4. Decentralization?

1 DECENTRALIZATION(S)

The subject of decentralization has long been discussed in political literature. However, it has a distinct meaning in the blockchain space, where it is seen as a way to create efficiency. In this chapter, I introduce a new analytical framework for evaluating decentralization in this context.

1.1 Multiple Features

The virtues of decentralization have been debated for centuries – most famously by thinkers like Alexis de Tocqueville, Pierre Joseph Proudhon, Frédéric Bastiat and Friedrich Hayek.

Tocqueville is known for his book *Democracy in America* (1835), whose vision is praised to this day. Tocqueville stressed that he could not imagine that a “nation could live or, above all, prosper without strong governmental centralization.”¹ On the contrary, Proudhon pointed out that centralized states “crushed all freedom,”² as centralization leads to the “disarmament of a nation for the benefit of its government.”³ Following this logic, he underlined that the “salvation of the people” required decentralization, “for it saves them both from the tyranny of their leaders and from their own folly by dividing them.”⁴ Both authors also discussed decentralization from the perspective of individual

¹ Alexis de Tocqueville, *Democracy in America* (1835, Laffont, 2012): 146, 154 (“Centralization succeeds without difficulty in imparting a steady appearance to everyday affairs; in skillfully dictating the details of social order; in suppressing slight disturbances and small transgressions; in maintaining society in a status quo which is not exactly either decadence or progress; in keeping a kind of administrative somnolence in the social body that administrators customarily call good order and public tranquility. In a word, it excels at preventing, not at doing.”)

² Pierre-Joseph Proudhon, *Du Principe Federatif et de la Necessite de Reconstituer Le Parti de la Revolution* (Kessinger Publishing, 2010): 71.

³ *Id.* at 103.

⁴ *Id.* at 101.

freedoms, leading them to opposite conclusions.⁵ These debates neatly illustrate the spectrum of arguments that have been made regarding the virtues of decentralization (or lack thereof).

Bastiat and Hayek were more interested in the dynamics of economic systems. The former emphasized that decentralization is to be preferred over centralization because relying on the state for economic prosperity is “a fertile source of calamities and revolutions.”⁶ The latter pointed out that “the competitive system is the only system designed to minimize the power exercised by man over man.”⁷ One may infer two general features of decentralization from their early work.

The first relates to the democratic nature of decentralized systems. They allow for coordination without vertical hierarchy,⁸ as the absence of a strong central authority makes exclusion more difficult.⁹ Of course, the tyranny of the majority may oppress dissenting voices, but that tyranny may seem more bearable than the tyranny of the few. This explains why the growth of decentralized systems is more inclusive than that of centralized ones.¹⁰

The second feature of decentralized systems relates to the power and impact of decision making. In principle, decentralized systems allow for more informed decision making than centralized ones, as they empower individuals to protect their own interests. The upside is that this overcomes the fact that not all knowledge can be communicated to a centralized system that would act

⁵ Tocqueville favored centralized institutions, while Proudhon preferred decentralized ones.

⁶ See Frédéric Bastiat, *Sophismes Economiques* (Institut Coppet, 2015): 33. Bastiat was talking about “une force irrésistible de décentralisation” (“an irresistible power of decentralization”). According to Nathan Schneider, “Decentralization: An Incomplete Ambition,” *Journal of Cultural Economy* 12, no. 4 (2019): 265, 267 (“The earliest reference to decentralization cited in the Oxford English Dictionary dates to 1846, in Popular Fallacies Regarding General Interests, translated from a treatise by the French laissez-faire economist Frédéric Bastiat.”)

⁷ Friedrich Hayek, *The Road to Serfdom* (IEA, 2005): 41.

⁸ Yochai Benkler, *The Wealth of Networks* (Yale University Press, 2006): 62.

⁹ Discussing this point, see Philip E. Agre, “P2P and the Promise of Internet Equality,” *Communication of the ACM* 46, no. 2 (2003): 39.

¹⁰ Sibylle Stossberg and Hansjörg Blöchliger, “Fiscal Decentralization and Income Inequality: Empirical Evidence from OECD Countries,” *Jahrbücher für Nationalökonomie und Statistik* 237, no. 3 (2017): 225.

upon it.¹¹ The drawback is that the decision taken at a decentralized level may ignore information held by others.¹²

In any case, the impact of erroneous decisions is lower in decentralized systems than centralized ones, as in theory they tend to affect only those who have taken the decision. In Nicholas Nassim Taleb's words,¹³ these systems "love mistakes," and allow more experimentation than centralized ones. Conversely, adverse decisions in a centralized system impact the entire system.¹⁴

The vast majority of cyber-communities promote decentralization across all cyberspace levels, often indirectly praising one of these two features.¹⁵ Blockchain results from that desire.¹⁶ That being said, pursuing this sole

¹¹ Friedrich A. Hayek, "The Use of Knowledge in Society," *The American Economic Review* 35, no. 4 (1945): 519, 524 ("The ultimate decisions must be left to the people who are familiar with these circumstances, who know directly of the relevant changes and of the resources immediately available to meet them. We cannot expect that this problem will be solved by first communicating all this knowledge to a central board which, after integrating all knowledge, issues its orders. We must solve it by some form of decentralization").

¹² *Id.* at 524.

¹³ Nassim Nicholas Taleb, *Antifragile: Things That Gain from Disorder* (Random House Trade, 2014): 21.

¹⁴ Alessandra Arcuri and Giuseppe Dari-Mattiacci, "Centralization versus Decentralization as a Risk–Return Trade-Off," *The Journal of Law & Economics* 53 (2010): 359 ("This paper characterizes the choice between centralization and decentralization as a risk–return trade-off and examines it in a model that integrates ideas from committee decision-making and portfolio theories. Centralization, by pooling expertise, rarely yields erroneous decisions; however, when it fails, the consequences are global. In contrast, in a decentralized system, erroneous decisions are more frequent, but their consequences are locally confined.")

¹⁵ For a sub-distinction within this community, see Philip E. Agre, "Cyberspace as American Culture, 11 *Science as Culture*," *Science as Culture* 11, no. 2 (2002): 171, 185 ("[T]he libertarian left and the libertarian right both invest hopes for decentralization in the technology, one group identifying the Internet with democracy and the other group identifying it with markets. There remains a non-libertarian left, just barely, for which the Internet is purely an instrument of capitalist domination, and a non-libertarian right, now ascendant, for which the Internet is purely a vector of moral decay.")

¹⁶ As we have shown, blockchain has libertarian roots. Not surprisingly, several famous libertarian thinkers were in favor of decentralization. For instance, Murray Rothbard defended the idea according to which every state should "be allowed to secede from the nation, every sub-state from the state, every neighborhood from the city, and, logically, every individual or group from the neighborhood," see Murray Rothbard, "Libertarian Forum," May 1969. As he further argued: "If it were in any way possible to grant this right of self-determination to every individual person, it would have to be done," see Murray Rothbard, In *Liberalism* (Germany: 1927). This is the objective of blockchain communities. Robert Nozick defended a similar idea, arguing for a minimal state acting as a "night watchman" and letting its citizens

objective is not enough to ensure blockchain development and prosperity. For that, blockchain relies on increasing participants' own (financial) interest. The system is indeed designed to maximize their welfare while pursuing the overall objective of decentralization. I will come back to that in Chapter 7, but here I want to emphasize the importance of considering each blockchain participant's personal interest. The same applies to other technologies and management systems, which are also emerging to pursue the same goal of decentralization. Their capacity to benefit their participants at the individual level will determine their ability to achieve this objective. That applies to non-blockchain distributed ledger technologies and Solid – the technology promoted by Tim Berners-Lee (often described as the inventor of the World Wide Web).¹⁷

1.2 One Objective

Decentralized systems offer unique features, but what are they good for? The answer depends on the system being studied. One may wish to decentralize a political system to revive civic engagement; another may wish to decentralize corporate governance to make a company more inclusive.

Blockchain harnesses the power of decentralization to enable the emergence of a more efficient transactional infrastructure.¹⁸ Let me return to the words of Satoshi Nakamoto for corroboration. When introducing his Bitcoin white paper, she/he/they/it explained that “[d]igital signatures provide part of the solution” for sending information “without going through a financial institution,” yet “the main benefits are lost if a trusted third party is still required to prevent double-spending.” For that precise reason, Nakamoto proposed “a solution to the double-spending problem using a peer-to-peer network.”¹⁹ The intention is solutionist: there are costs, and one must find a way to reduce

build concomitantly the different types of societies in which they want to live, see Thibault Schrepel, “Anarchy, State, and Blockchain Utopia: Rule of Law versus Lex Cryptographia,” in *General Principles and Digitalisation* (Hart Publishing, 2020): 367. As we will see later on, other thinkers on the “left side” of the political debate were also in favor of decentralization, making it a non-partisan concept.

¹⁷ 13D Research, “Why Decentralization Could Prove the Most Disruptive Tech Megatrend of the Next Decade,” Medium, October 17, 2018, <https://perma.cc/HRW2-W5VS>; Berkman Klein Center, “The Future of the Decentralized Web,” Medium, July 31, 2019, <https://perma.cc/MB9D-KBZG>.

¹⁸ The search for efficiency, in fact, is a common trait to most technologies; on that, see Aldous Huxley, “Foreword” in *Brave New World* (1932, HarperCollins, 1994) (“In an age of advanced technology, inefficiency is the sin against the Holy Ghost.”)

¹⁹ See Satoshi Nakamoto, *Bitcoin: A Peer-To-Peer Electronic Cash System* (2008): 1.

them. Blockchain is described as the ideal candidate, as it “requires minimal structure,” being “robust in its unstructured simplicity.”²⁰ The two features of decentralized systems – that is, coordination without vertical hierarchies and the reduction of an individual’s decision making impact – are used to increase monetary exchange efficiency.

Ethereum has built on this foundation to develop a blockchain that enables more complex applications.²¹ Its ambition is to allow “users to create any of the systems ... and many others that we have not yet imagined, simply by writing up the logic in a few lines of code.”²² Vitalik Buterin, Ethereum co-founder, declares in the blockchain white paper:

The intent of Ethereum is to create an alternative protocol for building decentralized applications, providing a different set of tradeoffs that we believe will be very useful for a large class of decentralized applications, with particular emphasis on situations where rapid development time, security for small and rarely used applications, and the ability of different applications to very efficiently interact.²³

Ethereum praises the simplicity of the project by pointing out that: “A bare-bones version of Namecoin can be written in two lines of code, and other protocols like currencies and reputation systems can be built in under twenty.” Blockchain’s unique features – such as simplicity, universality, modularity, agility and non-discrimination – all create efficiencies redirected toward creating a new institutional technology.

Efficiency is a noble aim. Efficiency makes human flourishing possible by creating wealth²⁴ – a prerequisite for its distribution and the creation of a better society for the greatest number.²⁵

Unfortunately, decentralization and efficiency sometimes cut in opposite directions. Outside of the blockchain sphere, it is not unusual for centralized

²⁰ *Id.* at 8.

²¹ Overall, the Ethereum White Paper mentions the word “efficient” eight times and the word “inefficient” five times, <https://perma.cc/ZTR8-8PUF>.

²² Ethereum, “A Next-Generation Smart Contract and Decentralized Application Platform,” GitHub, <https://perma.cc/G72K-YUVJ>.

²³ Vitalik Buterin, “Ethereum White Paper,” Ethereum, last modified December 9, 2020, <https://perma.cc/M6FU-NVTY>.

²⁴ Steven Pinker, *Enlightenment Now* (Penguin Books Limited, 2018) (Chapter 8, explaining that the enlightened economy, by using machines toward better efficiency, helps in reducing poverty).

²⁵ Kenneth G. Elzinga, “Goals of Antitrust: Other Than Competition and Efficiency, What Else Counts,” *University of Pennsylvania Law Review* 125, no. 6 (1976): 1191, 1193 (“Once it is perceived that efficiency and equity are not mutually exclusive domains, and that both are susceptible to economic analysis, the nature of their relationship becomes the pertinent inquiry.”)

systems to be more efficient than decentralized ones, as centralization allows for a reduction in many transaction costs. Given this, it is important to ask whether decentralization is cost effective in this context. The situation is different for blockchain, as the technology generates efficiency *because* of decentralization. That will prove essential when it comes to antitrust law, as we shall see.

1.3 A Comprehensive Theory of Decentralization

Blockchain communities often see decentralization as the best path to efficiently enable transactions and social interactions. However, one still needs to agree on what decentralization means and how it can be achieved – doing so proves to be the only way to assess if blockchain achieves this aim and how the law could help. Giving decentralization a proper definition is challenging.²⁶ This chapter attempts to address this difficulty; at the very least, it introduces the reader to what I mean by “decentralization” throughout the book.

Let me start with a proper definition: “decentralization” is a dynamic and multi-level concept that measures the autonomy enjoyed by a given subject in determining its competence. Now, let me unpack that definition.

By “competence,” I mean the ability to determine the spheres of action within which a given individual can decide. In centralized systems, one can take action only if another subject has been granted the right to do so. Central systems may be horizontal (when the individual attributing competence is on the same layer) or vertical (when the individual attributing competence is on an upper layer). Systems in which one can decide without being formally granted the right to do so are decentralized,²⁷ both horizontally and vertically.

The concept of decentralization is also dynamic, meaning that one must consider the time factor. On a scale ranging from absolute autonomy to total determinism, the degree of decentralization should capture more than an instant. It needs to be analyzed over time; a system is not decentralized (or centralized) when it just presents certain momentary features. Evaluating decentralization requires one first to analyze the different factors leading to it,

²⁶ Nathan Schneider, “Decentralization: An Incomplete Ambition,” *Journal of Cultural Economy* 12, no. 4 (2019): 265. Already, Alexis de Tocqueville, *Democracy in America* (Laffont, 2012): 153 (“Centralization is a word repeated constantly today, and, in general, no one tries to clarify its meaning”).

²⁷ For example, Article 5 of the Treaty of Lisbon provides that the Union shall act only within the limits of the powers conferred upon it by the Member States in the Treaties in order to achieve the objectives set out in those Treaties. Any competence not attributed to the Union in the Treaties belongs to the Member States.

and second to understand how these different forces interplay with each other over the medium and long run.

And the concept is multi-level. One must analyze the extent to which the (de)centralization of one layer leads to the (de)centralization of an upper layer. Sometimes, different layers are tightly related, and the decentralization of one layer will lead to decentralization or the centralization of another one. Other times, layers do not show a causal link. Overall, a system is fully decentralized only when all layers are significantly decentralized. When this is not the case, and when moving one layer toward decentralization leads another toward more centralization, choices should be made regarding which one should be preferred.

Figure 4.1 Representation of one ecosystem decentralization

Several questions arise from the chart in Figure 4.1.

First, how are the dots positioned on each layer? The answer depends on the subject being analyzed, but it always results from various constraints. With blockchain, Vitalik Buterin has pointed out that defining the degree of decentralization includes three axes.²⁸ The first is architectural decentralization, which represents how many computers the system comprises. The second is political decentralization, which represents how many individuals

²⁸ Vitalik Buterin, “The Meaning of Decentralization,” Medium, February 6, 2017, <https://perma.cc/6FP5-9L8Z>.

or organizations control these computers. The third is logical decentralization. In Buterin's view: "Blockchains are politically decentralized (no one controls them) and architecturally decentralized (no infrastructural central point of failure), but they are logically centralized (there is one commonly agreed state and the system behaves like a single computer)."²⁹ I will return to this later; but for the time being, let us keep in mind that each of the dots representing the degree of decentralization of one layer results from these different forces.

Second, what is the effect generated by one dot's motion on the upper and lower layers? One should distinguish three hypotheses falling under what I would call "complex decentralization."³⁰

One, there might be no strong correlation between a layer and those that surround it. When this is the case, one should abandon efforts that seek to decentralize one layer in order to affect another. Two, there might be a robust correlation between the different layers. In such a scenario, one should analyze whether pushing one layer further toward decentralization (even the slightest) has acceptable consequences for the other layers. Three, one might observe only a mild correlation between the different layers. Here, it is necessary to analyze which types of (extreme) efforts would be required to push another layer toward more decentralization and whether the consequences are acceptable.

Third, where are decisions regarding the appropriate level of decentralization taking place? Here again, the answer depends on the subject. Legal structures (e.g., states or international unions) are typically top-down. Decisions regarding decentralization are primarily made at the upper level and are centralized by nature. Blockchain's structure is bottom-up: decentralization is generally embedded in lower layers. Where it exists, decentralization emerges rather than being decided.

Finally – and this brings me to the core of our subject – how can decentralization be achieved? Can the law help achieve this aim; and if so, under what conditions and with what drawbacks? Answering this question involves two separate interrogations. First, is the law a legitimate means of decentralizing a particular layer? Second, if this is the case, is the law effective at achieving this end? I tackle these issues in the following chapters.

²⁹ *Id.*

³⁰ Here relying on complexity theory, see W. Brian Arthur, *Complexity and the Economy* (Oxford University Press, 2014).

2 BLOCKCHAIN'S DECENTRALIZATION

I have just shown that decentralization is a dynamic and multi-level concept. In this section, I apply this finding to the blockchain sphere and analyze its implications. This leads me to study each layer of a blockchain and examine whether participants are free to determine their competence.

2.1 Layers and Interactions

Blockchain's overall governance is more horizontal than that of firms (as I will discuss later); nevertheless, its architecture comprises several layers. And each of these layers can be more or less decentralized. Let us investigate this together.

The first level is the "real space." While blockchain is undoubtedly a digital technology, it is made up of different components that exist in the material world. To cite but one example, the Chinese government's control over the Internet shows that power in the real space has an important impact on digital ecosystems. Accordingly, the separation between the real space and cyberspace, as proposed by the cypherpunks, has important limitations that should not be neglected.³¹

The second level is cyberspace and, more specifically, the Internet.³² Blockchain exists only thanks to the Internet, as the technology is based on Transmission Control Protocol and Internet Protocol. Whoever controls the Internet can ultimately affect blockchain. The Internet Corporation for Assigned Names and Numbers, and the Internet Engineering Task Force, for example, could exert a decisive influence on blockchain if they wanted to. To date, these international bodies have been great in their neutrality – also because they have limited power. For that reason, barring a significant departure from the status quo, there appears to be little link between the (de)centralization of the Internet (as a technology) and that of blockchain. But this could change.

The third level is the "blockchain" layer or, put differently, the ledger (database). Often referred to as the "layer 1" (from a blockchain-based perspective),

³¹ This is shown by the fact that governments are decreasing Internet freedom for the tenth year in a row (deliberately spreading false information to manipulate citizens, enforcing censorship and internet shutdowns...), as is shown by Freedom House, *see* Adrian Shahbaz and Allie Funk, "The Pandemic's Digital Shadow," Freedom House (2020), <https://perma.cc/4JNE-A9AD>.

³² For a distinction between cyberspace and the Internet, *see* Lawrence Lessig, *Code: And Other Laws of Cyberspace*, Version 2 (Basic Books, 2006): 9 ("Though built on top of the Internet, cyberspace is a richer experience").

it contains the data that shows the current state of the blockchain, combining all transactions coming from higher layers.³³ The link between the (de)centralization of the third and fourth levels depends on whether the blockchain is public or private.³⁴ When a blockchain is public, anyone can explore the entire third level. It is wide open. But when a blockchain is private, only selected users can view it and, by definition, build its infrastructure and governance. In that regard, the third layer may play an essential role in attributing blockchain participants' competence at higher levels.

The fourth level is the blockchain infrastructure. I refer to this as the blockchain "constitutional level," as it has a defining impact on the higher levels, therefore defining the "rules of the game."³⁵ This level comprises the client's core code(s) that run on top of the third level.³⁶ It governs all transactions. This fourth level also contains what is often referred to as the "layer 2" (i.e., technical solutions increasing blockchain scalability, such as Bitcoin Lightning).³⁷ By determining whether a blockchain is permissionless or permissioned, this fourth level also plays a crucial role in distributing specific skills. In permissionless infrastructures, any user can participate in the consensus and thus ensure the blockchain's integrity; while in permissioned infrastructures, only selected users can do so. The decentralization of that fourth level is thus a precondition for the decentralization of higher levels.³⁸

³³ Bitcoin and Bitcoin Cash are two "layer 1" examples.

³⁴ See Chapter 2, explaining the difference between public and private blockchains.

³⁵ It is called the bottom layer because it "provides formal network participants with ultimate decision-making authority regarding what software application to run or whether to update the software application with new versions that exist. Due to the strong positive network effects experienced by public blockchain networks, the decision of each of the formal participants is influenced by their perception of other formal network participants' likely choices." Raina S. Haque, Rodrigo Seira Silva-Herzog, Brent A. Plummer and Nelson M. Rosario, "A Blockchain Development and Fiduciary Duty," *Stanford Journal of Blockchain Law & Policy* 2, no. 2 (2019): 140, 158.

³⁶ For instance, Bitcoin Core (fourth level) is the main client running on top of the Bitcoin blockchain (third level). Bitcoin Unlimited (fourth level) is one of the main clients running on top of the Bitcoin Cash blockchain (third level).

³⁷ Vitalik Buterin called it the "ultimate deciding layer," see Vitalik Buterin, "Notes on Blockchain Governance," Vitalik Buterin's website, December 17, 2017, <https://perma.cc/34AB-ZL62>.

³⁸ Primavera De Filippi, "Blockchain Technology and Decentralized Governance: The Pitfalls of a Trustless Dream," *Decentralized Thriving: Governance and Community on the Web 3.0* (2019): 7 ("While it is, indeed, difficult to deploy a distributed governance system on top of a centralized infrastructure—because the party who controls the infrastructure inherits the power to influence the system—at the same time, a decentralized infrastructure does not necessarily entails a decentralized governance structure.")

The fifth level is the blockchain governance mechanism. It results from all the constraints imposed on the blockchain's participants when they interact among themselves. While the "blockchain" and "constitutional" layers may have architectural limits that exert a strong constraint over the governance of this fifth level, economic, political and logical considerations are also important.³⁹ Contrary to popular belief, the link between this level and the sixth level (blockchain applications) is not necessarily strong. For example, the centralization of blockchain miners does not rhyme with the centralization of blockchain uses. One should not attach too much importance to potential centralized outcomes on the fifth level when analyzing lower and higher levels. I will come back to this point.

The sixth level is comprised of blockchain applications. As I have explained, three types of applications can be distinguished: cryptocurrency (blockchain 1.0), smart contracts (blockchain 2.0) and the decentralized version of any kind of program a computer can run (blockchain 3.0). The lower levels partially determine the degree of (de)centralization at this sixth level. For one, monocentric blockchains are centered around one application only. Although platform blockchains permit different uses, they can nonetheless restrict the ability to run some applications on top of them, notably for compatibility reasons.

The seventh level is comprised of blockchain users. Its degree of (de)centralization depends on concepts that will be familiar to antitrust-savvy readers, such as network effects, lock-in and switching costs. Decentralization at this level is affected by design choices at the lower levels, and vice versa (if users cluster around a few applications, this will have the effect of centralizing the sixth level). It is also a function of first-mover advantage, the utility provided by each blockchain application and other market characteristics. One should note that ensuring the seventh level's decentralization is not the aim of blockchain or antitrust law, since it is not inversely correlated with users' welfare. Indeed, should a blockchain application prove more useful or better designed

³⁹ Vitalik Buterin, "The Meaning of Decentralization," Medium, February 6, 2017, <https://perma.cc/6FP5-9L8Z> ("Blockchains are politically decentralized (no one controls them) and architecturally decentralized (no infrastructural central point of failure) but they are logically centralized (there is one commonly agreed state and the system behaves like a single computer).") These three elements are important, *see*, for example, Napster which had a centralized logic, according to Philip E. Agre, "P2P and the Promise of Internet Equality," *Communication of the ACM* 46, no. 2 (2003): 42 ("Napster had a fatal flaw: although it afforded P2P sharing of music files, its centralized directory made it susceptible to legal attack.") Underlining the need to aggregate different parameters in order to assess decentralization, *see* Angela Walch, "Deconstructing 'Decentralization': Exploring the Core Claim of Crypto Systems," in *Cryptoassets*, ed. Chris Brummer (Oxford University Press, 2019): 24.

than others, all users would benefit from using it. It would create a network effect, increasing the utility they can derive from this application.⁴⁰

One can represent these levels as illustrated in Figure 4.2.

These levels should be analyzed together, as should competing blockchain ecosystems (i.e., a set of levels). In other words, there is significant and dynamic competition within each of these levels, between each of them and between separate ecosystems. This could be represented as an eighth level, as illustrated in Figure 4.3.

Finally, these blockchain ecosystems collaborate and compete with other technologies, services and applications, whether decentralized or centralized. I will study this dynamic in Part 3 of the book; but Figure 4.4 presents a representation of the entire landscape – this can be thought of as a ninth and final level.

3 HOW TO PROCEED FURTHER

I studied the decentralization of each level in terms not of participants' numbers (i.e., rivalry), but of each participant's capacity to determine its competence. Blockchain decentralization is a question of decision making processes rather than particular outcomes. Indeed, focusing on the latter would lead to a structuralist vision of blockchain, according to which one should prevent all centralized outcomes for its sake (e.g., applications with over X million users). As Vitalik Buterin underlines in a video we did together:

blockchain communities also have centralization when it results in providing very valuable services (such as companies that are building projects, exchanges, people running layer 2 transaction systems of different kinds, companies providing wallets). Sometimes you find centralized actors because they deserve to succeed.⁴¹

I will come back to that idea later.

I should make two further observations at this stage regarding the degree of blockchain's decentralization. First, studies of decentralization should always specify which level is being discussed. I will endeavor to proceed accordingly, while keeping in mind that (de)centralization at one level may impact others. In fact, analyzing correlations with higher levels comes naturally,⁴² but one must

⁴⁰ See Thibault Schrepel and Vitalik Buterin, "Blockchain Code as Antitrust," *Berkeley Technology Law Journal* (2021).

⁴¹ Thibault Schrepel and Vitalik Buterin, "Blockchain Code as Antitrust," YouTube, published July 16, 2020, 12:37, <https://perma.cc/A6VH-VJJR>.

⁴² Philip E. Agre, "P2P and the Promise of Internet Equality," *Communication of the ACM* 46, no. 2 (2003): 40 ("At least sometimes, then, centralization on one layer is a precondition for decentralization on the layers above it").

Figure 4.2 A view of blockchain layers

DIGITAL COMPETITION

DECENTRALIZED APPLICATIONS AND SERVICES

CENTRALIZED APPLICATIONS AND SERVICES

Competitive pressure

Figure 4.4 A view of blockchain cooperation and competition with the outside world

not forget that it may also affect lower levels. For example, when a blockchain is forked – that is, duplicated by a group of users to make it function based on new rules (see Chapter 8) – the centralization of the fifth level (blockchain governance) can lead to the creation of a new group of participants within the fourth level, and possibly even the third. This complex interplay makes it difficult to predict how given decisions will affect the (de)centralization of blockchain ecosystems.

Second, I want to recall that the present book is concerned with the interaction between blockchain and antitrust law. Thus, the study of decentralization aims to ascertain whether anti-competitive practices may artificially centralize blockchain ecosystems and thus reduce their efficiency and consumer welfare. Some might legitimately ask whether other objectives, such as protecting less efficient players, fit in this picture. But let us first agree on the means that are necessary to maximize decentralization before turning to these other considerations.

4 CHAPTER SUMMARY AND BEYOND

In this chapter, I have explained that the concept of “decentralization” – that is, the autonomy enjoyed by a given subject in defining its competence – is a multi-faceted concept with a rich history.

Although decentralization and efficiency are often opposed, the opposite is true in the blockchain space. With that in mind, I analyzed the degree to which blockchain is indeed decentralized. This required a dynamic and multi-level analysis: dynamic because blockchain ecosystems are rapidly evolving; and multi-level since these ecosystems have multiple interrelated layers. On that basis, the chapter discussed each layer of a blockchain ecosystem, and explained their interactions.

One may now question whether antitrust law can contribute to the overall decentralization of blockchain ecosystems, and if blockchain decentralization can help antitrust achieve its objective. Antitrust has been referred to as the Magna Carta of the free enterprise system⁴³ and, for that reason, the law of all economic transactions. It plays a central role in decentralizing the economy, including in the crypto space.

⁴³ *United States v. Topco Assocs. Inc.*, 405 U.S. 596, 610 (1972).