STANDALONE REPORT

GLOBAL STANDARDS MAPPING INITIATIVE 4.0
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SUPPLY CHAIN

GLOBAL BLOCKCHAIN BUSINESS COUNCIL

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GSMI 4.0 IN-DEPTH REPORT

SUPPLY CHAIN

EXECUTIVE SUMMARY

Most people didn't really focus on or even take note of what is referred to as the global supply chain until the Covid pandemic, when they weren't able to get goods that had always been available to them, virtually instantly. The global supply chain is actually made up of millions of entities that make, buy, sell, move, or, in the case of entities like customs organizations, even clear items to move out of or into a country. We will go more deeply into this throughout this document, but for now let's start with what would initially appear to be a very simple example:

Maria ordered a birthday present online

A simple online order can be much more complex than it appears.

- If it actually comes from a different country, it needs to clear customs.
- It may take much longer than anticipated to ship, so it wouldn't be delivered until after the birthday party.
- Because of the delay, she'd have to buy a replacement birthday present locally.
- Now she needs to work through the details to return the original present.

Now, a simple online purchase has potentially turned into an ordeal that is requiring Maira to jump into the details of cross-border movement.

- It took a dozen or more steps, and multiple entities, to get the shipment to Maria, which she had no visibility of.
- It also had to clear customs, which includes documentation she was unaware of.
- Now to return the birthday present and get her money back, she has to reverse a process she didn't know even existed.

Ultimately, stating that 'Maria orders a birthday present online' gets us to 50+ steps along the way, with multiple underlying processes and corresponding data points.: If and when she decides to return her order, a reverse supply chain process retraces all these steps, working through all the details of the same complex, multi-step, and multi-party process backwards.

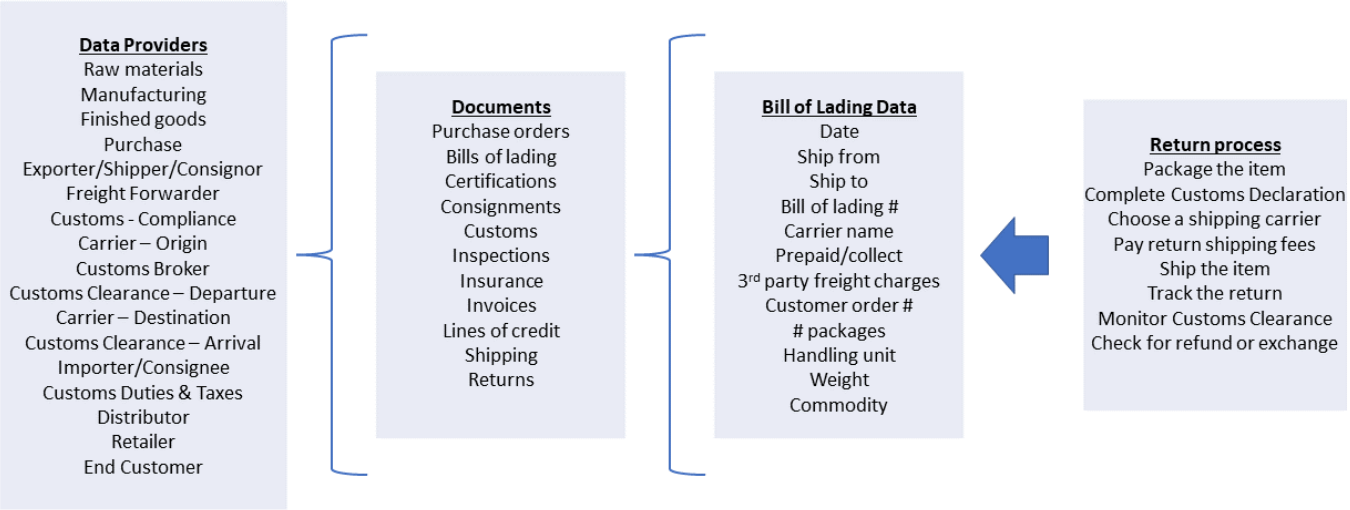


Figure 1: Complexity of today's global supply chain

As shown in the image above, the complexity of the global supply chain highlights a need for harmonization of processes and alignment of stakeholders. Beyond digitizing global supply chains, we need open-source standards to facilitate collaboration and reduce frictions. For digitization to scale we need a common data language and standards that all can use whether the largest companies, or the smallest.

This paper discusses the state of global supply chains today, defines the problems, and outlines solutions as enabled by emerging technologies to foster a Web3-enabled global commerce built on common standards. We feature specific business use cases of technology solutions, and ultimately emphasize the importance of common standards as a key underlying factor.

THE GLOBAL SUPPLY CHAIN

Global commerce involves multiple players, jurisdictions, and processes. The 'global supply chain' today refers to the intricate network of literally millions of interconnected organizations, processes, and resources involved in producing and delivering goods and services on a global scale. A typical example could span multiple countries and continents, with each participant playing a specific role in the production, distribution, and delivery of products to end consumers. This network of stakeholders collectively converts basic commodities or raw materials (upstream) into finished products (downstream) for delivery to end customers, with financial transactions and data being exchanged at each stage.[1]

Global supply chains encompass various stages and entities, including:

SOURCING	Acquiring raw materials, components, or services from suppliers around the world
MANUFACTURING	Transforming raw materials and components into finished products
DISTRIBUTION	Storing, transporting, and managing inventory throughout the supply chain
CLEARANCE BY REGULATORY AND CUSTOMS AUTHORITIES	Government agencies responsible for enforcing trade regulations, tariffs, and customs procedures, for both export and import into each country involved
RETAILING	Selling products to end consumers through various channels, such as physical stores, e-commerce platforms, and more

Every step of these processes has documentation to establish necessary checks and balances including movement, payment, and applicable Customs duties and taxes.

Global supply chains are essential for virtually all industries, enabling companies to access cost-effective resources, expand their markets, and optimize production processes. However, they also introduce complexities and challenges, such as logistical issues, regulatory compliance, and the need for risk management.

This all started with 'trade' by the Phoenicians, the Indus Valley trade, Egyptians, Silk Road, and Romans, as far back as 15,000 BCE ('Before Common Era'). Methods of movement were limited to the tools and innovations available at the time, including ships for maritime trade, overland caravans for land-based routes, and river transport, where applicable. The choice of transportation method depended on geographical factors, available infrastructure, and the nature of goods being traded. In the same way, supply chains today are shaped by the technology available which shapes all facets of the lifecycle of the physical movement of goods, records of those movements, and corresponding transactions.

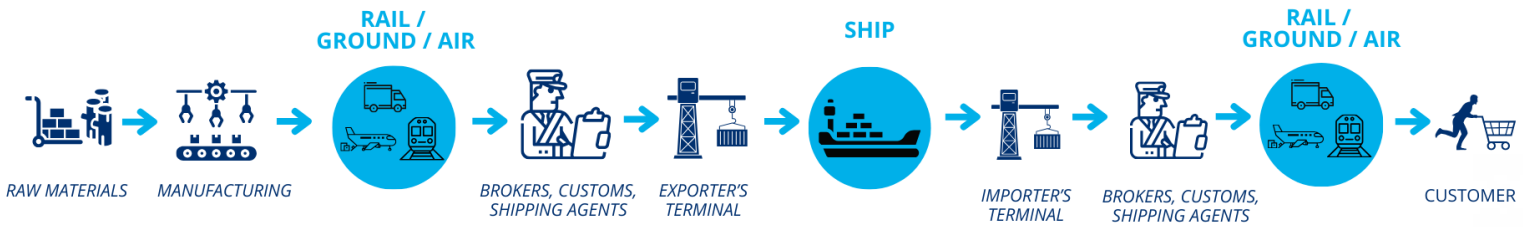
Modes of Transportation

'Movement' of goods being traded gets us to 'mode' (initially, overland caravan or ship, and, later, rail, road, air, etc.), and as additional modes were developed, especially with highways and air movement, we quickly get to speed. Finally, once multiple speed options exist, and increased technology like the internet, deeper fragmentation has occurred to create Business-to-Business (B2B), Business-to-Consumer (B2C), and other similar areas of focus and types of commerce.

Global supply chains have been foundational to the millennia of human civilization, and they are continuing to evolve today with technology and innovation that enable different modes of transportation. Today, the main modes of transport are ship, rail, ground, and air, listed in order of speed. The most complex scenario actually includes multiple modes, known as intermodal or multimodal, in which two or more modes of transportation are involved to ship a package from its point of origin to its final destination.

- **Ship –** Ships are used for transporting goods over water, including oceans, seas, rivers, and canals. They are especially efficient for long-distance and bulk cargo transport. Ships typically are the slowest and least expensive mode.
- **Rail –** Rail transportation involves the movement of goods on railroad tracks using trains. It is known for its reliability and cost-effectiveness for land-based, long-distance transportation.
- **Ground –** Ground transportation includes movement by road (trucks and vehicles). It is versatile, used for both short-distance and regional transportation of goods on land.
- **Air –** Air transportation relies on aircraft to carry goods quickly over long distances. It is known for speed and is often used for high-value or time-sensitive cargo. Increasingly, drones will likely play a larger role in air transportation. Air is typically the fastest and most expensive mode.
- **Intermodal/Multimodal -** Intermodal shipping is the transportation of freight using two or more modes. The concept was brought about in the mid 20th century through the development of modern containerization. As standards were developed for container sizes and shapes, it scaled beyond ships to include rail and ground movement. Intermodal freight can reduce costs and handling on cargo, and is more eco-friendly, but is also much more complex due to multiple entities each having their own processes and requirements.

Figure 2: Modes of transportation



Types of Commerce

The notion of "business-to-business" (B2B) and "business-to-consumer" (B2C) in commerce began to gain prominence with the rise of modern industrialization and the development of mass markets in the 19th and 20th centuries. These distinctions became more pronounced as economic structures, trade practices, and technology evolved.

- **Business-to-Business (B2B) – Late 19th century onwards –** The growth of industrialization and the expansion of manufacturing industries led to increased trade between businesses. Companies began to specialize in producing goods and services for other businesses rather than solely for consumers.

- **Business-to-Consumer (B2C) – Late 19th century onwards –** With more significant distinctions in the mid-to-late 20th century, mass production, marketing and advertising strategies emerged, leading to the development of consumer markets. The advent of the internet and e-Commerce in the late 20th century further transformed various types of commerce, leading to even more distinctions in these categories.

- **Other categories –** Business-to-Government (B2G), Business-to-Business-to-Consumer (B2B2C), Business-to-Employee (B2E), Consumer-to-Consumer (C2C), Consumer-to-Business (C2B), Business-to-Government-to-Government (B2G2G – national level), Government-to-Government (G2G – international level), and Business-to-Business-to-Government (B2B2G – Traders/Regulatory), etc. have emerged with the increased sophistication of supply chains involving multiple parties.

Parties Involved

There are millions of entities involved in global commerce, across 200+ countries, conducting business in thousands of languages. In addition, each transaction requires multiple documents (could be up to 100 or more), making the end-to-end process extremely complex.

- **Manufacturers –** Produce goods and products for the global market, playing a central role in the supply chain by creating the physical items that are bought and sold.

- **Wholesalers –** Facilitate the distribution of goods by purchasing large quantities from manufacturers and selling them in smaller quantities to retailers, helping products reach a broader market.

- **Transport Companies –** Ensure the physical movement of goods across borders and regions, using various modes of transportation as defined above, to connect producers and consumers.

- **Logistics Providers –** Manage the movement and storage of goods, optimizing supply chains to ensure efficient, timely, and cost-effective delivery.

- **Financiers –** Provide the capital and financial services necessary for businesses to operate and expand globally, offering funding, loans, and investment opportunities.

- **Insurers –** Mitigate risks associated with global commerce, offering coverage for cargo, shipping, and other business risks to protect against potential losses.
- **Payment Providers –** Facilitate international financial transactions, enabling secure and efficient cross-border payments between buyers and sellers.
- **Retailers –** Sell products directly to consumers, offering a wide range of goods and services through various channels, including brick-and-mortar stores and e-Commerce platforms.
- **Regulators –** Oversee and enforce laws and regulations related to international trade, ensuring fair competition, consumer protection, and adherence to trade agreements.

Data Exchange

As the multiple stakeholders that make up the global supply chain convert basic commodities or raw materials (upstream) into finished products (downstream), and ultimately deliver them to end customers who will utilize them, data is exchanged at every stage. Flows of information include records of the trajectory of inputs and finished products, financial transactions, and personal information from customers and all stakeholders involved carrying out activities.[2]

The following image illustrates the flows of information, represented as arrows, between the typical parties involved in international commerce, as inputs become transformed into finished goods and transported from shippers to final consumers.

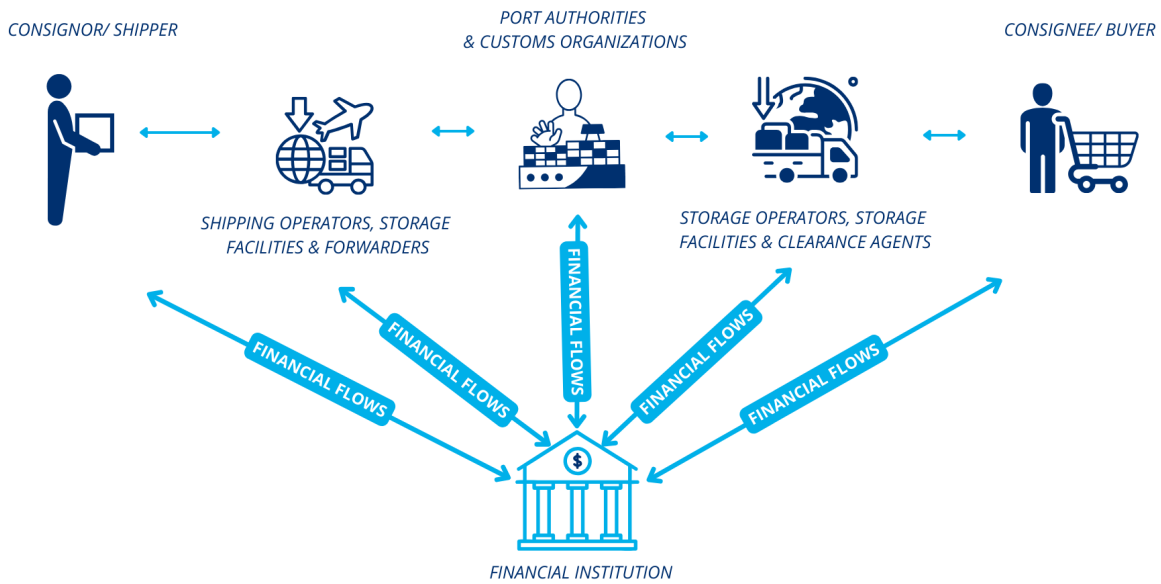


Figure 3: Data exchange across the supply chain

Documentation & Trust

A key part of the story of trade, leading to what we now think of as global commerce, is documentation, which emerged as a proxy to ensure trust. In the context of global digital trade, trust requires verifiable trust of the physical, financial, and informational exchanges. In all cases, trust requires the presence of a human subject (or a trustor) who forms a trust perception about an object trust (or trustee) in a specific context. A human may trust another individual, group, organization, or society; humans may also trust a thing, such as a policy or technology.[3]

Historically, all examples previously covered used some type of documentation for trade contracts, letters of credit, manifests, etc. By 3,000 BCE, the first customs and regulatory roles appeared in Mesopotamia. Since then, many of the underlying processes have been in place for as long as several thousand years, relying on a form of documentation to verify information.

Documentation, starting originally with clay tablets, and then papyrus, and and eventually paper, allowed some level of subjective 'trust' to be built into the movement of goods, such that, when something was being moved for the past several thousand years, the person/entity moving the items had some type of documentation to address custodianship, ownership, value, etc.

Today, current technologies are allowing us to digitize these traditionally document-driven processes, and digitalization and emerging technologies will allow us to completely rethink not only entire global movement processes, but how to significantly streamline those processes. These technologies will, for the first time, allow us to move from subjective trust to objective trust, where we know the true source of the data.

Current and emerging technologies allow virtually all paper documents to be replaced, and, once digitized, the data can be analyzed and optimized, significantly reducing delays that currently exist at borders and when changing hands between the many parties involved in global commerce.

Peer-to-peer technology, like blockchain, will allow digital 'trust' to be built into new solutions. Emerging technologies allow us to completely rethink processes that may have been used for millennia. The result will be significantly reduced friction (paper, delays, resources) in these processes, which across borders, has a major impact on global commerce. Increasingly, global supply chains are also expected to capture data to make sure goods were produced with fair labor practices and with environmentally sustainable practices.

PROBLEM & SOLUTION

Problem

Today there is no end-to-end visibility into the supply chain lifecycle. The magnitude of this problem can be seen with major global concerns such as undetected forced labor scenarios and mislabeled products that mislead consumers (e.g., murkiness in the beef supply chain, where not only the origin but also the nature of the product have been misrepresented). This section covers those undesired aspects of the global supply chain, from the past hundreds, and in some case thousands of years, in the context of the following: What failed in the past? What problems can be addressed? What are the implications?

Global supply chains today are not harmonized.

Virtually none of the processes in global commerce today were designed with a 'global' focus, so it should not be surprising that global supply chains are not harmonized. In this case, 'harmonized' means interoperable, with a common data language and open data standards. Lack of standardization causes myriad complexities and difficulties, where inconsistencies in formats and access to data lead to inefficiencies and unnecessary friction, including massive amounts of paperwork, resources, and delays. The world experienced this in real time during the COVID-19 pandemic, when many everyday products suddenly became unavailable and supply chains experienced massive bottlenecks.

DATA SILOS & INCONSISTENT DATA STANDARDS

With multiple stakeholders collecting massive amounts of data throughout the supply chain in disparate ways, a range of inefficiencies can be attributed to data silos and complexities of information flow. While data on physical and financial flows across every step of the supply chain remains inconsistent, it can be very difficult (if even possible currently) to create a holistic view of the end-to-end journey from raw material to finished product. Data silos and inconsistent data standards are estimated to cost the global supply chain **$1.1 trillion** each year.[4]

Inconsistent records across trading partners can also trigger disputes, while loopholes can enable counterfeit and sub-par products to slip through the supply chains. Missing paperwork and disparate records can also lead to assets getting lost or stolen, causing shipping containers to be delayed in ports, just as one example.

Moreover, data silos can hinder communication and collaboration across stakeholders. Not only do parties across the supply chain often create and store data in their own separate formats, they may also share it only with the next partner in the supply chain to create a limited "one step up, one step back" visibility that makes it very difficult to have a holistic view of the end-to-end trajectory of a product.

As a result, in cases where a retailer must respond to a food recall, for instance, the task of tracing produce on the shelves to the farmers who grew it can be a daunting task taking days or even weeks.

LACK OF TRUST

In order to build trust into the system, we operate in a complex, often cumbersome and document-laden process, in place for centuries, even millennia. Most of that trust has been artificially created within these processes as a system of documents and signatures, and, in some cases 'chain of custody' scenarios. Manual processes bring time consuming documentation and revisions procedures. Many of these processes and requirements have essentially been created as proxies for trust.

In only a small subset of the global commerce space, a single delivery carried out by a truck to fulfill a single invoice can involve hundreds of data elements. Moreover, additional charges for wait times, layovers, and specialized services (e.g., liftgate services, inside delivery, temperature-controlled services, handling of hazardous materials, unloading, etc.) can add to the amount and complexity of data far beyond basic shipping information and freight description.

Often customers dispute the charges presented to them by freight carriers. In the US transportation industry, which amounts to $8 trillion annually, an average of $140 billion in invoices are disputed daily, with disparate accounting records among different stakeholders.[5]

It is estimated that up to 38% of invoices are overpaid, as a cheaper alternative for enterprises than investigating unexpected charges. Other indications of lack of trust include disputes over the condition of freight and compliance with specialized requirements for certain supply chains, such as keeping items at the proper temperature throughout the entire route.

Counterfeiting in particular is a major concern. For instance, in 2019, the global fake foods market was estimated at **$449 billion**, or 2.5% of all global trade – greater than the entire economy of Ireland.[6] The COVID-19 pandemic further aggravated the concern of counterfeiting, particularly for vaccines. Counterfeit medicines have been on the rise globally, with nearly 6,000 pharmaceutical crime incidents recorded by PSI in 2021 – a rise in 38% from the prior year, and a new 20 year high.[7] In addition to counterfeit products as a concern, goods may be unsafe or contaminated.

Finally, vulnerability to fraud can lead to security concerns due to lack of transparency. This can lead to poor collaboration between partners in the supply chain, where incentives toward dishonest behavior may prevail. Unethical and unsustainable practices can also go unchecked.

OUTDATED PROCESSES

Digitization alone does not solve the underlying issues that come from outdated processes, which to lead to a wide range of inefficiencies. Friction in supply chains, caused by document-laden processes, is estimated to cost the global supply chain **$1.2 trillion** each year.[8] It is difficult to align incentives among stakeholders across common global supply chain processes (e.g., export clearance, import clearance), and also across industry-specific processes (e.g., batch traceability for pharmaceuticals).

The sheer number of intermediaries and lack of openly available, harmonized data can lead to significant logistical and operational challenges, alongside outdated and inconsistent infrastructure. The average international trade transaction involves dozens to hundreds of original documents, copies, and entities to send them to, often involving cumbersome manual processes.[9] Sourcing raw materials at a global scale, and shipping, and any stage along the supply chain becomes highly, and unnecessarily, complex.

Often delayed payments and verifications lead to a wide range of friction stemming from disparate and long reconciliation times, lack of clarity on how items are transported, and lack of data. The complexity of payments in shipping is best exemplified by the payment of truck drivers. One challenge facing ground transportation drivers is that they do not get paid until a shipment is delivered, and they may have to wait weeks, or even months, to receive payment. This creates cash flow challenges, so entire business models have emerged to pay these operators 70%-90% of their invoiced amount at an earlier point in time, which introduces yet another party in the process, with its own set of complex systems. Drivers can choose to be paid – albeit less than what they are owed – more quickly, or they must wait much longer to receive the full amount.

Figure 4: Each stakeholder faces a particular set of challenges along the supply chain

BUYER/CONSUMER

- It is very difficult to have an accurate view of booking status on shipments, or estimated delivery schedules. This can lead to multiple backorders, with no transparency on stock.
- Often products remain stuck at customs, with no visibility on why. This requires follow-ups and may be caused by a single entry in a document being mis-coded.

SELLER/ SHIPPER

- No single global back office for managing shipment processes exists, as each exporting and importing country has different document standards and formats.
- Responsible for updating customers on the status of their shipments, requiring integration with multiple forwarders and carriers. Tracking each shipment at the stock keeping unit (SKU) level is often difficult, costly, and involves manual processes.

FORWARDERS

- Evolving global regulations on documentation are difficult to comply with in a timely matter, requiring coordination with shippers prior to shipments taking place, leading to last minute rush episodes.
- To avoid clearance issues, compliance checklists must be thoroughly verified, which is often highly cumbersome.

CUSTOMS

- Deviation or complexity in declared value, goods type, and origin can hinder pre-arrival clearance.
- While technology for true value reconciliation exists, there is still little know-how, and hence recognizing scanned documents is still inefficient.
- There are no periodic updates of validated information about the Shippers and Consignees that can be used to understand the risks.

LACK OF INCLUSION & RESILIENCE

Foreseeable and unanticipated disruptions in the supply chain can have significant repercussions. The world immediately discovered just how fragile global supply chains were during COVID-19, and other examples could be natural disasters or other catastrophes. These systems can be far from resilient with seemingly minor events taking place to start a domino effect with major repercussions on the ability to deliver of essential products to those who need them most.

Global commerce, with its cumbersome processes and siloed data as it istoday, can make it very difficult to access global markets for small and medium enterprises, particularly in economically disadvantaged areas. This affects those players who would most benefit from accessing global markets. Roughly one in five adults, or around **1.7 billion** people in the world still do not have access to formal banking services, with women more likely to be unbanked than men. Lack of access to mainstream marketplaces can perpetuate global inequalities, which often fuel geopolitical conflict.

Solutions

With Web3/blockchain and emerging technologies, along with the desire and ability to create common and open data standards to reduce friction in existing processes, there is a – much – more efficient and digitized global supply chain in our future. This is not a process improvement exercise, where we are essentially trying to improve processes that in some cases are literally hundreds to thousands of years old. Today's emerging technology will allow us to completely rethink and reinvent existing processes, making life much easier for Maria making everyday purchases, as opposed to the state of supply chains today.

This section discusses the following key elements toward optimizing supply chains:

- Harmonization
- Common language and standards
- Trust through data
- Better processes
- Resilience

HARMONIZING GLOBAL SUPPLY CHAINS

Harmonization is at the core of every solution to address the issues mentioned in the section above, to reduce friction across the life cycle. This requires reimagining a new model for supply chains that are efficient and resilient.

The attributes of blockchain technology, in convergence with other emerging technologies, can have numerous benefits across several solutions that ultimately are pointed toward harmonizing supply chains at a global level. First, blockchain allows participants to store digital records of information, exchange that information directly among participants, and abide by common business rules (e.g., smart contracts, standards, etc.).

> **Interoperability** is key, where open data is fundamental for scale. A new model leveraging emerging technology can enable a pro-competitive coopetition to increase the available opportunities to all stakeholders with increased collaboration and alignment.

COMMON LANGUAGE AND SHARED OPEN STANDARDS

Consistency for the financial and physical movements of data is key. Shared records that blockchain technology allow can be revolutionary. The need for interoperability in the blockchain space goes beyond connecting multiple blockchains, but also implies the ability to integrate with existing systems. Shared data can streamline processes, reducing time and paperwork required do complete tasks. Open standards enable interoperability and ease of communication among devices and systems, toward more efficient use of existing resources.

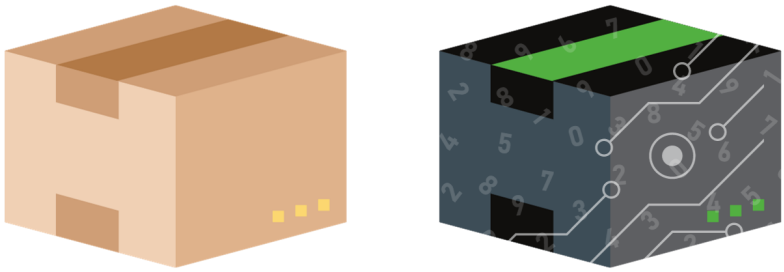
Open data can also enable a single source of trust for vendor verification, stakeholder authenticity, and authenticity of products. For instance, a public key infrastructure to verify digital signatures or zero-knowledge proofs can increase trust in authenticated evidence on physical and financial flows. In turn, developers of digitized solutions can also quickly adapt to changing circumstances and conditions, leading ultimately to faster development, better applications, and greater trust.

Shared invoices, for instance, can greatly reduce disputes. The disputed invoicing problems mentioned above in the context of truckers can be solved by creating one shared version of the invoice, managed with a smart contract, and integrated with IoT devices that can monitor the temperature and location of freight, as applicable. When freight carriers can move to a shared invoice managed with smart contracts using blockchain technology, which can connect to IoT data, invoice disputes can fall from as high as 70 percent to as low as under 2 percent. Invoices can also be finalized more quickly – such as within 24 hours instead of days, weeks or longer. Moreover, with costs reductions for both parties in a commercial exchange, relationships can also be improved.

Emerging technologies, such as blockchain, enable an unprecedented level of transparency, allowing an end-to-end view of the status of a shipment. The concept of a 'digital twin' will be used by industry to model opportunities in a number of areas, and, with tokenization, representations of data or value on a blockchain can be exchanged and new value created. Self-sovereign identity will also be foundational with these emerging technologies. 'I am who I say I am' is a dramatic improvement over legacy paper-driven processes.

As physical and digital worlds are colliding such that physical and digital information flows alongside in parallel, the opportunities of digital twins for global supply chains highlight how the information about a package may be as important than the shipment of the package itself.

Figure 5: Digital twins for packages



PHYSICAL PACKAGE

BLOCKCHAIN-TOKENIZED DIGITAL TWIN

Current technology allows us to create a 'digital twin' of virtually anything, and in the context of the global supply chain, it becomes possible to essentially clone the data from all packages moving around the world, along with many other applications. There will still be a physical movement from point 'A' to point 'B,' but having a digitized version of that will streamline a wide range of activities, from crossing a national border to creating virtual supply chains where efficiencies can be modeled for improvement. All of this allows opportunities for analytics, optimization, and both predictive models ('What -will- happen?') and prescriptive models ('How can we -make- it happen?') to enhance and streamline existing, and, in some cases, archaic processes. Such a digitized process can significantly reduce friction across borders (e.g., paper, delays, resources, etc.). True paperless trade will transform global supply chains and customs processes, disrupting business models that are currently reliant on multiple 'middlemen.'

Figure 6: End to End Supply Chain Matrix Subset Example

	Process
	Raw materials
	Manufacturing
	Finished goods
	Purchase
Movement	Exporter/Shipper
Movement	Freight Forwarder
Movement	Customs Compliance
Movement	Carrier - Origin
Movement	Customs Export Docs
Movement	Customs Broker
Movement	Customs Clearance - Departure
Movement	Carrier - Destination
Movement	Customs Clearance - Arrival
Movement	Importer/Consignee
Movement	Customs Duties & Taxes
Movement	Distributors/Retailers
Movement	End Customer

EFFICIENCY WITH BETTER PROCESSES

Updating current models to harmonize global processes is the essence of the "true north" to which global supply chains are pointing toward, as enabled by emerging technology. Blockchain and emerging technologies allow us to completely rethink systems and processes that weren't originally built with digital/ paperless and trusted systems in mind. Processes centered on sharing open data and common standards are fundamental.

These processes will be redesigned with digitalization in mind, ensuring objective trust is built into future systems, not only significantly streamlining many of these processes, but also minimizing the friction that has always existed in these processes to date. A streamlined and paperless supply chain framework can provide a full end-to-end life cycle view of the whole supply chain, as well as subsets of the full lifecycle.

Technology allows users to hold a digital asset that represents value, and transfer the digital asset, as a replacement to the historical model of a paper data record. Digital records on a blockchain will consist of information captured in a standardized format. Transfer of information directly among different parties without intermediaries increases transparency and reduces costs, besides having the ability to verify information and authenticity of the publisher of information regarding the legitimacy of players involved and goods produced & shipped. Blockchain technology provides an opportunity to create seamless information exchange between various parties, where information and trust can be established. Peer-to-peer interactions can reduce costs and streamline processes, allowing feedback loops from top down and bottom up.

PUBLIC & PRIVATE MODELS FOR SUPPLY CHAIN LIFECYCLES

Broadly speaking, a private blockchain prioritizes controlled access and confidentiality among a select group of companies and participants in a network, while a public blockchain emphasizes transparency and trust across a broad network of participants. The choice between the two depends on the specific needs and objectives of the supply chain participants.

In a private (also known as a 'permissioned') blockchain, normally a consortium of companies involved in a specific supply chain (e.g., manufacturers, distributors, retailers, etc.) operates the network. They maintain control over who can participate and what data is openly visible. Each participant has a designated role, and sensitive pricing or proprietary information is kept confidential.

In a public blockchain, multiple stakeholders in a global supply chain use a shared, transparent ledger to track the movement of goods. Any participant can join the network, view the entire transaction history, and validate transactions. For instance, consumers can scan a QR code on a product and see its entire journey from the manufacturer to their hands. Benefits of a public blockchain include transparency, immutability of records, and decentralization.

To scale globally, the shared transparent ledger of a public blockchain must also address confidentiality while preserving the benefits of transparency.

Figure 7: Public vs. private models for supply chains

Public blockchains	Open to anyone to update and view with full access. For instance, a supply chain ledger for a retail brand would be viewable by anyone in the network.
Private blockchains	Permissioned model restricted to authorized set of participants to authorize updates and make changes. For instance, industry specific ledgers with payment contracts may restrict sensitive data. In the enterprise sector, ledgers may be shared between a parent company and subsidiaries with restricted access.

TRANSPARENCY

Transparency doesn't mean everything is visible to everyone in the network, or blockchain and emerging technologies would simply not scale because no one would (or should) share confidential information such as intellectual property, pricing information, etc. There are also laws such as the EU's GDPR (General Data Protection Regulation), which introduce obligations such as 'the right to be forgotten.' GDPR would require administrators to comply with requests such as making changes or even remove records from a ledger. If I have the right to be forgotten, how can that take place if the data on a blockchain is immutable? The answer is, it can't when sensitive or personal informational is recorded directly on the ledger. This is the same reason why private information will be kept behind a firewall. On a blockchain, when information is recorded in a pseudonymous format through encryption mechanisms, it can be made available upon request to authorized parties that receive an anonymized link to the underlying data.

Transparency in the reference around blockchain, Web3, and broader emerging technologies, means creating a trustworthy, accountable and visible environment for transactions and processes along the supply chain lifecycle. For public blockchains to scale globally, technologies like zero-knowledge proofs, permissioned data access, control mechanisms, and keeping private information off-chain will all likely play a key role.

TRADELENS

While blockchain and emerging technologies have the potential to be transformative for global commerce, not all are created equal. TradeLens is an early example of a deployment on a permissioned blockchain, launched by Maersk's GTD Solution division in collaboration with IBM. This was a business model attempt to digitize and simplify global supply chains through an electronic shipping ledger that would track cargo shipments from origin, ports, overseas locations, and, ultimately, final destinations.

While the business model did not work for multiple reasons (high costs, broad scope, significant system integrations and consulting services, and unwillingness among key players and competitors to share data they considered business sensitive), the belief is that a public version of a blockchain solution for supply chains can still scale with open data standards, and, assuming confidentiality can be managed, as discussed in the 'Transparency' section.

RESILIENCE

Transparency and open data also make supply chains more resilient, able to adapt and respond to unexpected events and disruptions, and able to recover from negative consequences by maintaining the continuity of essential operations and functions. Connectedness is key to resilience, and the attributes of blockchain technology can enable an unprecedented level of visibility into potential bottlenecks across the supply chain. Providing organizations in a supply chain with the ability to be predictive and proactive, rather than reactive, in terms of risk management, can greatly decrease the severity of an unwanted event before it happens. Ultimately this can save money, reduce the stress of managing these situations, and avoid compliance violations that can damage the reputation of companies and organizations.

In addition, a decentralized and peer to peer system can facilitate access to global markets and business opportunities for smaller businesses and less developed geographical regions, which would support their global competitiveness. Increased inclusion of entities can also mitigate the impacts of strained supply chains, providing additional access to suppliers.

REAL WORLD USE CASES

Successful real-world applications of blockchain technology for the global supply chain are already addressing the multiplicity of issues emanating from a lack of harmonized supply chains, connecting various disjointed steps along the way, and ultimately facilitating outcomes for everyday individuals like Maria above, who buy and sell items consistently.

Provenance (authenticity/pedigree) is key in this context, where the benefits of recording and sharing provenance data can provide tremendous value across industries. In a 2020 report, economists at PwC identified provenance as the top application of blockchain technology that is driving adoption and has the potential to yield the most economic value. The potential boost to global GDP by 2030 was estimated to be US$962 billion.

With reliable provenance data, organizations can also demonstrate that their products are environmentally friendly, and produced in a socially responsible way. This is increasingly relevant with upcoming forced labor compliance rules, where shipments will be halted at customs upon the mere suspicion of involving forced labor at any point across the supply chain.

These applications are deploying Web3 technology to connect multiple exporters and importers to participate in a larger connected ecosystem where commercial interactions can take place. A technology platform that can validate a shipment, including all its parts and inputs, can optimize and harmonize the process for all participants in this ecosystem – with benefits ranging from improved resilience, authenticity, security and privacy, and interoperability.

By increasing efficiencies, reducing costs, and expanding market opportunities, blockchain technology can foster coopetition among traditional competitors, where collaborative practices can improve outcomes for all entities, even traditional competitors, and can do so in a pro-competitive way, to the benefit of all.

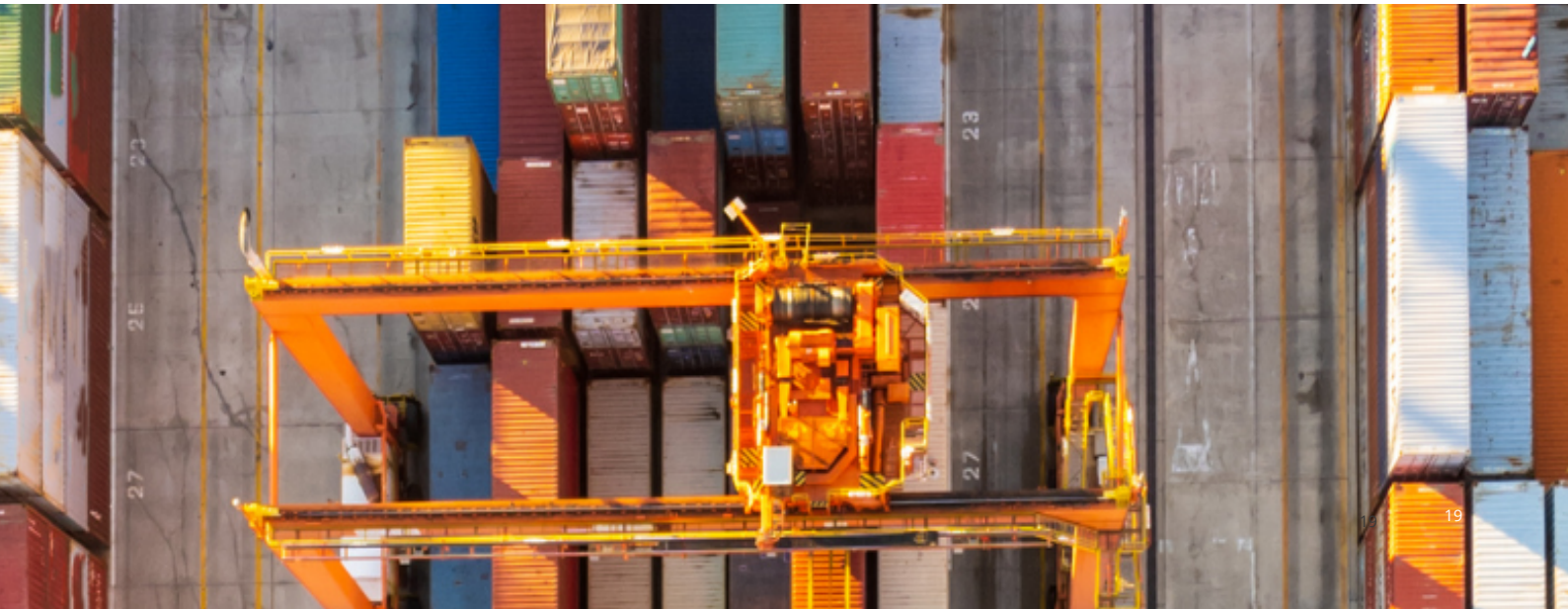
Circular Economy with End-to-End Traceability: Battery Passports

Digital product passports (DPP) are being envisioned to establish and contribute to a circular economy. Early work in the EU revolves around battery passports, digitally documenting every step of the life of a battery, from raw material, through all the stages of the supply chain, and even throughout the lifetime of the battery's use, and ultimately connecting to ways to reclaim and recycle the product at the end of its lifetime. The battery passport work in the EU will become foundational for Digital Product Passports in many other areas and for the logic of a circular economy.

Better Economic Outcomes for Producers: Coffee and Cacao Supply Chain Traceability in Honduras

Provenance enabled by blockchain technology can serve to greatly improve economic opportunities for producers of basic commodities. As customers are increasingly demanding insight into the provenance of products, the ability to demonstrate who grew the coffee bean becomes a competitive advantage. Consumers value access to this data, and with it they are more willing to purchase finished goods where a fair portion of the profits go to the farmers who did the work.

For instance, smallholder coffee and cocoa farmers in Honduras are leveraging public and private blockchain infrastructure to enhance transparency and make informed business decisions. These farmers, who often operate at a significant loss and earn a mere fraction from the sale of coffee and chocolate in retail outlets, are now empowered by a traceability system that provides insights from farm to point of sale. Blockchain has allowed farmers and their cooperatives to upload lot, quality score, certification, and other provenance data. This transparency not only offers buyers a clear view of the product supply chain but also positions farmers to negotiate better prices. The intricate journey of coffee and cacao, from farmers to consumers, involves multiple intermediaries, often diluting the profit margins for the initial producers. However, with blockchain solutions, there's an authentic record of provenance, granting these smallholder farms a competitive edge in the market, and increasing the resiliency of commodity-based supply chains. This enhanced resiliency is crucial in mitigating risks such as market fluctuations, climate change impacts, and geopolitical tensions, thereby ensuring a more stable and sustainable supply chain for all stakeholders involved.



Efficiency for Global Customs Organizations

There are approximately 200 customs organizations around the world, which would greatly benefit from an efficient chain of custody and provenance for cross-border shipments and returns, with a resulting duty drawback. Customs organizations are also undergoing increasing pressure from growing small packet commerce to handle the regulatory export and import clearances and associated duties.

Transparent value reconciliation, which is a major initiative for several customs organizations, can reduce frictions where blockchain-based and other emerging technology solutions can benefit all participants in a network with authenticated, trusted information exchange. In addition, manifest reconciliation can also record areas of labor exploitation, resource waste, plundering the earth, and pollution of natural ecosystems. This is particularly relevant today given upcoming regulations on stamping out forced labor, sustainable sourcing, and overall responsible behavior. These solutions can also improve turnaround time for clearances, thereby reducing customs holds caused by missing information or data silos. Customs compliance scores recorded on blockchain networks can help importers evaluate alternate sourcing options to mitigate risks and enhance planning and execution, ultimately resulting in more resilient supply chains.

Ensuring Specified Conditions for Supply Chains: Global Pharma

In combination with sensors across a supply chain capturing data through the Internet of Things, blockchain technology can record that data immutably to verify that specified conditions required for certain supply chains have been met across the journey from production, shipment, and final sale and use by the customer. In global pharmaceutics, requirements for cold chains are often necessary to ensure medical products such as certain critical vaccines (e.g., Covid vaccines) are fit for use. One example would be the combined use of IoT sensors and blockchain technology, where a blockchain would record the sensor information about a cold chain shipment and permanently memorialize that data, confirming whether the temperature requirements have been met across the entire journey. This helps identify with certainty the instances where IoT sensors detect a breach in the cold chain. This process can help stakeholders identify a batch that is deemed no longer safe for use, and take actions accordingly. Smart contract functionalities can make an autonomous decision to return the faulty batch back to the shipper, based on proof and understanding that across the lineage of destination the cold chain was broken.

Streamlining Payment Processes: Invoicing

Blockchain technology enables open sharing of validated information among network participants. In the case of global freight, a single invoice for one truck to make one delivery can have up to 200 data elements. Besides the obvious shipping information and freight description, freight carriers add accessorial charges are added to the invoice along the way, such as charges for wait times and layovers. Other common accessorial charges can include liftgate services, inside delivery, temperature-controlled service, hazardous materials handling, and unloading services. The customer must review accessorial charges, which can lead to disputes when the customer expects costs to be lower than the freight carrier's charges. In addition to disputes over costs, disputes also arise pertaining to the condition of the freight, such as if the freight was kept at the proper temperature during the entire route. Across the U.S. transportation industry, for instance, an average of $140 billion worth of invoices are in dispute on any given day while partners attempt to reconcile disparate accounting records across firm boundaries. Up to 38% of invoices are overpaid because it's sometimes cheaper for enterprises to simply pay these invoices than to investigate unexpected charges.

The series of issues associated with disputed invoices can be solved by creating one shared version of the invoice, managed with a smart contract, and integrated with IoT devices that can monitor the freight conditions such as temperature and location. For instance, when Walmart Canada and its freight carriers adopted a shared invoice system managed with smart contracts using a distributed ledger connected to IoT data, invoice disputes fell from 70 percent to under two percent. This system also allows invoices to be finalized within 24 hours instead of days, weeks or longer. Finally, reduced costs as a result also improved commercial relationships for both parties.

STANDARDS

While multiple data elements and standards exist in global commerce, they don't exist at the International Space Station – that is, truly global – level. Existing standards cover different aspects of supply chains and blockchain technology, although there still exist gaps where standards are unclear or non-existent, and ultimately certain standards may overlap.

This points to the need for a "harmonizer" role where open standards can apply to the full data journey of elements across the entire supply chain. Global standards for open data, precisely in the context of supply chains, are what it will take to scale Web3 technologies consistently in a way that can transform global commerce. Standards are the underlying condition for harmonizing global supply chains, allowing the solutions outlined above to address the challenges that have faced global commerce for thousands of years. Standards also lower the hurdles to leveraging blockchain as an achievable solution.

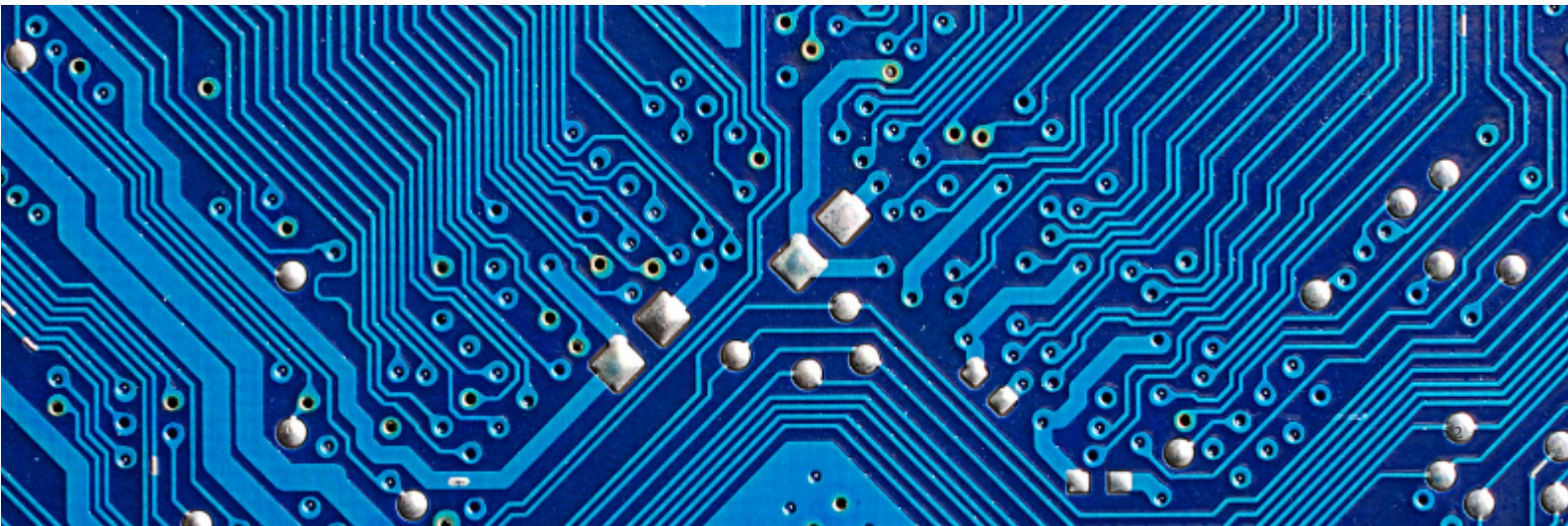
At the truly global International Space Station level, there is no individual company, no industry, and no borders. Data knows no geographic borders, but we don't yet have global standards to enable this vision. Global, pro-competitive, royalty-free, and open-source data standards must also apply to all players across the supply chain, which is key for scalability of Web3 technology solutions that are built on open data (e.g., digital twins). To optimize supply chain enhancements enabled by these innovations, open and interoperable standards provide a common data language to reinvent and redefine processes. Only then will global commerce accelerate to the speed of data.

The diagram below is a mapping of the existing standards as they are, an assessment of expected standards in development, and a gap analysis that identifies areas where there is still a need for standards. The resulting standards framework ultimately demonstrates a hierarchy of standards, where often standards bodies focused on certain aspects of the global supply chain draw their requirements from larger global standards bodies. For instance, many standards bodies dictating requirements on aspects of the supply chain, such as data elements on country of origin, ultimately point to requirements set by larger global standards setters such as the International Organization for Standardization (ISO).

Figure 8: Landscape of standards across supply chain data elements

			Type of element			Reference				
	Data Element	Description	Standard	Free Form	Standard	WCO	DSI	OCB	CO	CI
1	Country code/Country of origin	Code representing a specific country	x		ISO 3166 EDIFACT 3207	x	x	x	x	
2	x	x		x	x			x	x	x
3	x	x		x	x			x		
4	x	x		x	x		x		x	x
5	x	x	x		x			x		
6	x	x	x		x			x		
7	x	x		x	x				x	
8	x	x	x		x	x	x	x		
9	x	x		x	x			x		
10	x	x	x		x					x

WCO - World Customs Organization
DSI - Digital Standards Initiative
OCB - Open Customs Blockchain
CO - Certificate of Origin
CI - Commercial Invoice

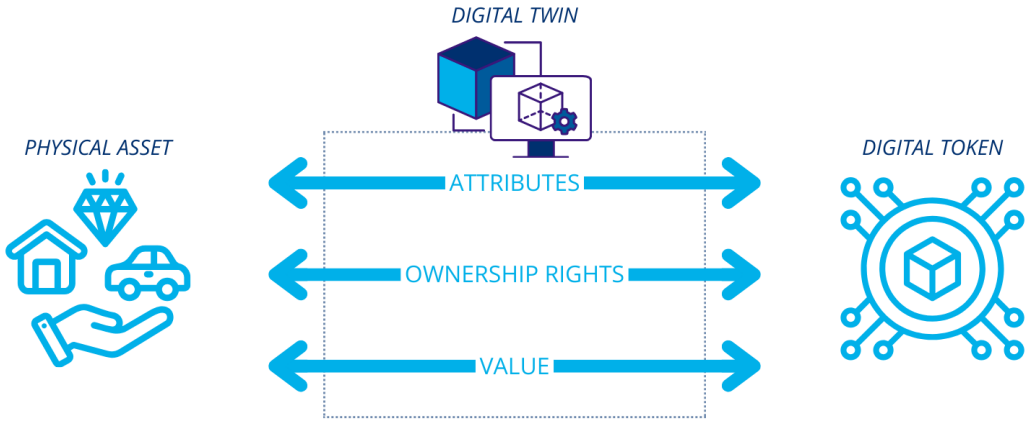


Examples

1. Tokenization allows for a digital representation on a blockchain of a real world asset that is not native to the blockchain. While this term has mostly been associated with a cryptocurrency token, a token is not a currency but a representation of any form of data, which functions as an "asset" (e.g., document, data files, historical tracking) . This digital representation is a key aspect of supply chain optimization using technology to efficiently transact at a global scale.

   GBBC's **InterWork Alliance (IWA)** has developed a **Token Taxonomy Framework** that has already produced a blueprint to develop open source, platform neutral tokenization standards to promote interoperability between disparate systems. With the shift to digitizing the supply chain ecosystem, adopting the needed data standards will be key to ensure token ("data") interoperability (e.g., cross-chain), while connecting legacy logistics systems to trigger token transfers for certain supply chain events. While the data standards will still be important, the tokens themselves will serve as a gate to the data recorded on a chain. Token standards can provide stakeholders with access to more industry-specific taxonomies. When the taxonomy and the underlying technical code for a use case are available to the community via open-source standards, they provide the blueprint that enables faster implementation of products and services.

Figure 9: Tokenization to trace supply chain packages through digital twins



2. For instance, **W3C's PROV-O**[10] open specification provides a foundation to implement provenance applications in various domains that can represent, exchange, and integrate provenance data generated by multiple parties, across different systems, and under diverse contexts.

3. The **Digital Container Shipping Association (DCSA)** has set a goal by 2030 of 100% adoption of standards-based electronic bills of lading for its members, contributing to end-to-end digitization.

4. The **Digital Standards Initiative (DSI)**, hosted by the **International Chamber of Commerce (ICC)**, has provided recommendations to harmonize digital trading standards to benefit businesses, governments, and individuals.[11] These standards are designed to ensure trust, where trust in global trade requires verifiable trust with respect to the physical, financial, and information exchange involved in the trade of goods and services, which ultimately depends on trust in legal, governance, and technology infrastructures underlying. [12]

Methodology

Due to the relatively short time between the announcement that BITA and GBBC had merged (July 2023) and the delivery date of GSMI 4.0 Supply Chain, the initial review of standards was limited. We will use the 4.0 version as our backbone/foundation moving forward, as we expand both the number of data elements included, and the number of standards entities and documents.

The initial 48 data elements included come from multiple sources, as explained below, and from business data element requirements, and are intended to form the backbone of future work as data elements and standards entities are added.

The one example above walks through the methodology:

- **Data Element –** Country Code/ Country of origin
- **Description –** Code representing a specific country
- **Type of standard**, e.g., an actual standard to be followed, or a free form entry
- **Identified standard(s) –** e.g., ISO, UN Trade Directory Code, WCO, etc.
- **Entities reviewed –** for the 4.0 version, this included World Customs Organization (WCO, Digital Standards Initiative (DSI), and Open Customs Blockchain (OCB)
- **Documents reviewed –** for the 4.0 version, this included Certificate of Origin (CO) and Commercial Invoice (CI)

This early work points out multiple observations, all pointing to the need for global harmonization, e.g., a common language, in global commerce:

- Some entities focus on specific forms or only customs, etc., and map their data elements that way, but we started with the business/movement/transportation side of this, e.g., what data elements are the most basic that are required to move a shipment from point 'A' to point 'B'? This list is likely in the hundreds, and BITA/GBBC/GSMI will continue to move forward with additional data elements and standards entities reviewed to make this more comprehensive and also to create a living, breathing list with applicable links.
- We quickly realize that not every data element has been identified by all entities, or exists on all forms, and we also quickly realize some data elements have a hierarchy of standards. In the country example shown, there is a UN EDIFACT number assigned (3207), but if you refer to that, it also points you to ISO 3166. There are numerous examples where multiple standards exist, or one standard points you to another standard, though, again no fully harmonized code.
- Other items above were simply reduced to an 'x' in appropriate cells just to further show the diversity of responses. The full list of 48 items, with all applicable responses, is included with this document for review.

This initial effort (GSMI 4.0 Supply Chain) points out that the more we can put into focus the full list of data elements, and a single standard, or multiple standards, or, likely, no standard, the more we can discuss with other like-minded open standards entities so we can agnostically align and harmonize these open standards results, to the benefit of all. One great example is that as recently as 2019, World Customs Organization (WCO) had proprietary standards, and as of 2023, those standards are now open.

CONCLUSION & BITA FUTURE OUTLOOK

While thousands of years of trade have led us to the global supply chain of today, blockchain and emerging technologies are leading us to a future where paperless trade can become a reality, transforming industry and regulatory processes, and entire industries. That is why GBBC's BITA initiative has come to fruition, bringing together major global logistics and transportation stakeholders to thoughtful adoption of Web3 innovations toward a new generation of global commerce that can finally adopt an "International Space Station" view. BITA is working as a global harmonizer for open data standards in global commerce.

An effort to map, produce, publish, and implement open data standards harmonization for emerging technologies in the global supply chains is the "True North" guiding this initiative. Moving forward, the goal is to produce a living repository of standards documentation that is constantly updated (e.g., Wikipedia concept), to serve as an open-source standards foundation for emerging technology for global supply chains. These standards are meant to support future reference architecture for foundational use cases.

These standards will also serve as a roadmap to educate stakeholders and guide public and private models of that can shape a new era of commercial activity that can include a wider range of large, small, and medium enterprises and organizations from around the world to participate in connected, trusted, efficient marketplaces. New and efficient processes based on these standards can also enable point-to-point global commerce, addressing barriers that currently prevent individuals, for instance, to make purchases directly from manufacturers abroad.

CALL TO ACTION

The BITA initiative calls companies and organizations participating in the global supply chain to commit to collaborating on open source solutions.

Tomorrow, with emerging technologies deployed in harmonized and scalable ways underlying the processes involved in global commerce, Maria can make her daily purchases in a much simpler world. We expect most 10-year-olds today, as adults in the future, will want to know where the coffee they are drinking came from, if the clothes they are wearing are sustainably made, and many other details on the products they consume, which originate from data collected along global supply chains.

ENDNOTES

SUPPLY CHAIN

1 (Harrison et al. 2014)
2 (Harrison et al. 2014)
3 Lacity, M., Schuetz, S., and Steelman, Z. (2023). IT's a Matter of Trust. University of Arkansas white paper: https://walton.uark.edu/departments/information-systems/files/bcoewhitepaper2023post.pdf
4 2022 Deloitte Report
5 https://www.computerworld.com/article/3454336/walmart-launches-world-s-largest-blockchain-based-freight-and-payment-network.html (Computerworld, 2019) - "Logistics and transportation is an $8 trillion industry and as much as $140 billion per day can be tied up in disputes or settlements between supply chain participants, according to Laurie Tolson, chief digital officer of GE Transportation."
6 https://www.statista.com/chart/27289/global-trade-volume-with-counterfeit-goods-compared-to-gdp-of-selected-countries-regions/
7 https://www.statista.com/chart/30067/worldwide-counterfeit-pharmaceuticals-incidents/
8 2022 Deloitte report
9 Global Express – [source]
10 https://www.w3.org/TR/prov-o/
11 Key Trade Documents and Data Elements paper: https://www.dsi.iccwbo.org/_files/ugd/8e49a6_2d93b2f219cf404ab91bafd028e31fcc.pdf
12 Trust in Trade paper: https://www.dsi.iccwbo.org/_files/ugd/8e49a6_5a75a77950d7474da772bf9cfc2d985b.pdf

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