Vanderbilt Journal of Transnational Law

Volume 56 | Issue 2 Article 2

5-2023

Globalize Me: Regulating Distributed Ledger Technology

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ABSTRACT

Distributed Ledger Technology (DLT)—the technology underlying cryptocurrencies—has been identified by many as a game-changer for data storage. Although DLT can solve acute problems of trust and coordination whenever entities (e.g., firms, traders, or even countries) rely on a shared database, it has mostly failed to reach mass adoption outside the context of cryptocurrencies.

A prime reason for this failure is the extreme state of regulation, which was largely absent for many years but is now pouring down via uncoordinated regulatory initiatives by different countries. Both of these extremes—under-regulation and over-regulation—are consistent with traditional concepts from law and economics. Specifically, whenever DLT implements a "public blockchain"—where there is no screening of who joins the network—both the technology and its regulation constitute what economists call "non-excludable goods." For these types of goods, two classical incentive problems emerge: (i) over-regulation, due to the "tragedy of the commons," and (ii) under-regulation, due to the "free-rider problem."

We argue that these problems are best solved using some form of global regulation. Comparing alternative paths to such regulation, including (i) centralized regulation, (ii) decentralized regulation, and (iii) international standards, we analyze how global regulation of DLT could be implemented using a mixture of "on-chain" (embedded in the technology itself) and "off-chain" measures.

Our Article is the first to analyze why global regulation of DLT makes sense from a law and economics perspective and is also the first to provide concrete suggestions on how to implement such regulation.

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I. INTRODUCTION

Distributed ledger technology (DLT) has received much attention in recent years due to its central role in the operation of cryptocurrencies.[1] Although the technology itself is somewhat complex,[2] its value proposition is rather simple: preventing data manipulation.[3] DLT achieves this through decentralization: instead of authorizing a single entity to overwrite the data, new additions can only be made through a validation process that includes multiple actors and adherence to a strict set of algorithmic conditions.[4] Consequently, attempts by any one entity to *unilaterally* manipulate the data are unlikely to succeed—the attempts would be blocked by the decentralized mechanism.[5]

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1. *See* Yesha Yadav & Chris Brummer, *Fintech and the Innovation Trilemma*, 107 GEO. L.J. 235, 266 (2018); Dan Awrey, *Unbundling Banking, Money, and Payments*, 11 GEO. L.J. 715, 739 (2022); Kimberly Houser & John T. Holden, *Navigating the Non-Fungible Token*, 2022 UTAH L. REV. 891 (2022); Carla Reyes, *Creating Cryptolaw for the Uniform Commercial Code*, 78 WASH. & LEE L. REV. 1521 (2022); Saule T. Omarova, *New Tech v. New Deal: Fintech as a Systemic Phenomenon*, 36 YALE J. ON REG. 735 (2019); Emmanuelle Ganne, *Blockchain for Trade: When Code Needs Law*, 115 AJIL UNBOUND 419 (2021); Roee Sarel, *Property Rights in Cryptocurrencies: A Law & Economics Perspective*, 22 N.C. J.L. & TECH. 389, 390 (2020); Emily Behzadi, *The Fiction of NFTs and Copyright Infringement*, 170 U. PA. L. REV. BLOG (2022).

2. *See* Bailey R. Ulbricht, Christopher Moxley, Mackenzie D. Austin & Molly D. Norburg, Note, *Digital Eyewitnesses: Using New Technologies to Authenticate Evidence in Human Rights Litigation*, 74 STAN. L. REV. 851, 851 (2022); Nathan Fulmer, *Exploring the Legal Issues of Blockchain Applications*, 52 AKRON L. REV. 161, 190 (2019); Agata Ferreira & Philipp Sandner, *EU Search for Regulatory Answers to Crypto Assets and their Place in the Financial Markets' Infrastructure*, 43 COMPUT. L. & SEC. REV., Nov. 2021, at 1, 12.

3. *Cf.* Shaanan Cohney, Jeremy Sklaroff & David Wishnick, *Coin-operated Capitalism*, 1198 COLUM. L. REV. 591, 611 (2019) (arguing that the "crypto industry" uses code to recreate the protections against market manipulation that the law must provide for other markets); Agnes Beatrice Gambill, *The Future of Voting Reform with Blockchain Technology*, 56 IDAHO L. REV. 167, 177 (2021) (evaluating the potential benefits of using blockchain technology in voting systems); Dirk A. Zetzsche, Linn Anker-Sørensen, Maria Lucia Passador & Andreas Wehrli, *DLT-based Enhancement of Cross-border Payment Efficiency–A Legal and Regulatory Perspective*, 15 L. & FIN. MKTS. REV. 70, 72 (2021) (noting the argument that DLTs can provide increased transparency and reduce the risk inherent in the use of intermediaries compared to non-crypto markets).

4. *See, e.g.*, Hadar Y. Jabotinsky, *The Regulation of Cryptocurrencies: Between a Currency and a Financial Product*, 31 FORDHAM INTELL. PROP. MEDIA & ENT. L.J. 118, 138 (2020) ("This technology connects users to one another through a series of blocks, which together build a platform for digital assets. . . . A blockchain is usually managed by a peer-to-peer network, in which peers collectively adhere to a protocol for validating new blocks. Once a block is formed, it is impossible to alter it without traces. Put simply, it is like having a common Excel page shared by an entire community of users. Once something is changed on one Excel sheet, the same Excel sheets on all the computers of all of the users are updated automatically. Since it does not exist in any centralized physical location, hacking it is almost impossible.").

5. *See id.*; *see also* Paul Belonick, *Transparency is the New Privacy: Blockchain's Challenge for the Fourth Amendment*, 23 STAN. TECH. L. REV. 114, 129 (2020) ("No single party controls or stores the data or acts as the central point of reconciliation. But neither can any party unilaterally manipulate the data.").

It is easy to see why such technology is beneficial for monetary transactions, as it overcomes the double-spending problem[6]—no one can manipulate his currency balance in order to claim he still owns money that has already been spent.[7] Indeed, this is the key role of the technology in the world of cryptocurrencies: by creating a decentralized database (a ledger), and documenting who has transferred which cryptocurrency to whom, DLT protects the market from malicious agents who might otherwise manipulate their balance.[8] In the context of cryptocurrencies, the technology does so by creating a chain of digital blocks, yielding its colloquial nickname "blockchain."[9]

However, the promise of DLT goes far beyond financial transactions: whenever data integrity is important, one might turn to DLT as a solution that creates a "trustless" environment,[10] eliminating the need to trust a central authority not to manipulate the data. Examples

6. *See* SATOSHI NAKAMOTO, BITCOIN: A PEER-TO-PEER ELECTRONIC CASH SYSTEM 8 (2008), https://bitcoin.org/bitcoin.pdf (last visited Jan. 29, 2023) [https://perma.cc/7AUY-TMEW] (archived Feb. 10, 2021).

7. *See id.* at 6; *see also* Ganne, *supra* note 1, at 419; Caline Hou, *A Bit-ter Divorce: Using Bitcoin to Hide Marital Assets*, 16 N.C. J.L. & TECH. 74, 85 (2015).

8. *See, e.g.*, Manuel Klein, Jonas Gross & Philipp Sandner, *The Digital Euro and the Role of DLT for Central Bank Digital Currencies* 6 (FSBC Working Paper, 2020), https://www.researchgate.net/profile/Jonas-Gross-2/publication/341354711_The_Digital_Euro_and_the_Role_of_DLT_for_Central_Bank_Digital_Currencies/links/5ebc116a92851c11a867533a/The-Digital-Euro-and-the-Role-of-DLT-for-Central-Bank-Digital-Currencies.pdf [https://perma.cc/ZXM9-WAVF] (archived Dec. 28, 2022).

9. The original paper that introduced Bitcoin, NAKAMOTO, *supra* note 6, did not explicitly use the term "blockchain" but only explained that the technology uses blocks. Furthermore, blockchain is only a sub-category of DLT. *See* Claudio Lima, *Developing Open and Interoperable DLT/ Blockchain Standards*, 51 COMPUT. 106, 108 (2018); Yadav & Brummer, *supra* note 1, at 266 (". . . [B]lockchains represent operating systems that allow information to be organized within "block[s]" or "ledger[s]" of transaction data that can facilitate digital representation of entitlements and ownership."); Angela Walch, *Blockchain's Treacherous Vocabulary: One more Challenge for Regulators*, 21 J. INTERNET L., Aug. 2017, at 10, 10.

10. Fulmer, *supra* note 2, at 169 ("[T]his process allows cryptocurrencies to establish trust between users who do not know each other, sometimes called 'trustless trust.'"). *See generally* Arzoo Miglani, Neeraj Kumar, Vinay Chamola & Sherali Zeadally, *Blockchain for Internet of Energy Management: Review, Solutions, and Challenges*, 151 COMPUT. COMMC'NS 395 (2020) (discussing the potential and applications of blockchain in the energy sector).

are abundant and include the registration of property rights,[11] intellectual property rights,[12] movements of items in supply chains,[13] and even cap-and-trade systems for gas emissions.[14]

Notwithstanding the potential of DLT to solve many problems, the technology has, thus far, struggled to reach mass adoption outside the context of cryptocurrencies and finance.[15] In fact, the only alternative use for DLT that has gained significant traction so far seems to be supply chains,[16] where the ledger keeps track of units exchanging hands along the delivery route.

The most important difference between the use of cryptocurrencies and that of supply chains lies in the type of DLT used: cryptocurrencies are supported by a *public* blockchain whereas supply chains are supported by a *private* blockchain (a.k.a. "permissioned blockchain").[17] The difference between the two is the following: Public blockchains are open for anyone to join—a feature much needed to facilitate an open market. Conversely, a private blockchain allows (at least) one decision-maker to exclude users from the network[18]—a

11. *See, e.g.*, Karen Yeung, *Regulation by Blockchain: The Emerging Battle for Supremacy between the Code of Law and Code as Law*, 82 MODERN L. REV. 207, 208 (2019) (alluding to the UK's Chief Scientific Officer's reference to "blockchain's potential to help governments to collect taxes, deliver social security benefits, issue passports, record land registries, assure the supply chain of goods and ensure the integrity of government records in a more transparent and accountable form"); Edmund Schuster, *Cloud Crypto Land*, 84 MODERN L. REV. 974, 975 n.2 (mentioning an attempt in Sweden to test a land-registry using blockchain technology).

12. *See, e.g.*, Tim Wu, *Will Artificial Intelligence Eat the Law? The Rise of Hybrid Social-ordering Systems*, 119 COLUM. L. REV. 2001, 2001–02 (2019) ("Much enforcement of the intellectual property laws is already automated through encryption, copy protection, and automated takedowns . . . Blockchain agreements are beginning to offer an alternative mechanism to contract law for the forging of enforceable agreements."); Hadar Y. Jabotinsky & Michal Lavi, *NFT for Eternity*, 56 MICH. J.L. REFORM, at 20 (forthcoming).

13. *See* Yeung, *supra* note 11, at 208.

14. *See generally* Xiaoping Xu & Tsan-Ming Choi, *Supply Chain Operations with Online Platforms under the Cap-and-trade Regulation: Impacts of Using Blockchain Technology*, 155 TRANSP. RES. PART E: LOGISTICS & TRANSP. REV., Nov. 2021.

15. *See* Mohammed Al-Shamsi, Mostafa Al-Emran & Khaled Shaalan, *A Systematic Review on Blockchain Adoption*, 12 APPLIED SCI. 4245, 4256 (2022).

16. *See* Al-Shamsi, Al-Emran & Shaalan, *supra* note 15, at 4253; Lawrence J. Trautman & Mason J. Molesky, *A Primer for Blockchain Symposium Issue: Blockchain Technology and the Law*, 88 UMKC L. REV. 239, 269 (2019) ("Business supply chains appears to be an area having unusually robust promise for successful blockchain applications.").

17. Schuster, *supra* note 11, at 993–94. Some people distinguish between fully private blockchains and permissioned blockchains by focusing on the degree of control in exclusion. For instance, a "permissioned blockchain" can, in principle, allow anyone to join but then to only perform certain actions with permission. *See* Shobhit Seth, *Public, Private, Permissioned Blockchains Compared*, INVESTOPEDIA (July 28, 2022), https://www.investopedia.com/news/public-private-permissioned-blockchains-compared/ [https://perma.cc/93DU-8D4T] (archived Dec. 29, 2022). For simplicity, we use a dichotomous classification, distinguishing only between private and public blockchains. *See infra* Part II.B for more details.

18. Seth, *supra* note 17.

necessary feature for a company that does not want to publicly disclose the precise details of its logistics.[19]

Our main insight is that the distinction between public and private blockchains is critical for understanding both the technological development and the regulatory landscape of DLT. Specifically, we propose to view DLT and its regulation through the lens of law and economics by focusing on the traditional taxonomy of economic goods.[20] Importantly, this taxonomy differentiates between *excludable* and *non-excludable* goods,[21] which precisely reflects the difference between public and private blockchains.

Non-excludable goods are challenging to manage because they invoke two classical incentive problems. First, such goods run the risk of overconsumption: if individuals can simply use the good without paying for it (as they cannot be excluded), they will intuitively overconsume.[22] When everyone behaves this way, there is a risk of depletion of the common good.[23] This problem is known as the tragedy of the commons.[24] Second, non-excludable goods might suffer from undersupply: if owners cannot exclude others, it will be difficult for them to charge money for the use. Consequently, producing such goods—or otherwise maintaining them—is potentially less profitable, so that there is a concern that not enough goods are produced.[25] As every producer prefers that others will invest in production—a typical free-rider problem[26]—there might be no production at all.

In the context of public blockchains, these problems arise both at the technology-production level and at the regulatory level. At the technology level, public blockchains are known to suffer from congestion,[27] which occurs because too many users utilize the network at the same time. Consequently, the speed of transaction processing decreases,[28]

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19. A private blockchain alone is still not a perfect solution for privacy because every user has access (and even a copy) of the ledger. *See, e.g.*, Andreas Park, Managing Blockchain Transparency 7 (Nov. 2017) (unpublished manuscript) (on file with Blockchain Research Institute).

20. The original problem was formulized by Garrit Hardin. *See generally* Garrit Hardin, *The Tragedy of the Commons: The Population Problem has no Technical Solution; It Requires a Fundamental Extension in Morality*, 162 SCI. 1243 (1968). We discuss the problem in further detail, *infra* Part IV.A.

21. *See infra* Part IV.A.

22. However, this is only true for "rivalrous goods," in which the consumption of one user interferes with the consumption of others. We explain why that is likely to be the case for blockchain, *infra* Part III.

23. *See* ROBERT COOTER & THOMAS ULEN, LAW & ECONOMICS 140 (6th edition).

24. *See infra* Part IV.

25. *See infra* Part IV.

26. *See infra* Part IV.

27. *See generally* Konstantin Sokolov, *Ransomware Activity and Blockchain Congestion*, 141 J. FIN. ECON. 771 (2021) (investigating congestion during ransomware attacks).

28. *See, e.g.*, Gönenç Gürkaynak, Ilay Yılmaz, Burak Yesilaltay & Berk Bengi, *Intellectual Property Law and Practice in the Blockchain Realm*, 34 COMPUT. L. & SEC. REV. 847, 850 (2018) ("The fundamental problem currently facing blockchain concerns

which has a negative effect on everyone. In other words, there is a tragic over-use (i.e., over-consumption) of the technology.[29] Furthermore, there is an under-supply of public blockchains; currently, they exist primarily in finance-related contexts (with cryptocurrencies as the main example) but have failed to develop in other fields.[30]

The same problems are then mirrored in regulation: with public blockchains, anyone in the world can access them, such that everyone uses the same infrastructure. However, no regulator can simply fence off a part of the technology and subject it to local rules. Thus, local regulation can directly affect the entire network of users (e.g., cryptocurrency traders), but a local regulator does not have the power to exclude other (foreign) regulators from intervening. Figuratively speaking, local regulators each take a bite and consume some of the benefits of regulation, potentially leading to depletion in the form of an over-regulated and non-functioning market.[31] In particular, a stark concern is that the different regulations might clash with each other, applying contradictory rules and creating legal uncertainty.[32] In other words, regulators' behavior can result in a problem akin to the tragedy of the commons.[33] Respectively, there is also under-supply of *efficient* regulation, meaning a regulation that protects the entire (global) public. This occurs due to the free-rider problem: local regulators only have an incentive to adopt rules to protect the local set of users but have no reason to exert effort to protect the entire globe.

Given this diagnosis, the most straightforward remedy is global regulation of public blockchains—that is, regulation that aims to protect the entire public and not any specific jurisdiction. There are

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the speed with which these transactions can be processed through blockchain technology. Compared to traditional transaction platforms, such as VISA or PayPal, blockchain is significantly slower at this time.").

29. *See* Nazli Cila, Gabriele Ferri, Martijn de Waal, Inte Gloerich & Tara Karpinski, *The Blockchain and the Commons: Dilemmas in the Design of Local Platforms*, PROC. 2020 CHI CONF. ON HUM. FACTORS COMPUT. SYS. 1, 1 (2020).

30. *See generally* Al-Shamsi, Al-Emran & Shaalan, *supra* note 15.

31. *See generally* Hadar Y. Jabotinsky, The Structure of Financial Supervision: A Game Theoretic Approach (Sept. 2013) (unpublished manuscript) (on file with the Tel Aviv University) (arguing that the self-interest of regulators results in a "sub-optimal" social outcome in financial regulation).

32. *Id.*; *see also* Sarel, *supra* note 1, at 415–17 (discussing conflicting rules applied in the federal courts with respect to cryptocurrencies). *See generally* Hadar Y. Jabotinsky, *The Federal Structure of Financial Supervision: A Story of Information-Flow*, 22 STAN. J.L. BUS. & FIN. 52 (2017) (claiming that the greatest drawback of a fragmented regulatory structure relates to lack of sufficient coordination between regulators which can lead to legal uncertainty and contradicting regulations).

33. *Cf.* Hardin, *supra* note 20. The problem could also be restated as an externality problem. Note that whether it is regulation that creates a negative externality on other regulators or non-regulation that creates a positive externality is mostly a matter of framing. *See* Lisa Grow Sun & Brigham Daniels, *Mirrored Externalities*, 90 NOTRE DAME L. REV. 135, 138 (2014) ("That is, if an act results in a negative externality, refraining from that act necessarily creates a positive externality, and vice versa. As a result, any potential decision that implicates externalities can be described, alternatively, as acting or failing to act and thus can be framed as creating either negative or positive externalities.").

reports of early initiatives to create a global regulation for crypto-currencies.[34] The United States, in particular, is now pushing this idea forward.[35] However, it is not fully clear whether global regulation would actually be adopted and even less clear in which form.

We explore three different paths to a global regulation: (i) a centralized global regulator, (ii) decentralized (global) regulation, and (iii) international standards. We also discuss the need to lubricate negotiations between countries by reducing their transaction costs.[36] Our analysis points at advantages and disadvantages for every path and discusses how to potentially implement the regulation. To the best of our knowledge, this is the first article to explain the problem of global regulation using law and economics and to compare potential remedies.

As regulators around the world are currently focusing on crypto-currencies, our analysis will also use the crypto-market as a leading test case. Many of the insights developed in this Article apply to other types of DLT as well, with the necessary adjustments. The remainder of the Article is organized as follows: Part II briefly reviews the development and current state of affairs with respect to DLT. Part III summarizes the traditional taxonomy of economic goods and how it applies to DLT. Part IV reiterates the two incentive problems—the tragedy of the commons and the free-rider problem—and explains in further details how they apply to both the technology and the regulation. Part V entails an extensive discussion on the different paths to global regulation. Part VI describes implementation, differentiating between on-chain and off-chain regulation. Part VII concludes.

II. DISTRIBUTED LEDGER TECHNOLOGY (DLT): OVERVIEW AND REGULATORY LANDSCAPE

A. *What Is Distributed Ledger Technology?*

In 2008, a mysterious person (or persons) using the pseudonym "Satoshi Nakamoto" released a paper titled "Bitcoin: A Peer-to-Peer

34. *See* Euronews, *Global Crypto Regulation Body Likely in Next Year as COVID-19, Climate and Crypto Top Concerns*, REUTERS (May 13, 2022), https://www.euronews.com/next/2022/05/13/global-crypto-regulation-body-likely-in-next-year-as-covid-19-climate-and-crypto-top-conce [https://perma.cc/WUP8-7HV4] (archived Dec. 29, 2022).

35. *See* Justin Baltrusaltis, *U.S. Treasury Pushes for Uniform Global Cryptocurrency Regulations*, FINBOLD (July 8, 2020), https://finbold.com/u-s-treasury-pushes-for-uniform-global-cryptocurrency-regulations/ [https://perma.cc/L3YP-594D] (archived Feb. 13, 2023); *see also* Press Briefing, White House, Background Press Call by Senior Administration Officials on the First-Ever Comprehensive Framework for Responsible Development of Digital Assets (Sept. 15, 2022), https://www.whitehouse.gov/briefing-room/press-briefings/2022/09/16/background-press-call-by-senior-administration-officials-on-the-first-ever-comprehensive-framework-for-responsible-development-of-digital-assets/ [https://perma.cc/37KR-M9CA] (archived Feb. 13, 2023) (mentioning the strengthening of global regulation).

36. *See infra* Part V.B.

Electronic Cash System," [37] which described a new version of "electronic cash"—Bitcoin.[38] The idea behind Bitcoin was to allow individuals to make online payments without having to go through a financial institution. However, without an intermediary that can verify whether a transaction took place, how can individuals be certain that money was actually transferred from A to B (and thus will not be double spent via another transfer from A to C)? Nakamoto's revolutionary proposal was to exploit an existing technology known as Distributed Ledger Technology (DLT) for the purpose of registering transactions in Bitcoin.

The origin of DLT dates back to the year 1991, when two researchers published an article on how to time stamp a document.[39] The idea was developed in further work, including a suggestion predating Bitcoin to launch a similar token named "Bit gold,"[40] but rose to fame only with the launch of Bitcoin.

In a nutshell, DLT works as follows: A digital ledger is created in order to register some information of interest. For instance, the ledger may contain a list of transactions, specifying that Abraham transferred money to Betty, who then transferred money to Charles. As this list is not managed by a financial intermediary, such as a bank, the way to ensure its accuracy lies in how it is stored. Namely, instead of saving one unique copy of the ledger in the hands of a bank, every user of the network receives a copy. This ledger then continuously updates whenever someone transfers money (i.e., each transaction gets documented on each copy of the ledger).[41] To illustrate why this is helpful, suppose Abraham wanted to claim he did not spend money that he actually did spend. Abraham could not simply change his own document—he would need to change each and every copy, on each and every computer on the network, which is very difficult to do. Thus, the only real way of changing the ledger is by utilizing the computerized protocol that is allowed to continuously make changes in the copies of the ledger.

For the sake of brevity, instead of explaining the many technical details of how this protocol works, let us only highlight some key concepts: First, the ledger is programmed such that, with existing

37. NAKAMOTO, *supra* note 6.

38. *Id.*

39. *See generally* Stuart Haber & W. Scott Stornetta, *How to Time-Stamp a Digital Document*, 3 J. CRYPTOLOGY 99 (1991). For an overview, see Blockstreet HQ Team, *Before Blockchain, There Was Distributed Ledger Technology*, MEDIUM (Sept. 6, 2018), https://medium.com/blockstreethq/before-blockchain-there-was-distributed-ledger-technology-319d0295f011 [https://perma.cc/VS72-2MAJ] (archived Dec. 29, 2022).

40. *See* Nick Szabo, *Bit Gold*, SATOSHI NAKAMOTO INST. (Dec. 29, 2005), https://nakamotoinstitute.org/bit-gold/ [https://perma.cc/L9VG-SG2R] (archived Jan. 18, 2023).

41. In a way, this method of registering is similar to a shared document on Google Drive where any changes to the document can be seen by all participants of the group. *See, e.g.*, Joshua Fairfield, *Tokenized: The Law of Non-fungible Tokens and Unique Digital Property*, 97 IND. L.J. 1261, 1272 (2022). However, the storage is very different: it is not a single document that everyone can access at the same time, but rather a distribution of identical copies of the same document whenever a change occurs.

technology,[42] it can never be changed retroactively—it can only be appended (by adding new lines).[43] Second, a party seeking to make a transfer must have access to an online account (a "wallet") which has an address (a "public key") and a password (a "private key").[44] When a transfer takes place, the ledger only specifies which accounts are involved, but not the identity of the account holder. Third, a transaction only goes through if it is validated in accordance with a "consensus protocol."[45] There are many such protocols, but the most well-known one (which is used also in Bitcoin) is called Proof of Work, where a group of computers ("nodes") use computing power to solve puzzles.[46] As solving the puzzle requires a large amount of computing power, the assumption is that currently, no single person has enough computing power to validate the transaction unilaterally.[47] Therefore, by decentralizing the validation of transactions, DLT circumvents the need to rely on a (centralized) financial intermediary.[48] Fourth, the ledger can entail whatever content that it is designed to hold, but the most common use is perhaps the registration of transactions in digital tokens, such as Bitcoin, also known as crypto-tokens, crypto-assets, or simply cryptocurrencies (we provide further details on the market for cryptocurrencies below).[49] Fifth, the transactions themselves are executed using so-called smart contracts[50]—algorithms that transfer a token

42. There are concerns that quantum computing can allow a single computer to provide the necessary power needed to make a unilateral change. *See generally* Dan A. Bard, Joseph J. Kearney & Carlos A. Perez-Delgado, *Quantum Advantage on Proof of Work*, 15 ARRAY (2022).

43. *See, e.g.*, Yeung, *supra* note 11, at 210 (referring to blockchain as "append-only").

44. Sarel, *supra* note 1, at 398.

45. *See, e.g.*, Christoph Van der Elst & Anne Lafarre, *Blockchain and Smart Contracting for the Shareholder Community*, 20 EUR. BUS. ORG. L. REV. 111, 126 (2019).

46. *See* NAKAMOTO, *supra* note 6, at 3.

47. *Cf. id.* ("If a majority of CPU power is controlled by honest nodes, the honest chain will grow the fastest and outpace any competing chains. To modify a past block, an attacker would have to redo the proof-of-work of the block and all blocks after it and then catch up with and surpass the work of the honest nodes. We will show later that the probability of a slower attacker catching up diminishes exponentially as subsequent blocks are added."); *see also* Oleksandr Vashchuk & Roman Shuwar, *Pros and Cons of Consensus Algorithm Proof of Stake. Difference in the Network Safety in Proof of Work and Proof of Stake*, 9 ELEC. & INFO. TECH. 106, 106–07 (2018) ("To increase the profit, miners are compelled to continuously deploy more resources for mining. This makes the cost of an attack on PoW-secured system extremely high . . .").

48. *See* NAKAMOTO, *supra* note 6, at 3; *see also* Renato Mangano, *Blockchain Securities, Insolvency Law and the Sandbox Approach*, 19 EUR. BUS. ORG. L. REV. 715, 716 (2018).

49. *See infra* Part II.D.

50. For an overview of smart contracts and their legal status, see generally Riccardo De Caria, *The Legal Meaning of Smart Contracts*, 26 EUR. REV. PRIV. L. 731 (2018); Michel Cannarsa, *Interpretation of Contracts and Smart Contracts: Smart Interpretation or Interpretation of Smart Contracts?*, 26 EUR. REV. PRIV. L. 773 (2018); Primavera De Filippi & Andrea Leiter, *Blockchain in Outer Space*, 115 AJIL UNBOUND 413, 415 (2021).

only if a predefined set of conditions is fulfilled (e.g., that the transferor used the correct private key).[51]

Finally, DLT's flexibility allows it to customize how the data is precisely stored, but the predominant sub-category of DLT is the one proposed by Nakamoto, in which the data is stored in "blocks" that are linked to one another in a chain (i.e., a blockchain).[52] Hence, DLT is nowadays often referred to simply as "blockchain technology."

B. *Public and Private Blockchains*

Blockchains can be divided into two different types: (i) public blockchains and (ii) private (or "permissioned") blockchains.[53] Public blockchains are designed such that they are open for all—that is, any person who is in possession of a computer can join the network and observe the contents of the ledger. The most prominent example is the Bitcoin blockchain. Additional examples can be found in other blockchains in the realm of cryptocurrencies, such as the Ethereum blockchain[54] and the EOS blockchain,[55] which register transactions in customizable tokens that are used in decentralized apps,[56] or the Steem blockchain,[57] which registers transactions in tokens that are used in (decentralized) social media platforms.

Conversely, private blockchains leave some control in the exclusion of new users. This may often entail some form of screening, meaning that not everyone can join immediately. The screening may be either external to the blockchain—for example, when an administrator has the power to define who can join—or embedded inside the technology. For instance, one can construct a permissioned blockchain

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51. Jabotinsky, *supra* note 4, at 138–39 ("Blockchain technology makes use of smart contracts, which are run and verified by many computers to ensure trustworthiness and allow users to instruct the computer program to transfer the currency from one to another given that certain conditions apply. In other words, they are programs that execute 'if this happens, then do that' commands.").

52. NAKAMOTO, *supra* note 6, at 3.

53. *See, e.g.*, Schuster, *supra* note 11, at 993–94.

54. *See* Ethereum Foundation, *What is Ethereum?*, ETHEREUM.ORG (Dec. 18, 2020), ethereum.org/en/what-is-ethereum [https://perma.cc/B6YE-9CLD] (archived Jan. 18, 2023).

55. BRENT XU, DHRUV LUTHRA, ZAK COLE & NATE BLAKELY, BITMEX, EOS: AN ARCHITECTURAL, PERFORMANCE, AND ECONOMIC ANALYSIS, (Nov. 2018), https://blog.bitmex.com/wp-content/uploads/2018/11/eos-test-report.pdf [https://perma.cc/8554-ZHY6] (archived Dec. 29, 2022); *see also* EOS, *The EOS Public Blockchain*, EOS.IO, https://eos.io/eos-public-blockchain (last visited Dec. 29, 2022) [https://perma.cc/CWD8-NAHE] (archived Dec. 29, 2022).

56. *See, e.g.*, Chris Brummer, *Disclosure, Dapps and DeFi*, 5 STAN. J. BLOCKCHAIN L. & POL'Y 137 (2022).

57. STEEM, AN INCENTIVIZED, BLOCKCHAIN-BASED, PUBLIC CONTENT PLATFORM (June 2018), https://steem.com/steem-whitepaper.pdf [https://perma.cc/6ZTT-74KY] (archived Jan. 18, 2023); *see also* Cheick Tidiane, Matteo Zignani & Sabrina Gaito, *The Role of Cryptocurrency in the Dynamics of Blockchain-based Social Networks: The Case of Steemit*, 16 PLOS ONE, June 2022, at 1, 2.

such that multiple nodes serve as a gatekeeper,[58] thereby making permission-granting also decentralized. The most prominent examples of permissioned blockchains can be found in intra-business solutions such as supply chains. Consider, for instance, a business owner who is concerned that transporters might steal some of the transported goods and then manipulate the delivery documents to appear as if the stolen goods never existed. Such an owner may, therefore, opt to use a reliable digital record. At the same time, the owner does not want his competitors to know the details of his deliveries, so that a publicly available digital record would be counterproductive. A private blockchain is a solid solution for such a problem, as it prevents the transporters from manipulating the data and, at the same time, allows the business owner to exclude strangers from observing the ledger. Hence, it is unsurprising that blockchains that are typically used for supply chains, such as Hyperledger Fabric [59] (by IBM) or Azure [60] (by Microsoft), are private blockchains.

C. *Why Should We Care about DLT?*

A first, obvious answer for the question of why one should care about DLT is the technology's potential. DLT has been described as "one of the most promising emerging technologies which will transform the future business and social consumer behavior in several industrial segments fundamentally,"[61] and "a promising technology to remove the multiple frictions and inefficiencies that plague international trade."[62]

However, to fully understand the repercussions of DLT's emergence, it is far more illustrative to consider *why* and *how* it disrupts the existing legal order. In other words, the importance of DLT is not only its benefits but also its disrupting effects. In a nutshell, the very

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58. *See* Yannis Bakos, Hanna Halaburda & Christoph Mueller-Bloch, *When Permissioned Blockchains Deliver more Decentralization than Permissionless*, 64 COMMC'NS ACM 20, 22 (2021).

59. *See generally* Elli Androulaki, Artem Barger, Vita Bortnikov, Christian Cachin, Konstantinos Christidis, Angelo De Caro, David Enyeart, Christopher Ferris, Gennady Laventman, Yacov Manevich, Srinivasan Muralidharan, Chet Murthy, Binh Nguyen, Manish Sethi, Gari Singh, Keith Smith, Alessandro Sorniotti, Chrysoula Stathakopoulou, Marko Vukolić, Sharon Weed Cocco & Jason Yellick, *Hyperledger Fabric: A Distributed Operating System for Permissioned Blockchains, in* PROC. 13TH EUROSYS CONF. 1 (2018) (providing an overview of IBM's Hyperledger Fabric blockchain system).

60. *See generally* Yuepeng Wang, Shuvendu K. Lahiri, Shuo Chen, Rong Pan, Isil Dillig, Cody Born, Immad Naseer & Kostas Ferles, *Formal Verification of Workflow Policies for Smart Contracts in Azure Blockchain, in* VERIFIED SOFTWARE: THEORIES, TOOLS, AND EXPERIMENTS (Supratik Chakraborty & Jorge A. Navas eds. 2019) (examining the "safety and security" of smart contracts in Microsoft's Azure blockchain).

61. Umit Cali, Claudio Lima, Xuefei Li & Yasuhiko Ogushi, *Transactive Energy Blockchain Use Cases Segmentation and Standardization Framework*, IEEE 2019 TRANSACTIVE ENERGY SYS. CONF. (TESC) PROCEEDINGS (2019), https://ieee-tesc.org/wp-content/uploads/sites/68/2019/abstracts/TESC19-038-Cali-UNCC-IEEE-Blockchain.pdf [https://perma.cc/V5NC-P5EB] (archived Dec. 29, 2022).

62. Ganne, *supra* note 1, at 419.

same attribute that makes DLT so attractive also has the potential to destabilize existing institutions that rely on centralized control.[63] To illustrate, we focus on three prominent examples, all in the area of financial markets: central banking, anti-money-laundering regulation (AML), and some aspects of financial regulation.

One of the main roles of central banks is to ensure the stability of the local currency and that of local financial institutions.[64] As such, one of the main instruments available to a central bank is its ability to affect the relative price of the local currency and its supply using changes in the interest rate.[65] For instance, by increasing the interest rate, the central bank can encourage individuals to save and invest their money, rather than use it for consumption.[66] However, the effectiveness of the interest rate as a monetary instrument is closely dependent on the use of the local currency. Substitutes for the local currency lie outside of the bank's control. Thus, DLT-based currencies, as well as any "decentralized finance,"[67] disrupt the efficacy of the interest rate. This occurs because these substitutes lie outside of the central bank's control.

Similarly, AML regulation, which mostly imposes obligations on financial intermediaries (e.g., banks),[68] only works because the intermediaries have some form of centralized authority over the activity. This is why AML regulation tends to harness the (private) intermediaries as part of the regulation, by forcing them to monitor the activities under their control.[69] DLT undermines these efforts because

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63. *See, e.g.*, Christian Catalini, *Blockchain Technology and Cryptocurrencies: Implications for the Digital Economy, Cybersecurity, and Government*, 19 GEO. J. INT'L AFFS. 36, 37 (2018).

64. Willem H. Buiter, *The Role of Central Banks in Financial Stability: How Has It Changed, in* THE ROLE OF CENTRAL BANKS IN FINANCIAL STABILITY: HOW HAS IT CHANGED 11, 11–12 (Douglass D. Evanoff et al. eds., 2014) (discussing the traditional goal of a central bank to set interest rate and the shift to financial stability as a concurrent goal).

65. *See, e.g.*, John B. Taylor, *The Role of the Exchange Rate in Monetary-policy Rules*, 91 AM. ECON. REV. 263, 264 (2001) ("The exchange rate usually enters as part of an arbitrage equation relating the interest rate in one country to the interest rates in other countries through the expected rate of appreciation of the exchange rate.").

66. *See, e.g.*, Warren E. Weber, *The Effect of Interest Rates on Aggregate Consumption*, 60 AM. ECON. REV. 591, 591 (1970).

67. *See generally* Dirk A. Zetzsche, Douglas W. Arner & Ross P. Buckley, *Decentralized Finance*, 6 J. FIN. REG. 172 (2020); Hilary J. Allen, *DeFi: Shadow Banking 2.0?*, WM & MARY L. REV. (forthcoming) (on file with the William & Mary Law Review)

68. *See, e.g.*, Joras Ferwerda, *The Economics of Crime and Money Laundering: Does Anti-money Laundering Policy Reduce Crime?*. 5 REV. L. & ECON. 903, 915 (2009) ("The 'private sector' part of anti-money laundering policy includes mainly the duties (especially reporting) of private companies, like financial institutions and 'designated non-financial businesses and professions.'").

69. *See* Jack M. Balkin, *Free Speech Is a Triangle*, 118 COLUM. L. REV. 2011, 2016 (2018); Hadar Y. Jabotinsky & Michal Lavi, *Speak Out: Verifying and Unmasking Cryptocurrency User Identity*, 32 FORDHAM INTELL. PROP. MEDIA & ENT. L.J. 518, 532 (2022); Rory Van Loo, *The New Gatekeepers: Private Firms as Public Enforcers*, 106 VA. L. REV. 467, 467–68 (2020) (referring to the rise of the enforcer-firm regulation that gives

it facilitates alternatives to the said activities. For instance, by enabling the trade of cryptocurrencies as well as other crypto-assets such as Non-Fungible Tokens (NFTs),[70] DLT poses a risk to the efforts of regulators to combat money-laundering and terror financing. This occurs for two reasons. First, the trade can take place outside the control of traditional financial intermediaries. Second, crypto-tokens are sometimes traded anonymously, so tracing who is behind the transfer or money is very difficult, if at all possible.[71] In other words, as DLT facilitates substitutes for all sorts of financial intermediaries,[72] AML regulation can no longer easily harness the intermediaries to enforce the rules.[73]

Next, consider the relationship between DLT and financial regulation. Unlike the previous examples, DLT does not fully get in the way of financial regulation—although some parts of it do seem to be less effective. Specifically, financial regulation that targets banks directly, such as capital requirements or Know-Your-Customer procedures, can be fully circumvented by using DLT, as traders can cut-out the regulated intermediary and either trade directly with one another (peer-to-peer) or through an unregulated intermediary. For instance, in the crypto-market, the majority of the trade nowadays is executed through crypto-exchanges—intermediaries that allow users to exchange between different tokens (e.g., between Bitcoin and other cryptocurrencies) or between cryptocurrencies and regular (fiat) money.[74] Unless such exchanges are subject to the same rules as banks, the regulation (of banks) is ineffective, as money laundering and terror financing can simply be done using anonymous cryptocurrencies.[75] The same problems emerge with regard to risk regulation—if banks are regulated and the cryptocurrency market is not, and if the two markets are correlated, systemic risk might flow into traditional markets from the crypto-market.[76] Conversely, some aspects of financial regulation would be far less likely to be affected by the use of DLT. The most prominent example is securities law—if cryptocurrencies are designed

a prominent role to the administrative state's newest gatekeepers); *see also* Rory Van Loo, *The Revival of Respondeat Superior and Evolution of Gatekeeper Liability*, 109 GEO. L.J. 141, 172 (2020); ARI EZRA WALDMAN, INDUSTRY UNBOUND: THE INSIDE STORY OF PRIVACY, DATA AND CORPORATE POWER 106 (2021) (explaining that privacy law tactic changed from self-regulation to public-private partnership in the development of enforcement of law).

70. For a discussion on the problems with NFTs and how to regulate them, see generally Jabotinsky & Lavi, *supra* note 12. NFTs otherwise disrupt also other regulations, for example, those dealing with "the right to be forgotten" under the European General Data Protection Regulation (GDPR). *See id.* at 42.

71. *See id.*

72. *See generally* Hadar Jabotinsky & Roee Sarel, *How Crisis Affects Crypto: Coronavirus as a Test Case*, 74 HASTINGS L.J. 433 (2023).

73. For a detailed discussion as to why this is the case, see generally Jabotinsky & Lavi, *supra* note 12.

74. For a review of crypto-exchanges, see generally Henri Arslanian, *Crypto Exchanges*, *in* THE BOOK OF CRYPTO 335–50 (Palgrave Macmillan, 2022).

75. Jabotinsky & Lavi, *supra* note 12.

76. Jabotinsky & Sarel, *supra* note 72.

such that they are implicitly (or explicitly) a security, there is no obvious reason why the authorities cannot directly enforce the existing regulation, as long as the identity of those issuing securities is known.[77] And, indeed, securities regulation has been a significant exception in which regulators—most notably, the US Securities Exchange Commission (SEC)—have successfully taken action (we describe the regulatory sphere in further details below). Nonetheless, these examples illustrate why DLT is a game changer—not only does it solve various problems, but it also poses a significant risk to (some of) the existing regulatory regimes across different contexts.

D. *The Regulatory Landscape of DLT*

In its earlier days, DLT was virtually unregulated.[78] This was particularly true for its use in the crypto-market, as the market operated freely with barely any intervention for many years, earning it the reputation of being a wild west.[79] However, as time passed, regulators became increasingly concerned with the direction in which the crypto-market was headed, due to a multitude of problems:[80] high volatility, exploitation of investors, usage of cryptocurrencies for criminal purposes, and different externalities[81] (e.g., high energy consumption).[82] Hence, some countries began taking action to regulate cryptocurrencies. The United States was a relatively early mover, with different federal agencies adopting new rules (e.g., the Internal Revenue Service) or enforcing existing rules.[83] Most notably, the SEC decided to target the public sales of cryptocurrencies based on the view that *all* cryptocurrencies are generally securities.[84] Consequently, the SEC initiated proceedings against many launches of tokens—so-called Initial Coin Offerings (ICOs)—imposing large monetary fines. Two examples include (i) enforcement proceedings against Telegram, following the launch of their TON and GRAM tokens, ended in a massive

77. *See generally* Jabotinsky, *supra* note 4.

78. *See id.*

79. *See generally* C. Daniel Lockaby, *The SEC Rides into Town: Defining an ICO Securities Safe Harbor in the Cryptocurrency Wild West*, 53 GA. L. REV. 335, 335 (2018); Randolph A. Robinson, *The New Digital Wild West: Regulating the Explosion of Initial Coin Offerings*, 85 TENN. L. REV. 897 (2017).

80. *See generally* Jabotinsky & Sarel, *supra* note 72.

81. Externalities is a term taken from economics to describe effects that are not taken into account by the sellers and the buyers in the market and hence is not reflected in the price. *See, e.g.*, COOTER & ULEN, *supra* note 23, at 39.

82. In 2018, the global energy consumption of Bitcoin was estimated to exceed Switzerland's energy consumption. Edward A. Morse, *From Rai Stones to Blockchains: The Transformation of Payments*, 34 COMPUT. L. & SEC. REV. 946, 952 (2018).

83. *See, e.g.*, I.R.S. Notice 2014-21 (May 2014) (ordering to tax cryptocurrencies as property); Sarel, *supra* note 1, at 393.

84. This view is based on an application of the *Howey* test, SEC v. W.J. Howey Co., 328 U.S. 293, 298–99 (1946), which specifies when investment contracts constitute a security. *See* Jabotinsky, *supra* note 4, at 137; Sarel, *supra* note 1, at 408.

$1.7 billion settlement;[85] and (ii) more recently, proceedings against BlockFi—a firm offering crypto-lending services—ended in a $100 million settlement.[86] The SEC has received some pushback for this approach, with some arguing that it is overreaching its mandate[87] or that it engages in selective enforcement.[88] Even if that is true, this approach has been quite successful in discouraging unregistered ICOs.[89] This enforcement activity led also to the invention of a new compliance solution: "Security Token Offerings" that are registered at the SEC.[90]

While a few other countries also gradually adopted some form of crypto-regulation in parallel to the United States,[91] the more meaningful development occurred more recently—following the COVID-19 pandemic. In the early days of the pandemic, investors fled from traditional markets and into the crypto-market,[92] only to discover that the crypto-market co-crashed with everything else—which suggested that another externality of the crypto-market is an increase in the instability of the financial system as a whole (i.e., systemic risk).[93] Furthermore, intermediaries in the crypto-market (the crypto-exchanges) became increasingly involved not only in the secondary market but also in the primary market. This took place in the form of initial exchange offerings, where firms offer tokens directly through an exchange, which then promises to provide liquidity, as the offered token can be traded on the platform.[94] Regulators then began to see this development as an opportunity: the centralization of trade within exchanges provides a tangible target for financial regulation. That is, an intermediary that can be harnessed. The new desire to regulate cryptocurrencies was boosted by the outbreak of the war in Ukraine,[95] which emphasized the way in which DLT can circumvent regulation.

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85. Sarel, *supra* note 1, at 408.

86. *BlockFi Agrees to Pay $100 Million in Penalties and Pursue Registration of its Crypto Lending Product*, SEC. & EXCH. COMM'N (Feb. 14, 2022), https://www.sec.gov/news/press-release/2022-26 [https://perma.cc/8VS6-FJV3] (archived Dec. 29, 2022).

87. *See generally* Michael J. O'Connor, *Overreaching Its Mandate? Considering the SEC's Authority to Regulate Cryptocurrency Exchanges*, 11 DREXEL L. REV. 539 (2018).

88. *See generally* James J. Park & Howard H. Park, *Regulation by Selective Enforcement: The SEC and Initial Coin Offerings*, 61 WASH. U. J.L. & POL'Y 99 (2020).

89. *See, e.g.*, Escobar Rodas & Rosa Jacqueline, The ICO Is Dead, Long Live the ICO (June 1, 2019) (unpublished manuscript), https://ssrn.com/abstract=3715215 [https://perma.cc/NSX5-ZUS5] (archived Jan. 18, 2023).

90. Sarel, *supra* note 1, at 401; Dmitri Boreiko, Guido Ferrarini & Paolo Giudici, *Blockchain Startups and Prospectus Regulation*, 20 EUR. BUS. ORG. L. REV. 665, 690 (2019).

91. *See generally* Brian D. Feinstein & Kevin Werbach, *The Impact of Cryptocurrency Regulation on Trading Markets*, 7 J. FIN. REG. 48 (2021) (empirically analyzing regulatory announcements in the U.S., Japan, and other countries).

92. Jabotsinky & Sarel, *supra* note 72.

93. *See id.*

94. Sarel, *supra* note 1, at 402.

95. *See generally* Sabrine Ayed, Mohamed Arouri & Adel Barguellil, War and Cryptocurrency Markets: An Empirical Investigation (May 21, 2022) (unpublished manuscript), https://ssrn.com/abstract=4116377 [https://perma.cc/UGW2-KNC2] (archived Jan. 18, 2023).

Namely, the sanctions placed on Russia, such as disconnection from the international SWIFT banking system for monetary settlements,[96] were at risk of being bypassed through cryptocurrencies, which do not require banks.[97]

So began a new wave of crypto-regulations that included moves by various smaller and larger players across the globe.[98] In the United States, attempts to regulate DLT emerged both at the federal and the state level. At the federal level, multiple agencies adopted measures applying to cryptocurrencies, including the SEC, Commodity Futures Trading Commission, Office of the Comptroller of the Currency, Internal Revenue Service, and Financial Crimes Enforcement Network.[99] At the state level, different initiatives emerged as well. For example, Wyoming decided to market itself as a crypto-friendly region already in 2019,[100] whereas the governor of New Hampshire issued an executive order to construct a state Commission on Cryptocurrencies and Other Digital Assets.[101] In March 2022, President Biden issued his own executive order,[102] requiring different agencies to submit reports on aspects related to cryptocurrency regulation.[103] However, in June 2022, a bipartisan bill (the Lummis-Gillibrand Responsible Financial

96. Alicia Hinarejos, *Responding to Russia's Invasion of Ukraine*, 2 EUR. L. REV. 151, 151 (2022).

97. *See* Nizan Geslevich Packin & Hadar Y. Jabotinsky, Blacklisting Crypto (and More) (Aug. 16, 2022) (unpublished manuscript), https://ssrn.com/abstract=4191650 [https://perma.cc/AM2T-4YV3] (archived Feb. 13, 2023).

98. *See* Fredrik Vold, *Regulatory Scrutiny Increasing as Crypto Becomes Financial Stability Risk – Report*, CRYPTONEWS (July 6, 2022), https://cryptonews.com/news/regulatory-scrutiny-increasing-as-crypto-becomes-financial-stability-risk-report.htm [https://perma.cc/T8E3-TBF9] (archived Dec. 29, 2022) (reporting on a 7 percent increase in regulation compared to 2018).

99. *Blockchain and Cryptocurrency Law and Regulation | USA*, GLOB. LEGAL INSIGHTS, https://www.globallegalinsights.com/practice-areas/blockchain-laws-and-regulations/usa (last visited July 12, 2022) [https://perma.cc/A65Y-AKQS] (archived Dec. 29, 2022).

100. *See, e.g.*, Phoebus L. Athanassiou, *Shunning Banks or Depending on Them? Crypto Markets and the Rise of Crypto-Friendly Banking*, 18 EUR. COMP. & FIN. L. REV. 321, 329 (2021).

101. New Hampshire Executive Order 2022-1 (Feb. 9, 2022), https://www.governor.nh.gov/sites/g/files/ehbemt336/files/documents/2022-01.pdf [https://perma.cc/YVJ2-66DC] (archived Dec. 29, 2022).

102. Exec. Order No. 14067, 87 Fed. Reg. 14143 (Mar. 14, 2022); *see also* Hadar Jabotinsky & Roee Sarel, *When Biden Met Crypto: Thoughts on the President's Executive Order*, OXFORD BUS. L. BLOG (Apr. 11, 2022), https://www.law.ox.ac.uk/business-law-blog/blog/2022/04/when-biden-met-crypto-thoughts-presidents-executive-order [https://perma.cc/W2UU-6FB3] (archived Dec. 29, 2022).

103. A first report was filed by the White House concerning cryptocurrencies and climate change. WHITE HOUSE, CLIMATE AND ENERGY IMPLICATIONS OF CRYPTO-ASSETS IN THE UNITED STATES (2022), https://www.whitehouse.gov/wp-content/uploads/2022/09/09-2022-Crypto-Assets-and-Climate-Report.pdf [https://perma.cc/WRP5-BQLR] (archived Dec. 29, 2022); *see also FACT SHEET: Climate and Energy Implications of Crypto-Assets in the United States*, WHITE HOUSE (Sept. 8, 2022), https://www.whitehouse.gov/ostp/news-updates/2022/09/08/fact-sheet-climate-and-energy-implications-of-crypto-assets-in-the-united-states/ [https://perma.cc/43ZR-ANBS] (archived Dec. 29, 2022).

Innovation Act) was submitted to Congress, proposing, among other things, to grant exclusive authority to the Commodity Futures Trading Commission for matters of crypto-regulation.[104] The same thing was proposed by a subsequent bill in August 2022, initiated by members of the Senate Agriculture Committee (the Digital Commodities Consumer Protection Act).[105]

Outside the United States, some individual countries declared their own initiatives to regulate the crypto-market, including Panama,[106] Brazil,[107] the Ukraine,[108] and Paraguay.[109] Yet the more comprehensive process occurred in the European Union. At first, the EU applied existing directives dealing with securities regulation (using the so-called MiFID II approach),[110] and some updated AML directives.[111] However, a proposal for a new "digital finance" package was released

104. Lummis-Gillibrand Responsible Financial Innovation Act, S. 4365, 117th Cong. (2022), § 403(a)(1)(B).

105. *See* Digital Commodities Consumer Protection Act, S. 4760, 117th Cong. (2022).

106. In Panama, the attempt was later blocked by a veto of the country's president. *See* Jesse Coghlan, *President of Panama Shoots down Crypto Bill Citing FATF Guidelines*, COINTELEGRAPH (June 17, 2022), https://cointelegraph.com/news/president-of-panama-shoots-down-crypto-bill-citing-fatf-guidelines [https://perma.cc/5LJB-YSNY] (archived Dec. 29, 2022).

107. *See* Aakanksha Chaturvedi, *Brazil Passes Bill to Regulate Cryptocurrencies*, BUSINESSTODAY.IN (Apr. 27, 2022), https://www.businesstoday.in/crypto/story/brazil-passes-bill-to-regulate-cryptocurrencies-331396-2022-04-27 [https://perma.cc/X3WM-5CVK] (archived Dec. 29, 2022).

108. Arjun Kharpal, *Ukraine Legalizes Crypto Sector as Digital Currency Donations Continue to Pour in*, CNBC (Mar. 17, 2022), https://www.cnbc.com/2022/03/17/ukraine-legalizes-cryptocurrency-sector-as-donations-pour-in.html [https://perma.cc/87RP-DTEA] (archived Dec. 29, 2022).

109. Valentine Hilaire & Elida Moreno, *Panama Passes Bill to Permit Use of Crypto Assets*, REUTERS (Apr. 28, 2022), https://www.reuters.com/world/americas/panama-lawmakers-pass-bill-regulate-use-crypto-assets-2022-04-28/ [https://perma.cc/QKS3-AUYP] (archived Dec. 29, 2022).

110. The MiFID II framework consists of one directive, Directive 2014/65/EU of the European Parliament and of the Council of 15 May 2014 on markets in financial instruments and amending Directive 2002/92/EC and Directive 2011/61/EU (MiFID II), and one regulation, Regulation (EU) No 600/2014 of the European Parliament and of the Council of 15 May 2014 on markets in financial instruments and amending Regulation (EU) No 648/2012. *See* Emilios Avgouleas & Alexandros L. Seretakis, *Governing the Digital Finance Value-Chain in the EU: MIFID II, the Digital Package, and the Large Gaps between!*, 5 EUR. COMP. & FIN. L. REV.1 (2022).

111. *See generally* Christoph Wronka, *Money Laundering Through Cryptocurrencies-Analysis of the Phenomenon and Appropriate Prevention Measures*, 25 J. MONEY LAUNDERING CONTROL 79 (2021). More recently, a new Transfer of Funds Regulation (TOFR) was reportedly moving forward, which deals with the identification of those who transfer cryptocurrencies. *See* European Parliament, *Crypto Assets: Deal on New Rules to Stop Illicit Flows in the EU*, NEWS EUR. PARLIAMENT (June 29, 2022), https://www.europarl.europa.eu/news/en/press-room/20220627IPR33919/crypto-assets-deal-on-new-rules-to-stop-illicit-flows-in-the-eu [https://perma.cc/DBJ4-QCVN] (archived Dec. 29, 2022); Crystal Kim, *EU Lawmakers want to Track Crypto Transfers*, AXIOS (July 5, 2022), https://www.axios.com/2022/07/05/eu-lawmakers-want-to-track-crypto-transfers [https://perma.cc/GYT8-55GW] (archived Dec. 29, 2022).

in 2020, consisting of several pieces of regulations,[112] two of which concern DLT explicitly. The first is the Markets in Crypto-Assets Regulation (MiCA), a comprehensive attempt to harmonize the regulation of cryptocurrencies in the EU. After a long period of negotiation, a general agreement on adopting MiCA was reportedly reached at the end of June 2022,[113] but the final vote has been postponed to April 2023.[114] The second is a proposal that relates to the technology itself, dealing with a "pilot regime for DLT market infrastructures" (DLT-Pilot Regime).[115] The DLT-Pilot Regime specifies four goals of the regulation: (i) legal certainty, (ii) supporting innovation, (iii) instilling consumer and investor protection and market integrity, and (iv) financial stability.[116] More concretely, it (1) sets limitations on which DLT-transferable securities can be traded on intermediaries (e.g., crypto-exchanges),[117] (2) subjects intermediaries and operators to administrative requirements,[118] and (3) imposes reporting requirements to the European Securities and Markets Authority. The DLT-Pilot Regime entered into force in early June 2022.[119]

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112. The three proposals are: (1) *Proposal for a Regulation of the European Parliament and if the Council on Markets in Crypto-assets, and Amending Directive (EU) 2019/1937*, COM (2020) 593 final (Sept. 24, 2020) [hereinafter MiCA]; (2) *Proposal for a Regulation of the European Parliament and of the Council on a Pilot Regime for Market Infrastructures Based on Distributed Ledger Technology,* COM (2020) final (Sept. 24, 2020) [hereinafter DLT-Pilot Regime]; and (3) *Proposal for a Regulation of the European Parliament and of the Council on digital operational resilience for the financial sector and amending Regulations (EC) No 1060/2009, (EU) No 648/2012, (EU) No 600/2014 and (EU) No 909/2014*, COM (2020) 595 final (Sept. 24, 2020) [hereinafter DORA]. The digital finance package also includes an additional document which proposes to revise some existing regulations. *See Proposal for a Directive of the European Parliament and of the Council amending Directives 2006/43/EC, 2009/65/EC, 2009/138/EU, 2011/61/EU, EU/2013/36, 2014/65/EU, (EU) 2015/2366 and EU/2016/2341*, COM (2020) 596 final (Sept. 24, 2020).

113. *See* Ryan Browne, *EU agrees on Landmark Regulation to Clean up Crypto 'Wild West'*, CNBC (June 30, 2022), https://www.cnbc.com/2022/06/30/eu-agrees-to-deal-on-landmark-mica-cryptocurrency-regulation.html [https://perma.cc/78V4-ZZWA] (archived Dec. 29, 2022).

114. *See* Prashant Jha, *EU Postpones Final Vote on MiCA for the Second Time in two Months,* COINTELEGRAPH (Jan. 18, 2023), https://cointelegraph.com/news/eu-postpones-final-vote-on-mica-for-the-second-time-in-two-months [https://perma.cc/8M9H-JYZN] (archived Feb. 13, 2023).

115. § 1 of the Explanatory Memorandum of the DLT-Pilot Regime. The pilot regime is sometimes referred to as "PilotR." *See* Dirk Zetzsche & Jannik Woxholth, *The DLT Sandbox under the EU Pilot Regulation* (U. Luxembourg L. Rsch. Paper No. 2021-001, 2021), https://ssrn.com/abstract=3833766 [https://perma.cc/6LJ8-Z25J] (archived Jan. 18, 2023).

116. *See* § 1 of the Explanatory Memorandum of the DLT-Pilot Regime.

117. DLT-Pilot Regime, *supra* note 112, art. 3(1). Note that intermediaries are referred to as "DLT MFT." *See id.* art. 2.

118. *Id.* arts. 4–8.

119. *See* Regulation (EU) 2022/858 of the European Parliament and of the Council of 30 May 2022 on a pilot regime for market infrastructures based on distributed ledger technology, and amending Regulations (EU) No 600/2014 and (EU) No 909/2014 and Directive 2014/65/EU; *see also* Mirsolav Duric & Verena Ritter-Doring, *DLT Pilot Regime: the EU Opens the Door for DLT Market Infrastructures,* TAYLORWESSING (June

Notably, none of the proposals (MiCA and the DLT-Pilot Regime) seem to be particularly preoccupied with the non-excludable nature of DLT in the context of cryptocurrencies. In fact, virtually all of the aforementioned initiatives are highly market-focused, thereby neglecting the many alternative uses for DLT outside cryptocurrencies. And perhaps most importantly, the various initiatives do not seem to be coordinated, rather, each country has been unilaterally adopting its own measures.

Recently, however, there have been some meaningful movements on the international front as well. The Financial Stability Board (FSB)—"an international body that monitors and makes recommendations about the global financial system"[120]—released a detailed assessment of the risks involved in cryptocurrencies in February 2022.[121] Regulatory movements on the international level sped up after a massive crash in the crypto-market,[122] which wiped-out more than $2 trillion dollars in 2022.[123] In response to this crash, a G7 meeting took place in July 2022 that reportedly dealt with the coordination of crypto-regulation between its members (Canada, France, Germany, Italy, Japan, the United States, and the United Kingdom).[124] Around the same time, a bilateral meeting between the United States and the United Kingdom yielded a joint statement about their commitment to cooperate on crypto-policy.[125] Shortly thereafter, the US Department of Treasury called for unified rules for regulating cryptocurrencies

6, 2022), https://www.taylorwessing.com/en/insights-and-events/insights/2022/06/dlt-pilot-regime [https://perma.cc/78SQ-3C25] (archived Dec. 29, 2022).

120. *About*, FIN. STABILITY BD., https://www.fsb.org/about/ (last visited July 19, 2022) [https://perma.cc/6F2Z-G8YP] (archived Dec. 29, 2022).

121. *See* FIN. STABILITY BD., ASSESSMENT OF RISKS TO FINANCIAL STABILITY FROM CRYPTO-ASSETS (Feb. 16, 2022), https://www.fsb.org/wp-content/uploads/P160222.pdf [https://perma.cc/8NXV-47WP] (archived Dec. 29, 2022).

122. *See* Andrew Pimlott, *United States: The Crypto Crash and the Regulatory Response*, MONDAQ (July 7, 2022), https://www.mondaq.com/unitedstates/fin-tech/1209446/the-crypto-crash-and-the-regulatory-response [https://perma.cc/2FA4-ULYF] (archived Dec. 29, 2022).

123. *See* Elaine Yu, Joe Wallace & Paul Vigna, *Bitcoin Price Plunges as Crypto Lender Celsius Halts Withdrawals*, WALL ST. J. (June 13, 2022), https://www.wsj.com/articles/bitcoin-revisits-late-2020-levels-as-it-suffers-fresh-selloff-11655096332 [https://perma.cc/95LH-UXF2] (archived Dec. 29, 2022).

124. *See* Rudy Fares, *G7 Countries to Regulate Cryptos – is Crypto Regulation Good or Bad?*, CRYPTOTICKER (July 4, 2022), https://cryptoticker.io/en/g7-regulate-cryptos-is-crypto-regulation-good/ [https://perma.cc/HY34-5EB2] (archived Dec. 29, 2022).

125. *See Joint Statement on the U.S.-UK Financial Innovation Partnership Meeting 29th June 2022*, HM TREASURY (July 1, 2022), https://www.gov.uk/government/publications/joint-statement-on-the-us-uk-financial-innovation-partnership-meeting-29th-june-2022/joint-statement-on-the-us-uk-financial-innovation-partnership-meeting-29th-june-2022 [https://perma.cc/GCN4-UYPW] (archived Dec. 29, 2022).

across nations,[126] and emphasized its engagement within international frameworks on this matter (e.g., G7, G20, FSB, and the Financial Action Task Force (FATF)).

Finally, there have been news reports on the formation of a global regulator,[127] as well as an explicit statement by the FSB on the intention of adopting international regulation of crypto-assets by October 2022.[128]

However, this chain of events is far from self-explanatory: Why are there suddenly so many competing initiatives to regulate cryptocurrencies? Why are there no such initiatives for private blockchains? Why has the SEC been able to discourage non-compliant ICOs whereas other problems continue to linger? And why is global regulation helpful? The next Part lays out the theoretical background that will help shed some light on these questions.

III. CLASSIFYING DLT

A. *The Taxonomy of Economic Goods*

Economists traditionally define an "economic good" as a good that is relatively scarce,[129] as opposed to a "free good," which is abundant.[130] However, not all economic goods are the same—there are some distinctions that are helpful, as they bear significance to questions of policy. One of these distinctions is a taxonomy that maps economic goods across two features: (1) *rivalry* and (2) *excludability*.[131]

126. *See Fact Sheet: Framework for International Engagement on Digital Assets*, U.S. DEP'T OF TREASURY (July 7, 2022), https://home.treasury.gov/news/press-releases/jy0854 [https://perma.cc/47NJ-XKQV] (archived Dec. 29, 2022); *see also* Allyson Versprille, C*rypto Needs Consistent Regulation Across Nations, US Treasury Says*, BLOOMBERG (July 7, 2022), https://www.bloomberg.com/news/articles/2022-07-07/crypto-needs-consistent-regulation-across-nations-treasury-says [https://perma.cc/MJV7-CXF9] (archived Dec. 29, 2022).

127. *See* Euronews, *supra* note 34.

128. *See* FIN. STABILITY BD., FSB STATEMENT ON INTERNATIONAL REGULATION AND SUPERVISION OF CRYPTO-ASSET ACTIVITIES (July 11, 2022), https://www.fsb.org/wp-content/uploads/P110722.pdf [https://perma.cc/JK8A-EDHW] (archived Dec. 29, 2022).

129. Makoto Nishibe, *Ethics in Exchange and Reciprocity, in* COMPETITION, TRUST, AND COOPERATION 77, 80 (Springer, 2001) ("If the equilibrium . . . price of a good is positive it is held to be an 'economic' good. On the other hand, if the equilibrium price of a good is zero then it is called a 'free' good."). Equivalently, an economic good can be thought of as a good that requires scarce resources for its production. *See, e.g.*, Allen Parkman, *An Economic Analysis of the FCC's Multiple Ownership Rules*, 31 ADMIN. L. REV. 205, 206 (1979).

130. For instance, air is in general a free good, as anyone can breathe it without paying and without worrying about scarcity. *Cf.* Gerald A. Wright, *The Cost-Internalization Case for Class Actions*, 21 STAN. L. REV. 383, 402 (1968).

131. *See*, *e.g.*, COOTER & ULEN, *supra* note 23, at 39–42; Jan-Phillip Elm & Roee Sarel, *No Policy Is an Island: Mitigating Covid-19 in View of Interaction Effects*, 48 AM. J.L. & MED. 7, 15 (2022).

The first feature (rivalry) asks whether the consumption of a good by one consumer derogates from the ability of another consumer to consume the same good.[132] For instance, a chair is rivalrous, as two people cannot comfortably sit on it at the same time, whereas a song played on the radio is non-rivalrous, as one person's enjoyment of the music does not interfere with others' enjoyment.

The second feature (excludability) asks whether one can exclude others from consuming the good at a reasonable cost.[133] For instance, it is easy to exclude others from sitting on a chair, but it is difficult to exclude others from enjoying the benefits of national security.[134]

This famously yields a taxonomy that entails four types of goods: (i) "private goods" (rivalrous and excludable), (ii) "club goods" (non-rivalrous and excludable), (iii) "common goods" (rivalrous and non-excludable), and (iv) "public goods" (non-rivalrous and non-excludable).[135] Table 1 summarizes this taxonomy.[136]

Table 1: Taxonomy of Goods

	Excludable	Non-Excludable
Rivalrous	Private Goods (e.g., a chair)	Common Goods (e.g., a highway)
Non-Rivalrous	Club Goods (e.g., music at a concert)	Public Goods (e.g., national defense)

The table provides some typical examples for each type of good, including the previously given examples of a chair and music. Note that music played in a concert is a club good, as the club's managers can exclude those who did not buy a ticket, but those who are in the club can all simultaneously enjoy the music. Along similar lines, national defense is a public good,[137] because everyone enjoys the security at the same time and cannot exclude each other.

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132. *See* COOTER & ULEN, *supra* note 23, at 40*;* Elm & Sarel, *supra* note 131, at 15.

133. Some take the definition of whether a profit-maximizing firm would be willing to invest in exclusion given the benefit. *See* Dan Assaf, *Government Intervention in Information Infrastructure Protection, in* INTERNATIONAL CONFERENCE ON CRITICAL INFRASTRUCTURE PROTECTION 29, 31 (Springer, 2007) ("When a good is non-excludable, either it is impossible to exclude non-payers from using it, or the costs of excluding non-payers are high enough to deter a profit-maximizing firm from producing that good.").

134. COOTER & ULEN, *supra* note 23, at 40.

135. *See, e.g.*, Patrick McNutt, *Public Goods and Club Goods, in* ENCYCLOPEDIA OF LAW AND ECONOMICS 927, 930 (Alain Marciano & Giovanni Battista Ramello eds., 1999); Usman W. Chohan & Aron D'Souza, Club Theory: A Contemporary Economic Review 3 (Jan. 10, 2020) (unpublished manuscript) (on file with the UNSW Business School).

136. For a similar table, see Chohan & D'Souza, *supra* note 135, at 4.

137. COOTER & ULEN, *supra* note 23, at 40.

From a law and economics perspective, the taxonomy is important for determining whether the good should be privately owned or publicly owned.[138] This is due to the following: when goods are *non-excludable*, private persons might be unwilling to invest in producing and maintaining them.[139] For instance, individuals would probably be reluctant to pay money to construct a bathroom (or spend time cleaning it) if strangers can simply use it whenever they wish (due to inability to exclude such strangers). Respectively, goods that are *non-rivalrous* cannot be easily monetized,[140] as many people can use them at the same time without derogating from each other's uses. Hence, individuals might be reluctant to invest money to construct a non-rivalrous good, assuming it will not generate much revenue. Conversely, rivalrous goods invoke the concern of too much consumption, as consumers then, by definition, interfere with each other's enjoyment.

B. *Public Blockchains as a Non-Excludable Good*

At first glance, DLT neatly maps onto the taxonomy of economic goods on the criterion of *excludability*: A public blockchain is a non-excludable good, as anyone can join the network and no user can easily exclude others from joining. A private blockchain, in contrast, is an excludable good by design, as only permissioned users can join the network.

However, the application of the taxonomy is less straightforward if one considers regulation: a local regulator generally cannot exclude other (foreign) regulators from intervening in the local market—meaning that if a foreign regulator decides to apply exterritorial jurisdiction, there is no easy way to prevent this without some political solution. Nonetheless, there is a key difference on the side of the technology: a foreign regulator who seeks to target a private blockchain that only permits local users to use it (e.g., one firm's intra-state supply chain) is unlikely to succeed without the local authority's cooperation. Therefore, even if some foreign government claims to have authority over a private (local) blockchain, it might face enforcement difficulties, at least for regulation that deals with the technology itself. Consider, for example, a Russian regulator demanding that a US firm use some specific code when updating the ledger on its private blockchain: in the absence of an effective pressure mechanism or cooperation by the US government, the firm can simply ignore this demand. In this sense, the

138. *Id.* at 103.

139. *See* John Forster, *The Creation, Maintenance and Governance of Public Goods and Free Goods*, 1 PUB. MGMT.: AN INT'L J. RSCH. & THEORY 313, 315 (1999) (describing the standard treatment of public goods, which highlights the inability to directly commercialize such a good).

140. *See, e.g.*, Can Chen, *Public Infrastructure Finance: Symposium Introduction*, 30 J. PUB. BUDGETING ACCT. & FIN. MGMT. 126, 127 (2018) ("[P]ublic goods that are non-rivalrous in consumption, non-excludable in use, or both; typically exhibit natural monopoly; and often yield positive spillovers that are hard to monetize.").

US government can exclude the Russian regulator easily. However, this only holds in this example because the blockchain is private, which allows the firm to "fence-off" its supply chain from the rest of the world. If the firm was using a public blockchain, this would no longer be possible. For example, in an open market for crypto-assets, which is backed by a public blockchain, Russian traders can join in. Then, the Russian government can issue regulations that apply to their local traders, and this might already be enough to have an impact on the market as a whole—as all the users are trading on the same market. Hence, a more accurate classification of regulation would be that it is generally non-excludable in public blockchains but may or may not be excludable when private blockchains are concerned. For the remainder of the analysis, we will restrict attention to public blockchains, which are also at the heart of the current wave of regulations.

The taxonomy's second criterion, *rivalry*, is a bit trickier. Consider first the technology itself. At first glance, adding any one additional user to the network might seem like it matters little for others' enjoyment. In this sense, DLT is similar to the internet, which is usually defined as a global public good (and not a global common good).[141] However, infrastructures (e.g., roads and railways systems) are typically defined as a common good,[142] as there is fear of congestion—as more users join, the ability of others to use the network at the same quality decreases. In this sense, DLT (recall: we now restrict attention to public blockchains) seems to fall closer to a common good—an addition of users slows down the system. In fact, one of the major concerns expressed with respect to Bitcoin is scalability, given that the speed decreases as the DLT network grows.[143]

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141. *See* Bernardo A. Huberman & Rajan M. Lukose, *Social Dilemmas and Internet Congestion*, 277 SCI. 535, 535 (1997) (referring to the internet as a public good). Note that some refer to DLT or blockchain colloquially as a "public good," but this does not seem to be based on the definition used here. *See, e.g.*, Alex Grech, Ira Sood & Lluis Ariño, *Blockchain, Self-Sovereign Identity and Digital Credentials: Promise Versus Praxis in Education*, 7 FRONTIERS BLOCKCHAIN 4, 4 (2021). Others note that private blockchains allow for exclusion and hence are public-good-like in essence but are actually club goods. *See* Darcy Allen, Chris Berg, Sinclair Davidson, Trent MacDonald & Jason Potts, An Economic Theory of Blockchain Foundations 2 (May 8, 2021) (unpublished manuscript) (on file with RMIT University, Melbourne).

142. *See, e.g.*, Clarke E. Cochran, *Yves R. Simon and "The Common Good": A Note on the Concept*, 88 ETHICS 229, 233 (1978) *("*A public highway is a common good. It is so not because the happinesses of users may be summed in a fashion which increases total individual happiness. Rather, it is a common good because each may use it (it is constantly distributed to individuals) and, in so using it, enhance the common intercourse (life together) of the community.").

143. *See generally* Conrad Burchert, Christian Decker & Roger Wattenhofer, *Scalable Funding of Bitcoin Micropayment Channel Networks*, 5 ROYAL SOC'Y OPEN SCI., Jan. 2018, at 1; Mohammed Hammam, Mohammed Al-Madani, Yudi Fernando & Pua Wee Sin, *Implications of Blockchain Deployment in Energy Supply Chain Management: Report Integrity*, 18 INT'L J. INDUS. MGMT. 408, 412–13 ("[P]resent methods are slow and time-consuming, as transactions must be checked and reconciled many times from the beginning to the end. Due to the slow speed of transactions and exchanges, frictional costs are excessive for small-scale and distributed generators, which are effectively shut out of the market.") (internal citations omitted).

In a recent article,[144] James Grimmelmann and James Windawi propose to view blockchain technology as a "semicommon" good[145]—a sort of hybrid good with some elements held privately, some elements held in common, and dependency between the private and public uses.[146] As the incentive problems we describe below arise also for this classification,[147] we will restrict attention to the more general case of a common good. Therefore, we will henceforth assume that a public blockchain is a common good,[148] as it is non-excludable but rivalrous.[149]

Looking at the regulation of DLT, some tend to classify regulation as a clear *public good* irrespective of the context.[150] Indeed, the *users* of DLT seemingly enjoy the benefits of regulation in a non-rivalrous way (much like the example of national defense) and cannot exclude each other from these benefits. However, there are at least two reasons why the classification of DLT's regulation as a public good might be somewhat misleading.

First, true non-rivalry is very rare, and there are many ways in which adding new users indirectly imposes costs. For example, Rosolino Candela and Vincent Geloso analyze whether a lighthouse is

144. James Grimmelmann & James Windawi, *Blockchains as Infrastructure and Semicommons*, 64 WM. & MARY L. REV. (forthcoming) (on file with the William & Mary Law Review). Note that our Article differs from that of Gimmelmann & Windawi in two important ways. First, we mostly focus on the non-excludable nature of *regulation* (and the technology), whereas their argument does concern regulators. Second, we go one step further by connecting the general insight to the rationale for global regulation and current regulatory initiatives.

145. *See generally* Henry E. Smith, *Semicommon Property Rights and Scattering in the Open Fields*, 29 J. LEGAL STUD. 131 (2000) (discussing semicommon property rights and resultant "goods" and "bads" associated with these rights).

146. *See* Grimmelmann & Windawi, *supra* note 144, at 14–17.

147. *See infra* Part IV.

148. Due to difference in terminology across disciplines, one can locate articles that call blockchain technology a "public good" in the sense that it is used for the good of the public. S*ee, e.g.*, Grech, Sood & Ariño, *supra* note 141, at 1. However, this should not be confused with the meaning of a public good in law and economics, which is a non-excludable and non-rivalrous good.

149. Note that a private blockchain, which is certainly excludable, can be similarly classified either as a private good (if it is rivalrous) or a club good (if it is non-rivalrous). *See* Florian Glaser, *Pervasive Decentralisation of Digital Infrastructures: A Framework for Blockchain Enabled System and Use Case Analysis*, PROC. 50TH HAW. INT'L CONF. ON SYS. SCIS. 1543, 1546 (2017).

150. *See, e.g.*, Partik B. Griffin, *The Delaware Effect: Keeping the Tiger in Its Cage - The European Experience on Mutual Recognition in Financial Services*, 7 COLUM. J. EUR. L. 337, 339 (2001) ("[S]ome commentators have argued vehemently . . . that regulation is a public good."); Forster, *supra* note 139, at 319 ("In many ways regulations can themselves be regarded as public goods as they have some, if not all, the characteristics of pure public good."); *see also* Abul Hassan & Sabur Mollah, *Gaining Strength: Prudential Regulations in Islamic Banking*, *in* ISLAMIC FINANCE 217, 218 (Palgrave Macmillan, 2018) ("It is understood that regulation is a public good that the market cannot supply on its own."); Dahlia El-Hawary, Wafik Grais & Zamir Iqbal, *Diversity in the Regulation of Islamic Financial Institutions*, 46 Q. REV. ECON. & FIN. 778, 789 (2007).

rivalrous[151] and argue that the need to price the benefits of a lighthouse to different consumers implies that it is a rivalrous good.[152] Applied to DLT, this means that because the regulation serves many different uses (even simply because cryptocurrencies are customizable), the scarce resource—regulatory effort—implies that protecting every new group of consumers imposes a cost on society.

Second, the classification of regulation as rivalrous or non-rivalrous obviously depends on the context: is one interested in how the regulation affects the users of the DLT or rather in how it affects the regulators themselves? From the regulator's perspective, the benefits of regulation may be two-fold, and each could potentially be interpreted as a separate good. Namely, in addition to the benefits that regulation generates for the general public, regulation may also generate some separate benefits to the regulators themselves (for instance, in the form of reputation).[153] Suppose there is a limited amount of credit that one can claim for regulating DLT. In this case, reputation is likely to be a common good; it is rivalrous, because every new regulator who joins in takes away from the credit of the incumbent regulators, and it is non-excludable for the same reasons discussed above. Therefore, viewing regulation as a public good is a bit too simplistic: some aspects of it make it closer to a common good.

Thus far, we have separated the technology and its regulation. However, the incentive problems that exist because of non-excludability in both the technology and the regulation are intertwined. The next Part reviews these incentive problems.

IV. INCENTIVE PROBLEMS WITH NON-EXCLUDABLE DLTS

A. *Two Incentive Problems with Non-Excludable Goods*

The taxonomy of goods is closely related to two classical incentive problems in law and economics, which are best illustrated with an example.[154] Consider a group of village farmers, each owning one goat. There is a pasture with green grass in the middle of the village, but it grows rather slowly. If the farmers send their goats to eat from the grass once every two days, there is easily enough grass for everyone. But if all goats go to eat together, the grass is destroyed and will not

151. Rosolino A. Candela & Vincent Geloso, *Why Consider the Lighthouse a Public Good?*, 60 INT'L REV. L. & ECON. 1, 1 (2019).

152. *See id.* at 2 ("The fact that pricing lighthouse services across different markets requires scarce resources makes the provision of lighthouses inherently rivalrous.").

153. Hadar Y. Jabotinsky & Barak Yarkoni, The Network Effects of International Financial Regulation 23 (Nov. 20, 2018) (unpublished manuscript), https://ssrn.com/abstract=3309118 [https://perma.cc/5MJR-8QM2] (archived Feb. 13, 2023); Jabotinsky, *supra* note 32, at 64.

154. The example is a paraphrase of the story used by Ken Binmore in his commonly-used text book on game theory. *See* KEN BINMORE, PLAYING FOR REAL: A TEXT ON GAME THEORY 27–30 (Oxford University Press 2007).

regenerate in the following spring (as the goats will also eat the seeds). The pasture is a common good: farmers cannot exclude each other from sending their goat (non-excludable), but their consumption interferes with each other's (rivalrous). The first problem, known as the tragedy of the commons,[155] occurs when each farmer rationally sends their goat to eat using the following logic: *If the others do not send their goat, I can safely send my goat. And if they do send their goat, I better send my goat so that it at least grabs a bite*.[156] Self-interested behavior then causes *all* the farmers to send their goats, leading to overconsumption (a.k.a. "tragic overuse"[157]) and eventually to depletion of the grass.

Now, suppose that the farmers would want to avoid depletion by constructing a committee that can coordinate what goat grazes on the grass at what time. The committee is estimated to need a $1,000 budget per year. Unlike the grass, the committee is a public good: it is non-rivalrous (they all enjoy the coordinating mechanism at the same time) and it is non-excludable (once the committee is there, everyone enjoys the fact that the grass does not deplete). Here emerges the second problem, known as either a "public goods problem"[158] or, more generally, as a special case of the "free-rider problem."[159] Namely, each farmer applies the same logic as before: *A committee is nice, but my individual benefit from it is small. If everyone else pays for it, I do not need to also pay. And if they do not pay, I again should not pay*. As everyone goes through the same thought process, no one pays, and the committee is not established.

Notably, both of these problems lead to a similar outcome in terms of quantity. A non-excludable good will tend to suffer from inefficiently low quantity either because fewer people are willing to produce it (lower supply due to a free-rider problem) or because fewer people are willing to pay for consuming it (lower demand resulting in a tragedy of the commons).

Consequently, from an incentive-problem perspective, what matters is that public blockchains are non-excludable (and less so whether they are a rivalrous common good or a non-rivalrous public good). Thus, the main concern is that, due to non-excludability, the equilibrium quantity of a safe and regulated DLT would be too low. This

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155. *See id.* at 140. The original formulation of the problem can be found in Hardin, *supra* note 20.

156. This situation is what game-theorists call a "dominant strategy." *See, e.g.*, Dan Kahan, *The Logic of Reciprocity: Trust, Collective Action, and Law*, 102 MICH. L. REV. 71, 74 (2003). That is, irrespective of what the others do, we prefer to do the same.

157. This concept is sometimes referred to as "tragic overuse." *See, e.g.*, Xavier Basurto & Elinor Ostrom, *The Core Challenges of Moving beyond Garrett Hardin*, 1 J. NAT. RES. POL'Y RSCH. 255, 255 (2009).

158. *See, e.g.*, John C. Coffee, *Market Failure and the Economic Case for a Mandatory Disclosure System*, 70 VA. L. REV. 717, 727 (1984); Mark J. Roe, *Backlash*, 98 COLUM. L. REV. 217, 229 (1998); Mark A. Lemley, *Ex Ante Versus Ex Post Justifications for Intellectual Property*, 71 U. CHI. L. REV. 129, 138 (2004).

159. COOTER & ULEN, *supra* note 23, at 41.

occurs because generally, no one has sufficient incentive to *unilaterally supply, regulate, or maintain* a globally efficient public blockchain.

However, this insight requires some further clarifications, which can be illustrated by mapping the incentive problems in the context of a public blockchain to the aforementioned example of the farmers and the pasture. First, suppose that the regulators are the farmers and a market running on a public blockchain is the grass. Each regulator can rationally decide to "take a bite" of the market by applying some rules that are aimed to protect the local population but do little to help others. If every regulator chooses to do so, there is tragic overuse leading to depletion in the form of legal uncertainty, high compliance costs, and chilling of the willingness to participate in the market. In other words, in this example, there is a "tragedy of the common regulators." These rules created by local regulators can be either (formally) restricted to the local consumers or applied exterritorially (so that they apply globally *de jure*), but the result is the same.[160] Next, suppose instead that a new DLT is the committee in the example and that countries (or firms) decide rationally not to invest in development. Here, there is a free-rider problem, as everyone would welcome a well-functioning DLT but do not want to invest. Along similar lines, one can make the argument that countries prefer to free-ride on the efforts of other countries rather than invest in creating a public good of global regulation. In principle, this might also cause some countries to withhold local regulations until the global regulation is formed, leaving the market unregulated at some of the local levels.

Summarizing, our application of the classical incentive problems—the tragedy of the commons and the free-rider problem—suggests that there might be (i) *overregulation* and (ii) *underregulation*, depending on the regulators' incentives.

B. *General Solutions to the Incentive Problems*

How does one go about solving the incentive problems created by the non-excludable nature of a public blockchain? From a generic point of view, this question mirrors the more general questions of what should be privately owned, what should be publicly owned, and how to implement public ownership. Having diagnosed DLT as a non-excludable good, the law and economics literature offers different solutions, each with its own advantages and disadvantages.

As a general answer to the free-rider problem with public goods, the literature proposes that "public goods should be publicly owned."[161]

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160. *See generally* Jabotinsky, *supra* note 32.

161. *Compare* COOTER & ULEN, *supra* note 23, at 103 ("Efficiency requires that private goods should be privately owned and that public goods should be publicly owned. In other words, efficiency requires that rivalrous and excludable goods should be controlled by individuals or small groups of people, whereas nonrivalrous and nonexcludable goods should be controlled by a large group of people such as the state."),

The idea is then that a public organization, such as the state,[162] would have enough incentive to create and maintain goods that are not profitable for any one specific individual. For instance, national defense can be supplied by the state because no single person has an incentive to build up a national army on their own.[163]

This observation lies at the heart of our argument: as public blockchains serve a global audience, public ownership of DLT means *global* ownership, that is, some form of global management of the technology and its regulation.

Yet the prescription does not end there, as public ownership may take at least three different forms. The first is *open access*,[164] meaning DLT would be formally managed globally, but there would be no restrictions on access. This type of solution is unlikely to work well whenever there is congestion, let alone when there is tragic overuse. Hence, it would just perpetuate the problems discussed so far.

The second form is the opposite extreme—*unanimity*.[165] That is, unless every regulator (or in the more dramatic case, every user) agrees on a certain measure, it is not executed. Unanimity does not seem like a good idea, for obvious reasons.[166]

The third form, which will be the focus of our argument, is *political control*. Under political control, some governance mechanism is formed, which allows policymakers to impose rules restricting access.[167]

Finally, it is sometimes possible to convert a public good into a private good. For instance, suppose that the farmers in the example provided in Part IV.A elect a mayor, who then charges taxes that fund the activity of the committee protecting the grass. Once the committee is there, it can be privatized, for example, by granting a specific farmer with exclusive gate-keeping rights. For DLT, this neatly translates into the conversion of a public blockchain into a private blockchain. The problem is that this is easier said than done: it would either require some technological "magic bullet" that transforms an existing blockchain into a private one, or a switch of all users to a new private infrastructure (this could be done by making public blockchains

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with Grimmelmann & Windawi, *supra* note 144, at 1 (reaching a similar conclusion based on a different doctrine, where blockchain's classification as an infrastructure implies that common ownership is optimal).

162. *See* COOTER & ULEN, *supra* note 23, at 103.

163. The public authority can also intervene by incentivizing private actors to produce the good (e.g., through subsidies) instead of supplying the good directly through the public sector. *Id.* at 115.

164. *Id.* at 142.

165. *Id.*

166. Unanimity creates a reversed problem known as the "tragedy of the anti-commons," where the veto right of every player results in tragic under-use. *Id.* at 140.

167. *See id.* at 142.

illegal). One example for such a change in the realm of DLT is the recent trend of so-called central bank digital currencies (CBDC).[168] While the specifics vary from project to project, the general idea of these tokens is to reinstate some control to the central bank by launching a new cryptocurrency that will serve as a substitute for the local fiat currency.[169] In other words, central banks cannibalize their fiat currency in an attempt to gain control of its substitutes.[170] It seems likely that CBDCs would run on a new blockchain—one that is controlled by the central bank in some form. Yet, a central bank does not have a clear incentive to serve other countries or maintain a *global* currency. Thus, CBDCs illustrate the problem with switching to private blockchains: it might aggravate the problem of undersupply of regulation at the global level, because every country will only adopt rules that protect the local CBDC instead of adopting rules that are globally efficient.

However, converting public blockchains to permissioned blockchains might also be carried out as part of a political control solution, either as part of the enforcement or as means of facilitating voting.

V. GLOBAL REGULATION OF DLT

A. *Going Global: Existing Arguments*

The topic of global regulation for cross-border matters has long been discussed by legal scholars, in contexts such as climate change,[171] data privacy,[172] international sports,[173] and—perhaps most prominently—financial regulation.[174] For the latter, the discussion of global

168. *See generally* Shen Wei & Heng Wang, *Global Stablecoins and China's CBDC: New Moneys with New Impacts on the Financial System?*, 41 REV. BANKING & FIN. L. (forthcoming); Nerenda Atako, Note, *Privacy Beyond Possession: Solving the Access Conundrum in Digital Dollars*, 23 VAND. J. ENT. & TECH. L. 821 (2021).

169. *See, e.g.*, Katherine Foster, Sofie Blakstad, Sangita Gazi & Martijn Box, *Digital Currencies and CBDC Impacts on Least Developed Countries (LDCs), in* DIALOGUE ON GLOBAL DIGITAL FINANCE GOVERNANCE PAPER SERIES, at 15 (UNDP, Technical Paper 1.2, 2021) ("For instance, if a foreign government's CBDC is available in developing economies . . . the foreign government's CBDC could gradually substitute the local currency.").

170. Although outside the scope of our paper, a word of caution to regulators worldwide: this solution might backfire as people might get used to using CBDC and from there the switch to other less regulated cryptocurrencies is likely to be done with more ease. *See* Jabotinsky & Sarel, *supra* note 102.

171. *See generally* Jonathan B. Wiener, *Think Globally, Act Globally: The Limits of Local Climate Policies*, 155 U. PA. L. REV. 1961 (2007).

172. *See generally* Margaret Byrne Sedgewick, *Transborder Data Privacy as Trade*, 105 CALIF. L. REV. 1513 (2017).

173. *See generally* Eric L. Windholz & Graeme A. Hodge, *International Sports Regulation: An Evolving Private-public Partnership*, 45 MONASH U. L. REV. 298 (2019).

174. *See generally* Vasilisa K. Kulakova, *USA in the Emerging System of Global Financial Regulation*, 99 CORNELL L. REV. 1259 (2014); Jim Chen, *Soft Law and the Global Financial System*, 25 EMORY INT'L L. REV. 1561 (2011).

versus local is part of a more general ongoing debate regarding consolidation.[175] Those who support the consolidation of financial standards highlight the need to reduce systemic risk, solve coordination problems, and prevent a race to the bottom of financial standards.[176] Contrarily, those who object to consolidation advocate for diversification,[177] prevention of a democratic deficit,[178] financial inclusion,[179] and lack of justification.[180]

The arguments against global regulation are diverse. Roberta Romano argues that adopting a global standard, such as the one set by the Basel Committee on Banking Supervision,[181] is not sensitive to the local needs of each state. She further claims that states are urged to adopt a unified standard, which weakens financial firms because it makes them lose their diversity. Another concern of hers is that these standards are usually a political compromise and, as such, may not be adequate for regulation of different local financial markets.[182] In a different study, focusing on the United States' federal tax regulation, Ruth Mason claims that the practice of delegating up to the federal level causes states to adopt federal tax policies, which reflect national rather than state politics, thereby potentially creating a democratic deficit.[183] The loss of diversity, as identified by both Romano and Mason,[184] might even cause or deepen the next financial crisis. Those who oppose global standards are also concerned with the high costs that a switch to an international standard might bring.[185] Others argue that replacing old standards might generate a shock in markets

175. *See, e.g.*, Veerle Colaerts, *European Banking, Securities and Insurance Law: Cutting through Sectoral Lines?*, 52 COMMON MKT. L. REV. 1579 (2015); Eddy Wymeersch, *The Structure of Financial Supervision in Europe: About Single Financial Supervisors, Twin Peaks and Multiple Financial Supervisors*, 8 EUR. BUS. ORG. L. REV. 237 (2007); Eilís Ferran, *Institutional Design: The Choices for National Systems*, *in* THE OXFORD HANDBOOK OF FINANCIAL REGULATION 100 (Niamh Moloney et al. eds., 2015); Donato Masciandaro, *Politicians and Financial Supervision Unification Outside the Central Bank: Why Do They Do It?*, 5 J. FIN. STABILITY 124 (2009); Jabotinsky & Yarkoni, *supra* note 153.

176. *See* Andrew G. Karolyi & Alvaro G. Taboada, *Regulatory Arbitrage and Cross-Border Bank Acquisitions*, 70 J. FINANCE 2395, 2395–450 (2015).

177. Roberta Romano, *For Diversity in the International Regulation of Financial Institutions: Rethinking the Basel Architecture*, 31 YALE J. ON REG. 1, 1 (2014).

178. Ruth Mason, *Delegating up: Federal-State Tax Base Conformity*, 62 DUKE L.J. 1267, 1267 (2013).

179. Emily Jones & Peter Knaack, *Global Financial Regulation: Shortcomings and Reform Options*, 10 GLOB. POL'Y 193, 193–206 (2019).

180. Mason, *supra* note 178, at 1342.

181. For a discussion of the Basel Accords (specifically, the newest set of rules, titled "Basel IV"), see generally Peter Yeoh, *Basel IV: International Bank Capital Regulation Solution or the Beginnings of a Solution?*, 39 BUS. L. REV. 176 (2018).

182. *See* Romano, *supra* note 177, at 63.

183. *See* Mason, *supra* note 178, at 1269.

184. *See id.*; Romano, *supra* note 177, at 1–2.

185. *See generally* M.P. Van Alstine, *The Costs of Legal Change*, 49 UCLA L. REV. 789 (2001); Israel Klein, *Voting on Reporting*, 48 J. CORP. L. (forthcoming) (manuscript at 19) (explaining that standards-based disclosure increases a firm's over-all contracting costs and compliance costs).

that are slow to adapt, noting that conditions that have evolved over the years are also likely to be a better fit than any new standard.[186] Moreover, as not all countries are equally represented in the global standard-setting forums, the decisions of these forums might hurt financial inclusion.[187]

There are, however, also many arguments in favor of global regulation. A first argument relates to reduction of transaction costs by smoothening trade relationships.[188] Common standards help promote compatibility between different players which belong to the same value chain[189] and thus reduce the risk for each player.[190] A second argument relates to organizational and institutional deficits of the local regulators, which can be overcome by the global standards, thus allowing regulators to be more vigilant.[191] By overcoming the local regulators' deficits, the standards also facilitate economic and political cooperation between different jurisdictions.[192] A third argument relates to stability of financial institutions and prevention of systemic risk.[193] This is achieved as global standards constrain the race to the bottom of risk management standards.[194] A fourth argument—which we have provided in detail above—is the solution of incentive problems that are

186. *See, e.g.*, Ray Ball, *International Financial Reporting Standards (IFRS): Pros and Cons for Investors*, 36 ACCT. & BUS. RES. 5, 5–27 (2006); *see also* Ray Ball, Ashok Robin & Jonna Shuang Wu, *Incentives Versus Standards: Properties of Accounting Income in Four East Asian Countries*, 36 J. ACCT. & ECON. 235, 235–70 (2003).

187. Jones & Knaack, *supra* note 179, at 193–94 ("A two-tier structure dominates decision-making in international financial regulation. While the membership of standard-setting bodies varies, all restrict rule-making power to a select number of mostly developed economies. The Financial Stability Board (FSB) at the apex of international regulatory cooperation includes only 25 jurisdictions, while the Basel Committee on Banking Supervision has 28. All other jurisdictions have access to specific channels of consultation, but in practice they are relegated to the role of rule-takers . . . [G]lobal financial standards can be a poor match for the idiosyncratic conditions of domestic financial markets, particularly at an early stage of development.") (internal citations omitted); *see also* Emily Jones & Alexandra O. Zeitz, *Regulatory Convergence in the Financial Periphery: How Interdependence Shapes Regulators' Decisions*, 63 INT'L STUD. Q. 908, 908 (2019).

188. *See* Khalid Nadvi & Frank Waltring, *Making Sense of Global Standards*, *in* LOCAL ENTERPRISES IN THE GLOBAL ECONOMY 53, 53–54 (2004).

189. A value chain helps explain how distinct functions which turn raw materials into traded goods are inter-linked through a chain of complex arrangements between different global actors *Id.* at 54.

190. *See id.*

191. *See* Jabotinsky & Yarkoni, *supra* note 153, at 13.

192. *See* Josef Wieland, *Global Standards and Global Public Goods and Social Safeguards*, *in* GOVERNANCE ETHICS: GLOBAL VALUE CREATION, ECONOMIC ORGANIZATION AND NORMATIVITY ETHICAL ECONOMY 61, 61 (2014).

193. Eric Helleiner & Stefano Pagliari, *The End of an Era in International Financial Regulation? A Postcrisis Research Agenda*, 65 INT'L ORG. 169, 182 (2011).

194. A similar argument is that harmonization prevents competition between regulators, which might then yield a race to the top rather than a race to the bottom. *See* Michael S. Barr & Geoffrey P. Miller, *Global Administrative Law: The View from Basel*, 17 EUR. J. INT'L L. 15, 30 (2006).

created when there is a global non-excludable good.[195] A related, but separate argument, concerns network effects:[196] in addition to solving the incentive problems, global regulation may increase the "size of the pie" by creating synergies. This seems particularly relevant for crypto-currencies. For example, the more Bitcoin is accepted as a form of payment, the more useful it is to every user of the network: a typical positive network effect. At the same time, this has been argued to be a downside as well, because the switching costs to another form of payment then become higher.[197]

While our Article seems to be the first to provide a comprehensive analysis of the economic rationale for a global regulation of public blockchains, there exists some earlier legal literature that analyzed the potential need for such regulation. Omri Marian raises a type of forum-shopping argument: if there are countries that provide "Blockchain Havens" that are unregulated,[198] firms would simply choose to relocate to those countries, thereby circumventing regulation. This then creates a regulatory race to the bottom to attract the firms.[199] Nicholas Roide points at the problem of legal uncertainty in AML regulation, which may discourage firms from innovation.[200] He proposes to adopt a mix of local and international regulation, where local hubs are an access

195. Most of the literature focuses on global public goods. *See, e.g.*, Gregory Shaffer, *International Law and Global Public Goods in a Legal Pluralist World*, 23 EUR. J. INT'L L. 669, 670 (2012); Wiener, *supra* note 171, at 1964; Barnali Choudhury, *International Investment Law as a Global Public Good*, 17 LEWIS & CLARK L. REV. 481 (2013); Aleinikoff, T. Alexander, *Rethinking the International Refugee Regime*, 41 YALE J. INT'L L. ONLINE 1, 9 (2016); S. Niggol Seo, *Economics of Global Warming as a Global Public Good: Private Incentives and Smart Adaptations*, 5 REG'L SCI. POL'Y & PRAC. 83, 87 (2013) (noting that countries less impacted by climate change are less inclined to push for global regulation).

196. Jabotinsky & Yarkoni, *supra* note 153, discuss the network effects created by the global standard and point out that these are generated on three different levels: the regulators and politicians, the regulated firms, and social network effects. *See also* Karthik Ramanna & Ewa Sletten, *Why do Countries Adopt International Financial Reporting Standards?*, (Harv. Bus. Sch. Acct. & Mgmt. Unit, Working Paper 09-102, 2009) (surveying 102 non-EU countries in order to find out what motivated them to adopt the International Financial Reporting Standards (IFRS)). The findings show that more powerful states tend not to adopt the global standards. This is consistent with the claim that adopting a new financial regulatory standard is costly to the market. Further, this research found that countries are more likely to adopt the standards if other neighboring countries have also adopted it, which might indicate that there is an additional coordination problem of who makes the first move.

197. William J. Luther, *Cryptocurrencies, Network Effects, and Switching Costs*, 34 CONTEMP. ECON. POL'Y 553, 568 (2016).

198. Omri Marian, *Blockchain Havens and the Need for Their Internationally-Coordinated Regulation*, 20 N.C. J.L. & TECH. 529, 529 (2019) [hereinafter Marian, *Blockchain Havens*]. See also the reprinted version of this Article, Omri Marian, *Blockchain Havens and the Need for Their Internationally-Coordinated Regulation*, 23 FLA. TAX REV. 770, 770 (2020).

199. Marian, *Blockchain Havens*, *supra* note 198, at 529.

200. Nicholas Roide, *Fintech and Anti-Money Laundering Regulation: Implementing an International Regulatory Hierarchy Premised on Financial Innovation*, 9 TEX. A&M L. REV. 465, 472 (2021).

point for firms but there are international rules.[201] Matthias Lehmann reiterates the problem of conflicting regulations by local regulators—a problem we classify as a tragedy of the commons—and proposes global standards and repurposing the FSB to be more involved.[202] Hadar Jabotinsky and Roee Sarel analyze the general rationales for regulating cryptocurrencies and point at global regulation as one possible solution.[203] The suggestion to adopt global regulation has also received some support from think tanks.[204]

These suggestions, as well as others, can be organized according to different categories. In the following subpart, we highlight three possible categories, each capturing a different path to achieving a global regulation of DLT.

B. *Possible Paths to a Global Regulation of DLT*

Even with the conclusion that global regulation is likely to be superior to the current state of affairs, where countries are unilaterally declaring regulations (notwithstanding the public statements by the United States and others that global regulation is needed), what should global regulation look like?

There are at least three possible paths to a global regulation of DLT:[205] (1) endowing a centralized international entity with regulatory authority, (2) decentralized regulation, and (3) international standards. We consider each of these paths in turn.

1. Centralized Global Regulator

The first option, which corresponds most closely to the idea that a public authority should be in charge of a non-excludable good, is the

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201. *See id.* at 470–71.

202. *See* Matthias Lehmann, *Global Rules for a Global Market Place? – Regulation and Supervision of Fintech Providers*, 38 B.U. INT'L L.J. 118, 118 (2020).

203. *See generally* Jabotinsky & Sarel, *supra* note 72.

204. *See* Will Neal, *Experts Call for Greater International Collaboration on Crypto-Regulation*, OCCRP (May 19, 2022), https://www.occrp.org/en/daily/16341-experts-call-for-greater-international-collaboration-on-crypto-regulation [https://perma.cc/W5F2-26PY] (archived Dec. 28, 2022); Ussal Sahbaz, *It is G20's Imperative to Act as a Leader in Regulating Crypto-assets*, ORF (Oct. 30, 2021), https://www.orfonline.org/expert-speak/it-is-g20s-imperative-to-act-as-a-leader-in-regulating-crypto-assets/ [https://perma.cc/S4YG-TRXS] (archived Dec. 28, 2022); *see also* Dorothy Siron & Federico Paesano, *Cryptocurrencies in Asia and beyond: Law, Regulation and Enforcement* 35 (Basel Inst. On Governance Working Paper No. 38, 2022) (recommending international coordination, harmonized regulation, and attention to the global aspect).

205. *Cf.* Ying-Ying Hsieh, Jean Philippe Vergne & Sha Wang, *The Internal and External Governance of Blockchain-based Organizations: Evidence from Cryptocurrencies*, *in* BITCOIN AND BEYOND: CRYPTOCURRENCIES, BLOCKCHAINS, AND GLOBAL GOVERNANCE 48, 50 (Malcolm Campbell-Verduyn ed., 2017) (arguing that "blockchain-based organizations can . . . be governed by decentralized communities, by centralized corporations, or jointly by both as hybrids").

appointment of a global regulatory authority. Such an authority might be an existing international organization, such as the FATF or the FSB,[206] but could also be an ad hoc body that is founded with the specific task of regulating DLT technology. The main challenges of this option are less conceptual and more practical. The primary challenge lies in convincing enough countries to accept the authority of a global organization. This is due to several problems—some of which are the same problems that justify the foundation of the organization to begin with. For instance, if joining a global regulatory regime entails any local costs for a country (e.g., financing the negotiations between states), there might be a reluctance to spend any resources on this issue.[207] This leads to the same free-rider problem.

The problem can also be reframed as a generic problem in law and economics—one of high transaction costs. As predicted by the canonical Coase Theorem, if parties behave cooperatively and negotiate in order to reach a solution that increases the overall "size of the pie" (here, the benefits from DLT regulation) they should reach an efficient solution that maximizes their surplus and splits it between them.[208] However, this only works if transaction costs are low. To see why transaction costs seem likely to pose a problem, consider the traditional taxonomy of transaction costs: search costs, bargaining costs, and monitoring costs.[209] With respect to DLT, many of these costs should be high. Namely, one must find the right actors to negotiate with—these may not only be other countries (of which there are many) but also relevant industry players whose cooperation will be needed to implement feasible solutions, some of which are anonymous. Therefore, there are likely high search costs. Next, bargaining with many actors requires figuring out each country's willingness to pay (e.g., the amount each country will donate to finance the international organization's activity), as well as estimating the size of the local benefits to the country's nationals. Finally, monitoring costs—of both the organization itself and of other countries' compliance with the agreed-upon mandate to the international organization—should be also quite high. Another aspect of transaction cost relates to negotiations with countries that seem highly unlikely to fully cooperate with the West due to political reasons, such as Russia and China. This could be thought of as a special case of very

206. *See* Lehmann, *supra* note 202, at 144–45 (proposing to rename the FSB into the "Financial Stability and Innovation Board" and to grant it the authority to draft global soft law).

207. More generally, there may be various switching costs from the local regime to a global one. *See* Jabotinky & Yarkoni, *supra* note 153, at 14–15.

208. For an overview, see COOTER & ULEN, *supra* note 23, at 81–87. *See generally* Sarel, *supra* note 1 (explaining the application of the Coase Theorem in the context of cryptocurrencies).

209. *See* Carl J. Dahlman, *The Problem of Externality*, 22 J.L. & ECON. 141, 147–48 (1979) (discussing the three types of transaction costs that can be inferred from the Coase Theorem); *see also* Sarel, *supra* note 1, at 424.

high transaction costs, as one would need to design a selective treaty that applies differently to those who cooperate and those who do not.[210]

Yet even if one assumes that transaction costs are not too high, there are other challenges. In particular, a centralized authority will only have "teeth" if it can actively influence what goes on DLT platforms. This requires a link between the political side and the technological side, meaning some solution that allows enforcing the decisions of the regulator. This might prove challenging the more DLTs differ in their technology. For instance, some DLTs are characterized by some form of control by intermediaries. The market for cryptocurrencies is one such example, as many of the crypto-exchanges are actually centralized.[211] A global regulator can then oversee the activities of the exchanges and sanction undesirable activities by issuing fines—which would then be enforced locally by the member states of the organization.[212] However, in principle, one can construct a fully automated DLT with zero human involvement. For instance, decentralized crypto-exchanges generally operate without human intervention, and the only meaningful interaction is the payout of fees to accounts controlled by people. Therefore, while a centralized global authority may seem promising at first glance, it is unlikely to succeed unless some specific conditions hold or additional measures are taken (such as prohibiting unregulated exchanges altogether).

2. Decentralized Global Regulation

A polar opposite path is to create a fully automated regulation—so-called "regulation by code."[213] Such a solution could roughly work as follows: The same negotiations that are challenging due to potentially high transaction costs will no longer focus on the political question of who to appoint to an international organization that will regulate cryptocurrencies, but rather focus on the content of the regulation. Namely, there must be agreement on principles that are common for DLT and would be embedded into both existing and new infrastructure. As an example, consider a principle that most can agree on, such as the "prohibition of market manipulation."[214] A code would then need to be

210. *See generally* Paul B. Stephan, *Symmetry and Selectivity: What Happens in International Law When the World Changes*, 10 CHI. J. INT'L L. 91 (2009) (providing a general discussion of the selectivity problem in international law).

211. *See generally* Samantha Altschuler, *Should Centralized Exchange Regulations Apply to Cryptocurrency Protocols?*, 5 STAN. J. BLOCKCHAIN L. & POL'Y 92 (2022) (comparing centralized and decentralized exchanges in the context of cryptocurrency); Andrea Barbon & Angelo Ranaldo, On the Quality Of Cryptocurrency Markets: Centralized Versus Decentralized Exchanges (Dec. 18, 2021) (unpublished manuscript) (on file with Univ. of St. Gallen) (finding differences in quality between centralized and decentralized exchanges, depending on the amount of the transaction).

212. *See* Jabotinsky & Lavi, *supra* note 12.

213. *See infra* Part VI.A.

214. *See Proposal for a Regulation of the European Parliament and of the Council on Markets in Crypto-assets, and amending Directive (EU) 2019/1937*, at 101, COM

developed that identifies suspicious movements and immediately blocks them. Naturally, this can lead to mistakes, but if the algorithm is accurate most of the time, the benefits might outweigh the costs.

Of course, one could consider a combination of the first and second solutions. That is, semi-automated solutions that require human involvement by representatives of an international organization at different stages of the automated process (ex-ante or ex-post).

However, achieving consensus on content might even be more difficult than a consensus on the identity of the regulator.[215] Furthermore, as the technology changes rapidly, a pre-defined code may lack the necessary flexibility to address new challenges that arise. Hence, a more realistic approach is to try and aim for consensus on a *voting mechanism*. Interestingly, one of DLT's most promising features is precisely a revolution in how voting is conducted—the so-called Decentralized Autonomous Organization.[216] Specifically, a distributed ledger that records votes—and is not easy to manipulate—can potentially provide a reliable system for managing regulations democratically. For instance, countries preoccupied with a specific problem could then make a digitized proposal for a new rule, which would be voted on by regulators connected to the blockchain. Following a voting process, the new rule may be either adopted or rejected. Notably, some of these rules could be directly applied automatically on-chain (e.g., a rule proposing to change the voting mechanism) whereas other rules would need external enforcement (e.g., a rule creating a new protocol for Know-Your-Customers procedures by local authorities).[217]

More generally, it is illustrative to categorize the different modes of decentralized regulation of DLT by differentiating between the roles of regulators within the network. For example, Andrej Zwitter and Jilles Hazenberg distinguish between three types of decentralized governance: (i) "platform strategy," (ii) "private strategy," and (iii) "legal strategy."[218] In the first type, the regulators enable the crowd to

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(2020) 593 final (Sept. 24, 2020) (advocating for the prohibition of market manipulation); Lummis-Gillibrand Responsible Financial Innovation Act, S. 4356, 117th Cong. § 5i(d)(5)I(ii) (2022) (concerning the obligation of a digital exchange to monitor trade and prevent manipulation); Digital Commodities Consumer Protection Act, S. 4760, 117th Cong. § 5i (proscribing similar regulation for digital commodity platforms).

215. Andrew H. Van de Ven, *On the Nature, Formation, and Maintenance of Relations among Organizations*, 1 ACAD. MGMT. REV. 24, 28 (1976) ("From an agency's point of view, to become involved in an inter-agency relationship implies (a) that it loses some of its freedom to act independently, when it would prefer to maintain control over its domain and affairs, and (b) that it must invest scarce resources and energy to develop and maintain relationships with other organizations, when the potential returns on this investment are often unclear or intangible.").

216. *See* Jabotinsky, *supra* note 4, at 144.

217. *See infra* Part VI.A (discussing on-chain versus off-chain regulation).

218. Andrej Zwitter & Jilles Hazenberg, *Decentralized Network Governance: Blockchain Technology and the Future of Regulation*, 3 FRONTIERS IN BLOCKCHAIN 1, 9 (2020).

monitor specific features on the blockchain.[219] In the second type, crowds are the ones who propose changes to the regulation (rather than the state).[220] In the third type, the state exempts some actors from legal requirements, thereby allowing them to protest against stronger players.[221]

While the distinction between these categories seems somewhat vague, the categorization is helpful in emphasizing that there is more than one way to achieve decentralized regulation. In the global context, this simply means that the degree of involvement of local regulators may vary, but that decentralized governance is a feasible option.[222]

3. Coordination and Global Standards Backed by Administrative Law

An alternative approach to constructing a centralized international regulator (with or without automated features of regulations to assist) is to instead agree on international standards, which fall under what is known as "global administrative law."[223] Examples of such standards include the Basel Accords, international accounting standards (namely, the International Financial Reporting Standards),[224] and the FATF's recommendations intended to combat money laundering and terror funding.[225] The main difference between such standards and a centralized regulation lies in the identity of the enforcer: instead of centralized enforcement, each country would be responsible for implementing DLT regulation in its own territory in a way that is congruent with the international standards. The hope is that this will

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219. *See id.* (stating that the state can take an educational role of un-informed individuals in parallel).

220. *See id.*

221. *See id.*

222. S*ee* BIS, ANNUAL ECONOMIC REPORT 2022 101–02 (2022), https://www.bis.org/publ/arpdf/ar2022e.htm [https://perma.cc/NTL7-S2FZ] (archived Dec. 29, 2022) ("One way to address the governance problem among multiple parties is to adopt decentralization through a DLT platform. Trusted notaries can manage the shared ledger, and central banks are the natural candidates to take on this task domestically, with shared infrastructure at the global level.") (showing that the regulation of CBDCs might involve a mixture of central banks and some shared global standard).

223. *See, e.g.*, Benedict Kingsbury, Nico Krisch & Richard B. Stewart, *The Emergence of Global Administrative Law*, 68 L. & CONTEMP. PROBS. 15, 17 (2005).

224. *See* Israel Klein, *The Gap in the Perception of the GAAP*, 54 AM. BUS. L.J. 581, 629–32 (2017) (discussing SEC's global accounting vision and the proposal to allow IFRS-based disclosures, as supplemental to those of US-GAAP).

225. *See* FIN. ACTION TASK FORCE, INTERNATIONAL STANDARDS ON COMBATING MONEY LAUNDERING AND THE FINANCING OF TERRORISM & PROLIFERATION: THE FATF RECOMMENDATIONS (Mar. 2022), https://www.fatf-gafi.org/en/publications/Fatfrecommendations/Fatf-recommendations.html [https://perma.cc/N76T-QQY3] (archived Mar. 3, 2023). *See generally* Hadar Y. Jabotinsky & Eyal Sagi, The Responsiveness of Transnational Governance to Popular Sentiment: A Linguistic Analysis of the Basel Accords (unpublished manuscript) (on file with authors).

create some form of harmonization, or at least functioning coordination.[226]

Again, this approach could be combined with any of the two former approaches: one can construct a global regulatory body which designs a global standard or use a decentralized voting mechanism for determining the standards. One example that largely follows this path is the EU's MiCA: as most EU directives, the legislative body (the EU Parliament) imposes an obligation on its member states to adopt rules that are compliant with the regulation.[227] In other words, a centralized organization designed a set of global standards, which must then be applied by individual countries. In the EU, the directive is legally binding for the member states, but they usually have discretion on how to implement the principles set in the directive.[228] A global standard for DLT can follow the same path, but as countries may refuse to subject themselves to the new standard directly, some "soft law" may also be possible.[229] Another example is the set of recommendations issued by the FATF, an organization that was formed in order to combat money laundering and terror financing.[230] In 1989, a group of seven developed countries (the G7) established the FATF in order to combat money laundering and terror financing.[231] In 2004 the FATF issued a list of forty recommendations,[232] which provide a set of countermeasures to combat money laundering. These measures are supposed to be adopted by local jurisdictions. States that do not comply with the recommendations are then entered onto a blacklist.[233]

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226. *See, e.g.*, Benedict Kingsbury & Lorenzo Casini, *Global Administrative Law Dimensions of International Organizations Law*, 6 INT'L ORGS. L. REV. 319, 325 (2009); Barr & Miller, *supra* note 194, at 21 ("The Basel process was designed to achieve harmonization or convergence in bank capital standards and coordination.").

227. *See* MiCA, *supra* note 112, art. 2(1).

228. *See, e.g.*, Selena Aureli, Elisabetta Magnaghi & Frederica Salvatori, *The Role of Existing Regulation and Discretion in Harmonising non-financial Disclosure*, 16(3) ACCT. IN EUR. 290, 291 (2019) ("The EU allows discretion to Member States because it acknowledges that regulation cannot disregard the features of the country it applies to.").

229. *See* Charles W. Mooney Jr, *Global Standards for Securities Holding Infrastructures: A Soft Law/Fintech Model for Reform*, 40 MICH. J. INT'L L. 531, 543–44 (2019) (discussing soft law in the context of global regulation of securities); *see also* Lehmann, *supra* note 202, at 144–45. *See generally* Chen, *supra* note 174 (discussing the use of soft law to police global financial systems).

230. *See History of the FATF*, FIN. ACTION TASK FORCE, https://www.fatf-gafi.org/en/the-fatf/history-of-the-fatf.html (last visited Jan. 29, 2023) [https://perma.cc/V65N-Y3ZN] (archived Dec. 29, 2022); James T. Gathii, *The Financial Action Task Force and Global Administrative Law*, 2010 J. PROF. LAW. 197, 197–98 (2010) (discussing the origins and operating principles of the FATF).

231. *See* Gathii, *supra* note 230, at 197–98.

232. *FATF 40 Recommendations*, FIN. ACTION TASK FORCE (Oct. 2004), https://www.fatf-gafi.org/publications/fatfrecommendations/documents/the40recommendation-spublishedoctober2004.html [https://perma.cc/2AMN-9JHN] (archived Dec. 29, 2022).

233. *See About the Non-Cooperative Countries and Territories (NCCT) Initiative*, FIN. ACTION TASK FORCE, https://www.fatf-gafi.org/en/publications/Fatfgeneral/Aboutthenon-cooperativecountriesandterritoriesncctinitiative.html (last visited Jan. 29, 2023) [https://perma.cc/U6FB-CBPD] (archived Dec. 29, 2022). *See generally* Guy

Back to DLT, whether one path (hard law) or another (soft law) is preferred, reaching a consensus among different countries would require negotiations. In order to lubricate such negotiations, one has to consider the problem of transaction costs and how to minimize them.[234]

There are many possible mechanisms that can assist in reducing transaction costs in international negotiations. For instance, one could design regulation that needs to be renewed periodically, which might reduce the reluctance of countries to join in because they are only temporarily under obligation and because it will provide time to see what the distributional effects are (and, therefore, who benefits most from the regulation).[235] The combination of such an approach with a centralized regulator, for instance, can be helpful if that regulator has sufficient incentive to monitor countries that participate in the regulation, thereby reducing the enforcement costs. Countries that anticipate lower enforcement costs might be more willing to join the regulatory framework,[236] as they know that the cost of enforcing promises made to them is lower.

Alternatively, a decentralized and automated enforcement mechanism may also appease countries that fear that joining the global regulation would leave them without the ability to hold other countries liable. In other words, the first two approaches—a centralized regulator and decentralized regulation—are implicitly also important tools in the reduction of transaction costs.

C. *Is Global Regulation Really Necessary?*

Before we proceed to the details on how to implement global regulation in practice, it is first important to briefly consider a counterargument, or rather a fifth approach: letting some individual country dictate the rules of the game. As a leading example, consider the SEC's decision to diligently pursue the enforcement of securities law on the issuers of cryptocurrencies. We presented two examples of this approach in Part III.D, but to explain the approach better, we provide some more general details here.

The earlier days of the crypto-market were characterized by an utter lack of regulation, so that many firms issued their own cryptocurrencies in ICOs with little regulatory supervision. ICOs may have entailed some benefits (e.g., avoiding the cumbersome process of turning to venture capital firms for money),[237] but were also fertile ground

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Stessens, *The FATF 'Black List' of Non-cooperative Countries or Territories*, 14 LEIDEN J. INT'L L. 199 (2001).

234. *See, e.g.*, Robert O. Keohane, *International Institutions: Two Approaches*, 32 INT'L STUD. Q. 379, 387 (1988) (arguing that reducing transaction costs in the international context is supported by the rationalist view of international institutions).

235. *See, e.g.*, Barbara Koremenos, Charles Lispon & Duncan Snidal, *The Rational Design of International Institutions*, 55 INT'L ORG. 761, 793–94 (2001).

236. *See id.* at 795.

237. *Cf.* Sarel, *supra* note 1, at 399.

for scams.[238] Once the SEC realized the precarity of ICOs, extensive enforcement measures were taken—applying US securities law and imposing massive monetary fines on anyone issuing a security-like cryptocurrency without going through the usual submission of documents to the SEC.[239] This alone seems to have been sufficient in practically eliminating the market for unregistered ICOs.[240] The interesting question is then the following: as ICOs were certainly problematic across the board, and not just in the United States, why was the SEC not discouraged by a free-rider problem? In other words, how is it that even without global regulation, the action of one agency was enough to solve the particular problems that were caused by ICOs?

The answer is likely a combination of several factors. First, the market share of US investors in the crypto-market was likely very large.[241] Thus, the incentive to protect US investors was already sufficiently large to crowd out any incentive to free ride. The flip side is that other countries could have anticipated that the SEC would take action first, and hence were able to successfully free ride on the SEC's effort. From a theoretical perspective, this can easily happen whenever regulators are asymmetric, where some have a larger benefit from *unilaterally* regulating than others.[242]

Second, the fact that US securities law is exterritorial allowed the SEC to behave *as if* it is a global regulator.[243] This could have strengthened the free-rider incentive of other regulators around the globe, but at the same time also increase the potential benefits to US citizens who invest. The main reason is that US citizens all around the globe benefit from the regulation, not just those residing in the United States itself.

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238. *See* Jabotinsky, *supra* note 4, at 121.

239. *See generally* O'Connor, *supra* note 87; Yuliya Guseva, *The SEC, Digital Assets, and Game Theory*, 46 J. CORP. L. 629, 643 tbl.1 (2020) (presenting data on the magnitude of fines imposed by the SEC).

240. *See generally* Lockaby, *supra* note 79 (discussing the increased regulation of cryptocurrency and the impact of this regulation); O'Connor, *supra* note 87 (discussing SEC regulation of cryptocurrency); Park & Park, *supra* note 88 (discussing SEC regulation of the securities market and ICOs); Kenyon Briggs, *Taming the Wild West: How the SEC can Legitimize Initial Coin Offerings (ICOs), Protect Consumers from Bad Actors, and Encourage Blockchain Development*, 2 BUS. ENTREPRENEURSHIP & TAX L. REV. 424 (2018) (discussing potential SEC regulation of ICOs to prevent fraud and abuse).

241. *See* Andrea Eross, Frank McGroarty, Andrew Urquhart & Simon Wolfe, *The Intraday Dynamics of Bitcoin*, 49 RES. INT'L BUS. & FIN. 71, 82 (2019). It is difficult to ascertain the share of American investors due to the pseudo anonymity of crypto-accounts. However, there is some evidence that market movements in Bitcoin occur frequently when other US markets open, suggesting that US investors likely drive much of the trade. *See id.*

242. Formally, suppose there are N regulators. Regulator *i's* utility function is $U(r_i) = -e_i + \alpha_i \Sigma_{j=i}^{N}(b|e_j)$ where e_i is the quantity of regulatory effort of regulator i and α_i is the share that he gets out of the sum of benefits b that is created when all the regulators invest effort. If α_i is sufficiently large, there is no free-rider problem because then it is profitable to regulate even if others do not do so.

243. *See* Jabotinsky, *supra* note 4, at 130–35 (discussing the extraterritoriality of US securities law).

An additional reason is that the market for cryptocurrencies might (and indeed sometimes does) have an effect on domestic markets,[244] so that regulating it may also have an indirect positive effect on the United States.

The ability of a single entity to regulate global markets is demonstrated by the actions of a different regulatory body—the EU. Specifically, the EU's power and influence have often been argued to be sufficient to move entire markets (even if they are global)—a phenomenon known as the "Brussels Effect."[245] One can perhaps view the SEC's power in a similar way (a "Washington, DC effect")—an entity with sufficient power could move DLT markets and thereby solve some of the problems. Of course, the same could be said about the original Brussels Effect: as MiCA will likely enter into force soon, the rules that apply to the relevant industry players (e.g., crypto-exchanges) may already solve some of the issues faced by other countries as well.

Furthermore, letting a strong local regulator act may also be justified whenever the assumptions that give rise to the two incentive problems—free riding and the tragedy of the commons—do not apply. For example, perhaps the dilemma of whether to regulate DLT is closer to the one captured by the famous "Stag-Hunt" game.[246] That is, regulators might distrust each other, but once a first regulator moved, the others can comfortably join. However, for the Stag-Hunt setting to apply, each country should be able to catch a "Hare"—that is, get some benefit out of local regulation. With a global market, this benefit seems rather small due to the aforementioned concern of forum shopping. Hence, the tragedy of the commons seems like a better description for the current wave of regulations. Moreover, global regulation would be equally effective in a Stag-Hunt situation anyway, as a global joint

244. *See* Jabotinsky & Sarel, *supra* note 72, at 446–47 (discussing the potential spillover between crypto-markets and other financial markets and possible benefits of regulation of cryptocurrency for these other markets).

245. *See* Dominique Sinopoli & Kai Purnhargen, *Reversed Harmonization or Horizontalization of EU Standards: Does WTO Law Facilitate or Constrain the Brussels Effect*, 34 WIS. INT'L L.J. 92, 98–100 (2016). *See generally* Anu Bradford, *The Brussels Effect*, 107 NW. U. L. REV. 1 (2012) (examining the substantial impact of the EU on global markets); Quentin Levin, *The Brussels Effect by Anu Bradford*, 22 GEO. J. INT'L AFFS. 307 (2021) (discussing the indirect but powerful effect of EU regulation on global markets).

246. *See e.g.*, Paul G. Mahoney & Chris W. Sanchirico, *Competing Norms and Social Evolution: Is the Fittest Norm Efficient?*, 149 U. PA. L. REV. 2027–42 (2001). This article recounts the motivating story of the game, which revolves around two hunters who can either easily capture a Hare (a small rabbit) or cooperate by jumping on a Stag (a deer) together. They are both better off if they cooperate, but they might each distrust the other's willingness to cooperate, leading them to choose the Hare, which is a "sure thing" and doesn't require cooperation. This is easily resolved if the game is sequential: if the first hunter knows that the second hunter's best-response is to jump on the Stag if the first one already did so, the first one will definitely jump on the Stag to induce cooperation. *See id.*

move toward regulation would be just as helpful as one country making the first move.[247]

With this in mind, let us consider a more difficult challenge: how to implement global regulation in practice.

VI. IMPLEMENTING GLOBAL REGULATION

A. *Off-Chain and On-Chain Regulation*

Roughly speaking, one can dichotomize the regulation of DLT into two types: *off-chain* and *on-chain*.[248] Off-chain regulation concerns actions performed outside of the technology, that is, actions performed by the various actors involved in the crypto-market. For instance, a regulation mandating that intermediaries in the crypto-market submit reports related to theft or embezzlement by employees to the authorities would be off-chain, because the reports are (most likely) not delivered automatically or via the DLT itself. Similarly, the SEC's pursuit of unregistered ICOs is the enforcement of an off-chain regulation.

Conversely, on-chain regulation is a form of "regulation by code,"[249] meaning the technology itself is used to set the rules, enforce the rules, or both. For instance, the aforementioned concept of a decentralized regulation, where different regulators could vote on which rules should govern DLT, is a form of on-chain regulation. Similarly, one could, for example, design an algorithm that tries to detect market manipulation and block such transactions—again, an on-chain feature.

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247. *See* Jabotinsky, *supra* note 32, at 73–74 (offering a general discussion of the necessary conditions for cooperation) ("[C]ooperation only begins when a perceived problem is shared across agencies . . . Unless cooperation is grasped as the solution . . . [it] will not move forward. . . . The second step is to determine whether there are enough resources to handle the problem jointly. . . . The third thing [required] for agencies to cooperate is a capacity in each agency to accept cooperation.").

248. *See* Tuan Tran, Haofan Zheng, Peter Alvaro & Owen Arden, *Payment Channels Under Network Congestion*, 2022 IEEE INT'L CONF. BLOCKCHAIN & CRYPTOCURRENCY (ICBC) 1, 1 (2022) (describing the use of the on-chain/off-chain dichotomy to describe the features of the technology itself). For instance, one can use the distributed ledger to document either the transactions themselves (so that all transactions are "on-chain") or the final balance at the end of the trading day (so that the transactions themselves occur "off-chain"). The advantage of the latter is that less information needs to be recorded on the blockchain, which reduces congestion. *See generally* Thomas Hepp, Matthew Sharinghousen, Philip Ehret, Alexander Schoenals & Bela Gipp, *On-chain vs. Off-chain Storage for Supply-and Blockchain Integration*, 60 IT-INFO. TECH. 283 (2018) (discussing the use of off-chain storage in supply chains); Wessel Reijers, Iris Wuisman, Morshed Mannan & Primavera De Filippi, *Now the Code Runs Itself: On-chain and Off-chain Governance of Blockchain Technologies*, 37 TOPOI 1 (2018) (discussing on-chain vs. off-chain transactions).

249. *See* Georgios Dimitropoulos, *The Law of Blockchain*, 95 U. WASH. L. REV. 1117, 1142 (2020); Primavera De Filippi & Samer Hassan, Blockchain Technology as a Regulatory Technology: From Code is Law to Law is Code 2–3, 6–9 (Jan. 8, 2018) (unpublished manuscript) (on file with Cornell University) (describing regulation by code).

It seems quite clear that a comprehensive regulatory framework for DLT, especially a global one, cannot be fully on-chain.[250] International standards, for instance, are a set of rules that guide the regulators on the principles that should be included in the local set of rules, but are difficult to implement as code directly. At the same time, some regulatory features can only be done on-chain. For example, if one wanted to introduce a stop-loss mechanism, which allows regulators to halt trade in case of a financial crisis, granting regulators the formal legal authority to order the halt would be ineffective, as traders may not comply. Conversely, a code that stops trade with a click of a button (by the regulator), given certain conditions, would achieve the purpose of the regulation. Furthermore, enforcement of off-chain rules might also require an on-chain feature. Suppose that a rule obligates an intermediary to apply to the authorities for a license, where the sanction is a prohibition of activity. Unless this prohibition is coded, enforcing the rule would be difficult (albeit off-chain sanctions can still be imposed, including monetary fines).

B. *Three Principles of Implementation*

While the fine-grained details of how to implement the different paths to regulation that we propose is somewhat out of scope for this Article, we believe it is helpful to lay out some principal guidelines that focus the attention on what makes the regulation of DLT different than the regulation of other technologies. Among the special characteristics of the DLT are (a) on-chain regulation by embedding the rules inside the technology itself, (b) creating incentives to comply by establishing an embedded cost for non-compliance, and (c) automated enforcement of the rules. We provide details on each of these three features in turn.

1. Embedded Regulation

What makes on-chain regulation unique is the fact that this type of regulation is embedded inside the technology itself. To illustrate the importance, consider two examples. The first concerns the regulation of lasers used in medical procedures, which is implemented via external standards, such as safety requirements.[251] Such requirements

250. *See, e.g.*, Gimmelmann & Windawi, *supra* note 144, at 30 ("On-chain stability is possible only because participants engage in extensive off-chain governance work.").

251. *See generally* R. James Rockwell & Jay Parkinson, *State and Local Government Laser Safety Requirements*, 11 J. LASER APPLICATIONS 225 (1999) (discussing a variety of state regulations of lasers utilized in medical procedures); Steven Parker, *Laser Regulation and Safety in General Dental Practice*, 202 BRITISH DENTAL J. 523 (2007) (discussing a variety of regulations governing the use of lasers in dental procedures).

may, for instance, impose obligations on the technicians or the manufacturer, who must follow certain guidelines or be held accountable.[252] Notably, this is comparable to off-chain regulation of DLT—nothing about such safety requirements is built into the lasers. As a second example, consider the regulation of "regional management codes" in DVDs.[253] This regulation was implemented by embedding a line of code inside every DVD, which prevented it from being used abroad. In some senses, such regulation is closer to on-chain regulation, as it is embedded inside the technology. In other senses, it is exactly the opposite: the embedding of a local code effectively converts each DVD into an excludable good, thereby allowing local regulators to impose rules that only apply to those DVDs which entail the local code. Conversely, the premise of on-chain regulation is the attempt to handle a non-excludable good—one infrastructure that is shared by all users and cannot be fenced off. Still, on-chain regulation is one important principle of implementation for DLT because it blurs the lines between the technology and its regulation. Therefore, to successfully regulate public blockchains, implementation of global regulation would be required to either piggy-back on the existing infrastructure or somehow redesign it to entail the features necessary for regulation.

However, this seems challenging. Consider, for example, the issue of energy consumption caused by the use of blockchain technology. As of February 3, 2022, the Cambridge Centre for Alternative Finance estimates that the Bitcoin network alone consumes almost approximately 110.4 TWh annually,[254] representing 0.17 percent of the world's energy production and almost 0.5 percent of the world's electricity production.[255] A recent report of the White House on climate change and cryptocurrencies further estimates that the United States hosts "about a third of global crypto-asset operations, which currently consume about 0.9% to 1.7% of total U.S. electricity usage,"[256] and that "this range of electricity usage is similar to all home computers or residential lighting in the United States."[257]

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252. *See* Parker, *supra* note 251 ("It is the responsibility of all clinicians undertaking laser dentistry to observe safe practice and, where required, register such use with regulatory authorities.").

253. *See, e.g.*, Andrew Murray & Colin Scott, *Controlling the New Media: Hybrid Responses to New forms of Power*, 65 MOD. L. REV. 491, 513 (2002).

254. *Cambridge Bitcoin Electricity Consumption Index*, UNIV. OF CAMBRIDGE, https://ccaf.io/cbeci/index/comparisons (last visited Feb. 3, 2023) [https://perma.cc/SP8T-CJZN] (archived Dec. 29, 2022); *see also* Grimmelmann & Windawi, *supra* note 144, at 24 (showing that current numbers are a slight decrease from previous numbers, which were higher).

255. *Cambridge Bitcoin Electricity Consumption Index*, *supra* note 254; *see also* Anthony Cuthbertson, *How Bad is Bitcoin Mining for the Environment?*, INDEPENDENT (June 17, 2022), https://www.independent.co.uk/climate-change/news/bitcoin-crypto-currency-bad-for-environment-b2103634.html [https://perma.cc/D2BJ-X2HV] (archived Dec. 29, 2022).

256. WHITE HOUSE, *supra* note 103, at 5.

257. *Id.*

This occurs due to the aforementioned "Proof-of-Work" consensus protocol used in the Bitcoin network.[258] An on-chain solution to reduce energy consumption could *theoretically* be implemented, for example, by replacing the consensus mechanism with a more environmentally-friendly protocol.[259] In fact, such a step was recently taken in the Ethereum blockchain—a transition from Proof-of-Work to so-called "Proof-of-Stake," which is expected to reduce energy consumption by 99 percent.[260] However, as one cannot easily replace the whole consensus protocol in each and every existing DLT, there are also two other alternatives for implementation.

The first is to reduce the incentives of using non–environmentally friendly blockchains (e.g., by imposing a fine on using Bitcoin as long as the consensus mechanism remains Proof-of-Work). During the preparation of MiCA in the EU, an attempt was made to prohibit the use of Proof-of-Work due to its high energy consumption, but political pressure led to its retraction.[261]

The second is to make some (imperfect) changes through the concept known as a "fork."[262] There are "soft forks" that make a consensus protocol stricter (i.e., it rejects some transactions that would have previously been approved) and "hard forks" that permit new types of transactions to take place.[263] Both of these can potentially be used: a soft fork could, for instance, be adopted to block transactions unless the parties provide some (digitized) proof that their actions are in line with a green policy, whereas a hard fork could be used to potentially permit new types transactions that would consume less energy.[264]

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258. *See id.* at 5–6.

259. *See generally* Rong Zhang & Wai Kin (Victor) Chan, *Evaluation of Energy Consumption in Block-chains with Proof of Work and Proof of Stake*, 1584 J. PHYSICS: CONF. SERIES (2020) (stating that the so-called "Proof-of-Stake" mechanism has been argued to reduce energy consumption).

260. *See, e.g.*, Dan Milmo, *Ethereum Cryptocurrency Completes Move to Cut CO2 Output by 99%*, GUARDIAN (Sept. 15, 2022), https://www.theguardian.com/technology/2022/sep/15/ethereum-cryptocurrency-completes-move-to-cut-co2-output-by-99 [https://perma.cc/WU5Y-CKRE] (archived Dec. 29, 2022).

261. *See generally* Sandali Handagama, *EU's MiCA Bill Moves Forward without Bitcoin Limiting Provision*, COINDESK (Mar. 25, 2022), https://www.coindesk.com/policy/2022/03/25/eus-mica-bill-moves-forward-without-bitcoin-limiting-provision/ [https://perma.cc/3TM2-66ZX] (archived Dec. 29, 2022) (discussing the lack of limitations on the use of proof-of-work cryptocurrencies in EU legislation).

262. *See* Jan Lansky, *Possible State Approaches to Cryptocurrencies*, 9 J. SYS. INTEGRATION 19, 20 (2018).

263. *Id.*

264. *See generally* John Schmidt, *Why Does Bitcoin Use So Much Energy?*, FORBES (May 18, 2022), https://www.forbes.com/advisor/investing/cryptocurrency/bitcoins-energy-usage-explained/ [https://perma.cc/L5HM-KA3V] (archived Dec. 29, 2022) (discussing the interaction between blockchain technology and green policies and potential regulations to incentivize more climate-friendly energy usage).

2. Embedding a Cost for Non-Compliance

Another characteristic that distinguishes DLT from many other technologies is the fact that it can store cryptocurrencies, which implies that users operating on the network have some form of online account. Therefore, one could leverage these accounts as part of the incentive to comply with the rules. Consider, for example, a rule that requires users to take certain actions as a condition for approving their transaction. While this could be enforced by blocking the transaction, which is a very strict solution, an alternative would be to require every user to deposit some money (some cryptocurrencies) upfront as a condition for performing certain actions. If the conditions are not fulfilled, a user who failed to meet these conditions will then lose his deposit.[265] This process is, nowadays, standard in decentralized finance, when a lender receives a guarantee in the form of deposited tokens and the borrower forfeits the deposited tokens in case of non-compliance with the terms of the loan.[266] The same idea can be applied to regulation, in cases of non-compliance with the regulatory rules.

3. Autonomous Enforcement

The third feature concerns how the rules are enforced. For instance, one could design the aforementioned forfeiture of tokens in cases of non-compliance also as an off-chain regulation (i.e., the regulator issues a monetary fine, which is enforced by a court order), but DLT renders this type of solution overly cumbersome. Instead, the enforcement of the rules can be fully automated. For example, a smart contract can be designed such that if the terms of the loan are violated (e.g., if there is no timely repayment), then the deposited tokens are immediately forfeited. Similarly, one could develop an algorithm that checks whether the transaction meets the requirement set by the rules (either those on-chain or off-chain) and provide automated enforcement. As one example, to prevent money-laundering, the DLT network can entail a rule that (a) only permits transactions from accounts whose owner's identification has been disclosed and (b) imposes an automatic fine on anyone who attempts to execute a deal from an unreported account.

Such regulation may be costly to develop ex-ante, but can be quite efficient ex-post, as everything is automated. Thus, the regulator does not need to invest any resources in the enforcement itself.

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265. Note that this mimics the idea of a collateral.

266. *See generally* Kaihua Qin, Philipp Jovanovic, Liyi Zhou, Pablo Gamito & Arthur Gervais, *An Empirical Study of DeFi Liquidations: Incentives, Risks, and Instabilities*, PROC. 21ST ACM INTERNET MEASUREMENT CONF. (Nov. 2-4, 2021), *Virtual Event, ACM, New York, NY, USA* (discussing collateralized loans in decentralized finance and the liquidity risks involved).

Summarizing, regulation can combine off-chain and on-chain rules, which can be implemented using (at least) three related implementation principles: embedding rules on the blockchain, leveraging the accounts to reduce the incentive of non-compliance, and automated enforcement.

VII. CONCLUSION

DLT—the technology underlying cryptocurrencies—promises to solve an acute problem that is relevant whenever multiple entities coordinate on a joint database. By creating a trustless environment, DLT removes the need to rely on an intermediary—a feature that can be incredibly useful but, at the same time, threatens to reduce the efficacy of anti-money laundering regulations, central bank activities, and more.

As stated in the introduction of this Article, DLT can be used in many cases, including the registration of property rights, intellectual property rights, movements of items in supply chains, and even cap-and-trade systems for gas emissions. However, to this date, most of the regulation pertaining to DLT involves the regulation of crypto-assets such as cryptocurrencies and NFTs.

In the area of cryptocurrencies, there seems to be an understanding that some sort of global regulation is necessary, as current regulation is uncoordinated. In this Article, we view the lack of coordination as a byproduct of two phenomena: the tragedy of the commons and a free rider problem. These phenomena can create either over-regulation or under-regulation, both at the local and international level. However, the current state of affairs hints at a shift from under-regulation (where the crypto-market behaved as a wild west) into, potentially, overregulation, given the lack of coordination.

This Article discusses three main ways to move forward. The first is the appointment of a *centralized global regulator*, that is, an international organization that will be responsible for regulating all aspects of the crypto-market. The second is *decentralized regulation*, which involves many different jurisdictions. In particular, this approach can make sense technologically if it exploits the ability of the very same technology—DLT—to implement a voting mechanism. For instance, much like the concept of a decentralized autonomous organization that uses blockchain for registering votes, key regulators from different countries can each be granted a vote and decide (ex-ante or dynamically) on new regulations. The third is *international standards* similar to the ones decided upon by the FATF for fighting money laundering and terror or the Basel Accords, which create a global standard for bank risk regulation. In order to reach one of these solutions, an attempt must be made to reduce transaction costs for states to facilitate cooperation.