THE INTERNAL AND EXTERNAL GOVERNANCE OF BLOCKCHAIN-BASED ORGANIZATIONS: EVIDENCE FROM CRYPTOCURRENCIES[1]

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INTRODUCTION

Blockchain technology proposes to create value by decentralizing the creation, verification, validation, and secure storage of economic transactions, both within and between organizations. Since 2015, central banks across the world are exploring the possibility of issuing money on a blockchain (Del Castillo, 2017). This could streamline monetary policy implementation at a global level, help combat counterfeiting and tax evasion, and potentially affect the business models of retail banks.

While the changes that would result from implementing large-scale blockchain solutions are worth studying in themselves, we also need to gain a deeper understanding of how these blockchain solutions would be operated and by whom. Put simply, we need to ask: How does blockchain governance work, and what are the implications? To answer these questions, we look at the cryptocurrency setting and argue that

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cryptocurrencies represent the first real-world instances of blockchain-based *organizations*. In this chapter, we thus shift the level of analysis from the global economy level to the organizational level. Theorists define organizations as "collectivities oriented to the pursuit of relatively specific goals and exhibiting relatively highly formalized social structures" (Scott & Davis, 2007:29), and in the following we use theory on organizational and corporate governance to unpack how blockchain-based organizations operate.

In the organizational literature, corporate governance is defined as "the study of power and influence over decision making within the corporation", which defines the "rights and responsibilities of […] different stakeholders toward the firm" (Aguilera & Jackson, 2010: 490). Since cryptocurrencies reside to a large extent in cyberspace, they are not embedded in the specific institutions of any one country in particular. As such, for the purpose of this study we treat them as global organizations (Lee, 2015: 380). We anchor our arguments on the notion that blockchain represents a new "institutional governance technology of decentralization" (MacDonald, Allen & Potts, 2016:5) that can be implemented in various ways across blockchain-based organizations. We then link these various implementations to a measure of organizational value creation in order to assess their effectiveness for governance.

Cryptocurrencies differ in terms of software design, ownership structure, decision rights, and degree of decentralization. These variations in governance design features could have profound implications on investors' evaluation of a cryptocurrency's value, as reflected in cryptocurrencies' returns on investment. Indeed, prior research suggests that cryptocurrency returns are driven by much more than media hype and speculative behavior. Wang & Vergne (2017) show that the continuous improvement of the technology behind a cryptocurrency is the primary predictor of price increases (as captured by weekly returns). Thus, treating cryptocurrencies as traditional currencies or as commodities is misleading, since behind each cryptocurrency, there is a team of people who work hard to develop the technology. For instance, whereas developers such as programmers and technologists write the blockchain software program, miners validate and update transactions by devoting computing power to the network. In other words, cryptocurrencies are best conceived of as a new kind of transnational organizations. Understanding how these organizations then

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are governed is essential and will help devise formal policy recommendations at a macro level (Wright & De Filippi, 2015).

Blockchain governance is about determining who has authority (internal and external actors); how these actors are endowed (e.g., ownership rights vs. decision authority), in what form (formal and informal governance forms/structures), and at which level (Narayanan, Bonneau, Felten, Miller & Goldfeder, 2016). In the context of cryptocurrencies, whose success relative to one another is captured by superior market returns (a relative price increase from one period to the next), little is known about how internal governance (at the blockchain and protocol levels) and external governance (by the broader cryptocurrency community) affect cryptocurrency returns. Drawing on the corporate governance literature in organizational and management studies, we thus examine the relationship between internal and external governance design features and cryptocurrencies returns.

To shed light on this relationship empirically, we collected weekly panel data on five cryptocurrencies with varying degrees of decentralization and predict weekly returns in regression models using a number of governance-level indicators. In line with corporate governance research (Hambrick, Werder & Zajac, 2008; Yermack 2017), we look at several internal governance design choices: at the blockchain level, direct control by cryptocurrency owners over the consensus schemes; at the protocol level, the existence of formal voting mechanisms for miners to participate in decision making; at the organizational level, the existence of centralized funding backing the cryptocurrency creators. In addition, in line with the idea that the media act as agents of external governance for corporations (Aguilera et al. 2015, Walsh and Seward 1990), we also study the effects of both social (e.g. Reddit, Twitter, and Facebook) and traditional media (i.e. mainstream newspapers) governance on cryptocurrency returns, after controlling for a number of factors such as cryptocurrency supply and liquidity.

Our findings reveal a paradoxical pattern, namely, decentralization at the blockchain level affects returns positively – as one would expect, since the promise of blockchain is decentralization as a way to create value – but we also find that decentralization at both the protocol and organizational levels affects returns negatively. This is to say, while decentralization stands as an important value proposition which provides opportunities for the cryptocurrency community, this very feature can present challenges for investors. Investors generally value commercialization opportunities managed by centralized organizations. They also have more confidence in financing coordinated through centralized funding as a reliable source to motivate innovations. In this regard, decentralization brings about different opportunities and challenges for various stakeholders. Not unlike open source software projects, blockchain-based organizations can also be governed by decentralized communities, by centralized corporations, or jointly by both as hybrids. Our findings imply a wide range of blockchain-based organizational governance design options, which address various implementation settings. This study also highlights the need to investigate novel organizational forms including "decentralized autonomous organizations" (DAO; DuPont, 2017). In the following, we review the corporate governance literature, introduce cryptocurrency and our methodology, describe our analyses, and finally, we discuss our findings and contributions to the governance literature.

CORPORATE GOVERNANCE: WHAT WE KNOW

To understand how cryptocurrencies redefine organizational governance, we need to revisit the literature on corporate governance, which is concerned with organizational goals and the control of organizational stakeholders on collective outcomes (Aguilera, Desender, Bednar & Lee, 2015; Aguilera, Filatotchev, Gospel & Jackson, 2008; Moore & Kraatz, 2011; Williamson, 1996). Corporate governance concerns "who rules" and "how the organization is ruled" (Moore & Kraatz, 2011; Fama & Jensen, 1983; Hambrick et al., 2008). Similar to any governance issues, corporate governance is generally about the allocation of power and control. Historically, corporate governance has its economics roots in agency theory (Jensen & Meckling, 1976), which is concerned with mitigating opportunistic behavior. This is to say, owners and managers of a corporation can have very different risk attitudes and preferences. While owners attend to profit maximization, managers are assumed to be self-interested and can engage in misconducts that benefit their own career advancement or compensation at the expense of owner's benefits (Dalton, Hitt, Certo & Dalton, 2007). In other words, for managers, individual benefits can significantly outweigh the concern of the organization's profitability. Therefore, the main objective for governance is to design contracts with incentive mechanisms that optimally allocate ownership rights, design ownership structures and define control such that interests are aligned between owners (principals) and managers (agents) (Connelly, Hoskisson, Tihanyi & Certo, 2010; Fama & Jensen, 1983; Jensen & Meckling, 1976; Walsh & Seward, 1990).

Recent developments in the governance literature begin to embrace a broader range of roles for both internal and external organizational actors. While internal actors include owners, shareholders, and managers, external actors include customers, the media, government, and the broader community. These internal and external stakeholders can exert influence over the organization through not just economic but also social, behavioral, cultural, and political means (e.g., Aguilera et al., 2015; Dyck & Singales, 2002; Dyck, Volvhkova & Singales, 2008; Bednar, Boivie & Prince, 2013; Hambrick et al., 2008). In this view, organizational objectives are no longer tied with financial indicators capturing shareholder value such as stock returns, but take into account other stakeholders as alternative forces of control (Aguilera et al., 2008; Aguilera et al., 2015). When internal and external actors interact jointly, shareholder value maximization may not prevail anymore as the primary purpose of the corporation. Instead, corporations can also attend to corporate social performance, stakeholder orientations, restructuring or asset redeployment as alternative objectives (Aguilera et al., 2015).

CRYPTOCURRENCY GOVERNANCE

Blockchain-based organizations such as cryptocurrencies compete with traditional economic institutions by proposing alternative forms of organizational governance (Davidson, De Filippi & Potts, 2016a; 2016b; Narayanan et al., 2016). Specifically, they upset the traditional principal-agent relationships by placing machines (i.e., the blockchain software program) at the core of organizational governance, and human actors (i.e., stakeholders) at the edges (Buterin, 2014). Although humans are still involved in the creation, modification, and decision-making about the code, now formal organizational rules and routines are written directly in the software program. Instead of CEOs or top managers, it is core developers who write the organizational rulebook of cryptocurrencies in the software code, in a decentralized fashion. It is miners (or validators), rather than employees, who verify the validity of economic transactions and maintain a digitally shared, distributed ledger recording their history. Incentives are not defined by employment contracts, but written in the code. There are no headquarters or subsidiaries, but a network distributed in cyberspace that is inherently global and borderless. Coordination between stakeholders is lubricated by the exchange of cryptocurrency tokens, whose value is determined by supply and demand, among other things (Wang and Vergne, 2017). Finally, each cryptocurrency is embedded in a digital community that plays an important external governance role. All these stakeholders have power and govern the cryptocurrency at varying levels in different ways (Narayanan et al., 2016; Yermack, 2017). In short, blockchain-based governance in the context of cryptocurrencies calls for a revised understanding about power and control within the organizations.

In the context of cryptocurrencies, not only is governance borderless, but also decentralized, albeit to various extents (Atzori, 2015; Yermack, 2017). Anyone can decide to "join" a public cryptocurrency organization, maintain and update the open ledger based on "competitive bookkeeping" such as mining or other consensus mechanisms (Yermack, 2017). Admittedly, *decentralization* distinguishes blockchain-based corporate governance from the traditional model based on hierarchies. It is important to note that cryptocurrency governance models can exist in different degrees of decentralization. Decentralization, on the one hand, creates value for cryptocurrencies as a peer-to-peer payment system that does not rely on centralized financial intermediaries such as banks or payment companies (Nakamoto, 2008). On the other hand, decentralization can create excessive inefficiencies as governance decisions are made without centralized authorities, but through consensus mechanisms in a non-hierarchical fashion. It is generally believed in economics that there is a trade-off between decentralization and efficiency. For this reason, we think it is appropriate to think about blockchain-based corporate governance forms in terms of their degrees of decentralization. We will follow this logic throughout our reasoning and analysis.

Returns as a Measure for Cryptocurrency Investors' Value

Demand for cryptocurrencies mainly stems from two sources: first, consumers and merchants using cryptocurrencies as a means of payment; and second, investors holding a cryptocurrency as an investment, hoping that the price will rise (Narayanan et al., 2016: 100, 173). Here we focus on the latter, as the former, during our period of study, typically do not hold the cryptocurrency after the transaction has occurred, and tend to use it mostly as a payment rail (i.e., as a channel for fast and efficient fiat currency transfers; Hileman & Rauchs, 2017). Just like corporate shareholders multiply a firm's stock price by the number of shares outstanding to determine market capitalization, cryptocurrency *investors* multiply a cryptocurrency's price by the number of crypto-tokens in circulation to determine its market value (Narayanan et al., 2016). According to agency theory, the main objective of shareholders is their *return on investment*. Yet why do some cryptocurrencies generate more returns for investors than others? Since the overarching value proposition of cryptocurrencies is decentralization, we examine how different governance design features imply varying degrees of decentralization across cryptocurrencies, and how they end up affecting returns.

Cryptocurrency Governance: Internal and External

Following the corporate governance literature, we distinguish between the internal and external governance features of cryptocurrencies. While the effectiveness of internal governance is typically rooted in the design of incentives, the effectiveness of external governance depends on the influence exerted by the community, the media, and the general public over the organization. In line with the theme of this book, for each level, we think in terms of (1) who has power (empowerment), and (2) how are these actors empowered. Considering how cryptocurrencies are structured, we distinguish, internally, between the blockchain, the protocol, and the organizational levels, and externally between the community, media, and social levels. Below we discuss each level of analysis in detail.

Internal Governance

Here we identify three internal governance forms: *owner control at the blockchain level, formal voting at the protocol level,* and *centralized funding at the organizational level.*

The blockchain level. At the blockchain level, *miners* (or *validators* in general), whose behavior is guided by the rules and incentives encoded in the cryptocurrency's software, constitute the key stakeholder group. On the one hand, miners/validators work by the software's rulebook and are incentivized accordingly. In this regard, miners/validators work like "employees" who are governed by pre-determined incentive mechanisms. On the other hand, miners/validators have the power to decide which transactions to accept into a block, as well as to agree or disagree on the "longest chain" that will constitute the trusted version of the distributed ledger that all users will follow going forward (Nakamoto, 2008). However, there are different ways to tie transaction validation to cryptocurrency ownership. For instance, while a proof-of-work (PoW) miner does not have to own the cryptocurrency to mine, on Proof-of-Stake (PoS) blockchains, validators are incentivized in proportion to the amount of cryptocurrency tokens they hold. Owner control can thus increase centralization in governance by concentrating validation tasks in the hands of a small percentage of wealthy cryptocurrency owners. Similarly, if a cryptocurrency is "pre-mined" (i.e., a number of tokens are pre-attributed by design to the cryptocurrency founders), ownership will be more concentrated. In addition, some cryptocurrencies allow miners/validators to nominate other network nodes they consider more trustworthy to converge more rapidly to a common decision. In sum, there are three governance design features at the blockchain level associated with more centralization: the use of PoS, the use of pre-mining, and the use of nomination.

The protocol level. *Developers* who specialize in programming blockchain applications constitute the key stakeholder at the protocol level as they are the people who "write the rulebook" (Narayanan et al., 2016: 173). For most cryptocurrencies including Bitcoin, developers work on a voluntary basis and are not hired or funded by any centralized organization. The code that they work on is typically open source, meaning that any developer can contribute to the code using online repositories such as Github.com (which acts as the Wikipedia of software development). Still, a small group of very dedicated "core" developers can be formed and governance decisions may thus become more centralized. However, major changes to the underlying code can be contested by the wider community of miners/validators or users, who can voice divergent views on online forums or at conferences. Some cryptocurrency organizations formalize this process by requiring formal voting by the miners/validators before developers can roll out code changes across the network in the form of software updates. For example, Bitcoin requires voting backed by miners' computing power on

Bitcoin Improvement Proposals, or BIPs, before they get implemented. A cryptocurrency with a *formal voting* procedure in place is considered more decentralized in terms of the governance of its protocol, since developers are then unable to unilaterally impose code changes to the rest of the organizational stakeholders.

The organizational level. In theory, the formative ideology behind Bitcoin and many subsequent cryptocurrencies is rooted in the ideas of decentralized control over token distribution, network participation, and openness. However, there are still substantial differences in how cryptocurrencies are governed in practice. For example, unlike Bitcoin, Ripple has its network and tokens centrally managed by the Ripple company, a venture capital-backed start-up with offices based in five locations: San Francisco (headquarters), New York, London, Luxembourg and Sydney. While the Ripple blockchain is decentralized across approved nodes, like any other centralized company, it has top managers who make decisions on resource allocation and control the direction for code development. Developers are hired as formal employees; "trusted nodes" are selected into the network based on approval, along with other business functions such as product design, marketing, and business development. Under this more centralized model, management strategies not only are prevalent but necessary for the cryptocurrency-as-company to attract external funding and grow. The presence of such *centralized funding* reflects a more centralized form of governance.

External Governance

External governance mechanisms influence organizations less through formal mechanisms such as control over decision rights or ownership rights, than through informal social mechanisms such as social evaluations, reputation effects, informal voting, or public image (Aguilera et al., 2015; Dyck & Zingales, 2002; Walsh & Seward, 1990). Often times, external mechanisms are triggered by failures in internal organizational governance (Walsh & Seward, 1990). However, as noted, for most cryptocurrencies, the stakeholder structure is very different from traditional organizations'. For example, there are no CEOs or top management teams to be held accountable for the decline of performance, hence the absence of external market for corporate control and potentially weaker reputation effects (Walsh & Seward, 1990; Dyck & Zingales, 2002). In addition, at the center of the organization is the self-validating blockchain, which defines the internal governance rules.

Arguably there is very little room for external forces to exert formal and direct influence over the blockchain even through developers and miners. Further, external actors attempting to make alterations to technical features can create controversy. Does informal and indirect governance by external stakeholders such as media or the general public matter to investors in the same way as for traditional corporations? The Bitcoin blockchain scalability debate provides an interesting illustration. Whereas many users and developers in the community believe there is a clear need to expand the current limit of the Bitcoin block size (1MB) to accommodate the growing number of transactions by allowing for more transactions per block, making changes to the block size appears to be implausible to others. For example, many community enthusiasts firmly believe in the preservation of Bitcoin's core value rooted in the ideology of immutability and decentralization, even if it means Bitcoin will not scale as rapidly. As a result, the debate has been inconclusive since 2015 as of the time of writing (March 2017). In the following, we identify three specific external governance forms: *community governance at the community level, negative publicity at the media level*, and *public interest at the social level.*

Community level. Many cryptocurrencies were created from the open source Bitcoin software code, and follow the same open source development model. Like many open source software projects, initial participation is usually driven by the need for software-related improvements, but later evolves with developers becoming hobbyists (O'Mahony, 2007; Shah, 2006). However, compared to open source software communities, cryptocurrency communities generally consist of a much diverse base of stakeholders including: developers, miners, start-ups, enthusiasts, and users. Community governance involves forum discussions and sometimes informal online voting over decisions. The most used forums for cryptocurrency discussions include cryptocurrencies' official forums, specific cryptocurrency sub-groups within forums such as bitcointalk.org, Reddit.com, and social media such as Facebook and Twitter. Not unlike internal stakeholders, community members self-select into the roles driven by needs, beliefs in the ideologies or technologies, and business opportunities. These external stakeholders take on an "active and possibly democratic role in the management and operation of the organization" (Van Valkenburgh, Dietz, De Filippi, Shadab, Xethalis & Bollier, 2015; Dietz, Xethalis, De Filippi & Hazard, accessed in 2016). It is reasonable then to expect a greater level of participation (as observed in the online forums) to be associated with a more decentralized governance of cryptocurrency organizations by the digital community.

Media level. Recent developments in the corporate governance literature have treated media as an important source of external governance (Aguilera et al., 2015; Bednar et al., 2013; Dyck et al., 2008). Different from controlling through ownership and decision rights, the media can influence key stakeholders of an organization by serving as an information intermediary that plays a governance role through informing, monitoring and reputation effects (Bushee, Core, Guay & Hamm, 2010; Dyck & Zingales, 2002). In particular, scholars have demonstrated that *negative publicity* conveyed in the media is especially effective in influencing organizations. Durand and Vergne (2015), for instance, show that negative publicity targeting weapons manufacturers is associated with a higher probability of asset divestment. Since the early days of the cryptocurrency industry, when Bitcoin transactions were often associated with illegal exchanges on the dark web (Campbell-Verduyn & Goguen, 2017 *this volume*), there has been a lot of negative media coverage around blockchain-based organizations on issues related to fraud and various hacking scandals. While many expect that such negative attention should scare away investors and negatively affect returns, prior research failed to find a significant association between the two (Wang and Vergne, 2017).

Social level. The third source of external corporate governance mechanism is rooted in *public interest* from the broader society. Public interest pertains to aggregated search activities motivated by curiosity, attempts to learn or understand the technology and cryptocurrency-related affairs. Arguably, cryptocurrencies that receive greater public interest are also subject to more decentralized monitoring and scrutiny regardless of the nature of search and intention. Similar to the way market stakeholders (i.e., suppliers, customers, and shareholders) can exert pressure to corporate decision-making (Stevens, Steensma, Harrison & Cochran, 2005), for cryptocurrencies, social pressure comes from a broader range of external stakeholder groups such as merchants, regulators, and service providers. Therefore, public interest captures the aggregate external governance at the social level.

METHODOLOGY

To shed light on how internal and external governance affects cryptocurrency returns, in this study we focus on decentralization as the key dimension by which organizational governance forms vary. As the ideology that underpins the very notion of cryptocurrency, decentralization represents a continuum along which one can effectively distinguish between various forms of internal governance. At one end of the spectrum, one finds cryptocurrencies such as Bitcoin, Litecoin, and Peercoin, which strive to retain the self-organized transaction system allowing for pseudonymity, decentralization and disintermediation (Nakamoto, 2008). At the other end of the spectrum, one finds the less decentralized cryptocurrency organizations such as Ripple, built on a blockchain that is permissioned and wherein the nodes are known, trusted participants (e.g., financial institutions and organizations in the remittances industry). Following the method and analysis proposed by Wang & Vergne (2017), we sampled five cryptocurrencies corresponding to five different waves of blockchain innovation, and to various degrees of decentralization, in order to capture variance across several attributes of their external and internal governance.

Sampling

We collected data on Bitcoin (BTC), Litecoin (LTC), Peercoin (PPC), Ripple (XRP), and Stellar (XLM). These cryptocurrencies vary in terms of their technology, applications, and most importantly, degree of decentralization. Bitcoin is included in our sample because it represents the first and most established cryptocurrency. At the organizational level, Bitcoin is not centrally funded, and its core developers are not employed by the Bitcoin Foundation or other centralized entities associated with Bitcoin. Building on proof-of-work (PoW) consensus mechanism, Bitcoin distributes governance among miners who allocate external resource to mining (Narayanan et al., 2016: ch7.3). At the protocol level, miners can also have influence over code changes through a formal voting mechanisms such as the Bitcoin Improvement Proposals (BIPs), wherein proposals for code improvement are being reviewed, published and voted for (or against) by miners (for more details, please see https://github.com/bitcoin/bips).

Since Bitcoin's creation in 2009, new cryptocurrencies have been created to embrace new ideas such as faster transaction verification using Scrypt hashing algorithm (e.g., Litecoin). Introduced in 2011, Litecoin was built on the Bitcoin source code as a proof-of-work cryptocurrency but using a different hashing algorithm. It was created as "a lite version of Bitcoin", which improves the transaction processing speed and security (Lee, 2011). In contrast to Bitcoin, the identity of the Litecoin founder, Charles Lee, is known. Also, a small amount (150 units) of Litecoin was pre-mined.

We also included Peercoin due to its ability to achieve greater energy efficiency by incorporating a proof-of-stake (PoS) consensus mechanism. In contrast to PoW mining, PoS validators' voting power is in proportion to the amount of cryptocurrency one holds. Founded in 2012, Peercoin combines both PoW and PoS, and grants more decision-making power and control to current owners of the cryptocurrency.

Since 2013, blockchain-based implementations extended beyond strictly decentralized participation. For instance, centrally-funded blockchain organizations emerged as a solution for the financial industry. Some are permissioned, such as Ripple (founded in 2013), whose membership is set by a central authority. Ripple took on a distinct governance approach not only for the cryptographic consensus, but also regarding how participants need to be approved before joining the network. As noted above, Ripple is funded and managed by a centralized, for-profit organization called Ripple Labs. All Ripple coins (the cryptocurrency tokens) were pre-mined at founding.

Finally, we chose to include Stellar (founded in 2014), which incorporates further improvements on Ripple's model by using Federated Byzantine Agreement (FBA) to make participation open, while ensuring that the cryptocurrency is adoptable by financial institutions for instantaneous processing of transactions (Mazières, 2016). Similar to Ripple, Stellar is not minable, that is, most of it was pre-mined before launch. Despite being permission-less, Stellar is also centrally funded by a non-profit foundation to facilitate certain social objectives such as open financial accessibility and financial inclusion. Figure 1 summarizes where each cryptocurrency in our sample is located on the decentralization spectrum.

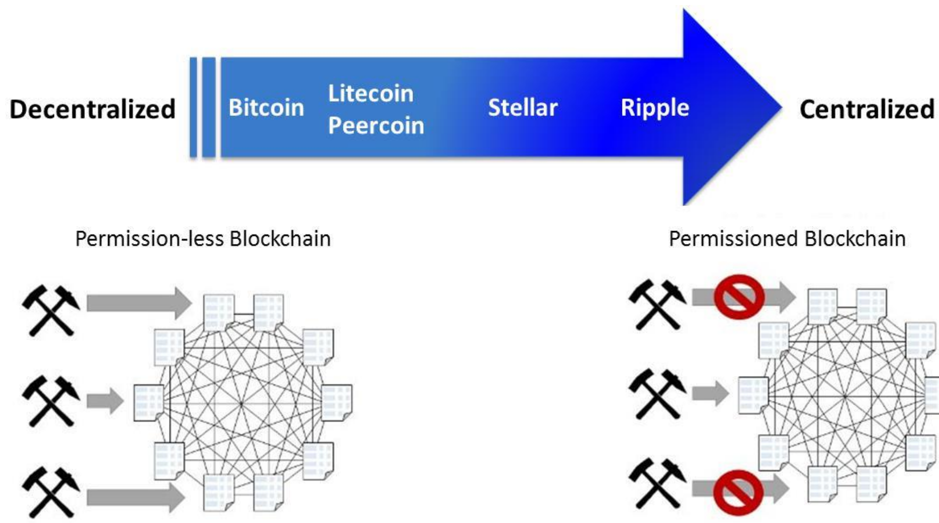

Figure 1 Variation of the five cryptocurrencies in our sample along the decentralization spectrum. (Source for graphs of permission-less vs. permissioned blockchains: https://www.linkedin.com/pulse/making-blockchain-safe-government-merged-mining-chains-tori-adams)

Data

We acquired panel data from CoinGecko.com, a leading scholarly project that collects daily and weekly data at both the market and community level (Wang & Vergne, 2017; Ong, Lee, Li & Lee, 2015). CoinGeck.com is an independent data source complied by two cryptocurrency academic researchers, Bobby Ong and Teik Ming Lee, at Singapore Management University's Sim Kee Boon Institute for Financial Economics. The CoinGecko database consists of information extracted and scrapped from cryptocurrency specialist websites (such as Coinmarketcap.com), code repositories (e.g., Github.com), community forums (such as Reddit.com), social media (e.g., Twitter and Facebook), and search engines (e.g., Bing or Alexa). In addition to information on price, volume, and market capitalization, CoinGecko.com also contains indexes measuring liquidity, protocol development, community activities, and public interests using composite scores. This database has been drawn upon in other scholarly analyses, including the book chapter co-authored by the two founders "Evaluating the potential of alternative cryptocurrencies" (Ong, Lee, Li & Lee, 2015) in "The Handbook of Digital Currency" (Lee, 2015).

We complemented CoinGecko data with weekly data from Factiva for media coverage, and manually coded several governance indicators such as the association with fraud, hacks, and Ponzi schemes. We did not make a distinction between the financial and the generalist media. Instead, we focused on mainstream media that follows closely the blockchain industry such as Financial Times, Wall Street Journal, and The Economist as they are generally more objective and neutral in commenting on the disruptive nature of cryptocurrencies and blockchains than pro-industry sources who tend to act as cheerleaders.

Observation Period

We study the five cryptocurrencies on a weekly basis between September 2014 and August 2015 (when we first began to collect the data). This is a period when the cryptocurrency market has become more established and stabilized in contrast to the earlier period in which only a handful of cryptocurrencies existed. More variations in cryptocurrencies were present in this period, with the introduction of Stellar at the start of our observation period. All cryptocurrencies in our sample existed throughout the period, forming a balanced panel data for analysis. The final dataset contains weekly data for 255 observations.

Measures

Dependent variable: Weekly returns

Supply and demand (by investors) determine cryptocurrency value (Narayanan et al., 2016). Financial returns are a common measure used to evaluate the performance of organizational governance. For example, stock returns have been used to measure the performance of internal (Ittner, Lambert & Larcker, 2003) and external governance (Daines, Gow & Larcker, 2010). We model returns using multivariate linear regression, where returns are a linear combination of various governance-related variables. In particular, we identified factors pertaining to multiple levels of internal and external governance that may directly or indirectly drive investment decisions. For example, whereas cryptocurrencies governed by highly decentralized blockchains may be more attractive as an investment target because of the value propositions rooted in security of the network and transactions, a centrally funded blockchain organization can be more appealing to investors who believe in managerial strategic planning.

Following Wang & Vergne (2017), we measured weekly returns as $[\text{Price}_{t+1}\text{-Price}_t]/\text{Price}_t$, whereby Price is the cryptocurrency's weekly average price weighted by trading volume. We build on Wang & Vergne's (2017) sample statistics which indicate that the distribution for returns is close to normal.

Independent Variables

Internal governance. As previously explained, we coded three internal governance variables at three different levels: *owner control*, *formal voting*, and *centralized funding* at the blockchain, the protocol, and organizational levels, respectively. We measured *owner control* using three binary indicators: 'PoS', 'nomination', and 'pre-mined'. We first studied in detail the whitepapers of the cryptocurrencies in our sample and identified blockchain design elements that are related to governance. 'PoS' was coded as a 1 if the consensus mechanism contains proof-of-stake and 0 otherwise. We assigned the value 1 (and 0 otherwise) to 'nomination' if the cryptocurrency allows the network participants to select a subset of nodes as trusted validators. Finally, we coded "pre-mined" as 1 if the cryptocurrency allocated certain amount of coins to the core developers or their closed loop before launch and 0 otherwise. We then added up scores of these three indicators and assigned the sums as scores for *owner control*. This aggregated score thus takes on higher values when cryptocurrency accumulation by owners is associated with more centralized control over the cryptocurrency.

We measured *formal voting* by coding the presence of formal procedures for miners to vote on protocol changes, using a binary variable. We coded 1 for the presence of formal voting, which indicates a democratic governance mechanism at the protocol level, and 0 for the absence of such mechanism.

We measured *centralized funding* as a binary variable by assigning 1 to the cryptocurrency if it is centrally funded by an organization and 0 if otherwise. For example, the Bitcoin Core projects (and the core developers) are funded through a "Sponsorship Program" by several organizations such as the MIT Media Lab, and start-ups such as Blockstream, Chaincode Labs, and BTCC (van Wirdum, 2016). Therefore, Bitcoin is coded 0 for centralized funding. Conversely, Stellar have their platforms and developers funded centrally by the Stellar foundation. Stellar tokens are centrally allocated toward salaries, Stellar grants for participants in the direct signup program and other strategic planning. Therefore, Stellar was assigned a score 1 for centralized funding.

External governance. We capture external governance of blockchain organizations by looking at *community governance, negative publicity,* and *public interest* using data from social media, traditional news media, and search engines, respectively. For social media, we adopted the composite score, "community governance", developed by CoinGecko to capture the degree of community participation in social media forum discussions. CoinGecko weighted indicators for each cryptocurrency consisting of: the number of Reddit subscribers, the number of Reddit active users, the number of Reddit new posts in 48 hours, the number of Reddit new comments in new posts in 48 Hours, the number of Facebook likes, and the number of Twitter followers. Due to our non-disclosure agreement with CoinGecko, we are unable to reveal the exact weightings for each indicator.

For news media, we adopted the measure *negative publicity* developed in Wang & Vergne (2017). The authors counted the weekly number of negative news articles using content analysis by keywords associated misconducts such as criminal or underground activities with the name of the cryptocurrency. A research assistant was hired to search in Factiva by keywords such as ["Bitcoin" AND ("fraud*" OR "hacked" OR "Ponzi" OR "theft")] or ["ripple" near7 ("bitcoin" OR "crypto*" OR "altcoin)] AND ("fraud*" OR "hacked" OR "Pomzi" OR "scam" OR "theft"). The results for coding were randomly cross-verified and validated by one of the authors. The final numbers of article counts plus one were logged for the regression model estimation.

Finally, we measure *public interest* from search engine data using the indicator developed by CoinGecko. It is a composite measure consisting of a weighted average of the number of web search results for each specific cryptocurrency on Bing and the Alexa web traffic ranking for the cryptocurrency website. This measure captures the interest that the public pays to particular cryptocurrencies, whether it is for general inquiries, searches for specific information, or technical details. Conceptualized as "buzz" around a cryptocurrency (Wang & Vergne, 2017), public interest serves as an indicator for external governance which influences investors' decision. CoinGecko computes the *public interest* variable by normalizing the raw value against the bitcoin value as a benchmark.

Control Variables

We control for cryptocurrencies' *supply growth, liquidity* and *technological development* for the analysis. Although the coin *supply growth* rate based on the speed of new block generation time is usually predefined in the protocol, variation exists when there is a surge or rapid decline in network activities, such as mining power for PoW cryptocurrencies. New coins can also be distributed unexpectedly to the network in the case of non-minable cryptocurrencies such as Ripple and Stellar. Despite the fact that coin issuance self-adjusts to account for network changes, temporary deviation in supply from the targeted average is still present, affecting returns in the short term. Therefore, we control for supply growth computed as ($Supply_{t+1}$ – $Supply_t$)/ $Supply_t$.

We also control for *liquidity* using the CoinGecko liquidity score obtained from major cryptocurrency exchanges such as Bitfinex and Okcoin. Finally, we control for *technological development* to capture the innovation potential enabled by cryptocurrencies' underlying software. Our previous research indicates that the extent to which the code base is maintained and the level of collaborated problem solving by developers is positively and significantly related to returns (Wang & Vergne, 2017). We adopted the technological development measure developed by CoinGecko who weighted the number of unique code collaborators, the number of proposals merged in the code repository, the number of issues raised and fixed, and the number of forks as indicators. We are unable to reveal the exact weightings for the composite measure due to a confidentiality agreement with CoinGecko. We lagged all external governance predictors except *liquidity* as in Wang & Vergne, 2017, to avoid the problems of contemporaneous feedback from return to community, media, and other internet activities.

A detailed list of variables and their definitions are presented in Table 1.

Table 1 List of variables

Variable	Level	Definition
Dependent variable		
Returns	Organization	Weekly weighted returns of the cryptocurrency

		$[Price_{t+1}-Price_t]/Price_t$
Internal Governance		
Owner control	Blockchain	The sum of three binary variables below: PoS: 1 if the blockchain consensus is proof-of-stake, else 0. Pre-mined: 1 if all or part of the cryptocurrency was issued to core developers or their closed loops before launch, else 0. Nomination: 1 if participants have the power to nominate their trusted nodes, else 0.
Formal voting	Protocol	1 if there exist formal voting mechanisms (e.g., BIPS) for miners to vote for protocol change, else 0.
Centralized funding	Organization	1 if the cryptocurrency core development activities and core developers are centrally funded directly by a firm or foundation, else 0.
External Governance Community governance(t-1)	Community	A composite score consisting of social media data: the number of Reddit subscribers, the number of Reddit active users, the number of Reddit new posts in 48 hours, the number of Reddit new comments in new posts in 48 hours, the number of Facebook likes, and the number of Twitter followers.
Negative publicity (t-1)	Social	Log (the number of negative media news articles in the previous period)
Public interest (t-1)	Social	A composite score consisting of the weighted average of web searches on Bing, and the Alexia web traffic ranking of the cryptocurrency's website in the previous period
Control variables		
Supply growth since t-1		$[Supply_{t+1} – Supply_t]/ Supply_t$
Liquidity		Liquidity measured and supplied by CoinGecko
Technological development (t-1)		A composite score including: the number of unique code collaborators, the number of proposals merged in the code repository, the number of issues raised and fixed, and the number of forks in the previous period

ANALYSES

We conducted three model estimations. Model 1 contains only the control variables, Model 2 includes the external governance variables, and Model 3 is the full model with both internal and external governance variables. Following Wang & Vergne (2017), we used fixed effect (FE) estimations for Model 1 and Model 2 to account for unobserved individual group-level heterogeneity. However, for Model 3, FE are inappropriate since internal governance variables such as owner control, formal voting, and centralized funding are coded as cryptocurrency-level time-invariant variables (they would be dropped from the FE estimates). Random effect estimation, on the other hand, can yield unbiased, consistent and efficient estimation on the condition that group-level variables are independent of the regressors. We conducted a Hausman test, which failed to reject the null hypothesis. Therefore, we ran random effect estimations for Model 3.

RESULTS

Table 2 displays the regression results. Model 1 includes control variables, cryptocurrency fixed effects and the time trend. Model 2 adds the external governance variables and Model 3 the internal governance variables. All models are estimated using Huber-White standard errors which are robust to heteroscedasticity.

Table 2 Regression Results

	Model 1 (FE)	**Model 2 (FE)**	**Model 3 (RE)**
External Governance effects			
Public interest (t-1)		-5.85 ***	-5.49 ***
		(1.543)	(1.110)
Negative publicity (t-1)		0.052	0.057
		(0.066)	(0.072)
Community governance (t-1)		-3.88	-3.15 **
		(3.401)	(1.506)
Internal Governance design choices			
Owner control			-0.30***
			(0.053)
Formal voting			-0.16 ***
			(0.021)
Centralized funding			0.10 ***
			(0.030)
Control Variables			
Liquidity	2.12 ***	2.34 ***	2.41 ***
	(0.564)	(0.617)	(0.667)
Supply growth since (t-1)	0.87 *	0.21***	0.20 ***
	(0.046)	(0.072)	(0.072)
Technological development (t-1)	1.40 ***	2.60 ***	2.53 ***
	(0.296)	(0.616)	(0.523)
Cryptocurrency fixed effects	included	included	n/a
Weekly trend	-0.000228	-0.00144	-0.00139
	(0.0007)	(0.001)	(0.0009)
Constant	-0.52 ***	0.20	0.40 *
	(0.088)	(0.526)	(0.263)
N	250	250	250
Within- or adjusted R^2	0.060	0.109	0.108

[1] All models instrument liquidity (not lagged) using all regressors.
* $p<0.10$
** $p<0.05$
*** $p<0.01$

Interpretation of the findings

Internal governance. Model 3 indicates that *owner control* at the blockchain level has a negative and significant ($p< 0.001$) effect on returns. For a one standard deviation increase in owner control (0.6330), returns decrease by 19% (i.e., 0.6330 * (-0.30) = (-0.190)). In other words, blockchain-level routines governed in a more centralized form yield lower returns. If decentralization is precisely what investors value in blockchain organizations, then they should indeed evaluate more highly the more decentralized blockchains.

Surprisingly though, at the protocol level, the existence of decentralized formal voting mechanisms is negatively and significantly ($p<0.001$) related to returns. When formal voting increases by one standard deviation (0.49029), returns drops by 7.8% (i.e., 0.49029 * (-0.16) = (-0.078)). It could be that investors perceive decentralization at the protocol level as a source of governance inefficiency. Indeed, voting on protocol changes is time-consuming and does not allow for quick decision-making, as illustrated by the lingering debates in the Bitcoin community around increasing block size.

Finally, at the organizational level, *centralized funding* is positively and significantly ($p<0.001$) associated with returns as shown in Model 3. For a one standard deviation increase in centralized funding (0.4903), returns increases by 4.9% (0.4903 * 0.10= 0.049). A centrally funded blockchain-based organization may appeal more to investors by demonstrating clear strategic directions and organizational mandates which lead to better efficiency and returns. Overall, our findings reveal that more decentralization adds value for investors only at the lower (blockchain) level of the governance hierarchy; when it comes to higher-level protocol changes or the overall strategic direction of the cryptocurrency organization, more centralization is preferred.

External governance. *Public interest* is negatively and significantly ($p<0.001$) associated with returns. In other words, the "buzz effect" does a disservice to returns— According to Model 3, for a one standard deviation (0.02146) increase in public interest, returns drop by 11.8% (i.e., 0.02146 * (-5.49) = -0.118; see Wang & Vergne, 2017, for a discussion). Furthermore, *negative publicity* is not significantly associated with returns. As such, unlike in prior studies of the media as agents of external corporate governance (e.g., Dyck et al., 2008), here we do not find that negative media coverage decreases returns. This could be explained by the fact that most cryptocurrencies do not have a central authority to which blame can be attributed, such as a top management team. In turn, the absence of a central authority could make negative publicity a lot less effective than in the context of traditional corporations. Finally, community governance is negatively and significantly

($p<0.05$) associated with returns. For a one standard deviation increase in community governance (0.58625), returns decrease by 18.5% (i.e., 0.05862 * (-3.15) = (-0.185)). We do not find increased community governance to be beneficial for the market returns of blockchain-based organizations. This could be because community involvement becomes more intense in periods of intense criticism (that is not captured by negative publicity), as was the case around the time of the attack against the decentralized, Ethereum-powered investment vehicle called "The DAO" (Breitman, 2017, DuPont, 2017 *this volume*). To explore further the relationship between community governance and cryptocurrency returns, future studies should not only capture the centralization and intensity of community governance, as we do here, but also the overall sentiment (positive or negative) of the community.

CONCLUSION

Our findings point to interesting effects of governance on returns. Internally, while centralized governance design choices at the blockchain level decrease returns, centralized governance design choices at the protocol and the organizational levels appear to be more beneficial for returns. The results correspond to the idea that, on the one hand, investors value cryptocurrencies' core value proposition, rooted in decentralization; but on the other hand, are suspicious of decentralized governance at higher levels in the organization because they could slow down strategic decision-making (e.g., regarding the introduction of new innovations) or create information asymmetries between investors and technologists.

Since March 2017, the cryptocurrency market has become increasingly competitive—Bitcoin's market dominance is reduced significantly, indicating the growth of a more diverse range of blockchain-based governance models, which entail additional complexity relative to traditional corporate governance. These new forms of governance, which place computer code at the center of the system, emphasize the need for new research on organizational governance accounting for the interdependence of various levels within blockchain-based organizations (i.e., the blockchain, protocol, and organizational levels). This study paves the way for crafting new theories about the governance with, and by "decentralized autonomous organizations" (DuPont, 2017) such as cryptocurrencies.

In terms of global governance, these new and open blockchain organizations embody more inclusive solutions to governance problems that could alter the balance of power between incumbent firms and start-ups. As noted at the beginning of the chapter, blockchain technology has attracted considerable attention from central banks and multinational retail banks. Today, many of these financial institutions turn to financial technology start-ups (e.g., Ripple) to leverage blockchain technology. Foreseeably, this collaboration between centralized financial institutions and decentralized blockchain organizations will also foster the emergence of hybrid governance forms across organizational boundaries, as was previously observed in the context of open source software communities (O'Mahony, 2007; Shah, 2006). It is therefore urgent for scholars in the social sciences to address the rise of blockchain with solid empirical research and fresh theory on these new forms of organization.

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