Can Blockchain Technology Facilitate International Trade?

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ABSTRACT

This study considers the potential role for blockchain technologies in international trade, specifically how such technologies might affect trade finance, customs procedures, and provenance (origin) of goods. For trade finance, blockchain could reduce the expense and time required to facilitate trade that depends on third-party lending or insurance. For customs procedures, blockchain could reduce costs, expedite customs procedures, and boost both global trade volumes and economic output more than the worldwide elimination of tariffs. For provenance, blockchain could improve management of supply chains by providing real-time information on the origin and movement of goods. Blockchain may also be used to improve detection of illicit trade flows and deter illegitimate efforts to circumvent trade rules. Such applications could aid customs and law enforcement in facilitating the flow of legitimate trade. Numerous efforts are underway to explore the benefits of blockchain as well as how to mitigate its risks for international commerce.

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This study considers the potential uses of blockchain technology in international trade. As trade economists, we are broadly interested in trade facilitation. International commerce faces numerous barriers that lower its efficiency relative to domestic commerce. These barriers stem from lack of transparency, increased risk in cross-border transactions, and bottlenecks at the border. Decreasing these barriers can lower the threshold for firms to access new markets and participate in global supply chains.

We focus on three areas in which blockchain technology could be applied: easing trade finance, improving customs procedures, and tracking the provenance (origin) of goods. We suggest that blockchain has the potential to ease trade finance by reducing the expense and time required to facilitate trade that depends on third-party lending or insurance (about 80 percent of all global trade). Improvements in trade finance are especially important for small and medium-sized enterprises (SMEs), which may have difficulty accessing credit, and for firms in countries with less developed finance markets. We propose that blockchain could improve customs procedures by reducing the costs associated with import and export licenses, cargo and shipping documents, and customs declarations. Using blockchain to expedite customs procedures could give global trade volumes and economic output a greater boost than eliminating tariffs throughout the world. Finally, we show how blockchain could enable more accurate tracking of goods' provenance: by providing real-time information on the movement and origin of goods, blockchain could improve how producers and retailers manage their supply chains. It could also be used to detect illicit trade flows and deter illegitimate efforts to circumvent trade rules. Such applications could aid customs and law enforcement officers while easing the flow of legitimate trade.

Numerous efforts are already underway across the private and public sectors to explore the benefits of blockchain technology in the realm of international commerce and to mitigate its risks. We cite some of these efforts below.

WHAT IS BLOCKCHAIN AND WHY IS IT USEFUL IN GLOBAL TRANSACTIONS?

Blockchain is not synonymous with Bitcoin or any other cryptocurrency. Bitcoin is merely one of many applications of blockchain technology. Blockchain is a virtual ledger that records transactions between distinct parties; the transactions can be pecuniary or of any other sort.

Traditionally, a trusted third party would keep the record of transactions between two parties. This centralization has its advantages, including technical efficiency; however, errors by the third party can delay or corrupt transactions. To decentralize record keeping, Bitcoin's pseudonymous creator, Satoshi Nakamoto, designed a system where transactions are publicly announced and recorded by every participant of the network, thus allowing a decentralized consensus about the history and order of transactions.[1] While a central authority or intermediaries all work together to validate, facilitate, and complete transactions, the existence of a digital distributed ledger removes the need for intermediaries and third parties to record peer-to-peer transactions.[2]

Understanding the Blockchain

As a distributed digital ledger, blockchain allows connected devices or "nodes" to securely reach consensus over shared data.[3] A blockchain node can be any internet-connected electronic device, such as a computer or smartphone. Together, nodes store and add to the network transaction data that are in a blockchain. Thus, the full blockchain transaction history is recorded across participating nodes.

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1. Satoshi Nakamoto, "Bitcoin: A Peer-to-Peer Electronic Cash System," 2008, https://bitcoin.org/bitcoin.pdf.
2. For a more comprehensive treatment, see David Lee Kuo Chuen and Robert Deng, eds., *Handbook of Blockchain, Digital Finance, and Inclusion*, 1st ed. (Academic Press, 2017). This is a compilation of academic contributions and looks at engineering theories and developments that encourage innovation. Numerous studies consider a range of sectors and applications, such as data storage and distribution, payment settlement, supply-chain management, titling, and so-called smart contracting, among other areas. See Steve Cheng et al., "Using Blockchain to Improve Data Management in the Public Sector," McKinsey & Company, February 2017, https://www.mckinsey.com/business-functions/digital-mckinsey/our-insights/using-blockchain-to-improve-data-management-in-the-public-sector; Michael Pisa and Matt Juden, "Blockchain and Economic Development: Hype vs. Reality" (CGD Policy Paper 107, Center for Global Development, Washington, DC, July 2017); Christian Catalini, "How Blockchain Technology Will Impact the Digital Economy," *Oxford Business Law Blog*, April 24, 2017 .
3. See Peter van Valkenburgh, "What Is 'Blockchain' Anyway?," Coin Center, April 25, 2017, https://coincenter.org/entry/what-is-blockchain-anyway.

Blockchain is a *distributed* ledger because it is held by more than one party. That is, any one party can broadcast the original information of a blockchain's entire transaction history. Any new transaction adds information to the blockchain, but the new information is added by consensus—that is, a majority of nodes must confirm the history over which the new information will be built, and the blockchain log is then updated across all nodes. Consensus occurs in this distributed manner instead of coming from the more traditional system that involves a centralized third-party authenticator.

All blockchain transactions follow a *security protocol* that employs encryption to ensure that new data are accurate and that stored data are incorruptible.

Once enough nodes report that they have confirmed the addition of one "block" to the blockchain, then that block is closed and becomes very difficult to tamper with. This process continues as additional transactions are completed and new information is added to the blockchain in the form of new blocks.

Depending on how a blockchain is set up, some actors, or blockchain participants, may have the authority to add information while others may be permitted only to view or monitor information. Still others may have access only to the part of the process that pertains to them. In international trade, examples of actors facilitating a trade using a blockchain might include inspectors verifying that a shipment has been inspected and adheres to regulations, an importer's bank setting up a letter of credit, an exporter's bank providing financing, a carrier issuing a bill of lading (a receipt of cargo for shipment), and a carrier using a tracking device that logs temperature and GPS data while a shipment is in transit.

A Better Way to Manage Ledgers

The ability to put multiparty data simultaneously on a shared ledger ensures that all parties can see the verified transactions as they occur. Data can be shared with a select group of users (by permission only) or with the public at large (with no permission necessary). As a transaction progresses through the required steps toward completion, each completed step is immutable. Blockchain enables any business, large or small, urban or remote, to engage in a transaction with multiple parties, and with greater speed than was previously attainable.

The public consensus mechanism of blockchain does more than just ensure the accuracy of a transaction ledger. In the realm of international trade, the distributed and digital nature of blockchain allows all the parties involved in a cross-border transaction to document the transaction's history, product, or raw material.

Empirical evidence shows that the closer two countries are to one another, the more likely they are to trade.[4] The distance between two countries can be geographic or economic in nature: economic distance reflects institutional, administrative, political, and cultural differences. The greater the distance between parties, whether geographic or economic, the greater the need for the transparency and accountability that blockchain can provide.

Buyers and sellers in cross-border transactions use trusted intermediaries to guarantee the proper execution of transactions, to ensure transparency, and to hold parties accountable. To the extent that blockchain technology works as a tool for disintermediation, there is great potential for its use across the trade landscape. As mentioned at the beginning of this study, we examine three applications of blockchain in international trade: easing trade finance, improving customs procedures, and tracking the provenance of goods. We also discuss the state of play in each of these areas and highlight pilot projects that are underway involving financial institutions, government agencies, and the private sector.

TRADE FINANCE

Purchasers importing goods from other countries generally wish to pay upon receipt of the merchandise in order to verify its physical integrity on arrival. Exporters prefer to be paid as soon as they ship the goods. In order to bridge this gap in preferences, a credit or guarantee of payment is generally required. Trade finance provides the credit, payment guarantee, and insurance needed to facilitate the transaction on terms that will satisfy all parties.

For the purposes of this study, the term *trade finance* includes lending, the issuance of letters of credit, factoring, and cargo insurance. A *letter of credit* is a guarantee from a bank that a buyer's payment will be received and be on time, or else the bank will take responsibility for the payment. *Factoring* is accounts receivable financing to accelerate cash flow. *Cargo insurance* is, broadly, the insurance of the merchandise while en route.

Intermediaries typically manage the goods' journey, getting merchandise from the original producer to the border, across the border (or borders), and to the final buyer. Each step requires verification: when merchandise is transported

4. A key empirical relationship in international trade is embodied in the so-called gravity equation, in which there is a strong negative relationship between physical distance and trade between countries. See Keith Head and Thierry Mayer, "Gravity Equations: Workhorse, Toolkit, and Cookbook" (CEPII Working Paper No 2013-27, Centre d'Étudesprospectives et d'Informations Internationales, September 2013).

from the factory or farm to a warehouse, when it is moved from the warehouse to a container, when the container is loaded onto a ship, when the ship is underway (to confirm that conditions are appropriate), when the container is unloaded from the ship at port, and when the merchandise is transported from the port to the end consumer.

The World Trade Organization estimates that 80 percent of global trade relies on trade finance or credit insurance.[5] A fundamental aspect of an international trade transaction is that there is a time gap between the product leaving the seller and reaching the buyer. Exporters and importers rely on third parties to promise payments on the basis of collateral as well as to ensure the indemnification of the exporter, importer, and related parties in the event that the merchandise is damaged, stolen, or lost while in transit. Before they will issue letters of credit in trade finance, banks require potential customers to present a solid credit history and a strong balance sheet[6]—conditions that tend to favor larger institutions.

The global trade finance sector (i.e., the global volume of letters of credit) is worth roughly $2.8 trillion.[7] Demand is much greater, however, and according to the Asian Development Bank, the global trade finance gap—the difference between the demand for and supply of trade finance—has reached $1.6 trillion.[8]

This shortfall reflects the complex and risky nature of trade finance, which often involves multiple parties,[9] a factor that can result in the underutilization of existing capital. SMEs face the largest obstacles, because they have the most difficulty dealing with the cost and complexity of banking regulations and navigating the trade finance process. In 2014, SMEs had a rejection rate for trade finance requests of over 50 percent by financial institutions. In comparison, the rejection rate for multinational corporations was only 7 percent.[10]

According to the United Nations, there are typically eight major steps required to obtain a letter of credit,[11] although in practice the number of steps

5. World Trade Organization, *Trade Finance and SMEs: Bridging the Gaps in Provision*, 2016, 6.
6. Capital Source Group, "Letter of Credit Financing," accessed April 2, 2019, https://capitalsourcegroup.com/letter-credit-financing/.
7. Bank for International Settlements, "Trade Finance: Developments and Issues" (CGFS Papers No. 50, Committee on the Global Financial System, January 2014), 14.
8. Alisa Di Caprio et al., "2016 Trade Finance Gaps, Growth, and Jobs Survey" (ADB Briefs No. 64, Asian Development Bank, Manila, Philippines, August 2016).
9. Deloitte and ASSOCHAM, *Role of Trade Finance for Inclusive Growth*, January 2018, 15.
10. World Trade Organization, *Trade Finance and SMEs*, 6.
11. United Nations, "Letters of Credit," Trade Facilitation Implementation Guide, accessed April 2, 2019, http://tfig.unece.org/contents/letters-of-credit.htm.

(without amendment) can be more than 20.[12] Each step of the process is dependent on the previous steps, and some steps involve sending the same document back and forth for verification purposes. The administrative burden is greater for SMEs than for large firms.

A survey of 2,350 SMEs and 850 large firms by the US International Trade Commission showed that lack of access to credit is the major constraint for SME manufacturing firms seeking to export or expand into new markets, and it is one of the top three constraints for SME services firms seeking to do so.[13]

How Blockchain Can Help

Blockchain technology can increase transparency across the trade finance process, which would decrease risk and, in turn, expand the supply of credit available. These are likely to be marginal improvements, however, because blockchain itself does not alter the fundamental credit risk of borrowers.

Attempts to authenticate transactions require large amounts of paperwork and result in delays as each party tries to verify each transaction of the trade finance and insurance process. Each handoff must be approved and verified. Using a blockchain as the ledger eliminates much of the paperwork delay by allowing involved parties to instantly track and receive secure information about the traded goods.[14] With blockchain, all interested parties can monitor the entire shipping process and verify the completion of each step in real time. This increased transparency and ease of monitoring reduces the risk that a borrower presents to a potential lender or insurer.

State of Play Regarding Blockchain and Trade Finance

Interested parties are seeking ways to use blockchain technology in international trade finance. A number of financial institutions have provided proofs of concept or launched blockchain-enabled trade finance platforms.

In 2016, Bank of America, HSBC, and the Infocomm Development Authority of Singapore developed a trade finance application and provided a valid proof

12. Credit Research Foundation, "Understanding and Using Letters of Credit, Part I," accessed April 2, 2019, https://www.crfonline.org/orc/cro/cro-9-1.html.
13. US International Trade Commission, "Small and Medium-Sized Enterprises: Characteristics and Performance" (Investigation No. 332-510, Washington, DC, November 2010).
14. Frances Coppola, "The Fast Changing World of Blockchain Solutions for Trade Finance," American Express, accessed April 2, 2019, https://www.americanexpress.com/us/content/foreign-exchange/articles/blockchain-can-potentially-streamline-trade-finance/.

of concept that "shows the potential to streamline the manual processing of import/export documentation, improve security by reducing errors, increase convenience for all parties through mobile interaction, and make companies' working capital more predictable."[15] With the trade finance application, all parties (the exporter, the importer, and their respective banks) can visualize data in real time, and each action in the workflow is captured in a distributed ledger, giving transparency to authorized participants while encrypting confidential data.

In 2017, Barclays described its first blockchain-based trade finance deal as a success, noting that parties were able to execute a deal in four hours that would usually take up to 10 days to complete.[16] The letter of credit reportedly guaranteed the export of $100,000 worth of agricultural products from Irish cooperative Ornua to the Seychelles Trading Company.

In July 2018, European banks launched a trade finance blockchain platform with at least nine major financial institutions.[17] The initial focus appears to be on small and medium-sized businesses trading within Europe, and the next phase reportedly will aim for buy-in from additional banks and from their customers in Europe and further afield. In September 2018, the Hong Kong Monetary Authority similarly announced plans to launch a trade finance blockchain platform.[18] Twenty-one banks are participating in the platform, including large institutions such as HSBC and Standard Chartered. The Hong Kong Monetary Authority is also reportedly working with its counterpart in Singapore to develop a blockchain-based trade finance network to settle cross-border transactions.

As the trade finance industry begins to utilize blockchain technology, there are some potential implications worthy of policymakers' attention. First, the reduced costs of access to trade finance could especially help small and medium-sized businesses. The large number of intermediaries and corresponding administrative costs in trade finance tend to fall particularly hard on SMEs. The banks' cost of each transaction is such that SME financing is often not cost effective. Second, increased transparency and access to information could help to make banks' risk assessments more accurate. If perceived risk is greater than actual risk, then

15. Bank of America Merrill Lynch, HSBC, and the Infocomm Development Authority of Singapore, "BofAML, HSBC, IDA Singapore Build Pioneering Blockchain Trade Finance App," news release, August 10, 2016.
16. Wolfgang Lehmacher and Jesse Mcwaters, "How Blockchain Can Restore Trust in Trade," World Economic Forum, February 1, 2017; see also Jemima Kelly, "Barclays Says Conducts First Blockchain-Based Trade-Finance Deal," *Reuters*, September 7, 2016.
17. Wolfie Zhao, "Banks Conduct Cross-Border Trades on IBM-Powered Blockchain," *CoinDesk*, July 3, 2018.
18. Wolfie Zhao, "Hong Kong's Blockchain Trade Finance Platform to Go Live by September," *CoinDesk*, July 16, 2018.

a nontrivial number of loan applications may be denied even though those loans have the potential to be successful—that is, the loans would be paid back if they were granted, and they would facilitate value creation in the economy.

To the extent that blockchain technology can reduce the administrative burden of international trade for SMEs, narrow the gap between perceived risk and actual risk (i.e., reduce unnecessary perceived risk), and serve as a vehicle for disintermediation, then blockchain in trade finance could prove beneficial.

CUSTOMS PROCEDURES

The customs process comprises all the rules and regulations related to transporting merchandise across a national border, and hence it is an integral component of any successful international trade transaction. The customs process encompasses the several separate steps that merchandise must clear to be ready for import or export. For instance, the import and export licenses, customs declaration paperwork, and cargo declaration paperwork must all be confirmed and verified, sometimes separately by different people. Trade security procedures must also be completed and verified.

Companies often have difficulty navigating the customs process because of its complexity. The procedures in both industrialized and developing nations are notorious for inefficiencies, typically caused by burdensome compliance requirements, costly delays, border corruption, and security breaches.

The simplification and modernization of customs procedures—commonly known as trade facilitation—has emerged as an important area for improvement of the world's trading system. Nearly all modern free trade agreements, both bilateral and regional, have a trade facilitation chapter, and the World Trade Organization has an entire Trade Facilitation Agreement devoted to eliminating red tape at national borders in order to streamline the movement of goods.

Compliance Requirements and Delays

The international shipping industry carries 90 percent of the world's trade in goods and still largely relies on paper documentation.[19] Hiring intermediaries to process the paperwork imposes a monetary and time cost. Customs rules that require multiple transmissions of information primarily using physical

19. IBM and Maersk, "The Paper Trail of a Shipping Container," infographic, 2017, https://www-01.ibm.com/common/ssi/cgi-bin/ssialias?htmlfid=XI912347USEN.

documentation mean that critical paperwork often gets lost in the shuffle, creating additional costly delays. A shipping container can spend significant time waiting for signatures, financing, or loading. These delays pose real costs to traders, and these costs represent a deadweight loss of resources that could have been spent elsewhere in a more productive manner.

In one account of the world's largest container carrier, Danish shipping company Maersk, "A single container could require stamps and approvals from as many as 30 people, including customs, tax officials and health authorities." According to Maersk, tracking containers is straightforward, but it is the "mountains of paperwork that go with each container" that slow down the process.[20]

The World Bank notes that much of the slowdown results from "burdensome documentation requirements" and "the need to obtain approval from too many officials."[21] Inefficiencies in customs processes result in costly delays at physical borders. For instance, at the critical border crossing between Bangladesh and India, there have been as many as 1,500 trucks lined up on both sides of the border. Many trucks wait up to five days before crossing.[22]

Beginning in 2014, Maersk began tracking specific goods, such as avocados and cut flowers, to determine the true weight of compliance costs and intermediation. The cost of handling documentation is so high that it can be even more expensive than the cost of transporting the actual shipping containers.[23] The company discovered that a single container moving from Africa to Europe required nearly 200 communications and the verification and approval of more than 30 organizations involved in customs-, tax-, and health-related matters.[24] Maersk's office in Kenya has storage rooms filled from floor to ceiling with paper records dating back to 2014.[25]

Delays for perishable items can be particularly costly. Economist Lan Liu and economist and horticultural scientist Chengyan Yue examined lettuce and apple imports in 183 countries. They determined that reducing delays from the median two days to only one day would increase lettuce imports in those countries by around 35 percent, or 504,714 tons, and would increase world consumer welfare by $2.1 billion. The authors found that the same change would increase

20. Nathaniel Popper and Steve Lohr, "Blockchain: A Better Way to Track Pork Chops, Bonds, Bad Peanut Butter?," *New York Times*, March 4, 2017.
21. Fink, "Transport Services."
22. Prabir De and Buddhadeb Ghosh, "Reassessing Transaction Costs of Trade at the India-Bangladesh Border," *Economic and Political Weekly* 43, no. 29 (July 2008).
23. Lehmacher and Mcwaters, "How Blockchain Can Restore Trust in Trade."
24. IBM and Maersk, "Paper Trail of a Shipping Container."
25. Popper and Lohr, "Blockchain."

apple imports by 15 percent, or 731,937 tons, and would increase consumer welfare by around $1.1 billion.[26]

The World Economic Forum estimates that reducing supply-chain barriers such as customs processes could increase global GDP by nearly 5 percent and trade by 15 percent, increases up to six times greater than the effect of removing tariffs.[27]

Corruption and Security Concerns

Besides outright bribery and the intentional delay of imports, fraud constitutes a major threat to the customs process. Fraudulent behavior can involve the forgery of bills of lading and other export documentation such as certifications of origin. One example of fraud is "lost" goods, when someone underreports cargo and is then able to steal the difference. Another example is when shippers misrepresent the amount or quality of shipped goods in order to seem to comply with customs requirements or in order to pay less for imports.

Fraud has the potential to operate in all directions: it may be perpetrated by the shipper, the receiver, a customs official, or an interloping third party. Deception regarding the quantity and quality of goods can have adverse effects on a company's reputation.

The World Bank notes that greater corruption is correlated with greater complexity of customs procedures and greater discretion granted to customs officials, with both characteristics more prevalent in the ports of developing countries.[28] The cost of corruption can appear either as the direct extraction of funds through bribes or as the losses of product quality and declines in price when shipments are delayed after bribery is refused. The World Economic Forum reports that the CPG Company refuses to pay bribes and, in turn, its shipments face harsh delays in African ports.[29]

At the firm level, it is estimated that corruption costs are equivalent to 6 percent of a firm's value-added.[30] The United Nations characterizes corruption

26. Lan Liu and Chengyan Yue, "Investigating the Impacts of Time Delays on Trade," *Food Policy* 39 (April 2013).
27. World Economic Forum, *Enabling Trade Valuing Growth Opportunities*, 2013.
28. Fink, "Transport Services."
29. World Economic Forum, *Enabling Trade Valuing Growth Opportunities*.
30. Rachid Laajaj, Marcela Eslava, and Tidiane Kinda, "The Costs of Bureaucracy and Corruption at Customs: Evidence from the Computerization of Imports in Colombia" (working paper, World Bank, June 2018).

as a "hidden tariff," and the World Customs Organization estimates the loss of revenue caused by customs-related corruption to be at least $2 billion.[31]

How Blockchain Can Help

Integrating blockchain technology into the customs process could allow shippers to digitize their supply chains and eliminate many of the intermediaries that lead to costly delays and corruption. The digital distributed ledger is secure by design, and each transaction is uploaded to the chain if and only if it is agreed upon by the other processing nodes. It is nearly impossible to make a fraudulent claim or edit past transactions without the approval of the other users in the network.

Blockchain could discourage corruption by simplifying procedures and reducing the number of government offices and officials involved in each transaction. A blockchain network would allow for disintermediation in trade by requiring total, decentralized consensus within the network. This would help to ensure that no one party could be cheated by another without consequence. Additionally, the real-time auditability of blockchain allows users to see exactly when and where disputes arise and exactly what the discrepancies are. This level of transparency would allow all participants in the network to hold each other accountable for mistakes or purposeful deception. Rather than relying on the good faith of shippers and customs agents, the parties involved could rely on the integrity of the transactional record. Blockchain does not prevent false information from being entered into the system, but it does reduce opportunities for the original information to be corrupted by intermediaries involved in the shipping process.

Blockchain technology in customs and border-crossing procedures could also be used to prevent circumvention and transshipment. Circumvention refers to the practice of sending goods to a neighboring country before the destination country in order to avoid tariffs that have been placed on goods from the country of origin. Currently, countries attempt to prevent circumvention by broadly applying a trade remedy regulation, such as an antidumping or countervailing duty, not only to the target country but also to many other countries that may be used for circumvention (sometimes without the countries' direct knowledge). Blockchain technology could be used by shippers and customs agencies in a mutually beneficial way: shippers could more easily demonstrate the origin of their goods, and customs agencies could more easily verify this information.

31. Organisation for Economic Co-operation and Development, "Fighting the Hidden Tariff: Global Trade without Corruption" (Background Document for the 2016 OECD Integrity Forum, Paris, April 19–20, 2016).

For instance, the US government cited circumvention to justify the necessity of applying section 232 steel and aluminum tariffs to all countries, including countries that do not necessarily pose a national security threat.[32] Steel from China, not Canada, was the stated target of the tariffs, but Chinese producers could have tried to reach the US market through Canada to evade the tariffs. To preclude circumvention, tariffs were applied to all countries. But if blockchain technology were used to allow shippers and national customs agencies to validate and verify the provenance of goods, broad trade restrictions would no longer be justified.

While there is no estimate of the economic effects of integrating blockchain into customs and border procedures, the effects may be similar to those that would accompany the complete implementation of trade facilitation measures outlined in the World Trade Organization's Trade Facilitation Agreement. That agreement estimates that, by streamlining border procedures and reducing trade costs more broadly, it could reduce trade costs by 16.5 percent for low-income countries, by 17.4 percent for lower-middle-income countries, by 14.6 percent for upper-middle-income countries, and by 11.8 percent for countries belonging to the Organisation for Economic Co-operation and Development.[33]

State of Play Regarding Blockchain and Customs Procedures

IBM and Maersk have teamed up to explore how blockchain can simplify shipping.[34] The scheme would allow all parties involved in a container's shipment to observe and track the container from inception to endpoint, meaning the shipping record would be completely transparent and immutable. For example, after a customs agent has checked and verified the contents of a container, the agent could immediately scan and upload this information to the blockchain with a unique digital fingerprint, allowing all other users to see the transaction. This would ensure almost immediate auditability to protect against later disputes

32. In a congressional hearing, Commerce Secretary Wilbur Ross noted the possibility of circumvention, transshipment, and evasion of trade remedy orders in explaining the Trump administration's decision to apply the steel and aluminum tariffs broadly, beyond the targeted country. See "Hearing with Secretary Ross," US House of Representatives, Committee on Ways and Means, Washington, DC, March 22, 2018.

33. Organisation for Economic Co-operation and Development, "Implementation of the WTO Trade Facilitation Agreement: The Potential Impact on Trade Costs" (OECD Policy Brief, 2015); Organisation for Economic Co-operation and Development, *Overcoming Border Bottlenecks: The Costs and Benefits of Trade Facilitation*, OECD Trade Policy Studies (Paris: OECD Publishing, 2009).

34. The IBM-Maersk joint venture, called TradeLens, is sourcing its platform from Hyperledger Fabric, a collaborative effort hosted by the Linux Foundation to create blockchain standards.

and the search costs related to procuring the proper paperwork long after it has been filed away (or lost). The ease of access offered to every processing node or actor in the blockchain system ensures that time-consuming correspondence and transmission of information become unnecessary.

An advisory group for US Customs and Border Protection is exploring the role of emerging technologies, including blockchain, in global supply chains and customs procedures.[35] This advisory group, called the Commercial Customs Operations Advisory Committee, reported 14 proposed use cases, including "ideas such as capturing and keeping track of partnering government agencies' licenses, permits, certificate of origin reporting and free trade agreement product qualifications, carnets and bonded movement tracking."[36]

Cooperation between the public and private sectors is essential in order to effectively integrate blockchain technology into international trade processes. Integrating blockchain technology in the customs process will require technological updates and the cooperation of customs officials, governments, shippers, and suppliers. This cooperation may be harder to achieve in industries where there is excessive rent-seeking behavior—that is, where particular businesses work to manipulate public policy or economic conditions as a strategy to increase profits. Estimates suggest that in the United States, the average social cost of rent-seeking is somewhere between 7 and 23 percent of gross national output.[37] Such cooperation may also be difficult to achieve when there is corruption in the government bureaucracy.

PROVENANCE OF GOODS

The provenance of a good refers to the good's origin as well as to the chronological record of its ownership and location. Information on the provenance of goods can help firms meet consumer and producer demand for detailed information regarding the origin and ownership of goods as well as of all the materials, components, and ingredients that make up the goods.

Surveys show that consumers in the United States and around the world are becoming more conscious of the origins of the merchandise they buy and the food they consume, as well as of the impact of the production processes of

35. Commercial Customs Operations Advisory Committee, Global Supply Chain Subcommittee, "Executive Summary—Trade Progress Report," November 14, 2017.
36. Commercial Customs Operations Advisory Committee, "Executive Summary."
37. Matthew D. Mitchell and Peter J. Boettke, *Applied Mainline Economics: Bridging the Gap between Theory and Public Policy* (Arlington, VA: Mercatus Center at George Mason University, 2017), 75.

their consumption goods on the environment and society. The Pew Research Center found that 75 percent of Americans are "particularly concerned" for the environment, and 83 percent make an effort at least some of the time to live in ways that protect the environment.[38] Millennials are particularly paying attention—nearly three out of four surveyed in this age group say they would pay extra for sustainable offerings,[39] and 71 percent of people desire a comprehensive list of ingredients before purchasing a product.[40]

The Centers for Disease Control and Prevention estimate that each year roughly one in six Americans, or 48 million people, becomes ill as the result of a foodborne pathogen (e.g., salmonella, listeria, or *E. coli*).[41] One study estimated the annual cost of medical treatment for foodborne illness, lost productivity, and illness-related mortality in the United States alone to be $55.5 billion.[42]

Blockchain technology will not necessarily prevent infections. The application of blockchain technology could be used to prevent outbreaks from turning into epidemics. For instance, the Centers for Disease Control and Prevention investigate contagious diseases and employ some of the world's top disease detectives. The application of blockchain technology in this realm would be an example of entrepreneurship being useful because of existing public investment and infrastructure, not despite it.

The concern about the provenance of goods is global. For instance, the Chinese public has expressed rising concerns about the safety of food and medicine. According to a Pew Research Center survey, the shares of respondents who feel that the safety of food and medicine is "a very big problem" were 40 and 42 percent, respectively, in 2016, up from 12 and 9 percent, respectively, in 2008.[43]

Using blockchain to track the origins of raw materials and to follow domestic and international supply chains can meet this increasing demand for information with levels of transparency and accuracy not previously attainable. Tracking the origins of raw materials can also help companies improve their own internal processes.

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38. Monica Anderson, "For Earth Day, Here's How Americans View Environmental Issues," *Fact Tank* (Pew Research Center), April 20, 2017.
39. Nielsen, "Green Generation: Millennials Say Sustainability Is a Shopping Priority," *Newswire*, November 5, 2015.
40. Label Insight, "How Consumer Demand for Transparency Is Shaping the Food Industry," 2016.
41. Centers for Disease Control and Prevention, "Estimates of Foodborne Illness in the United States," July 15, 2016, https://www.cdc.gov/foodborneburden/2011-foodborne-estimates.html.
42. Robert L. Scharff, "Economic Burden from Health Losses Due to Foodborne Illness in the United States," *Journal of Food Protection* 75, no. 1 (2012).
43. Pew Research Center, "Rising Concerns about the Safety of Food, Medicine," *Chinese Public Sees More Powerful Role in World, Names U.S. as Top Threat*, October 4, 2016.

How Blockchain Can Help

By incorporating blockchain technology, buyers and sellers can track a physical asset through changes of ownership and handling, and consumers can discover the origin of an individual product. Provenance tracking works by using digital tokens issued by blockchain participants to authenticate the movement of the good. Every time the item changes hands, the digital token is moved in lockstep. In other words, the real-world chain of custody is mirrored by a chain of transactions recorded in the blockchain. The token acts as a virtual "certificate of authenticity" that is much harder to steal or forge than a piece of paper. This implicitly creates provenance information for goods and improves supply-chain quality.

Blockchain technology can also make the audit process more efficient. Because the ledger is operated by a collective, there is no point in the process where one party can enter or change information alone. Thus the transactions are transparent to all parties.

For consumers, blockchain provides greater information about the products they are purchasing. They can be better informed about the origins of a product and the transactions that took place during its manufacturing process. Even further, because blockchains can be public ledgers, they are able to communicate to consumers which products were created by trusted firms.

For producers, blockchain could ensure that the right product is getting to the right customer. Monitoring each step in a product's transaction history could help to prevent theft and maintain brand value.

With brand loyalty on the decline and consumer demand for information on the rise,[44] retailers have an incentive to explore using blockchain to track the provenance of goods. Some studies have shown that consumers' willingness to acquire information from labels is influenced by various socioeconomic characteristics, and that for some products high demand for information is associated with higher expenditures.[45] But willingness to pay for additional information and sourcing varies across products and consumers.[46]

By providing an auditable and tamper-proof record of product journeys, blockchain technology could also be used to address the counterfeit goods trade.

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44. Label Insight, "Confusing Ingredients Cause Shoppers to Consider Switching Brands Even If It Means Paying More," 2017.
45. Efthalia Dimara and Dimitris Skuras, "Consumer Demand for Informative Labeling of Quality Food and Drink Products: A European Union Case Study," *Journal of Consumer Marketing* 22, no. 2 (2005).
46. Jens Hainmueller, Michael J. Hiscox, and Sandra Sequeira, "Consumer Demand for Fair Trade: Evidence from a Multistore Field Experiment," *Review of Economics and Statistics* 97, no. 2 (2015).

According to a 2016 study by the Organisation for Economic Co-operation and Development, this trade was estimated to involve $461 billion in 2013.[47]

State of Play Regarding Blockchain and the Provenance of Goods

Companies are exploring the costs and benefits of using blockchain to track their supply chains in more detailed and expedient ways. In principle, blockchain could be applied to tracking provenance information for virtually any good. Below we describe some examples of existing applications of blockchain in the trade of agricultural and luxury goods.

For instance, in agriculture supply management and food retail, understanding the provenance of each input along the supply chain allows firms to identify sources of contamination more quickly. Walmart is using blockchain to maintain an easily accessible record of food provenance. In a simulated recall, Walmart was able to trace the origin of a bag of sliced mangoes in 2.2 seconds. In comparison, tracing the bag using Walmart's standard approach took 6 days, 18 hours, and 26 minutes.[48]

Australian exporter InterAgri is experimenting with using blockchain to track the production and global delivery of its Black Angus Aussie Beef.[49] By teaming up with JD.com, a major e-commerce site in China, InterAgri aims to detect and eliminate food fraud such as counterfeit Aussie beef. By some cost estimates, food fraud affects approximately 10 percent of all commercially sold food products.[50]

The global coffee shop Starbucks is piloting a blockchain program in its supply chain.[51] In 2004 the company launched Coffee and Farmer Equity (C.A.F.E.) Practices,[52] which has two key goals: sustaining farmers and strengthening communities. In 2015, Starbucks announced that 99 percent of its coffee was "ethically

47. Organisation for Economic Co-operation and Development and European Union Intellectual Property Office, *Trade in Counterfeit and Pirated Goods: Mapping the Economic Impact* (Paris: OECD Publishing, 2016).
48. Kim S. Nash, "Business Interest in Blockchain Picks Up While Cryptocurrency Causes Conniptions," *Wall Street Journal*, February 6, 2018.
49. JD.com, "JD Ramps Up Australian Imports with InterAgri Partnership on Pure Black Angus Beef," March 2, 2018.
50. Renée Johnson, *Food Fraud and "Economically Motivated Adulteration" of Food and Food Ingredients* (Washington, DC: Congressional Research Service, January 10, 2014).
51. Howard Bryman, "Starbucks Launching Pilot Program for Blockchain in Its Supply Chain," *Daily Coffee News* (Roast Magazine), March 22, 2018.
52. Starbucks, "Commitment to 100% Ethically Sourced," accessed April 12, 2019, https://www.starbucks.com/responsibility/community/farmer-support/farmer-loan-programs.

sourced," which means that Starbucks complied with the principles and practices involved in each step of the supply chain from farm to cup.[53] Using blockchain, Starbucks aims to connect the person growing the coffee bean to the person drinking the coffee in order to verify that it is keeping its brand promise.[54]

The luxury goods industry is working on using blockchain to provide a platform to verify the authenticity of purchases.[55] Industry observers have noted that blockchain technology could be used to create a database that verifies who owns what luxury goods (e.g., a luxury handbag or gown). The goods would have specific codes that retailers and consumers could use to track changes in ownership. Given the decentralized blockchain platform and multiple nodes that work to update the ledgers, making fraudulent entries will be nearly impossible.

In the diamond industry, De Beers, which controls 37 percent of the global diamond market, reported earlier this year that it was able to track 100 high-value diamonds from mine to retailer using blockchain technology.[56] This effort reflects a long-standing problem the industry has had with so-called conflict diamonds, which are uncut diamonds mined in areas of armed conflict and traded illicitly to finance the fighting. Previous efforts such as the international Kimberley Process Certification Scheme have garnered broad international support, but they have ultimately failed to prevent conflict diamonds from entering the market unnoticed because of an inability to trace the provenance of the diamonds.[57] A United Nations panel reported that 140,000 carats of diamonds were smuggled out of the Central African Republic between 2013 and 2015 in spite of an export ban on rough diamonds.[58] While there is no one precise estimate of the value of the illegal diamond trade, existing estimates are in the tens of billions of dollars.[59]

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53. Starbucks, "Doing Business with Starbucks," accessed April 12, 2019, https://www.starbucks.com/business/suppliers.
54. Starbucks, "Starbucks to Pilot 'Bean to Cup' Traceability with New Technology," *Starbucks Stories*, March 21, 2018.
55. Brady Dale, "Bitcoin Tech Will Verify If Your Luxury Bag Is a Knockoff or Not," *Observer*, January 13, 2016.
56. "De Beers Tracks Diamonds through Supply Chain Using Blockchain," *Reuters*, May 10, 2018. See also Paul Ziminsky Diamond Analytics, "De Beers Market Share to Rebound to 40% with Canada's Gahcho Kué Diamonds," July 8, 2014, http://www.paulzimnisky.com/de-beers-market-share-to-rebound-to-40-with-canada-s-gahcho-kue-diamonds.
57. Audrie Howard, "Blood Diamonds: The Successes and Failures of the Kimberley Process Certification Scheme in Angola, Sierra Leone and Zimbabwe," *Washington University Global Studies Law Review* 15, no. 1 (2016).
58. Louis Charbonneau, "Cameroon Involved in Central Africa 'Blood Diamond' Trade: U.N. Experts," *Reuters*, September 1, 2015.
59. In the 1990s, the National Union for the Total Independence of Angola's profits from the diamond trade were $13 billion. This money was used to fund arms purchases. See Howard, "Blood Diamonds."

RISKS, OPPORTUNITIES, AND PUBLIC POLICY CHALLENGES

The test cases to date shed some light on the potential economic implications of blockchain technology uses across the international trade landscape. They shed light on possible challenges as well as on opportunities for improved public policy outcomes.

No new technology is without risk. One key benefit of blockchain technology is that, owing to the distributed ledger and consensus mechanism, fraud by altering records is considered nearly impossible. However, that does not mean that it *is* impossible. There will always be actors with an interest or an incentive to commit fraud.[60] With blockchain technology, however, consensus-based ledger updates ensure that one compromised node is not able to complete fraudulent activity on the blockchain. Nevertheless, should a hacker gain control of a majority of the nodes in a system, the hacker may have the potential to corrupt the records.

Another potential pitfall of blockchain technology in trade is the fact that users can remain anonymous, and as yet there is no standardized identification process.[61] Institutions that are required to follow regulations such as know-your-customer rules will have to rectify this feature of the distributed ledger in order to come into compliance with laws governing international commerce. Technology is already evolving in this space, giving rise to the use of digital IDs and verifiable know-your-customer utility platforms.[62]

Because blockchain permits anonymity, trading companies could be even more wary of violating international restrictions or engaging in transactions with questionable actors. One solution might be to create a clear signature for authorized persons involved in transactions, including customs offices and trading companies. Singapore offers an example of a policy landscape that is actively addressing risk while promoting various applications of blockchain in trade, and policy safeguards appear to be tailored proportionally to the size of risks.[63]

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60. When asked about the rampant fraud in bills of lading, International Chamber of Commerce Commercial Crime Services Director Pottengal Mukundan responded, "There is no document which cannot be forged with ease. It is not the system that commits fraud, it is people." Quoted in James Brewer, "Bills of Lading and Trade Finance Fraud," International Maritime Industries Forum, May 7, 2014.

61. Lee Kuo Chuen and Deng, *Handbook of Blockchain*.

62. Loi Luu, "With Blockchain, Knowing Your Customer Is More Important Than Ever," *Forbes*, May 17, 2018.

63. Ravi Menon, "Economic Possibilities of Blockchain Technology" (keynote address at Global Blockchain Business Conference, Andhra Pradesh, October 9, 2017), available at http://www.mas.gov.sg/News-and-Publications/Speeches-and-Monetary-Policy-Statements/Speeches/2017/Economic-Possibilities-of-Blockchain-Technology.aspx.

CONCLUSION

In this paper we consider the potential uses of blockchain technology in international trade. The nature of cross-border transactions leaves a lot of potential for blockchain technology to facilitate trade. We explore three areas in which blockchain technology could be useful: easing trade finance, improving customs procedures, and tracking the provenance of goods.

The state of play described in the sections above indicates that the public and private sectors are conducting a range of use cases in these areas. Financial institutions are experimenting with blockchain to increase access to and decrease the costs of trade finance. The shipping industry is working with those along supply chains as well as with customs officials to see how a distributed digital ledger can facilitate the transparent movement of goods across borders and seas. Companies and retailers are exploring ways to track their own supply chains to communicate information to consumers who increasingly demand such information. To the extent possible, policymakers should encourage further cooperation, increased discussion, and even more trial and error.

Blockchain technology is still in its innovative infancy. Adaptability, interoperability, and a policy environment that welcomes experimentation will be essential if the US economy is to realize the potential benefits of blockchain technology across the international trade landscape. It is our hope that this scoping paper spurs further empirical research in these areas.

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