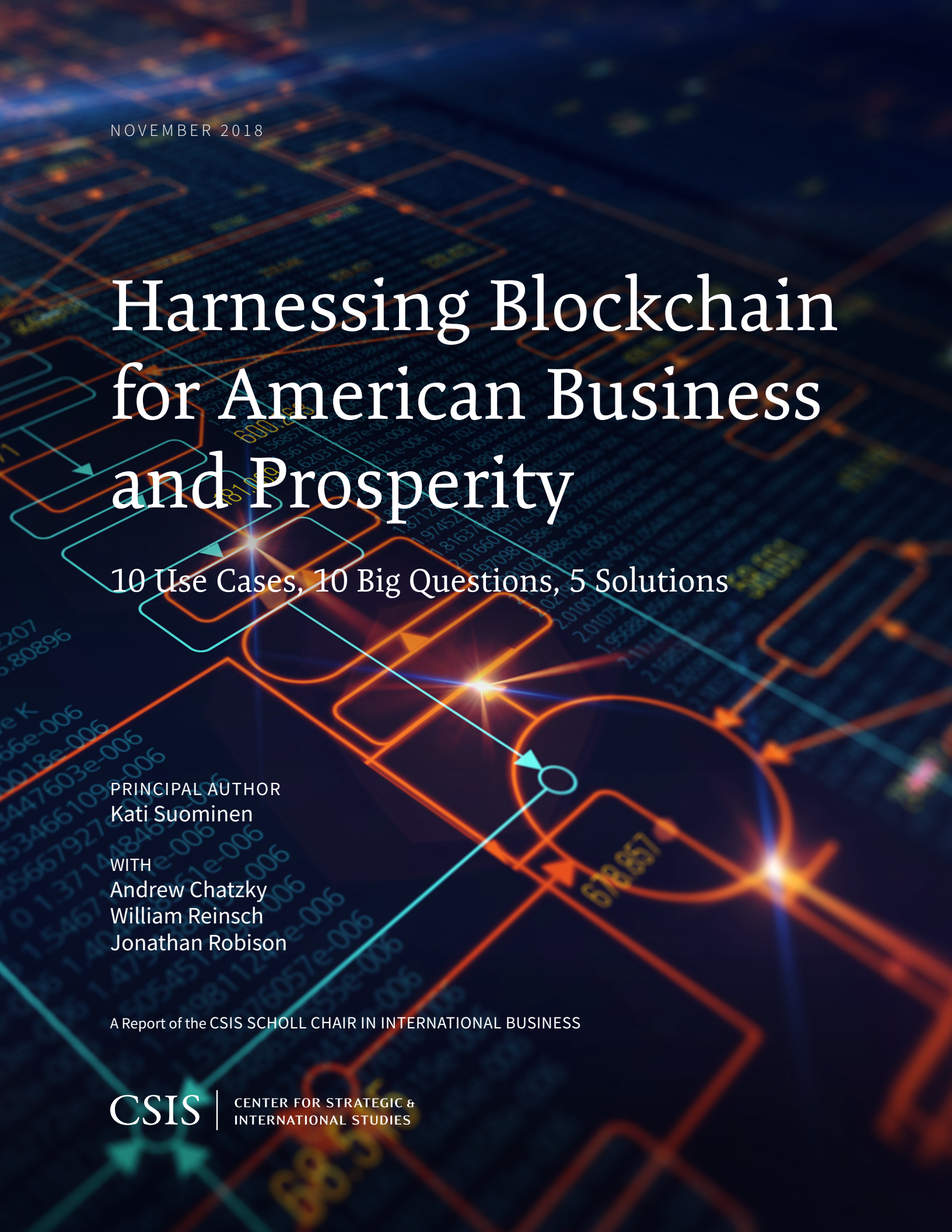


NOVEMBER 2018

Harnessing Blockchain for American Business and Prosperity

10 Use Cases, 10 Big Questions, 5 Solutions

PRINCIPAL AUTHOR
Kati Suominen

WITH
Andrew Chatzky
William Reinsch
Jonathan Robison

A Report of the CSIS SCHOLL CHAIR IN INTERNATIONAL BUSINESS

CSIS | CENTER FOR STRATEGIC & INTERNATIONAL STUDIES

NOVEMBER 2018

Harnessing Blockchain for American Business and Prosperity

10 Use Cases, 10 Big Questions, 5 Solutions

PRINCIPAL AUTHOR
Kati Suominen

WITH
Andrew Chatzky
William Reinsch
Jonathan Robison

A Report of the CSIS Scholl Chair in International Business

CSIS | CENTER FOR STRATEGIC & INTERNATIONAL STUDIES

About CSIS

For over 50 years, the Center for Strategic and International Studies (CSIS) has worked to develop solutions to the world's greatest policy challenges. Today, CSIS scholars are providing strategic insights and bipartisan policy solutions to help decisionmakers chart a course toward a better world.
CSIS is a nonprofit organization headquartered in Washington, D.C. The Center's 220 full-time staff and large network of affiliated scholars conduct research and analysis and develop policy initiatives that look into the future and anticipate change.

Founded at the height of the Cold War by David M. Abshire and Admiral Arleigh Burke, CSIS was dedicated to finding ways to sustain American prominence and prosperity as a force for good in the world. Since 1962, CSIS has become one of the world's preeminent international institutions focused on defense and security; regional stability; and transnational challenges ranging from energy and climate to global health and economic integration.

Thomas J. Pritzker was named chairman of the CSIS Board of Trustees in November 2015. Former U.S. deputy secretary of defense John J. Hamre has served as the Center's president and chief executive officer since 2000.

CSIS does not take specific policy positions; accordingly, all views expressed herein should be understood to be solely those of the author(s).

Acknowledgements

The author would like to thank Andrew Chatzky for excellent research assistance, William Reinsch and all participants in the workshops on July 26 and September 13, 2018 for outstanding comments and ideas, and Jonathan Robison for superb project management

This report is made possible through the generous support of IBM.

Center for Strategic & International Studies
1616 Rhode Island Avenue, NW
Washington, DC 20036
202-887-0200 | www.csis.org

Contents

1 | Introduction

Imagine running a restaurant and hearing about a food outbreak in your city stemming from contaminated spinach. You just ordered 200 pounds of fresh spinach to serve to your patrons. Wouldn't you love to be able to trace both the contaminated spinach and the spinach you just received to their origins to see if your spinach happens to be from the contaminated batch?

Now imagine running an airline. One of your paramount concerns is passenger and crew safety; another is speed of turnaround of planes at the gate. To accomplish both missions, you need to ensure each of the thousands of parts and components in your planes is top-quality and know which may need maintenance soon—so you can replace them before they break down and cause delays. Wouldn't you love to be able to verify where each part came from, have access to a reliable certificate on its quality, and know how parts made around the same time by the same company are performing?

Next put yourself in the shoes of a corn grower in a region with extreme weather conditions. Your instinct is to insure your crop against Mother Nature's fury, but you also know that the insurance is expensive, and getting a claim paid can take a long time and might require an expensive lawyer. Wouldn't you love to have insurance that would automatically be paid when a devastating hail storm damages your corn field?

Blockchain can resolve each of these challenges. A foundational technology that can transform social and economic interactions, transactions, and business models across such sectors as health care, manufacturing, and financial services, blockchain is being adopted by startups, major corporations, and government agencies. Globally, there have been over 650 equity investments totaling $2.1 billion between 2012 and 2017 in blockchain companies across industry verticals.[1] Fortune 500s such as Walmart and GE have made substantial investments in blockchain and participated in over 140 deals totaling $1.2 billion. It is hardly a stretch to claim that blockchain can unlock trillions in new economic value through efficiency gains, greater transparency, trust, and customization.

Blockchain may sound exotic, but it is not unlike the internet or social media—only it is more private and secure, and increasingly capable of automated transactions. One way to think of blockchain is like a basketball game: one person throws a ball to another and that person throws it to still another, and all these movements are recorded in real time and visible to everyone in the game. Blockchain codifies a series of movements—transactions, shipments, and so on—among parties in the same game or network. Once the parties have agreed that these movements (or "blocks") are real, blockchain makes the movement data accessible to all players and ensures none of them can contest or tamper with the data, such as on who got the ball moving to begin with. At any stage of the game and after it, everyone has an accurate, commonly agreed picture of every move throughout the game.

Blockchain is particularly useful in settings where there are large networks of players, high intermediation costs, significant informational asymmetries among the players, and concerns about veracity of data and frequent concerns about fraud. By enabling interactions among anonymous users without central authority, using tamper-evident data on those interactions that are visible to all users in real time, blockchain adds new value to economic and social life. For example, blockchain applications enable individuals to secure personal data and identities; help overcome lack of trust between two parties who do not know each other but wish to engage in transactions; save intermediation costs between two

transacting parties by automating verification and compliance with contractual obligations; and reduce coordination costs among multiple players needing access to the same information at the same time. These benefits have various second-order effects. By codifying parties' transactions and loan repayments, it can open credit to segments of the population that previously needed to show high levels of collateral. It can create market efficiencies in areas where buyers are inherently wary of sellers' motives and the quality of assets, such as in markets for used cars or fine art. It can improve data sharing among border agencies and accelerate customs clearance of imports.

The purpose of this paper is to review how blockchain can be used to solve complex business problems across various sectors and areas of life, assess myths and challenges surrounding blockchain, and, in particular, to discuss what the U.S. government's policy should be regarding blockchain. This paper does *not* focus on Bitcoin or other cryptocurrencies enabled by blockchain; rather, the focus is primarily on enterprise blockchains—blockchain applications operated by a company or an organization for a specific community of users. This paper uses the term "blockchain" loosely to refer to a family of distributed ledger technologies.

U.S. companies, a number of government agencies, and several state governments are already exploring and applying blockchain, for example, to trace products in supply chains, enable energy trading between households, and administer medical records. Several states have developed laws around blockchain to define the term "blockchain" and to make smart contracts embedded on blockchains legally enforceable. This report proposes that the U.S. government and companies can work together to take these efforts to the next level in five ways:

- Lead the development of global blockchain standards at the International Standards Organization (ISO) and beyond that encourage innovation and use cases involving blockchain applications, scalability of blockchain platforms and ecosystems, and integrity and usefulness of data and smart contracts built on blockchain.

- Encourage innovations around and investments in blockchain through regulatory certainty and flexibility, including via a blockchain sandbox—enabling businesses to test markets for new blockchain solutions without needing to meet the gamut of regulations that otherwise might apply—and via a safe harbor law allowing blockchain platform managers to be immune from liability for the platform users' activities.

- Commit federal funds to accelerate the development of blockchain use cases, blockchain security and encryption technologies, and public-private partnerships in such areas as defense, counterintelligence, customs and border protection, trade enforcement, and health care management.

- Create with key allies and development partners a Global Blockchain Development Fund (GBDF) to accelerate the uptake of blockchain in developing countries and by so doing improve business environments, advance the UN's 2030 Sustainable Development Goals, and open new opportunities for U.S. technology companies in developing economies.

- Accelerate blockchain's adoption through raising awareness about the benefits of blockchain among regulators, federal and state government agencies, and U.S. businesses.

The next section discusses blockchain's properties and why they are transformative. Section three discusses 10 use cases of blockchain and startups and the companies driving them. Section four turns to myths and thorny questions surrounding blockchain, such as whether the entries on it can truly be immutable and whether smart contracts built onto blockchains are smart enough to do what contract writers tell them to do. Section five discusses key considerations for policymakers considering ways to enable blockchain to benefit U.S. businesses, consumers, and government. Section six concludes.

2 | What Makes Blockchain So Seminal?

Blockchain, invented in 2008 by one person or a group of anonymous individuals who then published its seminal open source code in 2014, is slowly and quietly disrupting manufacturing, small business lending, supply chain management, and international trade logistics. It can be especially transformative in settings with high intermediation costs, large networks of players, significant informational asymmetries among the players, and concerns about fraud—industries such as food supply chains, trade finance, customs and border administration, and small business lending. Five properties make blockchain seminal:[2]

- **Blockchain can run without a central hub, authority, or clearing house in the middle; for example, it can operate among small business borrowers and lenders without a bank in between.** Blockchain is inherently decentralized, which is why it is also called a "distributed" ledger. For example, a blockchain can be composed of lenders and borrowers that interact directly with each other. Each interaction or transaction has an IP address attached to it, which enables blockchain users to see interactions made by any given IP holder. However, identities are sealed: all transactions are secure and carried out among anonymous private parties. A disintermediated system, blockchain has been hailed as a democratizing force that gives "power to the people."

- **Each entry on a blockchain is immutable, meaning it cannot be altered or deleted the way information in a typical database can.** It is the users of blockchain, not a central authority, that validate each entry made on blockchain. This implies major cost savings for companies and governments that typically carry out such activities as validating databases and computer systems. Data on a blockchain also fundamentally builds trust and removes informational asymmetries among users. For example, in the case of a blockchain for small loans, each user builds a credit history on the blockchain that is validated by and visible to all users, which mitigates the need for users making loans to consult third-party credit ratings. A blockchain for used cars could enable users to see each car's lifetime record of repairs, insurance claims, owners, and so on, and thereby quickly know lemons from peaches. On a blockchain, "what you see is what you get."

- **Each user on a blockchain has a secure identity and can reveal only parts of it.** In 2017, almost 17 million Americans became victims of identity fraud. Blockchain-based identities can be "self-sovereign," administered by the identity holder and based on the Decentralized Identifiers (DiDs) that are much like a secure website that is cryptographically stored on a blockchain ledger.[3] Each DiD is assigned to the different parts of a user's identity; one DiD could be your name, another your passport number, still another your date of birth. As a user, you could provide access to a DiD or DiDs of your choice to a third party, none of which could otherwise access any part of your identity.

- **Blockchain can automate the fulfillment of contractual obligations.** So-called smart contracts can be built on a blockchain to do *x* when event *y* happens and thus automate what in many cases are still manual, paper-based processes involving costly intermediaries. A good example is international trade: if the importer and exporter enter into a smart contract, the importer's bank would automatically pay the exporter when the importer has verifiably gained possession of the shipment—which in turn obviates the many interactions among banks and other players that are needed to do *x* (release payment) and verify that *y* (shipment has arrived) has indeed happened.

- **Blockchain enables assets such as energy, land, or clean water to be disaggregated into tokenized mini-assets.** While it is perfectly possible to buy parts of an ocean front mansion, racehorse, giant diamond, Picasso painting, or a ranch without blockchain, blockchain makes it easy to transact such pieces of assets by tokenizing them. Blockchains can convert just about any asset into a digitized token that is fungible and tradable—one that is easy to buy and sell among the users of a blockchain—but that is also secure. A token is an algorithmically generated random number that essentially converts sensitive data into non-sensitive data, and tokenization is already used to prevent credit card fraud. Once a user buys a token, his or her ownership is secure and cannot be erased: blockchain leaves a tamper-proof trail regarding who owns which asset when.

Blockchain is not new per se—it is a smarter and more secure version of any database that enables interactions among businesses, consumers, and governments. It can significantly improve the transparency of assets and transactions, accelerate the flow of payments, and secure users' identities. These properties enable users to trust each other. They create enormous efficiencies in different kinds of markets and enable the rise of markets in areas where certain frictions, such as lack of trust, kept parties from transacting with each other.

Who then gets to use blockchain? Blockchains can be "permissionless" like Bitcoin, where anyone can join the network of users. However, many blockchains are permissioned, meaning that users need permission to join. This is the case in such areas as energy exchange among households, crop insurance among farmers and insurers, or trade finance among global banks. There are a number of blockchain technologies such as IBM Hyperledger's Fabric and R3's Corda that are being used to create permissioned blockchains.

3 | How Does Blockchain Change Doing Business? 10 Use Cases

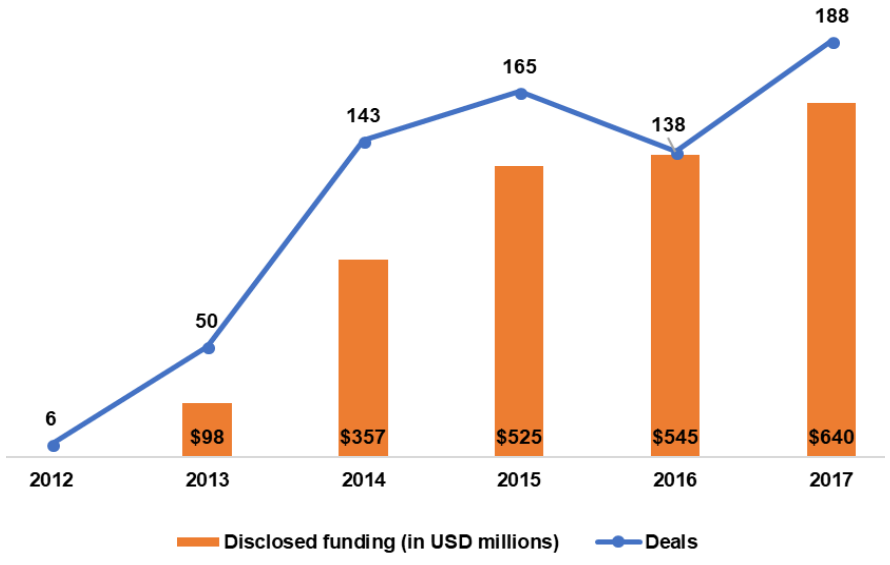
Blockchain has inspired countless businesses ideas, applications, and startups in various spheres, such as health care, manufacturing, logistics, and farming (Table 1). Several U.S. Fortune 500s and government agencies are applying blockchain. Equity deals in blockchain startups have exploded around the world, from $98 million in 50 deals in 2013 to $640 million in 144 deals in 2017 (Figure 1).

Table 1 – Illustrative Blockchain Initiatives and Startups, by Sector

Sector	Company / Organization	Blockchain Application
Supply Chain Management	Walmart	Walmart has incorporated blockchain technology in its live food business.[4] The world's largest retailer uses blockchain to track, identify, and if need be, remove food from its shelves. It has pitched the project as a method to cut down removal times during food recall from weeks to a matter of seconds.[5]
Additive Manufacturing	U.S. Department of the Navy, GE	The U.S. Navy and GE are on their respective fronts using blockchain to enhance the authentication and tracing of 3D printed parts in supply chains.
Logistics Management	IBM-Maersk	Maersk and IBM's joint venture blockchain started in June 2016.[6] Since then, the network has connected shippers, ports, customs offices, banks, and others in Maersk's global supply chains to track freight and replace redundant and time-consuming paperwork.[7] As the program has scaled, it's earned converts including Dupont and Dow Chemical.[8]
Cross-border E-commerce	Alibaba	Alibaba's T-Mall uses blockchain-based technology for its cross-border supply chain with logistics company Cainiao. It allows parties to record information on exports and imports onto a blockchain that keeps track of the products' country of origin, shipping and arrival port, shipment method, and customs information.
Trade Finance	HSBC	In May 2018, HSBC announced it had completed "the world's first commercially viable trade-finance transaction using blockchain, opening the door to mass adoption of the technology in the $9tn market for trade finance."[9] HSBC's proof of concept was a blockchain-based letter of credit for a transaction with Cargill.
Customs Administration	U.S. Customs and Border Protection (CBP) Korean Customs Service	CBP formed a group in September that will research the agency's potential use of blockchain. Already, the group has identified 14 specific use cases, ranging from tracking licenses and permits to certificates of origin.[10] In Korea, Malltail and KSC have signed an MoU to launch a blockchain-based customs platform. The goal is to use blockchain to speed customs clearance times in seven Malltail distribution centers across the United States, Japan, and Germany.[11]
Health Care Data	MedRec	Conceived by MIT, MedRec provides medical data management using a blockchain and smart contracts. Medical researchers provide the computer power blockchain

	SimplyVital Health	requires using a permissioned Ethereum network. They're enticed to participate through access to medical data they can use in their research.[12] SimplyVital Heath uses blockchain to both help health care providers streamline data and save money, as well as share customer data more securely.[13]
Insurance	Etherisic	Etherisic is building a platform for decentralized insurance applications. The platform aims to allow corporations, not-for-profit groups, and insurtech start-ups to provide better products and services through blockchain technology.[14]
Farming	AgriLedger	AgriLedger uses an app to connect various small farmers with one another. It helps them join together in co-ops with increased transparency that no longer rely on paper-based records or verbal promises.[15]
Mobile Voting and Vote Integrity	West Virginia Estonia	West Virginia became the first U.S. state to allow internet voting using blockchain. The project applied to a small group of voters in the state's most recent primary election.[16] Estonia uses blockchain perhaps more than any other country. 30 percent of Estonians use it for "i-Voting."[17] The country estimated that i-Voting saved 11,000 working days in the most recent elections.
Energy Management and Trading	LO3 Energy	Brooklyn startup LO3 Energy champions Exergy, a permissioned blockchain platform that enables localized peer-to-peer marketplaces for trading energy across existing grid infrastructure among users.[18]
City Administration	City of Dubai	Dubai wants to use blockchain by 2020 in over 100 million annual government documents, including all visa applications, bill payments, and license renewals.[19] According to estimates, Dubai's could save 25.1 million hours of work, or $1.5 billion, each year by using blockchain.[20]

Figure 1 – Global Angel and Venture Capital Investments in Blockchain Companies



Source: "Blockchain Investment Trends in Review," CB Insights Research, April 13, 2018, https://www.cbinsights.com/research/report/blockchain-trends-opportunities/.

The following sections examine 10 different ways blockchain is applied by some of these companies and initiatives.

1. *Tracking products in global supply chains*

Consumer concerns about food safety and ethics such as child labor have pushed companies to trace parts, components, and ingredients to their respective suppliers, suppliers' suppliers and their sources, and transport events on the way. For example, Walmart's food safety manager, Frank Yiannas, sought for years to track lettuce, fruit, steaks, and cakes from farm and factory to Walmart's stores in order to quickly identify the source of problems like salmonella outbreaks.[21] This process was difficult and often took days. Then Yiannas turned to blockchain to trace products to their origin and through all relevant transportation events to Walmart shelves. The efficiency gains were astounding. The tracing time of mangos fell to a mere 2 seconds, from what it used to be: 6 days, 18 hours, and 26 minutes.[22]

In manufacturing, blockchain enhances coordination and streamlining of complex supply chains. Consider making a typical car, which uses 30,000 parts often made in different parts of the world. If the manufacturer saw all "moves" in the supply chain down to tier 2, tier 3, and tier 4 suppliers and all the way to various raw materials, coordination costs and lead times could be reduced, providing customers cheaper products faster. Europe's airplane giant Airbus uses blockchain to analyze its suppliers and the origin of the parts and share revenue with partners.[23] The data also helps airliners: parts catalogued on blockchain can be read by airline maintenance staff to determine how many flight hours the part has accomplished and whether to replace or repair the part. This enables the airline to maintain planes and have a better record of turning planes around and getting passengers to their destinations on time.

This application can also be useful in verifying country of origin in products made in multicountry supply chains. For example, with 10 large exporters in Singapore, the International Chamber of Commerce is piloting blockchain-based certificates of origin for all parties to a shipment, allowing the tracing of goods across the supply chains.[24] Users can scan a QR code associated with a product and linked to a blockchain address to verify the product's authenticity. If the importer country does not use blockchain, a paper document is also created and linked to the digital counterpart stored on the ledger.

2. *Ensuring quality and tracking of 3D printed parts*

3D printing is reshaping U.S. manufacturing, with over 50 percent of U.S. manufacturers now using the technology for prototyping parts and final products in-house.[25] Also, desktop 3D printers for making smaller items are proliferating, many costing less than $1,000. Much like Kinko's bringing 2D printing to U.S. street corners in the 1980s for customers to print documents, banners, and business cards, UPS has set up 3D printing facilities in UPS stores for customers to print a product from a 3D printable model they bought online or developed themselves.

Blockchain can accelerate the uptake of 3D printing by solving thorny questions industrial manufacturers have about the quality, origin, and intellectual property rights of 3D printed products. Using blockchain to codify and encrypt the data on the production process and products creates a stream of secure data as to who made a given part where, when, and how (such as out of what materials). This in turn enables manufacturers to ensure and verify the quality of products and their producers, screen out pirated

products, trace problems in parts to their source, and carry out recalls quickly if needed, all while using secure data.

One of the pioneers in this area was Cubichain Technologies, which in 2016 announced an application to secure encrypted data of 3D printable parts on a blockchain.[26] More recently, the U.S. Department of the Navy brought blockchain to its additive manufacturing work, citing blockchain's security benefits.[27] General Electric (GE) has also seized on the opportunity, patenting a technology to use blockchain to validate and verify 3D files and the 3D printing process and thus enable certification of 3D printed parts.[28] GE is putting the technology to use in its own manufacturing processes to track and certify parts. This can also help in replacing parts. For example, blockchain can help the manufacturer ensure that a new part was produced using the correct build file and process.

Blockchain also helps small businesses access parts, components, and manufacturing horsepower that previously might have been very costly to secure, especially in products with short lead times, unique specifications, or small production runs. For example, an Italian initiative Politronica is developing 3D-TOKEN, a globally decentralized just-in-time factory that connects 3D printing projects.[29] This type of sharing can also fuel the boom in personal 3D printing where people can download 3D printable models online or design their own products—from ties to high heels to coffee cups—and print them with their desktop 3D printers. Conceptually, just like the internet-fueled the boom of phones, tablets, and PCs that enable people to leverage the internet and collaborate in developing and sharing documents, presentations, and so on, blockchain can fuel a boom of 3D printers that enable people to create and manufacture products with each other. Blockchain can also fuel payments among them: smart contracts on a blockchain can enable flexible pay-per-use payment models for the user to pay only when a given 3D model is printed.

3. Creating individualized, life-long "one-stop shops" of medical records

Blockchain can have a major impact on America's complex health care system. For example, a health care blockchain could track any one person's complete medical history, such as medications, illnesses, injuries, and dealings and transactions across health systems, doctors, pharmacies, and health plans, and help empower patients to control their own data.[30] If a person changed jobs or insurance programs or moved to a new state and had to change doctors, his or her medical history would travel along. For Americans who choose among a variety of insurance and medical care options, this would ensure their medical professionals had access to a patient's uncontestable full history.[31] Blockchain could also transform insurance payments: smart contracts could then trigger insurance coverage when a clinic confirms a patient has been treated and prevent fraudulent or inaccurate claims.

A number of initiatives are sprouting up to operationalize these concepts. For example, UK-based Medicalchain helps patients access and control their data and provide differing levels of access to various users.[32] Blockchain company Gem is working with a blockchain-based global patient identifier that could be linked to hospital records as well as data from other sources like employee wellness programs and wearable health monitors.[33] MIT researchers have created a prototype product called MedRec that tracks who has permission to view and change a record of medications a person is taking.[34] MedRec also incentivizes medical researchers to verify data on its blockchain by rewarding them with access to aggregated, anonymized data from patients' records that can be used, with the patient's consent, for epidemiological studies.

There are many other potential blockchain applications in health care. For example, the Department of Health and Human Services (HHS) envisions blockchain to be used as a more efficient method of tracking payments made into Medicare and Medicaid, for example, by allowing subscribers to calculate their specific costs and benefits more easily.[35] By enabling patient matching and monitoring and consent processes, blockchain could also facilitate the costly and complex recruitment of people to clinical trials and help monitor and secure data in such trials. Blockchain could also secure the quality and shipment of medical and pharmaceutical products, thereby combatting the proliferation of fake drugs that are contaminating drug supply chains and helping highlight the providers of uncontaminated products. The same application and tamper-proof logs would benefit any over-the-counter cures, herbal mixtures, organic foods and drinks, and so on.

Your fitness too could get a blockchain boost. For example, Nokia has announced a pilot program to store volunteer participants' activity and sleep data on a blockchain in order to give people access to the biggest possible picture of their health and fitness data and full control over it. Some blockchain initiatives give rewards for good health behaviors. For example, MintHealth providers people who make verifiably healthy choices "vidamints" to use to get frequent flier miles or other loyalty program points.[36] Such tokens could of course also be used to incentivize good behaviors further: an employee could exchange her vidamints for a gym membership paid by an employer wishing to encourage healthy behavior in employees.

4. Streamlining trade logistics

Up until now, all players in an international trade transaction—importer, exporter, shipper, banks, and so on—have had to maintain their own databases with all documents related to a transaction, such as the letter of credit, bill of lading, warehouse receipts, and invoices. Companies that trade have to re-key information from the paper letter of credit for an invoice, packing list, and the many other documents multiple times, interacting with multiple players in the trade process. Shipping giant Maersk has calculated that an exporter of cut flowers from Kenya needs to carry out 200 separate communications involving 30 players such as farmers, freight forwarders, land-based transporters, customs brokers, governments, ports, and carriers to move a shipment to the Netherlands.[37] In turn, shipping and logistics companies process over 40 documents for a single shipment, and up to 70 percent of their data are re-entered at least once, which takes time and increases the chances of errors.[38] Different databases need to be reconciled against each other and sources of discrepancies hunted down, often still by hand from paper documents. These hassle factors add as much as 20 percent in the exporter's shipping costs.[39]

Blockchain is ending this paper war. With IBM, Maersk has created a platform poised to bring the entire trade ecosystem—liners, warehouses, freight forwarders, ports, customs, exporters, importers, and trade finance banks—to interoperate with each other on a data exchange platform running on blockchain.[40] In this system, all players have a bird's eye view of the entire trade transaction, access all documents related to it, and share data and information; no entries can be changed and all entries are updated on everyone's screens in real time. The platform has already been piloted to ship flowers from Kenya, mandarins from California, and pineapples from Colombia to the port of Rotterdam. Each participant can also see the status of customs documents or view bills of lading and other data in real time. The data is secure, as no one party can modify, delete, or even append any one of the blocks without the consent of everyone else in the network.

5. *Facilitating and securing trade in customs*

Millions of products arrive on U.S. shores each day. Technologies such as predictive analytics and machine learning are enabling customs agencies around the world. In 2010, predictive analytics famously enabled U.S. authorities to identify a bomb that was contained inside a printer cartridge and shipped from Yemen to Chicago. The discovery was automatically made on the basis of trade data that showed that Yemen was an unusual provider of office supplies for the United States.41 In Singapore's customs, machine leaning models have spotted such frauds as underpayment of duty for cigarettes through analytics that showed that the weight of goods declared in a declaration for cigarettes was lower than the historical norm.42

As e-commerce burgeons and the number of parcels shipped mushrooms, more computing horsepower is needed to facilitate legitimate trade and capture fraudulent transactions while facilitating legitimate trade. While express shippers like Fedex and DHL require their customers to fill out customs forms and comply with trade rules, postal systems do not tend to be as rigorous. As part a five-day test at JFK airport, CBP and partner agencies found that of 3,000 packages, over 1,500 were not compliant with the U.S. Department of Agriculture, the Consumer Product Safety Administration, or with U.S. intellectual property laws.43 Yet inspecting each package and parcel by opening them is as unfeasible as it is foolish: most of the packages arriving on U.S. shores—457 million in 2016—carry harmless items, from clothing and exercise gear to electronics.

Blockchain is already being tested in many customs administrations, including in the United Kingdom, Korea, Singapore, Costa Rica, Mexico, Peru, and a grouping of 15 countries in East Africa. In 2017, U.S. Customs developed 14 use cases for blockchain, which are now being tested and assessed. Blockchain can be especially useful for the United Kingdom: when it leaves the EU customs union, its customs declarations will shoot up from 55 million to over 250 million (its non-EU trade plus its EU trade, where previously no customs documents were needed), something the United Kingdom's current software programs cannot quite handle. Blockchain can help: it enables tracing products to their very origin, which can help determine the origin of goods and the appropriate tariff, such as an EU tariff for a package destined for the European Union. Blockchain entries can be shared securely and transparently in real time across the 28 UK border agencies that need to analyze the incoming shipments for such things as food safety and intellectual property compliance. Every border agency can have a bird's eye view on any one shipment and all paperwork and events associated with it, which reduces every agency's administrative costs and facilitates customs clearance.[44]

6. *Preventing voting fraud and securing voters' identity*

In May 2018, West Virginia became the first state to allow internet voting by blockchain. The pilot project was the Mountain State's primary elections, and it was only offered to deployed military personnel and their dependents from two counties.[45] But the program appears to have worked without a hitch, and West Virginia's secretary of state is expected to announce if the project will be extended to the fall's midterm elections.

Using blockchain for elections is one of the most promising applications of the technology. Its security and identity protection features could reduce fraud, help voters trust that their vote remains anonymous, increase turnout, and allow for instant results in elections.[46] Using the technology, voters might be able to scan their thumb on a smartphone and vote on their commutes to work on election day. If everyone voted through blockchain, nobody could vote twice. The record of that vote would be inviolable, and every polling place would have an immediate record of every voting ID that had cast a ballot. According to Pete

Martin, the CEO of the mobile-voting startup Votem, voting over the internet could happen in two years.[47] Blockchain, with its distributed approach that makes hacking more difficult, could be the technology that bridges this divide.

7. *Triggering crop insurance for farmers*

Insurance is a massive industry, but customized policies are next to impossible in many sectors. For example, customized crop insurance policies tailored to the needs of specific farmers are often prohibitively expensive.[48] But blockchain could cut down on some of these costs by automating the processes that determine when claims are triggered. One example is Etherisic, which uses blockchain both to determine automatically when conditions are met that satisfy crop insurance claims and to create immediate payouts. For a small farm without access to a bevy of lawyers, this sort of automated crop insurance is appealing. The farmer could create, for example, an insurance policy against extreme weather conditions. If extreme weather impacted a harvest, the blockchain-based insurance contract would immediately recognize this and pay the farmer's claim.

Compare this process with how a small farm would have to seek compensation in the event of heavy rain today: the insurance contract, if there is one, would likely require the insurer's in-house claims adjuster to determine if specific conditions had been met. If the findings were regarded as unfair, farmers would have to decide whether to appeal—a long and potentially costly process.

8. *Creating a network of energy producers and users*

Some decades ago, several companies introduced smart grids that balance power generation in one part of a grid with demand in another part. One catalyst was households' growing ability to install solar panels, produce their own energy, and trade excess power to others. Now blockchain can optimize and scale these grids, essentially serving as a disintermediated energy trading platform among energy producer-consumers or "prosumers."[49] For example, in Germany, the southern industrial region wants more power from the windfarms in the north, but the grid is not sturdy enough to handle surges in that energy or to transport it. The cost of stabilizing the power flow is over $1.2 billion each year.

A company called TenneT is working to address this problem by using blockchain, with users being consumers of energy that can help stabilize the grid.[50] Specifically, individual households with storage batteries across a certain region are interconnected on a blockchain. Each household has an intelligent software that reacts to changes in the grid in real time: when the grid has too little electricity, the users feed power they have generated into it; when it has too much, the users charge batteries and appliances. Blockchain creates a secure log of all these transactions.

A Brooklyn startup LO3 Energy champions Exergy, a permissioned blockchain platform that enables localized peer-to-peer marketplaces for trading energy among users across existing grid infrastructure.[51] The company issues energy certificates as certain production thresholds are achieved and distributes energy from those who have it in excess to those who have demand.

9. *Creating smart cities that run on their own*

Hundreds of cities have turned to smart city applications to manage traffic flows, combat crime, deliver energy, and alert people about extreme pollution. Behind the scenes hums the Internet of Things (IoT) that connects sensors and other tools to capture data in a city with databases visible to various city officials and workers. Blockchain can now magnify the impact of IoT in making a city run on its own. For

example, Dubai has a pilot to implement blockchain in city services. Among other things, Dubai wants to use blockchain by 2020 in over 100 million annual government documents, including all visa applications, bill payments, and license renewals.[52] According to estimates, Dubai's could save 25.1 million worker hours or $1.5 billion each year by using blockchain.[53] The technology can also "give power to the people" and enable individuals to engage in transactions directly with each other. For example, Dubai has launched a blockchain-powered system to record all real estate contracts and connect homeowners and tenants to billable services such as electricity, water, and telecommunications.[54]

10. Automating payments for exporters when goods reach the foreign buyer

International trade finance is about ensuring that the seller of a product in country A will get paid once the buyer in country B gets the product. Sometimes the buyer and seller know each other very well, have done business for years, and trust each other. In those cases no trade finance is necessarily required: the seller simply trusts the buyer to pay because the buyer has paid every time in the past. However, in many cases buyers and sellers do not have such a long relationship, and the seller may want to ensure he or she gets paid, for example, in case the buyer happens to run into financial problems.

The uncertainties facing a seller of products about when and whether he or she gets paid by the buyer is why sellers and buyers in different countries have delegated the handling of the payments to banks or insurance companies that assess the buyers' ability to pay, track products as they make their way to the buyer, and release payment to the seller when the buyer is in possession of the product. While this sounds simple, it is not. Banks are worried about fraud for a reason. For example, in 2008, J.P. Morgan Chase was defrauded of almost $700 million with fictitious purchase orders and fake invoices used to get loans for nonexistent metal shipments.[55] To ensure their bases are covered, banks produce piles of paper that for bigger transactions can be 10 inches tall and take several weeks to compile. Bain Consulting estimates that 56 percent of banks' cost for a letter of credit arises from this long and often still manual document handling and checking.[56]

Blockchain changes this game by enabling the parties in a trade transaction to access the same data and digitized documents in real time. There is no need for multiple copies of the same documents stored on different databases across various entities. If a smart contract is used, the payment from the buyer to seller can be triggered automatically when the goods tagged with sensors connected to the smart contract arrive to the buyer. And unlike wire transfers that can take a number of days to clear, choking the exporter's cash flow, blockchain-based payments go through in seconds to the seller, just like emails.

The pioneering blockchain applications in trade finance included Singapore's DBS and Standard Chartered's 2015 proof of concept in trade finance invoicing and Bank of America Merrill Lynch, HSBC, and the Infocomm Development Authority of Singapore's blockchain prototype that mirrors a letter of credit transaction.[57] In Europe, Banco Santander, Deutsche Bank, HSBC, KBC, Natixis, Rabobank, Société Générale, and UniCredit announced a blockchain system called "we.trade" to streamline trade finance transactions in Europe. In a push to help developing country farmers get trade finance, IBM has partnered with BBVA and several Asian banks to test-drive blockchain in 12 currency corridors across the Pacific Islands, Australia, New Zealand, and the United Kingdom. The consortium's litmus test is to enable a small farmer in Samoa to enter into a trade contract with a buyer in Indonesia using smart contracts and blockchain.[58]

Blockchain can also improve supply chain finance, where the buyer or its bank pays the seller more quickly than it otherwise is supposed to, in exchange for a small cut. A smart contract could trigger payments from the bank to the seller and then, once payment is due, from the buyer to the bank. Blockchain could be especially useful for "chaining the supply chain," where a tier 1 supplier that gets a payment from the bank or the buyer then automatically passes a fraction of that due to the tier 2 suppliers, which in turn automatically pay tier 3 suppliers, and so on.[59] Once the entire supply chain is on blockchain, payments among the parties can be automated, accelerated, and digitized end-to-end. This in turn fuels all players' cashflows and removes financial vulnerabilities from the corporate buyer's supply chain.

4 | 10 Big Questions (and Myths) Surrounding Blockchain

The above examples illustrate how powerfully blockchain can transform economic and social systems and improve business models across sectors. It can also help mend some of the challenges that the internet is facing, such as managing users' identity and privacy, copyright protection, and the integrity of data and information.

At the same time, blockchain is still a very new technology. In many cases the main hurdle for its deployment is lack of knowledge about its benefits. And just like any technology and much like the internet itself, blockchain is surrounded by big question marks and many myths. There are at least 10 prominent questions surrounding it.

1. How "immutable" and "true" are data on blockchains really?

Blockchains are said to be immutable, but are they? Can blockchains be hacked?

The best answer is "possibly, but not likely." Not likely in the sense that each blockchain is established by consensus between the chain's users. This means that after a transaction has been validated a number of times, the cryptography in the blockchain ensures the entry cannot be reversed. However, blockchain does have three types of vulnerabilities.

The first is access to blockchain systems. Consider a large city that leverages blockchain applications. Who should be able to access the data on the blockchain? Should they be able to access it in full or in part? These questions are especially pressing when there is a "single point of failure," such as in a corporation or local or national government.[60] To answer them, the blockchain manager would need to balance many issues. One is security and accessibility: for example, to control access, the city might want to have several layers of passwords to a computer and store data in an encrypted format, yet enable city government officials to easily access data for improving their day-to-day operations.[61] In addition, the blockchain manager would need to protect unstructured data (information that is not reams of structured data such as numbers, but consists, for example, of written business documents), while also allowing for redaction of all or parts of them, depending on the role of the user.

The second vulnerability is the possibility that a blockchain could be hijacked and hacked if 51 percent of the chain is controlled by a bad actor that wants to tamper with the results.[62] The issue is not trivial: the state of Michigan has recently introduced a bill that imposes criminal penalties for manipulating data on blockchains in order to commit fraud. The upside of the famous "51% rule" is that it also makes it possible for a blockchain platform to "fork" out a hacker's data entry, capture the money, and leave the chain looking like the hack never occurred. This is what Verge, a cryptocurrency platform, did in April 2018 when an attacker stole 250,000 verge, the currency unit.[63]

The third vulnerability of blockchain systems is to the centuries-old garbage-in-garbage-out problem. Just like is the case of any database or statistical application, blockchain's value turns on the veracity of the data on it. What if the data imputed on the blockchain, for example, on a medical treatment are inaccurate or fraudulent to begin with? This is a thorny question, but one that can be overcome by replacing humans

with machines in making data entries. For example, sensors can do a more consistent job than humans in measuring and cataloguing the temperature in a warehouse for perishable foods. Also, technology can guarantee the integrity of entries. For example, Singaporean Fintech Trade Finance Market has a new product called Invoice Check that uses artificial intelligence data to spot fraudulent trade invoiced on the blockchain.[64]

2. *Who owns and maintains blockchains—and who is liable for problems and losses?*

Since blockchain is a decentralized community of users, who maintains it? Doesn't someone have to moderate it and maintain it just like websites are maintained?

The answer lies in the technology itself. That blockchain is decentralized applies also to the way it is managed and maintained. Rather than being run by a central authority, it is the users of a blockchain that administer it. This is case in permissionless blockchains: they are owned by no-one other than the community that runs them. That creates an important question: who is liable when a blockchain is run by users and no-one owns it?

In permissioned systems, the considerations are somewhat different. The entity that operates the chain can also determine who can access it. In permissioned systems, a "manager" maintains the network and acts as a gatekeeper, but it is the users that use the chain to transact, connect, and accept new data entries. However, the network is also smaller and thus possibly more susceptible to security challenges and risks than vast permissionless system where multiple users need to validate any one entry. This is a hypothesis that can be explored.

What about management of blockchains? Coordination costs for the manager are likely quite low in permissioned blockchains settings here as there are only a limited number of parties, such as among the small network of banks in we.trade, for example. Of course, entities that look to scale the user base need to factor in the costs of infrastructure and management of the network.[65] Unique costs and collective action problems can arise in permissioned systems as well. For example, imagine a setting where a million individuals own a token worth a dollar of a house.[66] Each of them wants the house to remain in great shape, but none has an incentive to maintain the house like a single owner would, as each only owns a tiny percentage. Blockchain governance needs to account for these types of considerations.

3. *Are smart contracts really that smart?*

Smart contracts trigger the fulfillment of a contractual obligation, such as payment when a buyer gets the product from a seller. Such automated contractual performance is nothing new: after all, many Americans make automated payments to their internet provider, for example. But more complex contracts that require a party or parties to fulfill some obligation after an event has occurred—contracts that have "if this happens, then this happens" clauses—are more complex to execute. Often intermediaries such as bankers or lawyers are needed to verify that something has indeed happened and then execute the next step.

However, now a smart contract can be summoned for the task. A smart contract uses an extrinsic data source that is programmed in a computer to "know" when to execute a contract. This data source is called "oracle" and it tells the smart contract that an event has indeed happened. For example, in trade finance, the registration number associated with an electronic bill of lading can be an oracle. To simplify somewhat,

when this oracle indicates that a shipment has arrived at the buyer, funds will automatically move from the buyer's bank to the seller's bank.

The purpose of smart contracts is to create efficiencies and take undue interactions (such as phone calls and emails) and human error out of a transaction. Governments are already realizing the benefits of smart contracts. For example, Delaware, a state where many U.S. businesses incorporate, now allows blockchain-based maintenance of corporate records, such as for listing shareholders in a company or recording share transfers, provided certain conditions are met, like that the records can be converted into clearly legible paper form within a reasonable time.[67]

Many other state governments have realized the benefits of smart contracts and enacted laws that legalize them. In 2016, Vermont passed a law whereby a blockchain-based digital record is considered a business record.[68] In Arizona, a March 2017 law legalized smart contracts as "an event-driven program, with state, that runs on a distributed, decentralized, shared and replicated ledger and that can take custody over and instruct transfer of assets on that ledger."[69] The law provides that smart contracts are like records and signatures in electronic format: they cannot be denied legal effect and enforceability.

But are smart contracts really smart thinkers with discernment over the completeness of contract fulfillment, or are they simply unthinking executors of orders coded in them? There are two reasons to believe the latter is still the case. The first is that smart contracts are as smart as the contract writers make them. There can be a difference between the assumptions contract writers make about the semantics associated with a contract execution and the semantics of the smart contract system.[70] The contract writers need to understand how the semantics they use can be interpreted by the smart contract. For example, a smart contract also does not have the human intuition to judge the behavior or intentions of parties. One example that is frequently used is whether parties to a merger agreement have made "reasonable efforts" to secure regulatory approvals.[71] Writers of smart contracts thus need to be mindful that they are not writing contracts that lawyers accustomed to dealing with terms such as "reasonable" interpret, but which a machine simply executes. Meanwhile, creators of smart contract systems need to learn to think like contract writers think.

The second reason why smart contracts are not yet that smart is that their entries can be manipulated by bad actors, whether those are contracting parties or miners that add transaction records to blockchain ledgers of past transactions. Research shows blockchains still have vulnerabilities. One study found that some 3.4 percent of Ethereum smart contracts, or 34,000 out of 1 million, are vulnerable to hacking.[72] This suggests smart contracts need improved smart security technology that detects bugs and breaches; another key element of the solution is for the blockchain ecosystem to widely share and adopt common best practices in using smart contracts. In addition, software built or used on top of a blockchain to create apps can, like computers or websites, have bugs, and they also have to conform to the underlying setup. For example, Ethereum does not accept decimal points, a fact that has be considered in coding smart contracts.

Third, while smart contracts provide the instantaneousness that consumers and businesses crave, sometimes delays and slack can actually be useful to prevent a lousy decision or a bad outcome. Businesses and regulators need to adjust their thinking and operations to a world where such room for error is more limited and transactions happen in a flash on their own.

Smart contracts can also grow smarter over time, for example, by using artificial intelligence to interpret various nuances related to compliance with contracts. In fact, blockchain itself can become much smarter. For example, it could be trained to only take in data that is relevant and classify it intelligently, thus saving in their storage space and costs.[73]

4. Is there identity theft on blockchain?

In July 2018, luminaries from Beyoncé to Barack Obama lost thousands of users on Twitter when fake accounts were purged. As many as 3 percent of user profiles on social media are fake. Can you then create a fake account on blockchain? And can your identity on blockchain be stolen?

These are huge questions. The internet was developed without clear and provable personal identity. Of course, it is possible to have a government-run digital identity database. A number of governments such as India and Estonia have created centralized digital IDs for all citizens that want them. A person can then use a digital avatar to vote, file taxes, register property, open bank accounts, and pay for groceries when that ID is linked to a bank account. No smartphones are necessary: in India, the ID verification can be made with a fingerprint, a major benefit for bringing the poorest citizens into the financial system. The fragility of these systems is that they are centralized: the data security requirements on governments that maintain them are extraordinary, and there are constant concerns about theft of these digital IDs. In part because of these concerns, India's Supreme Court has ruled that its digital ID system Aadhar must be voluntary.

Blockchain can solve concerns about identity theft. For example, the Illinois Blockchain Initiative is running a pilot where birth certificates are placed on a blockchain. These certificates are controlled by the user and can be quickly and easily validated without a consultation with a centralized repository. Blockchain could also help in voting where each voter has an ID code, but no one would be able to connect it back to the corresponding person. This is of course critical for the integrity of the democratic process.[74]

Similarly, blockchain can offer a viable alternative to a centralized database for storing personally identifiable information (PII): self-sovereign identity (SSI). The SSI solution uses blockchain to establish immutable recordings of the uses of globally unique decentralized identifiers (DIDs) that are essentially a secret website or URL that is cryptographically stored on a blockchain ledger.[75] One DiD could be your name, another your passport number, still another your date of birth. As a user, you could provide access to a DiD or DiDs of your choice to a third party, using a digital wallet app on your smartphone or desktop that transfers those DiDs to a blockchain. DiDs can also be automatically updated, for example, when parts of your identity such as your job title or your driver's license number change. Users can select what data to share with whom in specific cases and across different commercial, compliance, or other channels.[76] Startup Blockstack champions precisely such decentralized identity and domain name systems, giving people full ownership over their digital ID and footprint.[77] IBM and SecureKey Technologies have built a blockchain-based digital identity network for consumers on top of the Linux Foundation's Hyperledger Fabric v1.0, a permissioned system where users can determine who can access their information. The benefits could be massive, both in terms of securing identity and in furthering inclusion: the World Bank estimates that more than 1.1 billion individuals do not have any form of officially recognized ID with which to open bank accounts, vote, transact with the government, and so on.[78] With blockchain, they could leap into having a secure ID that they themselves manage.

Technology however still requires some testing to ensure DiDs are truly immutable and secure. Also pending is a way to determine how exactly to accurately connect individuals' physical and digital identities. There are also issues with incentives. Why would a business with millions of user records want to relinquish them and champion DiDs? One incentive could of course be the threat of hacking. Companies that are attacked and lose social security numbers or bank accounts might prefer users to manage their identity. But still, it is unlikely that the world would get on a blockchain-based identity system overnight. One way to transition is to permit companies to process personal data as usual but use blockchain technology to secure identities and access and verify these data and keep them updated.

A big question is whether users can delete their data on a blockchain. In principle, blockchains are subject to the same privacy laws that govern the internet. For example, the European Union's General Data Protection Regulation (GDPR) has a "right-to-be-forgotten" principle where a user can ask an internet service provider to remove his or her data from search results. Blockchain in theory needs to then reflect this principle as well. The owners of health, financial, and other sensitive data need to be able to request all or parts of their data be removed from the blockchain. But how this is done exactly is not clear, as the data on blockchain is designed to be immutable.

5. Can blockchains be connected to each other?

Just like a social media network with individual users or an e-commerce platform of independent buyers and sellers, blockchain's value tends to grow as its user base expands. However, there will not be one global blockchain in any domain; rather, multiple blockchain systems are sprouting up around the world in different areas of life. While this experimentation is very positive, it also implies that any one user, whether a business or a person, may end up being part of many blockchain systems, each with its own technology and governance. And it is likely that the data systems or "schema" of different networks will not always integrate and talk to each other well, preventing users of chain A from interacting with those of chain B.

Mishaps can also happen. For example, one blockchain records an entity or a user's data one way, while another records the same data referring to the same entity or user in another way. A fragmented system of multiple ledgers that are disconnected from each other would result in a world of operational silos, or "digital islands," where users would need to sign up on many systems at once to be able to transact with different parties for different purposes.

There are many realms with the same problem of "islands" or "walled gardens" that need to be interconnected, for all users of one garden to be able to interact with users of other gardens. Software talk to one another through APIs or "Application Programming Interfaces"; for example, PayPal has an API that can connect to multiple other software systems for a buyer and seller using different payment systems (like PayPal and a credit card) to interoperate. These systems are not always in place. Yet connecting blockchains to build a larger ecosystem takes willingness by blockchain managers to bring their user bases together and agree on principles related to such issues as the management and transfer of data and the use of smart contracts in the new, interconnected system. This points to a need for interoperability standards for blockchains. Several such interoperability standard processes are on the way or being contemplated, typically among parties in a sector that understand they all benefit from an interconnected, large network of users. Another possible solution (and one that does not obviate the need for standards) is to use smart contracts among users of multiple blockchains.[79]

Can blockchains in different jurisdictions then be connected? This does not seem like a stretch, given that finance, information on products, and payments are already flowing in a blockchain across borders. Various governments have already jumped to connect their blockchains. One prominent pilot has been launched between the blockchains of the Hong Kong Monetary Authority (HKMA) with Singapore's Monetary Authority of Singapore (MAS). These entities are implementing the Global Trade Connectivity Network (GTCN) that enables bilateral trade finance flows. Any countries that want to tag onto the network can do so by connecting their own blockchain system to the HKMA-MAS platform.[80]

6. How does blockchain speak with off-chain databases?

Can two parties interact if one party's data and documents are offline or off-blockchain and another party's data and documents are on a blockchain? How about inside a company: can a legacy database carrying, say, half of the company's data interact with a blockchain carrying the other half?

Clearly it would be ideal to get all data on a blockchain fast if it is the case that blockchain provides superior business insight and connections. But in practice this may not always happen smoothly. The problem of course multiplies if many new users have this same problem.

These challenges are well-known and are being tackled. It is, for example, becoming possible to run the same queries and analytics in on-chain and off-chain data systems. The one risk is that on-chain data are exported to an off-chain database that then is no longer immutable. Researchers recognize that data security and pooling, translating, and optimizing the sets of data on- and off-chain are challenges to work through.[81]

7. Will blockchain streamline money laundering?

Money laundering is a huge global problem, amounting to as much as $1-2 trillion, or about 2-5 percent of world GDP. Banks and authorities are pushing back, spending some $8 billion a year to combat the problem.[82] To comply with mandatory know-your-customer (KYC) checks, banks worldwide need to request new customers to submit identification documents each time an individual or corporate customer starts a new relationship with a bank (such as opening an account, applying for credit, or seeking trade finance) and to monitor flow of funds to detect money laundering. Banks also need to adhere to anti-money laundering (AML) and combatting the financing of terrorism (CFT) processes. Since the global regulatory environment is not harmonized, each bank needs to satisfy different levels of regulation. And in transactions involving many banks and players, duplication is rampant: each has to run its own KYC and AML process. Several leading global banks have been fined for failing to detect or prevent money laundering.[83]

Does blockchain help bad actors cover their tracks in illicit transactions if blockchain users are anonymous? One somewhat cynical answer might be that the banking system is too porous as is to stop money laundering such that criminals would benefit little from using blockchain. Another response turns on size of transactions: perhaps for smaller illicit transactions, permissionless blockchains can provide cover. But for larger transactions traveling through banking systems, blockchain can make it *harder* to commit fraud or launder money; for example, it makes it much harder for criminals to obscure the source and destination of a transaction by such tricks as making several transactions and deploying multiple "satellite" banks.[84] Pilots are already on the way. For example, in 2017, OCBC Bank, HSBC, IMDA, and Mitsubishi UFJ Financial Group (MUFG) completed a proof of concept for a KYC blockchain. The main benefit is reduced duplication: customers need to provide their information only once, all parties can

access the same information digitally in real time, and all information is secure and immutable. This lowers fraud and the odds of actual criminal events.[85] Blockchain could be used similarly in AML and CFT processes. For example, a blockchain-based AML process and platform could enable regulators, risk officers, auditors, and other relevant stakeholders to monitor complex transactions in real time and use the immutable audit trails to conduct retrospective analysis. The technology is there; the main challenge is to secure buy-in from regulators and financial institutions.[86]

8. Does blockchain end up guzzling all of the world's energy?

Just like an internet search on Google, entries and data on blockchain use energy. Bitcoin has astounding energy needs: today it takes the annual energy use of Ireland to run bitcoin for a year. The reason is bitcoin's original design. Bitcoin miners need to convert each list of most recent transactions into a signature that proves that the information is true. It is this process that takes up a great deal of computing power. Miners run computer calculations to track and verify transactions and solve complex puzzles to obtain bitcoin rewards. The founder of blockchain, Nakamoto, set up a competition to determine a very specific signature based on three inputs: the signature of the preceding block, the list of new transactions, and a random third number.[87] Since miners don't know the third number, they must generate signatures repeatedly until one guesses correctly. This method of reaching agreement—or "proof of work"—takes up tremendous computing power.

The concern naturally is that the growth of the network and the rise in the value of bitcoin will multiply the competitions and associated energy needs. The miners themselves have an incentive to prevent this future. Blockchain's scalability is limited by availability and cost of energy and by the miners' own wallets: some 80 percent of all expenses for the cryptocurrency miners scattered around the world go towards electricity.[88]

This is not lost on bitcoin fans and foes. One alternative to the current process is "proof-of-stake." While proof of work rewards participants for "working," or spending computational resources, proof of stake selects validators based in part on the size of their stake or their respective monetary deposits. Experts agree this is much more energy efficient but still unproven.[89] Meanwhile new energy sources such as solar power are contemplated as fuel for bitcoin mining.

Other blockchain applications demand less energy than Bitcoin, whose underlying structure is after all inefficient. And blockchain is emerging as a means to conserve energy—making it a product people can trade—and promote sustainability, as discussed in the cases of TenneT and LO3 Energy. There are also creative ideas to increase computing power. For example, the Department of Health and Human Services could mandate health care providers use a portion of their computing power to help run a national medical blockchain.[90] Patients could also choose to sell some of their health or demographic data to research studies, and researchers would then provide computing power for the health care blockchain.

9. Will blockchain take our jobs?

There has recently been tremendous hype about the impact of artificial intelligence on jobs. But what is the impact of blockchain on intermediaries like lawyers and bankers, if users can transact with each other?

Blockchain will unlikely be a job killer. It will, just like any technology, transform the nature of work by changing companies' business and revenue models. For example, law firms that want to be in the business of writing smart contracts will need to understand how blockchain "thinks" and how to ensure proper

programming of such contracts. Banks using blockchain in trade finance will need to reimagine their revenue models, for example, from charging for due diligence to charging pay-per-use fees for users to be part of the blockchain network and upselling services to them.[91]

The main challenge blockchain faces is not about the technology; it is about the value proposition for everyone on the blockchain. For example, in blockchains in international trade, there are several different players with different business models and ways to make money from banks that make money on letters of credit, to shippers that make money by moving a product from A to B, freight forwarders that help a business book its logistics services, trade lawyers that help the exporter fill the paperwork to enter a foreign market, customs that collect revenue on inbound shipments and ensure they are secure to enter into a country, and so on. A major challenge is how to apportion value to all these players and thus entice them to join the chain (whose value of course increases when all parties to a transaction are on it).

10. Is the United States a laggard in blockchain development?

Some experts would say yes. In fact, many developing countries have been applying blockchain faster at times than advanced economies for two reasons. First, this happens because blockchain can help solve challenges that are enormous in developing nations but minor issues in advanced economies, such as unclear property rights or low usage of bank accounts. Blockchain has also been applied in transnational problems such as tracking refugees. The urgency for using blockchain has simply been less in advanced economies. Second, in developing countries regulations can be less complex and developed than in advanced nations, enabling faster deployment of technologies.

While U.S. companies such as IBM and consortia such as R3 for banks are world leaders on blockchain technology and development, blockchain's use is still incipient in the United States, from a global point of view. In a 2018 Deloitte survey of 1,053 executives across financial services, health care, technology, telecom, manufacturing, and other sectors, only 14 percent of U.S. respondents said blockchain was already in production in their organization, compared to 49 percent in China, 48 percent in Mexico, 40 percent in the United Kingdom, and 36 percent in Canada. Planning is also lagging: 41 percent of U.S. companies planned to invest $1 million or more in blockchain as opposed to 85 percent of companies in China, 74 percent in Canada, 72 percent in the United Kingdom, and 65 percent in Mexico.[92]

5 | What Should U.S. Blockchain Policy Be?

Blockchain is a work in progress, often said to be in its lifecycle where the internet was perhaps a quarter century ago, in the early 1990s. Its benefits and possibilities are only now coming into focus. The question is what if anything should policymakers do to accelerate blockchain's benefits while mitigating pending security and privacy concerns. Since the technology is nascent, policy should be about encouraging blockchain innovation, usage, and scalability. There is no point in rushing to regulate a technology whose applications, benefits, and challenges are only emerging. This measured approach has also so far guided the work of the U.S. Congressional Blockchain Caucus set up in 2017.[93]

U.S. states have been much more active in blockchain regulation, mostly to bolster the use of the technology. Several states have passed laws, for example, to define the terms "blockchain" and "smart contracts," admissibility of smart contracts in courts, and taxation of blockchain use (Table 3). Some players in the industry as well as state attorney generals want states to lead the way, without federal preemption of state laws; others that have nationwide operations such as large banks tend to prefer national rules. To be sure, there are a number of areas where a patchwork of state rules can complicate citizens' lives: What if one state has driver's licenses on a blockchain as a legal ID, while a neighboring one does not? Or what if a company in one state that has explicitly made smart contracts binding has a smart contract with another company in another state where smart contracts are not binding?

The question of whether state laws conflict with each other, with federal laws, or with the Constitution is unsettled. For example, it is not clear whether Arizona's requirement that parties treat blockchain-secured records, signatures, and smart contract terms as "electronic signatures" under Arizona's version of the 1999 Uniform Electronic Transactions Act (UETA) conforms with the year 2000 federal Electronic Signatures in Global and National Commerce Act (ESIGN).[94] This has led some experts to advocate that ESIGN, which was aimed to unify U.S. laws related to e-commerce, be revised to define blockchain-secured records and signatures as "electronic signatures" that are entitled to legal effect. At the same time, one consideration for the federal government is that the demand by businesses for it to step in and sort out the patchwork of state rules is still limited. Demands have arisen in such areas as autonomous vehicles; they may be emerging later in blockchain, but so far there does not seem to be a major business push for federal action.

If the federal government were to consider a national definition of blockchain, a good one already exists: the National Institute for Science and Technology (NIST) has defined blockchains as "immutable digital ledger systems implemented in a distributed fashion (i.e., without a central repository) and usually without a central authority."[95] NIST further describes blockchain as follows: "A distributed digital ledger of cryptographically signed transactions that are grouped into blocks. Each block is cryptographically linked to the previous one after validation and undergoing a consensus decision. As new blocks are added, older blocks become more difficult to modify. New blocks are replicated across all copies of the ledger within the network, and any conflicts are resolved automatically using established rules."[96]

Table 3 – Selected State Laws Addressing Blockchain

State	Date of Law or Start of Engagement	Content
Arizona	April 2018	Recognizes data written and stored on blockchains; allows companies to hold and share data on a blockchain (previous legislation recognized smart contracts as legal documents).
Vermont	May 2016	Recognizes data stored on a blockchain is admissible in court.[97]
Nevada	June 2017	First state to ban local governments from taxing blockchain usage.[98]
Delaware	July 2017	Has passed amendments to state law that make explicit the right to trade stocks on a blockchain.[99]
New Hampshire	August 2017	Passed a law that exempted digital currency traders from New Hampshire's money transmission regulations.[100]
Tennessee	March 2018	Recognizes blockchain data as legally binding and gives smart contracts legal power.[101]
Washington	July 2017	Became the first state to regulate digital currency exchanges, requiring they post surety bonds as security deposits in case customers require compensation.[102]

While "hard law" regulations can wait, there does exist a need for voluntary industry standards to ensure the blockchain ecosystems in different sectors develop in ways that fuel innovation, build trust in the technology, and ensure scalability. Standards could provide several specific benefits:

- **Standards can provide for the interoperability of blockchain ledgers**. Interoperability is critical when blockchains in any industry proliferate to ensure that the ecosystem scales and that businesses and consumers can maximize their opportunities to connect and transact with each other and not just with users of a given ledger (or have to join multiple ledgers). Interoperability standards need to address issues related to governance, data share, and terminology.

- **Standards can help clarify how smart contracts operate.** Smart contracts open potential efficiency gains in such areas as insurance, financial services, supply chains, and logistics. Standards on how smart contracts should be written and the terminology to be used would provide market participants greater certainty as to what smart contracts should say and what they should do.

- **Standards can create commonly agreed blockchain terminology.** There are many words and concepts that are not necessarily used in the same way across the ecosystem that need to be standardized to enable parties to speak the same language. For example, when discussing the service that provides transaction ordering and timestamping, R3's Corda refers to "notaries" while Hyperledger's Fabric refers to "ordering service." Standards can iron out such discrepancies and establish a common vocabulary for the technology to help users of different platforms interact more easily.

- **Standards can further common understandings of how origin of products is tracked and determined in blockchain**, a question that impacts supply chains, finance, supply chain management, food and drug regulations, and customs administration, among other things.

- **Standards can also help clarify how data flows and is secured between on-chain and off-chain databases** and how data could be automatically converted from one system to another.

- **Standards can clarify how permissionless systems preempt the 51 percent problem**—essentially a hostile takeover of a blockchain system—and how bad actors can be weeded out, their transaction data forked out, and assets recovered.

Several public-sector entities are already driving blockchain standards, both domestically and internationally (Table 4).[103] The International Standards Organization (ISO) has a TC 307 Technical Committee defining a reference architecture, taxonomy, and ontology, a process initially spurred by Standards Australia's prior blockchain standards work. American National Standards Institute (ANSI) is a member to ISO's working group.[104] The Chinese government has set ambitious targets to reach blockchain standards by 2019, with the stated objective of fueling the development of the blockchain ecosystem and promoting innovation. Russian representatives to the ISO working group have mused about Russia wanting to own blockchain the way the United States "owned" the internet.

Table 4 – Illustrative Public-Sector Blockchain Standards Initiatives, by Sector

Entity	Goal	Comments
ISO (International Organization for Standardization)	27 member-countries met in November 2017 to establish ISO/TC 307: a committee to establish global blockchain standards (Australia is the leader). Thus far, there are 10 standards under development, 35 member countries, and 13 observing members.[105] The American National Standards Institute (ANSI) is among the members.	This is perhaps the closest to a uniform, global set of standards being developed. Some Western blockchain companies are hesitant to back it too strongly. While it is chaired by Australia, Russian FSB agents have actively participated in its talks.[106]

International Telecommunications Union (ITU)	The union established a focus group in May 2017 on distributed ledger technology. Its goal is to eventually reach "standardization roadmap for interoperable DLT-based services, taking into consideration the activities underway in ITU, other standards developing organizations, forums and groups."[107]	The focus group is chaired by a Swisscom executive and Russian and Chinese vice-chairmen.
Russia	Russia's goal is to "own" blockchain the way the United States owned the internet. President Putin himself has met with the creator of the Ethereum blockchain.[108] Russia plans to introduce rules for blockchain use by 2019.[109]	There's a great deal of skepticism about Russia's intentions.[110]
China	The goal is to establish national standards by 2019. The Blockchain Research Office is housed within the IT Ministry.[111] China's mission is, according to the head of the IT Ministry's Information and Software Department, "to expedite blockchain deployment in areas that most urgently need the nascent tech."[112]	The national standards will be based on the TC 307 standards.[113]
Japan Financial Services Agency (FSA)	A law went into effect in April 2017 that requires all virtual currency exchanges that do business in Japan to register with the FSA.[114]	
Accredited Standards Committee X9 (ASC X9)	The U.S.-based ASC X9 is a nonprofit representing the financial services industry and recognized by the American National Standards Institute (ANSI). It has a blockchain study group which is identifying areas where new standards must be developed or where existing standards must be modified in order to support the use of blockchain in financial services.[115]	
U.S. Department of Homeland Security	DHS has been "exploring the development of best practices for implementing the technology as well as globally available specifications to promote interoperability as a forerunner to established standards."[116] Particular goals are to combat counterfeit products and IP theft.	
U.S. Securities and Exchange Commission (SEC)	The SEC has a Distributed Ledger Technology Working Group (DLTWG) dedicated to protecting its users and investors from fraud in the sector.[117]	
European Blockchain Partnership	This consortium among EU member states aims "to exchange experience and expertise in technical and regulatory fields and prepare for the launch of EU-wide blockchain applications across the Digital Single Market for the benefit of the public and private sectors."[118]	
Australia	Australia is the chair of the TC 307 process and has used it to promote its standards blueprint finalized in 2017.[119]	

Several industry consortia and standards initiatives are also addressing blockchain interoperability and scalability issues, some specifically through standards (Table 5). For example, the Blockchain in Transport Alliance (BiTA) promotes blockchain applications in transportation and logistics industries and hopes to establish industry-wide standards for blockchain use in those fields. Its membership includes Fortune 500 companies and startups. There are also private-sector blockchain consortia aimed at building blockchain ecosystems; many of these will likely address standards as well.

Table 5 – Illustrative Private-Sector Blockchain Standards Initiatives and Consortia, by Sector

Industry	Consortium	Goals and Progress	Selected Participants
Internet of Things, Agriculture	IEEE-SA (IEEE is a professional organization that drives technology standards)	The IEEE has approached blockchain standardization on a sector-by-sector basis. It holds meetings on blockchain's use in various sectors (agriculture is next) and advances standards. Its most recent project has been on creating standards for blockchain use in Internet of Things (IoT) devices.	
Transport	BiTA (Blockchain in Transport Alliance)	BiTA promotes blockchain applications in transportation and logistics industries and hopes to establish industry-wide standards for blockchain use in those fields. Its membership includes Fortune 500 companies as well as small startups.[120]	UPS, FedEx, Schneider, Penske, SAP, and others.
Trade Finance	Hong Kong Monetary Authority (HKMA)	The HKMA is Hong Kong's de facto central bank. It has announced its intention to launch a blockchain-based trade finance platform by September 2018.[121] The *Financial Times* reports that 21 banks will take part, including HSBC and Standard Chartered.[122]	
Trade Logistics and Trade Finance	Digital Standards for Trade (DST)	DST was ideated by MasterCard and formed as an independent non-profit in December 2017 in Singapore to help entities such as the International Chamber of Commerce develop digital standards for trade, including for uses of blockchain in trade logistics and trade finance. Its goal is end-to-end digitized trade transactions.	Various bank members of the International Chamber of Commerce Banking Committee; Asian Development Bank, Singapore government, and National Trade Platform.

Trade Finance	UTN	This consortium of banks aims to drive standards on invoices and other documents on blockchain.	Various banks (under formation at the time of writing).
Finance, Trade Finance	SWIFT (Society for Worldwide Interbank Financial Telecommunication)	SWIFT hosts a standard secure messaging platform for financial institutions and is now exploring DLT for its network.	
Financial Services	R3	R3 was founded in 2014 and has over 200 members now.[123] Like any blockchain consortium, it allows firms to stay up-to-date on blockchain trends and mirror their competitors.	JPMorgan Chase, Goldman Sachs, Banco Santander, Morgan Stanley, National Australia Bank, and more than 80 of the world's biggest financial institutions, regulators, and central banks.[124]
Financial Services	Digital Trade Chain (DTC)	Launched in January 2017 by seven leading EU banks, Digital Trade Chain aims to build a better platform for cross-border trade for EU SMEs	Spearheaded by KBC (a Belgian bank),[125] other members include Deutsche Bank, HSBC, Natixis, Société Générale, and UniCredit.
Multiple	Hyperledger	Hyperledger's goal is to advance cross-industry blockchain technologies.	14 members including SAP, IBM, Intel, Fujistu, Daimler, Bank of England, among others. IBM provides a large amount of the computer coding for the Hyperledger.[126]
State Services	Illinois Blockchain Initiative	This consortium of state and county agencies will explore whether distributed ledger technology can be leveraged to improve state services.[127]	State of Illinois
Asset Management	Fundchain	This project aims to connect 401(k) plans and other funds through blockchains.	Brown Brothers Harriman, HSBC, ING, PwC, SWIFT, and others.
Insurance	B3i	B3i encourages swapping information and use cases, basically allowing insurance companies to learn from one another in applying blockchain.	Allianz, Liberty Mutual, Swiss Re, Zurich, and others.

Trade Finance	we.trade	We.trade is a trade platform that uses IBM's Hyperledger Fabric blockchain platform. It lets clients search for trade counterparties and uses smart contracts to ensure payments are made automatically.[128] We.trade already has nine banks on board, including Deutsche Bank, HSBC, Santander, and Société Générale, each of which operates a node on the blockchain.[129] It is explicitly focused on helping SMEs within Europe.	HSBC, KBC, Natixis, Deutsche Bank, HSBC, Santander, Société Générale, and others.

In light of the proliferating standards initiatives and laws, what, if anything, should the United States government do? There are several approaches to take:

- **Fuel blockchains' scalability and interoperability**. For U.S. companies and government, it is critical to lead the ISO process that will set the global standards across many areas for years to come. This can help ensure coordination among these many efforts to guarantee that the many standards-setting initiatives are complementary and coordinated, so that disparate standards themselves do not end up fragmenting the blockchain ecosystem. This coordinated approach is all the more relevant when blockchains cross borders and impact such issues as revenue collection. Ultimately, the United States can drive coordination at the G20, which for now has been focused, with the Financial Stability Board, on rules and anti-money laundering principles around cryptocurrencies.

- **Enable innovation through regulatory certainty and flexibility, including via a blockchain sandbox**. In a 2018 Deloitte survey, the largest set of business respondents, 39 percent, agreed that regulatory issues were a major barrier to their investment in blockchain, followed by challenges to replace legacy systems (37 percent).[130] It is of paramount importance that there be clear guidance and regulatory certainty so that blockchain initiatives and companies can keep moving forward and work on new innovations without having to worry that a new regulation is waiting around the corner that will obliterate their investment.

  This concern can be addressed in two ways. First, policymakers and businesses need to critically educate regulators in various sectors about blockchain and its uses; bringing regulators along early will set the table for open and frank communication. Second, regulators can accelerate their learning by setting up a blockchain sandbox, where companies can bring new applications to market without having to comply with the gamut of regulations that might otherwise apply, and regulators can monitor their uptake and outcomes and create regulations if and when legitimately needed. Sandboxes are widely used around the world to enable fintech applications to deploy quickly with temporary regulatory authorization for a certain period of time. Companies can quickly and more cheaply test the market for their technologies, and regulators can learn about the technology's uptake and operation and learn which, if any, areas would need to be regulated, for example, in such areas as consumer protection or competition policy. Similar testing grounds

could be established for companies that apply blockchain in different sectors, such as energy or insurance.

- **Create a safe harbor for permissioned blockchains**. Lawmakers can consider for blockchain a similar *federal* safe harbor as was created in the 1990s for internet intermediaries via Section 230 of the Communications Decency Act. The law exempted intermediaries such as social media and e-commerce platforms from liability for user generated content on their platforms. It is widely hailed as the key for the growth of America's online economy and angel and venture capital investments in internet services. Blockchains should be governed by the same principle: it is the users not the blockchain manager that are liable for the data entries. Some nuancing is required in that blockchain users are not generally trading content but real assets. Section 230 would shield a social media platform from liability if a user posted to his friends a chapter of a book manuscript whose copyright belongs to someone else or if the user posted libelous comments about another user. A blockchain user would "post" physical assets rather than content, and thus a Section 230-equivalent for blockchain would need to protect blockchain managers from liability if a user sought to, say, transact fake, stolen, or illicit goods. The liability would in most cases have to be on the users. A federal safe harbor could also be executed as "partial preemption": all states could have the safe harbor, but the federal law would provide exemptions for state policymakers to be able to override the safe harbor in cases of malign uses of blockchain.

- **Accelerate adoption through raising awareness about the benefits of blockchain.** Blockchain applications will catch on with the public if they enable people to do things cheaper, faster, and better—just like online search and email caught on in the 1990s. Just as an internet user did not need to understand how the internet works in order to grasp the benefits of email, a blockchain user does not need to understand how blockchain works to trade a house's excess energy to another house via a blockchain. However, education is critically needed among public officials, regulators, and U.S. businesses. For example, in voting, public officials will need to have greater knowledge about the technology's benefits in order to apply it. Government agencies such as the Small Business Administration (SBA) and the Department of Commerce could develop campaigns to raise awareness about blockchain and its benefits with U.S. businesses, and the White House can coordinate awareness-building across federal agencies. There can also be specific campaigns to promote the use of the technology by minority- and women-run businesses; similar language was included in the 2012 Jobs Act to educate these groups about crowdfunding. Prizes and competitions can be particularly powerful ways to focus businesses on developing blockchain applications.

- **Leverage existing laws and best practice standards rather than reinventing the wheel or imposing federal regulations early on.** Multiple laws and standards in areas such as data privacy and transfer, encryption, cross-border financial services, and custom cooperation already probably apply to issues related to blockchain. For private- and public-sector entities considering standards, there is in many cases no need to start from scratch but rather to take stock of standards that are already in place and identify "best practice" standards. It is also important to consider what the private sector is already applying; there is no need to redo standards if companies that make up a critical mass of 70-80 percent of the market cap or transactions in a sector already apply a certain practice as the de facto standard. In such cases, standards could simply codify what is already standard industry practice.

- **Opt for sector-specific approaches in lieu of blanket regulations.** Blockchain is fundamentally about improving the way business is done across multiple sectors. This, rather than the technology itself, is its main added value.[131] Blockchain is also not that valuable without being applied to a specific business issue. A blanket "blockchain regulation" aimed to regulate the technology is not at all helpful; it is unlikely targeted enough to address sector-specific issues and can also end up being too stifling for many sectors. It is also not that helpful: it is like regulating an engine when an engine is used in shipping, planes, and manufacturing, all very different sectors with their own issues and hazards and therefore requiring their own regulations. The regulations on blockchain are best crafted as regulations on sectors that leverage blockchain and are best done after the applications using blockchain have been tested for two years in a sandbox.

- **Take risk management—access, security, and identity issues—extremely seriously.** The founders of the internet have recognized that they did not pay sufficient attention to online privacy and security, two enormous and critical issues that policymakers and business leaders grapple with today. Blockchain promoters can learn from this and get privacy and security right from the start. At the same time, ledgers managed by public-sector entities that centralize user data, transactions data, and critical information flows—such as in managing a port of a smart city—must invest heavily in managing access and security issues. It is critical to develop blockchain applications like jet airplanes—where there is no single point of failure and odds of failure are miniscule.

- **Commit federal funds to accelerate blockchain development, use cases, and public-private partnerships in such areas as defense, counterintelligence, customs and border protection, trade enforcement, health care management, and smart city management.** Many U.S. government agencies from Health and Human Services to Customs, Treasury, and Defense have considered blockchain use cases or invested in blockchain applications to improve their own processes and products. Now it is time to systematize and amplify these efforts into mainstream blockchain use, promotion, and public-private partnerships across agencies, including through additional federal investments in the development of new use cases in these sectors. Several other governments have made significant investments in promoting blockchain. For example, the European Commission plans to invest another €300 million in blockchain by 2020, and the Chinese governments at various levels are aggressively investing in blockchain. The United States needs to step up if it wants to demonstrate leadership. In light of the threats posed by private and governmental bad actors to blockchain ledgers, some of this funding needs to go to identity issues, blockchain security, and encryption technologies to ensure a robust and secure U.S. blockchain ecosystem.

- **Help U.S. companies do business in developing nations by creating a Global Blockchain Fund.** U.S. businesses and the U.S. government stand to gain from the efficiencies, transparency, and security that blockchain offers in developing nations, for example, to combat red tape, corruption, and inefficient processes. Blockchain can also critically help attain the UN Sustainable Development Goals for 2030, a set of targets that many U.S. and foreign companies have pledged to help attain and the United States has participated in. As such, the United States should work with allies that are long-standing development partners such as the United Kingdom, Japan, Australia, Germany, Netherlands, and the Nordic countries to create a Global Blockchain Development Fund (GBDF) that provides funding for businesses, non-profits, and multilateral

development banks to catalyze creative, high-impact blockchain pilots in developing economies that aim to create market-driven networks and solutions that have lasting impact after the support of a donor ends.

The fund's board should consist of donor countries and private-sector representatives that help guide investments to where they can create significant new markets and efficiencies. The funding can also take the form of public-private partnerships where, for example, a set of banks co-invests with government donors to create a blockchain application for SME trade finance in Africa. Such a common facility would also enable the donor countries to coordinate efforts and ensure strategic, high-impact investments in a set of key sectors with high inefficiencies and great development impacts such as trade, health, and energy—rather than duplicating efforts and spreading resources thinly. There are several prior examples of such funds. For example, the Global Fund to Fight AIDS, Tuberculosis and Malaria mobilizes $4 billion annually from governments, civil society, and the private sector. In the area of trade, the United States has created with four other donor nations and the private sector the $50 million Global Alliance for Trade Facilitation that invests in customs reform projects worldwide. A sector-agnostic "horizontal" fund, the Global Blockchain Development Fund could support the objectives of such sectoral funds.

6 | Conclusions

This paper has made six main points:

1. **Blockchain has left the station and it is becoming a bullet train that can unlock trillions of dollars in efficiency gains in the U.S. economy.** Blockchain enables interactions among anonymous users without central authority, using immutable data on those interactions that are visible to all users in real time. As such, blockchain can enable businesses, individuals, and governments to do many activities better and faster, such as accelerate product tracing and quality assurance, automate verification and compliance with contractual obligations, secure personal data and user identities, and reduce coordination costs among multiple players needing the same information at the same time.

2. **Blockchain is still very nascent and it needs time and freedom to mature.** Blockchain is a foundational technology that transforms social and economic interactions and business models across sectors. Though the technology's "hype cycle" may be peaking, its many potential uses such as smart contracts and digital identities are a work in progress. In that sense, blockchain is where the internet was in the early 1990s, with its potential becoming evident only in the next 10 to 20 years. Various state governments have helpfully adopted laws that define blockchain and such areas as legality of contracts on blockchain, for example, but there is no particular urgency to impose federal regulations. Blockchain should not be regulated with blanket rules that stifle innovation; if anything, regulation should be done on a sectoral basis. Besides, many federal laws in the books in such areas as privacy already apply quite well to blockchain.

3. **The development, scaling, and automation of applications built on blockchain can be fueled by industry standards.** One of the best ways to catalyze blockchain innovations and enhance the technology's scalability are common standards that enable blockchain ledgers to interoperate and establish common blockchain terminology. For public-sector entities that manage blockchains, for example, smart city managers and development of a comprehensive set of rules and practices to manage access to ledgers and their security is of paramount importance.

4. **The United States needs to play a leadership role in providing coordination for the many standards initiatives around the world, in order for them to energize and help scale, rather than fragmenting, the blockchain ecosystem.** Several governments including China, Japan, Russia, and Germany and intergovernmental organizations are analyzing and developing blockchain standards. For U.S. companies and the U.S. government, one focus may be coordination among these many efforts to "standardize standards"—how governments and businesses ensure that the many standards-setting initiatives are complementary and coordinated, so that disparate standards themselves do not end up fragmenting the ecosystem. This coordinated approach is all the more relevant when blockchains cross borders and impact such issues as revenue collection, data management, and national security.

5. **The United States government needs to systematically invest in blockchain's development and integrity.** Already several agencies from the Department of the Navy to Health and Human Services and U.S. Customs and Border Protection have developed blockchain use cases. To ensure

U.S. leadership of blockchain and integrity of the technology, the U.S. government should make a major commitment in blockchain's development. In light of the threats posed by private and governmental bad actors to blockchain ledgers, some funding needs to go to blockchain security and encryption technologies.

6. **The United States can create with key allies and development partners a Global Blockchain Development Fund to accelerate the uptake of blockchain in the developing world, aiming to improve business environments in developing nations, advance the UN's 2030 Sustainable Development Goals, and open new opportunities for U.S. technology companies in developing economies.** The fund could provide support for businesses, non-profits, and multilateral development banks to catalyze creative, high-impact blockchain pilots in developing economies aimed to create market-driven networks and solutions that have lasting impact after donor support ends. The fund's board should consist of donor countries and private-sector representatives that help guide investments to where they can create significant new markets and efficiencies.

Blockchain is a seminal technology that can catapult the world to a new growth path and promises to become a marvel of twenty-second century economic historians. But it will not create value on its own: it requires the ingenuity of entrepreneurs and intrapreneurs and investments by businesses. These players in turn need a hospitable environment and funding to cultivate blockchain innovations, accelerate the development of new blockchain use cases, and ensure proliferating blockchains can interoperate. This is what the United States government now needs to help facilitate.

About the Author

Kati Suominen is an adjunct fellow with the CSIS Europe Program; founder and CEO of the data and research firm Nextrade Group, which helps multilateral development banks, governments, and Fortune 500s optimize public policies and investments in driving trade and e-commerce worldwide; founder of TradeUp Capital Fund, a platform for globalizing small to medium-sized enterprises; and founder of Business for eTrade Development, a global coalition of leading companies driving e-commerce development. She is the idea-woman behind such global initiatives as eTrade for All, a global multidonor initiative to accelerate the adoption of e-commerce worldwide; Alliance for eTrade Development, a public-private partnership among major digital companies and the U.S. Agency for International Development to fuel e-commerce development; and RTA Exchange, a new global forum on trade agreements sponsored by the Inter-American Development Bank and International Center for Trade and Sustainable Development. She has authored over 100 articles and written 9 books, and she is now working on her 10th, Making Trade Great Again: How Disruptive Technologies Open Opportunity for All (Stanford University Press, forthcoming 2018). She has provided commentary in the Wall Street Journal, Bloomberg, BBC, CSPAN, CNN, Washington Post, Los Angeles Times, Politico, USA Today, Time, Economist Intelligence Unit, and U.S. News and World Report. Dr. Suominen holds a B.A. from the University of Arkansas, an M.A. from Boston University, an M.B.A. from the University of Pennsylvania's Wharton School, and a Ph.D. from the University of California, San Diego. She is a life member of the Council on Foreign Relations.

Endnotes

1 "Blockchain Investment Trends in Review," CB Insights Research.
2 See, for example, Jim Haughwout, "Blockchain: A Single, Immutable, Serialized Source of Truth," Material Handling & Logistics, Oct 18, 2017, http://www.mhlnews.com/technology-automation/blockchain-single-immutable-serialized-source-truth.
3 For the explanation, see "Commentary: How Blockchain Could Put an End to Identity Theft," *Fortune*, http://fortune.com/2018/04/20/blockchain-technology-identity-theft-data-privacy-protection/.
4 Camila Russo, "Walmart Is Getting Suppliers to Put Food on the Blockchain," Bloomberg, April 23, 2018, https://www.bloomberg.com/news/articles/2018-04-23/walmart-is-getting-suppliers-to-put-food-on-blockchain-to-track.
5 Roger Aitken, "IBM & Walmart Launching Blockchain Food Safety Alliance In China With Fortune 500's JD.com," *Forbes*, December 14, 2017, https://www.forbes.com/sites/rogeraitken/2017/12/14/ibm-walmart-launching-blockchain-food-safety-alliance-in-china-with-fortune-500s-jd-com/#e9daf4b7d9c5.
6 "Transform Supply Chain Transparency with IBM Blockchain," IBM, June 18, 2018, https://www-01.ibm.com/common/ssi/cgi-bin/ssialias?htmlfid=93014193USEN&.
7 Robert Hackett, "IBM and Maersk Are Creating a New Blockchain Company," *Fortune*, January 16, 2018, http://fortune.com/2018/01/16/ibm-blockchain-maersk-company/.
8 Ibid.
9 Don Weinland, "HSBC Claims First Trade-finance Deal with Blockchain," *Financial Times*, May 13, 2018, https://www.ft.com/content/c0670eb6-5655-11e8-bdb7-f6677d2e1ce8.
10 Stan Higgins, "US Customs and Border Protection Advisors Form Blockchain Research Effort," CoinDesk, November 10, 2017, https://www.coindesk.com/us-customs-border-patrol-advisors-form-blockchain-research-effort/.
11 Marie Huillet, "Bitcoin Above $7,000 as Positive Momentum Continues Following Yesterday's Market Upswing," Cointelegraph, July 17, 2018, https://cointelegraph.com/news/bitcoin-above-7-000-as-positive-momentum-continues-following-yesterday-s-market-upswing.
12 Ariel Ekblaw and Asaf Azaria, "MedRec: Medical Data Management on the Blockchain," Viral Communications, April 11, 2016, https://viral.media.mit.edu/pub/medrec.
13 Jesse Damiani, "SimplyVital Health Is Using Blockchain To Revolutionize Healthcare," *Forbes*, November 7, 2017, https://www.forbes.com/sites/jessedamiani/2017/11/06/simplyvital-health-blockchain-revolutionize-healthcare/#67e307a1880a.
14 Michiel Berende, "The Potential of Blockchain: From Flight-delay to Agriculture Insurance," Medium, May 23, 2018, https://medium.com/impact-insurance/the-potential-of-blockchain-from-flight-delay-to-agriculture-insurance-eb774e8f8508.
15 "The Problem," AgriLedger, http://www.agriledger.com/.
16 Kevin C. Desouza and Kiran Kabtta Somvanshi, "How Blockchain Could Improve Election Transparency," Brookings, May 29, 2018, https://www.brookings.edu/blog/techtank/2018/05/30/how-blockchain-could-improve-election-transparency/.
17 "I-Voting," E-Estonia, https://e-estonia.com/solutions/e-governance/i-voting/.
18 See Heather Clancy, "The Blockchain's Emerging Role in Sustainability," GreenBiz, February 6, 2017, https://www.greenbiz.com/article/blockchains-emerging-role-sustainability; "The Future of Energy | Blockchain, Transactive Grids, Microgrids, Energy Trading | LO3 Stock, Tokens and Information," LO3 Energy, https://lo3energy.com/.
19 Saqr Ereiqat, "Blockchain in Dubai: Smart Cities from Concept to Reality - Blockchain Unleashed: IBM Blockchain Blog," IBM, August 06, 2018, https://www.ibm.com/blogs/blockchain/2017/04/blockchain-in-dubai-smart-cities-from-concept-to-reality/; Suparna Dutt D'Cunha, "Dubai Sets Its Sights On Becoming The World's First Blockchain-Powered Government," *Forbes*, December 18, 2017, https://www.forbes.com/sites/suparnadutt/2017/12/18/dubai-sets-sights-on-becoming-the-worlds-first-blockchain-powered-government/.
20 Ibid.
21 Michael Corkery and Nathaniel Popper, "From Farm to Blockchain: Walmart Tracks Its Lettuce," *New York Times*, September 24, 2018, https://www.nytimes.com/2018/09/24/business/walmart-blockchain-lettuce.html.
22 "Blockchain: A Better Way to Track Pork Chops, Bonds, Bad Peanut Butter?" *New York Times*, March 4, 2017, https://www.nytimes.com/2017/03/04/business/dealbook/blockchain-ibm-bitcoin.html.
23 See Victoria Bryan, "Aerospace suppliers look to blockchain for parts tracking," Reuters, May 2, 2018, https://www.reuters.com/article/us-aerospace-blockchain/aerospace-suppliers-look-to-blockchain-for-parts-tracking-idUSKBN1I32AW.
24 Finbarr Bermingham, "Singapore Chamber Brings Trade Documents onto Blockchain," Global Trade Review (GTR), May 09, 2018, https://www.gtreview.com/news/asia/singapore-chamber-of-commerce-brings-trade-documents-onto-blockchain/.
25 "3D Printing Comes of Age in US Industrial Manufacturing," PwC, https://www.pwc.com/us/en/industries/industrial-products/library/3d-printing-comes-of-age.html.
26 Tyler Koslow, "GE Files Patent to Improve 3D Printing Security with Blockchain Tech," All3DP, June 29, 2018, https://all3dp.com/ge-aims-to-use-blockchain-tech-to-eliminate-fake-3d-printed-objects/.
27 Tia Vialva et al., "US Navy to Employ Blockchain to Control 3D Printers," 3D Printing Industry, June 26, 2017, https://3dprintingindustry.com/news/us-navy-employ-blockchain-control-3d-printers-116968/.
28 Tyler Koslow, "GE Files Patent to Improve 3D Printing Security with Blockchain Tech."
29 Kata Karath, "Startup Wants to Connect Thousands of 3D-printers in a Blockchain-based Network Hub," Cointelegraph, February 7, 2018, https://cointelegraph.com/news/startup-wants-to-connect-thousands-of-3d-printers-in-a-blockchain-based-network-hub.

30 Greg Reh, "Beyond Bitcoin: Five Possible Uses for Blockchain in Health Care," Modern Healthcare, April 17, 2018, http://www.modernhealthcare.com/article/20180417/SPONSORED/180419934.
31 Mike Miliard, "Blockchain Is Proving Itself for Real-world Healthcare Applications," Healthcare IT News, March 8, 2018, https://www.healthcareitnews.com/news/blockchain-proving-itself-real-world-healthcare-applications.
32 "Blockchain for Electronic Health Records," Medicalchain, https://medicalchain.com/en/.
33 Mike Orcutt, "Blockchain Technology Will Revolutionize Medical Records-Just Not Anytime Soon," *MIT Technology Review*, September 22, 2017, https://www.technologyreview.com/s/608821/who-will-build-the-health-care-blockchain/.
34 Ibid.
35 Nikhilesh De, "HHS Architect Talks Blockchain's Potential Role in Healthcare Administration," CoinDesk, October 24, 2017, https://www.coindesk.com/hhs-it-architect-talks-blockchain-white-paper-results/.
36 "MintHealth Updates Toward Security Token Structure," Business Wire, March 14, 2018, https://www.businesswire.com/news/home/20180314006130/en/MintHealth-Updates-Security-Token-Structure.
37 "Maersk and IBM Unveil First Industry-Wide Cross-Border Supply Chain Solution on Blockchain," IBM, news release, March 5, 2017, https://www-03.ibm.com/press/us/en/pressrelease/51712.wss.
38 See Glen Williams et al., "Distributed Ledgers in Payments: Beyond the Bitcoin Hype," Bain Brief, July 13, 2016; "International Trade and Logistics," IMDA Singapore, November 28, 2016.
39 Ibid.
40 "Maersk and IBM Unveil First Industry-Wide Cross-Border Supply Chain Solution on Blockchain," IBM.
41 Lorraine Keyes, "Data Analytics: How data analytics can simplify and facilitate trade within the European Union," Europese Fiscale Studies, Post Masters in EU Customs Law 2015/2016, https://www.europesefiscalestudies.nl/upload/Keyes%20-%20verhandeling%20FINAL.pdf.
42 Medha Basu and Nurfilzah Rohaidi, "Exclusive: Singapore's plans for AI in border security," Gov Insider, May 14, 2017, https://govinsider.asia/smart-gov/singapores-customs-sung-pik-wan-innovation/.
43 "W Coast Trade Symposium recap: E-commerce is the Hot Topic" Customs and Border Protection, e-manifest, PGAs, PTI, Trade Transformation, May 31, 2017 http://www.customsnow.com/blog/2017/05/w-coast-trade-symposium-recap-e-commerce-is-the-hot-topic/
44 Lewis King, "UK traders say blockchain can ameliorate impending customs congestion," Air Cargo World, August 16, 2017; See also Kati Suominen, *Making Trade Great Again: How Disruptive Technologies Open Opportunity for All* (Stanford University Press, 2018).
45 Ben Miller, "West Virginia Becomes First State to Test Mobile Voting by Blockchain in a Federal Election," Government Technology: State & Local Government News Articles, March 28, 2018, http://www.govtech.com/biz/West-Virginia-Becomes-First-State-to-Test-Mobile-Voting-by-Blockchain-in-a-Federal-Election.html.
46 Desouza and Somvanshi, "How Blockchain Could Improve Election Transparency."
47 Ibid.
48 Michiel Berende, "The Potential of Blockchain: From Flight-delay to Agriculture Insurance," Medium, May 23, 2018, https://medium.com/impact-insurance/the-potential-of-blockchain-from-flight-delay-to-agriculture-insurance-eb774e8f8508.
49 Esther Mengelkamp at al., "A Blockchain-based Smart Grid: Towards Sustainable Local Energy Markets," SpringerLink, August 22, 2017, https://link.springer.com/article/10.1007/s00450-017-0360-9.
50 Ulrike Hörchens, "Europe's First Blockchain Project to Stabilize the Power Grid Launches: TenneT and Sonnen Expect Results in 2018," TenneT, November 2, 2017, https://www.tennet.eu/news/detail/europes-first-blockchain-project-to-stabilize-the-power-grid-launches-tennet-and-sonnen-expect-res/.
51 See Clancy, "The Blockchain's Emerging Role in Sustainability"; "The Future of Energy | Blockchain, Transactive Grids, Microgrids, Energy Trading | LO3 Stock, Tokens and Information," LO3 Energy.
52 Ereiqat, "Blockchain in Dubai"; D'Cunha, "Dubai Sets Its Sights On Becoming The World's First Blockchain-Powered Government."
53 D'Cunha, "Dubai Sets Its Sights on Becoming The World's First Blockchain-Powered Government."
54 Ibid.
55 Chanyaporn Chanjaroen, "Fraud in $4 trillion trade finance turns banks to digital ledger," liveMINTO, May 23, 2016, http://www.livemint.com/Industry/CXfxl1yePlwTDuokXU3c2K/Fraud-in-4-trillion-trade-finance-turns-banks-to-digital-le.html/.
56 "More than $150 billion in revenue at risk for banks that cannot overcome technical, adoption hurdles of digital currency," Bain & Company, July 15, 2016, http://www.bain.com/about/press/press-releases/150-billion-dollars-at-risk-for-banks-that-cannot-overcome-hurdles-of-digital-currency.aspx/.
57 Avi Mizrahi, "BofAML, HSBC and IDA Singapore Develop Blockchain for Letters of Credit," Finance Magnates, October 8, 2016, http://www.financemagnates.com/cryptocurrency/innovation/bofaml-hsbc-and-ida-singapore-develop-blockchain-for-letters-of-credit/.
58 Peter Lee, "Banking jumps to post blockchain," Euromoney, October 24, 2017, https://www.euromoney.com/article/b159v9n3cbm4p2/banking-jumps-to-post-blockchain?copyrightInfo=true/.
59 "Technology is revolutionising supply-chain finance," *The Economist,* October 12, 2017, https://www.economist.com/news/finance-and-economics/21730150-squeezed-suppliers-and-big-corporate-buyers-stand-benefit-technology/; See also Suominen, *Making Trade Great Again: How Disruptive Technologies Open Opportunity for All*.
60 Ronghya Xu et al., "BlendCAC: A BLockchain-ENabled Decentralized Capability-based Access Control for IoTs," April 24, 2018, https://arxiv.org/pdf/1804.09267.pdf.
61 Hoang Tam Vo, Ashish Kundu, and Mukesh Mohania, "Research Directions in Blockchain Data Management and Analytics," March 26-29, 2018, https://openproceedings.org/2018/conf/edbt/paper-227.pdf.
62 Christina Comben, "Are Blockchains Actually Immutable?" NullTX, April 07, 2018, https://nulltx.com/are-blockchains-actually-immutable/.

63 Kai Sedgwick, "Verge Is Forced to Fork After Suffering a 51% Attack," Bitcoin News, April 05, 2018, https://news.bitcoin.com/verge-is-forced-to-fork-after-suffering-a-51-attack/.
64 Finbarr Bermingham, "Blockchain solution aims to stop trade invoice fraud," GTR Review, August 30, 2017, https://www.gtreview.com/news/asia/blockchain-solution-aims-to-stop-trade-invoice-fraud/.
65 Marco Iansiti and Karim R. Lakhani, "The Truth About Blockchain," *Harvard Business Review*, March 6, 2018, https://hbr.org/2017/01/the-truth-about-blockchain.
66 An excellent example discussed in Eric Jackson, "How blockchain technology will reduce trade friction for everything from real estate to fine art," CNBC Tech, January 29, 2018, https://www.cnbc.com/2018/01/29/stephen-mckeon-on-asset-based-tokenization.html.
67 Catherine Simard, "Delaware Provides Legal Clarification for Blockchain Maintenance of Corporate Records – the View from Canada," Norton Rose Fulbright, September 2017, http://www.nortonrosefulbright.com/knowledge/publications/155384/delaware-provides-legal-clarification-for-blockchain-maintenance-of-corporate-records-the-view-from-canada.
68 Jeffrey Neuburger, "Arizona Passes Groundbreaking Blockchain and Smart Contract Law – State Blockchain Laws on the Rise," New Media and Technology Law Blog, April 20, 2017, https://newmedialaw.proskauer.com/2017/04/20/arizona-passes-groundbreaking-blockchain-and-smart-contract-law-state-blockchain-laws-on-the-rise/.
69 Ibid.
70 Loi Luu et al., "Making Smart Contracts Smarter," October 2016, https://eprint.iacr.org/2016/633.pdf.
71 Mike Orcutt, "Ethereum's Smart Contracts Are Full of Holes," *MIT Technology Review*, March 1, 2018, https://www.technologyreview.com/s/610392/ethereums-smart-contracts-are-full-of-holes/.
72 See Ivica Nikolic et al., "Finding The Greedy, Prodigal, and Suicidal Contracts at Scale," Arxiv.org, March 14, 2018, https://arxiv.org/pdf/1802.06038.pdf.
73 Hoang Tam Vo, Ashish Kundu, and Mukesh Mohania, "Research Directions in Blockchain Data Management and Analytics."
74 Daniel F. Runde and Phillip Andre Meylan, "Blockchains Will Change the Way the World Votes," Center for Strategic and International Studies, January 26, 2018, https://www.csis.org/analysis/blockchains-will-change-way-world-votes.
75 For the explanation, see Frederic Kerrest, "Commentary: How Blockchain Could Put an End to Identity Theft," *Fortune*, April 20, 2018, http://fortune.com/2018/04/20/blockchain-technology-identity-theft-data-privacy-protection/.
76 Shaan Ray, "Blockchains and Digital Identity – Towards Data Science," Towards Data Science, March 10, 2018, https://towardsdatascience.com/https-medium-com-shaanray-how-blockchains-will-solve-privacy-88944f3c67f0.
77 "Blockchain Identity Management: A Security Revolution," Toptal Engineering Blog, https://www.toptal.com/insights/innovation/blockchain-identity-management.
78 "G20 Digital Identity Onboarding," G20, 2018, https://www.gpfi.org/sites/default/files/documents/G20_Digital_Identity_Onboarding_WBG_OECD.pdf.
79 Hoang Tam Vo, Ashish Kundu, and Mukesh Mohania, "Research Directions in Blockchain Data Management and Analytics."
80 Eric Piscini, David Mapgaonkar, and Prakash Santhana, "Blockchain to Blockchains: Broad Adoption and Integration Enter the Realm of the Possible," Deloitte United States, December 5, 2017, https://www2.deloitte.com/insights/us/en/focus/tech-trends/2018/blockchain-integration-smart-contracts.html.
81 Hoang Tam Vo, Ashish Kundu, and Mukesh Mohania. "Research Directions in Blockchain Data Management and Analytics."
82 Floyd DCosta, "Blockchain for AML - Harnessing Blockchain Technology to Detect and Prevent Money Laundering," International Banker, November 10, 2017, https://internationalbanker.com/technology/blockchain-aml-harnessing-blockchain-technology-detect-prevent-money-laundering/.
83 Samee Zafar, "Can Blockchain Prevent Money Laundering?" Finextra Research, September 29, 2016, https://www.finextra.com/blogposting/13186/can-blockchain-prevent-money-laundering.
84 Ibid.
85 Anthony Strzalek, "Asean Consortium in KYC Blockchain First," FStech, October 3, 2017, http://www.fstech.co.uk/fst/Consortium_Completes_First_KYC_Blockchain_PoC.php.
86 Floyd DCosta, "Blockchain for AML - Harnessing Blockchain Technology to Detect and Prevent Money Laundering."
87 Mike Orcutt, "Blockchains Use Massive Amounts of Energy-but There's a Plan to Fix That," *MIT Technology Review*, January 19, 2018, https://www.technologyreview.com/s/609480/bitcoin-uses-massive-amounts-of-energybut-theres-a-plan-to-fix-it/.
88 Chris Mooney and Steven Mufson, "Why the Bitcoin Craze Is Using up so Much Energy," *The Washington Post*, December 19, 2017, https://www.washingtonpost.com/news/energy-environment/wp/2017/12/19/why-the-bitcoin-craze-is-using-up-so-much-energy/?utm_term=.d6bcf05aebd0.
89 Marta Garijo, "This Teenage Tech Prodigy Tells Us He Can Fix Bitcoin's Energy Consumption Problem," Business Insider, May 31, 2018, http://www.businessinsider.com/teenage-tech-prodigy-wants-to-fix-bitcoins-growing-energy-problem-2018-5; Ibid.
90 RJ Krawiec et al., "Blockchain: Opportunities for Health Care," Deloitte United States, August 2016, https://www2.deloitte.com/us/en/pages/public-sector/articles/blockchain-opportunities-for-health-care.html.
91 Marco Iansiti and Karim R. Lakhani, "The Truth About Blockchain."
92 Linda Pawczuk, Rob Massey, and David Schatsky, "Breaking Blockchain Open: Deloitte's 2018 Global Blockchain Survey," Deloitte, 2018, https://www2.deloitte.com/content/dam/Deloitte/us/Documents/financial-services/us-fsi-2018-global-blockchain-survey-report.pdf.
93 "Congressional Blockchain Caucus," https://www.congressionalblockchaincaucus.com/.
94 Riley T. Svikhart, "Blockchain's Big Hurdle," *Stanford Law Review*, December 01, 2017, https://www.stanfordlawreview.org/online/blockchains-big-hurdle/.
95 Dylan Yaga et al., "Blockchain Technology Overview," DRAFT NISTR 8202, https://csrc.nist.gov/CSRC/media/Publications/nistir/8202/draft/documents/nistir8202-draft.pdf.

96 Ibid.
97 "State laws recognize impact of blockchain on legal sector," Medium, April 2, 2018, https://medium.com/blockchain-for-law/state-laws-recognize-impact-of-blockchain-on-legal-sector-6749d71fc982.
98 Stan Higgins, "Nevada Becomes First US State to Ban Blockchain Taxes," Coindesk, June 6, 2017, https://www.coindesk.com/nevada-first-us-state-ban-blockchain-taxes/.
99 Joshua Ashley Klayman, Geoffrey R. Peck, and Mark S. Wojciechowski, "Why The Delaware Blockchain Initiative Matters To All Dealmakers," *Forbes*, September 20, 2017, https://www.forbes.com/sites/groupthink/2017/09/20/why-the-delaware-blockchain-initiative-matters-to-all-dealmakers/.
100 Stan Higgins, "New Hampshire Governor Signs Bitcoin MSB Exemption Into Law," CoinDesk, June 07, 2017, https://www.coindesk.com/new-hampshire-governor-signs-bitcoin-msb-exemption-law/.
101 "State laws recognize impact of blockchain on legal sector," Medium, April 2, 2018, https://medium.com/blockchain-for-law/state-laws-recognize-impact-of-blockchain-on-legal-sector-6749d71fc982.
102 Drew Atkins, "New Bitcoin Regulations Shake up Washington State's Cryptocurrency Industry," GeekWire, August 02, 2017, https://www.geekwire.com/2017/new-bitcoin-regulations-shake-washington-states-cryptocurrency-industry/.
103 David Hyland-Wood and Shahan Khatchadourian, "A Future History of International Blockchain Standards," ResearchGate, July 2018, https://www.researchgate.net/publication/326081291_A_Future_History_of_International_Blockchain_Standards.
104 Ibid.
105 "ISO/TC 307," Organisation Internationale De Normalisation (ISO), December 08, 2016, https://www.iso.org/committee/6266604.html.
106 Paul Rosenzweig, "Blockchain Standards," Lawfare, August 22, 2017, https://www.lawfareblog.com/blockchain-standards#.
107 "Focus Group on Application of Distributed Ledger Technology," International Telecommunications Union (ITU), https://www.itu.int/en/ITU-T/focusgroups/dlt/Pages/default.aspx.
108 Nathaniel Popper, "Blockchain Will Be Theirs, Russian Spy Boasted at Conference," *New York Times*, April 29, 2018, https://www.nytimes.com/2018/04/29/technology/blockchain-iso-russian-spies.html.
109 "Focus Group on Application of Distributed Ledger Technology," ITU.
110 Nathaniel Popper, "Blockchain Will Be Theirs, Russian Spy Boasted at Conference."
111 Samburaj Das, "China to Establish National Blockchain Standards by 2019: Govt. Official," CCN, May 10, 2018, https://www.ccn.com/china-government-to-establish-national-blockchain-standards-by-2019-report/.
112 Chuan Tian, "China Poised to Form Blockchain Standards Committee This Year," CoinDesk, May 28, 2018, https://www.coindesk.com/china-poised-to-form-blockchain-standards-committee-this-year/.
113 Ibid.
114 Amy Castor, "How Japan Is Creating a Template for Cryptocurrency Regulation," *Bitcoin Magazine*, May 11, 2018, https://bitcoinmagazine.com/articles/how-japan-creating-template-cryptocurrency-regulation/.
115 Mark Toner, "A Common Language for the Blockchain?" X9, March 22, 2018, https://x9.org/x9news/common-language-blockchain/.
116 Carten Cordell, "DHS Piloting Blockchain Standards for Supply Chain Security," Fedscoop, May 8, 2018, https://www.fedscoop.com/industry-dhs-call-blockchain-standards-supply-chain-security/.
117 https://share.ansi.org/Shared percent20Documents/Meetings percent20and percent20Events/WSW-2017/Services/Kreger_Services-2017.pdf
118 "European Countries Join Blockchain Partnership," European Commission, April 10, 2018, https://ec.europa.eu/digital-single-market/en/news/european-countries-join-blockchain-partnership.
119 "Roadmap for Blockchain Standards," Standards Australia, March 2017, https://www.standards.org.au/getmedia/ad5d74db-8da9-4685-b171-90142ee0a2e1/Roadmap_for_Blockchain_Standards_report.pdf.aspx.
120 See "Blockchain in Transport Alliance," BiTA, https://bita.studio/.
121 Wolfie Zhao, "Hong Kong's Blockchain Trade Finance Platform to Go Live By September," CoinDesk, July 16, 2018, https://www.coindesk.com/hong-kongs-blockchain-trade-finance-platform-to-go-live-by-september/.
122 Don Weinland, "Hong Kong Launches Blockchain-based Trade Finance," *Financial Times*, July 15, 2018, https://www.ft.com/content/f2cacb86-85a3-11e8-96dd-fa565ec55929.
123 Joel Clark, "Blockchain Initiative of the Year 2018: The Nominees," *Financial News*, March 29, 2018, https://www.fnlondon.com/articles/blockchain-initiative-of-the-year-2018-the-nominees-20180325.
124 Penny Crosman, "Banks Pour $107M into Blockchain Consortium R3," American Banker, May 23, 2017, https://www.americanbanker.com/news/banks-pour-107m-into-blockchain-consortium-r3.
125 Stan Higgins, "Digital Trade Chain: 7 Banks Could Go Live With Blockchain in 2017," CoinDesk, June 26, 2017, https://www.coindesk.com/digital-trade-chain-banks-blockchain-2017/.
126 "Bank of England, Boston Fed Join Hyperledger Blockchain Project," CNN, March 1, 2017, https://www.hyperledger.org/announcements/2018/09/26/hyperledger-continues-strong-momentum-with-14-new-members,
127 "Blockchain in Illinois," Illinois.gov, February 5, 2018, https://www2.illinois.gov/sites/doit/Pages/BlockChainInitiative.aspx.
128 "We-trade.com," We.trade, https://we-trade.com/.
129 Wolfie Zhao, "Banks Conduct Cross-Border Trades on IBM-Powered Blockchain," CoinDesk, July 3, 2018, https://www.coindesk.com/european-banks-complete-first-live-blockchain-financial-trades/.
130 Linda Pawczuk, Rob Massey, and David Schatsky, "Breaking Blockchain Open: Deloitte's 2018 Global Blockchain Survey."
131 Lamarque (2016) notes that 80 percent of the focus on DLT/Blockchain implementation is likely to be on business processes and only 20 percent on the technology.

COVER PHOTO ADOBE STOCK

CSIS | CENTER FOR STRATEGIC & INTERNATIONAL STUDIES

1616 Rhode Island Avenue NW
Washington, DC 20036
202 887 0200 | **www.csis.org**