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The Future of the Web? The Coordination and Early-Stage Growth of Decentralized Platforms

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Abstract

Research Summary. This abductive study investigates how management occurs without managerial authority as part of a previously unseen organizational form—the decentralized platform with an independent market value. Our mixed-methods study of the cryptocurrency industry draws on fuzzy-set qualitative comparative analyses (QCA) to analyze archival and interview data and offer new theory on how decentralized platforms coordinate activities to grow in an early stage, before network effects kick in. We find that, in the absence of a central authority, platforms coordinate activities with three mechanisms, namely decentralized (i) algorithmic coordination, (ii) social coordination, and (iii) goal coordination. Our QCA treat these mechanisms as explanatory conditions and, using a representative sample of 20 cryptocurrency platforms, reveal which configurations of decentralized coordination mechanisms nurture, or hinder, early-stage platform growth.

Managerial Summary. Firms operate around a managerial hierarchy that distributes tasks, resources, information, and rewards to organizational members who pursue common goals as contract-bound employees. From 2009, a new organizational form, called the "decentralized platform," emerged and diffused without relying on hierarchy nor managerial authority—and without having to employ anyone. The most prominent decentralized platform, Bitcoin, has millions of users, thousands of contributors, and a market valuation never achieved before by an organization without a CEO nor shareholders. This study explicates how this unprecedented level of organizational decentralization functions in practice. We foreshadow implications for the digital economy, wherein "Web3" innovations, such as NFTs and DAOs, have already shifted the orchestrating role played by platforms in capitalist societies.

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If there are important systems in the world that are complex without being hierarchic, they may to a considerable extent escape our observation and our understanding. *(Simon, 1962, p. 477)*

1 | INTRODUCTION

Digital platforms, underway to power 30 percent of global gross domestic product, represent both the information economy's core organizational form and the basis of an estimated 70 percent of new value to be created over the next decade (World Economic Forum, 2020). These platforms provide the online infrastructure to facilitate transactions (Gawer, 2010) for such activities as sharing digital content (e.g., youtube.com) and trading goods (e.g., alibaba.com). In recent years, new technology has supported the rise to prominence of a new breed of "decentralized platforms" (Chen, Pereira, & Patel, 2021; Vergne, 2020) with the "potential to disrupt the way collaborations are organized across a wide range of social and organizational settings" (Lumineau, Wang, & Schilke, 2020, p. 1). However, our understanding of how decentralized coordination supports the growth of these platforms is hampered by two limitations of prior accounts.

First, the persistent focus of platform research on how network effects accelerate platform growth (Rietveld & Schilling, 2021) has sidelined how platforms coordinate activities early on to start growing—that is, after platform launch, but before network effects kick in. As Evans (2009, p. 99) noted, most research "has focused on mature platforms and examined their pricing structures and other properties. Little attention has been given to critical issues that entrepreneurs must solve to create a viable platform business." These overlooked issues may be consequential because digital platforms in their "birth phase" require different capabilities than in their later stages of expansion (Teece, 2017, p. 211). Indeed, empirical studies have demonstrated that effective growth strategies for digital platforms are largely contingent upon their development stage (Gretz & Basuroy, 2013; Rietveld & Eggers, 2018), thereby confirming that prior research "insights [obtained from the study of mature platforms] find limited application to nascent [platforms] without existing customers or abundant resources" (Kyprianou, 2018, p. 340).

A second limitation comes from prior research focusing on corporate platforms, which has kept alternative arrangements out of sight. Within corporate platforms, coordination strategies typically shape "how the authority and responsibility for each class of decisions is divided between the platform owner and … developers" (Tiwana, Konsynski, & Bush, 2010, p. 680). However, some of the most intriguing digital platforms of the past decade, such as Bitcoin and Ethereum, do not have platform "owners" (Gawer & Cusumano, 2002), nor do they rely on managerial authority to coordinate strategy (Okhuysen & Bechky, 2009), as is the norm with platforms run by the likes of Meta in the United States, Yandex in Russia, Kakao in South Korea, and Tencent in China. In the absence of a central platform owner, prior theorizing loses explanatory power, since knowledge built from the study of centralized platforms does not readily transfer to decentralized settings (Kretschmer, Leiponen, Schilling, & Vasudeva, 2020; Logue & Grimes, 2020; O'Mahony & Karp, 2020).

This study jointly addresses these two blind spots by asking, *How do decentralized platforms coordinate activities to start growing in the post-launch period?* Coordination involves the "adjustment of partners' actions to achieve jointly determined goals" (Gulati, Wohlgezogen, & Zhelyazkov, 2012, p. 537) through "mutually consistent decisions" (Simon, 1947/1997, p. 190) and expectations alignment (Lumineau et al., 2020). In classic management (Fayol, 1949) and entrepreneurship theory (Greiner, 1972), centralized coordination is crucial to growth because it directs limited resources toward a common goal, as defined by top executives. Experimental evidence to date points to decentralization creating insurmountable coordination problems that impose limits on growth (Knez & Camerer, 1994; Weber, 2006). Therefore, by focusing on the early-stage growth of decentralized platforms operating without managerial authority, our study provides a counterpoint likely to be revelatory for our theoretical understanding of both decentralization and growth. It will shed light on a previously unstudied phenomenon and question a core tenet in our field, namely the necessity of centralized management for coordinating growth.

To address this puzzle, we build on the literatures on organizational coordination (e.g., Okhuysen & Bechky, 2009) and design (e.g., Puranam, Alexy, & Reitzig, 2014) to examine coordination and growth at decentralized platforms in the cryptocurrency industry. Our study first identifies, abductively, three mechanisms underpinning *decentralized coordination*. In the absence of hierarchy, platforms create mutual adjustment through (i) decentralized algorithmic coordination, which maintains a standard space and a standard time among participants; (ii) decentralized social coordination, which builds consensus around platform design and operations among contributors; and (iii) decentralized goal coordination, which aligns expectations about the platform's long-term evolution. After "scoping" out these mechanisms, we unpack their "linkages" (Furnari, Crilly, Misangyi, Greckhamer, Fiss, & Aguilera, 2021) in a second stage that reveals which configurations of mechanisms support or hinder early-stage platform growth. We conduct fuzzy-set qualitative comparative analyses (fsQCA) of 20 representative cryptocurrency platforms launched between 2009 and 2014. Our reliance on fsQCA is motivated by two emerging patterns from our interview data: (i) Multiple, yet markedly distinct, combinations of coordination mechanisms appear to explain growth and decline, thereby hinting at causal asymmetry and equifinality, best captured with a configurational approach (Misangyi, Greckhamer, Furnari, Fiss, Crilly, & Aguilera, 2017), and (ii) A platform can be more or less decentralized while remaining qualitatively distinct from a centralized platform, resulting in the need to "bridge quantitative and qualitative approaches to measurement" and capture decentralization with "fuzzy sets" (Ragin, 2008, p. 82), rather than with continuous or binary variables. Our fsQCA's explanatory conditions represent the extent to which each platform relies on decentralized algorithmic, social, and goal coordination. Two equifinal paths relying on decentralized algorithmic coordination support early-stage growth—one driven by core platform contributors, the other by an independent foundation's vision; meanwhile, we find early-stage decline to be primarily associated with insufficiently decentralized algorithmic coordination. Interestingly, no platform in our data had all of its coordination mechanisms strongly decentralized at the same time, which suggests that full decentralization is no panacea and, in practice, may not even be feasible.

Based on primary field data, our study unpacks how decentralization, against all apparent odds, can be made to work (Daft & Lewin, 1993). In contrast to the prevailing view that decentralization is binary (in its opposition to centralization) and structural (as a formal design feature), our findings show decentralization to be both fuzzy and relational (Nadler & Tushman, 1997). Such an alternative view is manifest in how decentralized platform contributors form a closely knit community that relies, to various extents, on novel modes of formal and informal coordination in lieu of a hierarchy (Galbraith, 1973). Far from being a design feature coded into existence, decentralization is a fragile equilibrium attained by carefully balancing sophisticated coordination mechanisms. At a practical level, design trade-offs revealed in our study should be of interest to the developers, firms, and investors who believe that the Web's next phase of evolution, sometimes referred to as "Web3", will come with a fundamental redesign (Englmaier, Foss, Knudsen, & Kretschmer, 2018) of digital platforms and the diffusion of new organizational artefacts, including digital property such as non-fungible tokens (NFTs) (Vergne & Swain, 2016).

2 | CENTRALIZED COORDINATION AND GROWTH

Classic explanations for the growth of modern organizations emphasize reliance on centralized hierarchy and employment relationships to allocate resources (Barnard, 1938; Chandler, 1977; Coase, 1937; Fayol, 1949; Perrow, 2002). Early on in a new venture's lifespan, a "critical task for management … is to find … organization practices that will become the basis for managing the next period of evolutionary growth" (Greiner, 1972, p. 40). In the digital sphere, the dominant organizational form is the "platform," whose launch and subsequent growth are coordinated by a "platform owner" (or "leader")—an organization that "plays a central, orchestrating role" (Gawer, 2014, p. 1239) and typically owns substantial equity shares in the platform's infrastructure and intellectual property (Boudreau, 2010; Pereira, Tavalaei, & Ozalp, 2019). This central organization (e.g., Nintendo Co.) manages relationships with peripheral platform players and, whether platform growth is achieved in combination with pricing tactics (Dushnitsky, Piva, & Rossi- Lamastra, 2020) or with institutional influence (Garud, Kumaraswamy, Roberts, & Xu, 2020), centralized control is there to ensure the integration of effort.

The unwinding of centralized control often results in a "leadership vacuum" that is harmful to platform growth, as shown in the hybrid governance of IBM's Eclipse platform (O'Mahony & Karp, 2020, p. 21). When centralized control is absent, contributor communities can fill the void by acting as custodians of a platform's "commons," including through open-source software (OSS) (Lee & Cole, 2003) and wikis (Forte, Larco, & Bruckman, 2009). However, such a scenario does not involve compensating contributors (Dahlander & O'Mahony, 2011) and stops short of creating organizations with market valuations (e.g., Linux does not have a market value, unlike Ethereum).

In an in-depth literature review, Okhuysen and Bechky (2009) noted that organizational coordination, independently of the setting, always relies on three pillars: *Predictability* pertains to participants' ability to anticipate task interdependence over time and across space; *accountability*, to whom should take charge of specific tasks; and *common understanding*, to maintaining "a shared perspective on … how individual tasks fit within the whole" (p. 488). While each pillar's ultimate purpose "can be accomplished through a variety of [coordination] mechanisms" (p. 483), many of these mechanisms involve a centralized managerial hierarchy. For instance, "defining responsibilities for tasks," "resource allocation," and "monitoring" all traditionally take place based on managerial input (p. 483). While management theory on coordination generalizes well to traditional platform settings, it remains insufficient for explaining coordinated growth in the absence of centralized managerial authority.

3 | CONTEXT AND STUDY OUTLINE

3.1 | Decentralized platform organizations: Blockchain as a revelatory setting

To improve our understanding of decentralization, management scholars have recently begun to examine blockchain settings, which enable high levels of decentralization (Cennamo, Marchesi, & Meyer, 2020; Chen et al., 2021; Hsieh, Vergne, & Wang, 2017). Notably, by 2027, "10% of global gross domestic product [will be] stored on blockchain" platforms (World Economic Forum, 2015, p. 24). To understand what's at stake, picture a group of people playing baseball in an open field.

Some volunteer to design a makeshift baseball diamond by drawing lines on the ground; others volunteer to take turns acting as referees. Players come and go but all agree on the rules and track the score without relying on a coach, a baseball league, or any other kind of central authority. If most agree that a temporary referee is biased or incompetent, another player replaces them. At the end of the game, the most competent referee keeps the ball as a token of appreciation. Given players' shared understanding of game rules and without incentives to bribe referees, the game can continue without a central authority. However, if the stakes were to increase, decentralization might become impractical. The top scorers might demand compensation, which creates incentives for cheating (e.g., by bribing referees). Game rules may need to evolve, but players would likely disagree on how. To address these and related issues, professional players typically centralize their operations by creating clubs and central regulatory bodies, each with its own relationships of authority over other participants.

By analogy, we can think of blockchain as software that enables a boss-less group of peers to play high-stakes games on an online platform without a central authority. Even without knowing each other, the players can still coordinate their actions and even exchange valuable items while tracking the score (e.g., who owns what). On such a platform, field players are called "users"; special users who take turns acting as referees are "network validators"; meanwhile, players who brainstorm on potential rule changes are "developers." Game rules are formally written with software as algorithms and players track the score with a tamper-proof record called a blockchain "ledger." Algorithms define how much referees are paid, provided they can show "proof" that they completed tasks. Every player has an authenticated copy of the ledger that updates synchronously with everyone else's, thereby mitigating cheating and removing the need for a central referee. Compared with centralized platforms, these significant differences enable the transparent compensation of platform contributors and incentivize the constant upgrading of the (software) infrastructure, as long as sufficient consensus surrounds the proposed changes. These features can make a decentralized platform valuable to outsiders, who may want to buy the platform's native currency. As a result, the platform organization can command a market valuation.

More formally, a blockchain is a "decentralized, transactional database … that facilitates validated … transactions that are consistent across a large number of … participants" (Beck, Müller-Bloch, & King, 2018, p. 1020). Blockchain enables the design of digital platforms without centralized task assignment (contributors self-select into tasks) and without top-down resource allocation (contributors volunteer resources). Contributors are rewarded but compensation is not based on employment contracts or managerial evaluations (rewards are determined algorithmically). No entity centralizes the information generated by platform activity, and users are on equal footing in terms of information access and decision making.[1]

For these reasons, blockchain represents a revelatory setting to study the heavier forms of decentralization. While scholarship has recently offered new theory to survey this landscape (Lumineau et al., 2020; Murray, Kuban, Josefy, & Anderson, 2019) and studies of decentralization's effect on mature platforms' performance (Cennamo et al., 2020; Chen et al., 2021), we have yet to understand, from the inside out, *how decentralized platforms coordinate activities to start growing*. As well, it remains to be seen how these platforms create the three pillars "for coordinated activity, [namely], accountability, predictability, and common understanding" (Okhuysen & Bechky, 2009, p. 463). We address this puzzle through a study of cryptocurrency platforms, which represent the past decade's most prominent decentralized platforms.

3.2 | Overview of industry setting and study design

The cryptocurrency industry emerged in 2009 with the launch of Bitcoin. All cryptocurrency platforms facilitate the exchange of digital value, but target different audiences, such as privacy-conscious users, the developing world, traders, and small businesses. In its first years, the industry

[1] This study focuses on public/permissionless blockchains, where "all nodes can read, submit, and validate transactions" (Beck et al., 2018, p. 1022). Alternatives include permissioned and private blockchains used internally or inter-organizationally by corporations, which resemble traditional distributed databases. The latter do not have independent market valuations. In line with prior research (e.g., Murray et al., 2019), we distinguish between platform *infrastructure*, including software and hardware (e.g., "the Ethereum platform"); the platform *organization* that operates such infrastructure through coordinated action by contributors (e.g., "Ethereum," capitalized); and the *cryptocurrency* minted by the organization (e.g., "ether," lower-cased).

has remained concentrated and relatively stable, with the top 20 platforms representing over 95 percent of industry capitalization. (Over the 2009–2014 period, these leading platforms form the basis of our data collection, as detailed below.) Bitcoin has remained the industry leader and has grown to become a competitor to payment companies in the developing world, while in the developed world, it has become more of a complementor to companies such as Visa, PayPal, and Stripe, which now support bitcoin transactions. Cryptocurrency platform organizations lack headquarters or offices, are primarily digital, and are not legally incorporated, which makes them inherently borderless. Platform participants, including users and contributors, have a stake in the platform via cryptocurrency ownership. Validators (e.g., "miners") are referees with limited discretion, who can be replaced if platform users deem their behavior to be inappropriate. At an operational level, validators are rewarded to process platform transactions. They can also vote to approve or reject proposals for new rules submitted by developers. Figure 1 provides an overview of a cryptocurrency platform organization representative of the industry's 2009–2014 period.

--- *Insert Figure 1 about here* ---

The remainder of this study develops abductive configurational theorizing (Furnari et al., 2021), which is particularly useful for studying new organizational forms and designs (Daft & Lewin, 1993). Growth without central coordination can be seen as an "anomaly," that is, as a "novel or unexpected phenomenon that … is poorly understood by existing knowledge" (Sætre & Van de Ven, 2021, p. 4). Our first-stage study sheds new light on this anomaly by scoping out mechanisms for decentralized coordination and explaining how they might create predictability, accountability, and common understanding. In a second stage, we link these explanatory mechanisms to decentralized platform growth (or decline) and discuss the "orchestrating themes" behind the configurations of mechanisms explaining these outcomes (Furnari et al., 2021).

4 | DECENTRALIZED COORDINATION AT CRYPTOCURRENCY PLATFORMS

4.1 | Scoping out coordination mechanisms: Overview of data collection and analysis

We reviewed a trove of industry documents, including books, websites, social media channels, and white papers, and engaged in informal discussions with experts at 11 industry events to gain a deep understanding cryptocurrency platform (see Online Appendix 1 for details). We also conducted 26 semi-structured interviews with prominent platform contributors (see Online Appendix 2). Interviews lasted for an average of 64 minutes and addressed the coordination of activities among contributors and how decisions are made without a central organization or managerial authority.

To analyze data, we relied on "abduction, which means connecting what you see in the empirical world with theoretical ideas which … can be further developed" (Gehman, Glaser, Eisenhardt, Gioia, Langley, & Corley, 2018, p. 297; Ozcan & Eisenhardt, 2009; Tavory & Timmermans, 2014). Guided by literature on design and coordination (Okhuysen & Bechky, 2009; Puranam et al., 2014) and interviews with experts, we identified three high-level coordination mechanisms that "anchor" explanations (Furnari et al., 2021) of platform growth, namely decentralized *algorithmic coordination*, *social coordination*, and *goal coordination*.[2] Algorithmic coordination relies on algorithms to maintain a standard space and time that enable predictable mutual adjustment among platform participants. Social coordination creates common understanding and accountability by both fostering consensus among primary contributors (developers and validators) and enabling the integration of effort around platform design. Goal coordination seeks to create common expectations about the platform's long-term evolution, thereby making future developments more predictable. Together, these mechanisms enable (decentralized) coordination, namely, the goal-oriented adjustment of platform participants' actions through expectations alignment (e.g., Gulati, Wohlgezogen, & Zhelyazkov, 2012). Sections 4.2 to 4.4 describe the mechanisms in detail and a visual summary is provided thereafter.

4.2 | Decentralized algorithmic coordination

[2] In our interviews, "consensus" initially emerged as a core theme. Respondents distinguished between "machine consensus" and "social consensus," two terms widely used in the industry to describe *an aspiration* (of reaching consensus) rather than the typical situation (where achieving consensus requires coordination and may or not be reached). For that reason, we eventually chose to name the corresponding constructs algorithmic and social *coordination*, respectively. We thank the editor and two anonymous reviewers for encouraging us to align the names of our constructs with theoretical processes rather than with actors' aspirations.

As argued by McGrath, Arrow, & Berdahl (1999), "coordination…is a synchronization and sequencing of member actions in time and place" (p.2). Maintaining a standard space and time is especially important for creating common understanding and predictability among organizational members (Okhuysen & Bechky, 2009). Indeed, in baseball, if the size of the diamond or the duration of each inning varied greatly with each new game, players would struggle to mutually adjust their moves—let alone build team routines replicable from game to game. In traditional organizational contexts, maintaining standard space and time is facilitated by the reliance on externally available standards, such as clock time (e.g., Eastern Standard Time) and conventional work hours (e.g., 9-to-5), which help coordinate interactions within a physical space structured around tasks (e.g., the meeting room for team discussions, the archival room to keep customer files). By contrast, in digital settings, maintaining a standard space and time to enable coordination is less straightforward. On the Internet, due to network latency, a message sent right now may reach its recipient *after* another message sent minutes from now, thus begging the question as to which communication happened when. Similarly, space in a digital setting is harder to delineate, as it can be extended arbitrarily (e.g., by adding server capacity). Thus, how much space is available to platform participants and how that space gets filled with new information can remain ambiguous. Coordination gets trickier.

Whether in the physical or digital realm, space is "real" to the extent that it exhibits "attributes that exist irrespective of empirical experiences" (Bansal, Kim, & Wood, 2018, p. 5). As such, network "servers occupy space at a point in time and form a complex relationship with the other physical objects with which they interact" (Bansal & Knox-Hayes, 2013, p. 15). In a board room meeting, the number of attendees is bound by the number of chairs around the table, whereas in a digital meeting, that number can be increased by adding server space. While space standards have real implications in both settings, the absence of self-evident boundaries in the digital realm is usually compensated for by reliance on a central authority. Thus, on a digital platform, it is often the central platform owner who maintains a standard space and time and enforces boundaries. Wikimedia, for example, centrally maintains the server space on which Wikipedia is stored and keeps a 1GB limit for photo uploads; it also makes the platform's metadata available to developers twice a month, on the 1st and the 20th, which maintains a stable standard timeline for development runs. But for digital platforms *without a central authority*, such a top-down approach cannot work. This is where algorithms are useful, as they shift the responsibility of maintaining a standard space and time to software code executed automatically for the benefit of all platform participants. For instance, each cryptocurrency platform has its own standard time elapsing in between blocks (e.g., 2.5 minutes for Litecoin) and a standard amount of digital space that can be used by participants during that period (e.g., 1MB for Litecoin). In the following, we discuss how algorithms concretely maintain a standard space and time under various degrees of decentralization.

4.2.1 | Decentralized algorithmic coordination of platform space

Cryptocurrency platforms coordinate activities in their digital space "decentrally," as insiders often say, by recording transactions inside "blocks" validated by rewarded contributors and stored in a digital archive synchronized locally on users' own hardware. In our context, therefore, the most essential space on the platform is its "block space", whose informational content (in bytes) is consolidated and made accessible thanks to algorithms. As put by Web3 entrepreneur and investor David Phelps, "the real metaverse real estate isn't virtual land, it's block space" (*Phelps, 2022).[3] As another expert explained, "block space is…used to facilitate so much of the decentralized and novel ways for human coordination" observed in innovative digital platforms (*Dameron, 2021). Ultimately, "access to block space and the coordination…of people coming together" rest on the platform's algorithms that piece together new data for adding them to a new block (*Trollz, 2022).

Given platform space limitations enforced automatically by algorithms, participants need to agree on who gets to use available platform space and fill it with transaction data. Two

[3] Archival industry sources are flagged with * and listed at the end of the *Online Appendix* to distinguish them from academic references. Several interviewees known pseudonymously in the industry have asked to be quoted under their pseudonym.

alternatives exist to coordinate this effort. Indeed, block space can be filled decentrally by using either "proof-of-work" or "proof-of-stake"—two algorithmic protocols that rely on validators' votes to accept or reject new data. With proof-of-work, a validator's voting power increases with their contribution in computing power; with proof-of-stake, in proportion with the amount of cryptocurrency owned. According to Palmer, cofounder of Dogecoin (interview #9), block space

> ultimately has to be secured through "proof of something." Earlier coins had proof-of-work…[to validate transactions], which [relies on] intense computing. Some coins moved to proof-of-stake…[where those] that carry the greatest consensus in the network are those who own the highest stake.

By analogy, insiders often depict proof-of-work as "meritocratic" and proof-of-stake as "aristocratic" coordination of a platform's "real estate." And because proof-of-stake tends to make the rich get richer, it does not sustain decentralization to the same extent as proof-of-work (this distinction later helps us delineate the fuzzy-sets where "strong decentralization" is present).

4.2.2 | Decentralized algorithmic coordination of platform time

In organizations, time can be experienced subjectively (Crilly, 2017), which means that, in the absence of a stable standard time, coworkers might struggle to mutually adjust their actions. Indeed, subjective and objective time can be at odds and Lee & Liebenau (1999: 1040) go as far as to claim that "the social time concept [is] the antithesis of the concept of clock time." Creating some alignment between the two is thus essential to coordinate activities, and this coordination typically crystallizes around a standard time that is made objective to participants. "An early example of a standardization mechanism that enabled coordination" is how "Railroad Standard Time replaced the over 500 local times that existed in 1883…[and] became the de facto temporal standard" in the economy (Okhuysen & Bechky, 2009, p. 465-6). Likewise, digital platforms need a standard time to infuse predictability and support coordination, but they lack senior managers with the authority to impose such a standard. As put by a cryptocurrency developer,

> keeping track of things in the informational realm implies keeping track of a sequence of events, which in turn requires keeping track of time …. PayPal, Venmo, Alipay, and all the banks of this world—including central banks—solve [this] problem via central authority (*Gigi, 2021)

Besides, in decentralized platforms with open membership, participants are free to join and leave at will, which, additionally, creates temporal instability—for instance, "as more 'miners' join" a cryptocurrency platform, transaction validation becomes computationally easier, so the platform's "clock…tend[s] to go faster and faster" and participants "quickly run into [a] coordination problem" (Trón, interview #19). To maintain a standard platform time, which Trón calls a "steady heartbeat", cryptocurrency platforms add new transaction data to the shared ledger at regular intervals using algorithmic coordination. Specifically, temporal "coordination is made possible by the difficulty-adjustment [algorithm], the magic sauce that links [platform] time to ours" outside the platform (*ibid*.). This algorithm automatically re-allocates computing resources to stabilize "block time" (the time elapsed between two blocks), much like a thermostat maintains a pre-set temperature. As such, "block time is the new unit of coordination" (*Rafa0, 2021) on cryptocurrency platforms in that it gives all participants a standard temporal anchor. When newcomers are influential enough to destabilize block time, it indicates that the platform can still be subject to centralizing forces—indeed, in a fully decentralized platform, the time elapsed in between blocks would remain perfectly stable over the long run, independently of members joining and leaving the platform. Thus, the degree of stability of a platform's block time is a good indicator of the extent to which the algorithmic coordination of time is decentralized within that platform.

4.3 | Decentralized social coordination

Decentralized social coordination creates common understanding and accountability among contributors (Okhuysen & Bechky, 2009) in the absence of a central authority. As explained by an industry expert, "humans must first decide what protocol to run before the machines can enforce it" (*Lopp, 2016). In our context, to grasp how social coordination builds consensus that enables the integration of effort across the entire platform, it is crucial to distinguish between the two primary groups of human contributors, namely OSS developers and network validators.

4.3.1 | Decentralized social coordination of OSS developers

The process by which developers coordinate to write cryptocurrency software without depending on a central authority shares similarities with other decentralized OSS communities (O'Mahony & Lakhani, 2011). Without substantial developer coordination, a cryptocurrency platform's development can become "hemorrhaged," as explained by Lovejoy, core developer of Vertcoin (interview #5). Looking back at the challenges he faced in Vertcoin's early days, he added:

> If you want the coin to grow and expand, . . . active development is probably one of the more important things… There were a number of ideas people wanted to develop. It really required a lot more time and thought than people had available or were willing to give.

To coordinate development, participants rely on formal and informal deliberations. Informal channels include online forums and social media (e.g., Twitter), where developers openly discuss potential rule changes. More formal documents help take the process to the next level. For example, Bitcoin uses "Bitcoin Improvement Proposals" (BIPs) to align developers' expectations. A BIP is a design document wherein developers formalize the proposed new features. Involving a larger number of independent developers is typically associated with more decentralized coordination, but ultimately it is the diversity of conversation topics explored in parallel, without centralized management, that determines the extent of this decentralization. Coordinated development advances when new ideas are translated into new code committed to the shared OSS repository.

4.3.2 | Decentralized social coordination of network validators

Validators volunteer costly resources (e.g., electricity) and "run network nodes," as insiders say, to act as platform referees—a role absent from traditional OSS communities. A referee, in this context, relays information among peers to align participants' understandings of who is transacting what and with whom. In exchange for their services, validators earn rewards determined algorithmically, without managerial intervention to evaluate performance. Validators also approve or reject developers' code improvement proposals by casting votes onto the blockchain, which helps developers and users anticipate platform evolution and adjust their behavior accordingly (*GitHub BIPs, 2016). As explained by Cassini (interview #16), if validators no longer support a platform's development, "then they turn to other ventures." Without them, information is not relayed as reliably and swiftly, and coordination can be derailed, both within and between groups of contributors. Indeed, a validator "node's value…is only in its implicit contribution to the coordination…onto the network" (*Buterin, 2018). "The more nodes, the better [the decentralization]…because it's a peer-to-peer technology" (Laurence, Reddcoin, interview #25). Having more validators both enhances social coordination and increases its decentralization.[4]

4.4 | Decentralized goal coordination

Cryptocurrency platform contributors share an interest in removing central authorities from value chains (e.g., Western Union in the payments sector). Although their personal motives vary greatly, from cutting transaction costs to making "government obsolete" (*Leonard, 2019), they agree that decentralized coordination is desirable and requires both algorithmic and social coordination. This convergence notwithstanding, contributors differ on how the platform's goals should be redefined over time. It can be done without any formal structure by having contributors interact online and offline until they reach agreement. In such a scenario, goal coordination is heavily decentralized across contributors, and it can be time-consuming to reach mutual agreement.

Some prefer to have a foundation in place to guide the goal definition process and provide more accountability (Okhuysen & Bechky, 2009). Foundations, staffed with volunteer contributors and, at times, platform cofounders, help "coordinate open-source projects" by "provid[ing] communication means and…information for newcomers, but have limited implication and influence in the…project's day-to-day work and decision process" (Izquierdo & Cabot, 2018, p. 8). In the cryptocurrency sector, a foundation's typical focus is advocacy, which includes educating users and fostering adoption (Vegetabile, interview #4). Unlike the platform itself, its foundation is sometimes incorporated (as a nonprofit) to enable donations, which can be used to compensate developers for their time, based on a grant system (similar to the research grant system in academia)

[4] A Bitcoin proposal passes if backed by 55 percent of the platform's computing power, and is considered "activated" when 95 percent of validators have implemented the software update. Note, however, that not all platforms have formal voting mechanisms like BIPs: Ethereum does, whereas Namecoin and Worldcoin do not. For the sake of simplicity, we do not distinguish, in this study, between the different types of nodes that provide refereeing services. The most important nodes in cryptocurrency platforms are the so-called "full" and "mining" (or "validating") nodes, although their labeling differs across platforms.

(Jameson, interview #20). Importantly, foundations are neither platform "owners" nor "leaders" (Gawer, 2014). The Ethereum Foundation, for example, clearly states that they "are not Ethereum…, do not own Ethereum, operate it, or manage it…. do not control Ethereum, nor are we the only organization that funds critical development of Ethereum-related technologies" (*Ethereum Foundation, 2022). This approach was confirmed to us in practice by Jameson:

> Ethereum Foundation is a flat organization…. It doesn't have a lot of direct say…into the direction the Ethereum platform is going to go…. There's a lot of autonomy given to the dev teams…. It's a very hands-off approach, where [they] aren't going to the teams to say "hey, have you met your goals? have you done this or that?" They're just kind of "let the devs code and here's some money!"

Developers value their freedom, and most would stop contributing to a platform if its foundation sought centralized control. That said, foundations can narrow the breadth of platform goals by offering grants to incentivize specific projects that align well with participants' interests. Foundations can then facilitate coordination around a narrower set of goals, thereby mitigating the risk of never reaching "community consensus" (Cohen, Blackcoin Foundation, interview #7).[5] Platforms with a foundation thus coordinate goal definition in a less decentralized way than platforms without one.

With or without a foundation in place, any lingering disagreement among contributors about long-term goals can be resolved in a fully decentralized fashion through a "hard fork," which occurs when contributors part ways by splitting the blockchain and creating a separate platform with its own validators, developers, users, and native cryptocurrency. "In principle, [contributors] can always just fork…and… try to convince the miners to switch" (Kraft, interview #18). By analogy, a hard fork is not unlike a province unilaterally declaring its independence without war—or a corporate spin-off—except that any group of participants can trigger a hard fork without legal liability (e.g., in the absence of employment contracts, there is no such thing as a non-compete clause, and OSS can be copy-pasted and reused at will).

4.5 | Plausible coherence and substitutability between coordination mechanisms

[5] A community is a "voluntary collection of actors whose interests overlap and whose actions are partially influenced by this perception" (O'Mahony & Lakhani, 2011:4). Community "consensus" means reaching broad agreement in the community.

The decentralized coordination mechanisms revealed in our study's first stage represent algorithmic and social methods used to align participants' expectations and actions within a standard space and time. Subsequent configurational theorizing should explain not only how "multiple attributes plausibly combine with each other to explain the outcome" (here, platform growth) but also when "explanatory attributes [can] serve as substitutes for one another" (Furnari et al., 2021, pp. 8, 17). To flesh out coherence between the revealed mechanisms, consider the concrete example of "mining." Validators perform the "mining" routine to record interactions between users on such platforms as Bitcoin, Ethereum, Litecoin, and Zetacoin. Each time a new block of validated transactions is added to the ledger, one miner is rewarded for providing a proof-of-work. The reward itself comes from minting new cryptocurrency as well as from transaction fees paid by users. Algorithms maintain the time interval between minting events stable by adjusting the mining difficulty to the number of participating miners. The more stable that time interval (a.k.a. "block time"), the more predictable the rewards, which incentivizes additional miners to join. Block time stability also attracts new users who create additional demand for mining. The more miners, the more decentralized the social coordination. Thus, the algorithmic coordination of time works in tandem with the social coordination of validators—and we would expect these two mechanisms to produce their effects jointly (indeed, our fsQCA will later show that these two mechanisms tend to be either jointly present in or jointly absent from our solution's configurations). Furthermore, we would expect some substitutability between mechanisms involving social and goal coordination. Indeed, in the presence of a foundation that narrows the platform's long-term goals, contributor expectations should be better aligned ex ante, which should make it possible to further decentralize social coordination (indeed, our fsQCA will provide evidence of a substitution effect between strongly decentralized social and goal coordination).

The mechanisms described previously can be seen as the tools available in the decentralized coordination toolbox. When dealing with platform design, these tools can be used in various ways, as complements or substitutes. In terms of explaining platform growth, our first-stage findings foreshadow the presence of both "conjunctural causation" (tools do not display effects on their own but in combination with other tools) and "equifinality" (different combinations of tools could have the same effect) (Schneider & Wagemann, 2012). At a theoretical level, our mechanisms coherently contribute, to various extents, to the decentralized coordination of information, resources, tasks, and rewards—the four domains referred to in the design literature as the "universals of organizing" (Puranam et al., 2014, p. 166). The mining example illustrated the role of algorithmic coordination in decentralizing the distribution of tasks (Who records new transactions?), resources (How to adjust mining difficulty to stabilize block time?), information (How to share block space in the ledger?), and rewards (How much to pay validators?). Likewise, our mechanisms feed into the "three integrative conditions for coordinated activity" (Okhuysen & Bechky, 2009, p. 463), with "accountability" being nurtured primarily by social and goal coordination, "predictability" by algorithmic and goal coordination, and "common understanding," by algorithmic and social coordination. Figure 2 provides an overview of how the mechanisms relate to organizational coordination and design.

--- Insert Figure 2 about here ---

5 | COORDINATION MECHANISMS AND EARLY-STAGE PLATFORM GROWTH

To help develop new theory on how decentralized coordination enables growth, the second stage of our study leverages fsQCA to identify the coordination mechanisms that are necessary or sufficient, either independently or jointly as configurations, for platform growth. Our use of fsQCA is motivated by several factors. First, our first-stage analyses hinted at the potential presence of "equifinal configurations" (Fiss, 2011, p. 398). Indeed, as put by a blockchain expert, "there are many ways to skin the decentralised cat" (*Leonard, 2018). Second, our analyses hinted at decentralization being a matter of degree while remaining qualitatively distinct from centralization. As blockchain entrepreneur Jimmy Song noted while illustrating the qualitative divide, "You either have control over your stuff or you don't. It's a zero or a one" (*Dale, 2019). Yet, blockchain decentralization is also a matter of degree and depends on such factors as the number of developers actively contributing to platform upgrades (Wang & Vergne, 2017). Decentralization is thus best captured using "fuzzy sets" because, "by assessing the degree of membership, they provide the precision of measurement valued by quantitative researchers; and by calibrating according to theory and substantive knowledge,…incorporate the best aspects of qualitative research measurement" (Misangyi et al., 2017, p. 262).[6] Third, "the 'configurational approach' in management" is "frequently associated with research on organizational design" due to their common focus on complex systems comprising interdependent parts (Misangyi et al., 2017, p. 257). Indeed, the three pillars of coordination—accountability, predictability, and common understanding—"are related to one another" with "tradeoffs and complementarities among them" (Okhuysen & Bechky, 2009, p. 489). Our data represent an opportunity to use a configurational approach to unpack decentralized platform design, especially since prior research on decentralized platforms has remained correlational and variance-based in nature (Chen et al., 2021; Hsieh et al., 2017). Here, fsQCA can "elaborate a new configurational perspective in [a] theoretical domain in which inherent complex causality ha[s] been acknowledged but ha[s] so far gone largely uncovered by conventional linear thinking and regression approaches" (Misangyi et al., 2017, p. 276). We now build upon our study's first stage to examine how coordination relates to platform growth.

5.1 | Case selection

We selected 20 cryptocurrency platforms created between 2009 and 2014—a number both small enough to gain a rich understanding of each case and large enough for theory building. Consistent with best practices of theoretical sampling, some cases were included because they represented the industry's "unusually revelatory, extreme exemplars" (Eisenhardt & Graebner, 2007, p. 27); for example, Bitcoin was the first cryptocurrency platform created. Others were included because they represented "polar types" that stood out along a potentially important dimension of coordination.

[6] By analogy, consider water temperatures (in Celsius) at standard atmospheric pressure. Below 0, water is ice, which represents a qualitative change relative to temperatures above 0, at which water is liquid. Yet, ice can still be more or less cold (have continuous variations) despite being "not liquid" (a binary distinction). Both qualitative and continuous differences can thus be captured with a "fuzzy" temperature scale interspersed with meaningful threshold values (> 0 degree for liquid water, > 100 degrees for steam).

For instance, Peercoin was the first cryptocurrency to use proof-of-stake to coordinate platform space. At the end of 2014, which marks the end of our sampling period, our sample's market capitalization represented 95 percent of the industry's total value; as of May 2020, it accounted for 85 percent. Further details on sampling are reported in Online Appendix 3; all sampled platforms are listed in the fsQCA results table in Section 6 below.

5.2 | Fuzzy-set design for the explanatory conditions and outcome

In line with best practices (Misangyi et al., 2017; Ragin, 2008; Schneider & Wagemann, 2012), (1) we chose data and operationalizations informed by theory on coordination and substantive knowledge on cryptocurrency platforms; (2) we chose qualitative anchors based on a combination of conceptual and industry knowledge triangulated from archival, qualitative, and quantitative sources (typically, at least one archival source and data from two distinct interviews); and (3) we used the log link function, where needed, to calibrate values between qualitative anchors. To enhance external validity, none of our calibrations depend on the specific set of cases sampled.

We calibrated one outcome, namely *Early-stage Growth*, and, based on the first stage of our study, five explanatory conditions: two fuzzy-sets capturing *Decentralized Algorithmic Coordination* (*of Platform Space* and *Time*); two fuzzy-sets capturing *Decentralized Social Coordination* (*of Developers* and *of Validators*); and one fuzzy-set capturing *Decentralized Goal Coordination* (without or with a foundation). Research has shown that, for new ventures, "failure to grow often reciprocally translates into failure to survive" (DeSantola & Gulati 2017, p. 641), thereby making early-stage growth a crucial outcome. The number of fee-generating transactions processed by cryptocurrency platforms—whose primary activity is to facilitate digital transactions between agents—represents a robust assessment of how large a given platform has become (Narayanan, Bonneau, Felten, Miller, & Goldfeder, 2016).[7] Accordingly, our measure of growth captures the increase in the number of

[7] Visa and MasterCard also quantify their growth in terms of the number of credit-card transactions processed. Cryptocurrency price and market capitalization, especially in early stages, "can be a rather slippery indicator when trying to measure growth. … If we truly want to get an understanding of how adoption … is looking on the ground, we'll need to look at … transaction rate and volume." (*Greenspan, 2018). Price is a slippery indicator since it captures speculative behavior independently of platform growth.

transactions processed during the quarter directly following each platform's launch; we refer to the launch quarter as "Q1," and to Days 91 to 180 post-launch as "Q2," independently of the calendar date of the launch. In their first six months of existence, seven of the 20 platforms we examined experienced post-launch growth, and 13 declined.

All explanatory conditions use Q1 data to explain Q2 growth outcomes. Since all explanatory conditions represent decentralized coordination mechanisms, we followed a simple, high-level rule to calibrate their fuzzy-set memberships: The more a platform relied on a given mechanism in a decentralized way, the closer to 1 its membership score. Our calibrations thus reflect, for each case, the extent of each condition's decentralization, while capturing distinctions that are discrete (e.g., no centralized coordination) and continuous (e.g., Bitcoin is "fully" in the set of platforms with strongly decentralized goal coordination, whereas Paycoin is "more out than in"). We thus calibrated *Decentralized Algorithmic Coordination of Space* above (below) 0.5 when proof-of-work (proof-of-stake) coordination was used to manage platform space—since proof-of-work enables, by design, stronger decentralization. We calibrated *Decentralized Algorithmic Coordination of Time* above 0.5 for platforms that were sufficiently decentralized to maintain a stable "block time" the vast majority of the time. For *Decentralized Social Coordination of Developers*, we calibrated data on the number of developers' conversations committed as new code to the OSS repository used to coordinate platform upgrades, as a diversity of conversations signals more decentralized coordination. Similarly, since having more validators enhances social coordination at the same time as it increases its decentralization, we calibrated *Decentralized Social Coordination of Validators* with data on the number of independent validators who act as referees on the platform's network. Finally, we calibrated *Decentralized Goal Coordination* depending on the absence (more decentralization) or presence (less decentralization) of an independent nonprofit foundation—in the latter scenario, we also captured the extent of cofounder influence on the foundation's board. Online Appendix 4 provides rationales and representative quotes in support of calibration decisions, analyses of sensitivity to threshold choices, and the data sources used in the fsQCA.

6 | RESULTS: CONFIGURATIONS AND ORCHESTRATING THEMES

To identify sufficient configurations of coordination mechanisms, we processed truth tables using fsQCA 3.0. Details about our analytical approach are reported alongside the calibrated dataset in Online Appendix 5; information about prime implicants and simplifying assumptions are reported in Online Appendices 6 and 7, respectively; and Online Appendix 8 examines alternative time horizons for capturing platform growth. Table 1 shows the intermediate solution that, conservatively, considers only the most plausible simplifying assumptions (Crilly, Zollo, Hansen, 2012). It is organized around core explanatory conditions, which have the most robust evidence linking them to the outcome (Fiss, 2011). We identified two configurations sufficient for early-stage growth—both involving the presence of strongly decentralized algorithmic coordination (G1 and G2). We thus characterize G1 and G2 as supporting *algorithmic growth*. By contrast, none of the three configurations sufficient for decline (D1, D2, and D3) involve strongly decentralized algorithmic coordination, and the vast majority of their coverage is associated with the absence of that condition. Strikingly, no platform has grown early on by strongly decentralizing *every* coordination mechanism (i.e., Table 1 has no column entirely filled with black circles).

--- Insert Table 1 about here ---

6.1 | Paths to algorithmic growth: Core contributor-driven (G1) versus vision-driven (G2)

Core contributor-driven algorithmic growth, in G1, relies on strongly decentralized algorithmic coordination of platform space and social coordination based around small groups of core platform contributors. Information is processed and allocated to platform space with little influence from developers and validators, who focus on distributing tasks and rewards (see Figure 2 above). The emphasis on decentralization algorithms to distribute information is visible in the design of platforms representative of G1—both Zetacoin and Megacoin began their growth in 2013 with proof-of-work coordination. On the other hand, these platforms' social coordination mechanisms have lower levels of decentralization, meaning that their developers and validators are part of smaller-scale communities, leading to both a more focused approach to OSS development and a lower likelihood of persistent disagreement among contributors; coordinating through a foundation is thus less necessary. In spite of its benefits, strongly decentralized coordination of platform space implies little human control over the distribution of information; however, this downside is mitigated by the smaller scale of developer and validator groups, as illustrated by Jeremy Rand, who recalls how developers once managed to reach out to most validators, one after the other, to convince them to activate an OSS upgrade needed to address a software vulnerability:

> We hadn't yet activated [the proposal], so we're vulnerable. We immediately contacted all of the mining pools and said, hey, you need to upgrade to the latest version ASAP. And most of the mining pools were fairly quick to respond. But we were not able to quickly contact sufficient hash power to reach the 95 percent threshold that's needed to activate…, so we were hovering around 92 percent. . . . After about a week or so, we were still having no luck reaching the last seven or eight percent of hash power, and finally . . . F2Pool contacted us . . . [with] enough hash power.

This quote illustrates that less decentralized social coordination can fast-track platform development in the early days. Those more focused groups of contributors are able to drive growth by swiftly coordinating the other participants' efforts in the absence of a foundation.

Vision-driven algorithmic growth, in G2, relies on both larger, more decentralized groups of developers and validators and an independent foundation. As Pike stated, "in a way the technology … is there for forming consensus without a trusted third party, but in another way, the human psychology is not quite ready for this type of dynamic" (interview #15). While "active development is one of the more important things" (Lovejoy, interview #5), when the developer group is large, a foundation may be required to provide a guiding vision. When contributors fail to reach agreement offline (e.g., during conferences) and online (e.g., via the GitHub code repository), a foundation can help achieve compromise, and the parties involved may have incentives to accept it, if only to preserve platform integrity. To provide such a vision, for instance, the Ethereum Foundation acts as a "flat hierarchy," which helps align the "operations team and the developer teams" while giving both "a lot of autonomy" (Jameson, interview #20). Also representative of G2 is Blackcoin, which, much like a traditional OSS project, used its foundation to "build community" around a vision. As put by Cohen (interview #1):

> The main people … on the foundation at the beginning would have had a larger public role within the community. For the most part it's still the same people who are advancing different projects and communicating with the developers and … the public…. Early on … it was an attempt to bring legitimacy and human faces … [and] to have some stable group of people who can address the community and become known and trusted at least within the community as the consistent names of people who communicate what is going on.

With this approach, Blackcoin was able to pioneer the development of proof-of-stake, which suggests that, by relying on its foundation, Blackcoin was able to speed up decision-making and introduce innovations faster despite strongly decentralized social coordination. Foundations can also incentivize development projects with grants, which can be funded "every time a block is mined [because] a percentage of the block reward goes to this fund that is administered by the … community grants board [of the foundation]" (Jameson, interview #20). Since rewards are distributed with each new block, maintaining "clockwork block regularity" is crucial in this scenario, as it keeps foundation incentives flowing with consistency (*heavymetaltcryp, 2021).

6.2 | Paths to decline: Unreliable algorithmic coordination (D1 and $D2_{a–b}$)

In keeping with our focus on platform growth, we more succinctly discuss findings from our supplementary analyses of platform decline. D1 and $D2_{a–b}$, which represent 84 percent of the sum of decline configurations' raw coverage scores, have in common the absence of strong decentralization for algorithmic coordination, in stark contrast with what was observed in growth configurations. In D1 and $D2_{a–b}$, the provision of refereeing services by validators is adjusted haphazardly due to insufficiently decentralized algorithmic routines. Without an "even heartbeat" (Trón, interview #19), attracting users is "a little hard … because of the … backup of transactions [that results in] a higher fee to get one's transaction in, which hurts everybody" and hampers platform growth (Jameson, interview #20). This issue is compounded in D1 by the strongly decentralized coordination of developers, who contribute a broad diversity of ideas that platform infrastructure may not be able to handle with consistency, due to volatile time coordination. Indeed, having a "stable" platform that "does not crash and has enough nodes online all the time" is a "precondition for evolving a system with development" ideas (Kraft, interview #18).

D2 comprises two "permutations of peripheral elements" around a second core condition (Fiss, 2011, p. 394), namely the absence of strong decentralization for the coordination of platform space, which can hamper early-stage growth:

> unfortunately, … the reason that we were the first … to roll a [proof-of-stake] blockchain back was because…, if people keep their coins on a [centralized online] exchange, and that exchange gets hacked, suddenly [voting power is concentrated and] you can attack [the entire platform] (Noskar, Vericoin, interview #23).

In $D2_b$, Vericoin's platform time is off and the needed temporal coordination is difficult to restore:

> if you're trying to coordinate with people, say, in Australia on the other side of the world, you're gonna have some … latency between communications…. If your block time [becomes] shorter than the latency, you'll have extreme volatility (Noskar, interview #23).

A vicious circle can arise, whereby communication latency nurtures block time instability, which deters validators from joining due to rewards unpredictability, which weakens the decentralization of validator coordination. When combined with the absence of strong decentralization for the coordination of platform space (that is, in proof-of-stake platforms), this can seriously damage growth prospects because, "as developers of a proof-of-stake project, we have very little ability to…drive the network without engaging the [validator] community" (Laurence, interview #25). Indeed, a lack of strong engagement among validators is manifest in $D2_a$.

Configuration D3, which only covers one case (Bitcoin) with potential outlier status, is discussed separately in Online Appendix 9. We show that Bitcoin's fast-paced growth from 2012 onwards, following early decline, is theoretically consistent with the pattern described in G2.

7 | CONTRIBUTIONS AND DISCUSSION

In classic management theory, "the visible hand" of the manager "coordinate[s] and plan[s] for the activities of … the enterprise as a whole" (Chandler, 1977, p. 315). By contrast, our findings suggest that organizations can be managed without managerial authority. Our study revisits, critically, the tenet that a central authority, whether in new ventures (Greiner, 1972), in established firms (Fayol, 1949), or in platforms (Cusumano, 2020), is necessary to coordinate for growth (Penrose, 1959). Specifically, in a platform context, we unpack how platforms operate and grow without reliance on a platform owner (Gawer, 2014). Before developing our contributions to the literatures on coordination and organizational design (Galbraith, 1974), platforms and meta-organizational growth (Kretschmer et al., 2020), and management decentralization (Chandler, 1977; Chen et al., 2021), we discuss the generalizability of our findings to other settings.

7.1 | Decentralized coordination beyond blockchain technology and cryptocurrency

Blockchain is neither necessary nor sufficient for decentralized coordination and our findings can generalize, at a theoretical level, to the interplay between coordination and design within organizations and communities and, at an empirical level, to platform research broadly speaking.

Decentralized digital platforms have already left their cradle in the cryptocurrency sector and diffused across industries. Cryptocurrency is now routinely attached to digital assets (e.g., image and audio files) and wherever the corresponding NFTs are traded, decentralized coordination has gained new ground, with decentralized platforms (e.g., LooksRare) now challenging their centralized counterparts (e.g., Christie's and OpenSea) (*Bambysheva, 2021). In web services, the "InterPlanetary File System" (IPFS) offers a peer-to-peer cloud as an alternative to centralized clouds provided by the likes of Dropbox and Apple. The IPFS does not rely on blockchain to deliver its core service but, similar to the platforms examined in this study, still employs decentralized coordination. "Decentralized autonomous organizations" (DAOs), which refer to decentralized platforms with an industry focus other than cryptocurrency, are on the rise. As of April 2022, there were 5,000 active DAOs and this organizational form is bound to attract further scholarly attention (Hsieh, Vergne, Anderson, Lakhani, & Reitzig, 2018). The cryptocurrency platforms examined in this study are the DAOs' predecessors and, in fact, many industry insiders today would argue that "Bitcoin was the first DAO" (*Woodbury, 2021).[8]

[8] To track DAOs, the reader can refer to: https://deepdao.io/organizations. Several technologies, aside from blockchain, enable platform decentralization. The IPFS, for instance, relies on "distributed hash tables" (DHTs). Other decentralization technologies include "conflict-free replicated data types" (as used to develop the "Atom" text editor) and "zk-SNARKs" protocols. By analogy, consider how virtual collaboration has been enabled not just by the SMTP protocol (for email) but by a broad range of tools. Like blockchain in our context, these tools substitute SMTP for virtual collaboration (e.g., instant messaging can substitute email).

Our findings reveal fundamental aspects of coordination that, too often, remain hidden in plain sight. To share a "common understanding, [which] coordinates through interdependent parties developing a shared conception of…activities" (Okhuysen & Bechky, 2009, p. 489), organizational members must first decide how to use "the same space at the same time" (p. 473). Wikipedia, for instance, must allocate dedicated server space to sections of its encyclopedia and decide where to locate its datacenters, knowing that these decisions affect the timing of online queries as well as governments' ability to censor content, thereby imposing constraints on the organization's strategy, which is to provide universal access to knowledge. On a decentralized platform, algorithms are used in lieu of a central authority to coordinate time and space, which opens new strategic opportunities for building censorship-resistant platforms.

Our findings also inform research on "open-source communities" (von Krogh, Spaeth, & Lakhani, 2003), which has recently begun to examine the role played by software foundations. In traditional OSS settings, foundations often "limit themselves to core legal aspects [and] do not play any role in the day-to-day operations of the project" (Izquierdo & Cabot, 2018, p. 3). Our data suggest that foundations may also play a subtle but crucial role as a countervailing force that balances extreme levels of contributor decentralization. In many traditional settings, "open-source projects and firms h[o]ld divergent interests" (O'Mahony & Bechky, 2008, p. 422), but our study demonstrates that, with the help of a foundation, monetary incentivization powered by algorithms can be built into OSS projects to re-align community and business interests.

7.2 | A configurational view on decentralized coordination and organizational design

Decentralized coordination mechanisms serve as tools that may be combined in various ways to integrate effort without relying on a central authority. That said, in our data, algorithmic, social, and goal coordination were never strongly decentralized at the same time, and no single decentralized mechanism was sufficient, on its own, to kickstart platform growth without a counterbalancing force at work. Growth is either driven by core contributors (G1) or corralled with the help of a foundation (G2). As a result, design trade-offs exist, and fully decentralized coordination may not be achievable in practice, at least not in the earlier stages.[9]

Our contribution to a configurational theory of decentralized platform design builds upon a well-established tradition (Doty et al., 1993; Misangyi et al., 2017). In particular, in Galbraith's "information processing view" of design, three types of coordination shape organizations. The first type, "coordination by rules and programs," enables routine task performance without "inter-unit communication" (Galbraith, 1974, p. 29) and maps well onto our study's notion of *algorithmic coordination*. The second type, "coordination by targets and goals," involves goal setting in such high-uncertainty scenarios as long-term planning and maps well onto our study's *goal coordination* mechanism. Galbraith's third type, coordination through "hierarchy," handles what "rules and programs" cannot, that is, the "infrequent situations" for which no rules exist and thus must be referred to managers with a "global perspective" on the organization. For Galbraith, who was writing during the heydays of the multi-divisional corporation and before the rise of digital technology, it may have been unthinkable for a firm to operate without a managerial hierarchy. Yet, in our setting, when a new situation arises that cannot be handled with existing protocols, it is not referred to a higher-level manager, but instead flagged by developers and validators, who then work on protocol changes decentrally, without a managerial hierarchy. This approach suggests that "hierarchy," as envisioned by Galbraith, represents but *one possible way* for organizations to achieve "social coordination." By recasting hierarchy as a special case of social coordination, our theoretical framework offers the potential to extend and generalize Galbraith's.

Daft and Lewin (1993, pp. i–iii) famously recommended "moving away from the paradigm within which organizations strive for … hierarchical organization and bureaucratic structures that provide central control over activities" and instead called for examining new designs with "flatter

[9] Kraft (interview #18) conjectures that later stages of growth might operate differently: "having some people have some control, … in the early stages, may be beneficial because [that's when] you need to build something. And then, later, you can decentralize it." Interestingly, this tactic, involving gradual decentralization over time, contrasts with Siggelkow and Levinthal (2003), who envision benefits to initial decentralization to tap into the value of exploration, followed by subsequent centralization to maximize exploitation. Addressing this apparent tension poses an exciting challenge—it may be that centralized organizations, such as firms, benefit from further centralization over time, while the reverse may be true for decentralized organizations.

hierarchies, decentralized decision making, [and] greater capacity for … empowerment of employees." Our study has taken their call a step further by examining which configurations of coordination mechanisms support or hamper the growth of organizations that are both hierarchy-*and* employee-less. Our configurational study re-emphasizes that there is no one best way of organizing (Doty et al., 1993; Galbraith, 1973), even in settings where algorithms are core to the organization and optimized for efficiency. Instead, our study stresses the value of a "multi-contingency" perspective on design, wherein "structural and human components" of coordination are considered in tandem (Burton & Obel, 2018, p. 6).

7.3 | Platforms and meta-organizational growth

This study shifts the focus of platform research from the network-effect strategies of corporate platform owners (Gawer & Cusumano, 2002; Parker & Van Alstyne, 2018) to the coordination strategies of early-stage platforms without corporate owners (Chen et al., 2021; Hsieh et al., 2018). As described by Evans (2009, p. 101), launching a centralized platform "involves solving a very difficult coordination problem between the platform and…groups of economic agents." The coordination problem is even greater in decentralized settings where no one has the authority to impose a decision (Knez & Camerer, 1994; Weber, 2006). Key to solving this problem is transparent and predictable incentivization built into algorithms. Due to specialization requirements, joining a traditional community of volunteer OSS contributors incurs a cost and does not typically generate monetary rewards (von Krogh et al., 2003). Thus, differing markedly from OSS communities, the decentralized platforms examined in this paper incorporate mechanisms for contributors to earn monetary rewards, much like business organizations. As a result, these decentralized organizations, unlike OSS communities, have a market value. Zurrer (interview #17) put this new reality in historical perspective: "We've had OSS development for long but never with incentivization built in. As a result, there was no way to apply management principles to OSS … but now we can!"

The idea that coordination can take place without hierarchy speaks to the literature on "meta-organizations," namely "organization[s] whose agents are themselves legally autonomous and not linked through employment relationships" (Gulati, Puranam, & Tushman, 2012, p. 573), such as trade associations, supply chain networks, and technology platforms (Berkowitz, Bucheli, & Dumez, 2016; Valente & Oliver, 2018).[10] Absent a central authority, meta-organizations cannot rely on the "co-ordinating function of the 'entrepreneur'" (Coase, 1937, p. 389) to leverage complementarities between players (Altman, Nagle, & Tushman, 2021; Ahrne & Brunsson, 2008). Against this backdrop, our findings delineate factors that support the growth of meta-organizations with an independently determined market value. First, a meta-organization can overcome the predicament of being neither a market nor a hierarchy (Jacobides, Cennamo, & Gawer, 2018; Kretschmer et al., 2020) by creating "a market within an organization" (Duffield, interview #2). To that end, meta-organizations can use a native currency to align expectations. When that currency's price is too low and contributors consider exiting, their rewards can be increased by other participants who may possess new information regarding the meta-organization's growth potential (Trabucchi, Moretto, Buganza, & MacCormack, 2020). Relatedly, a meta-organization can foster growth by providing contributors with a transparent record of the organization's protocols (e.g., via auditable OSS). While transparency does not solve, on its own, the chicken-and-egg dilemma that nascent meta-organizations typically face (e.g., users won't join unless developers join, and vice versa), it does create beneficial predictability (Okhuysen & Bechky, 2009). Indeed, if prospective contributors can estimate future earnings based on auditable algorithms, they can anticipate whether others may find the platform appealing, which creates incentives to join now, *rather than wait for others to join first.* Additionally, meta-organizations powered by OSS can address unresolved leadership crises (Greiner, 1972) through forking, a mechanism

[10] "In meta-organizations, formal authority … may exist within the boundaries of individual constituent organizations, but it does not extend to the ties that connect them" (Gulati, Puranam, & Tushman, 2012, p. 573). Likewise, among cryptocurrency platforms, any node can consist of an individual or a more organized participant (e.g., a merchant accepting bitcoin payments)—yet without formal authority being exercised between nodes.

that prevents damaging escalations of commitment among dissatisfied contributors by lowering the cost of exiting the meta-organization. Instead of growing the meta-organization, forking enables growing *near* the meta-organization by creating a "spin-off" based on a variant of the OSS. A case in point is the "Ethereum Classic" fork in 2015, which created a sister platform near the "Ethereum" meta-organization, thereby mitigating the risk of meta-organizational collapse.[11]

Having a native currency, rule transparency, and forking-as-last-resort fosters "meta-alignment" (Gulati, Puranam, & Tushman, 2012) among a meta-organization's contributors. In combination with algorithmic coordination, these features enable innovative meta-organizational designs that depart from traditional online communities (O'Mahony & Karp, 2020). It remains to be seen, with comparative research designs, if decentralized platforms can outperform centralized ones along important strategic dimensions, including appeal to complementors and value creation.

7.4 | Decentralization: Not binary nor structural, but fuzzy and relational

The difference between centralization and decentralization is often treated as binary (Csaszar, 2012; Forte et al., 2009). Our study shows the value of adopting a fuzzy-set approach, which allows for a sharp distinction between centralized and decentralized organizations while recognizing that a decentralized organization can be more, or less, decentralized (*Buterin, 2017)—just as a centralized organization can be more, or less, centralized (Chandler, 1962).

If we agree that a building is shaped by the structure of its foundations, such as the spatial distribution of its beams and pillars, then by analogy, it makes sense to conceive of decentralization as a *structural* property of organizations (Simon, 1962). In this view, coordination is determined structurally, with centralization requiring much coordination among members and decentralization, very little (Puranam, Singh, & Zollo, 2006). The original Bitcoin whitepaper echoes this view by claiming to design a system whose "nodes work all at once *with little coordination*" (Nakamoto, 2008,

[11] A profound divide separated "moderates [who] saw the hard fork as evidence of the flexibility [of the Ethereum Foundation]... [from] the more ideological [who] saw the hard fork as … proof that blockchain technology was unable to live up to its idealistic [decentralization] promise. For the minority of miners who refused to update their Ethereum software—refusing the hard fork—they split from the main blockchain" (DuPont, 2017, p. 165). Thus, was born *Ethereum Classic*.

p. 8, emphasis added). By contrast, our study shows that sophisticated mechanisms are employed to coordinate decentralized platforms' resources, tasks, information, and rewards (see Figures 1 and 2). We find that a lack of centralized coordination does not imply a paucity of coordination, but coordination achieved decentrally. Without a centralized hierarchy to provide a stable structure, platform participants must negotiate decentralization, which often constitutes a fragile equilibrium. As noted by Trón (interview #19), after a platform reaches "some sort of recognition, [sometimes] various interest groups emerge in the community, who want to organically claim part of the governance." To complement our structural understanding of decentralization, we thus advocate for a relational view, according to which the degree of structural centralization does not fully determine the amount of coordination needed; rather, it is the balance achieved (or not) across coordination mechanisms through contributor relationships that enables or hampers the overall decentralization of the meta-organization (Bakos, Halaburda, & Mueller-Bloch, 2021; Puranam et al., 2006; Wareham, Fox, & Cano Giner, 2014). While, in theory, everything could be decentralized and to extreme levels, in practice the result may never be a well-functioning organization.

Scholars now have an opportunity to integrate new knowledge on leaderless coordination within a high-level theorization of platforms to jointly account for the centralized (Cusumano, 2020) and decentralized (Vergne, 2020) ends of the spectrum. The surprising finding that an organization's management can flourish without managerial authority will, we hope, trigger renewed thinking of the many ways in which organizations can be designed and coordinated.

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TABLE 1 Decentralized coordination and early-stage platform growth and decline

	Growth configurations		Decline configurations			
	Core contributor-driven algorithmic growth	Vision-driven algorithmic growth	Unreliable algorithmic coordination			[Online Suppl. 9]
	G1	G2	D1	D2$_a$	D2$_b$	D3
1. Decentralized Algorithmic Coordination						
of Platform Space (proof-of-work/-stake algorithms to maintain a standard platform "block space")	●			○	○	
of Platform Time (difficulty-adjustment algorithm to maintain a standard platform "block time")		●	○	○	○	
2. Decentralized Social Coordination						
of OSS Developers (humans who contribute rule updates)	○	•	•			●
of Network Validators (humans who contribute refereeing services)	◦	•		◦		◦
3. Decentralized Goal Coordination ●: no foundation (more decentralized) ○: with foundation (less decentralized)	•	○			◦	●
Platforms covered by configuration *Total covered: 18/20 (90%)* *Not covered: Dash, Dogecoin*	Zetacoin, Megacoin	Ethereum, Quark, Worldcoin, Blackcoin	Namecoin, Vertcoin, Reddcoin, Litecoin, Auroracoin, Novacoin, Feathercoin	Paycoin, Xcurrency	Peercoin, Vericoin	Bitcoin
Consistency	0.95	0.80	0.96	0.88	0.97	0.89
Raw Coverage	0.28	0.44	0.53	0.31	0.33	0.22
Unique Coverage	0.22	0.39	0.24	0.07	0.01	0.10
Overall Solution Consistency	0.84		0.89			
Overall Solution Coverage	0.66		0.80			

Note. ●: presence of strong decentralization for the condition; ○: absence of strong decentralization for the condition; [no circle]: it does not matter to the overall configuration whether strong decentralization is present or absent for that specific condition. Larger circles indicate core conditions from the parsimonious solution. The intermediate solution reported here also includes peripheral conditions, displayed as smaller circles.

FIGURE 1 Decentralized cryptocurrency platforms: Overview and primary contributors

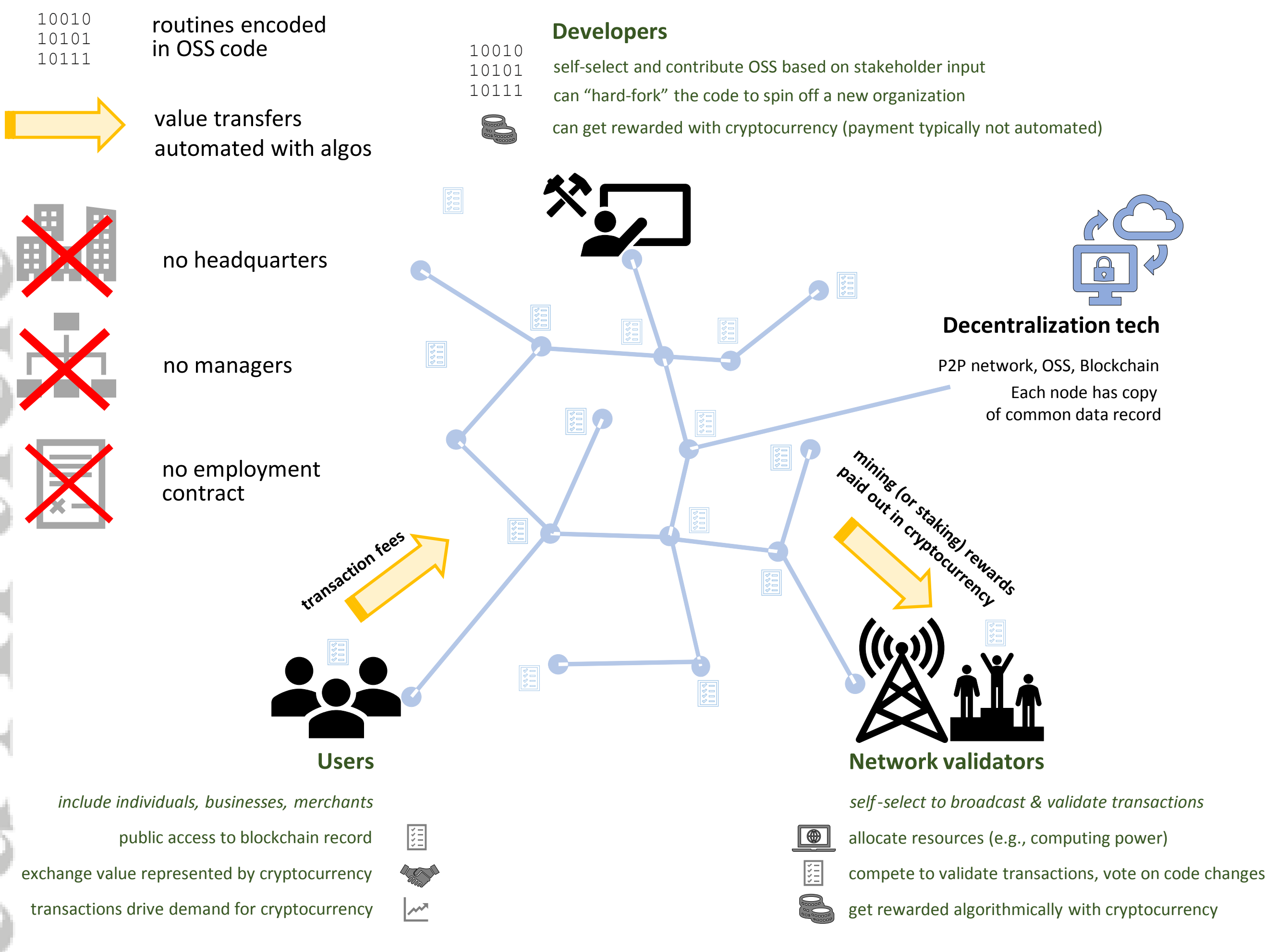

FIGURE 2 Mechanisms for decentralized coordination