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The Law of Blockchain

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Abstract: Blockchain technology is a new general-purpose technology that poses significant challenges to the existing state of law, economy, and society. Blockchain has one feature that makes it even more distinctive than other disruptive technologies: it is, by nature and design, global and transnational. Moreover, blockchain operates based on its own rules and principles that have a law-like quality. What may be called the *lex cryptographia* of blockchain has been designed based on a rational choice vision of human behavior. Blockchain adopts a framing derived from neoclassical economics, and instantiates it in a new machinery that implements rational choice paradigms using blockchain in a semi-automatic way, across all spheres of life, and without regard to borders. Accordingly, a global law and crypto-economics movement is now emerging owing to the spread of blockchain.

This Article suggests that such a rational choice paradigm is an insufficient foundation for the future development of blockchain. It seeks to develop a new understanding of blockchain and its regulation through code according to the emerging "law and political economy" framework. Blockchain is much more than a machine that enables the automation of transactions according to a rational choice framework. Blockchain should instead be understood as a technological infrastructure. Acknowledging the infrastructural dimension of blockchain technology may help identify a new role for the law in its interaction with blockchain, as well as for government in its interaction with the new technology. More precisely, identifying blockchain as an "infrastructural commons" helps us recognize that law and regulation should not be relegated to the role of merely facilitating the operation of the invisible hand of the market by and within blockchain, but should rather acquire more active roles, such as safeguarding access on non-discriminatory terms to users, on a model with net neutrality and other public utility safeguards. The Article closes by proposing a "law and political economy" framework for blockchain that is based on principles of publicness, trust, and interoperability.

Keywords: cryptoasset; Bitcoin; blockchain; Ethereum; infrastructure; law and cryptoeconomics; law and political economy

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INTRODUCTION

New technologies are testing legal systems and society at large. Advances in artificial intelligence (AI), biotechnology, and blockchain technology are changing existing social patterns and putting pressure on the legal status quo. While much discussed, blockchain is relatively little understood. As this Article describes, blockchain is a digital ledger that operates on a decentralized peer-to-peer digital network of computers and facilitates online transaction of many kinds.

Blockchain has one feature that makes it even more distinctive than any other disruptive innovation: it is by nature and design a global, transnational technology.[1] It was developed explicitly to circumvent national borders and established institutions. Blockchain facilitates the transmission of data and economic value independent of the geographical location of the participants in the blockchain network ("the nodes").

New technologies have historically had a transformational impact on the economy. Capital accounting in the form of the double-entry bookkeeping system is considered to be one of the most important foundations of modern capitalism.[2] Blockchain is arguably the most significant development in accounting since double-entry bookkeeping. Containerization, or the use of standard shipping containers, is said to have revolutionized international trade and facilitated globalization in the way we know it today.[3] Blockchain looks likely to become the "software" equivalent of the shipping container in its facilitation of international trade.[4]

The potential influence of blockchain on contemporary society, economy, and law becomes even more apparent considering the various areas in which blockchain is used.[5] The first and still most important

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1. Primavera De Filippi & Samer Hassan, *Blockchain Technology as a Regulatory Technology: From Code is Law to Law is Code*, FIRST MONDAY (Dec. 5, 2016), https://firstmonday.org/ojs/index.php/fm/article/download/7113/5657 [https://perma.cc/T24L-4CH3]; MICHÈLE FINCK, BLOCKCHAIN REGULATION AND GOVERNANCE IN EUROPE 58 (2018).

2. MAX WEBER, ECONOMY AND SOCIETY 93–95 (Guenther Roth & Claus Wittich eds., 1968); *see also* Bruce G. Carruthers & Wendy Nelson Espeland, *Accounting for Rationality: Double-Entry Bookkeeping and the Rhetoric of Economic Rationality*, 97 AM. J. SOCIO. 31 (1991).

3. *See* Daniel M. Bernhofen et al., *Estimating the Effects of the Container Revolution on World Trade*, 98 J. INT'L ECON. 36 (2016).

4. In the same way that the shipping container provided the "hardware" for international trade, Blockchain may become the software for the further facilitation of international trade. *See* EMMANUELLE GANNE, CAN BLOCKCHAIN REVOLUTIONIZE INTERNATIONAL TRADE? 44 (2018).

5. *See generally* Joshua A.T. Fairfield, *BitProperty*, 88 S. CAL. L. REV. 805 (2015); Joshua

application of blockchain is the facilitation of cryptocurrencies and other cryptoassets.[6] Bitcoin and the cryptocurrency movement emerged during the global financial crisis of 2008.[7] Bitcoin was an effort to bypass the mainstream global financial system.[8] At the same time, cryptoassets and blockchain are undoubtedly the product of globalization—a fundamentally global technology designed to bypass national and physical boundaries, they are both causes and consequences of globalization.

Since the creation of Bitcoin, the importance of cryptocurrencies has steadily increased. The price of Bitcoin first exceeded the price of an ounce of gold on March 3, 2017.[9] Cryptocurrencies have exponentially multiplied since,[10] and a separate category of "cryptoassets" has been developed. Cryptoassets are expected to become mainstream assets in the near future.[11] The explosion of the cryptocurrency market has predictably led to a regulatory backlash, a reaction by governments around the world to protect national interests and re-embed money into national jurisdictions.[12] The regulatory response has taken multiple forms, and

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Fairfield, *Smart Contracts, Bitcoin Bots, and Consumer Protection*, 71 WASH. & LEE L. REV. ONLINE 35 (2014); David Yermack, *Corporate Governance and Blockchains*, 21 REV. FIN. 7 (2017); Carla L. Reyes, *Conceptualizing Cryptolaw*, 96 NEB. L. REV. 384 (2017); Kevin Werbach & Nicolas Cornell, *Contracts Ex Machina*, 67 DUKE L.J. 313 (2017); Robinson Randolph, *The New Digital Wild West: Regulating the Explosion of Initial Coin Offerings*, 85 TENN. L. REV. 897 (2018); Jonathan Rohr & Aaron Wright, *Blockchain-Based Token Sales, Initial Coin Offerings, and the Democratization of Public Capital Markets* (Cardozo Legal Stud., Research Paper No. 527, Univ. of Tenn. Legal Stud., Research Paper No. 338, 2018), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3048104 [https://perma.cc/UV52-F987].

6. *See generally* FIN. CONDUCT AUTH., GUIDANCE ON CRYPTOASSETS (2019), https://www.fca.org.uk/publication/consultation/cp19-03.pdf [https://perma.cc/R3E9-LPYT]; CRYPTOASSETS: LEGAL, REGULATORY, AND MONETARY PERSPECTIVES (Chris Brummer ed., 2019); FIN. STABILITY BD., CRYPTOASSETS: WORK UNDERWAY, REGULATORY APPROACHES AND POTENTIAL GAPS (2019), https://www.fsb.org/wp-content/uploads/P310519.pdf [https://perma.cc/VGP6-THP6]; Syren Johnstone, *Taxonomies of Digital Assets: Recursive or Progressive?*, 2 STAN. J. BLOCKCHAIN L. & POL'Y 78 (2019).

7. SATOSHI NAKAMOTO, BITCOIN, BITCOIN: A PEER-TO-PEER ELECTRONIC CASH SYSTEM (2008), https://bitcoin.org/bitcoin.pdf [https://perma.cc/V766-N32V].

8. *Id.* at 1.

9. The price closed at $1,268 while a troy ounce of gold stood at $1,233. Rishi Iyengar, *Bitcoin Price Exceeds Gold for First Time Ever*, CNN BUS. (Mar. 3, 2017), https://money.cnn.com/2017/03/03/investing/bitcoin-gold-price-value/index.html [https://perma.cc/R8VL-PWV4].

10. The website CoinMarketCap lists more than 2,371 cryptocurrencies. *See All Cryptocurrencies*, COINMARKETCAP, https://coinmarketcap.com/all/views/all [https://perma.cc/G4MD-ZA6S].

11. *See generally Crypto-Assets: Implications for Financial Stability, Monetary Policy, and Payments and Market Infrastructures*, ECB Occasional Paper Series, Eur. Cent. Bank, No. 223 (May 2019).

12. Georgios Dimitropoulos, *Global Currencies and Domestic Regulation: Embedding through Enabling?*, *in* REGULATING BLOCKCHAIN: TECHNO-SOCIAL AND LEGAL CHALLENGES 112 (Philipp

largely depends on how the relevant legal actors perceive the threat posed by cryptoassets and their underlying technology.[13]

Blockchain technology as such and related blockchain markets are becoming more important as well.[14] Blockchain technology is a general-purpose technology that can be used to achieve multiple goals; while it was initially developed as Bitcoin blockchain to by-pass commercial

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Hacker et al. eds., 2019) [hereinafter REGULATING BLOCKCHAIN].

13. Accordingly, the literature on the legal aspects of cryptocurrencies and other cryptoassets has been expanding. *See* Reuben Grinberg, *Bitcoin: An Innovative Alternative Digital Currency*, 4 HASTINGS SCI. & TECH. L.J. 159 (2012); Tracey A. Anderson, *Bitcoin—Is it Just a Fad? History, Current Status and Future of the Cyber-Currency Revolution*, 29 J. INT'L BANKING L. & REGUL. 428 (2014); Alexandre Mallard et al., *The Paradoxes of Distributed Trust: Peer-to-Peer Architecture and User Confidence in Bitcoin*, J. PEER PROD., 2014; PRIMAVERA DE FILIPPI & AARON WRIGHT, BLOCKCHAIN AND THE LAW: THE RULE OF CODE (2018); BLOCKCHAIN & CRYPTOCURRENCY REGULATION (Josias Dewey ed., 1st ed. 2019), https://www.acc.com/sites/default/files/resources/vl/membersonly/Article/1489775_1.pdf [https://perma.cc/RJ2Q-RGNH]; REGULATING BLOCKCHAIN, *supra* note 12.

The issue of the regulation of cryptocurrencies has been prominent in the literature, again with a focus on Bitcoin. *See* Joshua J. Doguet, Comment, *The Nature of the Form: Legal and Regulatory Issues Surrounding the Bitcoin Digital Currency System*, 73 LA. L. REV. 1119 (2013); Andres Guadamuz, *Virtual Currency and Virtual Property Revisited*, TECHNOLLAMA (Feb. 11, 2013), http://bit.ly/1MaeW4N [https://perma.cc/6KZQ-MHXA]; Primavera De Filippi, *Bitcoin: A Regulatory Nightmare to a Libertarian Dream*, INTERNET POL'Y REV., May 23, 2014; GLOB. LEGAL RSCH. DIRECTORATE STAFF, LAW LIBR. OF CONG., REGULATION OF BITCOIN IN SELECTED JURISDICTIONS (2014), https://www.loc.gov/law/help/bitcoin-survey/regulation-of-bitcoin.pdf [https://perma.cc/5G94-EU94]; Stephen T. Middlebrook & Sarah Jane Hughes, *Regulating Cryptocurrencies in the United States: Current Issues and Future Directions*, 40 WM. MITCHELL L. REV. 813 (2014); Jerry Brito et al., *Bitcoin Financial Regulation: Securities, Derivatives, Prediction Markets, and Gambling*, 16 COLUM. SCI. & TECH. L. REV. 144 (2014); Nicholas A. Plassaras, Comment, *Regulating Digital Currencies: Bringing Bitcoin Within the Reach of the IMF*, 14 CHI. J. INT'L L. 377 (2013); Kevin V. Tu & Michael W. Meredith, *Rethinking Virtual Currency Regulation in the Bitcoin Age*, 90 WASH. L. REV. 271 (2015); Omri Marian, *A Conceptual Framework for the Regulation of Cryptocurrencies*, 82 U. CHI. L. REV. 53 (2015); Andres Guadamuz & Chris Marsden, *Blockchains and Bitcoin: Regulatory Responses to Cryptocurrencies*, FIRST MONDAY (Dec. 14, 2015), https://firstmonday.org/ojs/index.php/fm/article/view/6198/5163 [https://perma.cc/6QDW-M4ZC]; Michael Abramowicz, *Cryptocurrency-Based Law*, 58 ARIZ. L. REV. 359 (2016); Michèle Finck, *Blockchains: Regulating the Unknown*, 19 GERMAN L.J. 665 (2018); JEFFREY H. MATSUURA, DIGITAL CURRENCY: AN INTERNATIONAL LEGAL AND REGULATORY COMPLIANCE GUIDE (2018).

The views in legal commentary range from scholars against, in favor, and in favor of minimal regulation. *Compare* Nikolei M. Kaplanov, *Nerdy Money: Bitcoin, the Private Digital Currency, and the Case Against Its Regulation*, 25 LOY. CONSUMER L. REV. 111 (2012), *and* Joe Myers, *Joseph Stiglitz: Bitcoin Ought to Be Outlawed*, WORLD ECON. F. (Nov. 30, 2017), https://www.weforum.org/agenda/2017/11/joseph-stiglitz-bitcoin-ought-to-be-outlawed/ [https://perma.cc/7N3V-VWBE], *with* Daniela Sonderegger, *A Regulatory and Economic Perplexity: Bitcoin Needs Just a Bit of Regulation*, 47 WASH. U. J.L. & POL'Y 175 (2015).

14. *Blockchain Market Worth $39.7 Billion by 2025*, MARKETSANDMARKETS, https://www.marketsandmarkets.com/PressReleases/blockchain-technology.asp [https://perma.cc/468K-4RCA] ("[S]ize is expected to grow from USD 3.0 billion in 2020 to USD 39.7 billion by 2025 . . . .").

financial institutions and central banks, it was later welcomed by various private commercial actors as well as public bodies. Both the private sector and the government already have or are in the process of adopting the technology.

The adoption of blockchain, particularly by governments, does not come without challenges. According to de Filippi and Wright, blockchains accelerate the shift of power "from legal rules and regulations administered by government authorities to code-based rules and protocols governed by decentralized blockchain-based networks."[15] It has been suggested, moreover, that blockchain and other distributed ledgers are "the strongest challenge ever posed to the monopoly of the state over the promulgation, formation, keeping and verification of institutions and the public record."[16] This is because trust in blockchain may be in the position to replace trust in and through the government.[17] According to Satoshi Nakamoto, the pseudonymous developer of Bitcoin, blockchain technology can lead to a society where self-enforcing rules will supplant traditional laws.[18] As one of the developers of the Ethereum blockchain puts it, blockchain creates a "new kind of legal system."[19] Drawing on the notion of *lex informatica*,[20] scholars today even speak of the development of a *lex cryptographia* within blockchain.[21]

But blockchain may prove to be even more than that—not just a case in which code is law, but also a new application of law as code.[22]

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15. DE FILIPPI & WRIGHT, *supra* note 13, at 7.

16. Brendan Markey-Towler, *Anarchy, Blockchain and Utopia: A Theory of Political-Socioeconomic Systems Organised Using Blockchain*, 1 J. BRIT. BLOCKCHAIN ASS'N 13, 13 (2018), https://ssrn.com/abstract=3095343 [https://perma.cc/2TC8-3AW4].

17. *See generally* KEVIN WERBACH, THE BLOCKCHAIN AND THE NEW ARCHITECTURE OF TRUST (2018).

18. *See* NAKAMOTO, *supra* note 7.

19. Andy, *The Future of the Blockchain: Interview with Ethereum Co-founder Gavin Wood*, SIMPLEWEB (Sept. 18, 2017), https://simpleweb.co.uk/the-future-of-the-blockchain-interview-with-ethereum-co-founder-gavin-wood/ [https://perma.cc/NVN3-9DRC].

20. Joel R. Reidenberg, *Lex Informatica: The Formulation of Information Policy Rules Through Technology*, 76 TEX. L. REV. 553 (1998). This terminology reflects the supposedly autonomous "merchant law" of the Middle Ages, the *lex mercatoria*. *Id.* at 553.

21. Aaron Wright & Primavera De Filippi, Decentralized Blockchain Technology and the Rise of *Lex Cryptographia* (Mar. 10, 2015) (unpublished manuscript) (on file with SSRN), https://ssrn.com/abstract=2580664 [https://perma.cc/GHP3-MUWG].

22. *See* De Filippi & Hassan, *supra* note 1; Karen Yeung, *Regulation by Blockchain: The Emerging Battle for Supremacy Between the Code of Law and Code as Law*, 82 MOD. L. REV. 207 (2018); Carla L. Reyes, *Moving Beyond Bitcoin to an Endogenous Theory of Decentralized Ledger Technology Regulation: An Initial Proposal*, 61 VILL. L. REV. 191 (2016); Carla L. Reyes, *Conceptualizing Cryptolaw*, 96 NEB. L. REV. 384 (2017); *see also infra* section I.B. *See generally* LAWRENCE LESSIG, CODE AND OTHER LAWS OF CYBERSPACE (1999) (on the idea of code as law).

Governments all over the world are accordingly revealing an uneasiness with the rise of blockchain and its accompanying functionalities.[23] While the initial focus of regulators—and scholars alike—has been mostly on cryptocurrencies, the focus is starting to shift towards the technology supporting cryptocurrencies.[24] The law of blockchain is shaped by the nature of the technology, its uses, as well as the efforts at various levels of governance to regulate it. The Article identifies two layers of interaction between traditional law and blockchain: the law within blockchain, which has been termed *lex cryptographia*, and the law of the interaction between the real world and the online world.[25]

The most pressing issue for legal scholars working in the area of blockchain—as well as law and technology more broadly—is the role of the law in its interaction with new technologies. In the 20th century,

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23. This concern was showcased in the reaction of Members of Congress and other U.S. officials during a Senate Banking Committee hearing on Facebook's planned blockchain-backed currency, Libra. *See* Jack Kelly, *Facebook's Libra Comes Under Fire in Senate Hearing—Here's Why Congress Is Terrified*, FORBES (July 16, 2019), https://www.forbes.com/sites/jackkelly/2019/07/16/facebooks-libra-comes-under-fire-in-senate-hearing-heres-why-congress-is-terrified/#45f2537736b4 [https://perma.cc/A4M4-QLVA]. There seems to be a change in the perception of the need for the federal government to intervene in the sphere of blockchain technology and cryptoassets, not in a restricting but rather enabling manner. *See infra* section I.C (on the various types of interventions adopted by regulators around the world, including at the federal and the state level in the United States). A proposal has been even put on the table for the introduction of a U.S. "digital dollar." The COVID-19 pandemic crisis must have played a role in this change of heart. *See generally* Jason Brett, *Congress Has Now Introduced 32 Crypto and Blockchain Bills*, FORBES (Apr. 28, 2020), https://www.forbes.com/sites/jasonbrett/2020/04/28/congress-has-introduced-32-crypto-and-blockchain-bills-for-consideration-in-2019-2020/#3b64e34f1d61 [https://perma.cc/9VVF-GDGY]. On the other side of the Atlantic, the French Finance Minister, Bruno Le Maire, called Libra a "threat to national sovereignty." *See* Bruno Le Maire, *Facebook's Libra Is a Threat to National Sovereignty*, FIN. TIMES (Oct. 17, 2019), https://www.ft.com/content/bf2f588e-ef63-11e9-a55a-30afa498db1b [https://perma.cc/D67C-CX9B].

24. Various types of laws come into play for the regulation of blockchain, most importantly, data protection laws, and particularly within the European Union, the General Data Protection Regulation (GDPR). *See* 2016 O.J. (L 679) (on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing 1995 O.J. (L 281) (GDPR)); *infra* section I.C.

25. I have called this elsewhere "blockchain law." *See* Georgios Dimitropoulos, *Blockchain Law: Between Public and Private, Transnational and Domestic*, *in* THE FUTURE OF EUROPEAN PRIVATE LAW (Takis Tridimas & Mateja Durovic eds., forthcoming 2020); *cf. also* Stéphane Blemus, *Law and Blockchain: A Legal Perspective on Current Regulatory Trends Worldwide*, REVUE TRIMESTRIELLE DE DROIT FINANCIER [REV. TRIM. DR. FIN.] , no. 4, 2017, at 1; Reyes, *supra* note 5; Usha Rodrigues, *Law and the Blockchain*, 104 IOWA L. REV. 679 (2018); João Pedro Quintais et al., *Blockchain and the Law: A Critical Evaluation*, 2 STAN. J. BLOCKCHAIN L. & POL'Y 86 (2019). *See generally* THE STATE OF PLAY: LAW, GAMES, AND VIRTUAL WORLDS (Jack M. Balkin & Beth Simone Noveck eds., 2006); Mark Taylor & Matteo Matteucci, *Virtual Worlds*, 15 COMPUT. & TELECOMM. L. REV. 124 (2009) (on law in the virtual world).

rational choice theory's focus on using incentives to direct human behavior has influenced lawmaking.[26] Accordingly, the law may only be required to structure incentives for technology so that technology develops in accordance with policy objectives.[27] Importantly, blockchain is also a regulatory technology, as it guides the behavior of individuals operating in the blockchain network. This behavior-steering result is achieved through the use of what has been called "crypto-economics."[28] Blockchain technology embeds cryptoeconomic principles facilitating its internal operations and uses, based largely on rational choice theory.[29] It allows for the application of the rational choice paradigm in a semi-automatic way and on a global scale. Regulators and scholars working in this area need to be mindful of this capacity for several reasons. It is now well understood that rational choice theory does not always describe human agency with accuracy: Developments in the social sciences such as behavioral economics have proven this point repeatedly.[30] Accordingly, governments may have to intervene to protect blockchain participants and affected third parties.[31] Overall, we need a new framework for understanding and regulating blockchain technology.

Blockchain is much more than a mechanism that assumes that individuals are rational, and allows for the automation of transactions. Blockchain can be understood as a technological infrastructure.[32] Acknowledging the infrastructural dimension of blockchain technology

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26. *See generally* Thomas S. Ulen, *Rational Choice and the Economic Analysis of Law*, 19 LAW & SOC. INQUIRY 487 (1994).

27. *See* FINCK, *supra* note 1, at 118.

28. *See generally* Rainer Böhme et al., *Bitcoin: Economics, Technology, and Governance*, 29 J. ECON. PERSPS. 213 (2015); Sinclair Davidson et al., Economics of Blockchain (Mar. 9, 2016) (unpublished manuscript) (on file with SSRN) [hereinafter Davidson et al., Economics of Blockchain], https://ssrn.com/abstract=2744751 [https://perma.cc/SZ73-B9HD]; Sinclair Davidson et al., Disrupting Governance: The New Institutional Economics of Distributed Ledger Technology (July 22, 2016) (unpublished manuscript) (on file with SSRN), https://ssrn.com/abstract=2811995 [https://perma.cc/J7AE-CZ9J]; Roman Beck et al., *Governance in the Blockchain Economy: A Framework and Research Agenda*, 19 J. ASS'N FOR INFO. SYS. 1020 (2018); CHRIS BERG ET AL., UNDERSTANDING THE BLOCKCHAIN ECONOMY: AN INTRODUCTION TO INSTITUTIONAL CRYPTOECONOMICS (2019); *see also Cryptoeconomics Lab*, MIT, https://ce.mit.edu/ [https://perma.cc/JQA9-WCD6].

29. *See infra* section II.A.

30. *See* Christine Jolls et al., *A Behavioral Approach to Law and Economics*, 50 STAN. L. REV. 1471 (1998) (on the application of behavioral economics in the law).

31. *See infra* section III.C.1 (on the risks posed by cryptoassets and blockchain technology overall).

32. *See also* Angela Walch, *The Bitcoin Blockchain as Financial Market Infrastructure: A Consideration of Operational Risk*, 18 N.Y.U. J. LEGIS. & PUB. POL'Y 837 (2015); *see also* DE FILIPPI & WRIGHT, *supra* note 13; FINCK, *supra* note 1, at 66 (noting that blockchains have "an extraordinary potential to form a regulatory infrastructure governing humans and machines").

may help identify a new role for the law in its interaction with blockchain, as well as for government in its interaction with the technology. More precisely, this Article presents the argument that blockchain should be understood as an "infrastructural commons." Accordingly, law and regulation should not be relegated to the role of facilitating the operation of the invisible hand of the market by and within blockchain, but should pursue more interventionary tasks, such as safeguarding access on non-discriminatory terms to potential users on the model of "net neutrality."[33]

The Article discusses the political economy of blockchain at two levels: at the level of the "societal economy" of the *lex cryptographia*, and the interaction between blockchain technology and the *lex cryptographia* of the digital world, on the one side, and the ordinary law of the physical world, on the other. It presents three phases of such interaction: the anarcho-libertarian phase, the mainstreaming phase, and the maturity phase. The phases present a different mix between public and private, transnational and domestic laws and values. A law shaping the interaction between *lex cryptographia* and the mainstream legal system is in the process of being developed, and the Article suggests that it should feature the following three characteristics and values: enabling public and permissionless blockchains; allowing for trust in blockchain to operate with the support of governmental trust; and bridging the gaps and creating interoperability between the public and the private, as well as the physical and the non-physical world.

The Article proceeds as follows: Part I discusses the rise of blockchain and cryptoassets in recent years, as well as the consequences that their

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33. The notion of infrastructure is directly linked to the idea of the commons. *See* BRETT M. FRISCHMANN, INFRASTRUCTURE: THE SOCIAL VALUE OF SHARED RESOURCES 1–9, 10–21, 59–72 (2012). Infrastructure is becoming more important as a conceptual category for the analysis of all areas of law. *See id.*; Benedict Kingsbury, *Infrastructure and InfraReg: On Rousing the International Law "Wizards of Is,"* 8 CAMBRIDGE INT'L L.J. 171 (2019) (putting forward the idea of developing a conceptual framework for the understanding and analysis of international law in terms of "thinking infrastructurally"); *see also InfraReg*, INST. FOR INT'L L. & JUST., https://www.iilj.org/infrareg/ [https://perma.cc/J9DE-SE67]; Claire Schupmann, *Blockchain as an Emerging Cross-Border Payments Infrastructure* (Inst. for Int'l L. & Just., Emerging Scholars Paper No. 28, 2017). In a similar vein, legal scholarship is rediscovering the importance of space in governance. *See* Sarah Blandy & David Sibley, *Law, Boundaries and the Production of Space*, 19 SOC. & LEGAL STUD. 275 (2010); Luigi Nuzzo, *Spatial and Temporal Dimensions of Legal History: International Law, Foreign Policy, and the Construction of a Legal Order*, *in* THE TRANSFORMATION OF FOREIGN POLICY: DRAWING AND MANAGING BOUNDARIES FROM ANTIQUITY TO THE PRESENT (Gunther Hellmann et al. eds., 2016); Ran Hirschl & Ayelet Shachar, *Spatial Statism*, 17 INT'L J. CONST. L. 387 (2019) (as well as the other articles of the special issue).

Primavera De Filippi discusses the related issue of commons-based peer production and its relationship to "commons-based cryptocurrencies." *See* Primavera De Filippi, *Translating Commons-Based Peer Production Values into Metrics: Toward Commons-Based Cryptocurrencies*, *in* THE HANDBOOK OF DIGITAL CURRENCIES 463, 474–79 (David Lee ed., 2015).

development has had on the legal system. The uses of blockchain have exponentially grown from cryptocurrencies to the mainstreaming of cryptoassets to the adoption of the technology by private sector and government. The process of recognition, control, and adoption is largely influenced by how the legal order of the "physical" (i.e., non-digital) world understands blockchain and cryptoassets, whether as money, commodity, or technology. Part II delves into the underlying regulatory techniques that blockchain has adopted to steer the behavior of blockchain participants. Blockchain rules invariably use incentive structures for the coordination of behavior in the cryptoenvironment that derive from rational choice economics. The result is a new law and economics of blockchain. But blockchain is much more than a mechanism for the automatic execution of transactions through the incentivization of individual behavior. It is an infrastructure that operates at a global scale facilitating a great variety of actions in all aspects of life. Part III presents the interaction between the ordinary "physical" legal order, and blockchain technology, and proposes a new framework for the *lex cryptographia* as well as the interaction between the law of the analog and the digital cryptoworld drawing on the emerging "law and political economy" movement.[34] Specifically, this Article argues that a reformed "law of blockchain" should have the following three aims: enabling public and permissionless blockchains; allowing for trust in blockchain to operate with the support of governmental trust; and bridging the gaps by creating interoperability between the public and the private, as well as the physical and digital world.

I. BLOCKCHAIN AS (LEGAL) CODE

Blockchain is a new technology that shares some of the features of other disruptive technologies, while being distinctly a global "technology of technologies" in that it facilitates interactions across borders. The first section of this Part discusses the technological features underlying the rise of blockchain in the private and public sector. The Part then proceeds to discuss the nature of blockchain as a special case of "code as law" as well as "law as code." The final section of this Part closes with an examination

34. Jedediah Britton-Purdy et al., *Building a Law and Political Economy Framework: Beyond the Twentieth-Century Synthesis*, 129 YALE L.J. 1784 (2020) (presenting a framework for identifying and critiquing the way the law has been understood since the twentieth century, as well as offering a new "law-and-political-economy approach" to legal scholarship). The law and political economy framework for blockchain is fine-tuned through the Polanyian concept of "embeddedness." *See* KARL POLANYI, THE GREAT TRANSFORMATION: THE POLITICAL AND ECONOMIC ORIGINS OF OUR TIME (1944). The first mention of the idea of "embeddedness" of economic institutions into social relations is in Karl Polanyi's The Great Transformation. *Id.* at 60.

of the various ways in which legal orders have responded to the rise of the cryptoworld.

A. The Rise of Blockchain

1. Technological Features of Blockchain Technology

Blockchain technology is much-discussed but little understood. The co-founder of Ethereum, one of the most successful blockchains, uses an apt definition of blockchain:

> A blockchain is a magic computer that anyone can upload programs to and leave the programs to self-execute, where the current and all previous states of every program are always publicly visible, and which carries a very strong cryptoeconomically secured guarantee that programs running on the chain will continue to execute in exactly the way that the blockchain protocol specifies.[35]

This definition presents blockchain as a magical apparatus with the capacity to create new economic and social institutions—a statement that obscures more than it illuminates. This section breaks down some of the features of blockchain technology with less hyperbole.[36]

At the most visible level, a blockchain is a digital ledger that operates on a decentralized peer-to-peer network of computers ("nodes").[37] Blockchain technology is a relatively new technology, which relies on previous innovations, primarily Distributed Ledger Technology (DLT) and cryptography. A blockchain is a digital database, which takes shape as a sequence of blocks in the form of a chain. Drawing on DLT, the ledger is not centrally managed, but rather "distributed," meaning it is shared among all participants of the network. In addition, the ledger records transactions among parties in a secure and permanent way through means

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35. Vitalik Buterin, *Visions, Part 1: The Value of Blockchain Technology*, ETHEREUM BLOG (Apr. 13, 2015), https://blog.ethereum.org/2015/04/13/visions-part-1-the-value-of-blockchain-technology/ [https://perma.cc/JV8Y-28MB].

36. There are various accounts on the function and operation of blockchain. This is due to the fact that the different blockchain ecosystems operate sometimes based on different rule-sets that deviate from the Bitcoin blockchain. *See generally* ANDREAS M. ANTONOPOULOS, MASTERING BITCOIN (2d ed. 2017).

37. There are of course other technological innovations that use peer-to-peer networks, such as filesharing websites like Napster or BitTorrent. *See generally* Srikanta Pradhan et al., *Blockchain Based Security Framework for P2P Filesharing System*, 2018 IEEE INT'L CONF. ON ADVANCED NETWORKS & TELECOMMS. SYS., May 2019, https://ieeexplore.ieee.org/abstract/document/8710078 [https://perma.cc/4ZKU-VXRD] (discussing peer-to-peer networks and how blockchain can be used to improve security on peer-to-peer networks).

of cryptography. DLT has made possible the connection of blocks of information as an online distributed database. Blockchain uses cryptography to link the blocks with a view to making it impossible to exchange transaction data.

In a blockchain, users submit their transactions—for example, the transfer of Bitcoins or Ethers or uploading of medical files—to the network. The transactions are recorded pseudonymously, as blockchain participants can remain and operate through pseudonyms.[38] Pseudonymity is guaranteed through multiple encryption and cryptographic techniques such as hashing—functions that create information pseudonyms—and key generators (or "key gens"). Key gens create cryptographic keys that are strings of numbers and letters with the use of very advanced mathematics involving prime numbers. There are two sets of keys that are used in all transactions: public and private. Public keys are "wallets," or addresses publicly visible to all nodes; private keys are used as digital signatures for the conduct of transactions and are therefore to be kept secret.[39]

The transactions are added to new blocks by miners that propose the new blocks. Before a block can be added to the chain, a cryptographic puzzle must be solved, creating the block. Miners are special nodes that place transactions in a block by successfully solving a Proof of Work (PoW) or other problems. PoW is a system that requires some work from the miner, usually processing power by a computer. Producing a PoW is a random process with low probability, so normally a lot of trial and error is required for a valid PoW to be generated. When it comes to Bitcoins, for example, a hash is what serves as a PoW. A hash is another string of numbers and letters. A hash function is a cryptographic mathematical function that transforms a variable number of characters into a string with a fixed number of characters. Even small changes in the original string create a completely new hash. Hashing is thus a cryptographic tool that allows the pseudonymization of the information included in the relevant transaction.[40]

The node that solves the puzzle shares the solution with all the other computers in the network. All nodes in the network verify the PoW, and

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38. Most cryptocurrencies are not completely anonymous. *See* EDWARD V. MURPHY ET AL., CONG. RSCH. SERV., R43339, BITCOIN: QUESTIONS, ANSWERS, AND ANALYSIS OF LEGAL ISSUES 3 (2015), http://fas.org/sgp/crs/misc/R43339.pdf [https://perma.cc/6WDM-MLAN].

39. *See How Blockchain Technology Works: Guide for Beginners*, COINTELEGRAPH, https://cointelegraph.com/bitcoin-for-beginners/how-blockchain-technology-works-guide-for-beginners [https://perma.cc/3EZG-5ZGZ].

40. *Id.*

if found to be correct and approved by an electronic consensus, a block is added to the chain. If a miner produces a block that is approved by an electronic consensus, then the miner is rewarded with coins or tokens. The block reward is not the only incentive for miners to keep running their hardware. Miners also get transaction fees that users pay. Even though the fees are usually voluntary on the part of the sender, miners will always prioritize transfers with higher transaction fees. That is why the blockchain economy has been characterized as a "fee economy."[41]

After a successful transfer—which goes through a process of successful mining and verification—a new block is created as part of the ledger. The ledger is decentralized and distributed across a network of computers. Blocks are linked together in a chronological order forming a continuous line, i.e., a chain of blocks—hence, "blockchain." A block contains a timestamp, a reference to the previous block—in the form of the hash of that block, the transactions and the computational problem that had to be solved before the block went on the chain—and the hash of the last block.

This complex process purports to do away with intermediaries and replace trust in them with trust in the digital decentralized cryptographic system, "a trustless trust" achieved through peer-to-peer interaction.[42] Blockchain technology is "trustless" in that it does not require third party verification. Instead, it uses a consensus mechanism with cryptoeconomic incentives to transcribe a transaction in the distributed database.

Blockchain technology thus has certain attributes that differentiate it from other new innovations. It can be used for the registration and transfer of data of all types such as information as well as assets; it is decentralized; it is tamper-proof; it is transnational. The first defining feature of blockchain is decentralization. Blockchain relies on a decentralized peer-to-peer network. Each participant maintains a copy of a shared ledger of digitally signed transactions. Moreover, all copies are maintained in synchronization when a transaction takes place through a protocol in the form of PoW or Proof of Stake (PoS).[43] In addition, a blockchain electronic ledger is tamper-proof, in the sense that transactions

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41. *See infra* section II.A.

42. *See* Kevin Werbach, *Trust, But Verify: Why the Blockchain Needs the Law*, 33 BERKELEY TECH. L.J. 487, 497–98 (2018) (citing Reid Hoffman, *Reid Hoffman: Why the Blockchain Matters*, WIRED (May 15, 2015), https://www.wired.co.uk/article/bitcoin-reid-hoffman [https://perma.cc/VU4U-LV5M]) (on the notion of "trustless trust"); *see also* Primavera de Filippi, Blockchain Technology and Decentralized Governance: The Pitfalls of a Trustless Dream (2019) (unpublished manuscript) (on file with HAL), https://hal.archives-ouvertes.fr/hal-02445179/document [https://perma.cc/5XL9-F7QP].

43. *See infra* section II.A (for a definition of Proof of Stake (PoS) as well as a discussion about the differences between PoW and PoS).

in blockchain are generally irreversible, which makes blockchain almost immutable.[44]

There are two main types of blockchain: public and private.[45] For public blockchains, there is no specific entity that manages the digital platform. In the case of private blockchains, the ledger is controlled by a single entity—or managed by a consortium of companies. There are moreover "permissionless" and "permissioned" blockchains.[46] Permissionless blockchains are accessible by everyone, while for permissioned blockchains restrictions can be imposed on who can access and change the blocks. Private or consortium blockchains use such restricted access protocols. Two of the most important blockchains, Bitcoin and Ethereum, are public permissionless blockchains. They can be accessed and used by any person—with access to a computer—anywhere in the world. The software Bitcoin uses, for example, is completely open source and available for anyone to download, modify, and create their own version, which then becomes a new cryptocurrency regime.[47] There are also hybrid public-private blockchains, in which nodes with private access can see all the information in particular blockchains, while the others cannot, or the other way around.[48]

Blockchain is rapidly evolving from a technology for information to a technology for value transfer to a broader "technology for decentralization."[49] Blockchain is nowadays understood as a new "general-purpose technology."[50] Blockchain is characterized by its malleability, as it can be used in multiple organizational and social contexts. Public permissionless blockchains, in particular, are a general-purpose technology that can be used to achieve multiple goals. "Blockchains promise to constitute a profound paradigm shift regarding

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44. *See* FINCK, *supra* note 1, at 30 (using the term "tamper-evident"). The reason that it is preferable to speak of a tamper-proof quality of blockchain ledgers rather than immutability is that blockchain is susceptible to the so-called "51% attack." Parties that control at least 51% of the verification power on blockchain, such as 51% computing power, can generally tamper with transactions. *See* Walch, *supra* note 32, at 861–65.

45. *See, e.g.*, Karl Wüst & Arthur Gervais, *Do You Need a Blockchain?*, CRYPTO VALLEY CONF. ON BLOCKCHAIN TECH., 2018, at 45, https://ieeexplore.ieee.org/document/8525392 [https://perma.cc/885K-9TKF] (on the differentiations between public and private, as well as permissionless and permissioned blockchains).

46. *Id.*

47. This availability has led to an explosion of "altcoins." *See infra* section I.A.2.a.

48. *See* Wüst & Gervais, *supra* note 45, at 48.

49. Davidson et al., Economics of Blockchain, *supra* note 28, at 6.

50. *See generally* Timothy F. Bresnahan & M. Trajtenberg, *General Purpose Technologies "Engines of Growth?,"* 65 J. ECONOMETRICS 83 (1995).

data collection, sharing and processing and to trigger related revisions of socio-economic and political arrangements" that depend on data-sharing and transaction.[51] "In a broader sense, blockchain technology is being lauded as transformative for every human practice that uses recordkeeping (so, all of them)."[52]

2. Applications of Blockchain Technology

Cryptocurrencies and the broader category of cryptoassets helped spearhead blockchain technology, but blockchain technology is much more than a technology for cryptoassets. Blockchain technology can help transfer any type of data and information, not restricted to the transfer of digitized value. Blockchains are a general-purpose technology—particularly in their public permissionless form—with a very wide range of applications. Blockchains can replace paper documents with digital ones stored in a tamper-proof ledger. Businesses in almost all industries are exploring ways to take advantage of these features of blockchain. In addition, governments are also trying to stay on top of these developments and explore the opportunities that blockchain technology may provide for the distribution and transformation of government services. This section discusses some current applications of blockchain technology in the private and the public sectors.

a. Cryptocurrencies and Other Cryptoassets

Cryptoassets are digital assets in which cryptographic techniques are used to regulate the generation of units of an asset and to verify the transfer of those units between parties in a decentralized way—i.e., without a central party—via a blockchain.[53] The original developers of cryptoassets were Financial Technology (FinTech) companies. Most cryptoasset class categories have moved from FinTech startups to mainstream financial institutions, as well as big tech companies. A decade after the emergence of Bitcoin, a boom in both number and type of cryptoassets has taken place. Among these, Initial Coin Offerings (ICOs)

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51. FINCK, *supra* note 1, at 1.

52. Angela Walch, *In Code(rs) We Trust, Software Developers as Fiduciaries in Public Blockchains*, *in* REGULATING BLOCKCHAIN: TECHNO-SOCIAL AND LEGAL CHALLENGES 58, 58–59 (Philipp Hacker et al. eds., 2019).

53. FIN. STABILITY BD., CRYPTO-ASSET MARKETS: POTENTIAL CHANNELS FOR FUTURE FINANCIAL STABILITY IMPLICATIONS (2018), https://www.fsb.org/wp-content/uploads/P101018.pdf [https://perma.cc/9YUH-X3P3]; ORG. FOR ECON. COOP. & DEV., CRYPTOASSETS IN ASIA: CONSUMER ATTITUDES, BEHAVIOURS AND EXPERIENCES 10 (2019).

or "token sales" first started to appear in 2013.[54] Since then, the number of ICOs has grown exponentially. ICOs are financial ventures based on cryptocurrencies. They emerged as a way of raising capital and as a solution for entrepreneurs looking to attract funding for their startups.[55] According to the Organisation for Economic Co-operation and Development (OECD), ICOs "consist of the creation of digital tokens by start-up companies . . . and their distribution to investors in exchange for fiat currency or, in most cases, mainstream cryptocurrencies."[56]

Cryptoassets are tokens that have a value in the digital world. There are three main categories of cryptoassets. First, there are payment tokens, i.e., digital means of payment or exchange, often referred to as cryptocurrencies, although cryptocurrencies are nowadays only one type of cryptoasset. Second, there are utility tokens that grant digital access to specific digital platforms and services. And third, there are security tokens, i.e., asset-backed tokens representing ownership interests in property.[57]

The most popular category is payment tokens, or cryptocurrencies. Cryptocurrencies are not necessarily identical to virtual currencies. "Virtual currencies" have been defined as a "digital representation of value, not issued by a central bank, credit institution or e-money institution, which in some circumstances can be used as an alternative to money."[58] The term "cryptocurrency" is used to refer to any virtual currency that relies on peer-to-peer cryptography for the validation of value transfers. The term "altcoin" is also very often used in this context, mostly to describe virtual currencies except for the "dollar" of

54. *See generally* Shaanan Cohney et al., *Coin-Operated Capitalism*, 119 COLUM. L. REV. 591 (2019).

55. *See* Sabrina Howell et al., *Initial Coin Offerings: Financing Growth with Cryptocurrency Token Sales*, VOX EU (July 23, 2018), https://voxeu.org/article/financing-growth-cryptocurrency-token-sales [https://perma.cc/CPG2-LGKE].

56. ORG. FOR ECON. COOP. & DEV., INITIAL COIN OFFERINGS (ICOS) FOR SME FINANCING 9 (2019), www.oecd.org/finance/initial-coin-offerings-for-sme-financing.htm [https://perma.cc/US7Z-H6Q5].

57. APOLLINE BLANDIN ET AL., CAMBRIDGE CTR. FOR ALT. FIN., GLOBAL CRYPTOASSET REGULATORY LANDSCAPE STUDY (2018), https://www.jbs.cam.ac.uk/fileadmin/user_upload/research/centres/alternative-finance/downloads/2019-04-ccaf-global-cryptoasset-regulatory-landscape-study.pdf [https://perma.cc/X9FL-D232]. The Swiss Financial Market Supervisory Authority (FINMA) has also made a distinction between payment tokens, utility tokens, and asset tokens. *See* FINMA, GUIDELINES FOR ENQUIRIES REGARDING THE REGULATORY FRAMEWORK FOR INITIAL COIN OFFERINGS (2018).

58. EUR. CENT. BANK, VIRTUAL CURRENCY SCHEMES–A FURTHER ANALYSIS (2015).

cryptocurrencies, Bitcoin.[59] There are no limits to the number of altcoins that can be developed and released.[60]

Stablecoins are one of the latest developments in the field of cryptoassets. In contrast with the first generation of cryptoassets, the value of a stablecoin is pegged to one or more external sources such as fiat currency or commodities. Stablecoins may be public or private. One example of a private stablecoin is "Libra," the planned blockchain-based currency of Facebook. Libra is designed as a stablecoin with a steady value 100% backed by a basket of securities and fiat currencies such as the dollar, euro, pound and yen.[61] Libra will be run by the Libra Association, an independent, not-for-profit membership organization, headquartered in Geneva, and supported by private companies, such as Facebook, Uber, and Vodafone, as well as non-profit organizations.[62] At the same time, some central banks—for example, in China, Sweden and Switzerland—have started to explore the possibility of developing their own version of stablecoins, so-called Central Bank Digital Currencies (CBDCs).[63]

Domestic legal orders have had great difficulty in grappling with cryptocurrencies and other cryptoassets. Being decentralized and global in nature, they cannot be identified as legal tender in the same way as national currencies. In the United States, only the U.S. dollar is legal

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59. For a definition of Bitcoin, see Guadamuz & Marsden, *supra* note 13, at 2.2 ("Bitcoin is a non-fiat cryptographic electronic payment system that purports to be the world's first cryptocurrency. In other words, it is a peer-to-peer, client-based, completely distributed currency that does not depend on centralised [sic] issuing bodies (a 'sovereign') to operate. The value is created by users, and the operation is distributed using an open source client that can be installed on any computer or mobile device.").

60. "[T]he Internet of money will be less concerned with creating one coin to rule them all, than it will be about finding one rule to coin them all." *See* GRANT K. NIVEN ET AL., WORLD GOV'T SUMMIT & ERNST & YOUNG, THE FUTURE OF MONEY: BACK TO THE FUTURE–THE INTERNET OF MONEY 7 (2017). In practice, there are only a few real alternatives that implement minor or major changes to the Bitcoin software; these are known as "forks." *See* Adam Hayes, The Decision to Produce Altcoins: Miners' Arbitrage in Cryptocurrency Markets (Mar. 17, 2015) (unpublished manuscript) (on file with SSRN), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2579448 [https://perma.cc/VAK4-ESR2].

61. LIBRA ASS'N MEMBERS, LIBRA WHITE PAPER V2.0 (2020), https://libra.org/en-US/white-paper/#cover-letter [https://perma.cc/JB26-P32W].

62. *Id.* PayPal, Stripe, eBay, Visa and Mastercard left the association in the last couple of months, despite having originally joined the association. Hannah Murphy & Kiran Stacey, *Mastercard, Visa, eBay and Stripe Quit Facebook's Libra*, FIN. TIMES (Oct. 11, 2019), https://www.ft.com/content/a3e952dc-ec5c-11e9-85f4-d00e5018f061 [https://perma.cc/D7FT-EXS8].

63. *See* Emilios Avgouleas & Sir William Blair, *The Concept of Money in the 4th Industrial Revolution–A Legal and Economic Analysis*, SING. J. LEGAL STUD. (2020).

tender;[64] accordingly, only the Mint and the Federal Reserve can produce coins and currency. Different jurisdictions take different views on the legal nature of cryptocurrencies, sometimes treating them as money, sometimes treating them as commodities.[65] Others identify their nature by focusing on their background technology.[66]

Various regulators around the world treat cryptocurrency as money. According to Financial Crimes Enforcement Network (FinCen) in the United States, cryptocurrencies and other virtual currencies are mediums of exchange that operate like a currency without having all the features of real currency, above all the legal tender status; in particular, "convertible" virtual currencies have an equivalent value in real currency, or may act as a substitute for real currency.[67] Similar views are held elsewhere as well. The German Federal Financial Supervisory Authority (*Bundesamt für Finanzdienstleistungen*) took a similar approach as FinCen in a communication on Bitcoins in December 2013. According to this communication, Bitcoins are legally binding financial instruments in the form of units of account that are similar to foreign currencies.[68] Her Majesty's Revenue and Customs (HMRC) in the United Kingdom also treats cryptocurrencies as money for tax purposes.[69] In an important decision concerning the nature of Bitcoin and other cryptocurrencies in the E.U. legal order, the Court of Justice of the European Union (CJEU) both implicitly and explicitly recognizes cryptocurrencies—also for tax, namely value-added tax, purposes—as some form of money.[70]

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64. 31 U.S.C. § 5103.

65. *See* REGULATING BLOCKCHAIN, *supra* note 12; *see also* Noah Vardi, *Bit by Bit: Assessing the Legal Nature of Virtual Currencies*, *in* BITCOIN AND MOBILE PAYMENTS: CONSTRUCTING A EUROPEAN UNION FRAMEWORK 55 (Gabriella Gimigliano ed., 2016).

66. *See infra* section I.C.

67. DEP'T OF TREASURY, FIN. CRIMES ENF'T NETWORK, FIN-2013-G001, APPLICATION OF FINCEN'S REGULATIONS TO PERSONS ADMINISTERING, EXCHANGING, OR USING VIRTUAL CURRENCIES (2013) [hereinafter FINCEN], https://www.fincen.gov/sites/default/files/shared/FIN-2013-G001.pdf [https://perma.cc/K6GT-38JP]. This definition brings cryptocurrencies very close to actual money but does not really equate them. The U.S. anti-money laundering regime applies to any "value that substitutes for currency." *Id.* at 3; *see* 31 C.F.R. § 1010.100(ff)(5)(i)(A) (2019).

68. Jens Münzer, *Bitcoins: Aufsichtliche Bewertung und Risiken für Nutzer*, BAFIN (Dec. 19, 2013), https://www.bafin.de/SharedDocs/Veroeffentlichungen/DE/Fachartikel/2014/fa_bj_1401_bitcoins.html [https://perma.cc/WSL3-3Y5G].

69. HER MAJESTY'S REVENUE & CUSTOMS, REVENUE AND CUSTOMS BRIEF 9: BITCOIN AND OTHER CRYPTOCURRENCIES (2014), https://www.gov.uk/government/publications/revenue-and-customs-brief-9-2014-bitcoin-and-other-cryptocurrencies [https://perma.cc/7NMR-R957].

70. Högsta förvaltningsrättens beslut [HFD] [Supreme Administrative Court Decision] 2015 case no. C-264/14, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A62014CJ0264 [https://perma.cc/ZSV3-Q6WM] (Swed.). The CJEU uses the terms "traditional currency" for national currencies such as the Swedish crown, and the term "non-traditional currency" for cryptocurrencies. According to the Court, non-traditional currencies are "currencies other than those

Other jurisdictions and regulators follow a different approach in identifying cryptocurrencies as commodities.[71] In the United States, the regulatory agency responsible for commodities regulation, the Commodity Futures Trade Commission (CFTC), has classified cryptocurrencies as commodities for the purposes of the Commodity Exchange Act of 1936.[72] The People's Bank of China (PBOC), together with four other regulators, has issued a "Notice on Precautions Against the Risks of Bitcoins,"[73] denying that cryptocurrencies are money and classified them as "virtual commodities."[74]

But cryptocurrencies, even when identified as money or commodities, are more than just that. Some regulatory actors have opted to focus on the underlying technology of cryptocurrencies. As will be highlighted later in this Article,[75] jurisdictions that focus on the underlying technology have adopted a more favorable and enabling approach to cryptocurrencies on the whole.

b. Private Uses

In the private sector, blockchain technology is increasingly being used to support "smart contracts."[76] A smart contract is a self-executing "contract," whereby the terms of the agreement between the two parties are directly written into code, reducing transaction costs, and facilitating transactions without third-party intervention.[77] But, "the name smart

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that are legal tender in one or more countries, in so far as those currencies have been accepted by the parties to a transaction as an alternative to legal tender and have no purpose other than to be a means of payment." *Id.* ¶ 49. It moreover explicitly denies them the nature of a good. Finally, it decided that the provisions of the E.U. VAT Directive applying to traditional money also find application in the case of virtual currencies.

71. Bank of England economists have also identified virtual currencies as commodities. *See* Robleh Ali et al., *The Economics of Digital Currencies*, 54 BANK OF ENG. Q. BULL. 276, 278 (2014).

72. Coinflip, Inc., CFTC No. 15-29 (Sept. 17, 2015), http://www.cftc.gov/ucm/groups/public/@lrenforcementactions/documents/legalpleading/enfcoinfliprorder09172015.pdf [https://perma.cc/LSR6-J695].

73. Press Release, Ministry of Indus. & Info. Tech. of the People's Bank of China, The People's Bank and Other Five Ministries Issued a Notice on Preventing Bitcoin Risks (Dec. 3, 2013) [hereinafter People's Bank of China], http://www.miit.gov.cn/n1146295/n1652858/n1652930/n3757016/c3762245/content.html [https://perma.cc/57DS-3TX7].

74. *Id.*

75. *See infra* section I.C.

76. The concept of the smart contract was developed in the mid-1990s. It was introduced and developed by cryptographer Nick Szabo in various publications during the Nineties. *See* NICK SZABO, SMART CONTRACTS: BUILDING BLOCKS FOR DIGITAL MARKETS (rev. ed. 2018).

77. *See generally* Roger Brownsword, *Regulatory Fitness: Fintech, Funny Money, and Smart Contracts*, 20 EUR. BUS. ORG. L. REV. 5 (2019); THE CAMBRIDGE HANDBOOK OF SMART

contracts is a misnomer: They are neither smart (there is no cognitive component, simply automatic execution once a precondition is fulfilled), nor a contract in a legal sense."[78] Blockchain technology allows smart contracts to be layered on top of token exchanges, whereby exchanges only occur if particular conditions are met.[79] The contracts are then self-executing. A smart contract using blockchain is a way of making an agreement that is fulfilled as soon as certain pre-determined conditions are satisfied. A blockchain-based smart contract can be coded between any party in the world, independent of their physical location. Smart contracts and blockchain can thus support and semi-automatically enforce legal contracts. According to some accounts, smart contracts are not only intended to support or enforce actual contracts; they are actually meant to replace them.[80]

Coding of legal and social arrangements on blockchain goes beyond smart contracts and has led to the development of Decentralized Autonomous Organizations (DAOs). A DAO is an organization constituted by rules coded into a blockchain based on principles agreed to by the stakeholders of the organization. Often, DAOs sell tokens online that give rights to holders such as voting rights—e.g., the right to vote on proposals for projects the DAO wants to fund. A DAO is "decentralized" because no centralized authority, person, or entity, controls it. It is "autonomous" because it runs itself through a series of connected smart contracts. Finally, it is an "organization" in the sense that it brings together a set of resources that refer to each other.[81] DAOs do not generally come under the conventional understanding of organizations, and thus create problems of legal categorization.[82]

CONTRACTS, BLOCKCHAIN TECHNOLOGY AND DIGITAL PLATFORMS (Larry A. DiMatteo et al. eds., 2019).

78. DELOITTE, BLOCKCHAIN: LEGAL IMPLICATIONS, QUESTIONS, OPPORTUNITIES AND RISKS (2019), https://www2.deloitte.com/content/dam/Deloitte/za/Documents/legal/za_legal_implications_of_blockchain_14052019.pdf [https://perma.cc/8EHC-HNDN].

79. Smart contracts were first introduced in 2015 in blockchain technology by Ethereum, and are being increasingly intertwined with blockchain technology. They have become a functionality of blockchain, currently considered as one of its most promising features.

80. *See* De Filippi & Hassan, *supra* note 1.

81. *See generally* Carla L. Reyes et al., *Distributed Governance*, 59 WM. & MARY L. REV. ONLINE 1 (2017).

82. "Organizations are special institutions that involve (a) criteria to establish their boundaries and to distinguish their members from nonmembers, (b) principles of sovereignty concerning who is in charge, and (c) chains of command delineating responsibilities within the organization." Geoffrey M. Hodgson, *What Are Institutions?*, 40 J. ECON. ISSUES 1 (2006). The precise legal status of DAOs is currently unclear in most jurisdictions. According to Usha Rodrigues, they are more of a "virtual

Another promising area of application of blockchain technology is supply chain management and logistics and all related applications in international business transactions. According to some accounts, blockchain will disrupt business practices and models in the same way that the Internet did in the field of communication.[83] According to the World Economic Forum, "[r]educing supply chain barriers to trade could increase GDP by nearly 5% and trade by 15%."[84] Global supply chains are very complex, involving diverse public and private bodies and multiple interests and intermediaries across many jurisdictions. Blockchain can cope with the complexity of global supply chains.[85] It can help connect the various parties outside of the jurisdiction in which they are located, as well as independently of whether they are government or private actors. All stakeholders can view and have online access to bills of lading and other data-related documentation, including the status of customs documents. Blockchain technology ensures data exchange in a secure way and offers a repository of information which is tamper-proof for multiple transactions across various private and public systems. New applications such as Polkadot and Cosmos will further facilitate the use of the blockchain for such purposes, as they permit interoperability among permissioned and permissionless blockchains creating "meta-blockchains."[86]

c. Government Uses

The application of blockchain technology is fast transitioning from the private to the public sector, as governments around the world do not want to be left behind when it comes to the use of the technology. The public sector is responsible for many areas of trust. Important public sector applications are: identity management and attestation; the keeping of government records, such as land registration and corporate registration records; citizen services management in areas such as healthcare; and the

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venture capital fund" than a corporation. *See* Rodrigues, *supra* note 25, at 680.

83. DHL TREND RSCH., BLOCKCHAIN IN LOGISTICS 4 (2018), https://www.logistics.dhl/content/dam/dhl/global/core/documents/pdf/glo-core-blockchain-trend-report.pdf [https://perma.cc/WG7G-UCW4].

84. WORLD ECON. F., BAIN & CO., & WORLD BANK, ENABLING TRADE: VALUING GROWTH OPPORTUNITIES (2013), http://www3.weforum.org/docs/WEF_SCT_EnablingTrade_Report_2013.pdf [https://perma.cc/47QB-Y4XW].

85. *See generally* DHL TREND RSCH., *supra* note 83.

86. Christine Kim, *A Blockchain to Connect All Blockchains, Cosmos Is Officially Live*, COINDESK (Mar. 13, 2019, 11:10 PM), https://www.coindesk.com/a-blockchain-to-connect-all-blockchains-cosmos-is-now-officially-live [https://perma.cc/DN25-9QJ]; *see also infra* section III.C.3.

conduct of government activities, such as voting, taxation, customs, and public procurement.[87] This type of trust may now be secured by blockchain. Many government-related services could thus be provided without direct involvement of government—at least in the way that government is involved today. As the *Economist* magazine put it a few years ago, the use of blockchain by the government means that "an anti-establishment technology faces an ironic turn of fortune."[88] Some governments are more reluctant to relinquish their traditional trust-mediating role, while others are more open to the idea. In the United States, while the federal government has been more risk-averse regarding the facilitation and adoption of blockchain technology, state governments seem to be more open to using the technology.[89]

Some countries use blockchain as part of a broader approach to public service delivery. Estonia was among the first countries to develop a vision for an electronic state through its E-Estonia initiative.[90] This coincided

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87. *See* Jorden Woods, *Blockchain: Public Sector Use Cases*, MEDIUM: CRYPTOORACLE (Oct. 2, 2018), https://medium.com/crypto-oracle/blockchain-public-sector-use-cases-49a2d74ad946 [https://perma.cc/5T8N-XXCF]. In the United States, Illinois, for example, has shown a particular interest in the areas of identity, attestation, and ownership registries, compliance and reporting ledgers, benefit and entitlement ledgers, and a set of new products and services including escrow as a service, governmental distributed ledgers, and securing the Internet of Things infrastructure. *See* CRAIG HOLLOWAY, DEP'T OF INNOVATION & TECH., STATE OF ILLINOIS: REQUEST FOR INFORMATION (RFI): DISTRIBUTED LEDGER AND BLOCKCHAIN APPLICATIONS IN THE PUBLIC SECTOR 5–6 (2016), https://www2.illinois.gov/sites/doit/Documents/BlockchainInitiative/RFI+Blockchain+and+Distributed+Ledger+Applications+in+the+Public+Sector.pdf [https://perma.cc/Y7G3-T4AB].

Identity management and attestation is an area that has seen a widespread use of blockchain. Legal documents often require notarization of signatures attesting to the identity of the signer. More than 1.1 billion individuals do not have any official identity documents at all. *See* Press Release, The World Bank, 1.1 Billion 'Invisible' People Without ID Are Priority for New High Level Advisory Council on Identification for Development (Oct. 12, 2017), https://www.worldbank.org/en/news/press-release/2017/10/12/11-billion-invisible-people-without-id-are-priority-for-new-high-level-advisory-council-on-identification-for-development [https://perma.cc/P5LQ-NUDX]. Many public and private institutions have been trying to remedy this. For example, the Digital Identity Alliance, or ID2020 Alliance, an organization affiliated with the United Nations, seeks to provide proof of identity to people without an official form of identification. Blockchain has been used to create secure digital identities and as a proof of identity. The ID2020 Alliance is an initiative of governments, NGOs, and the private sector to provide a blockchain-based framework for digital identity that will be personal, persistent, portable, and private. Private companies involved in the ID2020 Alliance are Microsoft and Accenture. The ID2020 Alliance is expected to assist millions of refugees all over the world over the next few years. *See* SCI. FORESIGHT UNIT, EUR. PARLIAMENTARY RSCH. SERV., TECHNOLOGICAL INNOVATION FOR HUMANITARIAN AID AND ASSISTANCE 57–58 (2019).

88. *Governments May Be Big Backers of the Blockchain*, ECONOMIST (June 1, 2017), https://www.economist.com/news/business/21722869-anti-establishment-technology-faces-ironic-turn-fortune-governments-may-be-big-backers [https://perma.cc/6XAY-NFQG].

89. *See infra* section I.C.

90. *See We Have Built a Digital Society and We Can Show You How*, E-ESTONIA, https://e-

with the popularization of blockchain technology, and the Estonian government has been testing the technology since 2008.[91] As of 2012, blockchain has been in operational use in Estonia's registries and for a majority of government services such as national health, judicial, legislative, security, and commercial code systems.[92] There are plans to extend its use to other spheres such as personal medicine, cybersecurity, and data embassies. For example, filing tax returns and buying a car can be done online in Estonia using blockchain for purposes of information accuracy.[93] The vision in Estonia even goes beyond public service delivery.[94]

In a similar vein, Dubai wants blockchain technology to power its entire government, making Dubai the first "city fully powered by Blockchain."[95] The plan is to move all government documents to blockchain by 2020, and have 50% of its services operating on a blockchain platform by 2021.[96] The government of the Emirate has moreover announced that it will introduce its own blockchain-based currency, called "emCash," to facilitate transactions in the public and private sectors in the country.[97]

Governments are using blockchain in increasingly varied ways: for

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estonia.com/ [https://perma.cc/3BP8-L5PG].

91. *See Frequently Asked Questions: Estonian Blockchain Technology*, E-ESTONIA, https://e-estonia.com/wp-content/uploads/2019aug-nochanges-faq-a4-v03-blockchain-1-1.pdf [https://perma.cc/56B2-PPYV].

92. *See* PRICEWATERHOUSECOOPERS, ESTONIA–THE DIGITAL REPUBLIC SECURED BY BLOCKCHAIN (2019), https://www.pwc.com/gx/en/services/legal/tech/assets/estonia-the-digital-republic-secured-by-blockchain.pdf [https://perma.cc/3VJF-DT7H].

93. *See* Clare Linda Sullivan & Eric W. Burger, E-Residency and Blockchain (Apr. 2, 2016) (unpublished manuscript) (on file with SSRN), https://ssrn.com/abstract=2757492 [https://perma.cc/8KVV-JMMW] (regarding Estonia's blockchain-based e-residency program and foreign citizens wanting to do business in or though Estonia).

94. According to former Estonian President Toomas Hendrik Ilves, "Estonia is now a blockchain nation." *See* Kaspar Korjus, *Welcome to the Blockchain Nation*, MEDIUM (July 7, 2017), https://medium.com/e-residency-blog/welcome-to-the-blockchain-nation-5d9b46c06fd4 [https://perma.cc/M7UN-GZ6L].

95. *See Blockchain*, SMART DUBAI, https://www.smartdubai.ae/initiatives/blockchain [https://perma.cc/C8HX-6CCF].

96. *Emirates Blockchain Strategy 2021*, U.A.E., https://u.ae/en/about-the-uae/strategies-initiatives-and-awards/federal-governments-strategies-and-plans/emirates-blockchain-strategy-2021 [https://perma.cc/7CNB-SU8U]. Dubai has developed the umbrella initiative of Smart Dubai that includes such other initiatives as Startup Support, the Happiness Agenda, the AI Lab, as well as the Dubai Blockchain Strategy. It has moreover established the Global Blockchain Council founded by the Dubai Future Foundation.

97. Samburaj Das, *emCash Is Dubai's First Official State Cryptocurrency*, CRYPTOCOINSNEWS (Oct. 3, 2017, 1:57 PM), https://www.cryptocoinsnews.com/emcash-dubais-first-official-state-cryptocurrency/ [https://perma.cc/JNC3-VENA].

registering land titles,[98] managing health data,[99] and promoting other technologies.[100] The use of blockchain technology has moved to the international level as well. In August 2018, the World Bank and CommBank from Australia launched bond-*i*, a blockchain-based debt instrument for bond issuance and bond lifecycle management.[101]

The most important government use of blockchain is by central banks.[102] It has even been suggested that cryptocurrencies may one day replace sovereign currencies.[103] Central banks all over the world have been working on the development of Retail Central Bank Digital Currency (CBDC).

CBDCs are not cryptocurrencies; they are rather digital blockchain-based fiat currencies, a digital form of blockchain-powered fiat money—i.e., money based not on the value of the commodity that backs it and physically represents it, but rather by trust in government and central

98. Georgia has moreover become the first country to register land titles using blockchain technology. *See* Frisco D'Anconia, *Georgia Becomes First Country to Register Property on Blockchain*, COINTELEGRAPH (Feb. 8, 2017), https://cointelegraph.com/news/georgia-becomes-first-country-to-register-property-on-blockchain [https://perma.cc/CG78-G9LW].

99. The U.S. Department of Health and Human Services has shown an interest in using blockchain to manage health data. *See* Joseph Bradley, *U.S. Department of Health Calls for Blockchain Research*, CRYPTOCOINSNEWS (July 8, 2016), https://www.cryptocoinsnews.com/u-s-department-of-health-calls-for-blockchain-white-papers [https://perma.unl.edu/JQ2J-J7B9].

100. Malta is a very interesting example of a country embracing blockchain technology; in 2018 the government put in place three legislative instruments for the promotion of new technologies, with an emphasis on blockchain. *See* Innovative Technology Arrangements and Services Act, 2018 (Law 43) (Malta); Virtual Financial Assets Act, 2018 (Law 44) (Malta); Malta Digital Innovation Authority Act, 2018 (Law 45) (Malta).

101. *See* Press Release, The World Bank, World Bank Issues Second Tranche of Blockchain Bond Via Bond-i (Aug. 16, 2019), https://www.worldbank.org/en/news/press-release/2019/08/16/world-bank-issues-second-tranche-of-blockchain-bond-via-bond-I [https://perma.cc/DK55-7DN8].

102. Many more possible central bank uses may be identified, apart from the ones mentioned in the body of the text, for example, interbank securities settlement, focused application of blockchain-based digital currency, including CBDC, enabling the rapid interbank clearing and settlement of securities for cash; central banks are moreover exploring use of blockchain technologies for purposes of payment system resiliency and contingency, including cases of technical or network failure, natural disasters and cyberattacks. *See* Ashley Lannquist, *10 Ways Central Banks Are Experimenting with Blockchain*, WORLD ECON. F. (Apr. 3, 2019), https://www.weforum.org/agenda/2019/04/blockchain-distrubuted-ledger-technology-central-banks-10-ways-research/ [https://perma.cc/X3NF-V5RC] (on this as well as on the central bank uses mentioned in the text). Project Ubin, for example, is a project developed by the Monetary Authority of Singapore with the industry to explore the use of Blockchain and Distributed Ledger Technology for clearing and settlement of payments and securities. *See Project Ubin: Central Bank Digital Money Using Distributed Ledger Technology*, MONETARY AUTH. OF SING., https://www.mas.gov.sg/schemes-and-initiatives/Project-Ubin [https://perma.cc/5Z3W-SMYQ].

103. *See* Adam James, *Will Cryptocurrency Replace National Currencies by 2030?*, BITCOINIST (Mar. 2, 2018, 8:00 PM), https://bitcoinist.com/will-cryptocurrency-replace-national-currencies-by-2030/ [https://perma.cc/SPR3-77UW].

banks—with legal tender status. Central bank-issued digital currency operates in a peer-to-peer and decentralized manner. It may be made available for consumer use, and could be used to complement or substitute for physical money and serve as an alternative to traditional bank deposits. Another use central banks have been experimenting with is wholesale CBDC, namely central bank-issued digital currency that operates in a peer-to-peer and decentralized manner but is only available to commercial banks and clearing houses for use in the wholesale inter-bank market. The People's Bank of China (PBOC) has been developing the "digital yuan" with the goal of improving the PBOC's ability to track money electronically as it changes hands, helping thus to combat money laundering and other illegal activities. Other examples include Uruguay's pilot program on the "e-Peso," which is supported by the International Monetary Fund. Venezuela has developed the "Petro," and Sweden's Riksbank has long been exploring an "e-krona."[104]

B. Code, Law, and the Lex Cryptographia

Professor Lawrence Lessig has famously explained how code can operate as law.[105] According to Lessig, there are four main ways through which individual behavior is constrained and regulated: the law, social norms, market forces, and architecture.[106] These forces shape individuals' actions in various ways. The law creates constraints on individuals by putting limits on actions through legislation and regulation, and punishing individuals that violate the rules. Social norms regulate cultural behaviors through social mechanisms such as peer pressure. The market incentivizes or disincentivizes certain behaviors through the mechanism of supply and demand. Architecture—of the natural or the artificial environment—imposes a series of limits on the type of actions that an individual can do.

Code is the man-made architecture of cyberspace and can thus regulate individual behavior via means of technology. It thus imposes systematic constraints on individual behavior in an artificial environment. The designer of code is the "rulemaker" of the technological environment.[107] For example, the designer of the Internet regulates behavior on the Internet; the designer of digital platforms regulates behavior on digital platforms.[108]

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104. *See supra* section I.A.2.a.

105. *See* LAWRENCE LESSIG, CODE AND OTHER LAWS OF CYBERSPACE (1999).

106. LAWRENCE LESSIG, CODE VERSION 2.0, at 123 (2006).

107. *But see* Tim Wu, *When Code Isn't Law*, 89 VA. L. REV. 679 (2003).

108. "An important difference between the physical and digital world is that, even though a single

According to some recent accounts, the lines of influence between law and code run in both directions. While code takes the form of law—in the sense of the regulatory power that the code exercises in certain environments, such as the Internet—the law may be gradually turning into code: "in the last few years (especially since the emergence of blockchain technology and corresponding smart contract transactions) the law is progressively starting to assume the characteristics of code."[109]

Blockchain technology is a prime example of "code as law." This is due to its distinct technological characteristics such as malleability:

> Blockchain technology reinforces the tendency to rely on code (rather than on the law) to regulate individual actions and transactions. The blockchain enables a whole new type of regulation by code, which — combined with smart contracts — also promotes a new way of thinking about the law. Indeed, as more and more contractual rules and legal provisions are incorporated into smart contract code, the traditional conception of the law (as a flexible and inherently ambiguous set of rules) might need evolve into something that can better be assimilated into code. As a result of this tendency, both lawyers and legislators could increasingly be tempted to *deliberately* draft legal or contractual rules in a way that is much closer to the way technical rules are drafted. *Code is Law* might therefore lead to *law progressively turning into code*.[110]

Blockchain, with its multiple uses and functionalities, and the *lex cryptographia* of blockchain present a new paradigm for law. It may affect individual rules, the legal system, and above all how lawmakers, regulators, individuals, and society at large think about the law. Removing the uncertainty and narrowing law down to technical codes may have an impact on how the law is interpreted, applied and enforced by the executive branch and above all the courts. By removing the ambiguity inherent in the law, it may in fact make legal interpretation and enforcement through the executive and the judicative branches of government increasingly redundant.

The nature of blockchain technology makes regulation through its code very powerful. The tamper-proof nature of the ledger, as well as its potential for automating transactions makes *lex cryptographia* a very

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individual cannot influence forces like *Law, Social Norms, Markets* and *Nature*, individuals are increasingly able to create and manipulate code (either by themselves, or by getting others to do it)." De Filippi & Hassan, *supra* note 1.

109. *Id.*

110. De Filippi & Hassan, *supra* note 1 (emphasis in original).

efficient regulatory code.[111] At the same time, *lex cryptographia* is subject to external regulation coming from the ordinary law of the "real" world. Most likely, the relationship between the two will not be one of substitution, but rather of complementarity, as this Article discusses in the next section.[112]

C. The Response of the Law of the Physical World: From Indifference to Recognition to Control to Adoption

It took many years before governments started reacting to the rise of cryptocurrencies, and even longer regarding their reaction to blockchain technology. The phase of indifference gave way in some countries to a phase of recognition. This section discusses the phase of control that followed the recognition phase, including various measures that governments implemented to exercise that control. Some countries have taken a different step by explicitly adopting the technology not only for the purposes of private transactions, but also for the purposes of transactions in the public sector.

Overall, there is a discrepancy as to how different countries around the word deal particularly with cryptoassets. A comparative look at cryptoasset regulation even reveals a paradoxical regulatory landscape. On the one side, some jurisdictions try to restrict their use—reaching from complete bans on the use of cryptoassets to restrictions on use to more spot on restrictions. On the other side, some governments have been trying to enable the operations of FinTech companies, including cryptocurrency startups, in their jurisdictions by using innovative regulatory instruments, such as "innovation hubs," and "regulatory sandboxes."[113] Looser regulatory standards apply to them than to conventional financial institutions.

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111. DE FILIPPI & WRIGHT, *supra* note 13.

112. *See* FINCK, *supra* note 1, at 85.

113. Regulatory sandboxes allow businesses to test new products, services, business models, and delivery mechanisms in a more relaxed regulatory environment. As the UK Financial Conduct Authority defines it, a regulatory sandbox is a "safe space in which businesses can test innovative products, services, business models and delivery mechanisms without immediately incurring all the normal regulatory consequences of engaging in the activity in question." *See* FIN. CONDUCT AUTH., REGULATORY SANDBOX 1 (2015), https://www.fca.org.uk/publication/research/regulatory-sandbox.pdf [https://perma.cc/8RMM-5U34]. The idea is to provide FinTech and startup companies with more pathways to start testing the viability of innovative financial services before being subject to the regulations and regulatory costs associated with the development of standard financial products. The underlying rationale is to strike a balance between facilitating innovation and competition, while at the same time ensuring consumer protection and the distribution of the benefits of innovative FinTech products to society at large.

There are different established practices and needs for the regulation of something depending on whether it is characterized as money, commodity, or technology. In a continuum of regulatory approaches, regulation of money will have the tendency to be heavier, regulation of a commodity will have the tendency to be lighter, while regulation of a technology will have the tendency to be not restricting, but rather enabling of the technology, as well as the private companies that develop the technology.[114] Even when blockchain technology is identified as a technology for regulatory purposes, different types of regulation will kick in. This is particularly the case with regard to privacy and data protection regulation. This section presents the response of legal orders to the rise of blockchain technology, including the rise of cryptoassets. Overall, a careful observation of the developments discussed in this and the previous section show a clear transition of the approaches by regulators from indifference, to recognition to control to eventually adoption by some of them.

During the first few years of the existence of cryptocurrencies, governments did not pay particular attention to the phenomenon. The lack of regulation or enforcement meant that intermediaries were left to self-regulation through terms of use and policies.[115] The indifference approach played out in very interesting ways when it comes to the relationship between blockchain and data protection laws. The situation in the European Union may be worth expanding on. Data protection has been elevated to the status of a fundamental right in the European Union, as well as elsewhere in the world.[116] Moreover, the CJEU has famously adopted a broad interpretation of data protection.[117] Data protection laws may thus be applicable in the case of blockchain.[118] The General Data

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114. *See also infra* sections III.C.1, III.C.2.

115. Lam Pak Nian & David Lee Kuo Chuen, *A Light Touch of Regulation for Virtual Currencies*, *in* HANDBOOK OF DIGITAL CURRENCY: BITCOIN, INNOVATION, FINANCIAL INSTRUMENTS, AND BIG DATA 309, 315 (David Lee Kuo Chuen ed., 2015).

116. The protection of natural persons in relation to the processing of personal data is inscribed in article 8(1) of the Charter of Fundamental Rights of the European Union, 2000 O.J. (C 364), as well as article 16(1) of the Treaty on the Functioning of the European Union (TFEU), 2013 O.J. (C 326).

117. In the *Breyer* case, the relevant data protection-related legislation has found application in cases of dynamic IP addresses. At the same time, the Court has acknowledged that storage of online data (by the German authorities) might be necessary for protection from cyberattacks. *See* BGH, Oct. 19, 2016, C-582/14, juris (Ger.) http://curia.europa.eu/juris/documents.jsf?num=C-582/14 (last visited Sept. 20, 2020).

118. *See generally* FINCK, *supra* note 1; Michèle Finck, *Blockchains and Data Protection in the European Union*, 4 EUR. DATA PROT. L. REV. 17 (2018); Primavera De Filippi, *The Interplay between Decentralization and Privacy: The Case of Blockchain Technologies*, J. OF PEER PROD., Sept. 2016, http://peerproduction.net/wp-content/uploads/2016/08/blockchain-technologies-draft.pdf

Protection Regulation (GDPR), which has applied in the European Union since May 25, 2018 has a very broad scope of application, and also applies extraterritorially.[119] There is a potential conflict between blockchain technology and the GDPR when it comes to two of blockchain's most important features: the technical rule that information on blockchain is visible to every node;[120] second, the non-removable nature of information on blockchain—a subsequent transaction can always reverse the first transaction, but the first transaction will remain in the chain. These features of the technology may be viewed as violating important principles of the GDPR such as data minimization,[121] the principle of accuracy and the right to rectification,[122] the principle of storage limitation,[123] the right of data subjects to withdraw consent to data processing,[124] and the right of access,[125] as well as last but not least, the right to erasure or "right to be forgotten" of data subjects.[126] The major issue here is whether there is consent by the users for the processing of their data.[127] Moreover, there are no clearly identifiable "data controllers" and "data processors" in the blockchain environment that could be requested to comply with the GDPR.[128]

Despite the development of blockchain technology since 2008, legislators and regulators in the European Union were slow to adapt to the technological advances brought about by blockchain. The general concept of blockchain and DLT is to move beyond the idea of centralized management of ledgers and information. In addition, nodes are decentralized entities that cannot respond to the tasks the GDPR requires of centralized agents. Overall, digital decentralization offers a completely

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[https://perma.cc/J9RS-Q55M].

119. *See* 2016 O.J. (L 119) 32–33 [hereinafter General Data Protection Regulation]. The Member States of the European Union have also developed national data protection laws and have in place independent agencies for the management of data protection laws, such as the Commission nationale de l'informatique et des libertés (CNIL).

120. According to an Opinion of the article 29 Working Party, encrypted data will often qualify as personal data, and not as anonymous data, *see* Article 29 Data Prot. Working Party, Opinion 5/2014 on Anonymization Techniques, at 20, Doc. 0829/14/EN WP216 (2014), the threshold for anonymization under the Regulation is very high and only results "from processing personal data in order to irreversibly prevent identification," *id.*

121. General Data Protection Regulation, *supra* note 119, at 35.

122. *Id.* at 43.

123. *Id.* at 36.

124. *Id.* at 37.

125. *Id.* at 43.

126. *Id.* at 41, 43–44.

127. *See id.* at 34, 36.

128. *See id.* at 33; *see also id.* at 47 (on the definition of "controller" and "processor").

different paradigm of data management, which could promote data protection,[129] and could thus be interpreted to fall outside the scope of the GDPR. This analysis becomes even more pertinent if one considers the extraterritorial application of the GDPR, as well as the adoption of similar legislative approaches to data protection such as the California Consumer Privacy Act.[130]

The phase of indifference gave way in some countries to a phase of recognition. Recognition did not necessarily translate to any distinct regulatory response. In the United States, some agencies opted not to intervene, while other chose to do so. Janet Yellen, the former Chair of the Board of Governors of the U.S. Federal Reserve System, noted at a Senate Banking Committee hearing that "[i]t's important to understand that [the Bitcoin] is a payment innovation that's happening outside the banking industry" and that "[t]he Federal Reserve simply does not have the authority to regulate bitcoin in any way."[131] Other jurisdictions, such as the United Kingdom, have recognized the existence of cryptoassets and blockchain technology in their jurisdictions, but deliberately made a decision not to intervene—at least restrictively—in the development of blockchain and cryptocurrencies.[132]

By contrast, many countries around the world have developed legal frameworks for the regulation of cryptocurrencies. These countries have realized the potentially disruptive nature of cryptocurrencies functioning as currencies and have mainly pursued two approaches in their regulation: command and control, and various intermediate interventions.

China has been the main example of a jurisdiction attempting a major ban on the use of cryptocurrencies. The PBOC issued jointly with four other government agencies the "Notice on Precautions Against the Risks of Bitcoins" disallowing banks and other financial and payment institutions from using and trading in Bitcoin.[133] This is not a direct

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129. Guy Zyskind et al., *Decentralizing Privacy: Using Blockchain to Protect Personal Data*, 2015 IEEE CS SEC. & PRIV. WORKSHOPS 180, 180–84, https://ieeexplore.ieee.org/document/7163223 [https://perma.cc/Y8G2-E56E].

130. *See generally* Lydia F. de la Torre, A Guide to the California Consumer Privacy Act of 2018 (Nov. 2018) (unpublished manuscript) (on file with SSRN), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3275571 [https://perma.cc/NRX9-ZG9B].

131. *See Janet Yellen: Fed Will Steer Clear of Bitcoin*, FORTUNE (Feb. 28, 2014, 2:27 PM), http://fortune.com/2014/02/27/janet-yellen-fed-will-steer-clear-of-bitcoin/ [https://perma.cc/HF4M-62EY].

132. *Cf., e.g.*, 18 Dec. 2013, HL Deb (2013) col. 202 (UK), http://www.publications.parliament.uk/pa/ld201314/ldhansrd/text/131218w0001.htm [https://perma.cc/T52C-Z4KG] (the Commercial Secretary to the Treasury stating that Bitcoin remained unregulated in the UK).

133. People's Bank of China, *supra* note 73.

prohibition of Bitcoin in China as Bitcoin and other cryptocurrencies can still be used. Nevertheless, the Notice restricts most of the money-like functions of Bitcoin since Chinese banks and payment institutions are prohibited from dealing in Bitcoins. Moreover, in 2017, a committee led by the PBOC imposed a ban on ICOs.[134]

Other countries have adopted softer approaches to the regulation of cryptocurrencies. There are three main intermediate responses, all pioneered by U.S. agencies. First, cryptocurrencies have been subjected to related "neighboring" regulatory regimes and disciplines. For example, one of the first measures adopted in the United States with regard to cryptocurrencies was the imposition of an anti-money laundering regime.[135] Likewise, the Securities and Exchange Commission (SEC) has successfully placed cryptocurrencies under its regulatory ambit by imposing sanctions on unauthorized traders operating securities online for cryptocurrencies like Bitcoin and Litecoin.[136] The SEC's Strategic Hub

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134. *See* Kenneth Rapoza, *China's "Bitcoin Ban" No Match for Stateless Cryptocurrency Market*, FORBES (Oct. 18, 2017), https://www.forbes.com/sites/kenrapoza/2017/10/18/chinas-blockchain-bitcoin-ban-no-match-for-stateless-cryptocurrency-market/#2032415e2de6 [https://perma.cc/F5H5-8QG5].

135. In 2013, FinCEN issued a Guidance specifying that "decentralized"—i.e., based on public permissionless blockchains—virtual currencies should comply with money laundering regulations. *See* FINCEN, *supra* note 67. While a user of virtual currency is not a Money Services Business (MSB) under FinCEN's regulations and therefore not subject to MSB registration, reporting, and recordkeeping regulations, an administrator or exchanger of virtual currency is regarded as an MSB and should generally be considered as a "money transmitter." At the same time, an administrator or exchanger is neither a provider or seller of prepaid access nor a dealer in foreign exchange, under the regulations of FinCEN.

136. *See* Press Release, U.S. Sec. & Exch. Comm'n, SEC Sanctions Operator of Bitcoin-Related Stock Exchange for Registration Violations (Dec. 8, 2014), https://www.sec.gov/news/press-release/2014-273 [https://perma.cc/4SEA-YN9V]. According to the SEC, investments in cryptoassets may be considered as securities for the purposes of U.S. securities laws. *See Final Judgment Entered Against Trendon T. Shavers, a/k/a "Piratreat40"—Operator of Bitcoin Ponzi Scheme Ordered to Pay More Than $40 Million in Disgorgement and Penalties*, U.S. SEC. & EXCH. COMM'N (Sept. 22, 2014), https://www.sec.gov/litigation/litreleases/2014/lr23090.htm [https://perma.cc/46EA-NYGB]; *cf. also* Ruoke Yang, *When Is Bitcoin a Security Under U.S. Securities Law?*, 18 J. TECH. L. & POL'Y 99 (2013). In a 2013 judgment, the U.S. District Court followed the interpretation of the SEC. *See* SEC v. Shavers & Bitcoin Sav. & Trust, No. 4:13-CV-416, 2013 WL 4028182 (E.D. Tex. Aug. 6, 2013). The same approach has been adopted by the SEC with regard to ICOs. *See* U.S. SEC. & EXCH. COMM'N, RELEASE NO. 81207, REPORT OF INVESTIGATION PURSUANT TO SECTION 21(A) OF THE SECURITIES EXCHANGE ACT OF 1934: THE DAO (2017); *see also* U.S. SEC. & EXCH. COMM'N, *Investor Bulletin: Initial Coin Offerings*, INVESTOR.GOV (July 25, 2017), https://www.investor.gov/additional-resources/news-alerts/alerts-bulletins/investor-bulletin-initial-coin-offerings [https://perma.cc/723K-FGJ5]. SEC Chairman Jay Clayton has differentiated between the regulation of cryptoassets as a means of exchange, securities, or commodities. *See* Public Statement, Jay Clayton, Chairman U.S. Sec. & Exch. Comm'n, Statement on Cryptocurrencies and Initial Coin Offerings (Dec. 11, 2017), https://www.sec.gov/news/public-statement/statement-clayton-2017-12-11 [https://perma.cc/U5GY-L7LL]. The SEC issued a report in 2017 labeling the

for Innovation and Financial Technology (FinHub) has published a framework for analyzing whether a digital asset is a security.[137] Second, domestic regulators, including the SEC and the European Banking Authority (EBA), have been issuing warnings regarding cryptoassets.[138] Third, many countries have introduced various taxation schemes for cryptocurrencies.[139] For example, the Internal Revenue Service (IRS) issued a Notice clarifying that while virtual currencies are used by consumers in the same way as legal tender, the disposition of Bitcoin is, unlike cash, a taxable transaction to the consumer.[140]

2016 DAO tokens securities under the Howey test, i.e., "a common enterprise with profits derived solely from the efforts of others." SEC v. W. J. Howey Co., 328 U.S. 293 (1946). If the tokens are securities, then the DAO's organizers may be violating U.S. securities laws by conducting a public offering without registering with the SEC or qualifying for an exemption from registration. Because the 2016 DAO was unwound, the SEC did not prosecute the 2016 DAO organizers, but the SEC has engaged in subsequent enforcement actions. *See* Press Release, U.S. Sec. & Exch. Comm'n, SEC Exposes Two Initial Coin Offerings Purportedly Backed by Real Estate and Diamonds (Sept. 29, 2017), https://www.sec.gov/news/press-release/2017-185-0 [https://perma.cc/2RAP-NDDT]; Complaint, SEC v. PlexCorps, No. 1:17-cv-07007-CBA-RML (E.D.N.Y. Dec. 1, 2017), ECF No. 1, https://www.sec.gov/litigation/complaints/2017/comp-pr2017-219.pdf [https://perma.cc/2RAP-NDDT]; Munchee, Inc., Securities Act Release No. 10445, (Dec. 11, 2017), https://www.sec.gov/litigation/admin/2017/33-10445.pdf [https://perma.cc/8S5V-W7LY].

137. *See Framework for "Investment Contract" Analysis of Digital Assets*, U.S. SEC. & EXCH. COMM'N (Apr. 3 2019), https://www.sec.gov/corpfin/framework-investment-contract-analysis-digital-assets [https://perma.cc/4HA3-7BYK]; *see also* Public Statement, Bill Hinman, Dir. of Div. of Corp. Fin., & Valerie Szczepanik, Senior Advisor for Digit. Assets & Innovation, Statement on "Framework for 'Investment Contract' Analysis of Digital Assets" (Apr. 3, 2019), https://www.sec.gov/news/public-statement/statement-framework-investment-contract-analysis-digital-assets [https://perma.cc/PH93-RNCP].

138. The SEC was also among the first to be involved in cryptoasset regulation in the form of warnings, having issued a statement warning investors about the dangers of investing in Bitcoin. *See Investor Alert: Bitcoin and Other Virtual Currency-Related Investments*, U.S. SEC. & EXCH. COMM'N (May 7, 2014), https://www.sec.gov/oiea/investor-alerts-bulletins/investoralertsia_bitcoin.html [https://perma.cc/5W7U-GLH5]. The European Banking Authority (EBA) also issued a warning in 2013 regarding cryptocurrencies raising the issues of monetary loss due to fraud, price instability, theft, and users' inexperience that makes consumers unable to adequately assess the risk of purchasing and using cryptocurrencies. *See EBA Warns Consumers on Virtual Currencies*, EUR. BANKING AUTH. (Dec. 12, 2013), http://www.eba.europa.eu/-/eba-warns-consumers-on-virtual-currencies [https://perma.cc/N28A-YSWZ]. Many agencies in EU Member States have followed the lead of the EBA and have issued similar warnings. *See, e.g.*, *Les dangers liés au développement des monnaies virtuelles: l'exemple du bitcoin*, BANQUE DE FRANCE: FOCUS, Dec. 5, 2013, https://publications.banque-france.fr/les-dangers-lies-au-developpement-des-monnaies-virtuelles-lexemple-du-bitcoin [https://perma.cc/U4F6-3NEQ] (following the lead of the EBA and issuing a circular on the dangers associated with cryptocurrencies).

139. *See generally* Omri Marian, *Are Cryptocurrencies Super Tax Havens?*, 112 MICH. L. REV. FIRST IMPRESSIONS 38 (2013).

140. I.R.S. Notice 2014-21, I.R.B. 2014-16 (2014). According to the IRS Notice, cryptocurrency is "property" in the hands of a taxpayer, which means that its disposition is a taxable event to the extent that the cryptocurrency's value has changed since its acquisition by the taxpayer. *See id.* at 2. As no traditional intermediaries are involved in the transactions, the collection of such tax will only

In a very interesting move, the New York State Department of Financial Services has imposed separate licensing requirements on intermediary service providers of cryptocurrencies. The BitLicense framework creates a very comprehensive licensing regime for a very wide range of virtual currency intermediaries, including exchanges, wallets, dealers and administrators.[141] The new rules require registration and licensing for certain cryptocurrency service providers. In the United States, the Uniform Law Commission developed a model law called "Regulation of Virtual Currency Business Act" for the regulation of virtual currencies, which is to some extent similar to the one that has already been adopted in New York.[142]

Other countries have focused on the benefits of blockchain technology in developing new cryptoasset applications and have adopted more favorable approaches to cryptocurrencies. The government may enable the adoption of cryptoassets and other blockchain applications in the private sector,[143] or even adopt blockchain for the provision of government services. Increasingly, countries around the world have started adopting policies directed towards the promotion of FinTech startups, prominently also including startups working towards the development of blockchain technology and cryptocurrencies. FinTech promotion policies involve predominantly two regulatory measures: launching innovation hubs to help FinTech startups comply with the relevant laws and regulations, and establishing regulatory sandboxes for new financial service participants,[144] including the lowering of licensing barriers—reaching sometimes all the way to FinTech licensing

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be possible if the taxpayers voluntarily report transactions. *See IRS Reminds Taxpayers to Report Virtual Currency Transactions*, U.S. INTERNAL REVENUE SERV. (Mar. 23, 2018), https://www.irs.gov/newsroom/irs-reminds-taxpayers-to-report-virtual-currency-transactions [https://perma.cc/7UYN-TT7E]. The IRS has reached a very high level of sophistication regarding taxing cryptoassets. In 2019, it issued guidance on issues of income tax in case of hard forks and airdrops. *See* Rev. Rul. 2019-24, 2019-14 I.R.B. 932.

141. N.Y. COMP. CODES R. & REGS. tit. 23, § 200 (2020).

142. UNIFORM REGULATION OF VIRTUAL-CURRENCY BUSINESSES ACT (NAT'L CONF. OF COMM'RS ON UNIF. STATE L. 2017), https://www.uniformlaws.org/HigherLogic/System/DownloadDocumentFile.ashx?DocumentFileKey=ef45a10b-ac62-ad3d-2f42-588d7eac3e40 [https://perma.cc/UTZ8-CQB2]; *see also* TIMOTHY G. MASSAD, ECON. STUD. AT BROOKINGS, IT'S TIME TO STRENGTHEN THE REGULATION OF CRYPTO-ASSETS 36 (2019), https://www.brookings.edu/wp-content/uploads/2019/03/Timothy-Massad-Its-Time-to-Strengthen-the-Regulation-of-Crypto-Assets.pdf [https://perma.cc/L8XP-VFCU].

143. *See* REGULATING BLOCKCHAIN, *supra* note 12.

144. *See generally* Herbert Smith Freehills, *Overview of Regulatory Sandbox Regimes in Australia, Hong Kong, Malaysia, Singapore, and the UK*, OXFORD BUS. L. BLOG (Dec. 18, 2016), https://www.law.ox.ac.uk/business-law-blog/blog/2016/12/overview-regulatory-sandbox-regimes-australia-hong-kong-malaysia [https://perma.cc/UEH7-8RWR].

exemptions.

Additionally, and as discussed in the previous section, governments have been utilizing blockchain, including at the state level in the United States. Arizona has passed a variety of measures along these lines, making signatures, records, and contracts secured through blockchain technology legally valid: "[a] contract relating to a transaction may not be denied legal effect, validity or enforceability solely because that contract contains a smart contract term."[145] Another Arizona law forbids any county from prohibiting individuals from "running a node on blockchain technology in a residence."[146] It is also unlawful to require people to use or be subject to electronic firearm tracking technology including distributed ledger or blockchain technology.[147]

Other U.S. states are following similar policies. In Washington State a law has been adopted to support digital signature verification with the use of distributed ledger technology.[148] The State of New York has established a taskforce with the aim of studying the potential assignment of economic empowerment zones for the mining of cryptocurrencies.[149] A draft bill has been proposed in the State of Hawaii proposing to make it legal for banks in Hawaii to store digital assets, a class that includes "virtual currencies," "digital securities," and "open blockchain tokens."[150] Cook County, Illinois, is trying to move towards a blockchain-based system for the transfer of real property.[151] Delaware is in the process of allowing corporations to issue shares on blockchain.[152]

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145. ARIZ. REV. STAT. ANN. § 44-7061 (2020); H.B. 2417, 53d Leg., 1st Reg. Sess. (Ariz. 2017).

146. ARIZ. REV. STAT. ANN. § 11-269.22 (2020).

147. ARIZ. REV. STAT. ANN. § 13-3122 (2020); H.B. 2216, 53d Leg., 1st Reg. Sess. (Ariz. 2017).

148. Substitute S.B. 5638, 66th Leg., 2019 Reg. Sess. (Wash. 2019). Recognizing the validity of distributed ledger technology Washington State has also taken a series of actions in the direction of recognizing cryptocurrencies. *See Bitcoin and Virtual Currency Regulation*, WASH. STATE DEP'T OF FIN. INSTS., https://dfi.wa.gov/bitcoin [https://perma.cc/NK8Y-NJMX].

149. Assemb. Bill A09862, 2018 Reg. Sess. (N.Y. 2018).

150. *See* Nick Chong, *Hawaiian Banks May Soon Dabble in Crypto: Lawmakers File Friendly Bill*, BLOCKONOMI (Jan. 27, 2020), https://blockonomi.com/hawaiian-banks-dabble-in-crypto/ [https://perma.cc/8LHP-9GNL].

151. JOHN MIRKOVIC, BLOCKCHAIN PILOT PROGRAM: FINAL REPORT (2017), http://cookrecorder.com/wp-content/uploads/2016/11/Final-Report-CCRD-Blockchain-Pilot-Program-for-web.pdf [https://perma.cc/3957-RPYP].

152. Pete Rizzo, *Delaware Governor Signs Blockchain Bill into Law*, COINDESK (July 24, 2017), https://www.coindesk.com/delaware-governor-signs-blockchain-legislation-law [https://perma.cc/9Y6Q-K5BH].

II. BLOCKCHAIN AS INFRASTRUCTURE

What we might call the "*lex cryptographia*" of blockchain uniquely combines two of Lessig's regulatory modalities of individual behavior: the market and code. This combination is very powerful, since it makes the application of some intrinsic market principles and values automatic (codified) among regulatees.[153] Moreover, it makes them global, as blockchain is by nature a transnational technology.

The first section of this Part explains the background understanding of blockchain technology: that it is powered by rational choice economics. The argument then proceeds to discuss the extent to which blockchain delivers on its promise to create a world without borders. The final section of this Part moves on to explain that blockchain technology is even more than a rational choice-backed mechanism. It is an infrastructure for the operation of multiple activities from information storage to trade to finance on a global scale. The identification of blockchain as an infrastructure has certain legal consequences that are further identified.

A. (Global) Law and Cryptoeconomics

1. From Cryptoeconomics to Law and Cryptoeconomics

Blockchain is, according to some commentators, even more than a technological development: it is a social technology for coordination of individuals.[154] In order to address coordination issues within the blockchain environment, developers have turned to economic theory. Applications of microeconomic theory to blockchain are still in their early stages but are already existent in the various governance protocols of blockchains.[155]

A new field of cryptoeconomics is developing and can be defined in several ways. One way to understand cryptoeconomics is as the economics of cryptoassets—namely, how they are spent and the economies surrounding them. Alternatively, while the term cryptoeconomics is usually reserved for the structure of the incentives

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153. *See generally* Lawrence Lessig, *The Law of the Horse: What Cyberlaw Might Teach*, 113 HARV. L. REV. 501, 511 (1999) (on the interplay of Lessig's modes of regulation); *see also* Paolo Tasca & Riccardo Piselli, *The Blockchain Paradox*, *in* REGULATING BLOCKCHAIN: TECHNO-SOCIAL AND LEGAL CHALLENGES 27 (Philipp Hacker et al. eds., 2019) (applying Lessig's analysis to the blockchain).

154. Davidson et al., Economics of Blockchain, *supra* note 28.

155. Marc Pilkington, *Blockchain Technology: Principles and Applications*, *in* RESEARCH HANDBOOK ON DIGITAL TRANSFORMATIONS 225 (F. Xavier Olleros & Majlinda Zhegu eds., 2016).

within the cryptoenvironment, Vlad Zamfir proposes a new discipline of "cryptoeconomics" as the economics of cryptography.[156] According to his definition, "cryptoeconomics is a formal discipline that studies protocols that govern the production, distribution and consumption of goods and services in a decentralized digital economy" and "a practical science that focuses on the design and characterization of these protocols."[157]

According to Ethereum's co-founder Vitalik Buterin, the notion "cryptoeconomic" refers to any decentralized cryptographic protocol "that uses economic incentives to ensure that it keeps going and doesn't go back in time or incur any other glitch."[158] Proof-of-Work and Proof-of-Stake mining protocols are cryptoeconomic for these purposes. Babbitt and Dietz use a broader definition of cryptoeconomy as an economy which is unconstrained by geography and mainstream institutions—political and legal—where blockchains, instead of trusted third parties, regulate behavior regarding transactions recorded on the ledger.[159] Sinclair Davidson, Primavera De Filippi and Jason Potts discuss innovation- and governance-centered approaches to cryptoeconomics and eventually opt for a governance-centered approach that is informed by institutional economics and public choice theory.[160]

Regardless of how one defines it, cryptoeconomics starts from the given that the *lex cryptographia* operates without control by a central state authority. The basic question is thus how to structure behavioral rules in an environment where hierarchy and an enforcement apparatus are absent. The absence of hierarchy and enforcement structures, which are essential features of legal orders, is a unique aspect of the cryptoenvironment, though it is not entirely novel. Arguably, international law operates in the absence of hierarchy and enforcement mechanisms. The cryptoworld is still different from the world of international law, however, as the horizontal co-existence of sovereigns in international law makes up to some extent for the absence of hierarchy. The lack of enforcement mechanisms has been remedied through the development of international courts, tribunals, and other compliance mechanisms, and international

156. Vlad Zamfir, *What Is Cryptoeconomics?*, YOUTUBE (Feb. 1, 2015), www.youtube.com/watch?v=9lw3s7iGUXQ [https://perma.cc/633V-ZJ2U].

157. *See* Alex Lielacher, *An Introduction to Cryptoeconomics*, BTCMANAGER (June 14, 2017), https://btcmanager.com/an-introduction-to-cryptoeconomics/ [https://perma.cc/3ZMK-KH5S].

158. Vitalik Buterin, *Visions, Part I: The Value of Blockchain Technology*, ETHEREUM BLOG (Apr. 13, 2015), https://blog.ethereum.org/2015/04/13/visions-part-1-the-value-of-blockchain-technology/ [https://perma.cc/JV8Y-28MB].

159. Dave Babbitt & Joel Dietz, Crypto-economic Design: A Proposed Agent-Based Modelling Effort, Presentation at SwarmFest 2014 18th Annual Meeting on Agent-Based Modeling & Simulation (June 29–July 1, 2014).

160. Davidson et al., Economics of Blockchain, *supra* note 28 at 7 *passim*.

reputation may be viewed as operating as a functional equivalent of sanctions.

The cryptoworld, however, does not share these features: it is composed of individuals that are unknown to each other, the only visible sign to other members of a peer-to-peer network being public keys. In order to make collaboration possible in this environment, given that public trust is absent, blockchain designers have utilized the conception of human agency developed in rational choice theory. The mutual interplay between law and code generates coordination rules in the crypto environment that are rule-like or quasi-legal; this *lex cryptographia* has been largely informed by a cryptoeconomics approach, generating what we may call a "law and cryptoeconomics" of blockchain.

Cryptoeconomics combines economic theory with cryptography to create protocols for decentralized platforms, in an environment where there is no trust—at least in the traditional sense—among the actors. Cryptoeconomics provides the means to get blockchain participants—developers, miners, nodes and users—to act in ways that would reduce the likelihood of behaviors harming the individual welfare of blockchain participants as well as social welfare in the cryptosociety. As De Filippi and Wright summarize: "every interaction with a blockchain is ultimately an economic transaction, and every party participating in the network serves as an economic actor."[161]

The concept of value provides a basis for all of economic theory. A market is a social system that operates through the price mechanism. Commodities acquire value through the interplay of supply and demand. Cryptoeconomics is based on a related theory of value. The commodity on blockchain is the token, a pure representation of exchange value in the cryptoeconomy. Tokens can be exchanged within the decentralized network of peers for a variety of goods and services. Token economies can either operate isolated on blockchain ("on-chain") or in interaction with the physical world ("off-chain").

From the beginning, the idea behind the creation of Bitcoin was essentially economic: it aimed to reduce transaction costs for financial transactions by transcending the physical and political dimensions of existing currencies.[162] Currency and monetary units have traditionally been physical units. The British "pound," the Spanish "peso," and the Israeli "shekel" derive from units of weight.[163] Other currencies are

161. DE FILIPPI & WRIGHT, *supra* note 13, at 185.

162. Transaction costs and externalities are the centerpiece of modern law and economics. *See* R. H. Coase, *The Problem of Social Cost*, 3 J.L. & ECON. 1, 1–2 (1960).

163. ALEC ROSS, THE INDUSTRIES OF THE FUTURE 76 (2016).

indicative of the material they are made of; for example, the "rupee" used in India and countries influenced by the Indian system, such as Mauritius, comes from a Sanskrit word for silver. In the twentieth century, "[m]oney moved from being the physical representation of a valuable commodity to an intangible symbol of trust."[164] This is what became known as "fiat money."[165] Digitization of money as figures in accounts that are expended with the use of credit cards followed towards the end of the century. Still, the term "plastic money" symbolizes the centuries-old understanding of basing money on a physical instrumentality. Cryptocurrencies are different.

Cryptocurrencies are fully built on codes rather than tangible materials. But even more important, cryptocurrencies are not controlled by a central authority. They are based on a system of production and management that is fundamentally decentralized. There is no issuing body per se and no governing authority in charge. Code regulates issuance, and management is achieved through the network of peers making up the network of the relevant cryptoasset. In a similar way, smart contracts and DAOs decentralize transactions of all cryptoassets without the need for physical and traditional intermediaries.

The immaterial and decentralized nature of cryptoassets makes them fundamentally global. Cryptoassets such as cryptocurrencies are actually designed for a transnational use via the Internet,[166] without being confined by state regulations or borders.[167] These attributes of cryptoassets bear important advantages for the payer. Cryptocurrency holders have to engage in fewer transactions than the traditional currency holder in order to conduct commerce in jurisdictions outside their own.[168] Moreover, there are no foreign exchange costs when using virtual currencies as opposed to national currencies that need to be converted.[169] This makes cryptocurrencies a very useful and efficient tool for cross-border payments and other money transfers.[170] The only incurred costs are the ones to convert the cryptocurrency into a national currency if the receiver

164. NIVEN ET AL., *supra* note 60, at 4.

165. *See* Stefan Eich, *Old Utopias, New Tax Havens: The Politics of Bitcoin in Historical Perspective*, *in* REGULATING BLOCKCHAIN: TECHNO-SOCIAL AND LEGAL CHALLENGES 85, 96 (Phillip Hacker et al. eds., 2019) (discussing the development of money and bitcoin in historical perspective).

166. Nicholas A. Plassaras, *Regulating Digital Currencies: Bringing Bitcoin Within the Reach of the IMF*, 14 CHI. J. INT'L L. 377, 388 (2013).

167. *Id.* at 405.

168. EUR. CENT. BANK, *supra* note 58, at 19.

169. *Id.*

170. Plassaras, *supra* note 166, at 388.

does not wish to keep the virtual currency for future usage.[171] Payees enjoy the same advantages, since cryptocurrencies have a global reach which allows products to be sold to consumers located anywhere in the world;[172] "In this sense, digital currencies are 'universal' in that they can operate *outside* a system that uses multiple currencies, thereby avoiding the transaction costs associated with currency exchange."[173] The same applies to all cryptotokens.

Blockchain technology can reduce transaction costs by reducing the role of intermediaries. While it is true that costs of transactions are reduced, not necessarily all transaction costs are: there are, of course, potentially high transaction costs for new users wishing to participate in the blockchain-backed network. Networks may not be hierarchical, but that does not mean they are without costs to entry and participation.[174]

2. Economic Incentives in the Blockchain Cryptographic Environment

Cryptoeconomics is based on two main building blocks: cryptography and economic incentives to keep the network secure and incentivize participation. The main cryptographic tools used in blockchain technology are hash functions and digital signatures. Cryptography allows for the transfer of information and value in ways that pseudonymize users and transactions. The decentralized nature of the network creates the need for mechanisms of coordination beyond hierarchy. Network participants need to reach a consensus about the state of the network and the blocks and accompanying transactions that are to be included in a blockchain. This is achieved through consensus mechanisms (based on cryptographic techniques) such as PoW and PoS.

It is in the design of these protocols that blockchain designers have relied on insights from rational choice theory, with the purpose of steering the behavior of blockchain participants towards maximizing social welfare in the system by adding value to the network. These incentives come in the form of block rewards and transaction fees for transactions that are included in blocks.[175] For example, PoW is the most commonly

171. *Id.*

172. *Id.*

173. *Id.* at 388–89 (emphasis in original).

174. DAVID SINGH GREWAL, NETWORK POWER: THE SOCIAL DYNAMICS OF GLOBALIZATION (2008).

175. *See* Raphael Auer, *Beyond the Doomsday Economics of "Proof-of-Work" in Cryptocurrencies* (Bank for Int'l Settlements (BIS), Working Paper No. 756, 2019) https://www.bis.org/publ/work765.pdf [https://perma.cc/4T63-E3SQ].

used algorithm and is used by Bitcoin. Miners have to "prove" their work to propose a new block, which means devoting great amounts of computational power to solve algorithmic hash puzzles that are based on the properties of hash functions.[176] Computing power can be translated into energy consumption for energy-intensive use of computers, which can be further translated into real-world money to buy computing power. These resources become sunk costs if their blocks are not included in the blockchain. Incentives and disincentives of this sort have led to the professionalization of mining, and the de facto exclusion of many home-based miners that do not have adequate computing power to compete in the system.

In essence, blockchain creates economic value out of the bits and bytes of information stored in computers and on the Internet by means of behavioral incentivization on the blockchain network. The first incentive to be part of and operate in the network are so called "block rewards."[177] Nodes that create new blocks for inclusion in a blockchain are rewarded for their work by being allowed to include a special transaction—the coinbase transaction, which allows the same node to send a block reward to their own address. The block reward decreases at a set rate.[178] The reward will only actually be received if the new block is accepted by the rest of the network participants. The other nodes express their acceptance by including the hash of the new block in the next block that is created. This includes a further incentive for mining nodes to only include blocks with valid transactions. Beyond block rewards, mining nodes also receive transaction fees for each transaction that is included in the blocks. This is a further incentive to mine for the system. Almost all cryptocurrencies today require their users to attach fees to their transactions. The miners then add transactions paying the highest fees into the blockchain and derive income. This has been termed the "fee market."[179]

The second most popular consensus mechanism is PoS, which weighs

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176. ARVIND NARAYANAN ET AL., BITCOIN AND CRYPTOCURRENCY TECHNOLOGIES: A COMPREHENSIVE INTRODUCTION 64–67 (2016).

177. *See* Caner Taçoğlu, *Block Reward*, BINANCE ACAD. (2017–2020), https://academy.binance.com/glossary/block-reward [https://perma.cc/VK63-YSKL].

178. This raises issues of inflation and deflation as well as other systemic issues that are beyond the scope of this paper. *See, e.g.*, Auer, *supra* note 175, at 4 (showing that once block rewards are near zero, it could take months before a Bitcoin payment is final unless new technologies are put to use to expedite them).

179. *See generally* Soumya Basu et al., Towards a Functional Fee Market for Cryptocurrencies (Jan. 30, 2019) (unpublished manuscript) (on file with SSRN), https://ssrn.com/abstract=3318327 [https://perma.cc/D8PN-XVQB] (discussing the concept of a cryptocurrency "fee market").

each validator's vote depending on the size of their staked deposit.[180] This consensus mechanism works by having a set of validators take turns proposing and voting on every next block. They lose their stake if the block is not included in the blockchain, which operates as an incentive to vote on blocks that include only valid transactions. In the PoS environment, there are thus also incentives in some blockchain networks for good blockchain citizenship and participation in the governance scheme of the relevant blockchain. Users on the Tezos blockchain, for example, are incentivized to be involved in the internal governance process as developers by being rewarded with tokens.[181] Ethereum has plans to switch to using PoS from PoW.[182]

B. A Spaceless World?

Blockchain is a machine that has the capacity to allow for the application of the rational choice paradigm in a semi-automatic way on a global scale. But what are the consequences of applying cryptoeconomics in a world without borders? It is now a familiar insight of behavioral law and economics that the rational choice paradigm fails to capture accurately many features of human agency. What are the policy implications of this new technology embedding these assumptions in a framework of transaction—and then globalizing it?

This section discusses the potential consequences of applying cryptoeconomics in a "spaceless world." Modernity has been identified as the era of anxiety for space.[183] Blockchain promises a new era of a

180. For PoS purposes, miners are usually referred to as "validators" (or sometimes "forgers"), and the generation of blocks as "minting." *See* Felix Kuestahler, *Polkadot Hello World #5: Minting, Bonding, Staking, Slashing*, MEDIUM (Nov. 21, 2018), https://medium.com/coinmonks/hello-polkadot-5-minting-bonding-staking-slashing-3c1a33c5a005 [https://perma.cc/Q68P-C8UR].

181. *See infra* section III.B; *The Voting Process*, *infra* note 295 and accompanying text.

182. *See Eth 2.0 Economics*, ETHHUB, https://docs.ethhub.io/ethereum-roadmap/ethereum-2.0/eth-2.0-economics/ [https://perma.cc/JPX3-WB42].

183. *See* Michel Foucault, *Of Other Spaces*, 16 DIACRITICS 22–23 (1986). There is a special position in modern societies for land and land-based law. Initially, nearly all land was owned by the government. Property in land is referred to as *real* property or *real* estate. *See* Massimo Meccarelli & María Julia Solla Sastre, *Spatial and Temporal Dimensions for Legal History: An Introduction*, *in* 6 SPATIAL AND TEMPORAL DIMENSIONS FOR LEGAL HISTORY: RESEARCH EXPERIENCES AND ITINERARIES 3, 15 (Massimo Meccarelli & María Julia Solla Sastre eds., 2016) (using the notion of "spatialization"); *id.* ("[B]y using this term we are underscoring the permanent tendency of law (understood in a broad sense) to take up a position in space, and to adhere to space. We wish thereby to highlight a process that has a bearing on the contents and configurations assumed in the legal dimension, a process that coexists with the moment of its manifestation."); *see also* Massimo Meccarelli, *The Assumed Space: Pre-reflective Spatiality and Doctrinal Configurations in Juridical Experience*, 23 RECHTSGESCHICHTE 241 (2015). The sale of land, for example, is more complicated and lengthier than the sale of a chattel and there are land registries and records in all countries—in

"spaceless society," whereby the digitization of transaction leads to the diminishing importance of the individual, and accordingly the law in society. This section questions the capacity of blockchain to achieve a spaceless society. It then moves on to discuss the potential consequences of developing a "spaceless economy" with the use of blockchain. Post-war neoliberal economists have already tried to advance the notion of an economy of zero transaction costs. By contextualizing law and cryptoeconomics with these efforts, this section lays the groundwork for a new law and political economy framework that is developed in Part III.

1. A Spaceless Society?

It is said that the world has already entered the Fourth Industrial Revolution.[184] The First Industrial Revolution was that of industrialization, and it was characterized by factorization—the factories and the machines that ran them.[185] Thus, it had a distinct spatial and infrastructural nature. In a historically unprecedented urbanization spree, people moved from rural places to booming cities, and new spaces were created.[186] The law had to react to the coming of the First Industrial Revolution, as it fundamentally changed to regulate the new spaces and the position of the individual in them.

The machine is coming back again, raising multiple societal and legal questions. The new coming of the machine is being shaped to a large extent by blockchain technology and is associated with a move from muscle power to knowledge-based work.[187] While during industrialization the machine replaced manual work and physical labor, new technologies such as AI, machine learning, and blockchain are and will be replacing knowledge-based work. The Fourth Industrial Revolution poses accordingly different challenges to law, regulation, and society at large.

Blockchain assumes that individuals are rational, as well as that all transactions can take place in an autonomous way.[188] Blockchain may even be something beyond that. It is a technology built to bypass borders

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fact usually, a central registry. This anxiety concerning land and space is now taking new dimensions—as an anxiety for infrastructure.

184. Klaus Schwab, *The Fourth Industrial Revolution: What It Means and How to Respond*, FOREIGN AFFS. (Dec. 12, 2015), https://www.foreignaffairs.com/articles/2015-12-12/fourth-industrial-revolution [https://perma.cc/3N3F-GF85].

185. *See generally* POLANYI, *supra* note 35, at 42, 78.

186. *See id.* at 96–97, 103.

187. *See* Schwab, *supra* note 184.

188. This is despite the fact that the technology was developed by individuals trying to move away from the mainstream, such as "techno-libertarians." *See infra* section III.C.1.

and space. It is argued that "[t]he notion of a '[magic] world computer' speaks to the idea that any application that runs on such a platform will be global in reach (without national or geopolitical boundaries) and extend without bound into the future."[189]

In a move away from the horizon of the present, blockchain technology is promising a new world. Blockchain promises the elimination, or rather the minimization, of the role of the individual as well as of space in society. This may potentially lead to the diminishing importance of the law—at least in its traditional form—in the future.[190] Almost all law is about the regulation of individual behavior and the space in which individuals live, work, and operate—but blockchain is founded on an anonymous network: a new social ontology.

The great aspiration of blockchain technology has been the elimination of financial intermediaries.[191] The removal of the human or institutional third party is a "core value proposition" of blockchain.[192] "Disintermediation is the technology's related promise. As a consequence of their very structure, blockchains are widely considered to decentralize and disintermediate economic relations."[193] When value is transferred through blockchain networks, the traditional human-based intermediaries responsible for verifying and validating transactions could become obsolete.[194] Disintermediation has the following double effect: first, it is an effort to de-personalize transactions. This is reflected in the idea of pseudonomity on blockchain.[195] A second major goal of blockchain technology has been to de-spatialize transactions. There should be no need for banks and other financial institutions so long as the network of peers can operate online.

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189. Davidson et al., Economics of Blockchain, *supra* note 28, at 6.

190. On the relationship between the State as space and law in modernity, see Meccarelli & Sastre, *supra* note 183, at 3, 9.

191. Brito, Shadab & Castillo, *supra* note 13, at 216–18.

192. FINCK, *supra* note 1, at 12.

193. *Id.* at 18.

194. Melanie Swan & Primavera de Filippi, *Toward a Philosophy of Blockchain: A Symposium: Introduction*, 48 METAPHILOSOPHY 603, 605 (2017).

195. Despite the usual misperception that the blockchain anonymizes transactions, it does not. It only achieves pseudonomity of transactions, with the potential of the identification of the persons behind the transactions. In the Bitcoin blockchain, for example, Bitcoin users usually rely on intermediaries to purchase Bitcoins; these intermediaries often require identifying information to open an account. Authorities and/or hackers can potentially use this personal data to de-anonymize the user. *See* Malte Möser, *Anonymity of Bitcoin Transactions: An Analysis of Mixing Services*, MUNSTER BITCOIN CONF., July 17–18, 2013, https://pdfs.semanticscholar.org/e1ae/d9296c3af9139f48d15e043e2e8beab55409.pdf [https://perma.cc/B7YR-8EFY].

Both claims are limited in their accuracy, however.[196] First, the development of blockchain technology has in fact led to the development of new intermediaries to replace banks and other traditional financial institutions. New intermediaries have arisen in the cryptoasset and blockchain environment. The cryptocurrency market has developed, and most people will still rely on intermediaries when using cryptocurrencies:[197] trading platforms and exchanges of cryptocurrencies to fiat currencies, digital wallet service providers, payment systems and pricing indices, and other clearinghouses for cryptocurrency transactions.[198] New types of intermediaries are also being developed. In order to preserve the anonymity of users, for example, new intermediary services have been created that allow users to mix their coins, swap them and change them from one address to another.[199] This achieves some further anonymity but adds one more intermediary between the user and the token. Intermediary intervention can only be expected to increase as the proportion of cryptocurrencies and other cryptoassets in the global economy increases. The Bitcoin model of production of new currency, for example, presents an effort to replicate scarcity in the market. Late adopters and other interested individuals that have no capabilities in coding will not be able to produce new coins through mining; the Bitcoin economy will thus rely mostly on users buying Bitcoins with fiat currency through exchanges, namely through the intervention of intermediaries.[200] Finally, existing payment system intermediaries like PayPal have included Bitcoin and other cryptocurrencies in their services.[201]

In addition, blockchain has very obvious physical, personal, and spatial representations which are showcased in the next section. At the same time,

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196. *Cf. also* Kelvin F. K. Low & Eliza Mik, *Pause the Blockchain Legal Revolution*, 69 INT'L & COMPAR. L.Q. 135–37 (2020) (discussing misunderstandings about the promises of the technology).

197. *See also id.* at 160–63.

198. *See* Tyler Moore & Nicolas Christin, *Beware of the Middleman: Empirical Analysis of Bitcoin-Exchange Risk*, *in* FINANCIAL CRYPTOGRAPHY AND DATA SECURITY: 17TH INTERNATIONAL CONFERENCE 25, 26 (Ahmad-Reza Sadeghi ed., 2013); *see also* Dorit Ron & Adi Shamir, Quantitative Analysis of the Full Bitcoin Transaction Graph (Oct. 15, 2012) (unpublished manuscript) (on file with Cryptology ePrint Archive), http://eprint.iacr.org/2012/584 [https://perma.cc/3F7Z-JRY3] (regarding transactions on Mt. Gox).

199. Cryptocurrency "tumblers" or "mixers" offer services that obscure the origin of cryptocurrencies. *See What Are Bitcoin Mixers?*, BITCOIN MAG., https://bitcoinmagazine.com/guides/what-are-bitcoin-mixers [https://perma.cc/K8L3-5N2S].

200. Guadamuz & Marsden, *supra* note 13; Moore & Christin, *supra* note 198, at 25–33.

201. *See* Ryan Mac, *PayPal Takes Baby Step Toward Bitcoin, Partners with Cryptocurrency Processors*, FORBES (Sept. 23, 2014), https://www.forbes.com/sites/ryanmac/2014/09/23/paypal-takes-small-step-toward-bitcoin-partners-with-cryptocurrency-processors/ [https://perma.cc/9PP4-BU59].

there is a new trend which is in direct confrontation with the initial promise of the new technologies, and more specifically blockchain technology: the importance of physical infrastructure is generally rising. There is an expanding practice to develop physical infrastructure within national borders, but also very importantly across national borders. There is an accompanying global trend in various countries to develop legal frameworks regarding infrastructure. These legislative instruments take two forms: screening mechanisms for foreign investors based on national security grounds[202] and legislation identifying a separate category of "critical infrastructure."[203]

Contemporary (public) law showcases two opposing trends: disintermediation versus infrastructure growth, development, and regulation. The next sections discuss the first trend in the context of previous efforts to interpret the global economy as a spaceless institution; other sections of the Article discuss the trends that contradict the developments in the sphere of blockchain technology: the trend of the rise of physical infrastructure in contemporary legal orders.

2. A Spaceless Economy?

Blockchain is a novel social and economic construct that uses principles of rational choice economics on a global scale. It promises a global spaceless economy, allowing capital to flow freely across borders[204] and facilitating the circulation of products, services, and

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202. Defense Production Act, Pub. L. No. 774, § 721 (1950), *amended by* Foreign Investment and National Security Act (FINSA), Pub. L. No. 110-49, 121 Stat. 246 (2007).

203. This is also reflected in statutes on the protection of critical infrastructure and critical technologies that various countries have developed alongside investment screening laws. *See* Press Release, Off. of the Press Sec'y, Presidential Policy Directive—Critical Infrastructure Security and Resilience (Feb. 12, 2013), https://obamawhitehouse.archives.gov/the-press-office/2013/02/12/presidential-policy-directive-critical-infrastructure-security-and-resil [https://perma.cc/ULH7-ELCM]. Since 9/11 there has been an increased awareness in the United States regarding a separate protected category of "critical infrastructure." *See id.* "The term 'critical infrastructure' has the meaning provided in section 1016(e) of the USA Patriot Act of 2001 (42 U.S.C. 5195c(e)), namely systems and assets, whether physical or virtual, so vital to the United States that the incapacity or destruction of such systems and assets would have a debilitating impact on security, national economic security, national public health or safety, or any combination of those matters." *Id.* This Presidential Policy Directive identifies 16 critical infrastructure sectors: Chemical; Commercial Facilities; Communications; Critical Manufacturing; Dams; Defense Industrial Base; Emergency Services; Energy; Financial Services; Food and Agriculture; Government Facilities; Healthcare and Public Health; Information Technology; Nuclear Reactors, Materials, and Waste; Transportation Systems; and Water and Wastewater Systems. *Id.*

204. This is something that is not necessarily endorsed by classical political economy. According to the founding father of comparative advantage theory, David Ricardo, capital does not and should not move freely across borders. This was not only an observation of the time, but also a normative

international trade more broadly. This is reminiscent of similar efforts in the past to develop a global "spaceless economy."

Since at least the 1820s, economic liberalism has maintained three classical tenets: a free labor market, the (international) gold standard, and free trade.[205] Free flow of capital was achieved in the nineteenth and twentieth centuries using the system of the international gold standard. The gold standard is a monetary system in which participating countries committed to fix their national currencies to a specified quantity of gold, which makes the creation of money depend on the naturally existing supplies of a scarce metal.[206] According to the theory, because the currency of each nation was backed by gold, a deficit in the balance of payments of a country would lead to gold flowing out of the country, causing a contraction in the money supply, an equivalent rise in interest rates, a fall in prices and wages, and thus a rise in exports. This system of free flow of money collapsed twice in the twentieth century.

There were later efforts to develop a new political economy for a globalized world mostly by neoliberal economists.[207] Austrian economist Gottfried von Haberler, for example, developed an economic theory of a "spaceless world," in which he equated tariffs, distances, and the actions of organized labor as obstacles comparable to the optimal distribution of natural resources in the world.[208] His image was that of a "spaceless closed economy embracing the whole world."[209] The ideal policy according to Haberler would make reality more closely resemble the model of a spaceless world economy; in this spaceless world neither man-made nor geographical obstacles hindered the most efficient allocation of resources

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underpinning of the theory; according to David Ricardo, "[e]xperience, however, shows, that the fancied or real insecurity of capital, when not under the immediate control of its owner, together with the natural disinclination which every man has to quit the country of his birth and connections, and intrust himself with all his habits fixed, to a strange government and new laws, checks the emigration of capital. These feelings, which I should be sorry to see weakened, induce most men of property to be satisfied with a low rate of profits in their own country, rather than seek a more advantageous employment for their wealth in foreign nations." DAVID RICARDO, ON THE PRINCIPLES OF POLITICAL ECONOMY AND TAXATION 128–29 (3d ed. 1817).

205. POLANYI, *supra* note 34, at 141.

206. *See* Michael D. Bordo, *Gold Standard*, ECONLIB, http://www.econlib.org/library/Enc/GoldStandard.html [https://perma.cc/S4WH-27WV].

207. *See generally* QUINN SLOBODIAN, GLOBALISTS: THE END OF EMPIRE AND THE BIRTH OF NEOLIBERALISM (2018) (on the global dimensions of neoliberalism). *See also* David Singh Grewal & Jedediah Purdy, *Introduction: Law and Neoliberalism*, 77 LAW & CONTEMP. PROBS. 1, 2–3 (2014) (on the definition of neoliberalism).

208. GOTTFRIED HABERLER, PROSPERITY AND DEPRESSION: A THEORETICAL ANALYSIS OF CYCLICAL MOVEMENTS 303 (1937).

209. *Id.*

through the mechanisms of the free market. In the world of hypothetical unity of Haberler, there were some obstacles that needed to be overcome. Haberler equated tariffs with communication, transportation, as well as physical and geographical barriers.[210] The target was to tame the rising tariffs that governments imposed to fence their economies from the outside world.[211]

This imagery of a spaceless economy and a world of zero transaction costs is the world that is promised and promoted by blockchain. Cryptocurrencies could potentially operate as a more efficient alternative to the gold standard because they minimize transaction costs for global transactions; blockchain, moreover, enhances economic liberalism through the facilitation of international trade. But both depend—as did classical liberalism and neoliberal efforts that followed—on what scholars have called the "depoliticization" of the economy. The next section proceeds to a reality check of this promise, as well as setting the basis for a normative reconsideration of the promise, which is the task for the final Part of the Article.

C. The Infrastructural Dimension of Blockchain

Blockchain has so far been identified as a new technology that has the potential to develop into an overarching global social structure backed by rational choice law and cryptoeconomics. This section demonstrates that blockchain is something beyond that even. Blockchain has an infrastructural nature: it is a global infrastructure that helps in the facilitation of other fields of life.

1. The Notion of Infrastructure

There is a new trend in the legal, economics, and more broadly social science literature to interpret law and society from an infrastructural perspective.[212] There are different ways to interpret the notion of

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210. Separating between "vertical" and horizontal distances for goods to travel. *See* GOTTFRIED HABERLER, THE THEORY OF INTERNATIONAL TRADE 309 (1936). This is brought to expression very vividly by Arthur Salter, the head of the economics and financial section of the League of Nations, who in 1932 wrote: "[t]he place which protective tariffs occupy in the world's economy and, regarded as a whole, their normal and inevitable effect, are perfectly clear. They are like the natural impediments of mountain-range or other obstacles to transport which increase the price paid for the benefits and economies resulting from the interchange of products of widely sundered regions." ARTHUR SALTER, RECOVERY: THE SECOND EFFORT 196 (1932).

211. "The liberal geography of the League economists cast tariffs as metaphorical barriers with height to be climbed over." SLOBODIAN, *supra* note 207, at 53.

212. *See generally* FRISCHMANN, *supra* note 33 (discussing how society benefits from

infrastructure.[213] The *Oxford English Dictionary* defines infrastructure as "the basic systems and services that are necessary for a country or an organization to run smoothly, for example buildings, transportation, and water and power supplies."[214] Professor Gómez-Ibáñez gives a definition that equates infrastructure services with public utilities and places a focus

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infrastructure resources, and presenting ideas on the design of infrastructure management); David Singh Grewal, *Before Peer Production: Infrastructure Gaps and the Architecture of Openness in Synthetic Biology*, 20 STAN. TECH. L. REV. 143 (2017) (using the example of synthetic biology, and offering ideas on a reorientation regarding how state action can help to generate the infrastructure of emerging fields in ways that prove conducive to their development); K. Sabeel Rahman, *Infrastructural Regulation and the New Utilities*, 35 YALE J. ON REGUL. 911 (2018) [hereinafter Rahman, *Infrastructural Regulation*]; K. Sabeel Rahman, *The New Utilities: Private Power, Social Infrastructure, and the Revival of the Public Utility Concept*, 39 CARDOZO L. REV. 1621 (2018) (offering an infrastructural understanding of new utilities such as the Internet, and a framework of "infrastructural regulation"); Kingsbury, *supra* note 33 (putting forward the idea of "infrastructure as regulation" as a way of opening up thinking about international law and technology).

Regarding the turn to infrastructure in the social sciences, see, e.g., Susan Leigh Star, *The Ethnography of Infrastructure*, 43 AM. BEHAV. SCIENTIST 377 (1999) (on an ethnographic account); Stephen Graham & Nigel Thrift, *Out of Order: Understanding Repair and Maintenance*, 24 THEORY, CULTURE & SOC'Y 1 (2007) (on a broad social scientific account to infrastructure relating to maintenance-related questions); Brian Larkin, *The Politics and Poetics of Infrastructure*, 42 ANN. REV. ANTHROPOLOGY 327 (2013) (on an anthropological account of infrastructure); KELLER EASTERLING, EXTRASTATECRAFT: THE POWER OF INFRASTRUCTURE SPACE (2014) (on an account from the perspective of the interaction between architecture and social science); SHEILA JASANOFF, THE ETHICS OF INVENTION: TECHNOLOGY AND THE HUMAN FUTURE (2016) (on the interaction between science and technology in law, politics, and policy in the State); Alec Ross, *Cities as Innovation Hubs*, *in* THE INDUSTRIES OF THE FUTURE 196–98 (2016); Jedediah Britton-Purdy, *The World We've Built*, DISSENT (July 3, 2018), https://www.dissentmagazine.org/online_articles/world-we-built-sovereign-nature-infrastructure-leviathan [https://perma.cc/J569-B3E6] (suggesting that human beings are infrastructural beings).

213. NAT'L RSCH. COUNCIL, COMM. ON INFRASTRUCTURE INNOVATION, INFRASTRUCTURE FOR THE 21ST CENTURY: FRAMEWORK FOR A RESEARCH AGENDA (1987), https://www.nap.edu/catalog/798/infrastructure-for-the-21st-century-framework-for-a-research-agenda [perma.cc/9BTQ-X8J9]; David Alan Aschauer, *Why Is Infrastructure Important?*, NEW ENG. ECON. REV. 21 (1990); Louis P. Cain, *Historical Perspective on Infrastructure and US Economic Development*, 27 REG'L SCI. & URB. ECON. 117 (1997); Lars-Hendrik Röller & Leonard Waverman, *Telecommunications Infrastructure and Economic Development: A Simultaneous Approach*, 91 AM. ECON. REV. 909 (2001); César Calderón & Luis Servén, *The Effects of Infrastructure Development on Growth and Income Distribution* (Working Paper No. 3400, 2004), https://openknowledge.worldbank.org/bitstream/handle/10986/14136/WPS3400.pdf?sequence=1&isAllowed=y [https://perma.cc/RFB8-676S]; Johan Fourie, *Economic Infrastructure: A Review of Definitions, Theory and Empirics*, 74 S. AFR. J. ECON. 422 (2006); Larry Beeferman & Allan Wain, Infrastructure: Defining Matters (Jan. 12, 2016) (unpublished manuscript) (on file with SSRN), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2714308 [https://perma.cc/2Q8J-VNZE].

214. *Infrastructure*, OXFORD LEARNER'S DICTIONARIES, https://www.oxfordlearnersdictionaries.com/definition/american_english/infrastructure [https://perma.cc/ES3A-Z4EN]; *see also Infrastructure*, ORG. FOR ECON. COOP. & DEV., https://stats.oecd.org/glossary/detail.asp?ID=4511 [https://perma.cc/ZD8A-5ZWD] (providing OECD's definition of infrastructure).

on the network structure of infrastructure.[215] His definition includes underground facilities "such as piped water and sewage," roads, railways, and "[e]lectric power and telecommunications" distributed via capital-intensive networks using durable, immobile investments.[216]

An older study of the U.S. National Research Council emphasizes the operational aspects of infrastructure:

> A comprehension of infrastructure spans not only these public works facilities, but also the operating procedures, management practices, and development policies that interact together with societal demand and the physical world to facilitate the transport of people and goods, provision of water for drinking and a variety of other uses, safe disposal of society's waste products, provision of energy where it is needed, and transmission of information within and between communities.[217]

According to Susan Leigh Star, infrastructure has nine key characteristics.[218] First, it is embedded, in the sense that it is "sunk into and inside of other structures;" second, it is transparent as "it does not have to be reinvented each time or assembled for each task;" third, it offers temporal or spatial reach or scope; fourth, it is learned by its users; fifth, it is linked to conventions of practice, e.g., routines of electricity use; sixth, it embodies standards; seventh, it is built on an installed base of sunk capital; eighth, it is fixed in modular increments, not built all at once or globally; finally, it tends to become visible upon breakdown.[219]

Economics differentiates between two main types of infrastructure: economic infrastructure as the basic facilities that directly affect the production and distribution in an economy (namely roads, railways, telecommunication systems, waterways, airways, financial institutions, electricity, water supply, and so on) and social infrastructure understood as basic amenities that do not directly influence the economic activities, but may have an indirect impact on the economy (namely education, health services, sanitation and so on).[220]

Blockchain has some of the attributes of infrastructure in the definitions presented in the previous paragraphs. It is a network-based system that

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215. JOSÉ A. GÓMEZ-IBÁÑEZ, REGULATING INFRASTRUCTURE: MONOPOLY, CONTRACTS AND DISCRETION 4 (2003).

216. *Id.*

217. NAT'L RSCH. COUNCIL, IN OUR OWN BACKYARD: PRINCIPLES FOR EFFECTIVE IMPROVEMENT OF THE NATION'S INFRASTRUCTURE 21 (1993), https://www.nap.edu/read/2205/chapter/4#20 [https://perma.cc/N2B5-2SCG].

218. Star, *supra* note 212, at 381–82.

219. *Id.*

220. *See* FRISCHMANN, *supra* note 33, at 65.

facilitates various operations in the lives of individuals in the economic, but also in the social, sphere of life through complicated cryptographic operating procedures and management practices. Although blockchain developed in the private sector, the public sector has adopted it, and blockchain has a unique tendency towards publicness in the sense of open access to all potential participants. The next section discusses the physical infrastructural dimensions of blockchain technology, while also showcasing the nature of blockchain as a non-physical infrastructure.

2. The Infrastructural Nature of Blockchain Technology: From "Utopia" to "Heterotopia"

Blockchain technology imagined and promised what Michel Foucault called a "placeless place," different from the spatial world, where everything would be possible.[221] This is what global collective imagery calls a "utopia," namely "fundamentally unreal spaces."[222] Bitcoin and other cryptocurrencies have been produced by libertarians, anarchists, and other opponents of the global financial system in an effort to by-pass the institutions of the financial markets, the central banks, and the commercial banks.[223] This at least was the dream of Satoshi Nakamoto and his followers.[224] Blockchain is now promising the same beyond the financial world into all aspects of individual and social life. Reality has—at least so far—turned out to be different. What is on offer rather is a "heterotopia," a place, according to Foucault, different from the normal space but within the actual world, that can eventually be captured by it.[225] Lawrence Lessig has already remarked about cyberspace in general that "[y]ou are never *just* in cyberspace; you never just *go* there. You are always both in real space and in cyberspace at the same time."[226]

Modern law has a distinct spatial dimension. Contemporary law is becoming even more infrastructural. Blockchain technology has a personal and spatial dimension, which may be termed the "infrastructural dimension" of blockchain. Blockchain has physical manifestations, as well as produces effects on the physical environment; it is at the same time a non-physical infrastructure.

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221. Foucault, *supra* note 183, at 24.

222. *Id.*

223. NAKAMOTO, *supra* note 7. *See also* Primavera De Filippi, *Bitcoin: A Regulatory Nightmare to a Libertarian Dream*, INTERNET POL'Y REV., May 23, 2014, at 1, 1.

224. NAKAMOTO, *supra* note 7.

225. Foucault, *supra* note 183, at 24.

226. LAWRENCE LESSIG, CODE AND OTHER LAWS OF CYBERSPACE 21 (1999) (emphasis in original).

a. Types of Infrastructural Dimensions of Blockchain

i. Physical Manifestations

Blockchain has its own distinct physical and spatial manifestations. First of all, individuals and computers compose the nodes of a blockchain; physical servers in the form of physical IT infrastructures are used to store the data produced on any blockchain. In addition, companies have nowadays been established and developed physical spaces in order to host miners and mining activities that are so vital for the operation of blockchain.[227] Moreover, while the pseudonymity of the founder of Bitcoin worked towards reinforcing a non-personal imagery of blockchain, blockchain leaders such as the founders of Ethereum have been very vocal about their technology and active in its promotion.[228] While software developers were initially in the background, they have come into the foreground of the technology and the eyes of the public, further adding to a more express understanding of the infrastructural dimension of blockchain. Overall, blockchain technology has not eliminated the need for consensus by individuals.[229]

In addition, governments are creating new spaces such as innovation hubs to host activities relating to new technologies. Increasingly, countries around the world have started adopting policies directed towards the promotion of FinTech startups, prominently also including startups developing blockchain technology and cryptocurrencies. FinTech promotion policies involve predominantly two regulatory measures: (i) launching innovation hubs to help FinTech startups comply with the relevant laws and regulations, and, (ii) establishing regulatory sandboxes for new financial services participants,[230] including the lowering of licensing barriers for digital financial services participants reaching sometimes all the way to FinTech licensing exemptions. The regulatory sandbox allows businesses to test innovative products, services, business

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227. *Bitcoin Mining Centralization: The Market Is Fixing Itself*, 99 BITCOINS (June 19, 2018, 6:21 PM), https://99bitcoins.com/bitcoin-mining-free-market/ [https://perma.cc/XL67-FAZ8].

228. *See, e.g.*, Press Release, President of Russ., Meeting with Founder of Ethereum Project Vitalik Buterin (June 2, 2017), http://en.kremlin.ru/events/president/news/54677 [https://perma.cc/8JUQ-9KXG] (on the meeting of Vladimir Putin with Vitalik Buterin discussing the possibility of using the Ethereum blockchain technology in Russia).

229. FINCK, *supra* note 1, at 6.

230. *See generally* Pavel Shoust, *Regulators and Fintech: Influence Is Mutual?*, RUSSIAN ELEC. MONEY ASS'N (Sept. 21, 2016), http://pubdocs.worldbank.org/en/770171476811898530/Session-4-Pavel-Shoust-Regulatory-Sandboxes-21-09-2016.pdf [https://perma.cc/F2TR-VLNQ]; Freehills, *supra* note 144.

models, and delivery mechanisms in a more relaxed regulatory environment.

Innovation hubs offer support to FinTech businesses, namely a dedicated team and contact for FinTech business that has the innovation potential and helps them understand the relevant regulatory framework and how it applies to them; moreover, they offer assistance in preparing and making an application for authorization and dedicated contact.[231] Since the United Kingdom took the lead in creating the U.K. Innovation Hub and a special regulatory regime for FinTech in 2015, many more countries, especially in the Asia Pacific region like Australia, Hong Kong, Malaysia, and Singapore, have followed its lead.[232] The Australian Government has undertaken important initiatives in regulating cryptocurrency as a technology.[233] The Australian Securities and Investment Commission (ASIC) has also launched an Innovation Hub to help FinTech startups on compliance matters; moreover, it established a regulatory sandbox for digital services participants. Australia's regulatory sandbox framework is comprised of three options for testing a new product or service without a license.[234] The SEC has also finally launched FinHub for the agency to connect with FinTech innovators, developers, and entrepreneurs.[235]

Finally, cryptoassets have an on-chain value that is endogenous to the token; this is for example the case with cryptocurrencies. Sometimes tokens only represent an asset, in the form of a product, service or entitlement, in the physical world.[236] There are thus very often gates from the digital to the physical world and the other way around. Smart contracts

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231. The U.K. FCA's "Project Innovate"—now "FCA Innovation"—is a very good example since it operates an Innovation Hub and a Regulatory Sandbox. Many of the projects under the FCA Regulatory Sandbox deal with blockchain technology-related products; *see generally FCA Innovation–Fintech, Regtech, and Innovative Businesses*, FIN. CONDUCT AUTH., https://www.fca.org.uk/firms/innovation [https://perma.cc/39UR-F5WQ].

232. *See* Freehills, *supra* note 144.

233. *See generally* COMMONWEALTH OF AUSTL., BACKING AUSTRALIAN FINTECH (2016), http://fintech.treasury.gov.au/files/2016/03/Fintech-March-2016-v3.pdf [https://perma.cc/A2ZF-E2R5] (discussing the initiatives in Australia).

234. *See* AUSTRALIAN SEC. & INVS. COMM'N, REGULATORY GUIDE 257: TESTING FINTECH PRODUCTS AND SERVICES WITHOUT HOLDING AN AFS OR CREDIT LICENCE (Aug. 2017), https://asic.gov.au/regulatory-resources/find-a-document/regulatory-guides/rg-257-testing-fintech-products-and-services-without-holding-an-afs-or-credit-licence/ [https://perma.cc/5BUA-G4LE]. The FinTech licensing exemption was initially proposed in Consultation Paper 260 (CP 260). Further, in CP 260 there are also measures to facilitate innovation in financial services.

235. *See generally FinHub: Strategic Hub for Innovation and Financial Technology*, U.S. SEC. & EXCH. COMM'N, https://www.sec.gov/finhub [https://perma.cc/P9UV-KW8B].

236. FINCK, *supra* note 1, at 10.

and DAOs have "exit-points" of interaction with the physical world using sensors that are called "oracles."[237] Oracles record and introduce information from the physical to the digital blockchain world, with a particular relevance for the Internet of Things.[238]

ii. Effects on Individuals and Society

New technologies will also unavoidably always have an effect on individuals and on the physical environment.[239] First, they create a sharp divide between those with access to the Internet and those without, or with very poor connectivity. The digital divide is even more pronounced in this sphere.[240] Bitcoin was created as the currency of a specific community of people, and is still very largely used by the same community. Cryptocurrencies as a new form of global currency may eventually turn out to be the currency of the privileged parts of the global population with access to the Internet. The same may apply to trade with cryptotokens.

This brings us to the second manifestation, namely the divide between those who know how to code and those who do not. Bitcoin and other cryptocurrencies are peculiar in the production of new value in the system in that new Bitcoins are generated as a reward and at the same time as an incentive for the miners as the guardians of the system. Not everybody has the knowledge, capabilities, or the desire to code and become a miner; the production of new wealth is thus reserved either to the individuals that belong to the first community that established Bitcoin as a club privilege or to new mining companies that are involved in the business of producing new Bitcoins.

The third possible manifestation is that caused by the geography as well as the natural and climatic conditions prevalent in a country.[241] Mining takes significant computing power.[242] Countries with colder climates may

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237. *See generally* @Artem, *How Do Oracle Services Work Under the Hood?*, ETHEREUM: STACK EXCH. (Jan. 23, 2017, 7:53 AM), https://ethereum.stackexchange.com/questions/11589/how-do-oracle-services-work-under-the-hood [https://perma.cc/F8B6-D2RN]. *See also* Alexander Egberts, The Oracle Problem: An Analysis of How Blockchain Oracles Undermine the Advantages of Decentralized Ledger Systems (Dec. 12, 2017) (M.A. thesis, EBS Universität für Wirtschaft und Recht) (on file with SSRN), https://ssrn.com/abstract=3382343 [https://perma.cc/HL9G-EKV8].

238. De Filippi & Hassan, *supra* note 1.

239. *See* REGULATING BLOCKCHAIN, *supra* note 12.

240. *Beyond Bitcoin: Using Blockchain to Advance the SDGs*, U.N. DEV. PROGRAMME, https://feature.undp.org/beyond-bitcoin/ [https://perma.cc/5C2N-MVT8] ("Then there is the digital divide: it is the most marginalized, the poor, rural populations, and the displaced who are the least likely to have access to reliable Internet connections.").

241. *See generally id.*

242. *See* Nosayba El-Sayed et al., *Temperature Management in Data Centers: Why Some (Might)*

be able to achieve greater computing power than those with warm climates. Huge parts of the world are by default excluded from the cryptocurrency map as a natural locus for mining, like the Middle East, large parts of Latin America, Central Africa, or even the Mediterranean. This creates new comparative advantages for the cooler countries in northern Europe and North America. Additionally, the verification process for blockchain, such as mining on the Bitcoin blockchain, is a very resource intensive exercise.[243] Mining and verification processes may have very adverse consequences on the environment that will eventually have to be mitigated.[244]

Finally, the rise of blockchain technology in the financial sector—currencies and transactions—led to some extent to the strengthening of banks and other financial institutions.[245] While they were meant to be bypassed, they have captured the field of development of new technologies relating to blockchain,[246] and are now at the forefront of blockchain technology developments.[247] This way they may be bypassing certain restrictions that were imposed on them in the aftermath of the financial crisis, which may eventually lead to the need for new interventions on behalf of financial and other regulators.

b. Blockchain as Non-Physical Infrastructure

"Nontraditional" or "intellectual infrastructure" is becoming at least as important as "traditional infrastructure"—i.e., physical infrastructure.[248] "Traditional infrastructure" is "large-scale physical resource made by humans for public consumption" and includes the "'underlying framework of a system' or the ' underlying foundation' of a system," like "transportation systems," including highway, railway, and airline systems as well as ports; "communication systems," such as telephone and postal

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Like it Hot, SIGMETRICS, June 11–15, 2012, http://www.cs.toronto.edu/~bianca/papers/temperature_cam.pdf [https://perma.cc/55QJ-L59G] (discussing temperature management in data centers, as well the effect of higher data center temperatures on server performance and power).

243. Jon Truby, *Decarbonizing Bitcoin: Law and Policy Choices for Reducing the Energy Consumption of Blockchain Technologies and Digital Currencies*, 44 ENERGY RSCH. & SOC. SCI. 399, 401 (2018). PoS algorithms aim at improving energy efficiency of public blockchains. *See Proof of Stake FAQs*, ETHEREUM WIKI, https://eth.wiki/en/concepts/proof-of-stake-faqs [https://perma.cc/W7C7-VYB6].

244. Truby, *supra* note 243, at 399.

245. *See* GANNE, *supra* note 4, at 53–54 (calling this development an "irony").

246. *Id.* at 51–55.

247. *Id.*

248. FRISCHMANN, *supra* note 33, at 4.

networks; "governance systems," like courts; "basic public services and facilities," such as schools, energy and water systems.[249]

According to Frischmann, "nontraditional" and "intellectual infrastructure" are nontraditional infrastructure resources enabling, framing, and supporting a wide range of productive activities—mostly downstream—of economic and social nature in our lives.[250] According to U.S. law, the term "critical infrastructure" as defined in section 1016(e) of the USA Patriot Act of 2001 and Presidential Policy Directive-21 covers "systems and assets, *whether physical or virtual*, so vital to the United States that the incapacity or destruction of such systems and assets would have a debilitating impact on security, national economic security, national public health or safety, or any combination of those matters."[251]

Blockchain is a general-purpose virtual technology with physical manifestations that purports to cover all areas of life by providing the background conditions for the exercise of the relevant activities, and thus enabling them. It may therefore be conceived of as an intellectual infrastructure of this sort.[252]

3. Blockchain as a Global Infrastructure

Blockchain has an infrastructural nature, both in its physical and non-physical dimension. Legislative frameworks around the world have started identifying blockchain technology as infrastructure.[253] At the same time, the infrastructure of blockchain has a global outreach. The Bitcoin blockchain operates as a "financial market infrastructure" for worldwide monetary transactions.[254] Blockchain could become the basis of the future "trade infrastructure," supporting transactions among logistics and transportation companies, which constitute the backbone of international trade.[255] In more general terms, blockchains provide the "infrastructure"

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249. *Id.* at 3–4.

250. *Id.* at 4, 253.

251. Press Release, Off. of the Press Sec'y, Presidential Policy Directive, *supra* note 203 (emphasis added).

252. *See* FRISCHMANN, *supra* note 33, at 253 (classifying general purpose technologies as intellectual infrastructure).

253. It may be interesting to note that the Russian Federation's legislation on foreign investment screening specifically mentions cryptographic services with a view to controlling foreign investment in companies working in the area of cryptography. *See, e.g.*, On the Procedures for Foreign Investments in Companies of Strategic Significance for National Defense and Security (the "Strategic Companies Law"), SOBRANIE ZAKONODATEL'STVA ROSSIISKOI FEDERATSII [SZ RF] [Russian Federation Collection of Legislation] 2008, No. 57-FZ.

254. Walch, *supra* note 32.

255. GANNE, *supra* note 4, at 41.

of the global services industry.[256]

The infrastructural re-interpretation of blockchain shows clearly that blockchains are more than "computers" or digital networks;[257] blockchains will moreover have effects on the physical environment on a global scale. It is on the infrastructural dimension of blockchain technology that a proper political economy of blockchain may be built. This is the task for the final Part of this Article.

III. TOWARDS A LAW AND POLITICAL ECONOMY FRAMEWORK OF BLOCKCHAIN

One cannot help but notice a considerable paradox in the development of blockchain. While Bitcoin, cryptocurrencies, and blockchain as such have been envisaged and created by opponents of the mainstream economic and financial system, they have resorted to mainstream economic principles for the structuring of the rules of the cryptoenvironment. This has led to a complex emerging political economy of blockchain.

Political economy was in the beginnings of the development of classical economics synonymous to economics.[258] Over the years it took on the meaning of the interplay between the State and the economy; given the dominance of the rational choice paradigm in economics and political science it (also) came to mean the application of rational choice theory to analysis of government decision-making.[259] Following recent scholarship on law and political economy, the Article in its final Part purports to develop a new "law and political economy" framework for blockchain.[260] The notion of political economy is used in the broadest sense of a discipline that looks into the relationship between politics and the economy generally.[261] This type of relationship is discernible both within

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256. *See id.* at 56 ("If a 'revolution' [of the services industry with the use of the blockchain technology] does occur, it is more likely to be internal: the intrinsic characteristics of Blockchain and the possibility to automate transactions through smart contracts make it an attractive tool for companies to cut costs and streamline processes. If the initiatives underway prove conclusive, Blockchain could well become the future 'infrastructure' of the services industry. Because of its automation capabilities, Blockchain could be to the services sector what robots have been to manufacturing.").

257. *See supra* section II.B.1 (discussing blockchain as a "world computer").

258. Samuel Bowles & Herbert Gintis, *Power and Wealth in a Competitive Capitalist Economy*, 21 PHIL. & PUB. AFFS. 324, 324 (1992).

259. *Id.*

260. *See infra* Part III.

261. *See* Britton-Purdy et al., *supra* note 34, at 1792 ("Rather, we intend the older and more foundational usage familiar to nineteenth-century audiences, which persisted in traditions of 'radical'

the *lex cryptographia*, and in the relationship between the *lex cryptographia* and the law of the physical world. The first section of the final Part of the Article discusses the nature of blockchain as commons; the subsequent sections then discuss law and political economy frameworks for *lex cryptographia*, which is in the process of being developed, alongside the political economy of the interaction between the law of the physical world and blockchain.

A. Blockchains as Infrastructural Commons

The significance of having identified blockchains as infrastructures lies in the consequences that may be drawn from such characterization. Infrastructures face the problem of underprovision, which is identified both by public welfare economics and regulatory economics.[262] Demand for infrastructure is derived from output markets.[263] Accordingly, demand manifestation problems may lead to undersupply of infrastructures and infrastructural services; the market mechanism will not fully take into account or provide the services for the broader set of social benefits attributable to public or social goods.[264] Various forms of government intervention can resolve underprovision problems.[265]

Infrastructures very often have the natural features of commons.[266] Mainstream economic theory suggests that the best way to manage commons is to privatize them.[267] Non-mainstream approaches to economics suggest that infrastructure may be managed as commons.[268] Frischmann summarizes commons management as a situation where

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political economy until a few decades ago. *This* political economy investigates the relation of politics to the economy, understanding that the economy is always already political in both its origins and its consequences." (emphasis in original)); Martha T. McCluskey et al., *Law and Economics: Contemporary Approaches*, 35 YALE L. & POL'Y REV. 297, 300–01 (2016). *See generally* Association for the Promotion of Political Economy and the Law (APPEAL) and the Journal of Law and Political Economy (JLPE).

262. FRISCHMANN, *supra* note 33, at 12–15. In addition, infrastructures present the decreasing cost phenomenon: high upfront cost for construction, and decreasing cost for maintenance, especially as use increases. There are moreover capacity constraints: there is a limit to nonrivalrous consumption. *Id.* at 13–14.

263. *Id.* at 66, 69.

264. *Id.*

265. *See id.* at 14–15.

266. *See id.* at 1–9 (on the identification of infrastructure as commons and the idea of "commons management"); Garrett Hardin, *The Tragedy of the Commons*, 162 SCIENCE 1243 (1968) (on the notion of "commons").

267. *See* Hardin, *supra* note 266, at 1245, 1247 (for a classical statement of this approach).

268. *See* FRISCHMANN, *supra* note 33, at 1–9.

resources are "shared among members of a community on nondiscriminatory terms . . . *that do not depend on the users' identity or intended use* . . . . This does not mean that use of the resource is free or comes without any terms and conditions."[269]

While commons management may not necessarily be justified by traditional economics that focuses on supply, a demand-side perspective to infrastructure may give an appropriate justification for commons management.[270] A demand-side perspective reorients the focus towards the user of the infrastructure. It actually looks at how to allow the user to make a decision about what to do with the opportunities and capabilities provided by the infrastructure. It, moreover, functions as a social option, when it is uncertain which users or even uses will generate social value with a view to the future. Additionally, a demand-side perspective allows us to focus on the variety of positive externalities that can take place under a commons management framework of infrastructural resources. Again, according to Frischmann:

> Commons management structures the relationships between infrastructure and infrastructure-dependent systems in a manner that creates a spillover-rich environment, where spillovers flow from the many productive activities of users. These activities yield new and unanticipated innovations, knowledge, social capital, and other public and social goods that lead to economic growth and development as well as social welfare improvements not fully reflected in traditional economic measures.[271]

Infrastructure managed as commons has the potential to generate significant "positive externalities,"[272] which are third-party effects that may result in social gains; it may thus permit a wide range of downstream producers of private, public, and social goods to flourish.[273] Infrastructure resources facilitate third-party effects, namely productive behaviors by users that affect third parties—users, or non-users of the infrastructure—in an "accidental, incidental, and not especially relevant" way to the infrastructure provider or user.[274] This may result in a scenario of a

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269. *Id.* at 92 (emphasis in original); *see also* LAWRENCE LESSIG, THE FUTURE OF IDEAS 19–25 (2001).

270. *See id.* at 93–95.

271. *Id.* at 94.

272. Positive externalities are otherwise referred to as "spillovers," or "external benefits." *See generally* Brett M. Frischmann & Mark A. Lemley, *Spillovers*, 107 COLUM. L. REV. 257 (2007).

273. YOCHAI BENKLER, PROPERTY, COMMONS, AND THE FIRST AMENDMENT: TOWARDS A CORE COMMON INFRASTRUCTURE 3, 47–49 (2001).

274. FRISCHMANN, *supra* note 33, at 11–12. For example, the electricity grid, telephone networks, the Internet, etc., contribute value by way of new opportunities, cost reduction, scale efficiencies, etc.

"comedy of the commons," where open access to a resource may lead to scale returns, namely greater social value with greater use of the resources.[275] Spillover effects may generate private value. Spillover effects may also very importantly generate social value (i.e., social returns on infrastructure investment contributing to the improvement of social networks and social ties, development of new ideas, innovation, etc.). For example, roads—except for commerce—also contribute to increased socialization, cultural and other types of social exchange.

Commons management is independent of market or government provision of the relevant infrastructural good. Governments and the private sector alike may choose whether or not to manage infrastructure and other public goods as commons. Finally, government may intervene to mandate the provision of a private infrastructure as commons.[276] In all three cases, affording access to infrastructure in a non-discriminatory way while managing congestion is key. Regulators in the United States and elsewhere have developed legal tools mandating such terms of use of infrastructural resources, such as the essential facility doctrine and the common carrier doctrine.[277]

Along the same lines, Sabeel Rahman suggests various regulatory tools with a view to holding infrastructural power accountable; these tools are largely inspired by twentieth century utility regulation.[278] The broader idea is to apply utility regulation to "infrastructural goods and services," with the ultimate goal of assuring fair and equal access to the identified infrastructural goods.[279] One proposed intervention is regulatory oversight, which imposes affirmative obligations.[280] These obligations include duties to provide services to marginalized individuals and communities, and to comply with legal standards for nondiscrimination—such as serving all customers, having reasonable rates, prohibiting unjust discrimination, and requiring service providers to establish connections

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Id.

275. Carol Rose, *The Comedy of the Commons: Custom, Commerce, and Inherently Public Property*, 53 U. CHI. L. REV. 711, 768 (1986).

276. *See* FRISCHMANN, *supra* note 33, at 99–114 (discussing the various ways in which government can intervene to establish commons management of infrastructure).

277. *See id.* at 100. Frischmann identifies four such types of intervention: "(1) public regulation of private infrastructure providers mandating nondiscriminatory access for *competitors*; (2) public regulation of private infrastructure providers mandating nondiscriminatory access for *consumers*; (3) dedication of privately produced infrastructure to the public domain; (4) public provision of infrastructure on a nondiscriminatory basis." *Id.* (citations omitted) (emphasis in original).

278. Rahman, *Infrastructural Regulation*, *supra* note 212, at 927–30.

279. *Id.* at 929, 931

280. *Id.* at 928.

with each other.[281]

Second, government may intervene to provide firewalls and structuralist regulation.[282] Instead of addressing individual transactions, government may alter the corporate structure of the infrastructural firm itself as a way to reduce ex ante the tendency towards problematic transactions in the first place.[283] An example of a firewall would be the mandate to isolate and separate the basic and stable core service from riskier or more unstable alternatives, e.g., mandating the separation of investment from commercial banking or not allowing mergers of oligopolistic companies. Many more conflict-of-interest requirements and financial regulations limiting the kinds of funding and investment regimes permitted for infrastructural firms may be envisaged.

Third, a solution would be for government to provide the infrastructural service, or for government to provide for public options.[284] Direct provision by government means that public bodies themselves would directly provide the relevant infrastructural good or service, either from the beginning or through expropriation in the form of nationalization, or municipalization.[285] The idea of provision of a "public option" means that a government provider would compete with private providers, offering, for example a basic version of the same service.[286]

Blockchain as infrastructure may also mean moving towards an understanding of blockchain management as infrastructural commons. Blockchain economics are based on traditional economics. New tools may thus be needed to move beyond the rational autonomy conundrum of blockchain. Acknowledging the infrastructural dimension of blockchain technology may potentially help identify new meanings and uses of blockchain, as well as a new role for government in its interaction with the technology. Most importantly, government may intervene to mandate the types of interventions that were identified above regarding infrastructure service provision. Commons management is a postulate both for the political economy of the *lex cryptographia* and the interaction between blockchain and the law of the physical world. Identifying blockchains as infrastructural commons would indicate that law and regulation should not be relegated to the role of facilitating the operation of the invisible hand of the market by and within blockchain; rather, law

281. *Id.*

282. *Id.*

283. *Id.* at 930.

284. *Id.*

285. *Id.*

286. *Id.*

and regulation should acquire more active roles, such as safeguarding access on non-discriminatory terms to potential users.[287] This is all the more the case given that there is a general tendency by big technology companies and mainstream financial institutions to create private and permissioned blockchains, despite the technology being initially developed to accommodate public and permissionless blockchains.

B. The Political Economy of Lex Cryptographia

Are new technologies, and blockchains, data-driven neutral machines that go beyond politics? There is one straightforward answer to this question: no. Blockchain governance and blockchain itself are heavily politicized enterprises. While blockchains are perceived as self-enforcing mechanisms, they are in fact, not. They are based on individuals who make decisions for internal governance purposes. Their decisions may be subject to political or other interests.[288] In addition, the code and underlying algorithms may be subject to various cognitive biases of the developers resulting in discrimination and unfairness.[289]

It may be said that a "societal economy" of blockchain has replaced traditional political economy. Namely, a non-State based economy has emerged in which certain societal rules replace the rules of a polity. The societal economy of blockchain is, moreover, by definition global and transnational. In its original and pure form, blockchain is supposed to be borderless and cover the exchange of data, value, and other types of transactions independent of the physical locations of the persons involved in the transaction. Still, this does not give a fully accurate picture of the blockchain economy. This economy is part of a specific subset of society: the programmers, coders, and software developers who are largely

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287. *See generally* FRISCHMANN, *supra* note 33, at 1–9, 91–114 (discussing various aspects of commons management).

288. *See generally* Langdon Winner, *Do Artifacts Have Politics?*, 109 DAEDALUS 121, 121–23 (1980). The politics of blockchain and the crypto community are now discussed in a series of book-length publications. *See* DAVID GOLUMBIA, THE POLITICS OF BITCOIN: SOFTWARE AS RIGHT-WING EXTREMISM (2016); KATHARINA PISTOR, THE CODE OF CAPITAL: HOW THE LAW CREATES WEALTH AND INEQUALITY (2019); FINN BRUNTON, DIGITAL CASH: THE UNKNOWN HISTORY OF THE ANARCHISTS, UTOPIANS, AND TECHNOLOGISTS WHO CREATED CRYPTOCURRENCY (2019). See also the discussion of the three books in Frank Pasquale, *Tales from the Crypto*, PUB. BOOKS (June 12, 2020), https://www.publicbooks.org/tales-from-the-crypto/#fn-36490-6 [https://perma.cc/R5AC-537Z].

289. *See* Danielle Keats Citron & Frank Pasquale, *The Scored Society: Due Process for Automated Predictions*, 89 WASH. L. REV. 1, 13–16 (2014); MEDIA TECHNOLOGIES: ESSAYS ON COMMUNICATION, MATERIALITY, AND SOCIETY (Tarleton Gillespie et al. eds., 2014); Malte Ziewitz, *Governing Algorithms: Myth, Mess, and Methods*, 41 SCI., TECH., & HUM. VALUES 3, 5 (2016).

responsible for internal blockchain governance.

Internal blockchain governance can be broadly separated into two categories: off-chain and on-chain governance.[290] Most cryptocurrencies use off-chain governance whereby core developers and miners are the main governance actors, and users and business entities participate as part of the community.[291] Software developments are typically achieved by leaders in the community. For instance, Bitcoin's off-chain consensus is reached by large mining players, core developers, and business entities interacting with each other and coming to an agreement.[292] Off-chain governance is thus relatively centralized and excludes many users that lack the technical knowledge or financial power to effect network decisions. Despite centralization, users of blockchains are granted some flexibility through some form of exit option such as hard forks.[293] Hard forks empower users not satisfied with the governance of a network to create their own system, in the form of a new cryptocurrency regime, by splitting the original blockchain. Both Bitcoin and Ethereum have experienced hard forks.[294]

On-chain governance is more recent in blockchains that allow more transfer of powers from the miners and developers to the users. Blockchains allowing on-chain governance implement some form of direct involvement for users through on-chain voting mechanisms. Voting and proposals for development happen transparently on-chain; voting is

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290. *See* Wessel Reijers et al., *Now the Code Runs Itself: On-Chain and Off-Chain Governance of Blockchain Technologies*, 37 TOPOI 1 (2018), https://link.springer.com/content/pdf/10.1007/s11245-018-9626-5.pdf [https://perma.cc/X22H-JLYN] (comparing on-chain with off-chain governance). *See generally* Walch, *supra* note 52 (on coders as fiduciaries in (public) blockchains). *See also* Philipp Hacker, *Corporate Governance for Complex Cryptocurrencies?*, *in* REGULATING BLOCKCHAIN: TECHNO-SOCIAL AND LEGAL CHALLENGES 140 (Philipp Hacker et al. eds., 2019) (discussing the application of complexity theory on blockchain governance).

291. *See* Wessel Reijers et al., *supra* note 290, at 2 n.2.

292. Off-chain coordination takes place via e-mails and online databases, *See Bitcoin Improvement Proposals*, GITHUB, https://github.com/bitcoin/bips [https://perma.cc/5RPW-P6PA].

293. *See* Jeffery Atik & George Gerro, *Hard Forks on the Bitcoin Blockchain: Reversible Exit, Continuing Voice*, 1 STAN. J. BLOCKCHAIN L. & POL'Y. 24 (2018).

294. *See* Walch, *supra* note 52, at 62–64. There are nowadays Bitcoin (BTC) and Bitcoin Cash (BCH) as an altcoin. *Compare Bitcoin Is an Innovative Payment Network and a New Kind of Money*, BITCOIN, https://bitcoin.org/en/ [https://perma.cc/GHL3-ACAT], *with Peer-to-Peer Electronic Cash*, BITCOINCASH, https://www.bitcoincash.org/ [perma.cc/Y528-R748]. There are also Ethereum (ETH) and Ethereum Classic (ETC), whereby the latter uses the original Ethereum blockchain after the hard fork of Ethereum that was initiated by the majority after The DAO hack took place. *Compare Ethereum Is a Global, Open-Source Platform for Decentralized Applications*, ETHEREUM, https://ethereum.org/en/ [https://perma.cc/QNG7-R5CY], *with Ethereum Classic: Building Unstoppable Applications*, ETHEREUM CLASSIC, https://ethereumclassic.org/ [https://perma.cc/FXG2-H3Y8].

governed algorithmically and automatic execution of results is built directly into the protocol. On-chain governance is also led by the blockchain law-and-economics incentive structures. On-chain voting depends on the selection of the consensus algorithm. In the PoS model, for example, voting is weighted based on user stakes.[295] Many average users will not have enough financial resources to make a substantial impact on decisions by stake-based voting, so this model may lead to centralization as well.

At the same time, users of cryptoservices are free to enter, exit, and choose the cryptoenvironment that is most suitable to their preferences depending on the value of that environment, its internal governance rules, as well as internal governance practices, etc. Trent MacDonald develops a blockchain political economy of the sort discussed in the beginning of this section that is derived from the nature of the cryptoworld that promises the elimination of rent-seeking given the giving up of centralized monopoly control over the constitutional rules.[296] The threats to the political and bureaucratic systems of the world by the new world proposed by blockchain and its underlying politics will eventually lead to a backlash[297]—this will be further elaborated in the next section. This may lead to a political economy rupture that MacDonald calls "cryptosecession."[298]

From a law and political economy point of view, it remains uncertain at this stage of development of the technology whether the government should—or could—intervene in the internal governance processes of the cryptoworld. The next section of this Article will consider this issue further.[299]

C. The Political Economy of Blockchain

This section develops a law and political economy framework for the interaction between the law of the digital and the physical worlds. It first explains the regulatory backlash against cryptoassets using the concepts

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295. *See, e.g.*, *The Voting Process*, TEZOS FOUND. (2020), https://tezos.gitlab.io/whitedoc/voting.html [https://perma.cc/6SX6-884R] (describing voting and the voting process on Tezos); *see also* Jacob Arluck, *Amending Tezos: Traversing the Amendment Process*, MEDIUM (Nov. 29, 2018), https://medium.com/tezos/amending-tezos-b77949d97e1e [https://perma.cc/K4XB-7UAF].

296. Trent J. MacDonald, Theory of Non-Territorial Internal Exit 6–7 (Feb. 1, 2015) (unpublished manuscript) (on file with SSRN), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2661226 [https://perma.cc/VFY7-8JHQ].

297. *See generally* Davidson et al., Economics of Blockchain, *supra* note 28.

298. MacDonald, *supra* note 296, at 3.

299. *See infra* section III.C.3.

of "embeddedness" and the "double movement" development by the twentieth century political economist Karl Polanyi. It then identifies three phases in the development of the law of the interaction between the ordinary law of the physical world and the *lex cryptographia* of the digital world: the anarcho-libertarian phase; the mainstreaming phase; and, the maturity phase. All three phases feature different levels and types of interaction between the self-regulatory *lex cryptographia*, and external regulation by the ordinary law. The Article closes with a discussion of the possible measures of regulatory intervention on behalf of the government in an effort to embed cryptoassets into domestic economies.

1. Explaining Regulatory Backlash

The concept of embeddedness, as defined by Polanyi and further used by economists and economic sociologists, refers to the fact and need for every economic activity to be embedded within institutions of society, like institutions of kinship, religion, politics, etc., that keep economic activity under certain control.[300] In pre-nineteenth century societies, there were no purely economic institutions outside of the frame of other societal institutions. In the market society that appeared in the nineteenth century, the economic system gained a certain degree of independence leading largely to this system being dis-embedded from society, with catastrophic results for society that eventually, according to Polanyi, led to the disaster of the two world wars.[301]

According to Polanyi, the market system necessarily produces two antithetical movements in society: one in favor of market expansion and free trade, and equally against government intervention in the economy; and one in favor of protective and interventionist measures prompted by a collectivist counter-movement, in an effort to embed the market into institutions of society.[302] This is the so called Polanyian "double movement" in society.[303] Economic and financial expansion through cryptocurrencies and other cryptoassets, and responses to their expansion can be explained and described in terms of the "double movement" that Karl Polanyi identified for the expansion of the market society in the nineteenth and twentieth centuries.[304]

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300. *See generally, e.g.*, Mark Granovetter, *Economic Action and Social Structure: The Problem of Embeddedness*, 91 AM. J. SOCIO. 481 (1985).

301. POLANYI, *supra* note 34, at 29–31.

302. *Id.* at 79–80, 136–40.

303. *Id.* at 79.

304. *See* REGULATING BLOCKCHAIN, *supra* note 12.

Polanyi expressed the hope that post-WWII society would again develop the appropriate institutions to re-embed the economy,[305] which was largely the case during the *trente glorieuses* with the various social protection programs and schemes of the post-war welfare state. This changed in the 1990s leading up to the 2008 global crisis. The crisis led to a new process of the embedding and dis-embedding of market forces; Bitcoin and other cryptocurrencies are a peculiar case of an effort to dis-embed money from the mainstream financial system and possibly (re-)embed it into new communities, such as the communities of crypto-specialists, like developers and miners. It is in this process that money may accidentally face a new phase of extreme dis-embeddedness, and economic liberalism may spread and expand its role and the remit of the market process. This process may be unique in the history of the market making it independent from any physical context, and introduced only into the cryptoworld of blockchain.

Blockchain disrupts to some extent the narrative of the double movement but produces the same effects in society as the double movement does. Bitcoin, other cryptocurrencies and cryptoassets, and ultimately blockchain technology have been produced by opponents of the mainstream financial system in an effort to circumvent institutions such as traditional banks.[306] For possibly the first time in the history of capitalism, a group that could be identified as the protective collectivist counter-movement in society has contributed to the further global expansion of the market system, including commodities, services, and capital.

This may thus explain the emergence of a countermovement, which has developed in order to address the potential negative effects of cryptoassets on economy and society at large by introducing interventions in favor of the vulnerable parties of cryptoasset transactions, and social protection more broadly, as well as the protection of the institutions of the State. This "anti-countermovement"[307] has appeared in countries like the United States that follow the system of market economy, and countries like China that follow their own variety of the market economy system.[308]

The emergence of the anti-countermovement explains the varying responses by countries around the world to cryptocurrencies and other developments of blockchain technology. "The anti-countermovement

305. *See* POLANYI, *supra* note 34, at 259.

306. *See supra* section II.C.2.a.

307. *See* REGULATING BLOCKCHAIN, *supra* note 12, at 114.

308. *See supra* section I.C. (discussing examples from the United States, China, and beyond).

may take the guise of the countermovement and try to block the spread of [cryptoassets and the blockchain]" in a restrictive way.[309] Other forces of the anti-countermovement may try to enable cryptoassets and blockchain.[310] Enabling is a novel effort of embedding which is characteristic of a society that has reached the extent of globalization and digitization of our contemporary society.[311]

The different Polanyian movements identified at play here face various regulatory dilemmas regarding the embeddedness of cryptoassets and blockchain technology into a domestic regulatory framework by regulating them or allowing both their market and underlying technology to develop outside the scope of domestic regulatory intervention. The advantages of embedding cryptocurrencies into a domestic legal order may be offset by the advantages brought about by allowing a new innovative technology, such as blockchain technology, to flourish without the restraints of regulation. Moreover, enabling cryptoassets through domestic legislation brings to the fore new risks for national jurisdictions.

From a domestic government's point of view, there are many reasons in favor of regulating cryptoassets and embedding them into a certain domestic legal order. The pseudonymity of cryptoasset market participants makes it difficult for regulators to identify individuals who use them for illicit value transfers. Cryptoassets are thus very often used for money laundering purposes.[312] This creates problems of enforcement of financial sanctions. It may also lead to tax evasion. Additionally, cryptoasset users are exposed to various consumer risks given the price volatility of cryptocurrencies. A related but more systemic issue is that of monetary and financial stability—a problem mostly of the future. This obviously also creates issues of trust in currency generally. Another set of issues is derived from the new intermediaries of the virtual currency environment. It may well be the case that the cryptocurrency system circumvents traditional national financial intermediaries like central and commercial banks; at the same time, it introduces new intermediaries. These new intermediaries are exposed to novel problems like, for example, the risk of hacking.[313]

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309. REGULATING BLOCKCHAIN, *supra* note 12, at 131.

310. *Id.*

311. *Id.*

312. *See* FIN. ACTION TASK FORCE, VIRTUAL CURRENCIES: KEY DEFINITIONS AND POTENTIAL AML/CFT RISKS 9 (2014).

313. *See, e.g.*, The Mt. Gox scandal, when hackers stole 850,000 Bitcoins in February 2014 that were more than $460 million from Mt. Gox, a Bitcoin exchange database handling at the time up to 70% of all Bitcoin transactions, showcased very vividly the technological risks that cryptocurrency users are exposed to. Robert McMillan, *The Inside Story of Mt. Gox, Bitcoin's $460 Million Disaster*,

Embedding through enabling also raises at least two major concerns at the global and domestic levels of governance that need to be mitigated: the peril of more finance and the peril of clash of agencies.[314] Since the global financial and economic crisis, there is a general tendency at the global, the regional, and the domestic governance levels to constrain more conventional finance.[315] At the same time, Bitcoin made its appearance on the Internet and the global money market and a similar trend to enable digital and virtual finance and financial technology more generally has been growing. This has been reflected in the implementation of a new type of law through the establishment of innovation hubs and regulatory sandboxes.[316] Enabling blockchain and FinTech raises the question of the viability of restraining conventional finance. Both conventional financial institutions and new startups now receive incentives from different regulators to work around conventional finance restrictions and develop new products that are potentially no less dangerous for consumers than the products developed by conventional financial institutions. In the long run, these developments may eventually lead to an overall less regulated field of finance.

There is a second way in which regulation of cryptoassets through enabling undermines policymaking by government that goes to the core function of governance. As novel phenomena of the digital world, cryptoassets may fall within the powers of many different regulators of one country;[317] cryptoassets leave space open for several agencies to capture the empty regulatory space and regulate them as money, commodity, technology, or otherwise. This has already led to a paradoxical approach to regulation of cryptoassets involving multiple

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WIRED (Mar. 3, 2014), https://www.wired.com/2014/03/bitcoin-exchange/ [https://perma.cc/WBQ7-93FQ]. Similar problems have arisen in the frame of DAOs. In May 2016, members of the Ethereum community announced the inception of the DAO, the first blockchain-based DAO, also known as Genesis DAO. The DAO was built using smart contracts on the Ethereum blockchain. In June 2016, a hacker took advantage of a vulnerability in the coding of the application that was built on Ethereum—not the Ethereum itself—that allowed him to steal 3.6 million ETH, which was the equivalent of approximately $50 million at the time. *See* Klint Finley, *A $50 Million Hack Just Showed that the DAO Was All Too Human*, WIRED (June 18, 2016), https://www.wired.com/2016/06/50-million-hack-just-showed-dao-human/ [https://perma.cc/2LC3-3RT7].

314. *See also* REGULATING BLOCKCHAIN, *supra* note 12, at 130–32.

315. *See generally* KEVIN DAVIS, REGULATORY REFORM POST THE GLOBAL FINANCIAL CRISIS: AN OVERVIEW (2011).

316. *See supra* sections I.C, II.C.2.a.i.

317. Ross Leckow, Notice & Comment, *Virtual Currencies – the Regulatory Challenges*, YALE J. ON REGUL. 132 (2017); *see also* FIN. STABILITY BD., CRYPTO-ASSETS REGULATORS DIRECTORY 1–5 (2019), https://www.fsb.org/wp-content/uploads/P050419.pdf [https://perma.cc/VGP6-THP6].

agencies. This can be seen in the United States, where several agencies have claimed jurisdiction over cryptoassets. CFTC classifies Bitcoin and other cryptoasset derivatives as commodities. The IRS considers Bitcoin to be "property" for U.S. federal tax purposes.[318] FinCEN treats virtual currency as "money" for purposes of the money services business (MSB) regulations.[319] The SEC has successfully argued that Bitcoin-denominated investments are "securities" that can be regulated under U.S. securities laws.[320] At the same time, governments at the state level are propelling the enabling of cryptoassets and blockchain technology.

In the future, this situation might end up with an even greater clash of agencies within some countries as to which regulator will regulate them and what regulatory approach should be taken.[321] Different national agencies may have different aims: Departments of Commerce and Ministries of Economy may typically want to create economic hubs via enabling regulation. On the other side, Treasury Departments and Ministries of Finance and Central Banks will have an interest in financial stability; the banking and financial supervision authorities may be willing to minimize the risk for market participants and consumers; anti-money laundering agencies will be willing to assume their powers to enforce anti-money laundering legislation; commodities regulators might be entering the regulatory arena as well, as is the case in the United States.[322] The interplay between the liberal and the collectivist countermovement are thus replayed within domestic governments as a struggle for regulatory and deregulatory power and competence among different agencies. At the moment the result is an odd mixture of constraining and enabling regulation.

This creates significant regulatory confusion, which is greater than regulatory uncertainties caused by exclusively domestic phenomena, and may undermine the power of the government to regulate. It may be undermining the "symbolic power" of the government as well,[323] namely the perception of the State and its institutions in the eyes of its citizens, further impacting its capacity to regulate. This may have very negative results especially in countries with less well-established institutions, or

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318. I.R.S. Notice, *supra* note 140, at 2.

319. *See* U.S. DEP'T OF TREASURY, FIN. CRIMES ENF'T NETWORK, *supra* note 67.

320. *See supra* section I.C.

321. REGULATING BLOCKCHAIN, *supra* note 12, at 132.

322. *Id.*

323. Pierre Bourdieu, *Rethinking the State: Genesis and Structure of the Bureaucratic Field*, 12 SOCIO. THEORY 1, 9 (Loic J.D. Wacquant & Samar Farage trans., 1994) (discussing the "symbolic power" of the State).

when the authority of the State is also undermined by external factors, like an economic and financial crisis or public health and national security emergencies.

From a more bird's eye view, the main reasons leading to the justification of domestic regulation—and potentially also of international regulation—of cryptoassets are related to new inequalities that they may create, and have been discussed in a previous section.[324]

There are also reasons that may speak against moving towards regulation and overall embeddedness of cryptoassets. The most important reasons against regulation are related to blockchain technology. Cryptoassets rely on algorithm-generated trustless trust.[325] Regulation might reduce trust in the technology and mathematics, which might eventually lead to the diminishing value or even dissolution of the assets. Moreover, there is inherent uncertainty as to how to regulate new technologies, as well as fundamental difficulties in regulating a new technology. The uncertainty surrounding the development potential of new technologies, namely the fact that we do not yet know how they will develop and be used in the future, makes regulation of new technologies very difficult.[326] Regulation may thus be an obstacle to innovation.[327] Regulatory responses to cryptocurrencies threaten to increase the cost of compliance and/or slow the development or adoption of beneficial innovations.[328] Government intervention in cryptoassets and blockchain might stall a necessary wave of technological development and innovation that, through economic and social spill-over effects, may benefit various sectors of the economy and, eventually, society at large.[329]

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324. *See supra* section II.C.2.a.ii.

325. De Filippi, *supra* note 42.

326. *See generally* Wulf A. Kaal & Erik P.M. Vermeulen, *How to Regulate Disruptive Innovation – From Facts to Data*, 57 JURIMETRICS (forthcoming 2017), http://ssrn.com/abstract=2808044 [https://perma.cc/NNG6-UCNQ].

327. *See* Luke A. Stewart, *The Impact of Regulation on Innovation in the United States: A Cross-Industry Literature Review*, INFO. TECH. & INNOVATION FOUND. (2010), https://www.itif.org/files/2011-impact-regulation-innovation.pdf [https://perma.cc/Y7PZ-CSMN] (presenting relevant literature and discussing the impact of different regulatory regimes on private sector innovation); Knut Blind et al., *The Impact of Regulation on Innovation* (Nesta Working Paper, Paper No. 12/02, 2016) (presenting empirical literature on the impact of different types of regulation on innovation and showing a rather diverse picture regarding the type of regulation, as well as the sectors, the companies and the time horizon of the impacts).

328. *See* EXEC. OFF. OF THE PRESIDENT, NAT'L SCI. & TECH. COUNCIL COMM. ON TECH., PREPARING FOR THE FUTURE OF ARTIFICIAL INTELLIGENCE (2016) (regarding AI).

329. *See generally* JOSEPH E. STIGLITZ & BRUCE C. GREENWALD, CREATING A LEARNING SOCIETY: A NEW APPROACH TO GROWTH, DEVELOPMENT, AND SOCIAL PROGRESS 135 *passim* (2014) (discussing the relationship between government intervention, innovation, and economic and social spill-overs).

2. *Ordinary Law and Lex Cryptographia: Three Phases of Development*

Three different phases in the development of the interplay between the ordinary law of the physical world and *lex cryptographia* may be identified: the anarcho-libertarian phase; the mainstreaming phase; and, the maturity phase.[330] Each phase favors different aspects of blockchain technology, and produces a different type of interaction between blockchain and the law.

Blockchain technology and DLT have their origins in the crypto anarchist and cypherpunk movements of the 1980s and 1990s with the goal of promoting as widespread use of cryptography as possible, as well as the adoption of technologies that would protect individual privacy; the final goal was social and political change through the means of cryptography.[331] The crypto anarchist and cypherpunk movements gave rise to similar online movements of cyberlibertarianism, i.e., the online independence of the individual from the government.[332] Bitcoin and blockchain technology are the offspring of this intellectual and technological tradition and were developed in an effort to by-pass the institutions of the financial markets, namely commercial banks, as well as central banks.[333] During this anarcho-libertarian phase, blockchains were mostly public and permissionless. Blockchains are moreover inherently "transnational constructs."[334] They are transnational "because they bypass the need for a central server (which necessarily needs to be located in a specific jurisdiction)."[335] The technology remained largely transnational

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330. *See also* Dimitropoulos, *supra* note 25, at 14. The three phases are partly chronologically overlapping.

331. The *Crypto Anarchist Manifesto* authored and originally circulated via e-mail in 1988 by Timothy May, one of the founders of the crypto anarchist movement, opens in a way that mimics the Communist Manifesto. *See* Timothy C. May, *The Crypto Anarchist Manifesto*, ACTIVISM: CYPHERPUNK (Nov. 22, 1992), https://www.activism.net/cypherpunk/crypto-anarchy.html [https://perma.cc/F6CG-S72E]. Eric Hughes, the co-founder of the cypherpunk movement, speaks in his *Cypherpunk Manifesto* of the need for a new social contract largely outside the State and with the goal of protecting privacy; this is to be achieved using the means of cryptography. *See* Eric Hughes, *A Cypherpunk's Manifesto*, ACTIVISM: CYPHERPUNK (Mar. 9, 1993), https://www.activism.net/cypherpunk/manifesto.html [https://perma.cc/J6AY-RXPN].

332. *See* JULIAN ASSANGE ET AL., CYPHERPUNKS: FREEDOM AND THE FUTURE OF THE INTERNET (2012); *see also* STEVEN LEVY, CRYPTO: HOW THE CODE REBELS BEAT THE GOVERNMENT–SAVING PRIVACY IN THE DIGITAL AGE (2002).

333. *See generally* Usman W. Chohan, Cryptoanarchism and Cryptocurrencies 13 (Nov. 27, 2017) (unpublished manuscript) (on file with SSRN), https://ssrn.com/abstract=3079241 [https://perma.cc/B6Y9-M94M].

334. FINCK, *supra* note 1, at 58.

335. De Filippi & Hassan, *supra* note 1.

in this first phase of development. In addition, in the first five to seven years of blockchain the technology remained largely unregulated as there was an absence of regulatory intervention by governments.[336]

The use of blockchains is becoming more common in many spheres of life and business, and the quantity and value of cryptoassets is increasing as well. Mainstream organizations such as tech giants and international banks have more recently come to terms with a technology that was developed to bypass them.[337] The increase in uses and value of the cryptoasset and blockchain markets has naturally attracted the interest of regulators that have been attempting to fit cryptoassets—mostly cryptocurrencies—under traditional regulatory categories. In this mainstreaming phase, blockchains still remained public and permissionless. It was during this phase though that an effort to "domesticate" them started taking place. Domestication of blockchain is an effort by legal orders all around the world to capture and regulate—i.e., embed into a domestic context—a technology that is by nature and design global and transnational. This is a process that may be observed with regard to other technologies as well such as the Internet. The Internet was conceived as a global network, but started developing a territorial dimension, with countries around the world developing domestic laws and other mechanisms to domesticate it.[338] Domestication took place through the means of regulation and embedding presented in previous sections of the Article, mostly regarding cryptocurrencies. Government intervention has been—and still remains—asymmetric; it sometimes favors the technology through sandboxes and innovation hubs for some users and uses, while at other times it is more restricting, particularly as it refers to the transfer-of-value functions of blockchain.

The third phase may be characterized as the maturity phase of blockchain. The public permissionless blockchains are spinning off to private and permissioned blockchains that have started booming in the last couple of years. Mainstream tech companies are now actively involved in the development of the technology, and mainstream companies have

336. FINCK, *supra* note 1, at 46.

337. *See, e.g.*, Wolfie Zhao, *Bank of America Files for 3 New Blockchain Patents*, COINDESK (Aug. 1, 2017, 10:00 PM), https://www.coindesk.com/bank-america-files-3-new-blockchain-patents [https://perma.cc/AD9Y-24BT] (discussing the three blockchain-related patents filed by the Bank of America).

338. *See generally* JACK GOLDSMITH & TIM WU, WHO CONTROLS THE INTERNET? ILLUSIONS OF A BORDERLESS WORLD (2006) (on the ways through which the attempts to control the Internet by powerful States has led to a rediscovery of some of the old functions and justifications for territorial government); Nicholas Tsagourias, *The Legal Status of Cyberspace*, *in* RESEARCH HANDBOOK ON INTERNATIONAL LAW AND CYBERSPACE 13, 17 (Nicholas Tsagourias & Russell Buchan eds., 2015).

started using the technology to improve their operations. In this maturity phase, there are blockchains of all types: domestic, transnational, and also international, as governments and international organizations have developed uses for blockchain. Regulation has started shifting towards adoption of blockchain for government service delivery. Regulation and adoption now take place at the domestic, international, and also regional level of governance.[339] In the United States, no consistent policy may be identified. At the state level, agencies seem to be moving towards promotion and adoption; at the federal level, the clash of agencies is only a symptom of incoherence at the policymaking level.

3. Government Intervention: Publicness, Trust, Interoperability

Blockchain technology and the applications it supports pose great challenges to law as a system, and domestic legal systems. Domestic jurisdictions have been faced with great challenges particularly when dealing with cryptoassets. On the other side, blockchain technology is faced with great challenges stemming from data protection-related laws, such as the GDPR in the European Union.[340] Most data protection laws were developed for the centralized collection, storage, and processing of personal data.[341] It becomes very difficult to transpose this logic to decentralized digital ledgers. The greatest challenge for the future becomes to protect individuals from the risks of cryptoassets including cybersecurity and hacking breaches while at the same time allowing for technological innovation.

The infrastructural understanding of blockchain as well as the discussion of the different phases of the interaction between blockchain and ordinary law help in developing a law and political economy framework of blockchain for the future shaping of the interaction between the law of the digital and the physical world. One may think of the

339. *See EU Blockchain Observatory & Forum*, EUR. UNION BLOCKCHAIN, https://www.eublockchainforum.eu/ [https://perma.cc/S8LX-4M6N]. The European Union has also launched an E.U. Observatory and Forum and is in the process of developing a European Union-wide blockchain infrastructure. *Id.*; *see also* ROBBY HOUBEN & ALEXANDER SNYERS, EUR. PARLIAMENT SPECIAL COMM. ON FIN. CRIMES, TAX EVASION & TAX AVOIDANCE, CRYPTOCURRENCIES AND BLOCKCHAIN: LEGAL CONTEXT AND IMPLICATIONS FOR FINANCIAL CRIME, MONEY LAUNDERING AND TAX EVASION (2018), http://www.europarl.europa.eu/cmsdata/150761/TAX3%20Study%20on%20cryptocurrencies%20and%20blockchain.pdf [https://perma.cc/YY99-TZU6]; *Communication from the Eur. Comm'n to the Eur. Parliament, the Council, the Eur. Cent. Bank, the Eur. Econ. and Soc. Comm. and the Comm. of the Regions*, COM (2018) 767 final (Nov. 28, 2018); *European Countries Join Blockchain Partnership*, EUR. COMM'N (Apr. 10, 2018), https://ec.europa.eu/digital-single-market/en/news/european-countries-join-blockchain-partnership [https://perma.cc/3SYK-2PFF].

340. *See supra* section I.C.

341. *See* FINCK, *supra* note 1, at 103.

following three principles and values as essential in this interaction: enabling public and permissionless blockchains; establishing new foundations of trust in society; and achieving new interoperability functions between the public and private sectors, as well as the physical and the digital world.

As has been observed above, there has been a general tendency in the more recent phases of development of blockchain technology to move away from public and permissionless blockchains and towards private and permissioned blockchains. Providing free access to all network participants has been the major innovation of blockchain technology. The "privatization" of blockchain may potentially stifle innovation, as well as create new dichotomies between those with access and those without access to blockchain. Legislators and regulators could think of ways to again favor public and permissionless blockchain networks. The government may thus consider further streamlining funding into activities relating to the promotion of public and permissionless blockchains. The government may be called upon in the future to develop government-based blockchains; in addition, it may have to interfere to develop alternatives in cases that certain services are provided on permissioned blockchains by private corporations, particularly in the sphere of cryptocurrencies, or potentially other cryptoassets that may in the future be viewed as essential.

Law differentiates itself from other social systems as it embodies a trust inculcated into it through mechanisms of government action such as legislation by the legislative branch of government and regulation by the executive branch of government. For certain actions of societal life that are perceived as needing to be infused with such trust, the law lends its trust quality to such transactions. Transactions in land, for example, require notarization by a notary as well as registration with the land registry.[342] So far, the government has always operated as the mediator of this type of trust in order to safeguard trust in the relevant system. Now, blockchain purports to take up some of these roles by being the generator of trust. The question thus arises as to what extent peer-to-peer trust in blockchain can replace trust in and by the government. The interplay between these two systems of trust, and the use of the blockchain trust mechanism by government is very important for the law and political economy framing of blockchain. Legislative interventions could allow for trust in blockchain to operate with the support of governmental trust. The government could intervene to support blockchain networks in cases of failure to react to the needs of the law and the realities of the physical

342. *See supra* sections II.B.1, I.A.2.b.

world. One example may be legislative provisions such as in (civil) codes, as well as financial and consumer law provisions mandating the reversal of blockchain transactions that would qualify as irregular under the ordinary legal system.

More broadly, the way to mitigate the dangers of embedding through enabling as well as allowing for an interplay between the trust mechanisms of government and blockchains may be by regulating the new cryptoasset and blockchain intermediaries, as opposed to intervening in the internal governance processes of the cryptocommunity or otherwise regulating the operations of developers or individual miners. Cryptoasset and blockchain intermediaries can be used as "regulatory agents,"[343] and be subjected to various types of regulation such as command-and-control regulation. The BitLicense framework may be viewed as a regulatory effort in this direction.[344]

One of the main themes of globalization of law was the effort to understand new institutions and organizations that present features of hybridity between the public and the private sectors. The Fourth Industrial revolution also produces a post-industrial globalization.[345] The new legal questions posed by globalization through the application of blockchain technology are not issues of hybridity; they are rather issues of interoperability of different systems:[346] at the private to private level; at the private to government level; and, at the government to government level. Trade is a case in point.[347] Blockchain technology can potentially facilitate the various dimensions of private to private, private to government, and government to government interactions involved, whether they are cross-border or not. Blockchain can facilitate technical interoperability allowing IT systems of private parties and different agencies to communicate with each other.[348] The problem is that at the moment there are different blockchain worlds designed by different developers that are in competition with each other. Paolo Tasca and Riccardo Piselli present three different scenarios in order to address the

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343. Marian, *supra* note 13, at 66. *See generally* GOLDSMITH & WU, *supra* note 338 (discussing regulatory access points that can be used for regulatory purposes).

344. *See supra* section I.C.

345. *See supra* section II.B.1.

346. *See* FINCK, *supra* note 1, at 152; Tasca & Piselli, *supra* note 153, at 35–40.

347. *See generally* GANNE, *supra* note 4 (discussing the use of blockchain in cross-border trade).

348. *See ISO/TC 307: Blockchain and Distributed Ledger Technologies*, INT'L ORG. FOR STANDARDIZATION, https://www.iso.org/committee/6266604.html [https://perma.cc/JDH2-6PGG] (ISO is in the process of elaborating technical and interoperability standards for blockchain and distributed ledgers).

current problem of "non-interoperability"[349] of various blockchains: the emergence of a single prevalent system, the affirmation of intermediary blockchain systems, or the adoption of middleware software that has the technological capabilities to serve as an intermediary technology for communication.[350] Government may in the future require the digitization and storage on blockchain of various documents, and make interoperability mandatory in one of the ways suggested here.

The infrastructural re-interpretation of blockchain helps us understand that interoperability may even have to go beyond that. The digital world of blockchain and the physical world do not always operate in the originally envisaged isolation. There are multiple access-points of the physical world into the digital blockchain world, and vice versa.[351] A new law and political economy framework for blockchain needs to also guarantee interoperability between the physical and the digital world by bridging the gaps between the physical and the non-physical world. Regulating access points, such as intermediaries, would accomplish this. One could potentially think of government interventions in the *lex cryptographia* and the cryptocommunity, by for example structuring arbitrations resolving disputes arising out of smart contracts, or regulating miners and mining pools. In the last scenario, a regulatory intervention for the regulation of mining pools, rather than individual miners would be closer to the here envisaged law and political economy framework for blockchain.

CONCLUSION

Blockchain technology is a new general-purpose technology that poses great challenges to society and the law. The *lex cryptographia* of blockchain has been designed based on the rational choice assumption of human behavior. The Article suggests that this is not a sufficient foundation for the future development of blockchain, and claims that it is necessary to develop a law and political economy framework of blockchain and its regulation through code. An infrastructural re-interpretation of blockchains as commons may help towards this direction. A law and political economy framework may mean the active involvement of government in the future shaping of blockchain. This will deterministically lead to the need in the future to resolve issues of

349. Tasca & Piselli, *supra* note 153, at 36.

350. *Id.* at 40.

351. *See* FINCK, *supra* note 1, at 86 (speaking of "bridges"); *supra* section II.C.2.a.i.

regulatory capture and failure.[352] As the political economy of the law of blockchain will become more intricate and multilayered, it is important to already lay the right foundations during the first steps of its development.

352. *See* Rahman, *Infrastructural Regulation*, *supra* note 212, at 931–32 (discussing issues of regulatory capture and failure in the new infrastructure economies).