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Blockchain Initiatives for Tax Administration

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ABSTRACT

A thriving body of literature discusses various legal issues related to blockchain. This literature often conflates the discussion about blockchain with cryptocurrency. But blockchain is not the same as cryptocurrency. Defined as a decentralized, immutable, peer-to-peer ledger technology, blockchain is a newly emerging data management system. The private sector and the public sector have all begun utilizing blockchain. Since more data is being processed remotely, and thus digitally, the evolution of blockchain is gaining stronger momentum.

While scholarship on blockchain is growing, none of the current scholarship has considered the impact of blockchain on the tax sector. This Article extends the study of blockchain to tax administration, evaluates the feasibility of incorporating blockchain within existing tax administrations, and provides policymakers with criteria to consider and some recommended designs for blockchain. Blockchain can enhance the efficiency and transparency of tax administration through its ability to deliver reliable, real time information from many sources to a large audience. Further, a well-designed private consortium blockchain, evolved from the classic public blockchain, may effectively protect taxpayers' information. Potential areas that blockchain could enhance are payroll and withholding taxes, value added taxes, transfer pricing, and the sharing of information between federal, state, and local governments as well as foreign countries.

This Article offers normative considerations for policymakers deliberating using blockchain initiatives for tax administration, such as the timeline, standardization, integration with other systems, limitations, and accompanying legislation to regulate the government and taxpayers' rights and privacy. Those implications may resonate with a broader audience beyond tax policymakers.

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INTRODUCTION

Blockchain technology was first outlined in the late 1980s by researchers who wanted to implement a system where a document's timestamps could not be tampered with.[1] But it was not until almost two decades later that blockchain had its first real world application with the launch of Bitcoin in 2009.[2] The Bitcoin protocol, or cryptocurrency more broadly, is built on blockchain,[3] and blockchain is the original, underlying technology.[4]

Blockchain is a decentralized, immutable, peer-to-peer ledger.[5] It is a newly emerged record keeping system where digital information is recorded in each block of blockchain and managed by the group of users distributed in the network. Blockchain does not require a middleman to validate information; instead, each user uses a consensus mechanism that is distributed across the network to collectively validate information.[6] Such decentralization enables trust among the parties in the system and improves transparency, data immutability, security, and efficiency. With Bitcoin, the information recorded in the blockchain network consists of Bitcoin transactions. Blockchain as a technology, however, is capable of recording and managing any digital information and has applications beyond Bitcoin.

Recent applications of blockchain are elevating the technology above and beyond what cryptocurrencies are capable of. Blockchain is in the limelight when it comes to dealing with information and records in the digital era. Before blockchain, a centralized database management system was considered the solution for managing and exchanging information. It is becoming increasingly less safe to store everyone's information in a single central database because

1. DYLAN YAGA, PETER MELL, NIK ROBY & KAREN SCARFONE, U.S. DEP'T OF COM., NAT'L INST. STANDARDS & TECH., INTERNAL REP. NO. 8202, BLOCKCHAIN TECHNOLOGY OVERVIEW 2 (2018), https://nvlpubs.nist.gov/nistpubs/ir/2018/NIST.IR.8202.pdf [https://perma.cc/ 99V7-VN2C].
2. *Id.* at 1.
3. In a research paper introducing the digital currency, Bitcoin's pseudonymous creator Satoshi Nakamoto referred to Bitcoin as a new electronic cash system that is fully peer-to-peer with no trusted third party. SATOSHI NAKAMOTO, BITCOIN: A PEER-TO-PEER ELECTRONIC CASH SYSTEM 1, https://bitcoin.org/bitcoin.pdf [https://perma.cc/5T3X-KP37].
4. *See infra* Subpart I.C.
5. YAGA, MELL, ROBY & SCARFONE, *supra* note 1, at 1.
6. Catherine Tucker & Christian Catalini, *What Blockchain Can't Do*, HARV. BUS. REV. (June 28, 2018), https://hbr.org/2018/06/what-blockchain-cant-do?referral=03759&cm_vc=rr_item_page.bottom [https://perma.cc/RS3L-G87T].

centralized databases are becoming targets for cyberattacks and data breaches.[7] Conversely, distributed ledger technology, or blockchain, is an alternative data management system with improved data integrity, immutability, and network resilience. In addition, it can protect the privacy of users contributing data by paring it with cryptography. Because of these features and its integration in areas such as healthcare systems and food supply chains, blockchain plays an important role helping institutions and governments around the world respond to the COVID-19 crisis.[8] Because more data is being processed remotely and thus digitally, data management systems using blockchain are gaining more traction.

Despite blockchain's recent popularity, discussions about blockchain technology are often erroneously limited to Bitcoin or cryptocurrency more generally. Even scholarly literature on blockchain conflates blockchain and cryptocurrency.[9] Tax literature on blockchain also embody the same limitations: dealing primarily with the nature of cryptocurrency for tax purposes and focusing on how users should comply with the tax system while failing to actually discuss blockchain technology itself from a tax perspective.[10] This historical confusion and the lack of a refined discussion on the broader concept of blockchain is understandable because cryptocurrency is the most famous and monetized product where individual taxpayers commonly face tax compliance issues.

7. Axel, *Major Centralized Systems Are Hacked Multiple Times a Year*, MEDIUM (Oct. 29, 2018), https://medium.com/@AxelUnlimited/major-centralized-systems-are-hacked-multiple-times-a-year-9c2ad612462b [https://perma.cc/WV9T-MX4A].

8. Nadia Hewett & Rasmus Winther Mølbjerg, *This Is How Blockchain Can Be Used In Supply Chains To Shape A Post-COVID-19 Economic Recovery*, FORBES (June 19, 2020, 10:03 AM), https://www.forbes.com/sites/worldeconomicforum/2020/06/19/this-is-how-blockchain-can-be-used-in-supply-chains-to-shape-a-post-covid-19-economic-recovery/#1a51e1f94c0e [https://perma.cc/BT9X-YK6W]; Irving Wladawsky-Berger, *Blockchain May Offer Solutions to Fighting Covid-19*, WALL ST. J. (May 1, 2020, 12:41 PM), https://www.wsj.com/articles/blockchain-may-offer-solutions-to-fighting-covid-19-01588351297 [https://perma.cc/J22Q-LJ4H].

9. *See, e.g.*, Carla L. Reyes, *(Un)Corporate Crypto-Governance*, 88 FORDHAM L. REV. 1875 (2020). *But cf.* Kevin Werbach, *The Siren Song: Algorithmic Governance by Blockchain*, *in* AFTER THE DIGITAL TORNADO: NETWORKS, ALGORITHMS, HUMANITY 215, 216 n.5 (Kevin Werbach ed., 2020) (recognizing the difference of blockchain and cryptocurrencies and stating that the author uses blockchain "as a generic term for the collection of cryptocurrency, blockchain, and distributed ledger technologies.").

10. *See, e.g.*, Omri Marian, *A Conceptual Framework for the Regulation of Cryptocurrencies*, 82 U. CHI. L. REV. 53 (2015); Eric D. Chason, *Cryptocurrency Hard Forks and Revenue Ruling 2019–24*, 39 VA. TAX REV. 279 (2019); Abraham Sutherland, *Cryptocurrency Economics and the Taxation of Block Rewards*, 165 TAX NOTES FED. 749 (2019).

Today, the confusion and lack of refined discussion on blockchain is no longer justified given the new important role blockchain plays for managing and exchanging information in the new normal. This Article goes beyond cryptocurrency to discuss how blockchain, or the distributed peer-to-peer ledger technology itself, can apply to the public sector. Specifically, this Article discusses how blockchain technology can be adopted by government actors in tax administration, its limitations, and what measures policymakers should consider in the process of implementing blockchain.

Blockchain is best suited for an area within the public sector that requires data redundancy, information transparency, data immutability, and a consensus mechanism.[11] With these criteria, tax administration is a strong candidate to incorporate blockchain because it requires at least three of the four factors: data redundancy, information transparency, and data immutability. Certain areas of taxation also require the fourth factor (consensus mechanism) because of the inherent lack of trust among parties.

The first area where tax administration requires the first three factors is payroll and withholding taxes. Tax administration is closely linked with collecting and managing tax information. A major goal of tax administration is to overcome the asymmetry of information between taxpayers and tax authorities. Tax information originates from various taxpayer activities, but it is not always readily available to the government although the government must acquire and process taxpayer information to enforce the tax system. Thus, people are required to share tax information with tax authorities via various routes. This information is sometimes self-reported by taxpayers, such as by filing tax and information returns, but often the information is reported by third parties, such as withholding agents or financial institutions as is the case in the payroll tax. To overcome information asymmetry, the tax compliance system requires transparency and data immutability.

Tax information collected during tax compliance may also be shared with other tax authorities or institutions and vice versa. In payroll taxation, the amount of wage is reported and shared with various government agencies and companies.[12] The payroll system not only processes Social Security or Medicare taxes, but also withholds and pays federal, state, and local income taxes. Tax authorities, the Social Security Administration, and financial institutions collect the same information to process wage income amounts. Thus,

11. DEP'T OF HOMELAND SEC., 2018 PUBLIC-PRIVATE ANALYTIC EXCHANGE PROGRAM, BLOCKCHAIN AND SUITABILITY FOR GOVERNMENT APPLICATIONS 5 (2018).
12. *See infra* Subpart II.C.1.

the various systems inefficiently impose significant burdens on intermediaries like employers because each government actor holds their own register, thereby duplicating data already held by other actors. Blockchain offers a better system addressing this inefficiency caused by data redundancy while also offering transparency and data immutability.

The second area where tax administration requires all four factors is the exchange of tax information between multiple governments. The fourth factor of blockchain, a consensus mechanism, is a solution in situations where parties in a peer-to-peer transaction do not fully trust each other or where there is no central authority to validate transactions. This trust issue exists when a tax authority shares its information with other tax authorities. If certain federal tax information is related to state and local taxation, then that information should be easily shared with state and local tax authorities and vice versa. Currently, the federal government shares tax information with states and localities. While states should, and sometimes do, share with the federal government, they do so less robustly. The resulting information gaps are bad for tax administration because the hierarchy between the federal government and state and local governments weakens when the two entities share information as peers. Blockchain enables a more robust exchange of information while respecting a more democratic relationship among the federal, state, and local governments.[13]

The same trust problem is even more conspicuous at an international level.[14] If tax information is related to the tax jurisdictions of multiple countries, that information should be shared between the relevant countries. In the past decade, the need to fill cross-border information gaps has developed, spurring the improvement of many information sharing systems such as systems designed to facilitate the automatic exchange of information. None of these systems have succeeded in creating a real time sharing of information, however, resulting in a significant time lag. Further, the systems remain too immature to fully monitor which information should be shared with what jurisdictions. The limitations of the systems are largely due to the distrust and lack of a central authority in the global community, thereby making blockchain a compelling alternative.

Even before the rise of blockchain, tax administration has engaged in significant efforts to improve the system propelled by a desire for greater efficiency, transparency, and better compliance to overcome the asymmetry of information. Tax authorities have attempted to collect and process information

13. *See infra* Subpart II.C.3.
14. *See infra* Subpart II.D.2.

digitally, providing a more efficient environment for creating foolproof solutions and software.[15] Taxpayers also expect that the process of taxpaying will become simpler, less costly, and less time consuming and that their tax information will be properly used, stored securely, and protected from undue disclosure to unrelated parties or the public. The competing goals of tax administration, such as efficiency, transparency, simplicity, and taxpayer protection, generate constant tension and policy concerns. Are the competing goals of tax administration impossible to achieve collectively? Or is there an optimal solution available to balance these stated goals? While tax administration has adopted various strategies to address these issues and questions, there is room for improvement.

Specifically, emerging technologies may solve this puzzle and contribute to the improvement of tax administration, considering that tax information is often collected and processed digitally these days. Blockchain is one of the most promising technologies to create a better system for managing digital tax information because of its ability to deliver reliable real time information from many different layers to a large audience, as is the case with taxation. For this reason, this Article focuses on blockchain technology and explores the possibility of incorporating blockchain technology in tax administration.

This Article not only contributes to the scholarly analysis on the feasibility of incorporating blockchain in tax administration but also offers a normative blueprint that policymakers and market players can refer to and, hopefully, readily adopt. Based on the author's extensive survey supported by the IRS Office of Chief Counsel and leading blockchain platforms, such as Coinbase and Ripple, this Article proposes a framework to help categorize areas of taxation in which blockchain would improve tax administration.[16] The recommended areas of taxation are the following: (1) reporting obligations of the same information to multiple tax authorities and agencies, such as payroll taxation and transfer pricing, (2) third-party reporting obligations, such as withholding tax, (3) transaction taxes, such as value added tax, and (4) information sharing among

15. For example, Congress established the Electronic Tax Administration Advisory Committee through the IRS Restructuring and Reform Act of 1998 to meet the goal for electronic filing of tax and information returns. *Electronic Tax Administration Advisory Committee (ETAAC)*, IRS, https://www.irs.gov/newsroom/electronic-tax-administration-advisory-committee-etaac [https:// perma.cc/EGN5-4U6X]. For scholarly efforts to urges tax authorities to take the leading role in incorporating emerging technology for the benefits of taxpayers, see, e.g., Joseph Bankman, Clifford Nass & Joel Slemrod, *Using the "Smart Return" to Reduce Evasion and Simplify Tax Filing*, 69 TAX L. REV. 459 (2016); David I. Walker, *Tax Complexity and Technology*, B.U. Sch. of L., L. Econ. Series Paper No. 20–28 (2020).

16. *See infra* Subpart II.A.

federal, state, and local governments and among multiple countries in international tax.

This Article suggests a private consortium blockchain, an evolution from the classic public blockchain, as the preferred structure for tax blockchain networks for the areas listed above. Parties in the blockchain consortium can trust each other without a third party because the data's immutability and decentralization ensure its integrity and network resilience, its confidentiality via encryption and access control, and its security. Moreover, a well-designed private consortium blockchain is effective in protecting taxpayer information from cyberattacks and controlling who can access and share tax information. Thus, blockchain technology can improve the existing tax administration's efficiency and transparency while maintaining taxpayer protection.

Applying blockchain to tax administration is not an impractical pipedream but can be adopted in the near future. Areas of the private sector that are closely related to tax administration, such as banking and financial services, have already adopted, or plan to adopt blockchain technology.[17] What is more, areas of the private sector that deal with information and record keeping, such as property and medical records, are also actively discussing incorporating blockchain technology.[18] Since 2017, several projects sponsored by the federal government have analyzed the potential pros and cons of applying blockchain in the public sector.[19] Notwithstanding these developments, there remains little study of applying blockchain in tax administration. This Article aims to fill this gap. This Article's analysis of blockchain designs and policy implications may also benefit broader audiences who are interested in diverse blockchain applications either in the private or public sector.

With that in mind, this Article provides normative considerations for policymakers deliberating blockchain initiatives in tax administration in several ways. First, the appropriate timeframe for blockchain implementation in tax administration depends on the timing of the widespread use of distributed ledger technology within many sectors of society.[20] Despite some skepticism of blockchain technology being overhyped, an overwhelming majority of business executives expect that blockchain will eventually achieve mainstream adoption.[21] So, it is wise to

17. *See infra* Subpart I.C.1.
18. *See infra* Subpart I.C.2.
19. *See infra* Subpart I.C.2.; *Blockchain and Distributed Ledger Technology*, ORG. FOR ECON. COOP. AND DEV. (OECD), http:// www.oecd.org/daf/blockchain [https://perma.cc/ZM6J-ZE3X].
20. *See infra* Subpart III.A.
21. DELOITTE, DELOITTE INSIGHTS: DELOITTE'S 2020 GLOBAL BLOCKCHAIN SURVEY 5 (2020) [hereinafter DELOITTE, SURVEY].

prepare for the next phase of blockchain development because the technology is likely become readily available sooner rather than later.

Second, the areas of tax fit to incorporate blockchain are heavily intertwined with other sectors, such as financial institutions as well as other regulatory agencies and foreign governments. For streamlined performance, blockchain in tax administration should include interchangeable modules that connect with other sectors seamlessly.[22] Standardization is also needed, but not at the price of harming innovation and competition by making the standards proprietary or less accessible.

Third, it is important to understand the limitations of blockchain for tax administration. Considering that the blockchain distributed ledger technology is the next phase of digital information management, the benefits of its application are limited to improving existing data management systems where information is already digitalized. It is uncertain how much the degree of voluntary input of tax data by taxpayers at the intersection of offline and digital recordkeeping can be improved. For example, blockchain may not be effective in reducing the tax gap that occurs with the self-employment tax and the individual tax on business income due to the primarily cash-based nature of the taxpayers.[23]

Finally, blockchain initiatives must be accompanied by additional legislation regulating the role of government and protecting taxpayers' rights and privacy.[24] A properly designed blockchain has great potential to address the privacy concerns of taxpayers because it can systematically prevent the undue sharing of information, such as the sharing of undocumented taxpayers' information with other agencies or the cross-border sharing of information with hostile foreign countries. The proposed blockchain networks for tax administration are consortium networks, however, meaning that most individual taxpayers cannot participate in the network as a node. Only tax authorities, other agencies, certain withholding agents, and third-party reporters can participate in the network and serve as a node. This raises the concerns of who controls the information system and how to protect taxpayers' rights and privacy. One might assert that the government is a trustworthy administrator for a solution, but that might conflict with the nature of blockchain as a decentralized system.[25] To truly be effective, blockchain must be accompanied by additional privacy legislation surrounding the control of tax information.

22. *See infra* Subpart III.B.
23. *See infra* Subpart III.C.
24. *See infra* Subparts III.D and E.
25. This is commonly referred to as Vili's governance paradox of blockchain. *See* discussion *infra* Subpart III.D.

These policy implications may resonate with a broader audience beyond tax policymakers. Anyone who seeks a more efficient, transparent, and safer data management system can learn lessons from the blockchain applications explored in this Article as well as in the simulation of a tax blockchain system. The attempt to build a more democratic tax system among federal, state, and local governments by adopting blockchain can inspire policymakers who struggle with federalism and state autonomy. Global leaders who have been hesitant to cooperate on many international administrative issues because of the lack of central authorities may welcome the idea that blockchain can offer a multilateral platform where information can be exchanged efficiently yet allow access to the information only to preselected parties, all of which is executed automatically without the need for a central administrator. To build upon this Article, scholars should explore other areas that can implement blockchain technology.

The remainder of this Article proceeds as follows. Part I overviews blockchain technology as a decentralized, immutable, peer-to-peer digital ledger. It introduces key features of important types of blockchain systems and applications in the real world to shed light on the design of blockchain systems for tax administration. Part II evaluates the feasibility of incorporating blockchain in tax administration and provides policymakers with both criteria to consider in adopting blockchain and some recommended designs for blockchain networks. It also illustrates promising areas of taxation for blockchain initiatives, both in domestic and international tax. Part III offers normative considerations for policymakers deliberating blockchain initiatives for tax administration, such as the timeline, standardization, integration with other systems, limitations, and considerations for taxpayers' rights and privacy. The Article then concludes that the thoughtful application of blockchain would improve tax administration's efficiency and transparency while also still protecting taxpayers' information.

I. UNPACKING BLOCKCHAIN

For many, the term blockchain has become synonymous with Bitcoin, a cryptocurrency that has garnered significant public interest by challenging many of the norms generally associated with traditional currencies.[26] While Bitcoin utilizes blockchain technology, blockchain is a far broader technology than simply Bitcoin or cryptocurrencies in general. Part I provides a primer on

26. *See, e.g.*, Marco Iansiti & Karim R. Lakhani, *The Truth About Blockchain*, HARV. BUS. REV. (Jan.–Feb. 2017), https://hbr.org/2017/01/the-truth-about-blockchain [https://perma.cc/UXX5-ZHPE].

blockchain technology by discussing the various types of blockchain systems, their applications in the private and public sectors, and how they are building blocks to expand blockchain's usage in tax administration.

A. Blockchain Primer

Although the media often highlights and publicizes stories on cryptocurrencies, what is far more significant is the technology behind cryptocurrencies, blockchain. Blockchain is best defined as "a peer-to-peer, distributed ledger that is cryptographically-secure, append-only [(the block is added to the end of the chain in chronological order)], immutable (extremely hard to change), and updateable only via consensus or agreement among peers [(power of decentralization)]."[27] This Subpart analyzes the definition and key features of blockchain technology.

1. A Distributed, Immutable, Peer-to-Peer Ledger

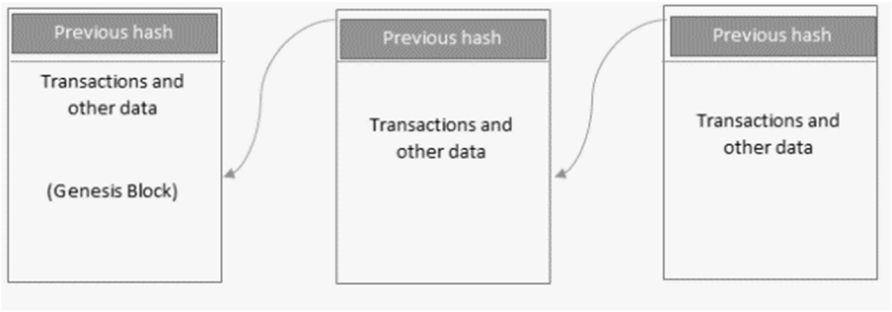
A blockchain is "a shared digital ledger of transactions between parties in a network, not controlled by a single central authority."[28] This shared digital ledger is similar to a traditional record book or database.[29] Like all ledgers, blockchain simply features a series of transactions or records. In the case of blockchain, these transactions take the form of individual blocks, each of which is recorded on the distributed ledger.[30] For example, if a person purchases a book from Amazon, information about the transaction, like the date, time, the dollar amount of the purchase, and who is participating in the transaction, is stored in the block.

Each independent block is incorporated into the chain by using a hashing system.[31] When the digital information about the transaction is stored in a block of the blockchain ledger, the specific input is assigned to a unique cryptographic

27. IMRAN BASHIR, MASTERING BLOCKCHAIN: DISTRIBUTED LEDGER TECHNOLOGY, DECENTRALIZATION, AND SMART CONTRACTS EXPLAINED 16 (2nd ed. 2018).
28. OECD, OECD BLOCKCHAIN PRIMER 4 (2019) [hereinafter OECD, BLOCKCHAIN PRIMER]; HYPERLEDGER, AN INTRODUCTION TO HYPERLEDGER 4 (2018), https://www.hyperledger.org/wp-content/uploads/2018/08/HL_Whitepaper_IntroductiontoHyperledger.pdf [https://perma.cc/DXT3-P8PA] [hereinafter HYPERLEDGER, INTRODUCTION]; BASHIR, *supra* note 27, at 19.
29. OECD, BLOCKCHAIN PRIMER, *supra* note 28, at 4.
30. *Id.*
31. *Id.*

code, called a hash, consisting of a set of letters and numbers.[32] The specific information of a given transaction always produces the same exact hash, like a digital fingerprint. And the block is added to the end of the blockchain in chronological order, as illustrated in Figure 1.[33] Each block contains its own unique hash and the hash of the preceding block, forming a chain.[34] Hence, if a malicious actor tries to alter the information stored in one block, the entire network would easily detect such an attempt because the chain of hashes and blocks would be disrupted.[35] Suppose that the information of the *UCLA Law Review* is stored in Block 101 and receives this hash: 607074abcb50b3517be8bf385b3297b8. If anyone tries to change the information to *uCLA Law Review* (the alphabet U is now a lower case), the hash would change to a completely different code: 8a79d4e2f288c99643d788e31937db7a, for example. This would be easily discoverable to the entire blockchain network because not only did the hash for *UCLA Law Review* in Block 101 change from the 60- code to the 8a- code, but also the changed 8a- hash does not match the 60- hash code stored in Block 102. Even if a hacker changes the hash code in Block 102 as well, such a change would result in a discrepancy between the hash codes stored in Block 103 and those stored in Block 102 which would cascade into subsequent blocks. Thus, the attempt to change the information would be rejected by the nodes distributed in the network.

Figure 1: Stylized Structure of a Blockchain[36]



32. *Id.* at 7. Sample hashes can be made easily online, such as at https://www.md5hashgenerator.com.
33. BASHIR, *supra* note 27, at 17.
34. *Id.*
35. OECD, Blockchain Primer, *supra* note 28, at 7.
36. BASHIR, *supra* note 27, at 20.

What makes blockchain unique from other ledgers in the current digital age is the fact that blockchain is "not controlled by a single central authority."[37] In traditional databases and information systems, data is stored on a centralized server that is owned and maintained by a central authority.[38] Blockchain, on the other hand, adopts a distributed ledger system described in Figure 2. Rather than relying on a central authority to ensure the accuracy of the ledger, the blockchain relies on having identical copies of the ledger on the various users' computers that are geographically separated. These users' computers that contain a copy of the ledger are referred to as "nodes."[39] In Figure 3, each computer in the blockchain network is a node. Because there is an identical copy of the ledger stored in the various nodes, the accuracy is ensured by consensus protocol (as discussed in more detail below). If the information on one computer were to be manipulated or changed, it would become apparent to the blockchain network because all the other nodes sharing the blockchain would be inconsistent and the nodes would reject that version of the ledger.[40] This guarantees the immutability of the ledger.[41] (Note, however, that the blockchain's immutability does not resolve the false input of the information from the beginning. *Infra* Subpart III.C. discusses this issue in detail.)

37. OECD, BLOCKCHAIN PRIMER, *supra* note 28, at 4.
38. JAMIE BERRYHILL, THÉO BOURGERY & ANGELA HANSON, OECD, BLOCKCHAINS UNCHAINED: BLOCKCHAIN TECHNOLOGY AND ITS USE IN THE PUBLIC SECTOR 11–12 (2018), https://www.oecd-ilibrary.org/governance/blockchains-unchained_3c32c429-en [https://perma.cc/ 7GAU-RU2P].
39. *Id.* at 12.
40. *Id.* at 7.
41. BASHIR, *supra* note 27, at 24.

Figure 2: Comparison of Centralized, Decentralized, and Distributed Networks[42]

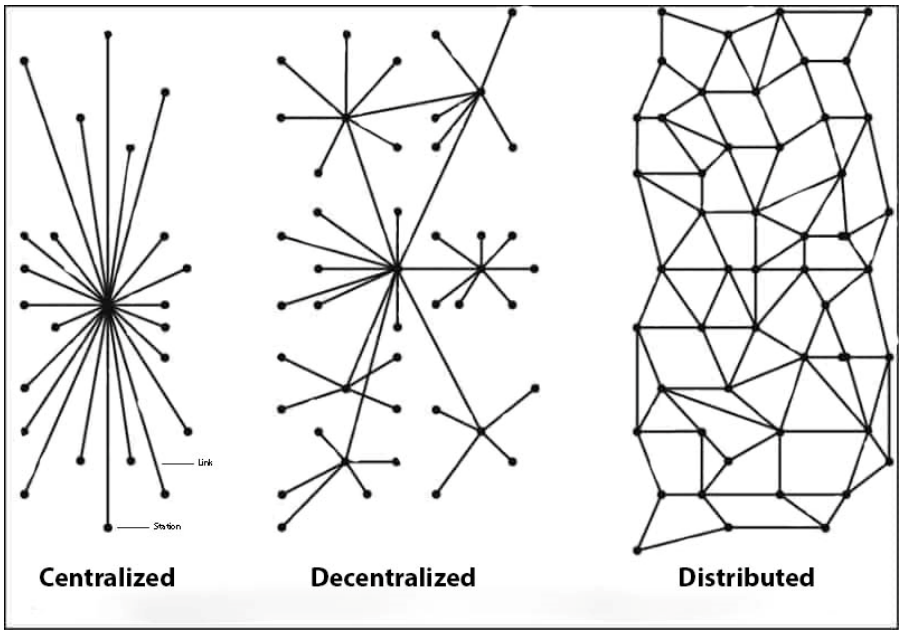
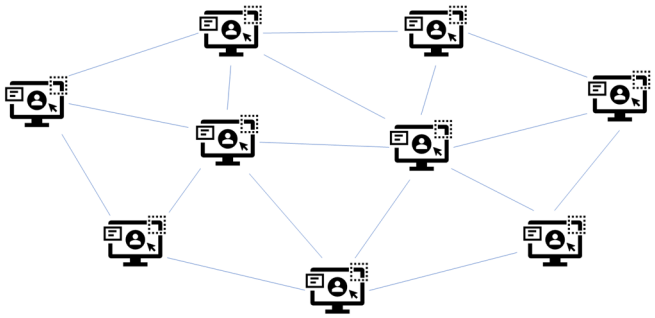


Figure 3: Distributed Blockchain Network



The process of how blockchain accumulates blocks is as follows. If one party requests a transaction, the requested transaction is funneled to a peer-to-peer network (as illustrated in Figure 3) and broadcast to each individual computer

42. PAUL BARAN, ON DISTRIBUTED COMMUNICATIONS: INTRODUCTION TO DISTRIBUTED COMMUNICATIONS NETWORKS, UNITED STATES AIR FORCE PROJECT RAND 1–2 (1964); *see also* BERRYHILL, GOURGERY & HANSON, *supra* note 38, at 12.

(or node).[43] Individual nodes receive the request and validate the transaction using a consensus algorithm. Other public records of information, like stock exchanges, the DMV, or your local library, require someone in charge to examine and validate the new data entries. Blockchain, however, does not require a trusted third party or intermediary that controls the ledger because a network of computers oversees that task.[44] These networks often consist of thousands of computers spread across the globe.[45] The network of computers in a blockchain system confirms the details of the information by a consensus mechanism. The approved transactions are represented as blocks and added to the blockchain ledger. Once the block is added to an existing chain, transactions are complete and permanent. Each computer in the blockchain network has its own copy of the blockchain. Although each copy of the blockchain is identical, spreading that information across a network of computers makes the information more difficult to manipulate. That is why blockchain is described as a distributed, immutable, peer-to-peer ledger.

Consensus algorithms are the backbone mechanism that guarantees that information in the distributed ledger is always correct.[46] Even if some of the nodes are likely to fail or to act dishonestly, a consensus system makes sure the information in the database is always correct by using preestablished rules based on the concept of Byzantine fault tolerance.[47] There are many different forms of

43. Nakamoto, *supra* note 3, at 3.
44. BASHIR, *supra* note 27, at 24.
45. In the case of Bitcoin, this network consists of about 5 million computers or wallets across the globe. GARRICK HILEMAN & MICHEL RAUCHS, GLOBAL CRYPTOCURRENCY BENCHMARKING STUDY 8 (2017), https://www.jbs.cam.ac.uk/faculty-research/centres/ alternative-finance/publications/global-cryptocurrency/.
46. BASHIR, *supra* note 27, at 35.
47. The Byzantine fault tolerance deals with the Byzantine generals' problem, which is a dilemma of how a group of Byzantine generals, each situated in a different location with their own division, agree to either attack or retreat. The communication among the generals may be done through messages forwarded by a courier but the message can get delayed, destroyed, or lost. In addition, some generals may act maliciously and send a fraudulent message. In order to prevent a total failure caused by this dilemma, the generals establish a rule exante, where: (i) each general must decide whether to attack or retreat, (ii) after the decision is made, it cannot be changed, and (iii) the action that the majority of the generals within such distributed network agree will be executed in a synchronized manner. Putting this dilemma in the context of blockchain, each general represents a network node and the nodes need to reach a consensus to add a block to the chain. *Byzantine Fault Tolerance Explained*, BINANCE ACAD. (Dec. 9, 2020), https:// academy.binance.com/blockchain/byzantine-fault-tolerance-explained [https://perma. cc/ 59FE-7AQA].

consensus protocol in a blockchain system.[48] For example, Bitcoin has adopted a proof of work (POW) protocol where the network nodes validate the information by competing among themselves to solve difficult math problems using their computer's processing power.[49] If one node finds the correct answer and the majority of the nodes agree that such answer is correct, a consensus is achieved. For this work, the node receives rewards and rights to publish the new block associated with that work.[50]

The goal of the consensus protocol is not to make a perfect system; rather, it aims to avoid the complete failure of the system.[51] As a result, the system can continue operating even if some of the nodes fail or act maliciously. If the majority of the network decides to act maliciously, however, the system is susceptible to failures and attacks. This is referred to as the 51 percent attack on blockchain.[52] For example, the POW and the proof of stake (POS) protocols are susceptible to the 51 percent attack.[53] In contrast, other types of consensus protocols, such as proof of elapsed time[54] and proof of activity,[55] incorporate the

48. In addition to the proof of work (POW), other types of consensus are called proof of stake (POS), proof of burn, proof of activity (POA), proof of capacity, proof of elapsed time, proof of authority, proof of importance, and Raft. BASHIR, *supra* note 27, at 37–39.
49. Sutherland, *supra* note 10, at 754; Sarwar Sayeed & Hector Marco-Gisbert, *Assessing Blockchain Consensus and Security Mechanisms Against the 51% Attack*, 9 APPLIED SCI. 1, 6–7 (2019).
50. *Id.*
51. *Byzantine Fault Tolerance Explained*, *supra* note 47.
52. *See, e.g.*, Sayeed & Marco-Gisbert, *supra* note 49 (discussing broadly the danger of a majority of the system becoming susceptible to failure).
53. For POS, users who want to participate in making and adding a block are required to lock a certain amount of its stake, such as coins, into the network. An algorithm chooses a node that will create, or forge in technical terms, a block based on the user's stake. The bigger the stake, the bigger the chances of the node being selected as the next validator to forge the next block. If the network detects a fraudulent block, the forger node will lose its stake and right to participate as a forger in the future. POS is still vulnerable to the 51 percent attack, however. Sayeed & Marco-Gisbert, *supra* note 49, at 7–8.
54. Proof of elapsed time, created by Intel for Hyperledger, decides the mining rights or the block winners based on a lottery system. Each participating node in the network is required to wait for a randomly chosen time period. The one which is assigned the shortest wait time wins the lottery and commits a new block to the blockchain. BASHIR, *supra* note 27, at 38.
55. Proof of activity (POA) tries to combine the best parts of POW and POS. The creation of blocks follows the POW mining process. Participating nodes must solve a mathematical problem with computing power to create a new block. Then, the system is switched to POS, except that a group of validators are selected randomly. POA can prevent a 51 percent attack because it becomes impossible to predict who the validators would be in the future and the competition to hoard more coin among the participants prevents the computing power from being accumulated within a particular group of users. *Id.* at 38.

feature of randomness in the protocol and reduce the chance of a 51 percent attack.

No matter what kind of consensus protocols blockchains adopt, all blockchains rely on cryptography, which is a method of protecting information through the use of codes in hashing so that it is difficult to decode by adversaries.[56] Digital signatures and a certificate of authority protected by cryptography can provide basic identity protection in the blockchain network.[57] There are also more advanced blockchain systems, such as private blockchain and permissioned blockchain, discussed in Subpart I.B, which also offer confidentiality and privacy by combining both encryption and access control.[58]

2. Blockchain's Key Features, Pros, and Cons

Based on the overview above, the key features of the blockchain system that distinguish it from existing ledger and database technology can be summarized as follows: blockchain systems are (1) distributed, (2) transparent, and (3) immutable. Accordingly, it provides improved data security, network resilience, and efficiency.

Distributed: In a blockchain system, the database is maintained and held by all nodes distributed in the network rather than being centrally located on a server or held by a central authority.[59] Any changes that are made to the ledger are agreed upon by a consensus of the nodes in the network.[60] Once the consensus is established, each node will update its own ledger.[61] This distributed nature provides a level of reliability that a centralized and concentrated authority cannot.

Transparency and trust via consensus: Blockchain systems are engineered to enable direct, peer-to-peer transactions between parties who do not fully trust each other or who do not trust any central authority to validate transactions or settle disputes. Although the parties do not trust each other, they can trust the technology to record the information in a tamper-proof way. This makes the system transparent and, as a result, trust is established. Blockchain relies on a consensus mechanism to establish such trust. The consensus protocols formulate a set of rules that all nodes have agreed to follow and ensure that each

56. *Id.* at 61.
57. BERRYHILL, BOURGERY & HANSON, *supra* note 38, at 46–47.
58. HYPERLEDGER, INTRODUCTION, *supra* note 28, at 4–5.
59. OECD, BLOCKCHAIN PRIMER, *supra* note 28, at 6.
60. *Id.*
61. *Id.*

node spread across the network adds the same new block.[62] Because blockchain implements these protocols by code and users can easily test these protocols by comparing an individual node's output against all the other nodes in the system, it ensures trust between all users in the system.

Immutability: In a traditional database system, an authorized user can generally access, modify, and even permanently delete data stored on the database. On the other hand, data in blockchain is immutable.[63] Once the data has been incorporated and recorded onto the blockchain, it is extremely difficult to go back and alter the contents of the block.[64] Blockchain systems implement a hashing system that ties each block together in a series that cannot be disturbed without violating the remainder of the chain.[65] For example, if a hacker were to attempt to edit your Amazon transaction, in order to change a single block (your block), the hacker would need to change each and every block that is added after your block and distributed across the entire blockchain. Recalculating all those hashes would take an enormous and improbable amount of computing power. Also, because the data contained on the blockchain is stored on thousands of independent nodes, changing any node will not affect the overall consensus.[66]

One of the most important advantages that blockchain systems provide over traditional databases and ledgers is reliability. Immutability and decentralization ensure data integrity and network resilience.[67] Any attempt to alter the data on the blockchain creates a discrepancy that other recordkeepers in the network immediately notice. The network then responds by shutting down the compromised node and removing it from the network. Thus, the accuracy of the data is guaranteed and the distributed network eliminates the risk of a single-point attack, such as a distributed denial of service (DDoS) attacks.[68] In addition, all transactions on a blockchain are cryptographically secured by the use of hashing, and thus data security is

62. *Id.*
63. BASHIR, *supra* note 27, at 24.
64. *Id.*
65. OECD, BLOCKCHAIN PRIMER, *supra* note 28, at 4.
66. *Id.* at 6.
67. BASHIR, *supra* note 27, at 24.
68. Phillip Shaverdian, *Start With Trust: Utilizing Blockchain to Resolve the Third-Party Data Breach Problem*, 66 UCLA L. REV. 1242, 1278–79 (2019).

provided.[69] Furthermore, private blockchains offer both confidentiality and privacy by combining encryption and access control.[70]

By the same token, blockchain systems can be efficient.[71] They can reduce cost because blockchain does not require any central authority to maintain the system. In the past, every transaction or system that involved managing information required a middleman, like a bank, credit card company, or librarian, to confirm the identity of the relevant parties and validate the information. Requiring a middleman creates friction, delay, and expense.[72] Blockchain, however, does not need a trusted third party or intermediary to validate transactions. Instead, a consensus mechanism is used to collectively validate transactions, enabling faster dealings, saving time, and reducing cost.[73]

Overall, the benefits of blockchain help create a better system for managing digital data. Parties in blockchain systems can trust each other without a third party. Blockchain's immutability and decentralization ensures data integrity and network resilience, confidentiality (encryption and access control), and data security.

Nonetheless, blockchain technology does offer some disadvantages that may diminish its value or applicability. First, blockchain systems, especially the type of Blockchain that uses the POW consensus protocol, consumes an enormous amount of energy.[74] Because the system is utilizing the computing power of thousands of nodes around the world, it ultimately ends up using more energy than a centrally located database. For example, the Bitcoin ledger used over 60 terawatt-hours in the past year.[75] That is more energy than what is used in over 5 million American homes and is comparable to the energy consumption of entire countries, such as Kuwait.[76]

Second, for many of the same reasons, blockchain systems do not process transactions as quickly as needed. This is the scalability problem.[77] This

69. BASHIR, *supra* note 27, at 29.
70. HYPERLEDGER, INTRODUCTION, *supra* note 28, at 4–5.
71. BASHIR, *supra* note 27, at 25.
72. *See, e.g.*, Catherine Bolgar, *Blockchain's Promise: Cut Out the Middleman and Boost Security*, WALL ST. J. CUSTOM CONTENT, https://partners.wsj.com/luxoft/the-new-perspective/blockchains-promise [https://perma.cc/H3UK-Q5TC].
73. BASHIR, *supra* note 27, at 24–25.
74. BERRYHILL, BOURGERY & HANSON, *supra* note 38, at 32.
75. The most recent figures are available at *Bitcoin Energy Consumption Index*, DIGICONOMIST, https://digiconomist.net/bitcoin-energy-consumption [https://perma.cc/NG38-3XKA].
76. BERRYHILL, BOURGERY & HANSON, *supra* note 38, at 32.
77. *Id.* at 33.

limitation is evident in blockchain systems using the POW consensus protocol.[78] This is not surprising given that a blockchain system is purposefully redundant by carrying out identical computations on thousands of computers for the sake of reliability. Further amplifying the problem, the more a blockchain platform becomes popular and the more its users send information, the more it must be broadcasted throughout the entire growing blockchain network redundantly.

Third, in recent years, illegal activity has proven that people can also use blockchain's unique capabilities for harmful purposes.[79] The FBI recently shut down a blockchain system known as Silk Road, an online dark web marketplace where criminals would take advantage of the confidentiality blockchain affords by making illegal purchases through the Bitcoin ledger.[80] Although current U.S. regulation prevents users of online exchanges built on blockchain from achieving full anonymity,[81] this incident has alerted society of a downside to blockchain technology.

These challenges, however, are relevant mostly to cryptocurrencies using the POW consensus protocol rather than the general blockchain technology behind cryptocurrencies. The challenges that are significant in some blockchain systems may not be significant in other systems with different designs. For example, the concerns about cryptocurrencies being used in illegal activities are not particularly relevant to a blockchain system that monitors food supply chains. The extreme energy consumption and scalability issues are big problems for public blockchains using the POW consensus protocol but they would not be issues for other blockchain platforms, especially private, permissioned ledgers using proof of authority consensus protocol.[82]

78. Bitcoin ledgers can process only about seven transactions per second, whereas more traditional financial transaction systems can process hundreds or thousands of transactions per second; companies such as Visa can process 1667 transactions per second, and PayPal can process 193 transactions per second. BERRYHILL, BOURGERY & HANSON, *supra* note 38, at 33.

79. NEEL MEHTA, ADI AGASHE & PARTH DETROJA, BUBBLE OR REVOLUTION: THE PRESENT AND FUTURE OF BLOCKCHAIN AND CRYPTOCURRENCIES 54–57 (2019).

80. *Id.* at 56. In the United States, online exchanges must obtain information about their customers when they open an account, verify the identity of each customer, and confirm that customers do not appear on any list of known or suspected terrorist organizations. *Anti-Money Laundering (AML) Source Tool for Broker-Dealers*, SEC. AND EXCH. COMM'N, https://www.sec.gov/about/offices/ocie/amlsourcetool.htm [https://perma.cc/JP52-Q6EJ].

81. Uniting and Strengthening America by Providing Appropriate Tools Required to Intercept and Obstruct Terrorism (USA Patriot Act), Pub. L. No. 107-56, § 326(a)(2), 115 Stat. 272, 317-18 (2001).

82. For public sector applications of blockchain, permissioned blockchain systems with proof of authority consensus protocol is recommended. BERRYHILL, BOURGERY & HANSON, *supra* note 38, at 32.

Furthermore, the technical challenges of energy consumption and scalability are somewhat outdated because blockchain systems have evolved so quickly and significantly. Recent engineering and computer science literature on this topic has largely focused on how to overcome the challenges described.[83] Thus, instead of weighing the pros and cons here, this Article will revisit the challenges and limitations of blockchain technology in Part III after exploring the application of blockchain in tax administration.

B. Types of Blockchain Systems

While all blockchain systems share the same core characteristics, not all blockchain systems are the same. Some of the most common variances that exist between systems are (1) public (or open) v. private (or closed) systems, which determines who can read and view the ledger, and (2) permissionless v. permissioned systems, which determines who can write and verify the ledger.[84] After comparing these four types of blockchains, this Subpart introduces consortium blockchains, which is a noteworthy example of a private and permissioned blockchain system. Table 1 offers a summary of the types of blockchain systems.

83. Overcoming the technical challenges of blockchain, including energy consumption and scalability, often boils down to the question of how to improve the consensus protocol for the various and evolving needs for blockchain. *See, e.g.*, Kyle Croman et al., *On Scaling Decentralized Blockchains* (Feb. 26, 2016), https://people.eecs.berkeley.edu/~dawnsong/papers/On%20Scaling%20Decentralized%20Blockchains_feb%202016.pdf [https://perma.cc/64AE-3REC] (diagnosing the scalability problem and proposing various solutions); BASHIR, *supra* note 27, at 561–81. Particularly for the consortium blockchains that this Article recommends for tax administration, *infra* Subpart II.B, many new consensus protocols have been developed. *See, e.g.*, MIGUEL CASTRO & BARBARA LISKOV, PRACTICAL BYZANTINE FAULT TOLERANCE 1 (1999), http://pmg.csail.mit.edu/papers/osdi99.pdf [https://perma.cc/2UW4-HX37] (introducing practical Byzantine Fault Tolerance (BFT) algorithm that works efficiently in asynchronous systems); Henrique Moniz, *The Istanbul BFT Consensus Algorithm* (May 20, 2020), https://arxiv.org/pdf/2002.03613.pdf [https://perma.cc/SYX8-ZFUS] (presenting a Byzantine Fault Tolerant system to be used in the Quorum blockchain); Kejiao Li, Hanxu Hou, Kedan Li & Kejio Li, IEEE, *Proof of Vote: A High-Performance Consensus Protocol Based on Vote Mechanism & Consortium Blockchain*, IEEE 19TH INT'L CONF. ON HIGH PERFORMANCE COMPUTING AND COMMC'NS (Dec. 2017), https://ieeexplore.ieee.org/document/8291964 (proposing a new consensus mechanism, called proof of vote, for consortium blockchains).

84. MICHÈLE FINCK, BLOCKCHAIN REGULATION AND GOVERNANCE IN EUROPE 14–16 (2019); Balázs Bodó, Daniel Gervais & João Pedro Quintais, *Blockchain and Smart Contracts: The Missing Link in Copyright Licensing?*, 26 INT'L J.L. INFO. TECH. 311, 317–318 (2018).

Table 1: Types of Blockchain System

		READ	WRITE	COMMIT	EXAMPLE
Public	**Permissionless**	Anyone	Anyone	Anyone	Cryptocurrency e.g., Bitcoin, Ethereum
	Permissioned	Anyone	Authorized participants	All or subset of authorized participants	Supply chain ledger for retail brand viewable by public e.g., Walmart China
Private	**Consortium**	Authorized participants	Authorized participants	All or subset of authorized participants	Multiple banks operating a shared ledger e.g., Quorum
	Private/ Permissioned "enterprise"	Fully private or restricted to a limited set of authorized nodes	Network operator only	Network operator only	External bank ledger shared b/w parent co. and subsidiaries e.g., IBM Blockchain Platform

1. Public v. Private

Public (or open) blockchains are "open for anyone to read and view."[85] Under these systems, "anyone can download the entire ledger and view transaction data."[86] Conversely, private (or closed) blockchains can "only be viewed by a chosen group of people."[87] "These systems are not open for anyone to join and see."[88] Instead, they require a gatekeeper to allow designated individuals to maintain a node on the network.[89]

Private blockchains are always permissioned, allowing only a select group of users to write and verify the new block addition to the chain, and vice versa.

85. OECD, BLOCKCHAIN PRIMER, *supra* note 28, at 5.
86. FINCK, *supra* note 84, at 14.
87. OECD, BLOCKCHAIN PRIMER, *supra* note 28, at 5.
88. FINCK, *supra* note 84, at 15.
89. *Id.*

Public blockchains are mostly permissionless blockchains, as observed in Bitcoin and other cryptocurrencies. Public blockchains, however, can be permissioned (defined and elaborated in the next paragraph), in which case anyone can read and view the ledger but only authorized participants can write and verify the ledger. For example, a supply chain ledger of Walmart China may be viewed by the public while only authorized suppliers may write and verify the ledger.[90]

2. Permissionless v. Permissioned

In addition to the distinction between public and private blockchains, blockchain systems also differ by being either permissionless or permissioned systems. Permissionless blockchains allow anyone to contribute by adding data to the ledger.[91] In contrast, permissioned blockchains permit only a "select group of users to write (i.e. generate transactions for the ledger to record) and commit (i.e. verify new blocks for addition to the chain)."[92] Permissioned blockchains are often used by individual companies or groups of organizations, referred to as a consortium.[93]

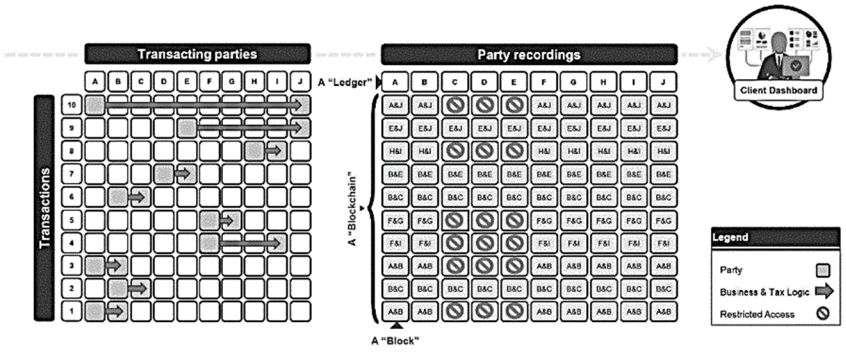
Permissionless blockchains are the traditional form of blockchain—open to anyone. Most cryptocurrencies, such as Bitcoin and Ethereum, adopt this form of blockchain.[94] Because of the public nature of permissionless blockchains, anyone can read and write on the ledger. Hence, it may require significant cost to maintain the network. To prevent malicious interference, most permissionless blockchains use some form of a consensus system.[95]

On the other hand, for permissioned blockchains, users must be "authorized by some authority" to participate.[96] The authority can be either an individual entity or a group of entities that verify admission based on an established set of rules. As a result, it is cheaper and more efficient to maintain the system, and such networks offer greater privacy among users.[97]

90. *See infra* Subpart I.C.1.d.
91. FINCK, *supra* note 84, at 15; YAGA, MELL, ROBY & SCARFONE, *supra* note 1, at 5.
92. OECD, BLOCKCHAIN PRIMER, *supra* note 28, at 5.
93. *Id.*
94. *Id.*
95. YAGA, MELL, ROBY & SCARFONE, *supra* note 1, at 5.
96. *Id.*
97. Jian Zhang, *Deploying Blockchain Technology in the Supply Chain*, INTECHOPEN (May 28, 2019), https://www.intechopen.com/books/computer-security-threats/deploying-blockchain-technology-in-the-supply-chain [https://perma.cc/S2Q7-4FGX] (discussing how permissioned blockchain allows for a "private blockchain" and often has "consensus protocols" that promote efficiency).

A unique feature of the permissioned blockchain is that it can restrict who can issue the transactions and who can access the ledger because only authorized users are participating in the network.[98] This is not possible with permissionless blockchains. Furthermore, permissioned blockchains are flexible enough that a user can decide whether they want the public to see the content of the transactions or restrict it to authorized users only.[99] Figure 4 illustrates the features of a permissioned, private blockchain where only Parties A through J have permission to access the blockchain. Each column represents transacting parties and each row represents transactions. Note row 1, columns A and B, representing a transaction between A and B. Suppose C, D, and E are not relevant parties to this transaction and the system wants to restrict their access to the information in block [A&B, 1]. When block [A&B, 1] is added, the transaction record is validated by and distributed to all parties, including C through J. C, D, and E are restricted from accessing and viewing the record, however, while F through J may access and view the record.

Figure 4: Restricted Access in Permissioned Blockchain[100]



Both permissionless and permissioned blockchains have consensus models. The consensus process, however, is much more efficient and cost-effective in permissioned blockchains compared to permissionless blockchains because a certain level of trust already exists between the parties that are authorized to

98. *Id.*
99. *Id.*
100. KPMG, BLOCKCHAIN AND ARTIFICIAL INTELLIGENCE IN TAX 9 (Sep. 2019) (on file with author).

participate in a permissioned blockchain.[101] Further, permissionless blockchains need some form of an incentive to encourage participants to participate and ultimately validate the transactions, thereby requiring additional cost that is associated with compensating participants.[102] Bitcoin is a good example.[103] Conversely, permissioned blockchains are used by persons who share a common incentive for using and validating the blockchain. Hence, users in a permissioned blockchain do not expect or require any monetary form of compensation for their participation in the network.

Because of this, a permissioned blockchain is a great option for organizations that want to work together but do not fully trust each other.[104] Many recommend permissioned blockchains for businesses, enterprises, and other areas where a blockchain can be used to build up a trustworthy ledger or database in order to share information among relevant parties. Blockchain participants can benefit from the ability to "selectively reveal transaction information based on a blockchain network user[']s identity or credentials,"[105] and limit which of those users have access to view the information within the transaction. For example, the IBM Blockchain Platform offers services for businesses to create their own private, permissioned blockchain.[106]

3. Consortium Blockchain

A noteworthy variation of the private blockchain system is a consortium blockchain. A consortium blockchain is a partially decentralized blockchain. Every node validates the list of transactions while only exposing the details of private transactions and contracts to relevant parties.[107] The main difference between the plain vanilla private blockchain and a consortium blockchain is who can write the transactions on the blockchain ledger. Both variations allow only authorized participants to read the ledger and view transaction data because

101. *Id.* at 5–6.
102. *Id.*
103. To encourage persons to mine Bitcoin, the company is currently promising 12.5 Bitcoins per block that is processed. Clem Chambers, *Cryptocurrency Mining Profits Are Way Down*, FORBES (July 2, 2018), https://www.forbes.com/sites/investor/2018/07/02/ cryptocurrency-mining-profits-are-way-down/#1bdc50086c50 [https://perma.cc/ Y86Z-XQXC].
104. YAGA, MELL, ROBY, & SCARFONE, *supra* note 1, at 6.
105. *Id.* (providing the example that a blockchain can show that a transaction between two parties occurred, but the content of the transaction is only visible to the involved parties).
106. *See IBM Blockchain Platform*, IBM, https://www.ibm.com/in-en/blockchain/platform [https://perma.cc/5GQ9-7W2R].
107. Shaverdian, *supra* note 68, at 1268.

both are private blockchains. Only the network operator or administrator, however, can write and commit to the plain vanilla private blockchain whereas all (or at least a subset) of authorized participants may write and commit to the consortium blockchain.

Thus, a consortium blockchain enjoys the same benefits as a private blockchain by being functional, cost efficient, and private without consolidating power in one user, thus offering the best of both worlds. As an example, JP Morgan has created a consortium blockchain called Quorum that aims to service the needs of a permissioned group of financial institutions.[108] Because of the wide range of benefits and design options that are possible with consortium blockchains, this Article considers a consortium blockchain as one of the best options for tax administration as discussed further in Subpart II.B.

C. Applied Blockchains in the Private and Public Sectors

Cryptocurrencies are the most famous application of blockchain technology. As previous Subparts explained, however, blockchain itself is a decentralized, immutable, peer-to-leer ledger technology with the benefits of transparency, immutability, and data security, which produces many applications across society. Recently, both the private[109] and public sectors[110] have begun to utilize blockchain technology as a data management system. This Subpart illustrates various applications of blockchain in both sectors, which provides insight into how blockchain design can benefit tax administration.

1. Private Sector Applications

The private sector includes some of the earliest adopters of blockchain technology, primarily in financial markets and services. Identifying these applications helps determine how blockchain could benefit tax administration. These applications include cryptocurrency, banking and payment services, and general financial services.

108. *See* QUORUM, https://www.goquorum.com [https://perma.cc/8HCP-UH87].
109. For example, financial services, supply chains, smart contracts, and personal records.
110. For example, property records, voting, public health, defense, and compliance.

a. Cryptocurrency

While blockchain has developed diverse applications in other areas, cryptocurrency is the earliest and the most wellknown application of blockchain technology.[111] Since the launch of Bitcoin in January 2009, thousands of cryptocurrencies have emerged, including Ethereum, Tether, Bitcoin Cash, Libra, and Monero.[112]

The backbone of cryptocurrencies is to offer a digital currency that can operate without the need for a central authority, and blockchain is their bedrock.[113] Satoshi Nakamoto, Bitcoin's developer, explained that fiat currencies like the U.S. dollar are regulated and verified by a central authority, usually a bank or government.[114] Under the central authority system, a user's data and currency are susceptible to the stability of their bank or government. If a user's bank collapses or they live in a country with an unstable government, the value of their currency is at risk. By spreading its operations across a network of computers, however, blockchain allows cryptocurrencies to operate without the need for such central authority. This not only reduces risk but also eliminates many of the processing and transaction fees.[115] Cryptocurrencies also provide people living through crises or in countries with unstable fiat currencies with a more stable currency that can apply to a wider network of individuals and institutions they can transact with, both domestically and internationally.[116]

Beyond cryptocurrency, blockchain technology is now being used across the financial industry, such as in banking and post-trading processing, because blockchain can reduce costs and make transactions faster and more transparent.[117]

111. KEVIN WERBACH, THE BLOCKCHAIN AND THE NEW ARCHITECTURE OF TRUST 54 (2018).
112. Luke Conway, *The 10 Most Important Cryptocurrencies Other Than Bitcoin*, INVESTOPEDIA (June 1, 2021), https://www.investopedia.com/tech/most-important-cryptocurrencies- other-than-bitcoin [https://perma.cc/XB49-Q75Y]. As of January 2021, there are over 4000 cryptocurrencies tradable at Coinbase, one of the biggest digital exchanges for cryptocurrency. *See* COINBASE, https://www.coinbase.com/price [https://perma.cc/ B6LE-WS7H].
113. Satoshi Nakamoto, *Bitcoin Open Source Implementation of P2P Currency*, P2P FOUNDATION: FORUM (Feb. 11, 2009, 10:27 PM), http://p2pfoundation.ning.com/ forum/topics/bitcoin-open-source [https://perma.cc/Y3WF-DRBQ].
114. *Id.*
115. *Id.*
116. Marcia Narine Weldon & Rachel Epstein, *Beyond Bitcoin: Leveraging Blockchain to Benefit Business and Society*, 20 TRANSACTIONS: TENN. J. BUS. L. 837, 845–46 (2019).
117. *Id.* at 864; BASHIR, *supra* note 27, at 555.

b. Banking

In banking, money transfer and payment services are actively considering blockchain.[118] Considering that tax administration closely relates to cash flow, the blockchain-based payment system has potential to be integrated to a blockchain for tax administration. In traditional banking, depositing checks or sending money via wire transfers can take several business days.[119] Once cleared, banks can settle the amounts only during business days. The delay is often exacerbated in cross-border payments. Conversely, blockchain never sleeps. By integrating blockchain, consumers can see their transactions processed in minutes, basically the time it takes to add a block to the blockchain, regardless of the time or day of the week. Beyond retail banking, banks also have the opportunity to exchange funds between institutions more quickly and securely.[120] Because of the benefits of the technology, established companies ranging from JP Morgan to the Ripple are building blockchain-based money transfer or payment services on either private or consortium blockchains.[121] Even central banks are implementing blockchain,[122] with over forty central banks implementing or

118. *See, e.g.*, Matt Higginson, Atakan Hilal & Erman Yugac, *Blockchain and Retail Banking: Making the Connection*, MCKINSEY & CO. (June 7, 2019), https://www.mckinsey.com/industries/financial-services/our-insights/blockchain-and-retail-banking-making-the-connection# [https://perma.cc/N3WV-FUFB].

119. HYPERLEDGER, INTRODUCTION, *supra* note 28, at 13 (discussing how bank regulations require verification of customers' identity for transactions).

120. Justin Pritchard, *How Blockchain Is Changing Banking and Financial Services*, BALANCE (June 30, 2021), https://www.thebalance.com/how-blockchain-is-changing-banking-and-financial-services-4174354 [https://perma.cc/ZQD3-TFD2].

121. Santander Bank with Ripple launched the first blockchain-based international money transfer service. *One Pay FX: Blockchain for Streamlining International Transfers*, SANTANDER (July 28, 2020), https://www.santander.com/en/stories/one-pay-fx-blockchain-for-streamlining-international-transfers [https://perma.cc/JH9Q-QJ2V]. Similarly, Ripple offers RippleNet, a payment business which connects hundreds of banks and payment providers to make payments with fiat currency or Ripple's own XRP cryptocurrency. RIPPLE, https://ripple.com/ripplenet [https://perma.cc/JSC2-J5C7]; (*see also* JP MORGAN, https://www.jpmorgan.com/ onyx/liink.htm [https://perma.cc/3HNV-NBSX]; Nate DiCamillo, *JPMorgan's Blockchain Lead Is Now in Charge of Ethereum-Based Interbank Information Network*, COINDESK (Oct. 8, 2020), https://www.coindesk.com/jpmorgans-blockchain-lead-is-now-in-charge-of-ethereum-based-interbank-information-network [https://perma.cc/ 6NKT-4LBP].

122. *See BIS Innovation Hub Work on Central Bank Digital Currency (CBDC)*, BANK FOR INT'L SETTLEMENTS, https://www.bis.org/about/bisih/topics/cbdc.htm [https:// perma.cc/N3M2-PFSQ] (introducing pilot projects to study blockchain for central banks by the Bank for International Settlements, an international organization to support central banks' pursuit of monetary and financial stability).

researching blockchain technology.[123] Some central banks have even implemented pilot programs based on Central Bank Digital Currency (CBDC), where "the central bank issues digital tokens on a distributed ledger that represent, and are redeemable for, central bank reserves in the domestic currency held in a separate account with the central bank."[124] The CBDC program uses a private, permissioned blockchain network to limit participants, and access must be granted to participate and view transactions.[125]

Despite the growth of blockchain technology, there remains some hesitancy. PwC found that 57 percent of those surveyed were unsure or unwilling to make use of this new technology.[126] This hesitancy may be because of the newness of blockchain technology and the uncertainty that comes with change.[127] Ripple argues, however, that mindsets are changing and more payment services are beginning to adopt blockchain technology.[128] Ripple conducted a survey among 854 respondents across 22 countries who are directly involved with payment services at their organization in 2020, and 59 percent of respondents indicated that their organizations are in production or near production for payments-related use cases and 99 percent indicate that their organization would consider using a digital asset either as a digital currency or as a means to instantly process cross-border payments.[129] Blockchain is scalable in payment solutions, and as more organizations adopt a blockchain in payment systems, the integration will become easier.[130] The COVID-19 pandemic eliminated some of the challenges in adopting blockchain

123. CHRISTIAN BARONTINI & HENRY HOLDEN, BANK FOR INT'L SETTLEMENTS, PAPER NO. 101, PROCEEDING WITH CAUTION—A SURVEY ON CENTRAL BANK DIGITAL CURRENCY 6 (2019), https://www.bis.org/publ/bppdf/bispap101.pdf [https://perma.cc/D9RS-BSKA].

124. WORLD ECON. F., CENTRAL BANKS AND DISTRIBUTED LEDGER TECHNOLOGY: HOW ARE CENTRAL BANKS EXPLORING BLOCKCHAIN TODAY? 5 (2019), http://www3.weforum.org/docs/WEF_Central_Bank_Activity_in_Blockchain_DLT.pdf [https://perma.cc/FQ5A-AWA9].

125. *Id.*

126. PRICEWATERHOUSECOOPERS, FINANCIAL SERVICES TECHNOLOGY 2020 AND BEYOND: EMBRACING DISRUPTION 45 (2020), https://www.pwc.com/gx/en/financial-services/assets/pdf/ technology2020-and-beyond.pdf [https://perma.cc/3YB6-CMGU].

127. William Girling, *Blockchain: Optimizing Payments or Disrupting Them?*, FINTECH (Oct. 9, 2020), https://www.fintechmagazine.com/digital-payments/blockchain-optimising-payments-or-disrupting-them [https://perma.cc/EA5G-VKBZ].

128. RIPPLE, FINDINGS FROM RIPPLE'S BLOCKCHAIN IN PAYMENTS REPORT 2020 (2020), https://ripple.com/lp/blockchain-in-payments-report [https://perma.cc/7YFM-3XTA].

129. *Id.* at 2.

130. *Id.* at 8, 18.

because the modernization and streamlining of one's payment solution system became imperative when the entire world went remote.[131]

c. The Financial Industry

Other financial industries, especially capital markets dealing with debt and equity securities, have great hope for blockchain to restructure the clearing and settlement system.[132]

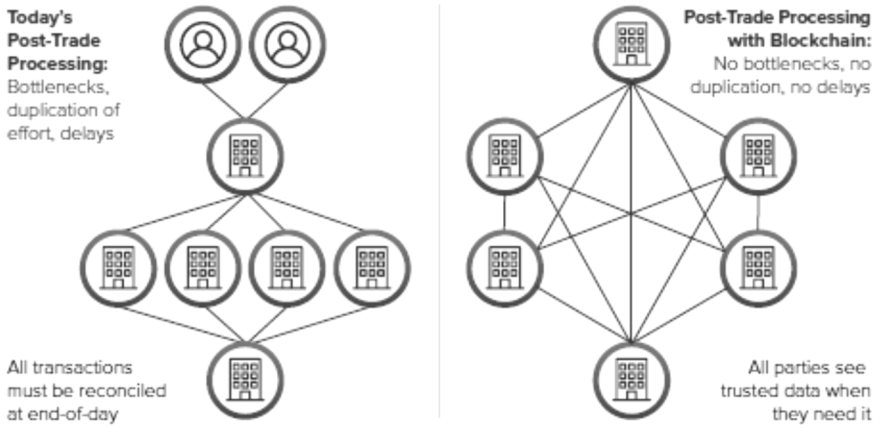
In capital markets, the post-trading process today suffers from significant bottleneck effects and duplication of effort because every transaction must go through a fragmented workflow involving multiple parties in each step of the process with different interfaces. To illustrate, if Parties A and B enter into a security transaction, a middleman must validate, clear, and settle such transaction.[133] This process, known as the post-trade process, includes several steps that can involve a third party—usually a clearinghouse—to clear trades. Then, the parties send separate settlement instructions to the settlement agent, and the settlement agent must collaborate to match the instructions.[134] Afterwards, custodians of the parties must adjust their position according to this transaction. On top of all this, there are also reporting requirements to multiple regulatory and risk management entities.[135] All these steps involving multiple parties with different interfaces must then be reconciled "at the end of the business day."[136]

On the other hand, a post-trade process with blockchain can be far more efficient.[137] The blockchain protocol can verify the transaction between Parties A and B without a third party. Other relevant parties, including the regulatory agencies, also join the blockchain network and receive the information on a "need to know basis." All post-trade processing is performed seamlessly without further duplicative reconciliation. Blockchain also performs the entire post-trade process in almost real time, significantly reducing transaction time and cost.[138] Because the post-trade process shares similar efficiency concerns to some

131. *Id.* at 20.
132. Weldon & Epstein, *supra* note 116, at 864–65.
133. HYPERLEDGER, INTRODUCTION, *supra* note 28, at 13.
134. *Id.* at 14.
135. U.S. CONG., OFF. OF TECH. ASSESSMENT, TRADING AROUND THE CLOCK: GLOBAL SECURITIES MARKETS AND INFORMATION TECHNOLOGY 81 (July 1990), https://ota.fas.org/reports/9043.pdf [https://perma.cc/92PF-ZK85] (describing how after clearance and settlement, "buy and sell data [is] reported by market participants").
136. HYPERLEDGER, INTRODUCTION, *supra* note 28, at 14.
137. *Id.*
138. *Id.*

of the tax systems, such as payroll and withholding tax system, the efforts of the financial industries may inspire the tax administration.

Figure 5: Comparison of Post-Trade Process with Blockchain-based System[139]



The Depository Trust & Clearing Corporation (DTCC), the premier market infrastructure for the global financial services industry, aims to shift the post-trade clearing and settlement system to a consortium blockchain system with relevant parties as members.[140] The DTCC thinks that blockchain is still too immature to be fully incorporated into the post-trading process because of its problem with scalability and integration, among other problems.[141] The DTCC continues to test the viability of blockchain, however, by launching projects such as a proof-of-concept blockchain to manage the netting process for repurchase agreement (repo) transactions and derivatives.[142]

139. *Id.* at 13.

140. *DTCC Unveils Proposals to Explore Further Digitalization in the Public & Private Markets*, DTCC: PRESS RELEASES (May 18, 2020), https://www.dtcc.com/news/2020/may/ 18/dtcc-unveils-proposals-to-explore-further-digitalization [https://perma.cc/4ZQ6-E66L] ("Project Ion explores whether the digitalization of assets and application of DLT can accelerate settlement and reduce cost and risk for the industry.").

141. Joseph King, *DTCC Sharpens Distributed Ledger Focus With White Paper*, DTCC: PRESS RELEASES (Feb. 3, 2016), https://www.dtcc.com/news/2016/february/03/dtcc-sharpens-distributed-ledger-focus-with-white-paper [https://perma.cc/ASP4-QUPA].

142. *See DTCC & Digital Asset Move to Next Phase After Successful Proof-of-Concept for Repo Transactions Using Distributed Ledger Technology*, DTCC: PRESS RELEASES (Feb. 27, 2017), https://www.dtcc.com/news/2017/february/27/dtcc-and-digital-asset-move-to-next-phase [https://perma.cc/VM5P-JVKB]; *DTCC Selects IBM, Axoni and R3 to Develop DTCC's Distributed Ledger Solution for Derivatives Processing*, DTCC: PRESS RELEASES (Jan. 9, 2017),

d. Supply Chains

Nonfinancial firms can also apply blockchain to supply chains to improve productivity and efficiency. They consider various architectures of blockchain model which gives insight of blockchain design ideas to tax administration. For example, Walmart has collaborated with IBM to introduce a blockchain system, called IBM Food Trust, to track the origin and travel of some of its perishable products.[143] This effort is tied to an attempt to curb and quickly identify food-borne pathogens common to such products. Before the project, it could take days, if not weeks, to identify the source of food-borne illnesses.[144] Because it is so hard to track the source of particular produce, governments commonly advise consumers to avoid products grown within a relatively large geographic area. As a result, millions of food items can be thrown out when an outbreak starts.[145] But, if the source of a product can be effectively traced, companies will be able to react quickly and "only discard[] produce from the affected farms."[146]

Walmart sees blockchain as a necessary tool in the supply chain of perishable foods because it provides traceability, immutability, and trustworthiness to the movement of the foods between differing parties.[147] Each member of the perishable item's supply chain makes an entry on a blockchain ledger, "signing off when they receive it and then when they move it onto the next person in the chain."[148] The initial pilot program showed great results, as Walmart was able to cut the time it took to track down the origin farm of mangoes from "7 days [to] 2.2 seconds with blockchain."[149] Walmart required all of its suppliers of fresh leafy greens to trace their products using the blockchain system by 2019[150] and now officially uses blockchain to "trace the origin of over 25

https://www.dtcc.com/news/2017/january/09/dtcc-selects-ibm-axoni-and-r3-to-develop-dtccs-distributed-ledger-solution [https://perma.cc/8HD8-64EL].

143. HYPERLEDGER, HOW WALMART BROUGHT UNPRECEDENTED TRANSPARENCY TO THE FOOD SUPPLY CHAIN WITH HYPERLEDGER FABRIC (2019), https://www.hyperledger.org/wp-content/uploads/2019/02/Hyperledger_CaseStudy_Walmart_Printable_V4.pdf [https://perma.cc/C6AC-3YZV] [hereinafter HYPERLEDGER, WALMART].
144. *Id.* at 2.
145. *See id.*
146. *Id.*
147. *See id.* at 3.
148. Michael Corkery & Nathaniel Popper, *From Farm to Blockchain: Walmart Tracks Its Lettuce*, N.Y. TIMES (Sept. 24, 2018), https://www.nytimes.com/2018/09/24/business/ walmart-blockchain-lettuce.html [https://perma.cc/Y9DU-YRRN].
149. HYPERLEDGER, WALMART, *supra* note 143, at 5.
150. Charles Redfield, Martin Mundo, Russell Mounce & Frank Yiannas, *Food Traceability Initiative: Fresh Leafy Greens*, WALMART (Sept. 24, 2018), https://corporate.walmart.com/

products from 5 different suppliers."[151] Walmart's technical partner, IBM, has been offering the IBM Food Trust to a broader circle of food industry members, including more than 80 members and tracking over 1300 products.[152]

The Walmart-IBM system is a private permissioned blockchain, where a member company can view a products' history, location, certifications, tests, and temperature data only if such member company is permissioned to access the data.[153] Customers, however, cannot access the detailed information on food safety and quality management. Given that one of the strong motivations to adopt blockchain in food supply chains is to improve data transparency, keeping the public from the data did not fulfill Walmart-IBM's goal for the blockchain project.

Walmart China made an improvement on the issue of transparency: Its new blockchain platform introduced in 2019 is using a hybrid blockchain—a public and permissioned blockchain.[154] Thus, Walmart China can transact with suppliers on a permissioned ledger while also sharing with its consumers information about products with consumers on a public ledger. Customers can scan QR codes related to dozens of products to discover their origin and authenticity.[155] Amid the COVID-19 pandemic, food industry supply chains have further required traceability and transparency, not only for the industry but also for customers, such as restaurants and the general public. Thus, the food industry may need to embrace hybrid public and permissioned blockchains more actively than it currently does.

media-library/document/blockchain-supplier-letter-september-2018/_proxyDocument?id=00000166-088d-dc77-a7ff-4dff689f0001 [https://perma.cc/7EDU-4PA4].

151. HYPERLEDGER, WALMART, *supra* note 143, at 1.

152. Biser Dimitrov, *How Walmart and Others Are Riding a Blockchain Wave to Supply Chain Paradise*, FORBES (Dec. 5, 2019, 8:47 AM), https://www.forbes.com/sites/biserdimitrov/2019/12/05/how-walmart-and-others-are-riding-a-blockchain-wave-to-supply-chain-paradise/?sh=732c97917791 [https://perma.cc/W2ZA-82SS]. Other notable members are Carrefour, Driscoll's, McLane, Kroger and Tyson.

153. IBM, ABOUT IBM FOOD TRUST 3–5 (2019), https://www.ibm.com/downloads/cas/8QABQBDR.

154. Daniel Palmer, *Walmart China Teams With VeChain, PwC on Blockchain Food Safety Platform*, COINDESK (June 25, 2019, 7:39 AM), https://www.coindesk.com/walmart-china-teams-with-vechain-on-blockchain-food-safety-platform [https://perma.cc/DF5Y-LD3V]. Walmart China is teamed up with VeChain, PwC, and others but not with IBM.

155. *Id.*

e. Smart Contracts

A smart contract is a computer code that can be built into the blockchain to facilitate, verify, or execute a contract automatically without human intervention.[156] Smart contracts are computer programmed rules stating "if-then" logic and do not require a blockchain to run. Due to the benefits that blockchain can offer, however, smart contracts are mostly executed on blockchain platforms.[157] The "if-then" logic operates as follows: If a set of agreed upon conditions are met, then the terms of the smart contract are automatically executed.[158]

For example, Amy is renting her apartment to Ben using a smart contract.[159] Amy agrees to give Ben the door code to the apartment as soon as Ben pays Amy his security deposit. Both parties would separately send their portion of the deal to the smart contract, which would hold onto and automatically exchange Amy's door code for Ben's security deposit on the date of the rental. Both Ben and Amy can know when the other party's commitment are fulfilled without delay and there is no need to confirm the receipt of payment or send the door code separately. If Amy does not supply the door code by the rental date, the smart contract refunds Ben's security deposit. This eliminates the risk of delays and reliance on middlemen to follow through on their commitments. Also, the information sharing between parties is transparent, time stamped, and irreversible.

Because of these unique features, smart contracts have benefits that are especially significant to the financial industry.[160] These features may also benefit blockchain for tax administration by reducing costs, improving precise execution, and increasing transparency. In addition, blockchain's smart contract feature may further develop or enable decentralized autonomous organizations (DAOs), where corporate governance and operations can be executed by computer codes automatically.[161]

156. David J. Shakow, *The Tao of the DAO: Taxing an Entity That Lives on a Blockchain*, 160 TAX NOTES 929, 930–31 (2018).
157. BASHIR, *supra* note 27, at 53–54.
158. *Id.* at 54.
159. This example is based on the explanation in Luke Conway, *Blockchain Explained*, INVESTOPEDIA (June 1, 2021), https://www.investopedia.com/terms/b/blockchain.asp [https:// perma.cc/5APN-GCMU].
160. BASHIR, *supra* note 27, at 261.
161. WERBACH, *supra* note 111, at 68.

f. IDs and Personal Data Management

Blockchain is essentially a data management system that contributes to securely managing personal information and records.[162] Existing data management systems might protect personal data with encryption and security protocol, but they remain susceptible to cyberattacks. Blockchain offers enhanced security because of its distributed and immutable nature, and at the same time, an individual owner of the data can control who has access to their data.[163] Such features can enhance taxpayer privacy if reflected in blockchain for tax administration.

The blockchain industry has developed portable digital identities for this purpose.[164] Such digital identities are protected by cryptography in blockchain protocol and can offer rich metadata of an individual's identity and sophisticated access control.[165] These digital identities are shared via the blockchain so that individuals may use their digital identity wherever the blockchain is accepted. This feature benefits financial data management institutions as well. Financial institutions are required to manage customer data while also having to abide by the laws and regulations that prevent money laundering and terrorist support.[166] Such data management is expensive and even more challenging if financial institutions must comply with different international regulations for cross-border transactions.[167] But blockchain is borderless. The digital identities and financial records managed via blockchain can reinvent the financial record management system.

Additionally, even healthcare patients can leverage blockchain to securely store their medical records and regulate access, thereby ensuring privacy.[168] When a medical record is generated and signed, it can be written into the blockchain with a private key, which provides patients with confidence that the record cannot be changed and is only accessible by certain individuals or organizations, such as their medical providers.[169] Furthermore, blockchain could

162. *See, e.g.*, HYPERLEDGER, INTRODUCTION, *supra* note 28, at 17.
163. *Id.*
164. *See, e.g.*, *id.*
165. *Id.*
166. Colleen Baker & Kevin Werbach, *Blockchain in Financial Services*, *in* FINTECH: LAW AND REGULATION X.24–25 (Jelene Madir ed., 2d ed. 2021).
167. *Id.* at X.26.
168. Ray Hales Hylock & Xiaoming Zeng, *A Blockchain Framework for Patient-Centered Health Records and Exchange (HealthChain): Evaluation and Proof-of-Concept Study*, 21 J. MED. INTERNET RSCH. 1 (2019), https://www.jmir.org/2019/8/e13592/pdf.
169. *Id.*

reinvent the way a patient's electronic health records are shared among medical providers.[170] In traditional health record management systems, each institution silos their patients' data, resulting in fragmentation and an inefficient data sharing mechanism. This results in inefficient care coordination during medical emergencies due to the lack of critical medical information.[171] As noted above, however, blockchain can offer safer mechanisms for the health industry's exchange of medical data.

2. Public Sector Applications

The primary benefits of blockchain—that is, promoting trust and greater transparency about data management—can benefit the public sector as well. Many countries are considering using blockchain in government settings in various ways, and the number of projects is growing. There were only 117 initiatives using blockchain in the public sector in 26 countries in 2017; in 2018, there were 202 initiatives in 45 countries.[172]

In the United States, the General Service Administration (GSA) launched the Emerging Tech Atlas program in 2017 to study the benefits that emerging technologies, including artificial intelligence and blockchain, may bring to public services.[173] Since then, many federal, state, and local working groups have explored the potential applications of blockchain in the public sector to promote trust and integrity in government.[174] Below are some of the notable initiatives.

a. Property Records

Today, the process of recording property rights in a local recording office is both burdensome and inefficient. A physical deed must be delivered to a government employee at the local recording office where the deed is manually

170. *Id.* at 2.
171. *Id.*
172. OBSERVATORY OF PUB. SECTOR INNOVATION, BLOCKCHAIN AND ITS USE IN THE PUBLIC SECTOR 17–18 (2018), https://oecd-opsi.org/wp-content/uploads/2018/06/Blockchains-Unchained-Slides.pdf [https://perma.cc/XF79-F4XA].
173. *GSA Launches Emerging Tech Atlas to Encourage Collaboration*, U.S. GEN. SERVS. ADMIN.: GSA BLOG (Oct. 25, 2017), https://www.gsa.gov/blog/2017/10/25/GSA-Launches-Emerging-Tech-Atlas-to-Encourage-Collaboration [https://perma.cc/U2AH-RTDM].
174. *See, e.g.*, PAUL NELSON, U. S. AGENCY FOR INT'L DEV., PRIMER ON BLOCKCHAIN 5 (2018), https://www.usaid.gov/sites/default/files/documents/15396/USAID-Primer-Blockchain.pdf [https://perma.cc/7654-RYPD] (discussing the ability of blockchain technology to be more "relevant" in "environments of incomplete trust" and how a "lack of trust, whether in people or in systems people rely on, will always be an underlying driver").

entered into the county's central database and public index.[175] In the case of a property dispute, claims to the property must be reconciled with the public index.[176]

This process is not just costly and time consuming but it is also riddled with human error where each inaccuracy makes tracking property ownership less efficient. Blockchain has the potential to eliminate the need for scanning documents and tracking down physical files in a local recording office and transform the process of recording property rights.[177] If all documents relating to property ownership are stored and verified on the blockchain, property owners would be able to trust that their deed is accurate and permanent without having to deal with the current burdensome process of authenticating deeds.[178]

Noting the potential benefits, Cook County, Illinois, piloted a program in 2017 to record the county land registry on a blockchain.[179] The program identified the potential application of the various features of blockchain technology, such as the decentralized ledger, to improve access to house titles and other verifiable property data. The pilot program concluded in 2017 with meaningful lessons in the final report, stating that some aspects of blockchain worked for the property recording system while others did not and that the government may implement certain aspects of blockchain individually or selectively.[180] Furthermore, the report suggests that "if the use of blockchain were to be extended to the maintenance of a records system, it would be most optimal if the record-keeping ledger were to be distributed across all land records offices in Illinois, allowing economies of scale and the ability to create true distributed consensus."[181] The report's emphasis of the decentralized blockchain model would be an important feature to consider in recommending a blockchain model for tax administration.

175. Weldon & Epstein, *supra* note 116, at 869.
176. *Id.*
177. *See id.*
178. *See id.* But blockchain cannot eliminate preexisting mistakes or inaccuracies in the deed. Suppose that a deed incorrectly identifies the property, or an owner makes a mistake in identifying the property when creating a deed. Those errors occur at the time of input, which is beyond the control of the blockchain system. Blockchain can guarantee the accuracy of the stored digital information only after the digital data is correctly inputted. *See infra* Subpart III.C for this limitation.
179. KAREN A. YARBROUGH & JOHN MIRKOVIC, BLOCKCHAIN PILOT PROGRAM FINAL REPORT 7 (2017), http://cookrecorder.com/wp-content/uploads/2016/11/Final-Report-CCRD-Blockchain-Pilot-Program-for-web.pdf [https://perma.cc/5DAN-RA2R].
180. *Id.* at 4.
181. *Id.*

b. Voting

Voting is still executed through a low-tech method despite this digital age, because security is far more important to the public and federal, state, and local legislative branches than efficiency.[182] Consequently, our low-tech voting process is susceptible to many errors, such as hanging chads (incompletely punched paper ballots) and miscounts.[183] Voting with blockchain carries the potential to eliminate election fraud and boost voter turnout, as was tested in the 2018 midterm elections in West Virginia as an alternative to mailed absentee ballots.[184] Each vote would be stored as a block on the blockchain, making the cast votes nearly impossible to tamper with. A voting blockchain would create an atmosphere of transparency and trust in the electoral process, reducing the personnel needed to conduct an election and provide officials with instant results.

Encouraged by West Virginia's experience, the City of Denver and Utah County also planned to implement a pilot program to offer blockchain-based voting services to active duty military in the future elections.[185] West Virginia passed a law requiring an electronic voting option for counties across the state.[186] In February 2020, however, West Virginia decided not to use the blockchain-based voting option after the audits by MIT and the Department of Homeland Security (DHS) revealed security concerns regarding the particular mobile app used by West Virginia.[187]

182. Sarah Holder, *Is This Experiment in Digital Democracy Too Crazy to Work*, BLOOMBERG CITYLAB (Sept. 11, 2018), https://www.bloomberg.com/news/articles/2018-09-11/blockchain-based-voting-is-coming-to-west-virginia [https://perma.cc/EAV5-B9A3].

183. *See, e.g.*, Samantha Levine, *Hanging Chads: As the Florida Recount Implodes, the Supreme Court Decides Bush v. Gore*, U.S. NEWS (Jan. 17, 2008, 5:00 PM), https://www.usnews.com/news/articles/2008/01/17/the-legacy-of-hanging-chads [https://perma.cc/3MUG-LVHN].

184. Aaron Mak, *West Virginia Introduces Blockchain Voting App for Midterm Election*, SLATE (Sept. 25, 2018, 12:00 PM), https://slate.com/technology/2018/09/west-virginia-blockchain-voting-app-midterm-elections.html [https://perma.cc/7E8H-VXC2].

185. Nikhilesh De, *City of Denver to Pilot Blockchain Voting App in Coming Elections*, COINDESK (Mar. 7, 2019, 6:00 AM), https://www.coindesk.com/city-of-denver-to-pilot-blockchain-voting-app-in-coming-elections [https://perma.cc/T4MH-2YP6]; Daniel Palmer, *Utah County to Offer Blockchain Voting App in Municipal Elections*, COINDESK (July 23, 2019, 4:09 AM), https://www.coindesk.com/utah-county-to-offer-blockchain-voting-app-in-municipal-elections [https://perma.cc/QFX6-W7W2].

186. Kevin Collier, *West Virginia Plans to Make Smartphone Voting Available to Disabled People for 2020 Election*, NBC NEWS (Jan. 31, 2020), https://www.nbcnews.com/ tech/security/west-virginia-plans-make-smartphone-voting-available-disabled-people-2020-n1127931 [https://perma.cc/55FW-6A8U].

187. Samuel Haig, *West Virginia Abandons Blockchain Voting in Favor of Paper*, COINTELEGRAPH (Mar. 2, 2020), https://cointelegraph.com/news/west-virginia-abandons-blockchain-voting-

Despite the controversy over the current flaws in blockchain voting systems, the need for secure remote voting increased in the wake of COVID-19. The U.S. Postal Service (USPS) filed a new patent in 2020 to use blockchain to make mail-in voting a safe alternative to traditional physical voting.[188] Furthermore, the trial and error in the voting system regarding security of the system and privacy of voters would offer a lesson to a potential blockchain for tax administration.

c. Public Health

Important developments of blockchain applications occurred in connection with the public health crisis. Since 2017, the Centers for Disease Control (CDC) has launched several projects to establish better public health surveillance.[189] Those projects aim to improve the continuous and systemic collection, analysis, and interpretation of health-related data to respond to public health crises.[190] Tracking major public health developments requires government agencies to collect and process tremendous amounts of data while addressing privacy and security concerns at the same time. These CDC projects would allow the agency to quickly respond to health crises as they unfold.

The CDC projects also explore the application of blockchain in many levels, such as within the CDC; between the CDC and partners in the private sector, such as health providers, financial institutions, and food suppliers; and a consortium blockchain among the entire public health community, including federal, state, and local governments.[191] The approach to create a consortium blockchain resonates with the tax administration considering blockchain initiatives, which will be further discussed in Subpart II.B.

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in-favor-of-paper [https://perma.cc/4GMN-YZTY]; Danny Nelson, Nikhilesh De & Benjamin Powers, *MIT Wasn't Only One Auditing Voatz—Homeland Security Did Too, With Fewer Concerns*, COINDESK (Feb. 20, 2020), https://www.coindesk.com/mit-wasnt-only-one-auditing-voatz-homeland-security-did-too-with-fewer-concerns [https:// perma.cc/LB34-AQ74]. West Virginia used the voting app developed by Voatz. MIT researchers found that hackers could alter, stop, or expose how an individual user has voted and that Voatz's use of a third-party vendor for voter identification and verification raises privacy concerns.

188. Benjamin Pirus, *US Postal Service Files Blockchain Voting Patent Following Trump Cuts*, COINTELEGRAPH (Aug. 14, 2020), https://cointelegraph.com/news/us-postal-service-files-blockchain-voting-patent-following-trump-cuts [https://perma.cc/8YCP-RD2U].

189. DEP'T OF HOMELAND SEC., *supra* note 11, at 29.

190. *Id.*

191. Tom Savel, Dir. of the Informatics Innovation Unit in the Div. of Pub. Health Info. Dissemination, February Presenter at the CDC Health Information Innovation Consortium Forum, at 33 (Feb. 20, 2018), https://www.cdc.gov/ddphss/chiic/ forums/CDC-Blockchain-Overview_-v16_tgs_2_2018-508.pdf [https://perma.cc/3LJ6-JYL8].

In the wake of COVID-19, the first real world application of blockchain in the public sector emerged to respond to the public health crisis. In July 2020, the U.S. Department of Health and Human Services (HHS) took control over COVID-19 data reporting from the CDC and launched a COVID-19 patient data tracking system, called the HHS Protect.[192] The HHS Protect uses blockchain technology to ensure that the data for COVID-19 hospitalizations is accurate, transparent, and its traceability is enhanced.[193] It is interesting to see that HHS Chief Information Officer Jose Arrieta had to explain to the public and the media that the blockchain the HHS uses is not like Bitcoin or Ethereum or that of "anarchists and disruptors," clarifying that the true nature of blockchain is ensuring data immutable and the sharing and tracing of such data.[194]

The Food and Drug Administration (FDA) and medical industry are discussing Blockchain as a possible solution for transparent and safe distribution of COVID-19 vaccines.[195] Before the COVID-19 pandemic, the FDA launched a blockchain project called Real-Time Application for Portable Interactive Devices (RAPID) as a tool to manage data for therapeutic drug interventions employed during public health crises.[196] This project can facilitate the real time exchange of data on vaccine distribution and possible harmful side effects among agencies and medical providers without requiring the data to go through the central database, which often results in a bottleneck effect.[197] Inspired by the existing efforts, the medical industry expects that blockchain could help resolve the concerns relating to the distribution and management of the COVID-19 vaccines.[198] With the use of blockchain, pharmaceutical companies can show step-by-step details of the manufacturing, distribution, and transportation of the vaccines, such as transportation temperature and vaccine life cycle.[199] Furthermore, blockchain

192. Jason Brett, *U.S. Health Department Chief Discloses Functioning Blockchain Project to Track Covid-19*, FORBES (July 24, 2020, 8:43 PM), https://www.forbes.com/sites/jasonbrett/2020/07/24/us-health-department-chief-discloses-functioning-blockchain-project-to-track-covid-19/?sh=7e4bf7991949 [https://perma.cc/WTC5-8BT9].
193. *Id.*
194. *Id.* Arrieta is a blockchain expert. While at GSA, Arrieta was one of the core members of a blockchain working group to study potential blockchain applications in various agencies in the U.S. government.
195. Peter Fretty, *FDA Approval Is Not the Only Vaccine Challenge*, INDUSTRYWEEK (Dec. 8, 2020), https://www.industryweek.com/covid19/article/21149716/fda-approval-is-not-the-only-vaccine-challenge [https://perma.cc/4ZMR-YLPK].
196. DATA FOUND., BRINGING BLOCKCHAIN INTO GOVERNMENT: A PATH FORWARD FOR CREATING EFFECTIVE FEDERAL BLOCKCHAIN INITIATIVES 11 (2019).
197. *Id.*
198. Fretty, *supra* note 195.
199. *Id.*

can also benefit vaccine suppliers and distributers as well as regulators by offering a tool to monitor fraudulent products and any harmful side effects associated with treatment.[200]

d. More Examples

In addition to the areas explored above, several working groups and pilot projects are exploring possible blockchain applications in the public sector.

A project launched by the U.S Citizenship & Immigration Services (USCIS) and the U.S. Department of Labor (DOL) shows a potential use of blockchain among multiple government agencies.[201] The Temporary Work Visa Program requires both the DOL and USCIS to gather and verify information, respectively, which requires significant and redundant paperwork for workers and employers. The two agencies launched a blockchain project to streamline the Temporary Work Visa process between them, hoping to "increase interoperability between agencies, allowing separate agencies (e.g., USCIS and DOL) to communicate more transparently, while permitting granular control of the permissions on shared information by making certain fields visible to some users and restricting access to others."[202]

Multiple projects are hoping to use blockchain as a secure supply chain program in the government sector. For example, the U.S. Department of the Treasury launched a pilot program using blockchain to track and manage government-owned inventory, such as computers and cell phones.[203] A more interesting project is considered by the U.S. Department of Defense, combining blockchain and 3D printing technology to produce on-demand fabrication of military equipment at military facilities located worldwide.[204] Suppose that an offshore military maintenance facility needs aircraft components but faces logistical challenges to receive the replacement parts in a timely manner.[205] With 3D printing technology, the logistical challenges can be resolved if the manufacturer offers the design information and files so that the maintenance facility can print those parts on-site. The interests of the military consumers and that of the producers, however, are not aligned. The military consumers wish to have confidence that the printed parts are a true representation of the original

200. *Id.*
201. DEP'T OF HOMELAND SEC., *supra* note 11, at 29.
202. DEP'T OF HOMELAND SEC., *supra* note 11, at 29.
203. DATA FOUND., *supra* note 196, at 9–10; DEP'T OF HOMELAND SEC., *supra* note 11, at 29.
204. DEP'T OF HOMELAND SEC., *supra* note 11, at 32–33.
205. *Id.*

specification and have not been tampered with by adversaries, whereas the commercial manufacturers are more concerned about appropriate compensation on each printing. In this situation where immutability of information is critical and parties do not fully trust each other, the employment of blockchain can lead to a good solution to guarantee the immutability, transparency, and security of the transaction.

Several projects take advantage of the blockchain networks in the cross-border context. The U.S. State Department is exploring projects to use blockchain to fight forced labor, child labor, human trafficking, third-country workers and shipping fraud, and other illegal practices worldwide.[206] Furthermore, a pilot program operated in 2018 by a joint taskforce between the DHS and the U.S. Customs and Border Protection (CBP) shows the advantages of blockchain in addressing cross-border activities similar to supply chains that involve multiple governments and private partners.[207] CBP is inspecting over 80,000 shipping containers and $6 billion worth of imported goods on a daily basis.[208] Although CBP has a digital platform, the Automated Commercial Environment, to process the reporting of imports and exports and the government approval thereof, the industry still uses numerous redundant paper forms.[209] The pilot program revealed that a blockchain platform can help replace the existing paper-based process and, with intensive planning for standardization, a blockchain adopted by CBP may be interoperable with other blockchains used by multiple private parties and trading partners.[210]

Thus, despite all its complexity and challenges, blockchain's potential as a decentralized form of recordkeeping is almost without limit, even in the public sector. From a bird's-eye view, many examples in the public sector in Subpart II.C.2 are related to regulatory compliance and reporting from the perspective of citizens, such as FDA regulations, election law, immigration law, labor law, military law, and customs. Furthermore, many examples in the private sector in Subpart II.A, such as banking, financial services, personal record management, and supply chains, inevitably invite the regulatory compliance aspect. Thus, the public sector relating to compliance and reporting is a good fit to incorporate blockchain. Tax is no exception. By benchmarking the examples discussed in this Part, Part II offers a framework that evaluates whether and what types of

206. *Id.* at 28.
207. *See generally* Svetlana Angert, Blockchain Technology Implementation in the U.S. Customs Environment (Sept. 2019) (M.A. thesis, Naval Postgraduate School), https://www.hsdl.org/?view&did=831027 [https://perma.cc/XS62-TR38].
208. *Id.* at 21.
209. *Id.*
210. *Id.* at 35.

taxes are recommended to incorporate blockchain technology. Part II also explores the possible blockchain architecture that is available for tax administration.

II. BLOCKCHAIN ARCHITECTURE FOR TAX ADMINISTRATION

A. Feasibility

A couple of government-sponsored reports on applying blockchain to governments have been released since 2017, but none of these reports seriously discuss tax as an area that could benefit from the application of blockchain.[211] Blockchain technology has already been applied to many areas, however, such as cash flow and property recordkeeping that are closely integrated with the tax compliance system. If these interrelated areas have already integrated blockchain is it not worth exploring blockchain initiatives for tax administration? This Part delves into this question.

Existing studies analyzing whether blockchain is recommended for a specific area within the public sector provide four criteria in common: data redundancy, information transparency, data immutability, and a consensus mechanism.[212] If a sector requires at least three of the four factors, then that public sector is recommended to incorporate blockchain. If a sector requires one or two factors, blockchain might still work but it is likely that simpler or cheaper options are available instead of blockchain.

Tax administration requires at least three of the four factors outlined above: data redundancy, information transparency, and data immutability. In fact, tax administration sometimes requires a consensus mechanism as well. Tax administration starts with an information asymmetry between taxpayers and tax authorities. To resolve any asymmetry of information and achieve transparency, tax administration requires significant compliance and administration efforts and often data redundancy. For example, the information of a taxpayer's income must be obtained by both the federal government and state and local authorities. With payroll taxation, the amount of a taxpayer's wages is reported and shared with various government agencies and companies. Various institutions, such as insurance companies and the Social Security Administration, also collect the same information to process wage income amounts. The systems impose significant burdens on the intermediaries, such as employers, yet remain far from

211. *See, e.g.*, DATA FOUND., *supra* note 196; DEP'T OF HOMELAND SEC., *supra* note 11.
212. DEP'T OF HOMELAND SEC., *supra* note 11, at 5.

efficient because each government agency and institution involved holds their own register, in effect duplicating data held by other institutions. Thus, the supporting system for managing tax information requires constant improvements for efficiency. Furthermore, tax information must be properly used, stored securely, and protected from any undue disclosure to unrelated parties or the public. For these reasons, it is worth examining the idea of integrating blockchain into existing tax administrations.

Based on the four criteria noted above, this Article proposes a framework to help categorize areas of taxation that can benefit from blockchain, such as (1) reporting obligations of the same information to multiple tax authorities and agencies, (2) third-party reporting obligations, (3) transaction taxes, and (4) information sharing among tax authorities. Table 2 summarizes the promising categories and examples in both domestic and international tax, some of which will be illustrated in Subparts C and D.

Table 2: Tax Categories and Examples for Incorporating Blockchain

Category	Domestic tax	International tax
Reporting obligations of the same information to multiple tax authorities and agencies	• Payroll tax	• Transfer pricing and country-by-country report
Third-party reporting obligations	• Withholding tax	• Withholding tax • DAC6
Transaction tax	• Value-added tax • Sales tax • Tax on property transaction	• Customs, tariffs
Information sharing among tax authorities	Among federal, state, and local governments: • State Audit Report Program (SARP) • State Reverse File Match Initiative (SRFMI) • Municipal Agency Partnering Program	Among multiple countries • Bilateral Tax Information Exchange Agreement (TIEA) • Multilateral Tax Information Exchange Agreement • Automatic Exchange of Information

On the other hand, certain individual income taxes, including the self-employment tax and the tax on business income, would not be ideal situations to incorporate blockchain technology within. Subpart III.C discusses such limitations and why.

Subparts C and D illustrate some of the areas that are recommended in Table 2. As a preview, blockchain can benefit both tax authorities and taxpayers in those areas listed in Table 2. Tax authorities can have a better tax data management system that is more efficient and transparent and can process data in real time. In addition to the classic efficiency gain of blockchain that resolves information asymmetry between tax authorities and taxpayers, blockchain can build a more democratic system among tax authorities because it can be decentralized and distributed among federal, state, and local governments, all of whom would participate in the blockchain network on the equal footing.

Taxpayers can also benefit from the transparent and efficient blockchain system. They do not have to report their tax information separately to federal and state tax authorities nor to multiple institutions, because blockchain can eliminate the need for redundant data entry. Also, with proper design, a taxpayer's information can be further protected and shared only among the regulators and

institutions that have permission to access such data. The next Subpart envisions the desirable blockchain architecture for tax administration.

B. Recommending a Private Consortium Blockchain

To determine which type of blockchain is recommended for tax administration, it is helpful to review the pros and cons of various types of blockchains discussed in Subpart I.B.

In theory, all versions of blockchain are decentralized peer-to-peer networks that utilize some form of a consensus model to verify transactions. Public or permissionless blockchains are typically what first come to mind when one thinks of blockchain.[213] In public blockchains, anyone can read, send transactions, and participate in the consensus process. The openness of the system prevents one entity from possessing a majority control over the network.[214] The process is very costly, however, because the large number of nodes required to verify the transactions consume substantial computation power.[215] Furthermore, a key aspect of public blockchains is that anyone can access them unless the public blockchains are permissioned. Thus, it is not likely to recommend public blockchains for tax administration where taxpayers' privacy must be protected.

If having some central control of the blockchain is important, as is expected in tax administration by tax authorities, then a private permissioned blockchain is a better option than a public one. In fully private blockchains, a single organization maintains control over the entire system.[216] Unlike with public blockchains, not just anyone can participate in the network. Users must be invited into the blockchain by either the starter of the network or by a set of rules that were enacted when the network was created.[217] Private blockchains are always permissioned blockchains, so restrictions on access to certain information can be placed on private blockchains.[218] Also, private blockchains are much more

213. Shaverdian, *supra* note 68, at 1267 (noting how permissionless blockchains are the "most well-known blockchain network.").
214. *Id.*
215. *Id.*
216. Vitalik Buterin, *On Public and Private Blockchains*, ETHEREUM FOUND. BLOG (Aug. 6, 2015), https://ethereum.github.io/blog/2015/08/07/on-public-and-private-blockchains [https://perma.cc/9SWC-KPCT].
217. Praveen Jayachandran, *The Difference Between Public and Private Blockchain*, IBM: SUPPLY CHAIN AND BLOCKCHAIN BLOG (May 31, 2017), https://www.ibm.com/blogs/blockchain/2017/05/the-difference-between-public-and-private-blockchain [https://perma.cc/VGQ5-YVPB].
218. Shaverdian, *supra* note 68, at 1268.

efficient and cost-effective in comparison to public blockchains because not as many users are required to validate the transactions.[219]

Hence, private permissioned blockchains, as opposed to public blockchains, would be the recommended design for a blockchain in tax administration where the goal is to let the general public or other agencies view certain information while keeping confidential information private. Under this scenario, the central tax authority, such as the IRS, could control the blockchain and modify it as needed. Private blockchains would benefit the tax sector for two reasons. First, incorporating blockchain into tax administration can improve transparency and protect tax privacy at the same time. A private permissioned blockchain can allow the public to see certain statistical tax information while limiting the exposure of taxpayers' sensitive information. This would make it possible for the public to use this new public information from the blockchain to judge the effectiveness of the IRS's tax administration while also limiting sensitive information like names, addresses, and social security numbers from being disclosed. Second, that same blockchain can also improve efficiency beyond tax administration. Private blockchains could be used to disclose mandated information to other government agencies, while at the same time systematically keeping confidential information private.

Yet, private blockchains can raise governance issues. The blockchain's distributed network system is one of the most important advantages that blockchain can offer, as opposed to central data management, but private blockchains may retreat to another form of a central data management system.[220] In a rare case, it might be possible that the blockchain administrator acts maliciously and cause problems for the entire blockchain, such as excluding certain users, rewriting block history, or deleting resources.[221]

However, this governance problem may be mitigated if the private blockchain is also a consortium, rather than a plain vanilla private blockchain (distinction discussed in Subpart I.B.3). Consortium blockchains have all of the benefits of private blockchains while also retaining a "partially decentralized" aspect to its operation.[222] A single organization or person does not have all of the control to the blockchain network, and thus the blockchain is programmed to

219. *Id.*
220. This so-called Vili's governance paradox will be discussed in depth *infra* Subpart III.D.
221. YAGA, MELL, ROBY & SCARFONE, *supra* note 1, at 38.
222. *What Are Consortium Blockchains?*, INFINITY BLOCKCHAIN LABS (Jan. 16, 2018), https://www.blockchainlabs.asia/news/what-are-consortium-blockchains [https://perma.cc/ GL9Y-T3VT].

ensure that there is consensus amongst participants to take action. Consortium blockchains are also permissioned blockchains that allow users to join only by invitation. The blockchain network can be set up so that only a set number of nodes are required to verify a block, rather than requiring all nodes to verify. Consortium blockchains are best suited for participants who want to work together but do not completely trust each other and want to keep some information private.[223]

Therefore, a private consortium blockchain seems like the logical type of blockchain solution for tax administration. Recall the areas that could benefit from blockchain in Table 2. The areas in Table 2 primarily involve multiple tax authorities and parties who contribute tax data, making a consortium blockchain a promising architecture for tax administration.

A private consortium blockchain can resolve information asymmetry not only between tax authorities and taxpayers but also among tax authorities and other agencies in the private sector. In particular, consortium blockchains are likely the most helpful for sharing information among tax authorities in interstate and international tax. For example, a consortium blockchain could be set up to only allow certain states or countries to participate and also allow additional states or countries to join based on consensus by the participating members. Under such circumstances, a traditional plain vanilla private blockchain would not work because it is unlikely that all countries could decide which country should have all of the control. With this consortium blockchain, the exchange of tax information can be executed more efficiently and transparently. Notably, however, this process does not require a central authority, making the system democratic among the members. Also, the exchange system could be more secure since tax information could be exchanged among preselected members and further verified without other participating states or countries knowing the content of the information. This allows relevant tax information to be kept confidential within the entire network while allowing only preselected members chosen by smart contracts to have access to the content.

To illustrate, suppose that the federal government and fifty states create a blockchain network to share tax information. If only the federal government and the state of California need to access tax information of a California resident taxpayer without sharing such data with other states, such as New York, the consortium blockchain could make that possible while all states, including New

223. *Id.*

York, participate in validating the exchange of taxpayer information without accessing the content of the information.

In international tax, suppose that G20 countries create a consortium blockchain network for tax information sharing. If only the United States and the United Kingdom need to access tax information of their dual residents without sharing such data with other countries, such as China, consortium blockchain could make this possible. This feature of blockchain is particularly beneficial for international tax which inherently lacks central authorities that could guarantee the trust in multilateral cooperation. Subparts II.C.3 and II.D.2 elaborate on these domestic and international opportunities.

In sum, a private consortium blockchain is likely the most useful form of blockchain for tax purposes. With the general features of blockchain, a tax blockchain can enhance the efficiency and transparency of the tax administration system by eliminating redundant reporting and data management. With the features of private and permissioned blockchain, participants can limit what information is seen by the various users and the public. These restrictions advance the security of the tax administration system and taxpayer privacy. Furthermore, the features of consortium blockchain, as opposed to a plain vanilla private blockchain, can improve transparency and efficiency among multiple tax authorities, agencies, and private parties who contribute tax data. Consortium blockchains offer the best tools to share information among participants. At the same time, the network would be partially decentralized so that a consortium blockchain can overcome the potential drawbacks of a plain vanilla blockchain.

Building upon the general architectural recommendation, Subparts II.C and D illustrate specific areas of tax administration in domestic and international tax that might benefit from incorporating a blockchain system.

C. Examples in Domestic Tax

1. Payroll and Withholding Taxes and Beyond

Payroll taxes generally include taxes for social insurance and hospital insurance, commonly referred to as Social Security and Medicare, that, separately and collectively, are taxes under the Federal Insurance Contributions Act (FICA).[224] In addition, federal, state, and local taxes are also withheld. Although

224. John Olson, *What Are Payroll Taxes and Who Pays Them?*, TAX FOUND. (July 25, 2016), https://taxfoundation.org/what-are-payroll-taxes-and-who-pays-them [https://perma.cc/V69P-LB5E].

the ultimate tax obligation is shared between employers and employees, employers have the responsibility to withhold the employee's share from their wages and deposit such amounts.[225] Employers also withhold the employee's federal, state, and local income taxes from the employee's paycheck and pay it to the IRS on behalf of the employee.[226] Because the FICA taxes and withholding taxes operate in the same payroll system, where the tax base is the employee's income and employers are acting as a withholding agent of the employee, payroll and withholding taxes in this Article refer to all taxes withheld from the wages and salaries for simplicity.

If blockchain was incorporated into tax administration, the payroll and withholding tax system would be the frontrunner. There are many government agencies and financial institutions involved in the payroll tax, and each one collects the same data and holds its own register centrally.[227] This process duplicates data and overlaps compliance efforts, making it an ideal setting to consider blockchain to improve the systemic flaws.[228] Furthermore, the fact that the payroll and withholding tax system is already digitalized in most developed countries is an additional reason to consider blockchain.[229]

Implementing a blockchain based system can be done, for example, by embedding smart contracts that fully automate calculating and transferring tax and social security payments from employee salaries to relevant agencies and institutions.[230] The system can be expanded to include various savings and retirement plans. The process could be done in the following steps:[231]

(1) The employer enters the gross amount of compensation into the consortium blockchain system comprising of the tax authorities, government agencies, financial institutions, and the other necessary parties.

225. I.R.C. §§ 3101–3102, 3121.
226. I.R.C. § 3402.
227. Richard T. Ainsworth & Ville Viitasaari, *Payroll Tax Compliance and Blockchain*, 85 TAX NOTE INT'L 1007, 1018 (2017).
228. *Id.*
229. DELOITTE, BLOCKCHAIN TECHNOLOGY AND ITS POTENTIAL IN TAXES 11 (2017), https://www2.deloitte.com/content/dam/Deloitte/pl/Documents/Reports/pl_Blockchain-technology-and-its-potential-in-taxes-2017-EN.PDF [https://perma.cc/2P3M-8YRU] [hereinafter DELOITTE, BLOCKCHAIN TAX].
230. Ainsworth & Viitasaari, *supra* note 227, at 1021.
231. *Id.* at 1020; *see also* DELOITTE, BLOCKCHAIN TAX, *supra* note 229, at 11.

(2) Within the blockchain system, smart contracts match the data of the employee and calculate the correct tax and social security amounts.

(3) The net salary is automatically transferred to the employee's account and the calculated tax is sent to the federal and state treasury, government agencies, and other organizations.

Despite the potential benefits of a faster, less costly, and more efficient process, there are not yet many real world blockchain applications in the payroll and withholding tax system. This is because it requires an extreme level of coordination among the regulatory agencies and other players in the private sector and many are hesitant to try this new technology.[232] A handful of blockchain based platforms, however, such as Futurice and Bitwage, offer limited payroll services for processing payrolls domestically and globally.[233]

2. Value Added Taxes

Another type of tax where blockchain can provide benefits is the taxation of transactions where multiple parties and intermediaries are involved for collecting and paying the taxes. One example of this is a value-added tax (VAT).[234] Instead of taxing a percentage of the entire sales price at the time the goods or services are finally sold to the consumer, as a sales tax normally does in the United States, a VAT imposes a tax on the value added to the goods or services during each stage of the supply chain.[235] Each taxpayer in the supply chain pays VATs on any increase in value that person contributes, which is the difference between the value of an enterprise's sales (outputs) and purchases (inputs).[236]

232. Ainsworth & Viitasaari, *supra* note 227, at 1018.
233. *Id.* at 1020.
234. To be precise, a VAT is a consumption tax rather than a transaction tax imposed on a particular transaction. A VAT is placed on goods and services whenever value is added at each stage of the supply chain, from production to the point of sale, and each stage involves a transaction and conveyance. In this context, this Article uses VATs to demonstrate tax administrative problems in transactions.
235. WILLIAM G. GALE & BENJAMIN H. HARRIS, NEW SOURCES OF REVENUE AND EFFICIENCY, PROPOSAL 10: CREATING AN AMERICAN VALUE-ADDED TAX 2 (2013), https://www.brookings.edu/wp-content/uploads/2016/06/THP_15WaysFedBudget_Prop10.pdf [https://perma.cc/ 3PP8-UL4Z].
236. *Id.*

VATs are considered administratively superior to sales taxes.[237] Therefore, scholars and policymakers advocate for the adoption of VATs in the United States.[238] Nonetheless, the VAT process is complex and burdensome for taxpayers. A taxpayer must issue invoices that include output VAT, collect output VAT, pay their supplier's bills that include input VAT. Such processes make the taxpayer ultimately pay the net VAT due, which is output VAT minus input VAT.[239]

Blockchain has the potential to notably reduce the administrative burden of companies subject to VATs by streamlining the process through a decentralized system.[240] Every transaction implicating the VAT could be conducted and reported in real time, as opposed to having a team of accountants who have to dig through relevant transactions to calculate the VAT. Further, because of smart contracts, all transactions executed on the blockchain would be tamper proof and transparent, reducing the risk of fraud and mistakes.

Being able to view the effects of the VAT in real time, as opposed to only seeing the effects at the time of reporting VATs, also provides immediate insight into a company's finances.[241] When paying the VAT via a blockchain platform, high speed money transfers can take place between businesses and the government. Taxpayers can calculate the VAT amount due at the invoice level instead of the tax return level. Room for VAT fraud would also be drastically reduced because the same blockchain system processing VAT could allow multidimensional checks and verifications of the transaction's details, including the legal and business issues of the relevant parties.

In many countries, the VAT is the largest contributor to government tax revenues, and thus, tax authorities are eager to find ways to enhance the efficient collection of VATs.[242] This suggests that governments may be motivated to try a

237. *Why Is the VAT Administratively Superior to a Retail Sales Tax?*, TAX POL'Y CTR. (May 2020), https://www.taxpolicycenter.org/briefing-book/why-vat-administratively-superior-retail-sales-tax [https://perma.cc/34NB-U5JE].

238. *See, e.g.*, Reuven S. Avi-Yonah, *Summary and Recommendations (Symposium on Designing a Federal VAT, Part I)*, 63 TAX L. REV. 285 (2010); *see also* William G. Gale, *Raising Revenue With a Progressive-Value Added Tax*, BROOKINGS INST. (Jan. 28, 2020), https://www.brookings.edu/research/raising-revenue-with-a-progressive-value-added-tax [https://perma.cc/C8VA-9LJ5].

239. This process is even more burdensome for countries that require the VAT to be reported and paid on a monthly (like in most EU countries) or on a quarterly basis. *EU VAT Returns*, AVALARA, https://www.avalara.com/vatlive/en/eu-vat-rules/eu-vat-returns/eu-vat-returns.html [https://perma.cc/D3EF-LNHY].

240. DELOITTE, BLOCKCHAIN TAX, *supra* note 229, at 13.

241. *Id.*

242. *Id.* at 12.

blockchain solution for their current VAT system. Brazil and Hungary require electronic invoices, making real time reporting available via blockchain.[243] Poland is working on creating a daily reporting system of VATs.[244] The European Union (EU) proposed a blockchain solution for the VAT to prevent ongoing VAT fraud.[245] In the Middle East, the Gulf Cooperation Council (GCC) appears to have introduced the first real time blockchain VAT, and some commentators believe that the GCC's blockchain VAT system solves many of the potential fraud problems that exist in the EU's system.[246]

3. Information Sharing Among Federal, State, and Local Governments

Bringing blockchain into tax administration can offer a possible solution to the information asymmetry that currently exists among federal, state, and local governments.

Currently, federal, state, and local governments share specific tax information through various programs such as the State Audit Report Program (SARP), the State Reverse File Match Initiative (SRFMI), and the Municipal Agency Partnering Program.[247] These information sharing programs identified an estimated $6.8 billion in tax liabilities from 2013 through 2016.[248]

The federal and state governments do not equally leverage the shared information, however. The IRS shares tax information, such as audit results, with states and localities via those information sharing programs.[249] While states and localities also share tax information with the IRS, the IRS has not used "[s]tates['] audit report information effectively due to differences in the [s]tate laws, report formats, inconsistencies in the use of referrals among divisions, and changing

243. *Id.*
244. *Id.*
245. *See generally* Richard T. Ainsworth, Musaad Alwohaibi, Michael Cheetham & Camille V. Tirand, *A VATCoin Solution to MTIC Fraud: Past Efforts, Present Technology, and the EU's 2017 Proposal*, 89 TAX NOTES INT'L 335 (2018) (discussing the EU's proposal to prevent fraud within their VAT system).
246. Richard T. Ainsworth & Musaad Alwohaibi, *The First Real-Time Blockchain VAT: GCC Solves MTIC Fraud*, 86 TAX NOTES INT'L 695, 696 (2017).
247. *Local Information Sharing*, INTERNAL REVENUE SERV., https://www.irs.gov/government-entities/governmental-liaisons/local-information-sharing [https://perma.cc/53MN-8YPP]; *see also* TREASURY INSPECTOR GEN. FOR TAX ADMIN., THE INTERNAL REVENUE SERVICE CAN MORE EFFECTIVELY ADDRESS NONCOMPLIANCE BY BETTER USING AND CONTROLLING THE FED/STATE PROGRAM 1–2 (2018) [hereinafter TIGTA].
248. TIGTA, *supra* note 247, at 7.
249. *Id.* at 1.

priorities."[250] The resulting information gaps have asymmetrical consequences in tax administration. For example, if only a state finds out about additional income, federal tax repercussions rarely occur. On the other hand, if the federal government finds out about additional income, it is only a matter of time before the state or local governments also find out and challenge the taxpayer.

Another problem is caused by the state and federal tax inconformity: Because the state tax base can deviate from the federal tax base, states may be interested in different types of information than the federal government.[251] The amount of information shared also varies from state to state and is limited to the information agreed upon in individual federal-state agreements.[252] This can cause issues in compiling data, and the data may not end up serving either party.

Implementing a consortium blockchain among various governments could result in a greater possibility for federal, state, and local governments to collaborate on tax compliance. In the blockchain, tax audit information and other raw, tax related information on tax filers could be recorded. All member states can participate in verifying such information, but only relevant agencies would get permission to access such data. Implementing this type of infrastructure would eliminate the delays in exchange tax information among federal, state, and local governments. The system would also create a more standardized approach in tax compliance, which would contribute to a path toward greater conformity between state and federal authorities, as many scholars have longed for.[253]

D. Examples in International Tax

International tax has ideal conditions that could benefit from incorporating blockchain. Inherently, there is no central government or authority to resolve various issues of international tax. But international tax has many areas where tracking down the cross border cashflow or information is essential for tax administration, yet information asymmetry between relevant governments and taxpayers has been severe. To combat offshore tax evasion and achieve

250. *Id.* at 5.

251. For state and federal tax inconformity, see, e.g., Ruth Mason, *Delegating Up: State Conformity with the Federal Tax Base*, 62 DUKE L.J. 1267 (2013); Erin Adele Scharff, *Laboratories of Bureaucracy: Administrative Cooperation Between State and Federal Tax Authorities*, 68 TAX L. REV. 699 (2015).

252. TIGTA, *supra* note 247, at 2.

253. *See, e.g.*, DANIEL SHAVIRO, FEDERALISM IN TAXATION: THE CASE FOR GREATER UNIFORMITY (1993); Mason, *supra* note 251. *Cf.* Scharff, *supra* note 251 (being more sympathetic to federal-state base nonconformity and rather emphasizing state and federal tax authorities to develop cooperative tax compliance and enforcement programs).

transparency in tax information, the international community has developed many policies, such as country-by-country reporting for transfer pricing and information sharing among the relevant governments. The efficacy of those policy tools, however, is far from perfect because of the fundamental lack of trust on the management of tax data between taxpayers and governments and between relevant governments. Without a central authority's oversight, a taxpayer or government may very well hesitate to voluntarily report and share the tax information with other countries.

Blockchain enables direct, peer-to-peer data management between parties who do not fully trust each other or who do not trust any central authority to validate information. With a proper design, such as a consortium blockchain, blockchain could systematically restrict access to a particular piece of tax information, such as restricting certain countries or parties who are not pertinent to that information even if those countries or parties are a member of the consortium. This Subpart delineates two examples to show how blockchain would improve transparency and resolve information asymmetry in international tax.

1. Transfer Pricing, Country-by-Country Reporting

International transactions within the ambit of multinational enterprises (MNEs), such as a transaction between a parent company in country A and its subsidiary in country B, are called intrafirm transactions or related-party transactions.[254] In contrast, international transactions among unrelated parties are called arm's length transactions. Intrafirm trade represents a significant portion of global trade, accounting for about half of global trade volume.[255]

The term "transfer pricing" refers to tax policies and rules to regulate the setting of prices on related-party transactions in international tax.[256] If related parties could decide transfer prices of intrafirm transactions as they wish, they would have strong incentives to allocate profits to an entity in low tax jurisdictions and losses to an entity in high tax jurisdictions. Suppose that Apple Inc., the parent company in the United States, pays royalties to its wholly owned

254. Rainer Lanz & Sébastien Miroudot, *Intra-Firm Trade: Patterns, Determinants and Policy Implications*, OECD TRADE POLICY PAPERS NO. 114, June 24, 2011, at 5.

255. Intrafirm trade represented 48 percent of the U.S. imports and 30 percent of U.S. exports in 2009, and about half of export across nine OECD countries. *Id.* at 5, 12.

256. CHARLES H. GUSTAFSON, ROBERT J. PERONI & RICHARD CRAWFORD PUGH, TAXATION OF INTERNATIONAL TRANSACTIONS 710 (4th ed. 2011).

Irish subsidiary for the use of intellectual property rights owned by the Irish subsidiary.[257] If the corporate income tax rate is 35 percent in the United States but the royalty payments are taxed at very low rates in Ireland, Apple, Inc. has strong incentives to balloon the royalty payment amount that is deductible from its income because the royalty payment can reduce its U.S. tax liability whereas the royalty income of the Irish subsidiary is subject to little tax in Ireland. As a result, Apple, Inc. as a group can reduce its global tax liability using this technique often called base erosion and profit shifting.

Transfer pricing rules are designed to combat such practices that distort taxable income allocable to a particular country.[258] Tax authorities can adjust intragroup transfer prices if such prices differ from what would have been charged by unrelated enterprises dealing at arm's length.[259]

Transfer pricing rules are different for each country, however, and thus create a significant compliance burden for both tax authorities and MNE taxpayers.[260] In order to assess transfer pricing compliance, many countries require taxpayers to provide transfer pricing documentation, such as intrafirm documents and correspondence, to define the role of each involved party and comparable data.[261] Because each tax authority requires different documentation as to what they perceive as necessary (although many overlap) taxpayers are required to submit similar documents to multiple tax authorities, causing redundant data management efforts. This data is stored centrally by each country individually. Thus, there is significant risk that tax authorities cannot timely detect the possible manipulation of transfer pricing documents by taxpayers.[262]

Blockchain offers a clean solution for this problem.[263] If a blockchain was used, then intrafirm agreements and other transfer pricing documentation would be recorded on the blockchain. Such data is timestamped and cryptographically secured, reducing the risk of data manipulation. Tax authorities could easily track the flow of transactions and the identity of relevant entities in the group. Furthermore, the blockchain could be designed as a consortium among multiple countries, where MNE taxpayers can enter one

257. This is a stylized fact of an *Apple* case regarding an EU doctrine known as "state aid." *See* Joined Cases T-778/16, Ireland v. Eur. Comm'n, T-892/16, Apple Sales Int'l v. Eur. Comm'n (July 15, 2020); Ruth Mason & Stephen Daly, *State Aid: The General Court Decision in* Apple, 99 TAX NOTES INT'L 1317 (2020).
258. GUSTAFSON, PERONI & PUGH, *supra* note 256, at 710–12.
259. *Id.*
260. OECD, DISCUSSION DRAFT ON TRANSFER PRICING DOCUMENTATION AND CBC REPORTING 3 (2014).
261. *Id.*
262. DELOITTE, BLOCKCHAIN TAX, *supra* note 229, at 12.
263. *Id.*

document in the system without redundant reporting. The information on the blockchain would only be visible to the relevant tax authorities that need to have access to certain information.

Moreover, the Organisation for Economic Cooperation and Development's (OECD) recent efforts to standardize and coordinate the transfer price reporting, known as Country-by-Country Reporting (CbC Reporting), can bolster the initiatives to consider blockchain in transfer pricing. Instead of filing separate transfer pricing documentation with different countries, CbC Reporting requires that only the parent company files a country-by-country report along with a master file, while the local subsidiary files to its home country.[264] There is a common template for CbC Reporting, including the breakdown of the "group's revenue, profits, tax, and other attributes by tax jurisdiction" to give tax administrations a global picture of where MNE profits, tax, and economic activities are reported.[265] As of December 2020, over 89 countries had introduced, or taken steps to implement, CbC Reporting.[266]

The CbC Reporting system likely mitigates the data redundancy problem in transfer pricing compliance. There is still blockchain's important contribution in the international tax space, however—that is, to facilitate data exchange without a central governing authority. Once the parent company provides its CbC Report to the tax authority in its home country, such country is expected to exchange the report with foreign countries where a member of the MNE group is required to pay tax as a tax resident.[267] The first automatic exchange of CbC Reports took place in June 2018, and over 2700 CbC Reports have been bilaterally exchanged as of December 2020.[268] These information exchanges are carried out via existing exchange of information programs, but, as the next Subpart recommends, blockchain offers a better solution to the system.[269]

264. OECD, BEPS ACTION 13 COUNTRY-BY-COUNTRY REPORTING: HANDBOOK ON EFFECTIVE IMPLEMENTATION 9 (2017) [hereinafter OECD, CBC HANDBOOK]. The OECD also acknowledges that there may be certain circumstances where a "constituent entity (i.e. an entity within the MNE group)" is required to file the CbC report directly with its own tax authority. *See also* OECD, GUIDANCE ON THE IMPLEMENTATION OF COUNTRY-BY-COUNTRY REPORTING: BEPS ACTION 13 5 (2019) [hereinafter OECD, CBC GUIDANCE].

265. OECD, CBC HANDBOOK, *supra* note 264, at 3.

266. *Action 13: Country-by-Country Reporting*, OECD, https://www.oecd.org/tax/beps/beps-actions/action13 [https://perma.cc/UK42-LXED].

267. OECD, CBC GUIDANCE, *supra* note 264, at 5.

268. *Activated Exchange Relationships for Country-by-Country Reporting*, OECD, https://www.oecd.org/tax/beps/country-by-country-exchange-relationships.htm [https://perma.cc/M2WU-2J5V].

269. *Id.*

2. Exchange of Information

The exchange of information regime in international tax is the area most recommended to incorporate blockchain into the system. In parallel with a federal and state tax blockchain consortium, a multinational blockchain consortium is recommended for the international exchange of tax information.

In the late 2010s, many scandals about offshore tax evasion, such as the LGT Bank affair[270] and the UBS scandal,[271] raised huge concerns in tax administration. The rampant offshore evasion was possible because tax information relevant to multiple countries, such as a U.S. citizen's Swiss bank account information, was not shared among relevant tax authorities. This information asymmetry triggered a global discussion to enhance the transparency of international financial and tax data, including bolstering the exchange of information.[272]

An important development was the initiative for automatic exchange of information.[273] Traditionally, tax information had been exchanged between two countries under bilateral tax treaties, and the exchange occurred upon request.[274] Tax authorities, however, wanted to make the system more robust and proposed the multilateral automatic exchange of information on an annual basis. In 2014, the G20 countries endorsed the automatic exchange of information as the "new single global standard,"[275] and the OECD released the Common Reporting

270. *See* Lynnley Browning, *Banking Scandal Unfolds Like a Thriller*, N.Y. TIMES (Aug. 14, 2008), https://www.nytimes.com/2008/08/15/business/worldbusiness/15kieber.html [https://perma.cc/3ZRW-DSLC] (explaining that a former employee of LGT Bank group stole customer data and provided it to the EU and the IRS under a new whistleblower program).

271. In 2007, Bradley Birkenfeld exposed that UBS advised U.S. taxpayers to establish foreign shell entities, which then opened offshore accounts at the UBS, based on the position that those accounts need not be taxed nor disclosed to the IRS. Joshua D. Blank & Ruth Mason, *United States National Report on Exchange of Information*, LAW & ECON. RSCH. PAPER SERIES, Aug. 2014, at 1, 2–3; Itai Grinberg, *The Battle Over Taxing Offshore Accounts*, 60 UCLA L. REV. 304, 325–27 (2012).

272. Young Ran (Christine) Kim, *Engineering Pass-Throughs in International Tax: The Case of Private Equity Funds*, 56 SAN DIEGO L. REV. 707, 763 (2019).

273. *See generally Global Forum on Transparency and Exchange of Information for Tax Purposes, Putting an End to Offshore Tax Evasion*, OECD, http://www.oecd.org/ tax/transparency [https://perma.cc/XP9M-FGJG] (describing the Global Forum on Transparency and Exchange of Information for Tax Purposes' efforts).

274. Kim, *supra* note 272, at 764.

275. *OECD Delivers New Single Global Standard on Automatic Exchange of Information*, OECD (Feb. 13, 2014), https://www.oecd.org/tax/oecd-delivers-new-single-global-standard-on-automatic-exchange-of-information.htm [https://perma.cc/NF45-ZSRV].

Standard (CRS) to standardize the automatic exchange of information process.[276] As of December 2020, there are over 4400 bilateral exchange relationships activated with respect to more than 100 jurisdictions committed to the CRS.[277]

Despite such efforts, the system is not yet perfectly efficient and secure. The framework for the automatic exchange of information is based on two multilateral instruments—Convention on Mutual Administrative Assistance in Tax Matters and the CRS Multilateral Competent Authority Agreement.[278] Countries have to exchange information bilaterally even if both the sending and receiving parties are members of the multilateral instruments, however, because there is no central administrator who can collect the information from the whole group and distribute the information only to relevant parties.[279] This still results in a redundant data management setting. Furthermore, the United States has not committed to any multilateral instrument not only because of the privacy concerns, but also because it has built its own automatic exchange of information network pursuant to the Foreign Account Tax Compliance Act.[280] The history of the automatic exchange of information system shows how an international system becomes ineffective when there is no central authority and countries do not fully trust each other.

A consortium blockchain can overcome the systemic defect of international tax administration and can be set up to allow only certain countries to participate but still allowing additional countries to join based on consensus by participating countries. Smart contracts embedded in the blockchain enable tax information to be shared only among preselected countries and be further verified without other participating countries knowing the content of the information. This allows the tax information in the blockchain to be kept confidential while allowing only the preselected countries involved in the information sharing to have access to the content. All exchanges would occur automatically through smart contracts without having additional steps to execute bilateral exchanges. Indeed, the exchange of information in international tax is the classic efficiency environment that can harvest the most benefits from blockchain.

276. *See* OECD, STANDARD FOR AUTOMATIC EXCHANGE OF FINANCIAL ACCOUNT INFORMATION IN TAX MATTERS 29 (2014), https://www.oecd.org/ctp/exchange-of-tax-information/standard-for-automatic-exchange-of-financial-account-information-for-tax-matters-9789264216525-en.htm [https://perma.cc/MB9S-5N9M].

277. *International Framework for the CRS*, OECD, https://www.oecd.org/tax/automatic-exchange/international-framework-for-the-crs [https://perma.cc/CG65-TKHR].

278. *Id.*

279. *Activated Exchange Relationship for CRS Information*, OECD, https://www.oecd.org/tax/automatic-exchange/international-framework-for-the-crs/exchange-relationships [https://perma.cc/CG65-TKHR].

280. Kim, *supra* note 272, at 766.

III. NORMATIVE CONSIDERATIONS FOR BLOCKCHAIN IN TAX

Part II demonstrated that there are promising applications where blockchain can improve tax administration by fixing information asymmetry among taxpayers, tax authorities, and beyond. The use of blockchain can enhance the efficiency and transparency of tax administration and strengthen taxpayer privacy and the confidentiality of their tax information with a proper design, such as a consortium blockchain. Part III proposes the normative considerations of the blockchain initiatives for tax administration, such as timeline, standardization, integration with other systems, limitations, and accompanying legislation for taxpayers' rights and privacy.

A. When is a Good Time to Incorporate Blockchain?

The appropriate timeframe for blockchain implementation in tax administration depends on the timing of widespread use of distributed ledger technology in various sectors of society.

There has been skepticism on whether blockchain will become readily available as a technology, eventually achieving mainstream adoption.[281] The skeptics argue that blockchain is overhyped and will wither away with time. But blockchain has already begun to replace existing systems, such as payment services,[282] as illustrated in 3. Substitution phase of Chart 1 below, showing that blockchain technology is not going away soon. A recent survey by Deloitte showed that while 54 percent of respondents answered that blockchain is overhyped, 88 percent of respondents believe that blockchain will eventually achieve mainstream adoption.[283] This positive belief in regard to blockchain is increasing with time, from 84 percent in 2018 and 86 percent in 2019.[284] Furthermore, about 40 percent of respondents reported that they have already adopted blockchain into their businesses in 2020, which is a substantial increase from 23 percent in 2019.[285]

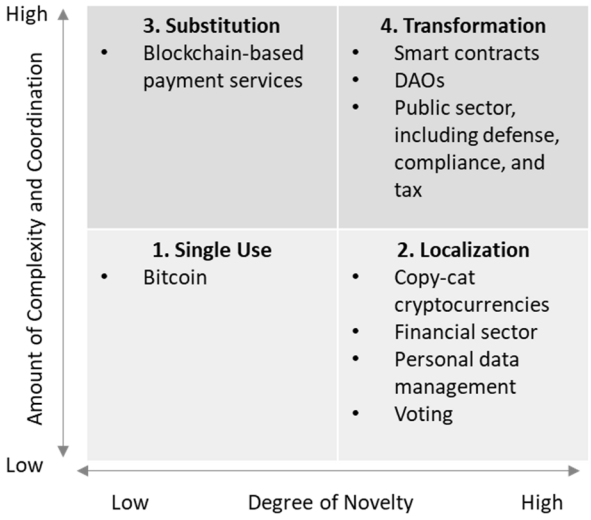
Marco Iansiti and Karim Lakhani from Harvard Business School offer a useful tool to assess the extent of blockchain technology's development and the

281. *See, e.g.*, Shaverdian, *supra* note 68, at 1286.
282. *See supra* Subpart I.C.1.b.
283. DELOITTE, *supra* note 21, at 5. The survey polled about 1500 senior executives and practitioners in 14 countries and regions who have a broad understanding of blockchain.
284. *Id.*
285. *Id.* at 7.

technology's anticipated path in real world applications,[286] a path Richard Ainsworth has further developed in tax law.[287] Iansiti and Lakhani provide four phases showing the process of societies' adoption of new technologies, such as blockchain, that could change the fundamentals of society. Chart 1 describes the four phases based on a two-by-two matrix with two axes—(i) the application's degree of novelty, and (ii) the amount of complexity and coordination required to apply such technologies to the real world.

286. Iansiti & Lakhani, *supra* note 26.
287. Ainsworth & Viitasaari, *supra* note 227, at 1008–18.

Chart 1: The Four Phases of Technology Development[288]



The first phase is a single use case, where (i) an emerging technology has a low level novelty, and (ii) the use of the technology is not complex and does not require a lot of coordination with other infrastructure.[289] Bitcoin is an example of a single use case in blockchain. One might wonder why the emergence of the new technology is considered low novelty, whereas the next phases are an upgrade of the technology. Note that Iansiti and Lakhani use the term "novelty" to measure the societal impact of the emerging technology, rather than the novelty of the technology itself. Even if an emerging technology is very novel, a single use case has low societal impact, which is considered less novel. When the application of the technology "could change the very nature of economic, social, and political system," however, it is considered highly novel.[290]

The second phase is localized use cases. After a single use case, the emerging technology develops to the next level of novelty, but the level of complexity and coordination for the use and application remains at a low level. The "proliferation of copy-cat cryptocurrencies" is a good example of the localization of blockchain.[291] In addition, many applications in Subpart I.C, such as banking,

288. *Id.* at 1025; Iansiti & Lakhani, *supra* note 26. This chart is recreated and developed by the author.
289. Ainsworth & Viitasaari, *supra* note 227, at 1009–12.
290. Iansiti & Lakhani, *supra* note 26.
291. Ainsworth & Viitasaari, *supra* note 227, at 1017.

post-trading processing, managing personal records relating to health or financial data, and voter fraud prevention, are mainly related to this phase.

The third and fourth phases push development of technology to a higher level of complexity and coordination. The third phase (substitution) requires a low level of novelty, whereas the fourth phase requires a high level of novelty. Blockchain applications that replace traditional business, such as payment services as explained in Subpart I.C.1.c, are in the third phase.

The fourth phase of transformation is the most advanced of them all because it requires both a high level of novelty, complexity, and coordination. In the fourth phase, the technology "could change the very nature of economic, social, and political system[s]" and its application requires a significant amount of coordination with existing institutions. Commentators consider self-executing smart contracts and DAOs to be in this phase. Furthermore, most blockchain applications in the public sector would be in the fourth phase. A defense system deploying military supplies via 3D printers, a regulatory compliance system, or a tax system incorporating blockchain would be examples of transformation as these systems would involve coordinating the activity of many actors and require institutional agreement on standards and processes.

Currently, the blockchain technology seems to be in the second and third phases and has started entering the fourth phase. The examples of the second and third phases are already in place, and many businesses, especially the financial industry, are testing whether to deploy smart contracts in their business model.[292] Subpart I.C.2 showed the increasing number of projects in the public sector to incorporate blockchain. Thus, the blockchain application in the tax sector that this Article explores is expected to occur in the fourth phase. It is difficult to predict how soon the fourth phase will be prevalent. But considering that the fourth phase has already started, the application of blockchain in tax administration might occur sooner than many expect.

B. Standardization and Integration

The recommended areas of taxation to incorporate blockchain in Subpart II.A are heavily intertwined with other sectors, such as financial institutions, foreign governments, and other regulatory agencies. Because other regulatory agencies and third parties may have their own blockchain network, a tax blockchain network is necessary to connect other blockchain networks seamlessly. Platform fragmentation is not desirable. The more sectors that

292. BASHIR, *supra* note 27, at 261.

ultimately adopt blockchain networks, the more standardization will be required. This obvious statement, however, would require significant effort across the board.

Accordingly, there are strong needs for the standardization of blockchain technology to improve interoperability, adaptability, and capability of integration. Blockchain may grow exponentially with standardization because standardization will eliminate some of the hurdles that may be caused by different blockchain designs that prevent the broad adoption of blockchain.[293] According to an interview with Liz Chien, ex-Vice President of Global Tax and Chief Tax Counsel at Ripple Labs, the standardization of blockchain technology is key for the success and advancement to the next phase of blockchain application in both the private and public sectors.[294]

As a preliminary issue, there are discussions on whether standardization may harm innovation and competition.[295] Generally, standardization promotes competition.[296] Standard settings promote the interoperability of different technologies providing similar services by allowing "manufacturers to innovate and compete to provide products conforming to the same" requirements.[297] If the standards are proprietary, however, controlled by big financial and tech firms and inaccessible to competitors, then standardization could harm innovation and competition.[298]

With those concerns in mind, many countries, such as the United States and the member countries in the EU, have developed standards through standards development organizations (SDOs) rather than by letting a market leader lead the standard-setting processes.[299] These SDOs develop standards through the work of technical committees, consisting of volunteer experts in the industry.[300] The relationship between SDOs and the governments are different in the EU and

293. *Id.* at 585.
294. Interview with Liz Chien, then Vice President of Tax at Ripple Labs, in S.F., Cal. (Oct. 4, 2019). Ms. Chien is the current Head of Global Tax at Protocol Labs.
295. Timothy S. Simcoe & Allan L. Shampine, *Economics of Patents and Standardization: Network Effects, Hold-up, Hold-out, Stacking*, *in* THE CAMBRIDGE HANDBOOK OF TECHNICAL STANDARDIZATION LAW: COMPETITION, ANTITRUST, AND PATENTS 100, 104–18 (Jorge L. Contreras ed., 2017).
296. *Id.* at 102–04.
297. Samuel N. Weinstein, *Blockchain Neutrality*, 55 GA. L. REV. 499, 558 (2021).
298. *Id.* at 577–78.
299. *See id.* at 576–77; Simcoe & Shampine, *supra* note 295, at 101–102; Emily S. Bremer, *Government Use of Standards in the United States and Abroad*, *in* THE CAMBRIDGE HANDBOOK OF TECHNICAL STANDARDIZATION LAW: FURTHER INTERSECTIONS OF PUBLIC AND PRIVATE LAW 28, 29 (Jorge L. Contreras ed., 2019).
300. Bremer, *supra* note 299, at 29.

the United States, however. In the EU, the government can play a key role in planning and initiating standardization at the SDO level so the resulting standardization system is coordinated with, and directly regulated by, the government.[301]

On the other hand, the United States takes a more indirect and informal approach to collaborate with SDOs.[302] The National Technology Transfer and Advancement Act requires government agencies to use only private standards that have been developed through a voluntary consensus process, limiting government agencies to an indirect role in the process.[303] In short, there is no governmental entity that has the authority to command an SDO to develop or maintain a particular standard in the United States. Thus, for the United States to implement a standardization for blockchain technology, including those applicable to tax administration, the United States will require governmental entities to work with SDOs on the same footing as those in the private sector when developing the appropriate standard.[304] Once developed, the government can legally enforce the adopted private standards by incorporating them in federal regulations.[305]

Interestingly, there have been two different attempts to address standardization in blockchain. First, on an international level, the International Organization for Standardization (ISO), an independent, nongovernmental international organization with a membership of 165 national standards bodies, established a technical committee called ISO/TC 307 to study the scope of standardization of blockchain technology.[306] Second, open source blockchain platforms, such as R3 and Hyperledger, are contributing to the standardization of blockchain technology by sharing ideas and codes with other participants in consortia.[307] Consortia built upon R3 or Hyperledger have at least dozens, if not hundreds, of members who adopt the

301. *Id.* at 37–40.
302. *Id.* at 32–35.
303. National Technology Transfer and Advancement Act of 1995, Pub. L. No. 104-113, § 12(d), 110 Stat. 775, 783 (1996); Bremer, *supra* note 299, at 32.
304. Bremer, *supra* note 299, at 30.
305. *Id.* at 33.
306. *See* Int'l Org. for Standardization, *Technical Committees ISO/TC 307, Blockchain and Distributed Ledger Technologies*, ISO, https://www.iso.org/committee/6266604.html [https://perma.cc/8NAZ-QE4P]; BASHIR, *supra* note 27, at 585.
307. BASHIR, *supra* note 27, at 585.

same blockchain architecture and are connected with other blockchain networks, creating a blockchain ecosystem.[308] This, in a way, results in standardization.

These efforts demonstrate the need for standardization in blockchain technology. The standardization of blockchain technology in tax administration is essential because a tax blockchain network needs to be connected with other sectors, such as financial networks and other regulatory networks, to be successful. Thus, policymakers should consider standardization and interchangeable modules for a successful tax blockchain network. It is worth emphasizing that consortium based blockchains, which are recommended by this Article, are a good way to achieve standardization. Furthermore, policymakers and regulators should diligently participate in the standard-setting process alongside SDOs to make sure that the standardization is appropriate and to allow for the standardization to be incorporated in regulations at a later stage.

C. At the Intersection Between Offline and Digital: Limitations of Reducing Tax Gap

Although blockchain may improve tax administration, it is important to understand its limitations. Blockchain is most useful when data are of high quality and already digitalized. At the intersection between old school physical data and its digital representation, the effectiveness of blockchain technology has to rely on humans who can correctly—and honestly—bridge the last mile between two forms of the same data.[309] If the humans in charge of translating physical data to digital data or entering digital data make a mistake or manipulate the data input, there is nothing blockchain can do.

Such a constraint due to human error is not limited to blockchain technology. Rather, it is a common problem in most data management systems, regardless of physical or digital data. Humans who are in charge of entering data in a ledger can manipulate the data even if the ledger is physical. So is the case if the ledger is digital, such as blockchain. The key point here is that blockchain or distributed ledger technology has some of the same problems as other data management systems. Moreover, formalizing the data into something that

308. *Id.* For the R3 Blockchain Ecosystem, see *World's Largest Permissioned Enterprise DLT Production* Ecosystem, R3, https://www.r3.com/ecosystem [https://perma.cc/CRH2-5QJL]; *see also Join Hyperledger Foundation*, HYPERLEDGER, https://www.hyperledger. org/about/join [https://perma.cc/WR9V-VDEG].

309. Tucker & Catalini, *supra* note 6.

emerging technology, such as blockchain and artificial intelligence, can read and process is a subject many innovation scholars have taken up.[310]

Thus, although blockchain would be the next phase in digital information management systems, the benefits of its application are limited to an incremental improvement of the existing system of data management. To illustrate, let us examine whether blockchain can resolve three prominent tax noncompliance categories that have existed since the twentieth century: "(1) the failure to report cash payments and receipts, (2) the use of sophisticated tax shelters to manufacture noneconomic losses, and (3) the establishment of hidden offshore accounts."[311] Blockchain is promising to resolve the third problem by enhancing the transparency of cross-border cash flow, as shown in Subpart II.D. Blockchain is not likely to enhance tax compliance in the first and second categories, however. The second category regarding tax shelters may be improved by other emerging technology, such as artificial intelligence and machine learning. Additionally, blockchain is not likely to resolve the first problem about cash businesses since blockchain itself cannot improve the integrity of data input by taxpayers.

These prominent tax noncompliance categories reveal the limitation of blockchain to improve an important issue in tax administration, commonly referred to as the tax gap. The tax gap is the difference between the total taxes owed to the government if taxpayers are fully compliant and the taxes that are actually paid on time.[312] According to the IRS's recent statistics, the IRS should have collected $2683 billion each year between 2011 and 2013 but $381 billion each year was not eventually collected, and the amount not collected is called the tax gap.[313] This means that $1 out of every $7 of tax due was not paid.

310. *See e.g.*, Sarah B. Lawsky, *Formalizing the Code*, 70 TAX L. REV. 377 (2017) (proposing to draft tax legislation that is legible by legal artificial intelligence); Marcos Pertierra, Erik Hemberg, Sarah B. Lawsky & Una-May O'Reily, *Towards Formalizing Statute Law as Default Logic Through Automatic Semantic Parsing*, PROC. OF THE SECOND WORKSHOP ON AUTOMATED SEMANTIC ANALYSIS OF INFO. IN LEGAL TEXT (2017); Denis Merigoux, Raphael Monat & Jonathan Protzenko, *A Modern Compiler for the French Tax Code*, PROC. OF THE 30TH ACM SIGPLAN INT'L CONF. ON COMPILER CONSTR. 71 (2021).

311. James Alm, Joyce Beebe, Michael S. Kirsch, Omri Marian & Jay A. Soled, *New Technologies and the Evolution of Tax Compliance*, 39 VA. TAX REV. 287, 304 (2020).

312. *Id.* at 290.

313. To be precise, this amount is net tax gap, as opposed to the gross tax gap of $441 billion before the IRS's audit and collection efforts. BARRY W. JOHNSON & PETER J. ROSE, INTERNAL REVENUE SERV., FEDERAL TAX COMPLIANCE RESEARCH: TAX GAP ESTIMATES FOR TAX YEARS 2011–2013 1 (2019).

The three major groups of offenders contributing to the tax gap include (i) non-filers, (ii) underreporters who file their tax returns on time but understate their true tax liability, and (iii) underpayers who file their returns but fail to pay in full. The second group accounts for 80 percent of the tax gap, so most efforts addressing the tax gap focus on this under-reporters group.[314]

Of the $352 billion underreporting tax gap between 2011 to 2013, underreporting on individual income tax returns alone, including the self-employment tax, was $245 billion, making up about 70 percent of the underreporting tax gap.[315] Almost 45 percent of the underreported individual income tax is owed on business income, but the IRS has no easy way to independently verify when "taxpayers are intentionally noncompliant and conduct business in cash with poor or non-existent record keeping."[316] In contrast, only about 11 percent of the underreporting gap was attributable to corporate income tax, and 20 percent was attributable to the employment tax, including payroll tax.[317]

Further segmenting the individual income tax underreporting tax gap by type of income reveals that individual taxpayers fail to report about 55 percent of income from sources for which there is little or no information reporting obligations by a third party, such as in business income from sole proprietorships.[318] In contrast, only 5 percent of income from easily verified sources that are subject to substantial information reporting, such as pensions, unemployment compensation, dividends, and interest, goes unreported.[319] When income is subject to both information reporting and withholding tax, as with wages and salaries, only about 1 percent goes unreported.[320]

Unfortunately, the categories where the tax gap is not significant, such as taxes on income with easily verifiable sources, payroll taxes, and corporate income taxes, are where the current recommendations exist to incorporate blockchain. Tax gaps on other types of income, such as individual business income, cannot be reduced by simply introducing blockchain into the tax system as long as the problem is deeply rooted in the failure to report cash payments and receipts.

In short, blockchain is not a silver bullet for tax data management or resolving the tax gap problem. A more effective solution for those areas with big

314. *Id.* at 11.
315. *Id.*
316. *Id.* at 16-17.
317. *Id.* at 11, 16–17.
318. *Id.* at 14.
319. *Id.*
320. *Id.*

tax gaps would be to introduce a third-party reporting obligation or withholding tax system. Then, those areas would fall under the first or second category of Table 2 in Subpart II.A that are recommended to incorporate blockchain.

D. Vili's Governance Paradox and the Role of Tax Authorities

An important benefit of blockchains as distributed ledger technology is that "they can eliminate the need for a central authority."[321] This is incorrect, however, not only for private, permissioned blockchains, but also for public and permissionless blockchains. Blockchains need code developers and engineers during development and continue to need decisionmakers for governance issues when operated. These key players serve as a "a de-facto central authority" in blockchain governance structure.[322] Thus, blockchains need to nominate trustworthy administrators who are authorized to alter the ledger. But this contradicts the decentralized characteristic of blockchains. When blockchain networks embrace such a governance structure, it is not entirely accurate to describe them as decentralized.[323]

This governance paradox in blockchain is called "Vili's Paradox," named after Vili Lehdonvirta, who first introduced this concept.[324] Vili Lehdonvirta, an economic sociologist at the Oxford Internet Institute and one of the candidates for the true identity of Bitcoin founder Satoshi Nakamoto,[325] is one of the first people who explored blockchain governance issues. Kevin Werbach of the Wharton School of the University of Pennsylvania responded to Vili's Paradox by distinguishing the rule-creation stage from the rule-enforcement stage.[326] He explains that Vili's Paradox may hold in the rule-creation stage of blockchains, but the rule-enforcement stage is still decentralized.[327] Blockchain has eliminated the need for a trustworthy third party who can verify the information that would be recorded in the ledger. Thus, Werbach vindicates the possibility of blockchain applications to various systems with different degrees of centralization.[328]

321. BERRYHILL, BOURGERY & HANSON, *supra* note 38, at 30.
322. *Id.*
323. WERBACH, *supra* note 111, at 133.
324. *Id.*
325. Lehdonvirta denied this claim. Joshua Davis, *The Crypto-Currency*, NEW YORKER (Oct. 3, 2011), https://www.newyorker.com/magazine/2011/10/10/the-crypto-currency [https://perma.cc/M6ZB-GNBH].
326. WERBACH, *supra* note 111, at 134.
327. *Id.*
328. *Id.*

Nonetheless, Vili's governance paradox raises an important question about the creation and operation of blockchains: Who should be the legitimate governing entity or administrator of blockchains?[329] For blockchains in the public sector, it raises an additional question: What should be the administrator's role?

The proposed blockchain networks for tax administration are private consortium networks. This means that individual taxpayers cannot participate in the network as a node. Only tax authorities, other agencies, certain withholding agents, and third-party reporters can participate in the network and serve as a node. This would raise concerns about taxpayer rights and the privacy of tax information recorded in the blockchain. A taxpayer may want to exercise the right to be forgotten when the taxpayer dies or when a certain statute of limitation expires.[330] A taxpayer might want to verify and correct certain tax information about herself. Can the taxpayer exercise any rights to protect her information and tax privacy? Because of its immutability, it may be difficult to exercise the right to be forgotten or the right to correct information once the information is recorded in blockchain.[331]

Two options might be considered. First, blockchain systems can nominate trustworthy administrators who are authorized to alter the ledger.[332] For blockchains in the public sector, government officials will have such authority to control the ledger.[333] But this may contradict with the decentralized characteristic of blockchains. Second, the system may destroy the decryption keys and make the data unreadable, instead of compromising the immutability.[334] But an administrator may easily restore the decryption keys. Furthermore, it may be a solution for the right to be forgotten, but not for the right to correct the data.

Hence, commentators largely recommend the first option over the second and admit the need for administrators for blockchain operation.[335] Putting the system in tax administration, tax authorities in the blockchain network can perform that role.[336] As an administrator, the government must carefully

329. BERRYHILL, BOURGERY, & HANSON, *supra* note 38, at 30.
330. Shaverdian, *supra* note 68, at 1287.
331. BERRYHILL, BOURGERY & HANSON, *supra* note 38, at 29.
332. Shaverdian, *supra* note 68, at 1287.
333. BERRYHILL, BOURGERY & HANSON, *supra* note 38, at 29.
334. Shaverdian, *supra* note 68, at 1287.
335. *See, e.g.*, BERRYHILL, BOURGERY & HANSON, *supra* note 38, at 30–31.
336. The governance issue may persist, however, if there are multiple government entities involved in a blockchain network. For example, in a consortium blockchain consisting of multiple tax authorities, such as federal, state, and local tax authorities in domestic tax and multiple countries in international tax, the participants still need to decide which authorities would be in charge of the role of an administrator.

consider taxpayer rights and privacy in the rule-creation stage, such as which information should be recorded in the tax blockchain, resulting in the data entered becoming immutable, and which information should not be recorded in the tax blockchain.[337] This discretion requires the government to build a technical knowledge base to ensure that these decisions are well made.

The blockchain governance issue is not peculiar to tax administration but is rather a general tension between data immutability in a blockchain and the need for necessary modifications, particularly for private consortium blockchains. Though it is beyond the scope of this Article to propose a concrete solution for who should control the system and how to protect taxpayers' rights and privacy, this is an essential issue to be contemplated when governments consider incorporating blockchain in tax administration. The next Subpart further discusses the taxpayer privacy in blockchain.

E. Taxpayer Privacy: The Case of Undocumented Taxpayers

The rules of a blockchain system, especially private or consortium blockchain, enable some safeguards for access to private or confidential information. This may strengthen taxpayer privacy or confidentiality for sensitive data. If certain sensitive tax data must be shared with other government agencies under laws and regulations, however, blockchain itself is far from a cure-all for taxpayer privacy.

Let us examine whether blockchain can improve taxpayer privacy concerns in the case of undocumented taxpayers. There is consensus among scholars that, on average, most undocumented immigrants pay taxes.[338] In 2014, the Pew Research Center estimated that 8 million undocumented individuals were in the U.S. workforce, and of those, 3.4 million (nearly half), paid social security

337. *See* BERRYHILL, BOURGERY & HANSON, *supra* note 38, at 30.

338. Francine Lipman, *The "Illegal" Tax*, 11 CONN. PUB. INT. L.J. 93, 107 (2011); Nneka Obiokoye, *Taxation of Undocumented Immigrants: The Uneasy Connection Between Regulating the Undocumented Immigrant and Fostering Illegal Activity*, 2 BUS. ENTREPRENEURSHIP & TAX L. REV. 359, 364–66 (2018); Evan Nolan, *Picking Up After the Baby Boomers: Can Immigrants Carry the Load?*, 24 GEO. IMMIGR. L.J. 77, 85–86 (2009) (noting between one-half and three quarters of all undocumented workers pay taxes); Andrew Tae-Hyun Kim, *Deportation Deadline*, 95 WASH. U. L. REV. 531, 557–58 (2017) (expecting that undocumented immigrants contribute an estimated $11.64 billion each year in state and local taxes and that granting legal status to all undocumented immigrants would increase state and local tax contributions by an estimated $2.1 billion per year).

taxes.[339] The Social Security Administration (SSA) stated that unauthorized workers contributed roughly $13 billion in payroll taxes in 2010,[340] but it does not track how many undocumented persons pay income taxes. Nonetheless, that 3.4 million number regarding social security taxes sheds some light. Because social security taxes are most often taken from a person's W-2 salary, it follows that those same undocumented people with W-2 based jobs likely also have income taxes withheld from their paychecks.

Undocumented workers also fear filing documentation with any government agency, however, because they do not want to be discovered and ultimately deported.[341] Technically, undocumented individuals are not allowed to work in the United States, and therefore should not be working in W-2 based employment, but many still manage to obtain such jobs. Undocumented workers often use a U.S. citizen's social security number when seeking employment, and therefore, receive W-2s.[342] But, a problem arises when they try to file taxes. A fake social security number will allow undocumented individuals to work but they are unable to use that same social security number to file taxes.[343] Therefore, those same workers will have to obtain an Individual Taxpayer Identification Number (ITIN) from the IRS if they wish to file a return.[344] Although it is against the law to use a fake or stolen social security number to gain employment, the IRS has issued formal guidance to ensure undocumented persons that there will not be any consequences from the IRS for using a false social security number to obtain employment so long as they use their correct ITIN on their tax forms.[345] This is all in an effort to increase undocumented taxpayers' confidence and ensure them that they can safely file taxes without fear of being deported.

339. These numbers are based on reporting by the SSA. Kim, *supra*, note 338 at 557–58; Octavio Blanco, *Why Undocumented Immigrants Pay Taxes*, CNN: BUS. (Apr. 19, 2017), https://money.cnn.com/2017/04/19/news/economy/undocumented-immigrant-taxes/index.html [https://perma.cc/QD3V-U45N].

340. *Blanco*, *supra*, note 339.

341. *See, e.g.*, Lipman, *supra* note 338, at 107 (noting how undocumented immigrants fear deportation and therefore many "do not prepare and file tax returns"); Obiokoye, *supra* note 338, at 383–84; Leo P. Martinez & Jennifer M. Martinez, *The Internal Revenue Code and Latino Realities: A Critical Perspective*, 22 U. FLA. J.L. & PUB. POL'Y 377, 389 (2011); Chrystin Ondersma, *Undocumented Debtors*, 45 U. MICH. J.L. REFORM 517, 555 (2012) (discussing the undocumented immigrants' challenge to seek bankruptcy relief due to the documentation hurdles).

342. Obiokoye, *supra* note 338, at 383–84.

343. Blanco, *supra* note 339.

344. *Id.*; Obiokoye, *supra* note 338, at 367 (describing an ITIN as one assigned to a foreign national or other person who does not qualify for a social security number).

345. *Id.* at 375.

The IRS would like to increase undocumented taxpayer confidence with a promise of confidentiality to encourage them to continue filing returns. But undocumented workers still fear filing documentation with any government agency. Therefore, a strange phenomenon exists here. Although most undocumented individuals, especially those with W-2 producing jobs, do pay taxes, many scholars believe that fear comes into play when undocumented persons are deciding whether or not to file a tax return.[346] In many instances, undocumented individuals fear filing a tax return and ultimately identifying themselves. This means that most undocumented persons are likely paying more taxes than they should. When employers withhold taxes from each employee's paycheck, it is common that the employer withholds more than the taxpayer's actual tax burden, which can be fixed when the employee files tax returns.[347] If undocumented individuals do not subsequently file their tax returns out of fear, then they lose the money they overpaid throughout the year. Others point out that undocumented individuals do tend to file their tax returns at the end of the year because they believe that doing so will bear positively on their character if they are ever before an immigration judge.[348] If they do not file a tax return, it can be seen as evading the law and thus risk having a deficit on their taxes they never pay if they do not file a return. In any event, it seems that undocumented persons frequently file taxes, but do so with fear of deportation.

The IRS is required by law to keep tax information confidential from the public and all other government entities.[349] Therefore, in theory, undocumented persons should not fear that they will be discovered by filing tax returns. The confidentiality requirement is filled with exceptions, however. For example, the IRS is obligated to disclose tax return information to law enforcement investigating nontax crimes and the IRS may also disclose information regarding payroll and income taxes to the SSA.[350] Although the SSA is required to keep the acquired information confidential, the SSA must disclose certain nontax information it receives from the IRS to the DHS and the USCIS.[351] This information includes

346. Lipman, *supra* note 338, at 96, 101 (noting how "billions" of dollars are paid in taxes each year by undocumented immigrants).
347. *Id.* at 101.
348. Blanco, *supra* note 339.
349. *Id.*; Obiokoye, *supra* note 338, at 375.
350. *Id.*, at 376.
351. *Id.* at 376–77 (noting that much disclosure requires specific requests by the DHS or USCIS, however, those agencies can nonetheless obtain that information).

names, addresses, and other sensitive identifying information.[352] Therefore, even though the IRS does keep taxpayer information confidential, there are many exceptions provided by laws and regulations that expose undocumented immigrants to the risk of deportation.

Blockchain has the potential to ensure that only the permissible information is released to other federal agencies. Hopefully, this creates a more transparent process while also keeping some privacy for undocumented immigrants. A tax blockchain could hypothetically be programmed to allow the IRS to only disclose to other agencies the information required by law. Such programming must be accompanied by legislation that increases privacy for undocumented taxpayers and prohibits the IRS from releasing sensitive information to any other agency like the SSA, DHS, or USCIS. Otherwise, a tax blockchain would not enhance the process to be more confidential. Even if the IRS were to only release the mandated information to immigration agencies, and all other information was restricted by the blockchain, that mandated information consists of all of the identifying information that the undocumented person wants to keep confidential. Therefore, accompanying legislation is needed to make blockchain technology useful to protect undocumented persons, and more generally, taxpayer privacy.

CONCLUSION

As blockchain technology develops, it will grow beyond the early stages of a single use case and localization into the substitution and transformation phases. Scholars, engineers, and users emphasize blockchain's original technology as a distributed, immutable, peer-to-peer ledger for future data management systems. The evolution from public blockchains to private and consortium blockchains also expands the scope of blockchain applications.

Blockchain has shown promising applications in the private sector, such as financial services and supply chains. But this Article focuses more on blockchain's potential to play a greater role in the public sector, such as property records, public health, and compliance, where data redundancy, information transparency, data immutability, and a consensus mechanism are required. Tax administration is one promising blockchain application in the public sector, and

352. *Id.*

this Article recommends the adoption of a private consortium blockchain when architecting the system.

Some might see an irony with blockchain being used in the public sector because "blockchain heralds revolutionary decentralized economic order"[353] that hopes to depart from arguably authoritative government oversight as illustrated in George Orwell's novel, *1984*. But the reality is that the advantages of blockchain, such as transparency, efficiency, data integrity, and security, can also benefit the public sector in tremendous ways. Specifically, the feature of decentralization can improve tax administration among multiple tax authorities by offering a more equitable setting for all stakeholders. In international tax, there are areas where tracking down the cross-border cash flow and information is important, but the information asymmetry has been severe because there is no central government or authority. Similarly, in domestic tax, the information sharing among federal, state, and local governments has been far from ideal. Blockchain can enable direct, peer-to-peer data management between parties who do not fully trust each other or who do not trust any central authority to validate information. Thus, blockchain may suggest a new path for improving tax administration regardless of the various power dynamics involved.

Blockchain may not be a silver bullet for tax data management because the technology itself faces some implementation issues, including a steep trade-off between efficiency and decentralization, explained as Vili's Paradox. By appropriately implementing blockchain, however, such as when data is high quality, blockchain can revolutionize society in many ways. Yet, any benefits of blockchain cannot materialize when quality data may never make its way onto the blockchain in the first place.

Finally, tax authorities must carefully perform the role of administrator on the tax blockchain network to protect taxpayer rights and privacy. Blockchain has the potential to enhance tax administration and taxpayer privacy at the same time, as in the case of undocumented taxpayers in filing their taxes. To truly be effective, however, blockchain technology must be accompanied by additional privacy legislation surrounding the release of tax information.

353. WERBACH, *supra* note 111, at 134.