swaziland, Uganda, Zambia and Zimbabwe, announced plans to implement a digital free trade area (DFTA)–Africa's first. COMESA aims to connect sellers and buyers in real time via blockchain technology (through a series of decentralized virtual ledgers). The DFTA would also generate certification of origin, creating an extra layer of security and assurance for e-vendors and buyers. | 1.5 | COMESA (2018) BitcoinAfrica (2018) |
| ZIM WAVE Sparx Logistics | In November 2017, ZIM Integrated Shipping Services completed the first pilot of paperless Bills-of-Lading based on blockchain technology, in cooperation with Sparx Logistics and Wave Ltd. During the trial, all participants issued, transferred and received original electronic documents using the Wave Application; the containers, shipped by Sparx Logistics from China to Canada, were delivered to consignees without issue. | 3 | DHL (2018) ZIM (2017) |
| DP World Australia DB Schenker Hamburg Sud IUS | In July 2018, the blockchain-based system called TBSx3 was successfully tested in the logistics chain that runs between the wine region in Southern Australia and the port in Northwestern China. Among the partners that participated in the pilot test were the terminal operator DP World Australia, the logistic operator DB Schenker, the Hamburg Sud shipping company and the Australian wine producer IUS, which exports to the Chinese market. | 3 | American Shipper (2017) L&M Handling (2017) |
| Mitsui OSK Lines IBM | In December 2017, Japanese shipping firm Mitsui OSK Lines announced a project with partners such as IBM to undertake a blockchain proof-of-concept to streamline international trade flows. The project will see trade agreements, logistics, and insurance documents, and more, digitized, stored and shared among participants, bringing a number of benefits over traditional trade systems. | 2 | Coindesk (2017) Mitsui OSK Lines (2017) |

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| Modum<br>Swiss Post | In April 2018, Switzerland's national postal service Swiss Post announced that it would integrate a blockchain-based solution developed by industry startup Modum in deliveries of pharma shipments and other temperature-sensitive products. The solution will provide players in the pharma sector with a reliable and scalable process for monitoring the state of goods and demonstrating legal compliance to auditors | 2 | Modum (2018)<br>ECIPE (2018)<br>Cointelegraph (2018) |
| SUNAT (Peru Customs)<br>IBM | In June 2018, SUNAT–the Peru Customs administration– presented its customs solution developed in partnership with IBM. | 4 | SUNAT (2018)<br>SUNAT |
| Korea Customs Service<br>Samsung SDS | In September 2018, Samsung SDS and the Korea Customs Service signed an MOU to have Samsung's Nexledger blockchain utilized for a new decentralized customs clearance system. | 1 | Coindesk (2018) |

## TABLE 3 – TRACEABILITY

| Implementers | Activity | Stage | Links |
|---|---|---|---|
| Provenance | In May 2016, Provenance used blockchain technology to track tuna fish caught in Maluku, Indonesia from landing to the factory to the point of sale. | 3 | USAID (2018)<br>Provenance (2016) |
| Walmart<br><br>IBM | In June 2018, it was reported that a year after initial tests, 10 of the world's biggest companies, including Walmart Inc. and Nestlé SA, are building a blockchain to remake how the industry tracks food worldwide. The so-called Food Trust aims to improve recalls, quickly identifying the issue and shrinking the time consumers are at risk. The Food Trust group, which also includes Dole Food Co., Driscoll's Inc., Golden State Foods, Kroger Co., McCormick and Co., McLane Co., Tyson Foods Inc., and Unilever NV, are also participating in this project | 4.5 | USAID (2018)<br>DHL (2018)<br>IBM (2017)<br>OECD (2017) |
| BanQu | In June 2018, BanQu piloted a new partnership with the world's largest brewer, Anheuser-Busch InBev, working to connect 2,000 Zambian farmers to the mobile platform as they harvest and sell a projected 2,000 tons of cassava, producing a high-quality starch used in beer—by the end of Zambia's growing season in August. | 4 | BanQu (2018)<br>PR Newswire (2018) |
| Everledger | Everledger works with industry and governments to support the Kimberley Process set up in 2003 to increase transparency and eliminate trade in conflict diamonds. Since 2015, Everledger has tracked 2.5 million diamonds, with diamonds in China, Hong Kong, the United States, Australia, and soon Canada. The system verifies a diamond's origin in a three-step process. First, a unique identification (ID) is given to each diamond, which is then uploaded to a private blockchain run off the Hyperledger Fabric, and a cryptographic hash is anchored on the Ethereum blockchain. | 3.5 | ECIPE (2018)<br>USAID (2018)<br>DHL (2018)<br>IBM<br>CGD (2017) |
| Responsible Cobalt Initiative (RCI) | The RCI seeks to trace cobalt from mines in the Congo to ensure child labor was not used. The RCI is based on the OECD Due Diligence Guidance on Responsible Supply Chains of Minerals from Conflict-Affected and High-Risk Areas. As China is the main destination for Congolese cobalt from artisanal mines, the Chinese Chamber of Commerce for Metals, Minerals & Chemicals Importers & Exporters spearheaded the development of the RCI. Member | 1 | Reuters (2018)<br>Mining Global (2018)<br>White & Case (2018) |

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|---|---|---|---|
| | companies include Apple, HP, Samsung SDI, Sony, Mercedes-Benz, and Daimler. The plan for the Congo pilot scheme is to give each sealed bag of cobalt produced by a vetted artisanal miner a digital tag then entered on blockchain using a mobile phone, along with details of the weight, date, time and perhaps a photo. | | |
| Starbucks | In March 2018. Starbucks announced a pilot 'bean to cup' traceability project with select farmers in Colombia, Costa Rica, and Rwanda over a two-year period. The company is exploring the use of various technologies to accomplish this, including blockchain. Following its completion, Conservation International will measure the impact of traceability to understand the potential benefits to farmers and Starbucks plans to share this system and lessons learned. | 1 | Starbucks (2018) <br><br> ThirtyK (2018) |
| Dorae Government of DRC | In March 2018, Dorae Inc. launched a pilot blockchain project in the Democratic Republic of the Congo to secure supply chain data for cobalt, coltan, and diamonds. The project is notable for establishing coordination with the Government of President Joseph Kabila. When raw materials are sold, the information on place of origin, extraction method, inspection details and quality is logged in system. | 2 | PR Newswire (2018) African Mining Market (2018) |
| DHL Accenture | In March 2018, DHL and Accenture announced a blockchain prototype, which tracks pharmaceuticals from the point of origin to the consumer and aims to prevent tampering and errors. The blockchain contains nodes in six geographic areas. The two companies announced that the blockchain might be shared with stakeholders such as manufacturers, warehouses, distributors, pharmacies, hospitals, and doctors. | 2 | DHL (2018) <br><br> Supply Chain Digital (2018) |
| BHP Billiton | BHP Billiton is one of the world's largest mining firms. It relies on various subsidiaries or vendors at each production stage. In 2016, the company began testing a blockchain developed by BlockApps and Consensys to track material movements of rock and fluid samples that are generated from vendors. The aim is to replace static spreadsheets with live data. | 2 | OECD (2017) |
| Provenance Martine Jarlgaard | The fashion designer Martine Jarlgaard partnered with Provenance, consultancy A Transparent Company, and London College of Fashion's Innovation Agency. Each step of the process—shearing at the British Alpaca Fashion farm, spinning at Two Rivers Mill, knitting at Knitster, and finally to Ms. Jarlgaard's studio in London—is registered and tracked on the blockchain via the Provenance app and the product's QR code or NFC-enabled label. | 4 | Forbes (2017) <br><br> Provenance <br><br> DHL (2018) |

| TABLE 4 – OTHER APPLICATIONS IN TRADE | | | |
|---|---|---|---|
| **Implementers** | **Activity** | **Stage** | **Links** |
| Singapore Hong Kong | In November 2017, representatives from Singapore and Hong Kong government agencies signed an MOU for the Global Trade Connectivity Network (GTCN), a proposed blockchain-enabled "information highway" joining the National Trade Platform of Singapore and the Trade Finance Platform of Hong Kong. The project anticipates further connections with the national platforms of Japan, South China via Shenzen, and Thailand. In 2018, the GTCN has conducted many pilots and is now in the process of scaling to an active live system. | 4 | Cryptovest (2017) <br> GTR (2017) <br> WCO (2018) |

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|---|---|---|---|
| Tokio Marine<br>NTT DATA<br>Corporation | In August 2017, it was reported that Tokio Marine & Nichido Fire Insurance, a property/casualty insurance subsidiary of Tokio Marine Holdings, and NTT DATA Corporation, a leading business and IT services provider, have successfully tested the first blockchain-based insurance policy for marine cargo insurance certificates | 4 | EconoTimes (2017) |
| SkuChain<br>NTT DATA | In January 2018, blockchain technology startup Skuchain and NTT DATA Corporation announced a partnership to develop a system that integrates blockchain with IoT and combines Skuchain's EC3 blockchain platform and NTT DATA's iQuattro platform. Before the announcement, Skuchain and NTT DATA successfully completed a proof-of-concept prototype with the Bank of Tokyo-Mitsubishi UFI, Ltd. and its supply chain in China. It continued to pilot projects in 2018. | 4 | Coindesk (2018)<br><br>NTT DATA (2018) |
| BASF<br>Quantoz<br>Ahrma | In July 2017, German chemical manufacturer BASF, collaborating with start-ups Quantoz and Ahrma, announced the creation of smart pallets to inform distributors about location and movement of chemical deliveries, as well as loading status and impact. The goal is to mitigate loss and unexpected damage during shipment. The collaboration would combine blockchain and IoT technology. | 1 | Coindesk (2017)<br><br>BASF (2017) |

# BIBLIOGRAPHY

Association of Banks in Singapore (ABS) and Hong Kong Trade Finance Platform Company Ltd. "Request for Proposal – Global Trade Connectivity Network." February 13, 2018. https://abs.org.sg/docs/library/gtcn-joint-release-(website).pdf.

Barclay, Eliza. "Most Americans Eager To Buy Seafood That's 'Sustainable'." NPR: February 12, 2013. https://www.npr.org/sections/thesalt/2013/02/11/171743185/most-americans-eager-to-buy-seafood-thats-sustainable.

Blockchain Review, The. "Ethereum White Paper Made Simple." Accessed: August 2018. https://blockchainreview.io/wp-content/uploads/2018/03/02.01._final_Ethereum-White-Paper-Made-Simple.pdf.

BlockchainHub. "Blockchains & Distributed Ledger Technologies." Accessed: August 2018. https://blockchainhub.net/blockchains-and-distributed-ledger-technologies-in-general/.

Churchill, John. "Can the cloud lift global trade?" Maersk: May 25, 2015. https://www.maersk.com/en/news/2018/06/29/can-the-cloud-lift-global-trade.

Ethereum. "Ether: The crypto-fuel for the Ethereum network." Webpage. Accessed: August 2018. https://www.ethereum.org/ether

Fersht, Phil. "The top 5 enterprise blockchain platforms you need to know about." Horses for Sources: March 16, 2018. https://www.horsesforsources.com/top-5-blockchain-platforms_031618.

Future of Fish. "Seafood Traceability: The Business Case for Better Data." April 9, 2014. http://www.futureoffish.org/blog/seafood-traceability-business-case-better-data.

Gerard, David. *Attack of the 50 Foot Blockchain: Bitcoin, Blockchain, Ethereum & Smart Contracts*. July 2017.

Hodal, Kate, Chris Kelly, and Felicity Lawrence. "Revealed: Asian slave labour producing prawns for supermarkets in US, UK." The Guardian: June 10, 2014. https://www.theguardian.com/global-development/2014/jun/10/supermarket-prawns-thailand-produced-slave-labour.

Hyperledger. "Hyperledger Quilt." Accessed: August 2018. https://www.hyperledger.org/projects/quilt.

IBM Blockchain. "IBM and Maersk Demo: Cross-Border Supply Chain Solution on Blockchain." March 25, 2017. https://www.youtube.com/watch?v=dcddYatMCGQ&feature=youtu.be.

IBM. "TradeLens Overview." Presentation. August 13, 2018.

Legal Geek. "#TBT World's First Blockchain Trade Finance Deal." February 12, 2018. https://www.legalgeek.co/read/first-blockchain-deal-wave/.

MAS (a). "Singapore and Hong Kong bolster FinTech ties with cooperation agreement." October 25, 2017. http://www.mas.gov.sg/News-and-Publications/Media-Releases/2017/Singapore-and-Hong-Kong-bolster-FinTech-ties-with-cooperation-agreement.aspx.

MAS (b). "Singapore and Hong Kong launch a joint project on cross-border trade and trade finance platform." November 15, 2017. http://www.mas.gov.sg/News-and-Publications/Media-Releases/2017/Singapore-and-Hong-Kong-launch-a-joint-project-on-cross-border-trade-and-trade-finance-platform.aspx.

Michail, Niamh. "Seafood shoppers place sustainability above price or brand." Food Navigator: July 13, 2016. https://www.foodnavigator.com/Article/2016/07/13/Seafood-shoppers-place-sustainability-above-price-or-brand.

MSC. "The MSC Fisheries Standard." Accessed: August 2018. https://www.msc.org/standards-and-certification/fisheries-standard.

Nelson, Paul. *Primer on Blockchain*. USAID: April 2018. https://www.usaid.gov/digital-development/digital-finance/blockchain-primer.

Provenance. "From shore to plate: Tracking tuna on the blockchain." July 15, 2016. https://www.provenance.org/tracking-tuna-on-the-blockchain.

Singapore Customs. "Global Trade Connectivity Network." Presentation. 2018.

Tan, Yao-Hua, Nicolas Buhmann, and Norbert Kouwenhoven. "CORE WP23 Global Trade Digitization (GTD) Platform Presentation." TU Delft, Maersk, IBM.

UNECE. "Introducing UN/EDIFACT." Accessed: August 2018. https://www.unece.org/cefact/edifact/welcome.html.

Visser, Candice and Quentin Hanich. "How blockchain is strengthening tuna traceability to combat illegal fishing." The Conversation: January 21, 2018. https://theconversation.com/how-blockchain-is-strengthening-tuna-traceability-to-combat-illegal-fishing-89965.

**TRADE FINANCE**

*BBVA & WAVE*
Fernandez Espinosa, Luz. "BBVA and Wave carry out the first blockchain-based international trade transaction between Europe and Latin America." BBVA: November 2017. https://www.bbva.com/en/bbva-and-wave-carry-first-blockchain-based-international-trade-transaction-europe-and-latin-america/.

Nelson, Paul. USAID: April 2018.

*Absa Group & Wave*
Kelly, Jemima. "Barclays says conducts first blockchain-based trade-finance deal." Reuters: September 7, 2016. https://www.reuters.com/article/us-banks-barclays-blockchain/barclays-says-conducts-first-blockchain-based-trade-finance-deal-idUSKCN11D23B.

*we.trade*
Condon, Mairin. "we.trade blockchain platform completes multiple real-time customer transactions." we.trade: July 3, 2018. https://we-trade.com/article/we-trade-blockchain-platform-completes-multiple-real-time-customer-transactions.

Nelson, Paul. USAID: April 2018.

*Infosys, Emirates NBD, and ICICI Bank*
ICICI Bank. "ICICI Bank on-boards over 250 corporates on its blockchain platform for trade finance." ICICI Bank: April 17, 2018. https://www.icicibank.com/aboutus/article.page?identifier=news-icici-bank-onboards-over-250-corporates-on-its-blockchain-platform-for-trade-finance-20181704141936142.

IFC. "Blockchain in Financial Services in Emerging Markets Part I: Current Trends." EMCompass Note 43: August 2017. https://www.ifc.org/wps/wcm/connect/0514f539-b97e-4d43-b2d1-e2cdc010ad54/EMCompass+Note+43+FINAL+8-21.pdf?MOD=AJPERES.

*HSBC, ING Bank, and Cargill*
Feferer, Rachel F. "Blockchain and International Trade." Congressional Research Service: May 14, 2018.

Hochfelder, Barry. "HSBC, Cargill successfully complete blockchain trade-finance transaction." Supply Chain Dive: May 15, 2018. https://www.supplychaindive.com/news/hsbc-cargill-blockchain-pilot/523554/.

*ING, Société Générale, ABN AMOR*
"Compelling results for Blockchain oil-trade test ING and Societe Generale Corporate & Investment Banking." ING and Societe Generale: February 22, 2017. https://cib.societegenerale.com/en/press-room/press-releases/press-releases-details/news/compelling-results-for-blockchain-oil-trade-test-ing-and-societe-generale-corporate-investment-banking/.

*AIG Inc., TradeIX, and Standard Chartered*
AIG, TradeIX, and Standard Chartered. "AIG and TradeIX Complete Blockchain-Enabled Trade Finance Transaction with Standard Chartered. AIG: October 5, 2017. https://www.aig.co.uk/content/dam/aig/emea/united-kingdom/documents/Press%20Release/aig-scb-trade-ix-press-release.pdf.

TradeIX. "Case Study: Receivable Finance." November 20, 2017. https://tradeix.com/case-study-receivable-finance/.

Wass, Sanne. "Standard Chartered and Siemens pilot blockchain-based trade finance guarantees in UAE." Global Trade Review (GTR): August 29, 2018. https://www.gtreview.com/news/fintech/standard-chartered-and-siemens-pilot-blockchain-based-trade-finance-guarantees-in-uae/.

*R3CEV*
Rizzo, Pete. "15 R3 Members Trial Distributed Ledger Tech for Trade Finance." Coindesk: August 10, 2016. https://www.coindesk.com/15-r3-members-trial-distributed-ledger-tech-trade-finance/.

*Bank of America Merrill Lynch, HSBC, and IDA*
Bermingham, Finbarr. "HSBC ready to do live trade finance transactions on blockchain." GTR: February 28, 2018. https://www.gtreview.com/news/fintech/hsbc-ready-live-trade-finance-transactions-blockchain/.

DHL. "Blockchain in Logistics." 2018. https://www.logistics.dhl/content/dam/dhl/global/core/documents/pdf/glo-core-blockchain-trend-report.pdf.

Hoareau, Guillaume. "Making Blockchain Real for Business: Demonstration of Blockchain Scenario Part II." IBM: November 2016. https://www-01.ibm.com/events/wwe/grp/grp308.nsf/vLookupPDFs/24943227/$file/24943227.pdf.

IFC. EMCompass Note 43: August 2017.

*Mizuho Bank*
Mizuho. "[FinTech] Mizuho Embarks on Project with R3 and Cognizant to Conduct Actual Trade Transactions Using Blockchain." April 26, 2017. https://www.mizuho-fg.com/release/20170426_2release_eng.html.


**SUPPLY CHAINS**

*Maersk and IBM*
DHL. 2018.

IBM. "Maersk and IBM Unveil First Industry-Wide Cross-Border Supply Chain Solution on Blockchain." March 5, 2017. https://www-03.ibm.com/press/us/en/pressrelease/51712.wss.

Nelson, Paul. USAID: April 2018.

Okazaki, Yotaro. "Unveiling the Potential of Blockchain for Customs." WCO Research Paper No. 45. WCO: June 2018. http://www.wcoomd.org/-/media/wco/public/global/pdf/topics/research/research-paper-series/45_yotaro_okazaki_unveiling_the_potential_of_blockchain_for_customs.pdf?la=fi.

*COMESA*
Barigaba, Julius. "Africa's first digital free trade area for rollout in 2018." National Institute for African Studies: August 1, 2018. http://africanstudies.org.uk/2018/01/09/africas-first-digital-free-trade-area-for-rollout-in-2018/.

COMESA. "Speech by Secretary General of COMESA Mr. Sindiso Ngwenya during the Opening of the 38th COMESA Council of Ministers." July 14, 2018. http://www.comesa.int/summit2018/2018/07/14/speech-by-secretary-general-of-comesa-mr-sindiso-ngwenya-during-the-opening-of-the-38th-comesa-council-of-ministers/.

Mbogo, Angeline. "Africa to Adopt Blockchain for New Digital Free Trade Area." BitcoinAfrica.io: February 28, 2018. https://bitcoinafrica.io/2018/02/28/africa-to-adopt-blockchain-for-new-digital-free-trade-area/.

*ZIM and Wave*
DHL. 2018.

ZIM. "ZIM's Groundbreaking Blockchain-Based Bill of Lading." November 20, 2017.
https://www.zim.com/news/press-releases/zims-groundbreaking-blockchain-based-bill-of-lading.

**TBSx3 (DP World Australia, DB Schenker, Hamurg Sud, and IUS)**
Landrum, Elizabeth. "DP World: Joint blockchain trial between Australia and China a success." American
Shipper: June 5, 2017. https://www.americanshipper.com/main/news/dp-world-joint-blockchain-trial-
between-australia-67728.aspx.

Logistics & Materials Handling. "DB Schenker, DPWA and Hamburg Sud join forces for blockchain trial."
June 2, 2017. https://logisticsmagazine.com.au/db-schenker-dpwa-and-hamburg-sud-join-forces-for-
blockchain-
trial/?mod=djemlogistics&utm_campaign=Logistics%2BWeekly&utm_medium=web&utm_source=Logisti
cs_Weekly_8.

**Mitsui OSK Lines and IBM**
Mitsui OSK Lines. "Demonstration Test of Blockchain Technology in Cross-Border Trade Operations."
December 12, 2017. https://www.mol.co.jp/en/pr/2017/17090.html.

Sundararajan, Sujha. "Japanese Shipping Giant, IBM to Trial Blockchain in Cross-Border Trade."
Coindesk: December 14, 2017. https://www.coindesk.com/japanese-shipping-giant-ibm-to-trial-
blockchain-in-cross-border-trade/.

**Modum and Swiss Post**
Alexandre, Ana. "New Trade Organization to Promote Blockchain Established in Switzerland."
Cointelegraph: June 13, 2018. https://cointelegraph.com/news/new-trade-organization-to-promote-
blockchain-established-in-switzerland.

Botton, Nicolas. "Blockchain and Trade: Not a Fix for Brexit, but Could Revolutionise Global Value
Chains (If Governments Let It)." ECIPE: January 2018.
http://ecipe.org/app/uploads/2018/01/ECIPE_PB0118_V3.pdf.

Modum. "Modum announces its cooperation with Swiss Post." April 23, 2018.
https://modum.io/news/modum-announces-its-cooperation-swiss-post.

**SUNAT and IBM**
SUNAT. *Resolution of Superintendence No. 178-2018.* July 24, 2018.
http://www.sunat.gob.pe/legislacion/superin/2018/178-2018.pdf.

Huaman Camayo, Maria Del Rosario. "Piloto GTD – Blockchain." SUNAT.
https://www.eiseverywhere.com/file_uploads/d55bb976558c73bd6d7f7d9612eaf7f2_S6SandraCorcueraS
antamaria.pdf.

**Korea Customs Service and Samsung**
Zhao, Wolfie. "Korea Taps Samsung's Blockchain Tech to Fight Customs Fraud." Coindesk: September
14, 2018. https://www.coindesk.com/korea-taps-samsungs-blockchain-tech-to-fight-customs-fraud/.

## TRACEABILITY

*Provenance*
Nelson, Paul. USAID: April 2018.

Provenance. July 15, 2016.

*Walmart and IBM*
DHL. 2018.

IBM. "IBM Announces Major Blockchain Collaboration with Dole, Driscoll's, Golden State Foods, Kroger, McCormick and Company, McLane Company, Nestlé, Tyson Foods, Unilever and Walmart to Address Food Safety Worldwide." August 22, 2017. https://www-03.ibm.com/press/us/en/pressrelease/53013.wss.

Kim, Kibum and Taewon Kang. *Does Technology Against Corruption Always Lead to Benefit? The Potential Risks and Challenges of the Blockchain Technology.* OECD Global Anti-Corruption & Integrity Forum: 2017. https://www.oecd.org/cleangovbiz/Integrity-Forum-2017-Kim-Kang-blockchain-technology.pdf.

Nelson, Paul. USAID: April 2018.

*BanQu*
BanQu. "Case Study." Accessed August 2018. https://banqu.co/case-study/.

PR Newswire. "BanQu Launches Trailblazing Partnership with Anheuser-Busch InBev to Revolutionize Supply Chain Transparency in Zambia." August 29, 2018. https://www.prnewswire.com/news-releases/banqu-launches-trailblazing-partnership-with-anheuser-busch-inbev-to-revolutionize-supply-chain-transparency-in-zambia-300703561.html.

*Everledger*
Botton, Nicolas. ECIPE: January 2018.

DHL. 2018.

Feferer, Rachel F. Congressional Research Service: May 14, 2018.

IBM and Consumer Goods Forum. "Tomorrow's Value Chain: How blockchain drives visibility, trust and efficiency." https://www-01.ibm.com/common/ssi/cgi-bin/ssialias?htmlfid=REW03029USEN.

Nelson, Paul. USAID: April 2018. https://www.usaid.gov/digital-development/digital-finance/blockchain-primer.

Pisa, Michael and Matt Juden. "Blockchain and Economic Development: Hype vs. Reality." Center for Global Development (CGD) Policy Paper 107: July 2017. https://www.cgdev.org/publication/blockchain-and-economic-development-hype-vs-reality.

***Responsible Cobalt Initiative***
Benton, Dale. "Daimler joins the Responsible Cobalt Initiative." Mining Global: April 26, 2018.
https://www.miningglobal.com/sustainability/daimler-joins-responsible-cobalt-initiative.

Cambell, Rebecca, Kirsti Massie, John Tivey, and Saghar Khodabakhsh. "Building a sustainable battery supply chain: Is blockchain the solution?" White & Case: June 27, 2018.
https://www.whitecase.com/publications/insight/building-sustainable-battery-supply-chain-blockchain-solution.

Lewis, Barbara. "Blockchain to track Congo's cobalt from mine to mobile." Reuters: February 2, 2018.
https://www.reuters.com/article/us-mining-blockchain-cobalt/blockchain-to-track-congos-cobalt-from-mine-to-mobile-idUSKBN1FM0Y2.

***Starbucks***
Kaplan, Deborah A. "Why Starbucks May Use Blockchain to Track Your Coffee Beans." ThirtyK: April 24, 2018. https://thirtyk.com/2018/04/24/starbucks-blockchain/.

Starbucks. "Starbucks to pilot 'bean to cup' traceability with new technology." March 21, 2018.
https://news.starbucks.com/news/starbucks-to-pilot-bean-to-cup-traceability.

***Dorae and Government of DRC***
PR Newswire. "Dorae Inc's Blockchain for Cobalt Live in Congo." March 28, 2018.
https://www.prnewswire.com/news-releases/dorae-incs-blockchain-for-cobalt-live-in-congo-678173513.html.

Stevens, Laurence M. "Firms invest in technology to track DRC minerals." African Mining Market: May 30, 2018. https://africanminingmarket.com/firms-invest-in-technology-to-track-drc-minerals/1054/.

***DHL and Accenture***
DHL. 2018.

Henderson, James. "DHL and Accenture working on blockchain-based pharma supply chain project." Supply Chain Digital: March 12, 2018. https://www.supplychaindigital.com/technology/dhl-and-accenture-working-blockchain-based-pharma-supply-chain-project.

***BHP Billiton***
Kim, Kibum and Taewon Kang. *Does Technology Against Corruption Always Lead to Benefit? The Potential Risks and Challenges of the Blockchain Technology.* OECD Global Anti-Corruption & Integrity Forum: 2017. https://www.oecd.org/cleangovbiz/Integrity-Forum-2017-Kim-Kang-blockchain-technology.pdf.

***Provenance and Martine Jarlgaard***
Arthur, Rachel. "From Farm To Finished Garment: Blockchain Is Aiding This Fashion Collection With Transparency." Forbes: May 10, 2017. https://www.forbes.com/sites/rachelarthur/2017/05/10/garment-blockchain-fashion-transparency/#8a92a8474f39.

DHL. 2018.

Provenance. "Increasing transparency in fashion with blockchain." Webpage. Accessed: August 2018. https://www.provenance.org/case-studies/martine-jarlgaard.

**OTHER APPLICATIONS**

*Singapore and Hong Kong*
Antonovici, Anatol. "Japan, Singapore Start Blockchain Pilot to Improve Trade Links." Cryptovest: December 7, 2017. https://cryptovest.com/news/japan-singapore-start-blockchain-pilot-to-improve-trade-links/.

Bermingham, Finbarr. "Hong Kong-Singapore blockchain trade platform to go live in 2019." GTR: November 15, 2017. https://www.gtreview.com/news/asia/hong-kong-singapore-blockchain-project-to-go-live-in-2019/.

Okazaki, Yotaro. WCO: June 2018.

*Tokio Marine and NTT DATA*
EconoTimes. "Tokio Marine, NTT DATA successfully test blockchain-based cargo insurance certificates." April 24, 2017. http://www.econotimes.com/Tokio-Marine-NTT-DATA-successfully-test-blockchain-based-cargo-insurance-certificates-656880.

*SkuChain and NTT DATA*
Monahan, Jay. "Is Blockchain Ready for Primetime?" NTT DATA: March 2, 2018. https://us.nttdata.com/en/blog/2018/march/is-blockchain-ready-for-primetime.

Sundararajan, Sujha. "Skuchain, NTT Data Partner on Blockchain Supply Chain Venture." Coindesk: January 24, 2018. https://www.coindesk.com/skuchain-ntt-data-partner-on-blockchain-supply-chain-venture/.

*BASF, Quantoz, and Ahrma*
BASF. "'Steve Benz' wanted – BASF works with digital start-ups with visionary ideas for the mobility industry." July 25, 2017. https://www.basf.com/documents/corp/en/news-and-media/news-releases/2017/07/P277e_Startup%20Autobahn.pdf.

Zhao, Wolfie. "German Chemical Company Pilots Supply Chain Blockchain." Coindesk: July 28, 2017. https://www.coindesk.com/german-chemical-company-pilots-supply-chain-blockchain/.