

Decentralization and Feedback Effects

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Abstract

This article discusses the historical most relevant types of decentralization that helped usher in the age of decentralization. Key components of decentralization that are discussed herein include: decentralization of science, technological decentralization, organizational decentralization, market decentralization, governmental decentralization, and societal decentralization. The author discusses the feedback effects that exist between the respective types of decentralization.

Key Words: Decentralization, History, Digital Assets, Decentralized Finance, Blockchain, Start-up, Decentralized Commerce, Emerging Technology, Token Models, Incentive Design, Tokens, Distributed Ledger Technology, Decentralized Infrastructure, Reputation Staking

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I. Introduction

The very nature of decentralization and the resulting diversity makes categorization of decentralization difficult. Decentralized systems are constantly morphing and evolving with new features. The resulting diversity of facets of decentralization make categorization difficult. Yet, there are certain areas where the application of decentralization is of greatest impact and these areas tend to impact each other. Such applications can be categorized by core commonalities and iterative feedback effects. The resulting general types of decentralization include but are not limited to the following:

1. Decentralization of science
2. Technological decentralization
3. Organizational decentralization
4. Market decentralization
5. Governmental decentralization
6. Societal decentralization

These types of decentralization, among others, are each subject to iterative decentralization processes and affect each other by way of feedback effects. As one type proliferates, the other types are slowly but increasingly affected, leading to changes that, in turn, affect each other. The combined learning and feedback effects lead to the creation of new markets while changing other markets and, over time, create a slowly emerging new economy. The different forms of decentralized commerce affect society at multiple levels, as different constituents begin to experiment with their own applications and new solutions, in turn, create feedback effects for each of the six types of decentralization.

II. Decentralization of Science

Throughout history, science's evolution has been mostly centralized. Centralization in science has been a natural result of the scientific consensus of leading experts in a given field who later passed on their collective insights and their prevailing opinions to the general public. The general public had no means of fact checking scientific findings and the prevailing opinion,

partially because the general public lacked the sophistication, knowledge, and the tools to second-guess scientific expert consensus.

Experts enable scientific advancement. Science and its ever-increasing significance for society would not be possible without the expertise, knowledge, talent, and effort of naturally gifted experts who dedicate their lives to their respective fields. The division of labor and the specialization of experts in a given field is a natural way to increase scientific output for society.

Scientists were the first to realize the benefits of network infrastructure for enhanced scientific output. For example, the evolution of the internet would not have been possible without the significant input and volunteer work from the science community. Through networks, relatively small geographic groups of scientists in a given fields were able to increase their exposure to the insights of colleagues and improve their own findings and scientific output.

The centralized nature of instruments of scientific development and research results in naturally centralized scientific consensus. Without the ability to create a broader societal consensus, the need for peer recognition to advance a given field of research discourages individual responsibility and individual creativity. The centralized instruments developed to facilitate peer recognition can result in expert-focused thinking and practices that ignore community-driven ideas. The perceived need in the scientific community to place scientific output in ranked scientific journals can inculcate and perpetuate scientific bias. Scientific journals typically prefer to publish papers that reject the null hypothesis, use big datasets, and demonstrate big effect sizes. Significant findings that do not meet these criteria may simply be ignored. The use of peer reviews can further exacerbate these effects and can result in forms of cartelization of knowledge because non-conforming innovative ideas may not get full recognition. In an effort to protect and perpetuate existing scientific findings and the scientific hierarchies that helped create them, new findings may not (or only much delayed) get scientific peer recognition.

The centralization of scientific methods and output has led to suboptimal outcomes for society. A litany of studies suggest that

scientific findings are frequently questionable or cannot be reproduced.¹ Non-expert forecasters are often better than expert forecasters.² Random selection of stocks can produce superior results in comparison with expert selection.³ Perhaps the most notorious example of the vagaries of centralized expert opinions and their scientific support is provided by the health and nutrition industry. In particular, the often contradictory yet industry supported prevailing expert science/opinions on nutrition and dieting over the last century illustrate the detrimental effects on society created by path dependencies in science.⁴

Decentralization of science is an iterative process inaugurated by the increasing networkability of society. As interested parties are increasingly networked through technology, they can now collectively second guess the prevailing expert opinions in a given field of science. This collective decision-making process is most certainly afflicted by conspiracy theorists, pseudo-science, cranks, lemmings, and herd mentalities. Yet, the collective reasoning process creates a wisdom of the crowd that is often lead by experts in their respective fields. Over time, the impurities of collective decision-making filter themselves out as interdisciplinary feedback effects allow enhanced testability of outputs over time. Decentralized peer-to-peer paradigm shifts of prior-held centralized scientific insights are possible and will proliferate. Economics of science supports this decentralized paradigm shift because through the increased networkability the cost of ascertaining the accuracy of scientific results is decreasing while the price for being inaccurate or wrong as a scientist is increasing.

Public access to scientific output is increasing. The scientific community has started to realize the need to make their work

¹ Wikipedia. Reproducibility Project, https://en.wikipedia.org/wiki/Reproducibility_Project (accessed June 1, 2020).

² Wikipedia. Superforecasting: The Art and Science of Prediction, https://en.wikipedia.org/wiki/Superforecasting:_The_Art_and_Science_of_Prediction (accessed June 1, 2020).

³ S.H. (June 4, 2014). No Monkey Business? The Economist, <https://www.economist.com/free-exchange/2014/06/04/no-monkey-business> (accessed June 1, 2020).

⁴ Amidor, Toby (May 10, 2019). Has Nutrition Really Changed Over the Past 40 Years? U.S. News, <https://health.usnews.com/health-news/blogs/eat-run/articles/how-the-dietary-guidelines-have-changed> (accessed June 1, 2020).

accessible to a broader audience. Wikipedia illustrates the power of decentralized scientific paradigm shifts or affirmations. Wikipedia depends on the wisdom of the crowd with random experts in a given field leading entries for the greater good of society. Many scientists have begun to publish semi-popular or popular books that illustrate the significance and applications of their findings and research. For example, whereas in the past, econometric research was the domain of an elite group of research economists, popular books such as *Nudge*⁵ or *Freakonomics*⁶ have provided the public with easier access to and an enhanced appreciation for research findings in the fields of behavioral economics. In computer science, the open source movement has made scientific contributions to computer science publicly available. In other disciplines, online journals and public postings on the Social Science Research Network and Researchgate are increasingly influential and common. Moreover, other blogging outlets such as Medium are becoming an ever-increasing relevant medium of communication and information exchange. The centralized restrictions of publishing in academic journals do not apply to these emerging publication mediums. Overall, the public access to scientific output is increasing dramatically. This could suggest an overall move away from centralized scientific tools.

Technological Decentralization

Technological forms of decentralization are a natural extension of the decentralization of science. As scientific developments in a given field advance, the technological tools for such scientific discoveries evolve as well and in turn drive new scientific findings. Technological tools include materials, techniques, skill sets, and processes. For example, the invention of the printing press advanced scientific exchange which in turn enabled new insights and a broader dissemination of scientific discoveries.

⁵ Thaler, Richard H., & Sunstein, Cass R. (2008). *Nudge : Improving Decisions About Health, Wealth, and Happiness*. New Haven: Yale University Press.

⁶ Levitt, Steven D., & Dubner, Steven J. (2006). *Freakonomics : A Rogue Economist Explores the Hidden Side of Everything*. New York: William Morrow.

Such technological tools enable feedback effects for the advancement of science and society.

Historically, several technology-related infrastructure developments predated decentralized peer-to-peer technology solutions. Digitization in combination with the proliferation of the internet enabled the digital transformation of business and society. In turn, the digital transformation economy where digital transformation of a given business moves to the core of that business, became a natural precursor to the internet of things and its progeny. Cross-pollination from the proliferation of telecommunication and IoT accelerated the proliferation of social media and the associated increase in networkability of society. Cloud computing and peer-to-peer computing developed as a natural extension of digital transformation. The combination of these developments increased the networkability of society and enabled for the first time in history a form of decentralized production at lower cost. The combination of technology infrastructure and economies of scale facilitated peer-to-peer transactions at scale.

Technological forms of decentralization started to become increasingly possible in the aftermath of the invention of the internet. By creating online communities and giving them the ability to communicate across borders in real-time, the internet created new forms of communication, e-commerce, and knowledge exchange on the edges of the network. The initial pioneers of internet technology saw it as a fully decentralized network that could not be controlled by any one person or entity. When it became apparent that consumer preferences would require political compromises in the internet architecture, the initial vision of the internet morphed into the cyberpunk movement. BitTorrent demonstrated that decentralized protocols, applications, and ledgers are difficult to censor or regulate. Future versions of decentralized protocols will likely expand the visions of their predecessors, such as BitTorrent and the original internet architecture.

The transition from a traditional client-server computing architecture to a peer-to-peer networking architecture was the most significant step toward the evolution of decentralized technology.

Through the removal of centralized hosts and servers, the nodes that form the peer-to-peer network make computing resources, such as disk storage, network bandwidth, and processing power, directly available to each other. Network effects proliferate in peer-to-peer networks because, unlike the traditional client-server architecture which is subject to the linearly increasing per-unit costs, the peer-to-peer network costs decrease with each added node.

Blockchain-based decentralized technology solutions emerged almost a decade after the first instantiation of peer-to-peer networking. In 2009, Satoshi Nakamoto released the Bitcoin whitepaper which later was instantiated in code and created the cryptocurrency BTC. It was released as a blockchain with an incrementally growing registry of transactions that could not be changed. The cryptocurrency community continues to evaluate abstractions and use cases for the consensus mechanism of Bitcoin.

At the beginning of the twenty first century, blockchain technology epitomizes decentralized technology. Blockchains such as the Bitcoin blockchain distribute value and power across global systems. They allow the more equitable, open, and efficient exchange of information. Blockchain technology has the potential to transform the existing digital universe into a complex adaptive system of the kinds found in nature.

It can help facilitate complex coordination between unknown network participants on a global scale. The technology has the potential to create a complex yet efficient human-machine ecosystem that facilitates complexity without chaos, abundance without excess, multiplicity without superfluity, and coordination without control.

III. Organizational Decentralization

The central themes in the story of civilization revolve around the core challenge of coordinating human behavior and groups of humans to behave in peaceable and productive ways. To accomplish peaceable and produce coordination of human behavior it is necessary to align different groups of humans with

each other. Incentive coordination and incentive alignment between disparate groups of individuals play a central role in this context. In the post industrialized era, forms of limited liability entities became a focus point for the coordination of human behavior through incentive designs. In limited liability entities, coordination revolves around those individuals who delegate authority (principals) and those who are acting on behalf of others (agents). Because of naturally human shortcomings, bounded rationality, incomplete foresight, and information asymmetries between principal and agent,⁷ it is impossible for principals to contract for every possible action or inaction of the agent in order to induce the agent to act in the best interest of the principal.⁸ Agency theory is the leading theory for conflicts between the constituents of limited liability entities, such as shareholders, corporate managers, and debt holders, among others.⁹ A vast literature attempts to explain the nature of the agency conflicts and possible ways to resolve such conflicts.¹⁰ Theory and practice have not successfully addressed the outstanding issues. For example, the core agency conflicts emanating from the separation of ownership (shareholder principal) and control (manager agent) cannot be fully addressed by the existing theoretical and legal framework. Accordingly, peaceable and productive human behavior is still found wanting in many ways.

Organizational models are the product of path dependencies that undermine the evolution of organizational decentralization.

⁷ Kaal, Wulf A. (2014), *Evolution of Law: Dynamic Regulation in a New Institutional Economics Framework*. In Wulf A. Kaal, Matthias Schmidt, & Andreas Schwartz (Eds.), *Festschrift zu Ehren von Christian Kirchner*. Mohr Siebeck.

⁸ Brennan, Michael J. (1995). *Corporate Finance Over the Past 25 Years*. *Financial Management*, 24(2), 9.

⁹ Jensen, Michael C. & Meckling, William H. (1976). *Theory of the Firm: Managerial Behavior, Agency Costs and Ownership Structure*. *Journal of Financial Economics*, 3, 305. The agency model at its very basic level suggests that information asymmetries between the principal and the agent and agents' opportunistic behavior resulting from self-interest leads to principals' lacking trust in agents

¹⁰ For an overview of the relevant literature see, Shieffer, Andre & Vishny, Robert W. (1997). *A Survey of Corporate Governance*. *Journal of Finance*, 52(2), 737-783.

Society evolved under the paradigm of hierarchy and top-down command and control. Such hierarchical coordination of human behavior creates path dependencies for organizations that coordinate human behavior. Society tends to default to the existing centralized and hierarchical paradigm for the creation of organizational modes. Because of these societal path dependencies, organizational decentralization is subject to significant obstacles that hinder the transition of power from governments and large hierarchical organizations to the edges.

Business leaders have used early forms of organizational decentralization within hierarchical structures as a business management tool for the coordination of human behavior and for enhanced economic performance for decades. In the pre-and-post internet era, companies have used decentralization of their organizational structures to their advantage without significant new technological innovation. General Electric (GE) under Jack Welch provides a prominent example of successful organizational decentralization. Before GE was run by Jack Welch, it was a highly centralized institution with a highly centralized bureaucracy that created significant inefficiencies and depressed economic performance. Welch decentralized GE by separating out GE business units that had previously been linked in a conglomerate with associated reporting duties etc. Under Welch, each new business unit maintained its own profit-and-loss statement and were so independent that if Unit A wanted to buy a product from Unit B, it had to pay the full market price. Segmenting the company and creating distance and, in fact, competition between departments and business units worked. Welch's approach required each business unit to become fully accountable and remove inefficiencies. Welch's method enabled each business unit to be run efficiently and profitably, while allowing unit heads significant flexibility and independence. GE's market value skyrocketed as a result of its decentralization of business units.

Technological forms of decentralization via the internet enabled new hybrid forms of organization. Internet-based platform companies like eBay and Amazon provide examples of centralized companies that decentralized the customer experience. These companies combined the best of both worlds. They used the structure, control and associated profit optimization of centralized

entities and combined it with the bottom-up approach of decentralization in the form of customer reviews. This combination brought significant success to eBay but also created tensions. While people are willing to trust others by way of user ratings, they also require safeguards for consumers that typically require command-and-control centralized structures. eBay's use of network effects and network growth made it increasingly useful and increased the likelihood that customers would stay with the network. While the user ratings eBay uses clearly have flaws (that illustrate the need for a decentralized reputation verification system), so far, no entity or individual has been able to come up with a better technology. eBay's decentralized user ratings proved to be its biggest competitive advantage. Like eBay, Amazon is a hybrid organization in the sense that it has a centralized hierarchical control structure combined with a powerful set of decentralization features. Amazon also tapped into peoples' generosity and desire for community by channeling it in to a decentralized network of reviewers in a reviewer system.

Existing hierarchical organizations have long experimented with organizational designs that allow them to stay more nimble to foster innovation. As the bureaucratic hierarchy inevitably grows over time, creating red tape, inefficiencies, and ever increasing transaction cost, hierarchical organizations benefit from keeping a startup mentality that fosters innovation. Accordingly, they have started to experiment with flat hierarchies, co-creation, and best-idea-wins approaches, albeit in the existing hierarchical order. Especially the technology companies in Silicon Valley started this experimentation.

Decentralized autonomous organizations (DAOs) epitomize organizational decentralization. Launched in May 2016, the first DAO was set up as an organization based purely on code and smart contracts. It did not have a conventional corporate structure, no incorporation, and had no physical address or headquarter. All traditional control mechanisms employed by principals in agency relationships had been entirely removed. People who work for the DAO are subject to a different kind of agency relationship. DAO workers were engaged in a dynamic set of working relationships that continuously and dynamically self-organized around projects

and outcomes, not corporate hierarchies with implicit hierarchical biases.

The original DAO has a lasting impact on emerging DAO designs. It creates core commonalities and associated path dependencies in futures generations of DAOs. The core common denominator for all DAO token members is the unifying desire to optimize the DAO token value. Accordingly, performance assessment in the DAO structure is based on value optimization not on hierarchical or political processes. On the upside, token holders and contractors work towards a common goal of optimizing the DAO and the token value and non-performance reputational penalties are free from racial or cultural biases and associated implications as the token holders are unlikely to even know each other. Yet, the focus on the value enhancement of fungible tokens can lead to short termism and may ignore ethical and governance issues.

DAO developers are also subject to path dependencies which undermine the evolution of decentralized DAO designs. The communication structures in organizations will invariably influence future designs.¹¹ While groups of DAO developers certainly influence DAO designs with their collective assumptions about how their intended DAO users will engage with the DAO, the inherent structure and approach of a group of developers building a software solution typically has an even larger impact on DAO design. The collective reasoning process of DAO developers is based largely on their prior experiences with DAO software solutions which form path dependencies. The impact of such path dependencies became apparent in the Ethereum developer community and their attempts at upgrading Ethereum 1.0 to 2.0 in the late 2010s.

To overcome these shortcomings and path dependencies, the network of developers that builds decentralized software solutions

¹¹ Conway, Melvin E. (1968). How to Committees Invent? *Datamation*, 14(5), 28-31. "Organizations which design systems... are constrained to produce designs which are copies of the communication structures of these organizations."

and DAOs should be decentralized itself. Human brains naturally simplify complex systems for the sake of coherence. By contrast, complex adaptive systems constantly evolve through self-regulation of self-organizing group behaviors. The decentralized interaction of DAO developers could help support random developer interaction and make developer perspectives on software development more diverse. Epitomizing the participant design of system software by and for participants, decentralized software development could support software experiments in which cultivating or abandoning software takes place in a fluid state of co-relation coalescing around projects, not in top-down hierarchical structures. At the beginning of the 2020s, no forum existed that could support truly decentralized software development with a sufficient incentive design.

IV. Market Decentralization

Markets of the past evolved through centralized hubs. Historically, the physical location of hard assets determined trading relationships. Financial hubs evolved because they were able to connect interested trading parties that otherwise would not know of each other. Centralized financial hubs facilitate price discovery and increase liquidity. For example, connecting the east and west coasts in the US via the railway system enabled over time the creation of Chicago as a financial hub. The shipment of hard assets through Chicago and the need for physical settlement of trades in hard assets over time established Chicago as a hub for financial products and derivatives.

Market and economic liberalization policies often result in privatization and deregulation of formerly government-controlled functions. Privatization of former government functions shifts the responsibility for public services and products from the public to the private sector. Post privatization, the private sector, that is, any non-government organization such as a private corporation and businesses, fulfills functions that had prior to the privatization been the exclusive domain of the government. Examples include the privatization of the mail and railways, among others.

Despite the centralized infrastructure of most markets, some markets were able to evolve without meaningful centralized coordination. For example, the foreign exchange (FX) market evolved without centralized coordination because currency trading did not require a physical location. While a large part of FX trading takes place on the established exchanges, FX traders can also use decentralized forms of exchange via the internet for price quotes from FX dealers around the world. Similarly, over-the-counter (OTC) markets evolved decentralized because physical location is not determinative for the trade. OTC market participants can trade commodities, currencies, stocks, or other instruments directly, peer-to-peer, electronically and without a central exchange or broker. Another example is provided by real estate transactions. While the physical location is key, real estate transactions are not coordinated through centralized hubs or clearinghouses.

The digitization of content has made perhaps the most lasting contribution to the decentralization of markets. The digitization of content was a natural precursor for platform businesses, internet of things, and its progeny. The associated digital transformation of business provided new capabilities, enhanced innovation, and the creation of new revenue streams. The physical location of assets becomes less important when more content is digitized and online and virtual products emerge. As a result, markets are becoming increasingly decentralized. For example, with the removal of the traditional trading pits in Chicago and New York City, the move to electronic trading enabled trading around the clock independent of physical location of a given trading counterparty.

Internet-based e-commerce has prepared consumers for ever increasing decentralized forms of commerce. Electronically buying or selling of products or services over the internet has changed the economic realities for many countries and boosted

new industries. For example, since 2013, almost a quarter of the Czech Republic's total turnover is generated via online channels.¹²

With the emergence of the Bitcoin protocol in 2009, the digital asset market began to evolve. Until the creation of the first known alt-coin (e.g. an alternative coin to Bitcoin) around April 15, 2011, Bitcoin virtually dominated the market and was in fact the only digital asset. Between 2017 and 2019, the alt-coin market proliferated significantly. Correspondingly, from 2016 to 2017, Bitcoin's market share dropped dramatically. At the end of 2014, with the instantiation of smart contracting in the Ethereum ecosystem and the ETH currency, the market for digital assets started to diversify and proliferate substantially. New alt-coins emerged almost weekly, leading to over 2000 cryptocurrencies in circulation in late 2018.

Such new cryptocurrencies created a new market for initial coin offerings (ICOs). The ICO market peaked from March 2018 to June 2018. The percentage of ICOs in relation to total fundraising of blockchain startups dropped from 80% to around 35% in August 2018 and only marginally recovered between September 2018 and February 2019 at around 40% to 50% before dropping to 20% in March 2019. From March 2017 to June 2018, ICOs were the overwhelmingly dominant fundraising tool for the blockchain industry. The demise of the ICO market turned the overall trend away from ICO funding to venture funding in the blockchain industry.

The emergence of the ICO market changed the market for venture funding. In the existing venture capital model, venture capital funds invest significant amounts of money in the hope of finding the next unicorn start-up. This investment process is subject to long, complex, and time intensive processes leading up to a late

¹² Ecommerce News (June 18, 2013). Ecommerce Contribution in Europe [Infographic], <https://ecommercenews.eu/infographic-ecommerce-contribution-in-europe/> (accessed June 1, 2020).

liquidity event in the form of an IPO or acquisition. By contrast, ICOs provide liquidity to investors much faster and allow venture capital funds to capitalize on existing profits early. Venture capital funds who invested in crypto start-ups gain access to much earlier liquidity via ICOs by converting their cryptocurrency profits into Bitcoin or Ether through any of the cryptocurrency exchanges and can thereafter transfer into fiat currencies via online services such as CoinsBank or Coinbase. During the ICO boom years, the venture capital market in the decentralized technology sector ground to a halt. In the aftermath of the ICO boom and collapse, venture funding has become, again, the predominant model for funding blockchain startups.

Market decentralization via ICOs and other decentralized funding methods has significant disruptive effects on finance. ICOs provide lower barriers to entry for a more diverse body of investors and thus increase the diversity and the heterogeneity of start-up funding. Through borderless online sales, ICOs are directly marketed to a worldwide potential pool of investors, bypassing the typical legal, jurisdictional, and business hurdles in traditional venture capital financing.¹³ Moreover, ICOs benefit from limited accreditation standards, as well as from multiple global cryptocurrency exchanges that provide continuous access to trading.¹⁴ ICO promoters and their developers are not forced to sacrifice their equity in the project in exchange for the funds they raised.

Emerging decentralized technologies further expand the decentralization of markets. For example, the concept of tokenization, that is the tokenized instantiation and trade of physical assets, is an extension of the markets in stock, futures, and other derivatives. With tokenization, fractional interest in hard assets, such as art and real estate, can be traded without physical determinants.

¹³ *Ibid.*

¹⁴ Sunnarborg, Alex (June 11, 2017). ICO Investments Pass VC Funding in Blockchain Market First. *Coindesk*, <https://www.coindesk.com/ico-investments-pass-vc-funding-in-blockchain-market-first> (accessed June 1, 2020).

Decentralized Cryptocurrency Exchanges (DEX) provide a prominent example of increasing market decentralization. A DEX is a peer-to-peer cryptocurrency exchange. In 2019, prominent DEX included IDex¹⁵ and EtherDelta,¹⁶ and OAX.¹⁷ DEX provide an instantiation of a core promise of decentralized technology.¹⁸ DEX epitomize market decentralization because they allow users to interact and trade anonymously in a secure environment without the need for third party intermediation.

DEX can be distinguished from centralized cryptocurrency exchanges in several key ways. DEX have no centralized nexus or a jurisdiction where an identified exchange controller could reside. Users are not required to open a separate wallet on the DEX. Rather, they trade with other peers directly through their respective wallets. Settlement is effectuated on a delivery versus payment basis directly between the respective trading parties. Proprietary trading intermediaries, such as market makers and centralized third-party operators, cannot inject themselves in a transaction. As a result, conflicts and counterparty risks are absent in a DEX. The ownership of digital assets off-exchange delays trade execution but ensures higher levels of overall asset security. Moreover, the fee structure in a DEX is different from a centralized cryptocurrency exchange which typically charges a percent of the total value of the transaction. Instead, on a DEX, the users pay a fee as gas, more akin to a per-trade fee, which is a fraction of the percent transaction fees charged on centralized cryptocurrency exchanges. Because a DEX does not centralize authority over users' assets, users can sign and start trading anonymously, that is, without identify verification. Centralized cryptocurrency exchanges struggle keeping up with know your

¹⁵ IDEX, <https://idex.market/eth/idex> (accessed Oct. 29, 2019).

¹⁶ Etherdelta, <https://etherdelta.com> (accessed Oct. 29, 2019).

¹⁷ OAX Foundation, <https://www.oax.org> (accessed Oct. 29, 2019).

¹⁸ See, e.g., Dai, Wei. "B-Money". Archived from the original on March 28, 2018, <http://www.weidai.com/bmoney.txt> (accessed June 1, 2020); May, Timothy C. (Nov. 24, 1992). The Crypto Anarchist Manifesto, Activism.net, <https://activism.net/cypherpunk/crypto-anarchy.html> (accessed June 1, 2020).

customer and anti-money laundering rules. Most DEX have been struggling with liquidity and price discovery.

The code that constitutes the backbone of any DEX provides the operational rules for the exchange of digital assets between users. The code replaces the regulatory framework that applies to centralized cryptocurrency exchanges. Orders on a DEX are matched and settled through the operational rules provided by the code. Unlike central order books on centralized exchanges and the settlement back office that facilitates the finalization of a trade, on a DEX, the code facilitates the peer-to-peer exchange without the involvement of any intermediary. The DEX code also allows the avoidance of any third-party intermediary gateway to facilitate a given trade. While the creator of a given DEX typically only has a rather limited role in the evolution of the DEX, the code that provides the operational rules of the exchange may still be subject to the centralized control of certain developers. The idea of a completely open source DEX without any ongoing developer involvement remains untested. Architecturally, DEX can be seen as centralized because the DEX code and the operational rules of the DEX code in effect create the exchange and facilitate a central order exchange function and price discovery, not a peer-to-peer exchange.

Despite many of the benefits that derive from its decentralized exchange model, DEX may not be able to ensure market integrity. Just like centralized cryptocurrency exchanges provide certain traders with benefits that may provide them with advantages at the expense of others traders, the code that creates a DEX may also allow the asymmetric distribution of trading information based on user status.¹⁹ The code may also create new risks to market integrity because of its automation and lack of a human backstop in compliance, back office, and settlement. Wash trading, frontrunning, and insider trading are risks to market integrity that

¹⁹ See Underwood, Barbara D. (Sept. 18, 2018). Virtual Markets: Integrity Report, Office of the New York State Attorney General, <https://virtualmarkets.ag.ny.gov/> (accessed June 1, 2020).

can materialize on DEX, among other price-manipulation practices.

V. Governmental Decentralization

Democratic republics and their constitutions are brilliantly designed systems to maximize freedom and curtail hierarchical overreach. For example, the Constitution of the United States of America is intended to facilitate a political order that creates as much human autonomy as possible. Yet, like any operating system, constitutional democracies are slowly reaching their limits. Societal and constitutional change is an iterative piecemeal process through forms of silent withdrawal, disengagement, defiance, and truculence of ordinary people.²⁰

Governmental decentralization is incommensurable because of its different kinds, degrees, or dimensions. Governmental decentralization describes the process of transference of responsibility and authority for public functions from centralized governmental agencies to centrally subordinated but quasi-independent public or private entities. Governmental decentralization encapsulates and often overlaps with other forms of decentralization including: political, administrative, fiscal, and market decentralization. These permutations of governmental decentralization may appear in, yet again, different forms, instantiations, and combinations thereof. What makes matters even more complex are the heterogeneous geographical locations of these combined effects of governmental decentralization. Different forms of governmental decentralization can appear in different sectors and across country borders while transcending cultures.

²⁰ Kropotkin, Petr. (1896). *The State: Its Historic Role*, <https://theanarchistlibrary.org/library/petr-kropotkin-the-state-its-historic-role> (accessed June 1, 2020); Scott, James C. (2012). *Two Cheers for Anarchism: Six Easy Pieces on Autonomy, Dignity, and Meaningful Work and Play*. Princeton; Oxford: Princeton University Press.

Governmental decentralization appears in different levels of intensity. For example, de-concentration of centralized governmental functions can be identified as perhaps the weakest form of governmental decentralization. In de-concentration, the centralized governmental functions merely shift to more regional instantiations of the same function or by way of centralized supervision of the function in the region. By contrast, delegation is a heightened form of governmental decentralization because the central government transfers centralized public functions to a quasi-autonomous public or private entity. Examples of governmental delegation include semi-autonomous school districts, regional development corporations, housing authorities, transportation authorities, or special service districts. Finally, governmental decentralization may also consist of devolution. *Devolution* of otherwise centralized governmental functions typically consists of a more complete transfer of authority to quasi autonomous entities and local governments that have their own democratic legitimacy and independent sources of funding and taxing.

The impact of governmental decentralization depends on the combination of several key factors. The political, fiscal and administrative arrangements which characterize the decentralization can differ greatly. For example, private organizations and local governments can rarely fulfill government functions effectively if they do not control an adequate level of revenues. In turn, to be effective, local government control over revenue needs to be tied to the authority to make decisions about local government expenditures. The combination of local finance following local government functions while adhering to local priorities controlled by overall accountability is key to successful governmental decentralization. The training of both federal and local officials in decentralized administration methods is also a key to the success of government decentralization. In the transition process, private enterprises and local governments often depend on technical assistance as well as in the fiscal, planning, and management of decentralized government functions.

Governmental decentralization can create several improvements for society. By allowing local experimentation with governance solutions, government decentralization can lead to more

innovative and responsive programs for the greater good of the citizens and constituents. By facilitating citizens with improved control over public programs at the local level, government decentralization can increase political stability and national unity. It can remove the bottlenecks in decision making that are often associated with central government planning and simplify complex bureaucratic procedures. It can create a lasting improvement in the relationship between the government and its constituents. Governmental decentralization can result in enhanced and localized democratization, pluralistic politics, and representative government. The selection of representatives from local electoral jurisdictions enables constituents to be more familiar with their respective political representatives. In turn, it allows representatives to improve their knowledge of the needs and desires of their constituents. Local governments can make decisions with greater participation of their constituents which may result in better informed and more diverse interests in society – compared to decisions only made by national political authorities.

The degree of success in governmental decentralization is often associated with the level of accountability instituted in the process. Accountability depends on the availability of information. In the aftermath of governmental decentralization, politicians and local officials are more incentivized to be responsive to local needs if a system of accountability has been instituted based on public or otherwise available transparent information. The information enables the community to effectively monitor or react to the performance of the newly instituted local government.

Governmental decentralization also has several potential disadvantages. The economic rationale for decentralization and its impact on equity, efficiency, and macrostability are not always clear. In fact, decentralization may not always be efficient as centralized economies of scale create the near-optimal efficiencies for economic growth. Especially standardized network-based services are very difficult to improve with decentralized approaches when the level of technical and administrative know-how at the local level is suboptimal. This suboptimality is exacerbated if the local government does not have adequate financial resources. If instituted despite these shortcomings,

government decentralization may result in the loss of economies of scale. Furthermore, government decentralization at the local level can favor local elites and may overcomplicate the coordination of national policies.

Affirmative governmental decentralization can take different forms. Top-down governmental decentralization typically is initiated by the controlling governmental entity and its center of authority. Top-down decentralization is often motivated by fiscal considerations. A federal authority may consider decentralized solutions in an effort to find additional resources to pay off government debt or pay for services. By contrast, bottom-up governmental decentralization can result from regional governmental units and localities. Bottom-up governmental decentralization is often a result of an agreed upon combination of authority between the controlling federal or central government and their regional counterparts. Bottom-up governmental decentralization often follows from a realization that local or regional governmental responsiveness is superior. It increases local authority participation and often increases long-term political stability in the region.

Silent governmental decentralization is the process of decentralization that is not based on explicit policies. While most political decentralization is based on policy changes and affirmative reform efforts, silent governmental decentralization may occur as a result of inevitable changes in policy emphasis, networks, and resource availability.²¹ Such silent political change can lead inevitably to a more decentralized system.

Governmental decentralization often takes place during times of political or economic crises. The fall of a regime and the resultant power vacuum often causes power struggles. It is during those power struggles that forms of political decentralization emerge. For example, at the end the second decade in the 21st century, the

²¹ Dubois, Hans F.W. & Fattore, Giovanni (2009). Definitions and Typologies in Public Administration Research: The Case of Decentralization. *International Journal of Public Administration*, 32:8, 704-727.

increasing crises of legitimacy in politics resulted in democratically legitimized governmental decentralization. Political and regulatory decentralization of society are often public reactions to increasing economic decline, demands of minorities for a greater say in local governance, the general weakening legitimacy of the public sector, government's inability to fund services, the overall decline in government services, and global and international pressure on countries with inefficient, undemocratic, overly centralized systems. Decentralization reforms of government are typically motivated by society's desire to find solutions to new geopolitical problems, such as the emergence of a new automated workforce that replaces existing and traditional employment opportunities, the human migration from Africa to Europe, the disillusionment of large parts of society with existing political and social institutions, such as the European Union, the Brexit movement, among many other political issues that require solutions. Decentralization in the aftermath of political crises depends on forms of experimentation with decentralized functions.

Governmental decentralization in combination with increasing technological and organizational decentralization often inaugurates regulatory decentralization. For instance, in April 2016, the Financial Conduct Authority ("FCA"), the financial regulatory body in the United Kingdom, broke new ground by announcing the introduction of a "regulatory sandbox," which allows both startups and established companies to roll out and test new ideas, products, and business models in the area of fintech (i.e., new technologies aimed at making financial services, ranging from online lending to digital currencies, more efficient). The idea behind the sandbox is to provide a safe space for testing innovative and increasingly decentralized products and services without being forced to comply with the applicable set of rules and regulations. With the sandbox, the regulator aims to foster innovation by lowering regulatory barriers and costs for testing disruptive innovative technologies, while ensuring that consumers will not be negatively affected. What makes the regulatory sandbox so attractive is that, insofar as technology has consequences that flow into everyday lives, such technology will be open to discussion and democratic supervision and control. In this way, public entitlement to participate in regulatory debates can help to create a renewed sense of legitimacy that justifies the

regulation. Given these benefits, other regulatory sandboxes have been introduced by other regulators, such as the Australian Securities and Investment Commission (ASIC), Singapore's Monetary Authority (MAS) and Abu Dhabi's Financial Services Regulatory Authority (FSRA).

With the emergence of decentralized technologies, the role of the central government is increasingly under attack. For example, in the early 2020s, the Bitcoin cryptocurrency could not be controlled or regulated by centralized governments and has spawned a community effort to find more decentralized applications that are free from government control. Leading technologists are experimenting with ideas that would allow new forms of society that are free from centralized control. Seasteading, for example, would enable the establishment of human societies on permanent dwellings on the high sea and outside the territory claimed by any government. As such, seasteaders would be able to experiment with new societal solutions that are not subject to the control and oversight of centralized governments. In 2020, seasteading is at the very earliest point of implementation, subject to engineering challenges, and still largely experimental.

VI. Societal Decentralization

The historical evolution of technology created the foundation for the emerging societal decentralization. Vast technological innovation during the industrial revolution resulted in ever increasing social decentralization. For example, the printing press, digitization, and the internet allowed knowledge and information to reach a broader demographic. Similarly, technological innovations in personal transportation, such as steam engine for railway travel and the combustion engine for the automobile, increased personal freedom and social mobility. Social mobility and access to middle-class life was further enabled through the decentralization of manufacturing which created increasing employment opportunities in local areas.

As the broadest extension of technological decentralization, the internet era gave rise to the most significant societal decentralization. Communication and commerce were freed of geographic limitations. At the beginning of 2020, about one fourth of humanity engaged in virtual communication on social media in

some capacity. Social media created a form of social cohesion that was unprecedented in terms of geographic social interaction. Views and values could be exchanged and influenced with an unprecedented geographic reach. Prior marginalized groups can coordinate their efforts world-wide through online groups that promote their shared ideas. Social functions that formerly belonged to local groups were increasingly being fulfilled by social media exchanges where influence is allocated to the most popular content and its creator.

Societal boundaries are continuously being shifted via internet-based knowledge exchange and social media. In the pre-internet era, knowledge was mostly accumulated by and exchanged with specialists. Internet-based knowledge sharing helps remove information silos and information privileges that created societal structures and privileges. With the dawn of the social media age, the level of interaction between non-specialists has increased dramatically, removing hegemony and centralized control structures over information while creating a more skilled and knowledgeable work force. For example, micro task work via Crowdfunder and Amazon Mechanical Turk enable lower skilled or unemployed individuals to earn a living through micro task work over the internet. Recruitment for such work typically takes place over social media outlets, that is by word of mouth on social media channels.

Internet-based collective decision making via the crowd can replace the centralized coordination functions in society. For example, in the past, product quality assessments were centrally disseminated and evaluated on consumer's behalf, by way of Consumer Reports, among others. In the social media age, collective decision making through the power of the crowd is perhaps the most prevailing method of product evaluation and forces companies to take heed. Similarly, knowledge and views from the edges of society can be moved into societal mainstream very quickly via social media. This transfer can remove existing societal consensus, social cohesion among established groups, and order in the process. Otherwise less visible and influential social, ethical, environmental, political issues can thus gain traction rather quickly. Traditional modes of coordinating human behavior by way of political decision making, democratic institutions, business

governance, learning, among many others, become slowly less prevalent.

Societal decentralization is a byproduct of broader societal trends that derive from the combined feedback effects of decentralization of science, technological decentralization, organizational decentralization, as well as market and governmental decentralization. Such are the precursors of an ever freer and more open society.²² As each form of decentralization empowers heightened proliferation of other forms of decentralization, individuals in society perceive more opportunities for changes in consumer behavior, silent withdrawal, disengagement, and defiance of the established centralized order. For example, the emerging crypto movement that gave rise to a market capitalization of \$800 billion in cryptocurrencies at its heights in 2018 is the outcome of a smaller group in society that experiments with decentralized technology to effectuate broader societal change. Through the changes that occur in the day-to-day actions of ordinary people, societal change and decentralization materializes as an iterative piecemeal process.²³ Changes in consumer behavior, such as the use of cryptocurrencies, are possible through the combined effects of types of decentralization.

The coordination of human behavior and the organization of society are beginning to change with the evolution of the

²² Karl Popper conceptualized the open society before ever knowing how decentralized systems could help support the evolution of open societal systems. Popper, Karl (1966). *The Open Society and Its Enemies*. Princeton, NJ: Princeton University Press; “An open society has the hidden strength, in comparison to its authoritarian competitors, of a democratic epistemology. Its constitutions entrench power, and therefore knowledge, in competing institutions: the courts, the press, parliaments, oversight bodies, regulators, and last but not least, universities. It was Popper's great insight that where knowledge is subjected to competitive evaluation and peer review by autonomous communities of scholars, theories that genuinely advance human progress can be tested and improved. The unseen advantage of open societies over authoritarian ones lies here, in their capacity to innovate, to unleash creative minds, and to turn their knowledge into insights, products, techniques, and systems that reduce human suffering and improve our life together.”

Michael Ignatieff, ‘Rethinking Open Society, Introduction

²³ See Chapter 2, footnote 21.

decentralized coordination mechanism. The *decentralized coordination mechanisms*, such as protocols, ecosystems, and platforms are beginning to provide unprecedented democratic forms of coordination for society. For example, the public's disillusionment with existing political institutions' ability to address economic hardships that emerged in the aftermath of the financial crisis of 2008-9 inaugurated a new form of technological decentralization. As one result, among many, the Bitcoin protocol emerged in 2009 as an attempt by its founders to provide an alternative to the shortcomings of the financial system. Bitcoin and its progeny spawned a slew of additional decentralized protocols and decentralized technology attempts and solutions that, while mostly still experimental, provide a gateway to future forms of technological decentralization. The evolution of decentralized protocols, ecosystems, and platforms, in turn, may provide unprecedented democratic forms of organizing society and coordinating human behavior.

The crypto movement in the late 2010s exemplifies societal decentralization that results from the feedback effects between different types of decentralization. The crypto movement exemplifies the combination of political decentralization, technological decentralization, market decentralization, and organizational decentralization. The crypto movement started with a strong base of followers who believed in a form of crypto anarchism facilitated by the start of the Bitcoin protocol in 2009. A strong distrust of government and central banking is part of the political philosophy of the movement which emerged to create an alternative to fiat currencies that the movement believed to be controlled by one-sided political forces via central banks. The particular political philosophy could not be instantiated without a form of technological decentralization, that is cryptocurrencies, which the movement believed to be immune from governmental control. The combination of political philosophy and technology created new markets in cryptocurrencies. Most importantly, the movement also created new forms of organization as it promoted forms of decentralized autonomous organizations. The combined factors of decentralization enabled a form of societal decentralization instilled in the movement as it attempts to create a separate economy and political philosophy.

Broader societal trends enable a continuing proliferation of societal decentralization and separatist movements. The crypto movement encapsulates only a small fraction of society and provides only one example. Yet, the societal factors that created the crypto movement are a reflection of broader societal trends. For example, the growing distrust of government generally and the lack of voter participation and disbelief in the core pillars of democracies result in the increasing disengagement of large parts of society in the processes of democracy. As a result, alternative avenues of collective reasoning and decision-making processes are increasingly needed. The crisis in legitimacy in politics of the 2020s but also by the demise of some of the most centralized regimes in the world, such as the Soviet Union in the 1990s, are powerful reminders that the people increasingly seek alternatives rather than abide by the traditional social norms. People do look for new systems to replace the established socio-economic consensus on the engagement with the political establishment in a given country. Societal decentralization becomes increasingly prevalent as private sector and citizen participation in governance are perceived as real alternatives to the established order.²⁴

The decentralized internet impacts societal decentralization. Attempts to create a decentralized internet may help overcome existing centralized corporate and political regulation and influence over web content and the associated societal coordination. Because the initial vision of the founders of the internet, to create a truly decentralized network without central points of failure, could not be fulfilled, the community of internet idealists has been seeking technological ways to decentralize the internet. Decentralized encryption technologies that gave rise to the Bitcoin protocol allow nodes in unidentified networks of computers to coordinate. Advocates of the technologies believe that it can be used to re-decentralize the internet. For example, the founders of Wikipedia are working on a decentralized version of

²⁴ Joint UNDP-Government of Germany (Oct. 1999). Decentralization: A Sampling of Definitions [Working Paper], http://web.undp.org/evaluation/documents/decentralization_working_report.PDF (accessed June 1, 2020).

Wikipedia via decentralized encryption technologies.²⁵ If successful, such attempts could help shift content discovery and publishing away from corporate controls into the hands of the internet users as the technology is less prone to corporate and political influences. Without such centralized elements, societal coordination could emerge in a more decentralized way.

VII. Feedback Effects

Decentralization manifests itself through feedback loops between different decentralization phenomena, types of decentralization, industries affected thereby, and individual action that enables such decentralization. The often diametrically opposed outcomes of centralization and decentralization are observable not only in politics and administration and technology but also in culture, the economy, as well as in social and industrial organization and community formation.²⁶ Feedback effects between such social, economic, and societal phenomena allow decentralized systems to constantly morph and evolve with new features that, in turn, generate new feedback loops with existing systems. As one type of decentralization and its respective constituents proliferates, the other types are over time increasingly affected, leading to changes that, in turn, affect each other. The combined effects lead to the creation of new markets while changing other markets and, over time, create an emerging new economy. Society at large is affected at multiple levels because the different constituents that are affected in their respective fields begin to experiment with their own applications and decentralized solutions which in turn create feedback effects for other industries and society at large. Some may see this as a snowball effect.

²⁵ Knowledge Standards Foundation [ks_found] (2019). Nonprofit Defining Tech Standards for Encyclopedias [Tweet], https://twitter.com/ks_found?lang=en (accessed June 1, 2020); Sanger, Larry (2020) Larry Sanger: Education, Internet, and More, <https://larrysanger.org/> (accessed June 1, 2020).

²⁶ *Wikipedia. Wilhelm Ropke*, https://en.wikipedia.org/wiki/Wilhelm_R%C3%B6pke (accessed June 1, 2020).

The core feedback effects that enable decentralization revolve around technological forms of decentralization and associated forms of organization, decentralized markets, and overall emerging societal forms of decentralization. In the aftermath of the invention of the internet, decentralized technology evolved through cloud computing, even though the architecture of cloud computing is fully centralized, and the open source movement. Technological forms of decentralization via the internet, in turn, enabled new hybrid forms of organization that thrived through the combination of centralized control with the bottom-up approach of decentralization in the form of customer reviews. The evolving technological decentralization, in turn, has created new markets and continues to change existing markets. For instance, with the emergence of the Bitcoin protocol in 2009, the digital asset market began to evolve. Early forms of consumer buy-in, in turn, allowed experiments with Decentralized Autonomous Organizations (DAOs) which have started to challenge the core belief that governance necessitates agency. Many other examples exist that illustrate the feedback and knock-on effects between decentralized technology, organizational decentralization, regulatory decentralization, and decentralization (and disruption) of markets. Many other feedback effects are constantly emerging and affect other parts of society.

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