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Exam Preview:

1. Blockchain technology, also known as digital ledger technology, can be implemented in any field, as it can be applied to any digital asset or digital content: virtual currency, computer files, pockets of data, images, or digital identifiers assigned to physical goods.
    a. True
    b. False
2. According to the reference material, S&T partnered with CBP in __ POC projects to determine the effectiveness of using blockchain technology in the U.S. customs environment.
    a. 1
    b. 2
    c. 3
    d. 4
3. According to the reference material, which country, from the selection below, has NOT implemented a blockchain proof of concept for customs processing?
    a. Canada
    b. Singapore
    c. Australia
    d. China
4. According to the reference material, one of the biggest initial disadvantages of blockchain technology is that different blockchains could not, and many still cannot, interact with other blockchains.
    a. True
    b. False
5. According to the reference material, corporate government spending on blockchain technology is projected to reach $12.4 billion by what year?

a. 2020
b. 2021
c. 2022
d. 2024

6. According to Table 1, POC Stakeholders, which entity has the future benefit of "verifiable authenticity and immutability of digital documents"?
    a. Exporter
    b. Importer
    c. CBP
    d. Broker
7. Using Figure 1, August 2018 Hype Cycle with Blockchain in Government at Peak, which of the following functions will blockchain be used to solve when it is the "Plateau of Productivity"?
    a. Fraud detection
    b. Data loss prevention
    c. Predictive analysis
    d. Cloud services for government
8. According to the reference material, one of the biggest initial disadvantages of blockchain technology is that different blockchains could not, and many still cannot, interact with other blockchains.
    a. True
    b. False
9. According to Table 1, POC Stakeholders, which entity has the future benefit of "having full view of the goods brought directly on the blockchain"?
    a. Exporter
    b. Importer
    c. CBP
    d. Broker
10. According to the reference material, the hype cycle for blockchain includes the following phases: Innovation trigger, Peak of inflated expectations, Trough of Disillusionment, Slope of Enlightenment, and Plateaus of Productivity, and Drop off of disappointment.
    a. True
    b. False

ABSTRACT

Blockchain technology promises to revolutionize supply chain management and may improve the international trade environment as well as compliance and enforcement capabilities. Because blockchain technology is still developing, the government has an opportunity to collaborate with the trade industry and to explore the technology's capabilities. This thesis examines the first proof of concept (POC) blockchain implementation by U.S. Customs and Border Protection (CBP) and provides recommendations for future government involvement in the implementation of blockchain technology in the U.S. customs environment. The POC proved that blockchain technology can be implemented in the U.S. customs environment and that the technology can improve the processing and tracking of trade documents, facilitate interaction with multiple entities, enable better auditability, and expedite processing. The POC revealed that utilization of emerging interoperability specifications and standards is key for successful implementation. This research concludes that if government entities join the blockchain revolution early on, they have an opportunity to drive the change, rather than to react and adapt to systems established by others. This thesis recommends that CBP expand blockchain implementation by joining efforts with other government agencies and the trade industry. CBP can facilitate future coordination, implementation, and creation of global blockchain standards necessary in international trade.

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LIST OF ACRONYMS AND ABBREVIATIONS

ACE	Automated Commercial Environment
BTID	CBP Business Transformation and Innovation Division
CAFTA	Central America Free Trade Agreement
CBP	U.S. Customs and Border Protection
CRS	Congressional Research Service
DHS	U.S. Department of Homeland Security
ES/BSC	IEEE Consumer Electronics Society/Blockchain Standards Committee
FTA	Free Trade Agreement
HSI	Homeland Security Investigations
IPCSA	International Port Community System Association
NAFTA	North American Free Trade Agreement
NIST	National Institute of Standards and Technology
OCC	CBP Office of Chief Counsel
OFO	CBP Office of Field Operations
OIT	CBP Office of Information Technology
POC	Proof of Concept
R&D	Research and Development
S&T	Science and Technology Directorate
W3C	World Wide Web Consortium

EXECUTIVE SUMMARY

Blockchain technology has been surrounded by hype: first lauded for enabling the creation of cryptocurrencies and starting conversations about digital identity, blockchain technology now promises to revolutionize supply chain management. New blockchain technology applications in international supply chain management are gaining momentum; if these applications are successful, the next step will be to apply them toward the currently paper-heavy customs processing—a key element of international trade. The U.S. government has an opportunity to take an active role in the development of this technology to influence trade industry implementation in a way that supports U.S. interests, encourages global standards, and promotes economic growth and fair trade practices. Because blockchain technology is still developing, the government also has a rare opportunity to come together with the trade industry to explore the technology's capabilities and possibilities. Joining the blockchain revolution early on provides both private and government entities with an invaluable opportunity to drive the change rather than to react and adapt to systems established by others.

Customs agencies worldwide have begun testing blockchain technology. The U.S. Department of Homeland Security (DHS) Science and Technology Directorate (S&T) and the U.S. Customs and Border Protection (CBP) partnered in exploring blockchain technology implementation in proof-of-concept (POC) projects to determine the technology's effectiveness in the U.S. customs environment. This thesis examined the first POC blockchain implementation by CBP, including its execution and results, and provides recommendations for DHS and CBP's future involvement in the implementation of blockchain technology in the U.S. customs environment. The research revealed that CBP's first blockchain POC proved that blockchain technology can be implemented in the U.S. customs environment. The POC revealed that utilization of emerging blockchain interoperability specifications and standards allows multiple trade partners to seamlessly communicate with CBP via blockchain platforms. Furthermore, blockchain technology can improve the processing and tracking of trade-related documents, facilitate interaction with

multiple private entities via multiple blockchains, enable better auditability, and expedite CBP processing.

In addition to reviewing the POC, this thesis provides background on blockchain technology and examines its ongoing—and growing—implementation in the international trade environment. The research involved interviews of stakeholders from the trade industry and government who worked on the POC, as well as analysis of background information, blockchain standardization and interoperability efforts, fraud vulnerabilities, the POC, and ongoing blockchain implementation efforts following the POC.

While blockchain technology promises to improve numerous processes in supply chain management and international trade, the technology is still developing and issues such as key management, digitization of physical assets, lack of standards, and lack of interoperability remain key for future implementation. By continuing to demand interoperability in all implementations, the government can direct trade industry toward creating an environment that fosters global standards, promotes innovation, and precludes vendor-locking or monopolization.

Ultimately, this research led to the following recommendations for S&T, CBP, and Homeland Security Investigations (HSI):

- S&T should continue research and development work related to blockchain technology, interoperability standards, and potential implementations by DHS components. S&T should continue engaging various DHS components in blockchain implementation.

- CBP should continue working with the trade industry to explore potential applications of blockchain technology in the U.S. customs environment and to identify processes that can benefit from blockchain technology implementation. CBP should prioritize implementation of blockchain technology in a manner compatible and interoperable with the existing Automated Commercial Environment (ACE).

- CBP and S&T should continue maintaining the demand for interoperability standards within all DHS-sponsored POCs, pilots, and blockchain applications to foster technological development and guide private industry in a joint effort to build interoperable systems.

- CBP should consider expanding blockchain technology implementation efforts to include other U.S. partner government agencies, the World Customs Organization, and international customs agencies. Joint efforts among government agencies should enable future coordination, effective implementation, and—most importantly—the creation of global blockchain standards necessary in the international trade environment.

- CBP and HSI should consider joining efforts in analyzing fraud potential and reviewing the legal ramifications of blockchain technology implementation. Both agencies should involve policy and legal experts in all future blockchain implementation efforts. Both agencies should consider issuing new policies and regulations to enable effective and compliant blockchain technology implementation in the U.S. customs environment.

The international trade industry sees blockchain technology as a tool that may affect every aspect of international trade—from manufacturing to shipping and distribution, and even customs clearance. Wide-scale blockchain implementation is years away, but when it comes to the international trade environment, the U.S. government should actively engage in such implementation now in order to endorse systems that adhere to global standards and promote economic growth and fair trade practices worldwide. Blockchain technology is promising to revolutionize supply chain management; with proper government and industry support, this technology may also improve the international trade environment as well as compliance and enforcement capabilities.

I. BLOCKCHAIN IMPLEMENTATION IN THE U.S. CUSTOMS ENVIRONMENT

> If there's one thing we've learned from the recent history of the internet, it's that seemingly esoteric decisions about software architecture can unleash profound global forces once the technology moves into wider circulation.
>
> —Steven Johnson, *New York Times*[1]

Blockchain technology is exactly the kind of software architecture that can unleash global change. "At its core," explains Michael del Castillo in *Forbes*, "blockchain is simply a distributed database, with an identical copy stored on many computers."[2] Blockchain technology, also known as digital ledger technology, can be implemented in any field, as it can be applied to any digital asset or digital content: virtual currency, computer files, pockets of data, images, or digital identifiers assigned to physical goods. Blockchain technology also has potential for U.S. government functions, including customs operations. This research examines blockchain technology, its capabilities, future implementation in international trade, and, more specifically, implementation in the U.S. customs environment.

The development of blockchain technology will determine the changes that come with it and how systems and services will be built going forward. Once the technology is widely implemented by the private sector, however, government entities will have to update existing regulations or draft new policies and guidance to accommodate the way blockchain may change data sets, information storage, liabilities, responsibilities, and workflow. The true value of blockchain technology in any industry cannot be recognized, understood, or confirmed until the technology is actually implemented and proven to work on a large scale. Proofs of concept (POCs) and pilot projects appear to be the most effective

[1] Steven Johnson, "Beyond the Bitcoin Bubble," *New York Times*, January 16, 2018, https://www.nytimes.com/2018/01/16/magazine/beyond-the-bitcoin-bubble.html.

[2] Michael del Castillo, "Blockchain Goes to Work at Walmart, IBM, Amazon, JPMorgan, Cargill and 46 Other Enterprises," *Forbes*, April 16, 2019, https://www.forbes.com/sites/michaeldelcastillo/2019/04/16/blockchain-goes-to-work/.

way to explore future implementation, enabling an understanding of what the blockchain revolution brings and how the government can prepare, implement, and benefit from it. It is crucial that the government remains involved in the implementation of blockchain; the technology's immaturity provides a rare opportunity for the government to collaborate with the trade industry and to explore the technology's capabilities and possibilities. This continuous development gives the U.S. government a chance to take an active role and to influence trade industry implementation in a way that supports U.S. interests, encourages global standards, and promotes economic growth and fair trade practices.

U.S. Department of Homeland Security (DHS) Science and Technology Directorate (S&T) conducts research and development work to identify new technologies that could benefit DHS's various missions and components. As revealed in congressional testimony, S&T has been actively engaged in research to determine the necessity or appropriateness of utilizing blockchain technology and developing common specifications, standards, and overall interoperability, as well as best practices for connecting existing systems with blockchain platforms.[3] Customs and Border Protection (CBP), which is responsible for facilitating lawful international trade and travel, has been the most active operational DHS component to partner with S&T in exploring blockchain and distributed ledger technologies for its mission.[4] Of particular note, S&T partnered with CBP in two POC projects to determine the effectiveness of using blockchain technology in the U.S. customs environment.

These blockchain POCs are among a number of projects and pilots exploring blockchain technology worldwide. William Eggers, Pankaj Kishnani, and Mike Turley discuss this trend, which they refer to as sandboxes: "An accelerating trend for regulatory agencies is the creation of accelerators and 'sandboxes,' in which they partner with private companies and entrepreneurs to experiment with new technologies in environments that

[3] *Leveraging Blockchain Technology to Improve Supply Chain Management and Combat Counterfeit Goods*, 115th Cong., 2nd sess., May 8, 2018, 19–25, https://docs.house.gov/meetings/SY/SY21/20180508/108289/HHRG-115-SY21-20180508-SD004.pdf.

[4] Anil John, interview with author, May 9, 2019.

foster innovation."[5] Such sandboxes promote technology development and innovation diffusion. Later in the development stage, technological sandboxes can become regulatory sandboxes, or opportunities for the government to identify necessary policies and regulations and to determine the potential effects without crippling the technology.

CBP has engaged in blockchain POCs to explore the technology's potential in the U.S. customs environment, determine related technical and policy needs, and identify potential benefits to the CBP mission. Vincent Annunziato, Director of the Business Transformation and Innovation Division at CBP's Office of Trade, notes, "We strongly believe blockchain will help the United States maintain a competitive edge in the worldwide competition to grow stronger, better, and more reliable ways of protecting our country from illegal imports and exports."[6] CBP continues to explore blockchain implementation as a way to get ahead of the blockchain revolution, which many have compared to the internet revolution. If that analogy holds, existing government processes and policies may have to change to support and implement blockchain technology in international trade. This thesis examines the first POC implementation of blockchain technology in the U.S. customs environment, executed by S&T and CBP, and provides related recommendations for the government's further involvement.

A. RESEARCH QUESTION

This thesis seeks to answer the following question: How should DHS and its components be involved in the implementation of blockchain technology in the U.S. customs environment? At this time, the U.S. government has not issued any policies or guidance on the implementation of blockchain technology in customs clearing. New blockchain technology applications in international supply chain management are gaining momentum and creating an opportunity for implementation in currently paper-heavy

[5] William D. Eggers, Pankaj Kishnani, and Mike Turley, "The Future of Regulation: Principles for Regulating Emerging Technologies," Deloitte Insights, June 19, 2018, https://www2.deloitte.com/insights/us/en/industry/public-sector/future-of-regulation/regulating-emerging-technology.html.

[6] Vincent Annunziato, "Blockchain—A U.S. Customs and Border Protection Perspective," *Enterprise Security*, May 2019, https://blockchain.enterprisesecuritymag.com/cxoinsight/blockchain-a-us-customs-and-border-protection-perspective-nid-1055-cid-56.html.

customs processing. Blockchain capabilities and hype-driven applications provide an opportunity for academic, private industry, and government entities to research, set standards, and create policies and regulations to ensure effective implementation. This thesis examines the first POC blockchain implementation by CBP, including the POC's execution and results, and provides recommendations for DHS and CBP's future involvement in the implementation of blockchain technology in the U.S. customs environment.

Customs processing is a key element of international trade, and customs agencies worldwide are beginning to test and pilot blockchain technology. The Canada Border Services Agency (CBSA) is engaged in a pilot aimed to determine whether a blockchain platform can speed up business processes.[7] Singapore launched its Open Trade Blockchain tracking trade documentation with fraud prevention as a goal.[8] The Australian Chamber of Commerce is engaged in a POC testing blockchain-based supply chain management.[9] CBP's POCs are not only an example of innovative development by DHS components but also a step toward joining the trade industry in a potentially global change. If DHS and CBP do not proactively explore the addition of blockchain technology, they will lose the opportunity to develop the technology and to develop along with it. By joining the blockchain revolution early on, both private and government entities gain an invaluable opportunity to drive the change rather than to react and adapt to systems established by others.

B. LITERATURE REVIEW

The literature on blockchain technology implementation is recent and primarily covers the technology's potential, such as proof-of-concept projects, pilots, and developments, rather than exploring functioning, effective blockchains. Books, technical

[7] "Canadian Customs Joins IBM/Maersk Blockchain Platform," Ledger Insights, October 26, 2018, https://www.ledgerinsights.com/canadian-customs-joins-ibm-maersk-blockchain-platform/.

[8] Nicky Morris, "Singapore-Backed Global Trade Blockchain Launches," Ledger Insights, July 19, 2018, https://www.ledgerinsights.com/singapore-trade-blockchain-otb/.

[9] Mark Barley, "PWC, Port of Brisbane Creating Supply Chain Blockchain," Ledger Insights, May 31, 2018, https://www.ledgerinsights.com/pwc-port-of-brisbane-creating-supply-chain-blockchain/.

publications, popular magazines, blogs, and numerous white papers appear to agree that the technology is disruptive, potentially transforming, and relevant in many fields and for many organizations. Jai Singh Arun, Jerry Cuomo, and Nitin Gaur suggest blockchain technology is second only to the internet as "the most disruptive technology of the 21st century."[10] Paul Armstrong claims, "It is not hyperbolic to say that blockchain and the technologies it enables have the potential power to disrupt entire countries."[11] The official website of Estonia, recognized as a leading digital society, confirms Armstrong's claim:

> Although blockchain has only become hot technology in recent years, Estonia is leading the way in the blockchain revolution…. Since 2012, blockchain has been in operational use in Estonia's registries, such as national health, judicial, legislative, security and commercial code systems, with plans to extend its use to other spheres such as personal medicine, cyber security and data embassies.[12]

The World Economic Forum further claims that blockchain "may be the key to unlocking 'paperless trade'—a concept that may seem elusive in a document-heavy system."[13] Countless successful blockchain applications all over the world and the hype surrounding them introduce the technology to wider audiences and provide examples of new implementations.

This phenomenon has also influenced the U.S. government's interest in blockchain technology. Several reports issued by government entities focus on the technology and its potential, revealing U.S. government involvement in research and adoption of blockchain technology: the S&T's 2018 congressional testimony on leveraging blockchain technology for supply chain management, the 2018 *Illinois Blockchain and Distributed Ledger Task Force* report, a 2018 Congressional Research Service (CRS) report on blockchain, and the 2018 *Blockchain Technology Overview* by the National Institute of Standards and

[10] Jai Singh Arun, Jerry Cuomo, and Nitin Gaur, *Blockchain for Business* (Boston: Addison-Wesley, 2019), 19.

[11] Paul Armstrong, Disruptive Technologies: Understand, Evaluate, Respond (New York: Kogan Page, 2017), 18.

[12] e-Estonia, accessed May 5, 2019, https://e-estonia.com.

[13] Nadia Hewett and Sumedha Deshmukh, "3 Ways Blockchain Can Revolutionize Global Supply Chains," World Economic Forum, April 25, 2019, https://www.weforum.org/agenda/2019/04/3-ways-blockchain-global-supply-chains/.

Technology (NIST).[14] These reports provide unbiased technical overviews of blockchain technology and discuss its potentially broader applications in cybersecurity, healthcare, identity management, provenance, and supply chain management. Although these reports note blockchain's technological potential and capabilities to be effective in many fields, they also warn against the hype and identify possible challenges. In the CRS report, Chris Jaikaran notes, "Because of its novelty, blockchain is being piloted by industry, but at this time does not appear to be a replacement for existing systems."[15] The NIST overview seconds this conclusion:

> Blockchain technology is still new and should be investigated with the mindset of "how could blockchain technology potentially benefit us?" rather than "how can we make our problem fit into the blockchain technology paradigm?." Organizations should treat blockchain technology like they would any other technological solution at their disposal and use it in appropriate situations.[16]

Industry leaders recognize the hype surrounding the technology and note that while blockchains can be applied in many fields, only certain processes and organizations will truly benefit from the technology. A report by the Public-Private Analytic Exchange Program concludes,

> Blockchain is not a silver bullet for the U.S. Government; however, there are areas of government interest where distributed ledger technology appears to be well-suited to delivering specific and tangible benefits. These include public records, budget allocation, supply chain monitoring, and the government approval chain process.[17]

[14] H.R., *Leveraging Blockchain Technology*; Cab Morris, John Mirkovic, and Jennifer M. O'Rourke, *Illinois Blockchain and Distributed Ledger Task Force Final Report to the General Assembly*, House Joint Resolution 25 (Springfield, IL: State of Illinois, January 31, 2018), https://www2.illinois.gov/sites/doit/Strategy/Documents/BlockchainTaskForceFinalReport020518.pdf; Chris Jaikaran, *Blockchain: Background and Policy Issues*, CRS report no. R45116 (Washington, DC: Congressional Research Service, 2018), https://fas.org/sgp/crs/misc/R45116.pdf; Dylan Yaga et al., *Blockchain Technology Overview*, NISTIR 8202 (Washington, DC: National Institute of Standards and Technology, 2018), https://nvlpubs.nist.gov/nistpubs/ir/2018/NIST.IR.8202.pdf.

[15] Jaikaran, *Blockchain*, 10.

[16] Yaga et al., *Blockchain Technology Overview*, vi.

[17] Mark Gabriele et al., *Blockchain and Suitability for Government Applications* (Washington, DC: Public-Private Analytic Exchange Program, 2018), 5, https://www.dhs.gov/sites/default/files/publications/2018_AEP_Blockchain_and_Suitability_for_Government_Applications.pdf.

An International Port Community System Association (IPCSA) project, for example, confirms that not all blockchain implementations are effective: IPCSA members initiated a project analyzing the replacement of existing computerized import/export processes with a blockchain and determined that "merely switching an existing digital process to blockchain technology would deliver no significant benefit."[18]

Potential regulation and standardization is another emerging topic for blockchain technology. While the CRS report considers future regulations, Wonnie Song—in a *Harvard Business Law Review* article—addresses recent changes in state laws in several U.S. jurisdictions. Specifically, the article discusses Delaware's legal changes in response to the adoption of blockchain platforms in corporate governance.[19] International standards organizations, such as the IEEE Standards Association, World Wide Web Consortium (W3C), and International Organization for Standardization, are also involved in ongoing projects that explore standards for blockchain technology. The trade industry agrees that standards must develop for the technology to mature and become widely implemented.[20] D. Linda Garcia, Bethany Leickly, and Scott Willey discuss the government's role in regulating any innovation: "The government should not necessarily set standards—an approach that all too often leads to regulatory failures. Instead, the government must help to support the process, thereby reducing collective action problems."[21] The authors also provide further perspective on the options governments have in exploring innovation and related standards:

[18] "IPCSA Blockchain Bill of Lading Initiative," International Port Community Systems Association, May 2018, https://ipcsa.international/initiatives.

[19] Wonnie Song, "Bullish on Blockchain: Examining Delaware's Approach to Distributed Ledger Technology in Corporate Governance Law and Beyond," *Harvard Business Law Review Online* (2017): 9–20, https://www.hblr.org//wp-content/uploads/sites/18/2018/01/Bullish-on-Blockchain-Examining-Delaware%E2%80%99s-Approach-to-Distributed-Ledger-Technology-in-Corporate-Governance-Law-and-Beyond.pdf.

[20] Janet Nodar, "Blockchain Slow Steaming into Container Shipping," *Journal of Commerce*, March 11, 2019, https://www.joc.com/technology/blockchain-slow-steaming-container-shipping_20190311.html.

[21] D. Linda Garcia, Bethany L. Leickly, and Scott Willey, "Public and Private Interests in Standard Setting: Conflict or Convergence," Georgetown University, September 2015, 1, https://blogs.commons.georgetown.edu/cctp-644-fall2015/files/2015/09/Wk2-Public-and-Private-Interests-in-Standard-Setting-Conflict-or-Convergence.pdf.

> The government can also facilitate the standards-setting process, acting as an educator to reduce uncertainties; a broker to bring together players and aid in negotiations; or a subsidizer to provide critical resources. Acting more directly, the government plays the role of regulator, specifying and standardizing the characteristics and/or capabilities of a product, process or technology. The government is also a user or consumer of standards. Moreover, when necessary, the government is a developer of technology standards through its own research and development efforts.[22]

While the necessity of standards for blockchain technology is becoming a consistent message, the literature reviewed does not suggest that U.S. government entities would be the appropriate source of guidance on blockchain standards. None of this literature considers DHS or its components as potential sources of standard guidance for blockchain technology.

Consulting firms and software companies have initiated discussions and drafted white papers to assist industry and governments in blockchain implementation and regulation while simultaneously advertising themselves as experts in the field of blockchain technology. A 2017 Deloitte white paper concludes, "The most fundamental question for government leaders may be this: Do you want to be positioned to capture the benefits of the new, potentially transformative technology that is blockchain?"[23] Authors have noted numerous possible reformative implementations of blockchain technology, including effective implementation in the fraud-ridden international trade environment.[24] Eggers, Kishnani, and Turley touch on emerging technology regulation to provide potential guidance to regulators and lawmakers, noting that innovators need opportunity and space to truly harness new technology potential.[25] The consistent message among industry professionals is that blockchain technology is developing every day and will be applied in numerous business and government practices. Because the technology is developing so

[22] Garcia, Leickly, and Willey, 11.

[23] Jason Killmeyer, Mark White, and Bruce Chew, *Will Blockchain Transform the Public Sector? Blockchain Basics for Government* (Westlake, TX: Deloitte University Press, 2017), 16, https://www2.deloitte.com/content/dam/insights/us/articles/4185_blockchain-public-sector/DUP_will-blockchain-transform-public-sector.pdf.

[24] Killmeyer, White, and Chew.

[25] Eggers, Kishnani, and Turley, "The Future of Regulation."

rapidly, new literature is published almost every day all around the world, touching on the most recent developments, successes, and potential.

Because blockchain has not been implemented in the U.S. customs environment, no current literature discusses the effectiveness of such implementation. In *Unveiling the Potential of Blockchain for Customs*, Yotaro Okazaki suggests, "With the blockchain technology, Customs administrations and other border agencies would significantly improve their capacity for risk analysis and targeting, thus contributing to improved trade facilitation."[26] Alan Cohn, whose project for the Blockchain Research Institute explores how blockchain can be added to CBP's toolbox, notes the importance of government participation in blockchain technology development, and recommends CBP's continuous involvement in future implementation.[27] Cohn concludes:

> CBP's deep industry relationships, its international partnership, and its leading role in international organizations focused on customs practices all give CBP the opportunity to drive the global development of governance for how blockchain technology can be harnessed to enhance the safety and security of global trade.[28]

Reports of the initial POC blockchain implementation in the U.S. customs environment are limited to government-issued papers, news articles, and congressional testimonies. This thesis seeks to fill that gap by discussing the initial implementation and providing suggestions for the way forward.

C. RESEARCH DESIGN

Blockchain technology has been surrounded by hype: first lauded for enabling the creation of cryptocurrencies and starting conversations about digital identity, blockchain technology now promises to revolutionize supply chain management. And blockchain has

[26] Yotaro Okazaki, "Unveiling the Potential of Blockchain for Customs," WCO Research Paper 45 (research paper, World Customs Organization, 2018), 17, http://www.wcoomd.org/-/media/wco/public/global/pdf/topics/research/research-paper-series/45_yotaro_okazaki_unveiling_the_potential_of_blockchain_for_customs.pdf?la=en.

[27] Alan D. Cohn, "Blockchain at Our Borders" (report, Blockchain Research Institute, 2017), https://www.blockchainresearchinstitute.org/project/blockchain-at-our-borders/.

[28] Cohn, 4.

continued to grow along with the hype; corporate government spending on blockchain technology is projected to reach $12.4 billion by 2022.[29] Gartner, a leading research and advisory company, publishes yearly graphics as part of its Gartner hype cycle methodology that depict emerging and disruptive technology adoption and interest and forecast how a particular technology might develop. As shown in Figure 1, "blockchain in government" was at the peak of an August 2018 hype cycle for digital government technology, indicating high expectations from the technology.[30]

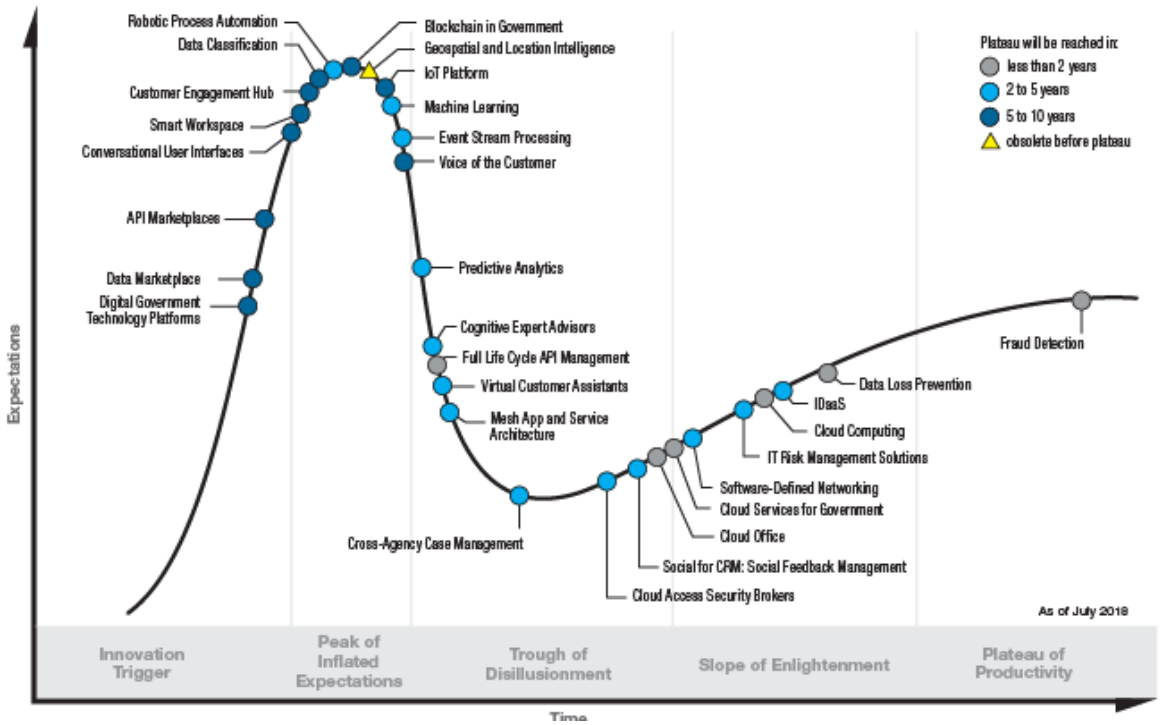

Figure 1. August 2018 Hype Cycle with Blockchain in Government at Peak[31]

[29] Michael del Castillo, "Blockchain 50: Billion Dollar Babies," *Forbes*, April 16, 2019, https://www.forbes.com/sites/michaeldelcastillo/2019/04/16/blockchains-billion-dollar-babies/.

[30] Susan Moore, "Top Trends from Gartner Hype Cycle for Digital Government Technology, 2018," Gartner, September 3, 2018, https://www.gartner.com/smarterwithgartner/top-trends-from-gartner-hype-cycle-for-digital-government-technology-2018/.

[31] Source: Moore.

According to Gartner's methodology, blockchain technology is going to remain at the forefront of innovations, will be adopted by the government, will then likely arrive at the "Trough of Disillusionment" due to potential failed implementations, and then move onto the "Slope of Enlightenment"—the stage where successful implementations will reveal technology's true benefits and value, leading to productivity and growth.[32] The key here is continuous implementation and testing to identify the failures, successes, and what implementations will outlive the hype and lead to productive working systems. This research examines where CBP's first blockchain POC and related outcomes fall in the overall hype cycle. Specifically, this thesis focuses on the first POC project to implement blockchain technology in the U.S. customs environment. The POC is extremely limited in scope, introducing the concept of the government accessing multiple private blockchains for the purpose of verifying product origin information for proper tariff calculation. This POC was initially introduced during a 2018 congressional hearing:

> We [DHS S&T] are currently executing the highest priority one [project] which is to track free trade qualifications of imported goods by providing greater supply chain visibility, which would answer the following question, "Can distributed ledger technology be used to verify that an item qualifies for a free trade import tax exemption by demonstrating that the necessary percentage of an item's components were produced/assembled in a FTA [Free Trade Agreement] country?"[33]

The first stage of the research was to gather relevant background information about blockchain technology basics, capabilities, considerations, and ongoing implementation in the supply chain management and customs process. The second stage involved collecting and analyzing publicly available materials related to the POC project, including congressional testimonies, presentations by S&T and CBP employees, public after-action reports, and relevant media coverage. This review was continuously updated throughout the research process as additional documents were published and information became public.

[32] "Hype Cycle Research Methodology," Gartner, accessed May 11, 2019, https://www.gartner.com/en/research/methodologies/gartner-hype-cycle.

[33] H.R., Leveraging Blockchain Technology, 22.

The third stage of the research consisted of interviews with subject-matter experts involved in the POC. The interviews covered the scope of the POC, technological aspects of the blockchains implemented, existing concerns, future blockchain implementation in the customs environment, the interaction of private blockchains with government, and related policies and guidelines. Information obtained in the interviews was reviewed to determine the effectiveness of the POC and the initial blockchain implementation in the customs environment and to identify future requirements and opportunities for blockchain implementation by CBP. The Naval Postgraduate School's Institutional Review Board reviewed the interview questions and determined they did not involve human subjects research.

The fourth stage of the research involved analyzing the information from the previous stages, including the results of the POC, the related assessment by the CBP, information about the second POC, and CBP's ongoing efforts in furtherance of the future blockchain implementation in customs processing. This analysis revealed points of successful implementation, determined the effectiveness of blockchain technology in the customs clearance process, and exposed potential concerns for CBP's blockchain implementation. The final step was to provide recommendations for CBP and S&T as they relate to future research and implementation of blockchain technology in the U.S. customs environment.

D. OUTLINE

Chapter II provides background information about blockchain technology and examines its implementation in the international trade environment. While blockchain technology promises to solve numerous existing processes, especially in supply management and international trade, the technology is still developing and issues such as key management, access, lack of standards, and interoperability remain key for the future technology implementation. Chapter II also offers a limited background of CBP's existing system, highlighting the need for blockchain technology to effectively interact with existing systems.

Chapter III provides an overview of the first blockchain technology implementation POC by CBP and details the POC's scope, relevant stakeholders, and software. The chapter concludes with an analysis of the results, addressing fraud vulnerabilities and analyzing the POC using the hype cycle framework. Chapter IV details CBP's ongoing blockchain implementation efforts and future projects, addressing the need for standard development, further technological advance, and a better understanding of the technology to develop for successful future implementations.

Chapter V serves as a conclusion, noting blockchain technology's potential to become a key element of international trade once technical, interoperability, and policy concerns are addressed by the trade industry and the government. The conclusion provides a final look at blockchain technology within the hype cycle as well as final recommendations for CBP and S&T's continuous involvement in blockchain development.

II. BLOCKCHAIN, INTERNATIONAL TRADE, AND CUSTOMS ENVIRONMENT

> Blockchains are tamper evident and tamper resistant digital ledgers implemented in a distributed fashion … and usually without a central authority…. At their basic level, they enable a community of users to record transactions in a shared ledger within that community, such that under normal operation of the blockchain network no transaction can be changed once published.
>
> —NIST, Blockchain Technology Overview[34]

A blockchain is a database shared by a network, wherein each node maintains a copy of the database. Blockchains can provide transparency, resilience, auditability, consensus, distributed access, and independent administration of a shared database without a central clearing entity. While blockchain technology promises to improve numerous existing processes, especially in supply management and international trade, the technology is still developing and issues such as key management, privacy, and access, as well as lack of standards and interoperability, remain key for its future implementation. Existing customs environments will also affect blockchain technology implementation in the customs clearance process. This chapter provides specific background information on blockchain and the customs environment relevant to future blockchain technology implementation by CBP.

A. BLOCKCHAIN TECHNOLOGY OR DISTRIBUTED LEDGER TECHNOLOGY

A blockchain functions as a digital ledger and enables a digital asset to be continuously tracked: once the digital asset is moved and the transaction is verified and recorded, its location is changed, recorded, and known to all blockchain participants. One of the most important aspects of blockchains is the elimination of digital asset duplication. As a recent McKinsey study notes, "Every piece of information is mathematically encrypted and added as a new 'block' to the chain of historical records. Various consensus

[34] Yaga et al., *Blockchain Technology Overview*, 1.

protocols are used to validate a new block with other participants before it can be added to the chain."[35] Blockchain technology allows direct interaction between parties and makes recordings of transactions immediately available to all participants, eliminating the need for intermediaries or central authorities. In this way, blockchains create transparency: participating entities can trust the transactions because users are conducting and verifying them all at the same time. A decentralized network provides transaction verification (trust), and once transactions are verified and added to the block (recorded), they cannot be modified. Achieved transparency then provides all participating entities with the ability to audit and review transactions at any given time without seeking permission or making notifications, therefore increasing trust and confidence in the accuracy of the data. Jaikaran further explains how blockchains build trust: "The strong relationship between identities, transactions, and the ledger enables parties that may not trust each other or an individual computing platform to agree on the state of resources as logged in the ledger."[36] Private blockchains, where parties already have established relationships, provide trust in transactions by giving all parties visibility into recording, verifying, and finalizing of the transactions. Because no modifications can be made to verified transactions, blockchains preclude corrections or retroactive additions of data. Organizations and companies considering blockchain implementation must therefore understand the barriers to adjusting, correcting, and moving existing data. The only way to correct the data is to record another transaction and add another block of data, which is, again, final upon input and visible to all parties.

Blockchain transactions are secured by encryption technology and are authenticated by private keys, much like complex computer-generated passwords that verify users and function as signatures. Every transaction requires a user to enter the private key to finalize and record the transaction.[37] Once the transaction is entered and verified, it

[35] Brant Carson et al., "Blockchain Beyond the Hype: What Is the Strategic Business Value?" McKinsey Digital, June 2018, https://www.mckinsey.com/business-functions/digital-mckinsey/our-insights/blockchain-beyond-the-hype-what-is-the-strategic-business-value.

[36] Jaikaran, *Blockchain*, 1.

[37] Jaikaran, 3.

is recorded on the blockchain and can be viewed and audited by any other user. Key management is easy for individual users but can become a complex task for companies and corporations where multiple individuals perform the same tasks. Various blockchain applications will dictate key management procedures, controls, and responsibilities. In regulated environments, key management may raise concerns about responsibility, liability, and penalties. Government entities must develop guidelines and policies to address key management where blockchain technology may be used to secure or certify data submitted to the government, or where the government may be a party to a network to account for possible civil or criminal liability.

Permissioned blockchains allow network entities or individual users to be assigned roles, which limits access and defines who can view the data and who can transact on the blockchain. Such an ability would work for networks with various roles within the participating organization, or for organizations with a hierarchy where some users, such as supervisors, would only need to review—but not initiate—the transactions. Permissioned blockchains remain decentralized with administrators controlling only users' rights within the blockchain and not the blockchain itself. Permissioned platforms could benefit supply chain management networks that include competitors, allowing for transaction monitoring but limiting access to proprietary information.

One of the biggest initial disadvantages of blockchain technology is that different blockchains could not, and many still cannot, interact with other blockchains. As Jaikaran explains, "If a user seeks to copy their data from one blockchain to another, there are no standards for data construction from one blockchain to the next, so all the elements of data from one blockchain may not be imbedded in another, nor will how they process public-private keys or hash values."[38] In other words, blockchains are not built for copying or transferring data from or between blockchains. This consideration is important for all potential users, especially the government. One company's software may enable successful blockchain recording of the existing data set, but it may be impossible to transfer or merge that blockchain with a different blockchain. A lack of interoperability between blockchains

[38] Jaikaran, 8.

might create dependency on a particular software company and vendor locks or monopolies. This issue can affect any company or government agency establishing a blockchain or planning to access various blockchains. The risk is especially big for government entities that have existing systems created to track, maintain, and transmit data. The government must ensure that any new system can interact or effectively replace the existing systems because utilization of the existing government systems is often mandated and regulated. Existing systems are also dependent upon by the public and the trade industry; any disruption may result in financial or operational losses.

Governments, corporations, and start-ups are embracing blockchain technology in the quest for efficiency, transparency, and better business practices. New blockchain applications range from smart contracts, identity verification, land-ownership recording, medical records, and supply chain management. International shipping companies and trade industry recognize blockchain technology's value in superior data tracking and have already begun implementation and testing the technology. Interoperability concerns will remain crucial in international implementation; common standards and interoperable platforms will be key for enabling global participation.

B. BLOCKCHAIN TECHNOLOGY APPLICATIONS IN SUPPLY CHAIN MANAGEMENT

Jaikaran breaks down potential benefits of blockchain technology for tracing the origin of a product: "Because asymmetric encryption allows for the authentication of users, blockchain has been suggested as a solution to the provenance of items. Provenance refers to the ability to know the history of an item."[39] Jaikaran elaborates on this concept by explaining:

> Utilizing blockchain technology for tracking of physical goods would require adding a digital value, such as a scannable code. This would allow tracking of the item to be recorded at each stage of manufacturing or transportation including cross border movement. Each entity involved in the movement of goods would utilize public-private key to record transactions

[39] Jaikaran, 6.

> on the blockchain and could then track the goods from creation to distributors, retailers and even end users.[40]

In other words, the ledger can allow any product or product part to be tracked throughout its life span. For instance, blockchain technology can track an avocado from the moment it is put in a box at a small farm, or a computer chip from the time it is created at a factory. Blockchain-based supply chain management could benefit manufacturers, distributors, retailers, and shipping companies and might replace various existing forms of digitized supply chain management. In 2018, IBM's Jerry Cuomo testified in a congressional hearing that blockchain technology has potential to save the global trade industry billions by replacing endless paper forms with superior digital tracking of trade documents, thereby simplifying the process, speeding up settlements, and providing a shared system for transaction verification.[41]

A notable industry example of a working supply chain blockchain is Walmart's blockchain platform, Food Trust, created to track goods—and to recall goods if necessary—ensuring enhanced food safety. According to Walmart's senior director of customs, the company is now in the process of requiring certain suppliers to join Food Trust and is actively exploring other ways blockchain can streamline supply chain management and improve business practices.[42]

Government entities are also starting to recognize blockchain's ability to track and manage supply chains, as confirmed by the first U.S. Department of Agriculture's certification of BeefChain—a company that uses blockchain technology to track and provide health, age, and origin records for cattle—as a Process Verified Program.[43] Another working and continuously developing system is a joint IBM–Maersk blockchain

[40] Jaikaran, 8.

[41] *Beyond Bitcoin: Emerging Applications for Blockchain Technology*, 115th Cong., 2nd sess., February 14, 2018, 3, https://science.house.gov/hearings/beyond-bitcoin-emerging-applications-for-blockchain-technology.

[42] Barry Baxter (senior director of customs, Walmart), interview with author, February 21, 2019.

[43] Benjamin Pirus, "BeefChain Receives First USDA Certification for a Blockchain Company," *Forbes*, April 25, 2019, https://www.forbes.com/sites/benjaminpirus/2019/04/25/beefchain-receives-first-usda-certification-for-a-blockchain-company/#39c610567607.

venture called the TradeLens platform. Numerous shipping companies, freight forwarders, and ports have already joined the platform and even Canada Border Services Agency is participating in a pilot project. *Ledger Insights* reports that TradeLens is hoping to work with World Customs Organization members to address their existing challenges and future needs by providing a more efficient way of processing global trade data.[44]

While blockchain technology can improve efficiency in the supply management life cycle and help streamline domestic and international shipments and distribution, it is important to recognize how concerns related to data verification apply in the field of supply chain management. Jaikaran warns that blockchain technology does not address the security and stability of the supply chain; anyone in the chain or an outside nefarious actor could manipulate the physical item, log a nonexistent transaction, or choose not to list a transaction.[45] International trade is ridden with fraud relating to product origin, product components, materials, tariffs, taxation, customs duties, and end-use verifications. Jason Killmeyer, Mark White, and Bruce Chew note: "With customs agents, shipping lines, shippers, consignees, brokers, and booking agents all involved, there are any number of actors in international shipping that could defraud the others."[46] While blockchain technology does not make the supply chain tamper-proof, verifying transactions or item provenance through the technology may improve efficiency.

The International Port Community Systems Association (IPCSA) launched an independent blockchain pilot to examine placing the current paper-based bill-of-landing filing process on a blockchain. The chief information officer of the Israel Ports Company is leading the project, with thirty-five international IPCSA-member ports planning to join, including Barcelona, Odessa, Le Havre, Bilbao, Marseilles, Trieste, and Valencia.[47] Research, development, and implementation will be the most decisive elements in the implementation of blockchain technology in supply management and international

[44] Ledger Insights, "Canadian Customs Joins IBM."

[45] Jaikaran, *Blockchain*, 8.

[46] Killmeyer, White, and Chew, Will Blockchain Transform the Public Sector, 10.

[47] International Port Community Systems Association, "IPCSA Blockchain Bill of Lading Initiative."

shipping. Because the technology is so new, it is impossible to predict real-life functions and problem sets until there are functioning blockchains that will become ultimate test beds.

C. BEFORE THE BLOCKCHAIN: AUTOMATED COMMERCIAL ENVIRONMENT (ACE)

The government's role in customs processing is a multifaceted one: the government facilitates the trade, protects the country from contraband and nefarious actors, and collects duties. The U.S. Customs Service was established in 1789, and the 229 years of customs processing "before the blockchain" reveal a complicated ecosystem with numerous partners and customers, involving a complex variety of processes. In *Blockchain at Our Borders*, Cohn notes the scale of this ecosystem: CBP is responsible for the daily inspection of over 80,000 shipping containers and $6 billion worth of imported goods, resulting in over $40 billion in customs revenue per year.[48] The international trade industry also connects Fortune 500 companies and third-world suppliers, and this industry still utilizes numerous paper forms. While paper-based processes still exist in the U.S. customs environment, many of the entities involved in imports and exports already interact with CBP via the Automated Commercial Environment (ACE), "the system through which the trade community reports imports and exports and the government determines admissibility."[49] ACE import and export missions include security, admissibility, and statistics. CBP began developing ACE, also referred to as a "single-window" system, in 2001 and is still in the process of implementing it, with additional deployments scheduled through August 2020.[50] The development has included in-depth reviews, such as the *Privacy Impact Assessment for ACE* issued by the CBP in 2015 which addresses all the

[48] Cohn, "Blockchain at Our Borders," 5.

[49] "ACE and Automated Systems," U.S. Customs and Border Protection (CBP), June 26, 2019, https://www.cbp.gov/trade/automated.

[50] "ACE Development—Deployment Schedule 2019," CBP, accessed May 26, 2019, https://www.cbp.gov/sites/default/files/assets/documents/2019-May/ACE%20Development%20-%20Deployment%20Schedule%202019.pdf.

import/export processes touched by ACE.[51] It took CBP over a decade to develop ACE, but most of the progress has happened in the last four years.[52] ACE has cost the U.S. government over $3 billion, and has resulted in a system that connects to forty-seven Partner Government Agencies (PGAs) and has automated 269 paper forms to track $4 trillion worth of goods crossing the border every year.[53] PGAs such as the U.S. Food and Drug Administration, U.S. Department of Agriculture, Office of Foreign Assets Control, and Homeland Security Investigations (HSI) are involved in the customs clearance processes when goods require certifications or specific clearances, or are imported/ exported in violation of federal laws and regulations. As an investigative arm of DHS, HSI is responsible for investigations related to criminal violations of customs laws.

CBP is still implementing ACE and figuring out how this system can fully replace paper-based processing for thousands of various customs transactions. While some of the information is submitted electronically, many processes combine electronic filing with paper submissions, or with submissions of scanned documents rather than process-ready data. Entry or export of a single shipment may be accompanied by numerous redundant forms that take extensive amounts of time to be processed and shared among all entities. Figure 2 provides a glimpse into ACE and some of the reports filed by the participating stakeholders, including data sets related to entry, manifests, compliance, declarations, profiles, exams, and broker data.

51 CBP, *Privacy Impact Assessment for the Automated Commercial Environment (ACE)*, DHS/CBP/ PIA-003(b) (Washington, DC: Department of Homeland Security, 2015), https://www.dhs.gov/sites/ default/files/publications/privacy-pia-cbp003-ace-march2018.pdf.

52 Mark Rockwell, "CBP Closes in on Completing 17-Year Multibillion IT Project," Federal Computer Week, March 5, 2018, https://fcw.com/articles/2018/03/05/cbp-ace-cargo-system.aspx.

53 Rockwell.

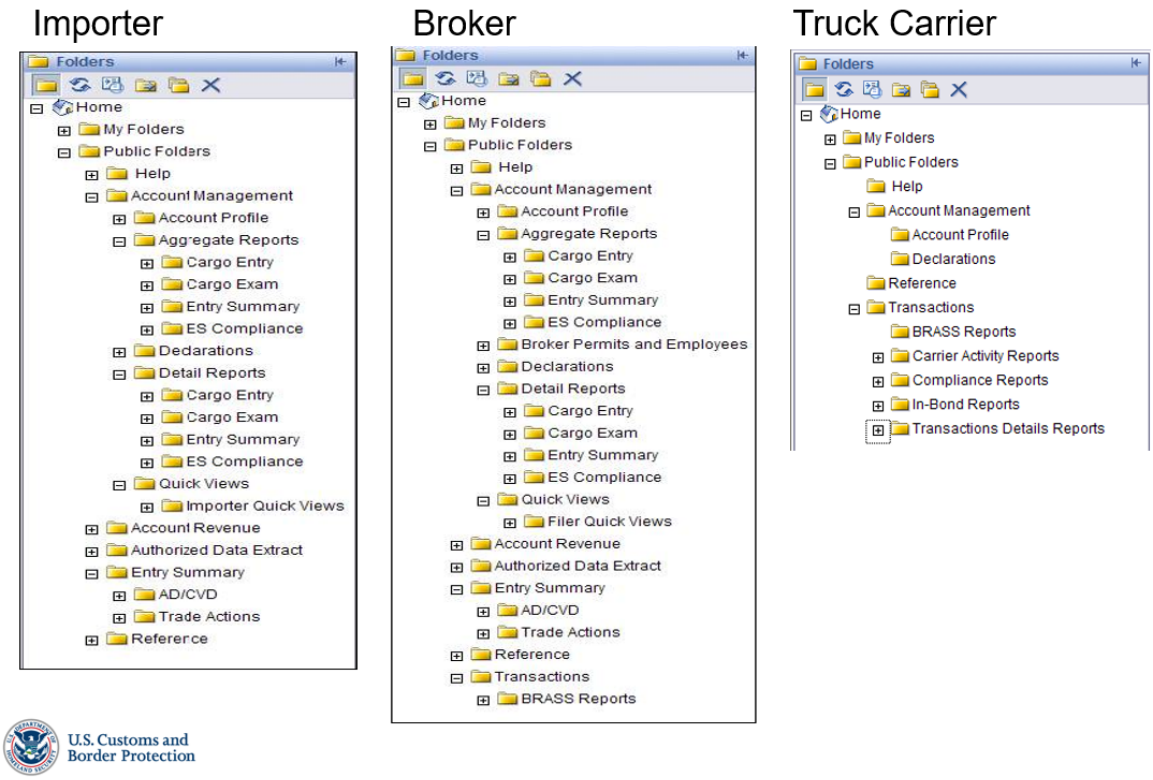

Figure 2. ACE Report Categories[54]

Because existing inefficiencies are often caused by numerous redundant paper forms, any system that will be implemented in the U.S. customs environment should aim to replace existing paper processing, and it must be able to interact with the existing digital system, ACE. And because CBP has invested so much time and money into the ACE platform, the organization is not looking to replace it; instead, CBP is looking at how new tools and technology can complement and improve the existing system.

Blockchain technology provides an avenue to digitize supply chain management. The international trade industry is beginning to implement blockchain technology worldwide, seeking efficiency, transparency, data sharing, and auditability. If blockchain technology implementation in international trade is successful, utilizing the same blockchain platforms for customs processing would be the next stage of adoption. CBP is interested in identifying whether blockchain-based processing can interact with ACE and

[54] Source: CBP, "ACE Overview and Status Update," presentation, April 2011.

benefit existing inefficient processes. Blockchain technology is still developing, so even if it lives up to the hype, the implementation by CBP is years away. The first step is to determine whether blockchain technology can be implemented in any of the numerous customs processes. The next stage is to determine whether the pain of the implementation is worth the gain. Lastly, CBP and the trade industry have to determine what defines "gain" in the world of customs processing: more efficient trade facilitation, the support of the trade industry, better targeting and screening, or maintaining a legally sound system that accounts for privacy and other concerns.

III. THE FIRST CBP BLOCKCHAIN PROOF OF CONCEPT

> What the government's trying to do is twofold: one is to help blockchain along in a healthy manner for increasing market adoption, and the other thing is we're trying to prepare ourselves in a proactive way to be ready for when private industry begins to really take off with this technology.
>
> —Vincent Annunziato, CBP Business Transformation and Innovation Division[55]

CBP's first proof of concept (POC) aimed to determine if any implementation of blockchain technology is possible in the U.S. customs environment. According to Annunziato, the POC proved that blockchain technology can, indeed, be implemented in the U.S. customs environment, and that the technology can improve the processing and tracking of trade-related documents, enable better auditability, and expedite CBP processing.[56] The first blockchain POC implementation in the U.S. customs environment should be seen as an example of proactive innovation by the government that seeks to improve business practices, understand new technology, and support global technology development.

A. FREE TRADE AGREEMENT VERIFICATIONS

The POC research and development work started with a blockchain workshop hosted by DHS S&T and CBP in October 2017. According to S&T Technical Director Anil John, S&T initiated this project through its identity management research and development (R&D) program after a long period of research into blockchain technology and after identifying numerous uses for the DHS components based on blockchain technology's promise of transparency, automation of paper-based processes, efficiency, immutability,

[55] Brian Bradley, "CBP Launching Blockchain Testing," American Shipper, August 14, 2018, https://www.americanshipper.com/main/fullasd/cbp-launching-blockchain-testing-72278.aspx.

[56] Vincent Annunziato (Director of CBP Office of Trade Business Transformation and Innovation Division), interview with author, March 18, 2019.

and auditability.[57] According to 2018 congressional testimony, S&T has conducted extensive blockchain R&D work:

> DHS S&T is pursuing two broad courses of action to encourage a more open and inclusive future for blockchain technology: 1. Support development of globally available specifications (precursor to standards) that are open, royalty free, and free to implement to ensure interoperability across systems while ensuring there is no vendor lock-in…. 2. Actively work with and support our DHS Component customers, such as CBP, to understand their potential use cases for blockchain and help them achieve their outcomes with the needed R&D expertise and technologies.[58]

Participants from the trade industry and CBP, as well as software developers, collaborated and identified possible use cases for blockchain implementation in the customs environment. This project was not initiated, however, because CBP identified an issue that could not be resolved with the existing systems. Instead, staff from the Business Transformation and Innovation Division (BTID) worked with S&T and the trade partners to identify a use case to explore blockchain technology in the problematic area within the existing customs environment: free trade agreement verification processes.

The Free Trade Agreement (FTA) verification process remains paper-heavy, inefficient, and ridden with errors, which can lead to incorrect or fraudulent filings—which often result in penalties. Blockchain-based processing promises to address these concerns and potentially eliminate cargo delays, penalties, and incorrect or fraudulent document filings. The FTA verification process is unique to products that qualify under FTAs. Importers must provide certificates of origin for goods entering the U.S. commerce to prove their eligibility under the FTAs. CBP's Office of Field Operations conducts FTA verifications.

The focus of the POC was specific: to test whether CBP could use blockchain technology to receive certificate-of-origin data and to conduct FTA origin verifications for goods under the North American Free Trade Agreement (NAFTA) and Central America

[57] Anil John (S&T Technical Director), interview with author, December 20, 2018.

[58] H.R., *Leveraging Blockchain Technology*, 19–25.

Free Trade Agreement (CAFTA).[59] While NAFTA/CAFTA FTA verification process is important for the understanding of the POC, the key to this discussion is not any particular customs clearance process—FTA verification or any other processing by CBP. CBP's goal was not to improve a particular process or fix a specific issue; the goal was to apply blockchain technology to any existing process involving trade stakeholders and to test CBP's ability to access trade data and interact with the trade industry via a blockchain platform. CBP's POC assessment provides an overview of the task:

> The aim of utilizing blockchain technology was to improve the processing of trade-related documents by hosting information about trade transactions on a decentralized, tamper-proof distributed ledger system, which can be authenticated and accessed by various stakeholders. The goal was to prove that a standards-based, fully digital system could be created to replace the existing paper-based system. The system would enable better auditability, expedite the evaluation of free trade agreement eligibility, and increase NAFTA/CAFTA transparency, and more clearly identify suppliers and manufacturers.[60]

The POC sought to determine if emerging blockchain interoperability specifications and standards could be implemented in the customs processing by CBP in a multi-blockchain environment in a way that does not require all the participants to use a single and/or proprietary blockchain platform.[61] Again, the goal was not to "fix" the FTA verification process but rather to establish an interoperable, blockchain-based process within a customs clearance environment involving multiple trade partners.

The POC began on September 11, 2018, and was completed on October 2, 2018. CBP's Office of Field Operations (OFO) conducted FTA verifications by accessing data on the blockchain via a web-based interface. The system was easy to access and allowed the OFO to verify information immediately rather than to submit a written request, followed by a wait of up to sixty days for the response. Within the POC, OFO operators reviewed the entry summary, identified the need to view certain certificates of origin or

[59] U.S. Customs and Border Protection Trade Transformation Office, "NAFTA/CAFTA Proof of Concept Assessment," version 2.0 (report, Department of Homeland Security, 2019), overview.

[60] CBP Trade Transformation Office, 4.

[61] Annunziato, interview with author, November 30, 2018.

underlying data, and received immediate access to the pocket of data containing the certificate information stored off the blockchain.[62] The blockchain platform was not connected to ACE and did not interact with ACE. The platform enabled FTA verifications but did not replace or eliminate ACE entry processing. The POC did not pilot a full-scale blockchain implementation or suggest that the trade industry should start blockchain implementation for the purpose of FTA verifications. Again, the goal of the POC was not to change the current process but simply to test the application of blockchain technology in the U.S. customs environment and to test CBP's ability to access trade data and interact with the trade industry via a blockchain platform. The first blockchain POC tested and proved that blockchain technology can be implemented in the U.S. customs environment, CBP can interact with multiple private entities via various blockchains, blockchain data can be authenticated and accessed by various stakeholders, the implementation can improve the processing and tracking of trade documents, the technology can enable better auditability, and blockchain processing can expedite the CBP entry process.[63] Thus, the POC achieved the goals set by S&T and CBP.

B. STAKEHOLDER ROLES

International trade and customs clearance processes involve numerous stakeholders, from global conglomerates, customs agencies, and large-scale distributors to local customs brokers, small businesses, and individual citizens. Blockchain technology implementation in the customs environment may affect many of these stakeholders. In fact, some industry leaders are interested in exploring the technology through POCs with CBP. *International Trade Today* reported the following participants of CBP's first blockchain POC: Walmart, United Parcel Service (UPS), Raytheon, Smucker's, Hershey's, DHL, and FedEx.[64] This section discusses the POC stakeholders, related activity, roles, and changes caused by the addition of blockchain technology into an otherwise functional, but largely

[62] Annunziato.

[63] Annunziato.

[64] Tim Warren, "Blockchain Seen as Promising, Though Many Legal Questions Remain," *International Trade Today* 35, no. 47 (March 11, 2019).

paper-based and slow, process of evaluating FTA eligibility. It should be noted that POC participation began with a signed nondisclosure agreement, so various data, including some of the names of the participating companies, must remain anonymous. CBP produced the data in Table 1 in the process of reviewing the POC to provide an overview of the roles and benefits of POC stakeholders such as manufacturers, exporters, importers, brokers, Partner Government Agencies, and CBP itself.

Table 1. POC Stakeholders[65]

	Stakeholder	Now	Future
Supplier	**Manufacturer** Adds value to the raw materials into other consumables and finally the end product	- Has limited ability to control and verify the flows coming from its suppliers	- Benefits from an integrated and distributed ledger that enables them to control the inputs and keep track of production
	Exporter Responsible for the information related to the entry/clearance of goods into the United States (U.S.)	- Limited certification ability and complex tracking	- Shared information system - Distributed and certified system - Ensure goods are transported in the right conditions
Trade	**Importer** Responsible for the purchase of goods entering the U.S.	- Limited certification ability and complex tracking	- Shared information system - Assurance that goods will arrive in due course
	Broker Responsible for facilitating transactions between Exporter and Importer	- Difficult to certify the origin and path of goods brought and sold	- Full end to end visibility - Verifiable authenticity and immutability of digital documents
Government	**PGA** Liaison between the stakeholders	- Difficult to certify the origin and path of the goods brought and sold	- Can easily check the origin of the goods and their transformation path on the blockchain - Check and prove its authenticity
	CBP Audit/compliance	- Difficult to certify the compliance, origin, and composition of the goods to be brought	- Have full view of the goods brought directly on the blockchain

65 Source: CBP Trade Transformation Office, "NAFTA/CAFTA Proof of Concept Assessment."

Foreign suppliers, manufacturers, and exporters did not participate in the POC directly. Outside of the POC, the certificates of origin and related information are provided by the foreign manufacturers or suppliers only when requested by CBP at the time of the entry. During the POC, certificate-of-origin data was input ahead of time as one of the initial blocks. Within the POC, the data was added and stored by the U.S.-based importers of record and the participating customs broker. Only one foreign supplier input the data directly, by way of a user interface and software provided by the participating customs broker.[66] Aside from this single exception, all trade data was input by the participating importers and customs brokers, which added additional work to their normal processing.

The importer is the party responsible for the customs entry and all the related paperwork and tariffs; it is also the party that pays the penalties if the certificate of origin data is filed incorrectly. For the POC, the importers and customs brokers also became blockchain network "nodes" and owners of the off-the-blockchain data storage, and they entered all of the certificate-of-origin data. As noted above, existing FTA verifications do not require production of the certificate-of-origin records ahead of time. Importers claim FTA status based on the information provided by the manufacturers, suppliers, or exporters, which can often be incorrect, incomplete, or fraudulent. CBP audits a limited number of entries, requesting certificate-of-origin records to verify document or data legitimacy, confirm claims, or reassess fees and penalties. With the addition of a blockchain, all the related data is already in the system, allowing the importers to make better-informed FTA claims, thus preventing mistakes in filings and avoiding penalties.

The role of the customs broker has been that of an ultimate middle man: to facilitate transactions between exporters and importers, transmit information to CBP, and assist with audits. Blockchain technology is all about removing the middle man through decentralization, transparency, and auditability capabilities. According to Jim Masloski, a customs broker and the owner of Customs Direct, LLC, blockchain technology will not replace customs brokers; rather, brokers will operate differently, ensuring consensus of

[66] Jim Masloski (customs broker, owner of Customs Direct, LLC), interview with author, June 14, 2019.

identities or otherwise adapting to the system-based future that will replace current paper-based reality.[67] Masloski's confidence is based on the three roles he played during the POC: a software provider, a customs broker, and an importer of record. Mr. Masloski provided perspective on the existing paper-based system, noting that he still occasionally receives faxes from his clients. Trade industry representatives interviewed for this research consistently agreed that blockchain may be the future of the international trade; however, they also noted that its wide-scale implementation is at least a few years away.[68]

CBP was the only active government participant in the POC. The BTID managed the POC while CBP's Office of Field Operations executed FTA verifications.[69] The CBP's Office of Policy, Office of Chief Counsel, and Office of Information Technology did not participate in the POC, and none of the PGAs participated in the POC due to its planned limited scope.

The software companies were not listed among the POC stakeholders in the table produced by CBP, but are crucial for the implementation of blockchain technology in international trade and customs clearance. Relevant software companies can be broken down at least into two categories. The first group comprises large companies that conduct extensive blockchain R&D work, build various opportunities around the blockchain hype, and create massive marketing campaigns selling blockchain technology as a solution to a variety of market needs. The second group is made up of smaller, often start-up, software companies that are attempting to find a niche in the development of this new technology and responding to specific market needs or opportunities. Both sets of software companies work with private-industry clients and government entities to develop blockchains capable of addressing supply chain management needs. Such work is usually either industry-specific—addressing a need in the supply chain management field that could be sold to a potential client—or specific to an existing client. In the latter case, software companies build custom-made software that addresses their client's internal needs. While software

[67] Masloski, interview with author, March 1, 2019.

[68] Christopher Rubio, interview with author, June 28, 2019; Barry Baxter, interview with author, February 21, 2019; Masloski, interview with author, March 1, 2019.

[69] Annunziato, interview with author, November 30, 2018.

companies are not considered existing stakeholders in the customs environment at this time, if the future of customs clearance is system-based rather than paper-based, they need to be brought in and treated as important stakeholders—ones that could facilitate and enable change.

C. THE SOFTWARE

One of the main goals of the POC was to test whether CBP could use emerging blockchain interoperability specifications and standards to interact with multiple blockchains for the purposes of customs processing. S&T's Anil John explains, "The need for interoperability in the multi-party POC environment was identified up front as a clear requirement and a goal of the POC was to demonstrate its feasibility by allowing participants to 'Bring Your Own Blockchain Node', if they so choose, to the POC."[70] This ensured that the POC demonstrated interoperability by using multiple blockchains that were engineered to adhere to common interoperability specifications and standards. The CBP blockchain node for the POC utilized blockchain software that was funded by the DHS S&T Identity Management R&D Program and developed by Digital Bazaar, a software engineering company. This blockchain application platform (Veres Delta) was unusual in that it was not built for a specific company, government entity, or use case, but instead was built with support for emerging specifications and standards that DHS S&T identified in its early research and development work as being critical to multi-product interoperability.[71] According to Digital Bazaar's founder, CEO, and owner, Manu Sporny, the custom-built system allowed CBP to gain access to data on multiple private, permissioned blockchains managed by importers and brokers, and to communicate with trade partners via the blockchain platform.[72] Within the POC, multiple independent parties, each with their own blockchain nodes, used either the same software as CBP or their own blockchain software.[73] Does the interoperability achieved during the POC mean

[70] John, interview with author, May 9, 2019.

[71] John.

[72] Manu Sporny (founder, CEO, and owner of Digital Bazaar), interview with author, March 26, 2019.

[73] John, interview with author, May 9, 2019.

different blockchains can, after all, be interoperable? At this time, the answer is that they may be, if systems are built in accordance with common specifications or standards.

An unexpected requirement for blockchain software interoperability is funding. Software companies do not immediately benefit from creating truly interoperable blockchains. In fact, locking clients into blockchain platforms can lead to long-term contracts; vendors therefore may prefer proprietary systems because of the prospect for long-term support contracts that extend well beyond the initial purchase of a system or software package. Since seamless blockchain interaction currently relies on users operating on the same blockchain platform, if a software company is able to secure large, international clients such as shipping or distribution conglomerates into long-term relationships, this may mean the software company will also win those conglomerates' respective clients or partners as new customers. Even if two blockchains are built on the same open-source software platform, however, they may not be able to interact and share data. Full interoperability would require the use of agreed-upon specifications and standards that are embraced by vendors and developers, and that are—perhaps most importantly—understood and required by companies operating in the customs environment.[74]

In the case of the POC, DHS S&T funded the development of a blockchain with support for open specifications and standards. Adhering to the standards for interoperability was a requirement for POC participants.[75] S&T funded the development of the software that could be provided to any interested POC participant. One POC participant, a customs broker, built a blockchain platform during the POC utilizing software and guidance provided by Digital Bazaar.[76] A large-scale importer that was already at the forefront of implementing blockchain technology also participated in the POC; however, because of the cost associated with modifying its system to achieve interoperability, the company did not use its existing blockchain platform in the POC,

[74] Sporny, interview with author, March 26, 2019.

[75] Annunziato, interview with author, November 30, 2018.

[76] Masloski, interview with author, March 1, 2019.

instead using the software provided by S&T and enabling seamless interaction.[77] UPS, participating as an importer, did use its existing blockchain software and made necessary adjustments to enable interoperability.[78] The willingness of a company such as UPS to adopt government-sponsored interoperability standards confirms the shipping industry's interest in blockchain technology in customs clearing and global standard development.

During the POC, proprietary information and personally identifiable information were not placed on the blockchain.[79] Sensitive data may not be appropriate for placement on the blockchain and could be replaced with a pointer or a link to a protected server location, where secure data is housed. The use of such pointers on the blockchain allows users to record transactions without sharing sensitive information. An existing data set can be captured and registered on the blockchain through an assigned hash value. The pointer contains the hash value and can provide users with a link to the actual data. All or limited users can then access the complete set of data, securely stored off the blockchain. If the data set is changed, the hash value also changes, therefore exposing that the data has been tampered with.[80] During the POC, storing proprietary information off the blockchain allowed trade partners to interact without sharing sensitive information. The POC architecture model paired a blockchain node without any sensitive data with a secure-sensitive data hub, owned and managed by the node operator and owner, with pointers from the node to the hub, allowing CBP to follow on-chain pointers to the secure data hub to view the certificate of origin data.[81] CBP was granted access to view sensitive data stored in the secure server by the data owner, without the data set being published on the blockchain or accessible to other parties.[82] Off-chain data access by CBP raises potential

[77] Anonymous POC participant, interview with author, 2019.

[78] Christopher Rubio (vice president of global customs and brokerage staff, UPS), interview with author, June 28, 2019.

[79] Sporny, interview with author, March 26, 2019.

[80] Sporny.

[81] John, interview with author, May 9, 2019.

[82] Sporny, interview with author, March 26, 2019.

concerns regarding an off-chain server's geographic location, related regulations, continued access, and possible legal requests for data stored on and off the blockchain.

D. POC RESULTS AND ANALYSIS

Overall, the POC revealed that a blockchain platform can be implemented in the customs environment to replace an existing paper-based process. After extensive planning, it took three months to bring all the stakeholders together and fine-tune the software, going from no system to a working system with multiple running blockchains.[83] Successful POC implementation proved that a standards-based, fully digital system can be used by CBP to interact with multiple private entities via various blockchains.

The POC also proved that blockchain technology can improve the processing and tracking of trade-related documents.[84] The POC confirmed that a blockchain-based system can enable better auditability, expedite the evaluation of entry documents, increase transparency, and more clearly identify suppliers and manufacturers.[85] Specifically, blockchain technology implementation in the NAFTA/CAFTA FTA verification process resolved numerous existing issues; as reported by the CBP POC assessment, "[The POC] standardized the process for filers, facilitated CBP's compliance evaluation process, eliminated the use of paper, allowed for the digital submission of certificates of origin, and overall expedites [sic] the filing process."[86] All parties interviewed during this research indicated that the POC was a success, which is also supported by the CBP POC assessment, which reported that, "respondents universally indicated that blockchain technology is a worthwhile investment for the future."[87] Trade industry members interviewed noted that the POC helped the understanding of how blockchain technology can simplify a complex and ineffective customs process. At the same time, however, the POC revealed numerous

[83] Sporny.

[84] Annunziato, interview with author, March 18, 2019.

[85] Annunziato.

[86] CBP Trade Transformation Office, "NAFTA/CAFTA Proof of Concept Assessment," 9.

[87] CBP Trade Transformation Office, 9.

aspects of blockchain technology application that require further research, larger-scale implementation, and additional review.

The POC established that, by implementing common interoperability specifications, CBP can interact with multiple private entities via various blockchains, while data on the blockchain can be authenticated and accessed by various stakeholders.[88] The POC revealed, furthermore, that the implementation of common interoperability specifications can allow CBP to interact with at least one supply chain blockchain that exists and functions outside of the POC—i.e., UPS's preexisting system. Ability to use existing independent systems for customs processing may be a decisive factor for the trade industry's willingness to implement global blockchain interoperability standards and to consider a blockchain-based customs clearance process. In the existing environment, interoperability may be irrelevant or unnecessarily costly to a client paying to develop a functional blockchain-based supply chain management platform. A company's goals are specific to its process: most entities want a blockchain to support internal needs, which means they are less likely to build software around potential interactions with another entity or the government. As the POC showed, unless interoperability becomes important, many private-industry clients would not fund additional work to preclude vendor locking and enable interoperability with entities like CBP.

CBP's first blockchain POC confirmed that blockchain interoperability can be achieved and common specification utilization can facilitate interaction with a government entity. In an interview, Masloski explained the importance of the government's requirement for blockchain interoperability: maintaining the demand for common standards means providing an opportunity to all the parties to join, rather than limiting the parties to a certain blockchain platform.[89] Interoperable specifications are necessary not

[88] Sporny, interview with author, March 26, 2019.

[89] Masloski, interview with author, March 1, 2019.

only for blockchain platforms but also for the decentralized identifiers and verifiable credentials used to identify entities on any given blockchain.[90]

Blockchain interoperability, specifications, and standards are crucial to the future implementation of blockchain technology in the customs environment. Every POC participant interviewed agreed that interoperability is a key for future blockchain implementation in the trade industry and in customs clearance. All parties interviewed also agreed that CBP's support for common standards is important and appropriate. The trade industry is interested in blockchain implementation and is willing to let the government drive the demand for interoperability. By continuing to demand interoperability in all implementations, the government can direct the trade industry toward creating an environment that fosters global standards, promotes innovation, and precludes vendor-locking or monopolization.

E. POC LIMITATIONS

(1) Scope

CBP's first blockchain POC was deliberately limited in scope, designed to test the initial ability to implement blockchain technology in the customs environment. The POC did not connect blockchain-based processing with the existing ACE system. As the POC assessment reported, "Members of the trade mentioned that the POC does not save them work and does not improve efficiency because it creates redundancies within the filing

[90] Decentralized identifiers are globally unique identifiers that do not require central registration authority: "Decentralized Identifiers (DIDs) are a new type of identifier for verifiable, 'self-sovereign' digital identity. DIDs are fully under the control of the DID subject, independent from any centralized registry, identity provider, or certificate authority. DIDs are URLs that relate a DID subject to means for trustable interactions with that subject." Drummond Reed, Manu Sporny, and Markus Sabadello, eds., *Decentralized Identifiers (DIDs) v0.13: Data Model and Syntaxes* (W3C Credentials Community Group, 2019), https://w3c-ccg.github.io/did-spec/.

Verifiable credentials are a digital version of physical credentials: "Credentials are a part of our daily lives; driver's licenses are used to assert that we are capable of operating a motor vehicle, university degrees can be used to assert our level of education, and government-issued passports enable us to travel between countries. This specification provides a mechanism to express these sorts of credentials on the Web in a way that is cryptographically secure, privacy respecting, and machine-verifiable." World Wide Web Consortium, *Verifiable Credentials Data Model 1.0* (W3C Credentials Community Group, 2019), https://www.w3.org/TR/verifiable-claims-data-model/.

process."[91] During the POC, importers submitted FTA verification information via the blockchain and entry information via ACE, which created redundancies in the submissions. The assessment report concluded, "All respondents supported expanding the POC project to adopt it into ACE and investing more time and effort into blockchain technology going forward."[92] Compatibility between blockchain processing and ACE may be key in the implementation of blockchain technology in U.S. customs clearance. The POC clearly revealed the need to determine if ACE can interact with blockchains established by the trade industry. Such interaction may be achieved in a number of ways. For instance, the trade industry may be able to create a way for all of the trade blockchain data to be converted into ACE entries, fully avoiding onboarding CBP to private blockchains. Alternatively, CBP may be able to build a bridge between blockchain software and ACE, enabling data transfers and ACE entry submissions. Further research and development are necessary to fully understand the software architecture needs behind blockchain interaction with systems such as ACE. CBP's initial POC revealed the need to connect blockchain processing with ACE; however, software development investments by CBP may depend on the noted earlier interoperability requirements. The industry must first develop and agree on global standards. Then, government agencies such as CBP can find a way to interact with standardized platforms.

(2) Data

The amount of data the trade industry provides to the government is one of the key factors in determining whether blockchain-based processing is beneficial to both the trade industry and the government. Prior to the blockchain implementation, certificate-of-origin data was provided to CBP only upon request, largely via paper shipments or scanned files. During the POC, however, this data had to be input or provided ahead of time for all shipments, not only for select ones. All of the parties interviewed during this research confirmed that the data set remained the same, and the government did not gain additional access by implementing a blockchain platform. Contrary to the information gathered

[91] CBP Trade Transformation Office, "NAFTA/CAFTA Proof of Concept Assessment," 10.

[92] CBP Trade Transformation Office, 10.

through the interviews, CBP's after-action assessment revealed that some of the POC participants noted the "POC required them to input data they were not previously required to input for NAFTA/CAFTA evidence."[93] It is possible that while the data set received by the government remained the same, the POC created a scenario in which importers performed the work typically done by exporters. It is important to determine if full-scale blockchain implementation would create an environment that requires companies to provide CBP with more information than is currently mandated. Such a determination can only be made in a full-scale pilot implementation involving all the stakeholders responsible for various data sets. CBP must consider possible data set changes in the implementation of blockchain technology; private industry may be willing to provide CBP with additional data, but likely in exchange for incentives.

(3) Processes

CBP's first blockchain POC revealed that implementation may require changes in the existing work processes for all parties, which would likely affect costs. As noted, importers provided FTA-related data in advance for all goods instead of only for select goods at the time of entry. In a full-scale implementation involving foreign suppliers, manufacturers, or exporters, blockchain-based FTA verification will require additional upfront work for these parties. While importers would experience the direct benefits of efficiency and faster processing by CBP, the suppliers would not directly benefit from this change in the process. Additional implementations are necessary to determine return on investment; as CBP's POC assessment reported, "Many respondents also indicated that they felt unable to estimate the scalability of the POC or its long-term return on investment."[94] Blockchain technology may provide better record keeping and auditability, but suppliers would have to conduct a long-term cost analysis to determine the costs of changing the workflow and the return on investment. Such an analysis is impossible for a small-scale POC limited only to FTA verifications.

[93] CBP Trade Transformation Office, 10.

[94] CBP Trade Transformation Office, 10.

(4) Cost Reduction

The POC did not reveal any cost-reduction opportunities, save for decreasing potential travel costs for government auditors.[95] When asked about the return on investment, multiple importers noted that, based on the POC, the government would need to incentivize the process for industry to buy in because the POC appeared to benefit the government more than the trade industry.[96] Large-scale implementations in multiple customs processes that engage existing blockchains are necessary to determine possible changes in work processes, responsibilities, and costs. Importers might be willing to pay more for goods even if such goods are accompanied by exceptional provenance records. Suppliers, manufacturers, exporters, importers, or customs brokers would become the owners of the blockchain software and the related off-chain data storage, adding the potential cost of building and maintaining the software and storage. The government would also face costs associated with the software and should consider whether the benefits justify providing trade industry with incentives such as priority processing, subsidies, or lowered fees. All of these considerations require additional research and implementations to determine if the pain of implementation is worth the gain provided by blockchain capabilities.

F. POC ANALYSIS

CBP's POC assessment, along with interviews conducted during this research, revealed that the scale of the POC was too small to determine the overall effectiveness of blockchain implementation in the U.S. customs environment at the time. Stakeholders agreed that further examination of blockchain technology implementation in the U.S. customs environment is a worthwhile investment. The trade industry is developing blockchains to streamline and improve supply chain management internally. If all parties recognize the value of blockchain implementation, it will gain further support and popularity. The POC and industry's increasing interest reveal the need for more research

[95] CBP Trade Transformation Office, 10.

[96] Baxter, interview, February 21, 2019; Masloski, interview, March 1, 2019; Rubio, interview with author, June 28, 2019;

to determine if blockchain platforms can be effectively utilized for customs clearance processes. Any implementation of the technology must be executed within an existing legal framework, and it has to benefit all stakeholders. CBP identified positive effects associated with blockchain implementation during the POC, but the trade industry was unable to determine a future return on investment or enough benefits from additional work and resources. All trade industry parties interviewed about the POC noted a great working relationship with CBP, adding that CBP's drive for innovation promotes the agency's relationship with the trade industry.

This research and related analysis suggest that the adoption of blockchain technology in customs clearance will be driven by the trade industry: if industry determines blockchain-based customs processing does not serve its needs, buy-in will be limited or nonexistent. The trade industry may be pushing for document processing that will enable a quicker cargo release, but may not be interested in providing additional information for the cargo. This research also suggests that CBP may find blockchain technology appealing for easier access to data previously provided on paper, but may be unable to overcome privacy and liability concerns unless the technology's development diminishes potential issues. Only future successful implementations of blockchain technology in international trade will reveal likely applications in the customs environment. This research revealed that CBP must continue R&D work to determine if blockchain-based customs processing will be effective and if it will benefit CBP's mission and customers.

The Commercial Customs Operations Advisory Committee (COAC) took an interest in the POC as well. The COAC, whose members represent industries affected by CBP's commercial operations, provides guidance and advises the secretaries of DHS and the Department of the Treasury on matters related to CBP's commercial operations, such as trade enforcement, modernization, automation, cargo security, regulations, and supply chain security.[97] Following the review of CBP's first blockchain POC, the COAC held a public meeting in Laredo, Texas, on May 30, 2019; following the meeting, the COAC

[97] "Commercial Customs Operations Advisory Committee (COAC)," CBP, accessed June 30, 2019, https://www.cbp.gov/trade/stakeholder-engagement/coac.

recommended that CBP continue to work on the potential blockchain implementation in customs processing.

G. FRAUD AND BLOCKCHAIN TECHNOLOGY

The POC confirmed that a blockchain platform promotes auditability and removes fraudulent document or signature submissions.[98] The POC also showed that the use of blockchain technology does not prevent users from entering fraudulent or incorrect data. Just because data is placed on the blockchain does not mean that it is correct. Blockchain technology can add efficiency and transparency and can assist in managing and tracking information, but there should not be an expectation of built-in fraud prevention. Blockchain data tracking and data aggregation can help identify issues and target suspicious shipments more efficiently. Effective implementation of blockchain technology in any field can help fight against fraud, but stakeholders must recognize the underlying issues that cannot be resolved by simply placing the data on a digital ledger.

Simply put: blockchains track and verify transactions, but they do not verify the data input for those transactions. The World Economic Forum notes, "While blockchain technology can guarantee that the data is not tampered with (the provenance and traceability data cannot be modified), it does not guarantee that the data recorded is accurate. Additional checks and balances may still be necessary to ensure increased data integrity."[99] This means that blockchains do not create a tamper-proof environment or superior transaction tracking and verification. As noted by Christine McDaniel, a senior research fellow at George Mason University's Mercatus Center, "The integrity of the [blockchain-based] data is as strong as the weakest link of the participants."[100] While blockchain technology can achieve effective and efficient recordkeeping, it cannot examine or analyze transactions. Transaction verification does not equal data verification and does not replace product examination or preclude potential replacement or augmentation of a

98 Annunziato, interview with author, November 30, 2018.

99 World Economic Forum, *Inclusive Deployment of Blockchain for Supply Chains* (Geneva, Switzerland: World Economic Forum, 2019), 12, http://www3.weforum.org/docs/WEF_Introduction_to_Blockchain_for_Supply_Chains.pdf.

100 Warren, "Blockchain Seen as Promising."

physical asset tracked digitally by the blockchain. Blockchain technology tracks assets in an unparalleled way, but it only tracks digital representations of the physical goods. The trade industry is riddled with fraud, and there are numerous opportunities for nefarious filings when it comes to customs processing.[101] Tracking/recording technology is unable to make the actual physical products tamper-proof or prevent all existing fraud related to the physical assets.

Therefore, while blockchain technology can help to organize processes and manage records, relying on a blockchain's recording of data may lead to false confidence in the records; the *recording* of data should not be confused with the *verification* of that data. For example, a blockchain can record the creation of a computer chip, but it cannot verify factory standards, materials used, or the chip's quality. Technological advances do allow developers to add other elements—such as radio-frequency identification, chemical testing, or photo verification—to enhance blockchain tracking. For a shipment of cotton t-shirts, for example, one blockchain expert agreed that digitally tracking every t-shirt imported into the United States might not be fiscally responsible; a customs official could, instead, take a photo of the sample material and, utilizing advanced technology, verify that a given t-shirt was made of the cotton reported to be produced in a country covered by an FTA.[102] The same idea applies to conducting a chemical field test of oil or fuel at the border and comparing the chemical structure of the shipment entering the United States with the chemical structure reported by the manufacturer—other technology can be utilized to capture the data that will be recorded on a blockchain. The problem of verifying that digital assets are true representatives of the physical assets appears to be solved by technological advances that can complement blockchain tracking. The investigator's perspective is different, however: Would customs officials test only one of a few hundred thousand t-shirts? How would that sample be determined? Would officials be expected to test every container of oil? The questions go on. This research and related analysis suggest that digitizing physical goods could be effective and is likely to diminish fraud by

[101] Cohn, "Blockchain at Our Borders," 5.

[102] Mark Fisk (partner, IBM Global Services Public Sector), interview with author, March 12, 2019.

promoting better data collection and tracking, but digitizing goods does not remove numerous exiting fraud vulnerabilities specific to tampering with the physical goods.

To determine how blockchain technology will affect existing fraud vulnerabilities, more analysis is needed regarding blockchain incorporation into various customs clearance processes. Such analysis will only be possible once the trade industry begins to actively implement blockchain technology in international shipping procedures. Pilot and full-scale implementations will reveal points of successful fraud elimination or potential loopholes. CBP and HSI should continue to participate in blockchain implementation efforts and work to identify and examine fraud vulnerabilities from a law enforcement perspective.

H. POC ANALYSIS WITHIN THE HYPE CYCLE

Figure 3 situates the POC's implementation of blockchain technology in the U.S. customs environment within the hype cycle methodology. Blockchain technology first created hype, which led to its implementation in supply chain management as well as research and development work by S&T, which was followed by the POC—coincidentally, at the peak of expectations for blockchain in government.

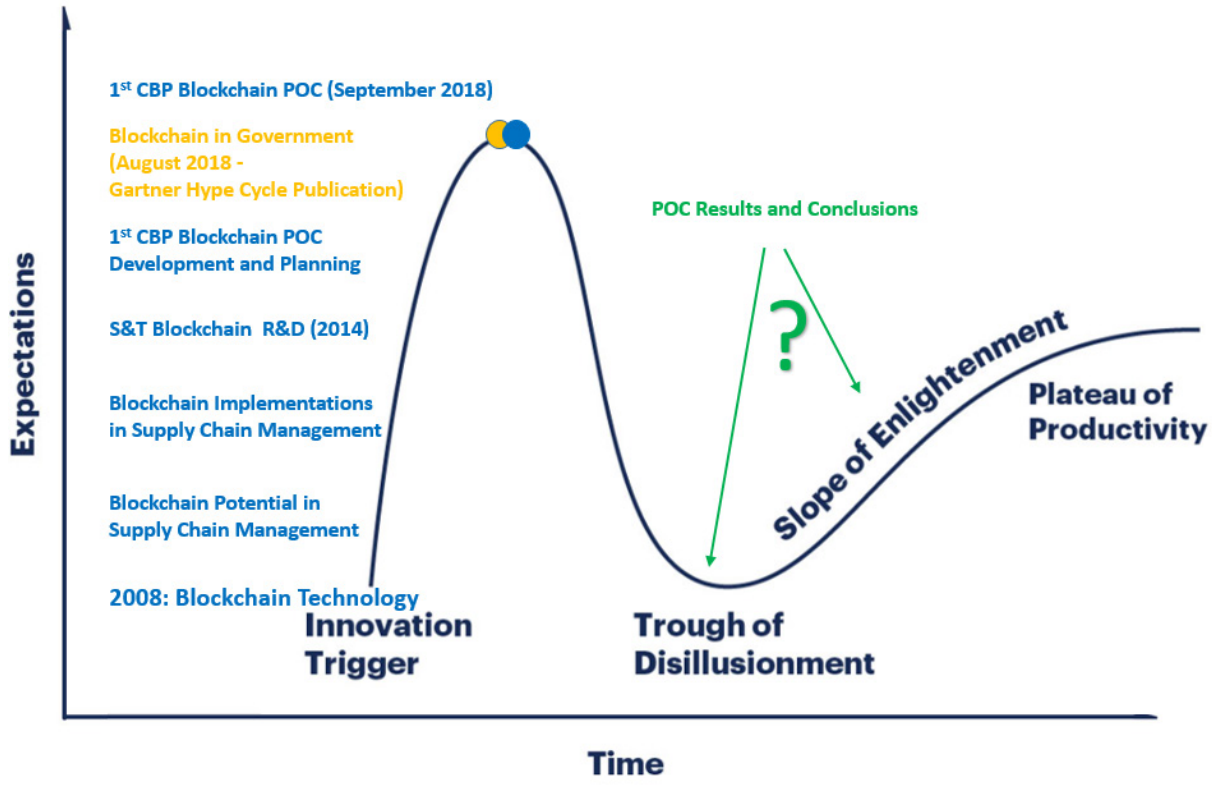

Figure 3. CBP Blockchain POC and Hype Cycle

The results of the POC shine light on the potential for blockchain implementation in the U.S. customs environment and reveal concerns, such as the complexity of merging with existing systems, lack of maturity or related expertise, lack of standards and interoperability, and the lack of policies that could be easily adopted—all leading to the trough of disillusionment. At the same time, the results reveal that implementation may lead to better auditability, efficiency, and transparency, therefore promising a future arrival at the slope of enlightenment. Blockchain implementations may have been initiated by the hype, but if the technology is able to deliver, it will outlive the trough of disillusionment. The length of the trough of disillusionment depends on the resolution of the identified concerns and realization of the promised efficiency, transparency, consensus, trust, resilience, distributed access, and auditability.

The POC also revealed that various stakeholders react to the novelty of blockchain technology differently. Some companies are attracted by hype, innovation, potential, and the ability to influence how the technology is implemented, while others see the technology's lack of existing implementation as an obstacle and reason for doubt. A number of the original POC participants noted the typical hesitation some of their customers and partners experience when it comes to blockchain technology due to blockchain technology's immaturity and the lack of information regarding its capabilities and benefits.[103] While it is possible that the international trade industry will adopt blockchain technology as a future platform, all parties must first undergo digital transformation. Blockchain technology may turn out to be one of the keys for such global digitization, but this change will require all entities involved in international trade to adapt to and embrace the technology. It is important to understand how blockchain technology can benefit existing stakeholders, such as customs brokers, who will be able to find a niche in the blockchain-based customs environment if they are able and willing to adopt it.

If blockchain technology were a new kind of car, then the POC was simply CBP taking it for a test drive around the parking lot to prove it can run. The drive was short and a little bumpy, and lacked the obstacles of oncoming traffic, stop signs, or traffic rules, which have yet to be determined. Most importantly, however: all the passengers who were in the car want to test drive it again, but this time on the highway, in the real traffic of international trade. If blockchain technology becomes the underlying platform for the future of international trade, CBP just proved that it can adapt to and join in on this future. Additional, larger-scale testing and pilot implementations are needed to determine if blockchain technology can get past the trough of disillusionment and the bumps in the ride, provide the best solutions to the existing problems, and achieve productive and effective implementation within the customs environment.

[103] Baxter, interview with author, February 21, 2019; Masloski, interview with author, March 1, 2019; Rubio, interview with author, June 28, 2019.

IV. BLOCKCHAIN IMPLEMENTATION: CONTINUING EFFORTS

> The ultimate uses of applications for disruptive technologies are unknowable in advance.
>
> —Clayton Christensen[104]

DHS S&T and CBP continue to explore blockchain technology's potential in government operations. CBP's proof-of-concept tests for blockchain technology have been a step in the right direction, regardless of what the results mean for future implementation. Any government agency that wishes to understand a technology—particularly a technology that promises to dominate the industry—is well suited to research and test the technology. POCs, pilots, and sandboxes are effective ways to explore potential technological advances, and they can help government agencies make decisions about future investments. CBP continues to work with the trade industry to explore additional blockchain applications and the best way to implement the technology.

A. NEW SANDBOXES

In March 2019, CBP initiated a second blockchain POC, focusing on another set of customs clearance processes—tracking intellectual property rights (IPR) licenses. The second POC was not related to the first; rather, it built on the experience and tested blockchain implementation in another aspect of CBP operations. The second POC introduced blockchain utilization to a larger group of stakeholders, including exporters, manufacturers, the CBP Office of Policy, the CBP Office of Chief Council, and HSI. This POC focused on IPR protection and verification, which affect trade industry interests as well as CBP's law enforcement mission of overseeing legitimate trade. While CBP would benefit from better license tracking, improved processes would also protect the trade industry's interests, especially those of trademark-holding manufacturers. The first blockchain POC revealed that manufacturers would have to assume a new role and perform

104 Clayton Christensen, *The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail* (Boston: Harvard Business School, 1997), Kindle.

more work upfront, making blockchain addition unattractive; this second POC, however, may provide manufacturers with a worthy incentive to consider blockchain technology. The second POC also involves a group of legal experts who examined the potential ramifications of utilizing blockchain technology in a customs clearance process. The second POC is the next step in exploring how blockchain technology can benefit existing CBP processes.

Another step in CBP's blockchain exploration was Blockchain Proposal Day, hosted by CBP BTID on June 4, 2019, which provided the trade industry with an opportunity to pitch future blockchain POC proposals. Walmart, UPS, Honda, Customs Direct, Intel, Kansas City Southern Railway Company, Expeditors, and Ernst & Young were among the companies that presented proposals for blockchain implementation in customs processing. CBP brought in a number of internal stakeholders as well, such as its Office of Information Technology (OIT), Office of Chief Council, and Office of Policy, along with DHS S&T, to participate and assess proposals from legal and technological perspectives. Proposals included a variety of supply management blockchains—recording pet vaccinations, processing rail cargo, recording foreign factory audits, and improving foreign supplier profiles, just to name a few. The trade industry has recognized blockchain technology's potential all around international trade and is interested in bringing government agencies onboard to expedite the entry of pets, food, cars, electronics, medication, and raw materials into the United States.

Most of the companies that participated in Blockchain Proposal Day are already running, or are building and testing, blockchains for internal use. Many of them are interested in the possibility of CBP joining their blockchains. During Blockchain Proposal Day, CBP received thirteen POC proposals, which raises a question: Can CBP become a blockchain node on every blockchain? Currently, the answer is absolutely not. During Proposal Day, BTID Director Annunziato continually stressed CBP's plan to adhere to interoperability specifications utilized during the first POC. Common blockchain specifications allowed CBP to interact with multiple blockchains during the first POC, showing that adhering to common specifications and maintaining interoperability is essential to CBP's ability to explore blockchain-based processing. CBP has to devise a way

to connect trade industry blockchains with the existing processing system, ACE. Trade industry stakeholders have proposed a number of implementations that may help find the best sandbox scenarios to engage OIT and policy in compatibility and feasibility research. OIT will need to determine early on how to make blockchain-based processing compatible and interoperable with ACE. Identifying the capabilities and limitations of adding blockchain technology to the existing system will dictate CBP's ability to implement blockchain technology in the U.S. customs environment.

B. BLOCKCHAIN INTEROPERABILITY DEVELOPMENT

The first blockchain POC revealed interoperability as a key factor in CBP's ability to adopt a blockchain-based system and interact with multiple trade partners via the same platform. It would be fiscally impossible and irresponsible for the government to build different platforms to interact with various trade partners. S&T invested in developing blockchain interoperability specifications and standards through a number of blockchain POCs with various DHS components, including CBP. In congressional testimony, then S&T Division Director Douglas Maughan noted,

> The challenge with blockchain technology is the potential for the development of "walled gardens" or closed technology platforms that do not support common standards for security, privacy, and data exchange. This would limit the growth and availability of a competitive marketplace of diverse, interoperable solutions for government and industry to draw upon to deliver cost effective and innovative services based on blockchain and distributed ledger technologies.[105]

Interoperability is crucial for government adoption since the government should not choose a blockchain platform for the industry to join.

Before CBP can truly consider adopting large-scale blockchain-based customs processing, the software and trade industries have to develop interoperability specifications and standards. This process will be lengthy, and unfortunately some industry leaders are not interested in establishing standards that may require adjustments to their software. The more time any given platform has to mature and attract clients, the better the chances of

[105] H.R., Leveraging Blockchain Technology, 19–25.

that platform driving or becoming the industry standard. Writing for *Forbes*, del Castillo provides an example of this development: IBM's Hyperledger Fabric is already used by numerous companies and advertised as the gold standard in enterprise blockchain.[106] It should be noted that utilizing the same blockchain type does not automatically guarantee interoperability. The industry recognizes the need for standards and future interoperability, as evidenced by the reporting from the Second Annual Blockchain Supply Chain Summit by IBM's chief architect, Ana Biazetti, who writes: "Industry standards are gaining importance. Partners understand the need for standards in supply chain and blockchain."[107] Biazetti also acknowledges interoperability concerns as one of the challenges in blockchain adoption due to different platforms and providers.[108]

A number of standards associations and consortiums are working on developing blockchain standards. The IEEE Standards Association, which focuses on consensus building and global development of innovative technologies, recently established a Consumer Electronics Society/Blockchain Standards Committee (CES/BSC).[109] In February 2019, CES/BSC issued a project authorization request for a new IEEE standard titled *Standard for Blockchain Applications in Governments*. CES/BSC provided the following justification:

> Most of the governments in the world are making government affairs more transparent and increasingly emphasizing anti-corruption, supervision, and taxpayers' participation. With blockchain technology, data can be stored in a secure and tamper-resistant manner with the capability to report on it for audit purposes. This project is needed to provide a standard from both technical and procedural perspectives for using blockchain in governments with typically large and complex organizational structures, multi-sectoral coordination, and a wide range of global intergovernmental cooperation.[110]

106 del Castillo, "Blockchain Goes to Work."

107 Ana Biazetti, "7 Takeaways from the Blockchain Supply Chain Summit," *TradeLens* (blog), April 18, 2019, https://blog.tradelens.com/news/7-takeaways-from-the-blockchain-supply-chain-summit/.

108 Biazetti.

109 "About Us," IEEE Standards Association, accessed April 20, 2019, https://standards.ieee.org/content/ieee-standards/en/about/index.html.

110 "P2418.8—Standard for Blockchain Applications in Governments," IEEE Standards Association, March 21, 2019, https://standards.ieee.org/project/2418_8.html.

IEEE's project authorization request estimates a draft submission in June 2020, with the following project scope:

> This standard provides a common framework for using blockchain in government affairs. The framework addresses scalability, security and privacy challenges in implementation and operation. It covers multiple aspects and features of blockchain, including tokens, smart contracts, off-chain data storage, as well as both permissioned and permission-less blockchain.[111]

The International Organization for Standardization and Blockchain in Transport Alliance Standards Council (BiTAS) are also working on future standards for blockchains in supply chain management and international trade. The World Wide Web Consortium (W3C), an international organization focused on the development of web standards, established the Blockchain Community Group to research and evaluate blockchain use cases. The group's mission is to develop standards and guidelines for blockchains.[112] W3C projects include creating standards for decentralized identifiers and verifiable credentials—both projects were propelled by S&T's funded research and development.[113] S&T's work and funding have potential to lay the groundwork for some of the related industry standards, and its work in promoting blockchain standards may support various future implementations by DHS components. The DHS components may then be able to benefit from the technology, once it is mature enough, once the specifications are developed, and once standards are agreed upon.

The government should continue to support standard development and research related to blockchain technology interoperability and implementation in supply chain management and international trade. At the same time, the government must recognize that the technology and capabilities will be driven by the software and trade industries, not the government. Currently, the U.S. government does not appear to have a big enough role in future blockchain implementation in supply chain management and international trade to

111 IEEE Standards Association.

112 "Blockchain Community Group," World Wide Web Consortium, accessed May 12, 2019, https://www.w3.org/community/blockchain/.

113 John, interview with author, May 9, 2019.

determine, direct, or force the creation of related blockchain standards. With time, additional funding, and new implementations, private industry and various worldwide standards associations will determine blockchain standardization and interoperability capabilities. According to S&T's technical director, Anil John, in order to achieve effective solutions and a technological advantage—as well as to preclude vendor locking—the government should assume an active support role in promoting standardization and blockchain interoperability.[114]

The POCs exemplify the ability of government agencies like S&T and CBP to participate in the development of blockchain technology, and to cultivate the technology while preparing for future innovations. This thesis suggests that S&T should continue to fund blockchain interoperability research. S&T and CBP should continue to foster environments supportive of specifications and standard development, and they should continue to require and cultivate blockchain interoperability in all future implementations of the technology. Government requirements for interoperability may drive the trade industry to implement systems that adhere to common specifications and standards. CBP's continuous efforts to foster interoperability standards may also affect blockchain decisions made by other U.S. partner government agencies and even international entities such as the World Customs Organization. Blockchain interoperability is more likely to be achieved if all industry stakeholders come together to support global blockchain standards.

C. BLOCKCHAIN WITHIN THE HYPE CYCLE

Blockchain's true revolutionary value will be determined in the course of the technology's development and will likely benefit the overall technological growth, regardless of whether it takes over any given industry. S&T's Anil John notes that the desire to treat blockchain technology as revolutionary will need to be balanced against the reality that many technologies have gone through a similar cycle: first comes the promise of revolutionary change, which is followed by the incremental addition of capabilities that help to build more robust and scalable systems and services. For example, the internet hype cycle transformed an academic and tech-focused network into one that allowed for

[114] John.

commercial transactions; the service-oriented hype cycle ultimately led to component-based services interacting over interfaces rather than monolithic systems; and the cloud hype cycle led to the development of outsourced capabilities that could be combined using application programming interfaces.[115]

Blockchain technology is still developing. Its capabilities are promising but are still unknown and dependent on implementation. One trade executive noted that the last two years of blockchain platform development could be described as over a year of "pain" with increasing glimpses of gain in recent months.[116] Companies like UPS and Walmart are implementing blockchain technology for internal use while also pursuing POCs, such as CBP's, revealing the industry's interest in exploring the innovative potential. Blockchain technology has much development and maturing to accomplish before it can be widely implemented by the trade industry or any government agency. Figure 4, from Gartner, reflects blockchain's continued growth in a variety of industries. Blockchain's implementation in manufacturing is only at the beginning of the cycle, while its implementation in the supply chain is still rising in hype. Meanwhile, blockchain in government is past the peak of expectations, projected to slide into the trough of disillusionment in the coming year.

[115] John.

[116] Anonymous trade executive, interview with author, 2019.

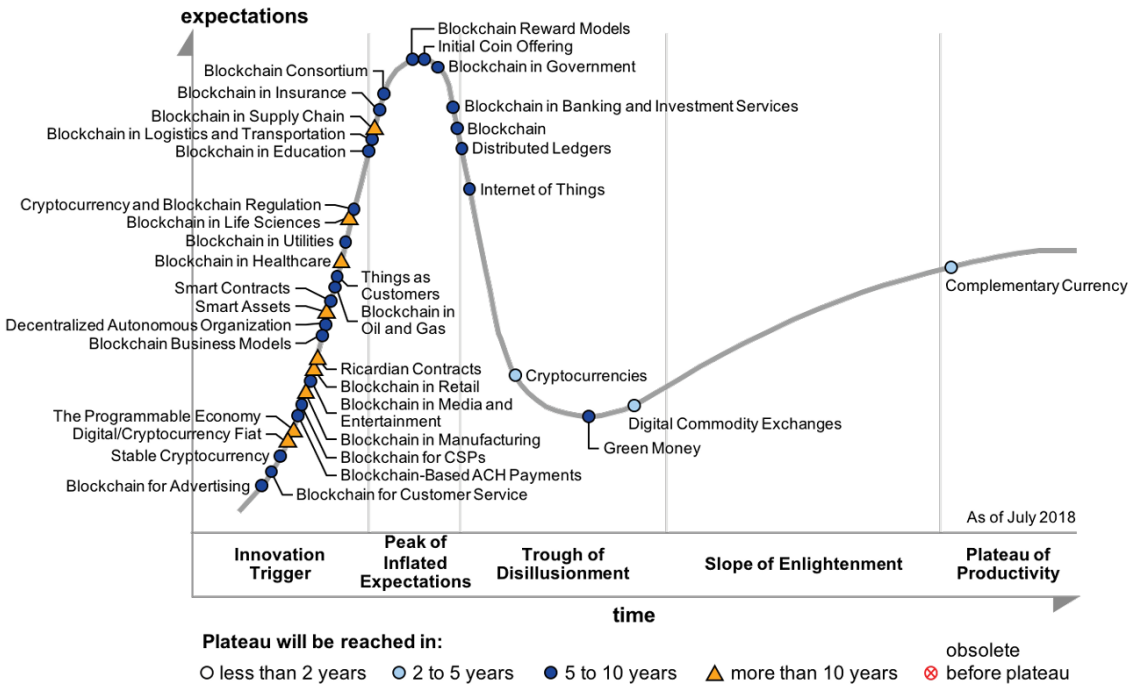

Figure 4. Hype Cycle for Blockchain Business 2018[117]

Various industries are still exploring blockchain's potential, searching for ways the technology can improve business operations and practices. According to Gartner, "Interest in blockchain continues to be high, but there is still a significant gap between the hype and market reality."[118] As shown in Figure 4, Gartner predicts that the plateau of productivity is more than ten years away for blockchain in the supply chain and five to ten years away for blockchain in government. This research confirms that prediction: all interviewees noted that blockchain implementation in customs is at least a few (up to five) years away. Interoperability remains key in the overall blockchain adoption, as confirmed by Gartner: "It is difficult to envision interoperability when most platforms and their underlying protocols are still being designed or developed."[119] Global specifications, standards, and

[117] Source: Heather Pemberton Levy, "The Reality of Blockchain," Gartner, October 16, 2018, https://www.gartner.com/smarterwithgartner/the-reality-of-blockchain/.

[118] "Gartner Reveals Seven Mistakes to Avoid in Blockchain Projects," Gartner, June 12, 2019, https://www.gartner.com/en/newsroom/press-releases/2019-06-12-gartner-reveals-seven-mistakes-to-avoid-in-blockchain.

[119] Gartner.

interoperability requirements are necessary for the trade industry to take blockchain technology from pilots to implementation. Continued blockchain research and development should lead to solutions.

When it comes to blockchain implementation in global trade, it is likely that global interoperability standards will become the element that moves blockchain technology out of the trough of disillusionment toward enlightenment and productivity. The government can become the driving force for blockchain adoption by fostering the technology through supporting standards development, requiring interoperability, and providing sandboxes to test potential implementations.

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V. CONCLUSION AND RECOMMENDATIONS

> Blockchain's identifying qualities center around trust, decentralization and group awareness. The government's role in blockchain will be predicated upon understanding those principles and applying them to a law enforcement system.
>
> —Vincent Annunziato, CBP BTID[120]

The government's adoption of blockchain technology will require established interoperability, resilience, compatibility with existing systems, updated privacy and policy regulations, and an understanding of the benefits provided by the system. CBP has determined that blockchain technology can be beneficial in fulfilling CBP's trade enforcement mission. Once trade and tech industries master blockchain platforms and necessary developments are made to enable interoperability and industry-wide adoption, realistic points of implementation for customs agencies will be revealed. At that time, enforcement agencies such as CBP can determine whether blockchain technology can solve operational issues and if its addition is beneficial for the mission of the agency. Such determinations and continuous testing of potential blockchain applications will drive CBP's decisions about implementation, which is years away.

The mission of S&T, on the other hand, calls for ongoing action when it comes to the development of a technology that may provide increased efficiency and effectiveness for multiple DHS components.[121] According to Anil John, the current trajectory of blockchain technology necessitates that the government take a leadership role, stay informed, and partner with industry to ensure standardized approaches for security,

[120] Vincent Annunziato, "Commercial Customs Operations Advisory Committee (COAC) Government Issue Paper: Emerging Technologies," CBP, February 2019, https://www.cbp.gov/sites/default/files/assets/documents/2019-Feb/CBP%20Next%20Generation%20Emerging%20Technologies%20External%202-12-19.pdf.

[121] S&T's mission is: "To enable effective, efficient, and secure operations across all homeland security missions by applying scientific, engineering, analytic, and innovative approaches to deliver timely solutions and support departmental acquisitions." "About S&T," Department of Homeland Security, October 30, 2014, https://www.dhs.gov/science-and-technology/about-st.

privacy, and data exchange, to ultimately enable efficient blockchain applications.[122] S&T should continue to explore the potential of blockchain technology benefits for all DHS components. This thesis detailed only one of the many ongoing blockchain implementation efforts among DHS's components. Every POC and pilot helps the technology to mature and develop, leading to future successful technological advances and productivity for government entities and private industry alike.

A. BLOCKCHAIN TECHNOLOGY AND CBP POLICY

Based on the first blockchain POC outcomes, CBP should involve the Office of Policy and the Office of Chief Council (OCC) to determine how the addition of blockchain technology interacts with existing regulations and whether new customs-specific policies or regulations are needed to allow for a smooth addition of blockchain-based systems. Blockchain implementation requires a policy and legal review that focuses on key management, data storage, and retention prior to full-scale implementation. CBP already involved the Office of Policy in the second blockchain POC to ensure the new blockchain-based process adhered to legal requirements. CBP should identify ways in which blockchain processing may change current procedures and determine future policy needs. Specifically, CBP should include OCC and policy officials when reviewing the process for legal issues such as data retention, privacy concerns, information sharing, discovery in court, and other legal matters. A complete legal review should be done by CBP's OCC and Office of Policy to identify potential legal and policy concerns for off-blockchain data storage, key management, and legal production of blockchain records. Once CBP identifies a method to bridge blockchain data with ACE, a separate review may be necessary to address existing rules and filing guidance.

Transparency is one of the most notable benefits of blockchain technology. Along with the benefits provided by transparency, however, come privacy concerns, especially regarding sensitive proprietary information or regulated data. If any federal government agency is a party to a private blockchain, it may expose the data to Freedom of Information

[122] John, interview with author, May 9, 2019.

Act requests. Another concern with granting the government access to a private blockchain is the potential use of the data in civil or criminal proceedings. If a government agency has a legal right to access the data, it may enable the government to use such data for penalty filings or criminal prosecutions. If a private blockchain is established by a corporation or used by multiple private companies and the government is not a party to it, subpoenas or court orders would be required for civil or criminal proceedings. As international partners join blockchains, another issue to consider is that of foreign-based servers and the potential obstacles and issues surrounding obtaining formal records.

Detailed research of legal ramifications for blockchain applications, where the government may become a party to the blockchain, is required to develop policies and regulations. An in-depth legal review should also be conducted by the HSI to identify data that could become evidence in criminal proceedings, issues or requirements associated with criminal court discovery, evidence retention policies, and other issues related to criminal prosecutions. HSI participated in the second CBP blockchain POC to provide a criminal investigation perspective, and HSI should continue to work with the CBP to identify areas of fraud vulnerabilities and review how the addition of blockchain technology might affect such vulnerabilities. HSI should continue, as well, to participate in CBP blockchain projects to provide a perspective on potential criminal vulnerabilities and identify how the addition of blockchain-based processing may affect existing evidence-collection practices. New policies and regulations may be required to address fraud vulnerabilities or loopholes that materialize in blockchain implementation. Additional research and development are required to implement blockchain technology in the customs environment. CBP, HSI, and other Partner Government Agencies should be involved in the implementation to identify potential legal concerns surrounding blockchain technology implementation in the U.S. customs environment.

B. RECOMMENDATIONS

This research and analysis led to the following recommendations for S&T, CBP, and HSI:

- S&T should continue research and development work related to blockchain technology, interoperability standards, and potential implementations by DHS components. S&T should continue engaging various DHS components in blockchain implementation.

- CBP should continue working with the trade industry to explore potential applications of blockchain technology in the U.S. customs environment and to identify processes that can benefit from blockchain technology implementation. CBP should prioritize implementation of blockchain technology in a manner compatible and interoperable with the existing Automated Commercial Environment (ACE).

- CBP and S&T should continue maintaining the demand for interoperability standards within all DHS-sponsored POCs, pilots, and blockchain applications to foster technological development and guide private industry in a joint effort to build interoperable systems.

- CBP should consider expanding blockchain technology implementation efforts to include other U.S. partner government agencies, the World Customs Organization, and international customs agencies. Joint efforts among government agencies should enable future coordination, effective implementation, and—most importantly—the creation of global blockchain standards necessary in the international trade environment.

- CBP and HSI should consider joining efforts in analyzing fraud potential and reviewing the legal ramifications of blockchain technology implementation. Both agencies should involve policy and legal experts in all future blockchain implementation efforts. Both agencies should consider issuing new policies and regulations to enable effective and compliant blockchain technology implementation in the U.S. customs environment.

C. CONCLUSION

The international trade industry sees blockchain technology as a tool that may affect every aspect of international trade—from manufacturing and shipping, to distribution and even customs clearance. The U.S. government has an opportunity to influence emergent blockchain technology applications in international trade and supply chain management, incorporating fair-trade practices, global standardization, product safety, and provenance requirements as well as intellectual property considerations, controlled-markets compliance, and fraud prevention. This, in turn, gives the government an opportunity to lead the international community in the implementation of blockchain technology in customs environments, encourage innovation, endorse global standards, promote auditability and transparency, and improve trade practices. If the U.S. government abdicates this role, another state actor will likely pick up the reins and drive implementation with a different set of governing values. Although wide-scale blockchain implementation is years away, the U.S. government should be actively engaged with current processes within the trade environment in order to endorse systems that adhere to global standards and promote economic growth and fair trade practices worldwide. Blockchain technology is promising to revolutionize supply chain management; with proper government and industry support, this technology may also improve the international trade environment as well as compliance and enforcement capabilities.

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LIST OF REFERENCES

Annunziato, Vincent. "Blockchain—A U.S. Customs and Border Protection Perspective." *Enterprise Security*, May 2019. https://blockchain.enterprisesecuritymag.com/cxoinsight/blockchain-a-us-customs-and-border-protection-perspective-nid-1055-cid-56.html.

———. Vincent Annunziato, "Commercial Customs Operations Advisory Committee (COAC) Government Issue Paper: Emerging Technologies." CBP, February 2019. https://www.cbp.gov/sites/default/files/assets/documents/2019-Feb/CBP%20Next%20Generation%20Emerging%20Technologies%20External%202-12-19.pdf.

Armstrong, Paul. *Disruptive Technologies: Understand, Evaluate, Respond*. New York: Kogan Page, 2017.

Arun, Jai Singh, Jerry Cuomo, and Nitin Gaur. *Blockchain for Business*. Boston: Addison-Wesley, 2019.

Barley, Mark. "Pwc, Port of Brisbane Creating Supply Chain Blockchain." Ledger Insights, May 31, 2018. https://www.ledgerinsights.com/pwc-port-of-brisbane-creating-supply-chain-blockchain/.

Biazetti, Ana. "7 Takeaways from the Blockchain Supply Chain Summit." *TradeLens* (blog), April 18, 2019. https://blog.tradelens.com/news/7-takeaways-from-the-blockchain-supply-chain-summit/.

Bradley, Brian. "CBP Launching Blockchain Testing." American Shipper, August 14, 2018. https://www.americanshipper.com/main/fullasd/cbp-launching-blockchain-testing-72278.aspx.

Carson, Brant, Giulio Romanelli, Patricia Walsh, and Askhat Zhumaev."Blockchain Beyond the Hype: What Is the Strategic Business Value?" McKinsey Digital, June 2018. https://www.mckinsey.com/business-functions/digital-mckinsey/our-insights/blockchain-beyond-the-hype-what-is-the-strategic-business-value.

Christensen, Clayton. *The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail*. Boston: Harvard Business School, 1997. Kindle.

Cohn, Alan D. "Blockchain at Our Borders." Report, Blockchain Research Institute, 2017. https://www.blockchainresearchinstitute.org/project/blockchain-at-our-borders/.

del Castillo, Michael. “Blockchain 50: Billion Dollar Babies.” *Forbes*, April 16, 2019. https://www.forbes.com/sites/michaeldelcastillo/2019/04/16/blockchains-billion-dollar-babies/.

———. “Blockchain Goes to Work at Walmart, IBM, Amazon, JPMorgan, Cargill and 46 Other Enterprises.” *Forbes*, April 16, 2019. https://www.forbes.com/sites/michaeldelcastillo/2019/04/16/blockchain-goes-to-work/.

Eggers, William D., Pankaj Kishnani, and Mike Turley. “The Future of Regulation: Principles for Regulating Emerging Technologies.” Deloitte Insights, June 19, 2018. https://www2.deloitte.com/insights/us/en/industry/public-sector/future-of-regulation/regulating-emerging-technology.html.

Gabriele, Mark, Melinda Nickelson, Lisa Price, George Bell, Jonathan Downing, Kaivan Rahbari, Katlyn Woods, Curtis Ting, Everette Jordan, and Aaron Varrone. *Blockchain and Suitability for Government Applications*. Washington, DC: 2018 Public-Private Analytic Exchange Program, 2018. https://www.dhs.gov/sites/default/files/publications/2018_AEP_Blockchain_and_Suitability_for_Government_Applications.pdf.

Garcia, D. Linda, Bethany L. Leickly, and Scott Willey. “Public and Private Interests in Standard Setting: Conflict or Convergence.” Georgetown University, September 2015. https://blogs.commons.georgetown.edu/cctp-644-fall2015/files/2015/09/Wk2-Public-and-Private-Interests-in-Standard-Setting-Conflict-or-Convergence.pdf.

Gartner. “Gartner Reveals Seven Mistakes to Avoid in Blockchain Projects.” Gartner. June 12, 2019. https://www.gartner.com/en/newsroom/press-releases/2019-06-12-gartner-reveals-seven-mistakes-to-avoid-in-blockchain.

———. “Hype Cycle Research Methodology.” Accessed May 11, 2019. https://www.gartner.com/en/research/methodologies/gartner-hype-cycle.

Hewett, Nadia, and Sumedha Deshmukh. “3 Ways Blockchain Can Revolutionize Global Supply Chains.” World Economic Forum, April 25, 2019. https://www.weforum.org/agenda/2019/04/3-ways-blockchain-global-supply-chains/.

IEEE Standards Association. “P2418.8—Standard for Blockchain Applications in Governments.” March 21, 2019. https://standards.ieee.org/project/2418_8.html.

International Port Community Systems Association. “IPCSA Blockchain Bill of Lading Initiative.” May 2018. https://ipcsa.international/initiatives.

Jaikaran, Chris. *Blockchain: Background and Policy Issues*, CRS report no. R45116. Washington, DC: Congressional Research Service, 2018. https://fas.org/sgp/crs/misc/R45116.pdf.

Johnson, Steven. “Beyond the Bitcoin Bubble.” *New York Times*, January 16, 2018. https://www.nytimes.com/2018/01/16/magazine/beyond-the-bitcoin-bubble.html.

Killmeyer, Jason, Mark White, and Bruce Chew. *Will Blockchain Transform the Public Sector? Blockchain Basics for Government*. Westlake, TX: Deloitte University Press, 2017. https://www2.deloitte.com/content/dam/insights/us/articles/4185_blockchain-public-sector/DUP_will-blockchain-transform-public-sector.pdf.

Ledger Insights. “Canadian Customs Joins IBM/Maersk Blockchain Platform.” October 26, 2018. https://www.ledgerinsights.com/canadian-customs-joins-ibm-maersk-blockchain-platform/.

Levy, Heather Pemberton. “The Reality of Blockchain.” Gartner, October 16, 2018. https://www.gartner.com/smarterwithgartner/the-reality-of-blockchain/.

Moore, Susan. “Top Trends from Gartner Hype Cycle for Digital Government Technology, 2018.” Gartner, September 3, 2018. https://www.gartner.com/smarterwithgartner/top-trends-from-gartner-hype-cycle-for-digital-government-technology-2018/.

Morris, Cab, John Mirkovic, and Jennifer M. O’Rourke. *Illinois Blockchain and Distributed Ledger Task Force Final Report to the General Assembly*. House Joint Resolution 25. Springfield, IL: State of Illinois, January 31, 2018. https://www2.illinois.gov/sites/doit/Strategy/Documents/BlockchainTaskForceFinalReport020518.pdf.

Morris, Nicky. “Singapore-Backed Global Trade Blockchain Launches.” Ledger Insights, July 19, 2018. https://www.ledgerinsights.com/singapore-trade-blockchain-otb/.

Nodar, Janet. “Blockchain Slow Steaming into Container Shipping.” *Journal of Commerce*, March 11, 2019. https://www.joc.com/technology/blockchain-slow-steaming-container-shipping_20190311.html.

Okazaki, Yotaro. “Unveiling the Potential of Blockchain for Customs.” WCO Research Paper 45. Research paper, World Customs Organization, 2018. http://www.wcoomd.org/-/media/wco/public/global/pdf/topics/research/research-paper-series/45_yotaro_okazaki_unveiling_the_potential_of_blockchain_for_customs.pdf?la=en.

Pirus, Benjamin. “BeefChain Receives First USDA Certification for a Blockchain Company.” *Forbes*, April 25, 2019. https://www.forbes.com/sites/benjaminpirus/2019/04/25/beefchain-receives-first-usda-certification-for-a-blockchain-company/#39c610567607.

Reed, Drummond, Manu Sporny, and Markus Sabadello, editors. *Decentralized Identifiers (DIDs) v0.13: Data Model and Syntaxes*. W3C Credentials Community Group, 2019. https://w3c-ccg.github.io/did-spec/.

Rockwell, Mark. "CBP Closes in on Completing 17-Year Multibillion IT Project." Federal Computer Week, March 5, 2018. https://fcw.com/articles/2018/03/05/cbp-ace-cargo-system.aspx.

Song, Wonnie. "Bullish on Blockchain: Examining Delaware's Approach to Distributed Ledger Technology in Corporate Governance Law and Beyond." *Harvard Business Law Review Online* (2017): 9–20. https://www.hblr.org//wp-content/uploads/sites/18/2018/01/Bullish-on-Blockchain-Examining-Delaware%E2%80%99s-Approach-to-Distributed-Ledger-Technology-in-Corporate-Governance-Law-and-Beyond.pdf.

U.S. Congress. House of Representatives. *Beyond Bitcoin: Emerging Applications for Blockchain Technology*. 115th Cong., 2nd sess., February 14, 2018. https://science.house.gov/hearings/beyond-bitcoin-emerging-applications-for-blockchain-technology.

———. *Leveraging Blockchain Technology to Improve Supply Chain Management and Combat Counterfeit Goods*. 115th Cong., 2nd sess., May 8, 2018. https://docs.house.gov/meetings/SY/SY21/20180508/108289/HHRG-115-SY21-20180508-SD004.pdf.

U.S. Customs and Border Protection (CBP). "ACE and Automated Systems." June 26, 2019. https://www.cbp.gov/trade/automated.

———. "ACE Development—Deployment Schedule 2019." Accessed May 26, 2019. https://www.cbp.gov/sites/default/files/assets/documents/2019-May/ACE%20Development%20-%20Deployment%20Schedule%202019.pdf.

———. "ACE Overview and Status Update." Presentation, April 2011.

———. "Commercial Customs Operations Advisory Committee (COAC)." Accessed June 30, 2019. https://www.cbp.gov/trade/stakeholder-engagement/coac.

———. *Privacy Impact Assessment for the Automated Commercial Environment (ACE)*. DHS/CBP/PIA-003(b). Washington, DC: Department of Homeland Security, 2015. https://www.dhs.gov/sites/default/files/publications/privacy-pia-cbp003-ace-march2018.pdf.

U.S. Customs and Border Protection Trade Transformation Office. "NAFTA/CAFTA Proof of Concept Assessment." Version 2.0. Report, Department of Homeland Security, 2019.

Warren, Tim. “Blockchain Seen as Promising, Though Many Legal Questions Remain.” *International Trade Today* 35, no. 47 (March 11, 2019).

World Economic Forum. *Inclusive Deployment of Blockchain for Supply Chains*. Geneva, Switzerland: World Economic Forum, 2019. http://www3.weforum.org/docs/WEF_Introduction_to_Blockchain_for_Supply_Chains.pdf.

World Wide Web Consortium. “Blockchain Community Group.” Accessed May 12, 2019. https://www.w3.org/community/blockchain/.

———. *Verifiable Credentials Data Model 1.0*. W3C Credentials Community Group, 2019. https://www.w3.org/TR/verifiable-claims-data-model/.

Yaga, Dylan, Peter Mell, Nik Roby, and Karen Scarfone. *Blockchain Technology Overview*. NISTIR 8202. Washington, DC: National Institute of Standards and Technology, 2018. https://nvlpubs.nist.gov/nistpubs/ir/2018/NIST.IR.8202.pdf.

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