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TWO SIDES OF THE SAME COIN? DECENTRALIZED VERSUS PROPRIETARY BLOCKCHAINS AND THE PERFORMANCE OF DIGITAL CURRENCIES

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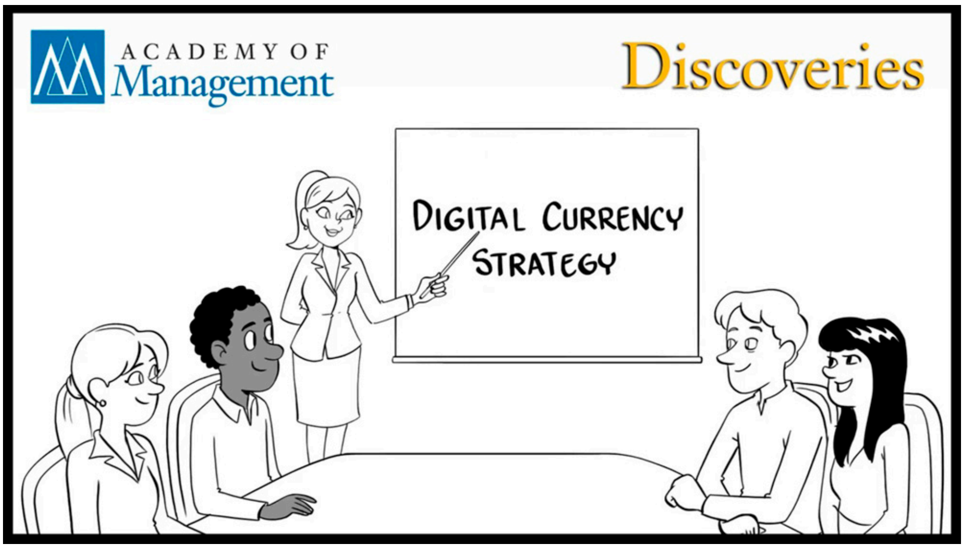

There is a shared view among practitioners that the blockchain is a revolutionary, decentralized technology that will have a larger impact than the Internet. Firms are increasingly using blockchains for various applications; the most prominent of which to date are digital currencies. In this article, we aim to increase our theoretical understanding of the driving forces behind the success and volatility of digital currencies. We use a detailed dataset of 345 digital currencies for our explorative analysis and identify some of the key factors that can explain their performance. We find that the success and volatility of digital currencies depend on their business type (i.e., whether they relate to a platform business or not) and on their technology type (i.e., whether they are based on their own specialized blockchain technology or on a third-party standardized platform blockchain). Our findings suggest that, paradoxically, to obtain the promised benefits of this decentralized technology, firms need to centralize part of it to retain control over critical strategic dimensions (data and rules for transaction). We discuss the implications of our discovery for other contexts undergoing digital transformation.

We would like to thank the guest editor, Professor Melissa Schilling, and the two anonymous reviewers for the constant and valuable feedback provided throughout the review process. Feedback from participants to the dedicated special issue workshop hosted at Cass Business School was also instrumental to improve the manuscript. We are also grateful to the start-up company Helbiz and his CEO for sharing with us "behind the scene" insights on the ICO process and the hidden challenges they faced while launching their business on the Ethereum blockchain. Any misinterpretation and error are our own.

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This innovation is more substantial then the internet. The blockchain is going to have an even larger impact. Brock Pierce, Director of the Bitcoin Foundation

Author's voice:
What motivated you personally to undertake this research?

INTRODUCTION

In 2018, *Helbiz*, a peer-to-peer mobility service startup, was able to raise about $40 million from anonymous investors by launching a digital currency through an initial coin offering (ICO) and, in less than a year, successfully launched its peer-to-peer mobility platform, offering a range of services that will soon include also flying taxi drones. This is not an isolated case; ICOs, and the associated digital currencies,[2] have emerged in recent years as a new mode of funding business venture initiatives, in alternative to the traditional investor-mediated capital markets (e.g., Initial Public Offerings (IPOs) and venture capitals) (e.g., Catalini & Gans, 2019; Garratt & van Oordt, 2019; Malinova & Park, 2018). The relevance of ICOs as a phenomenon is well reflected in the numbers. It is estimated that until 2017 included, ICOs raised as much as $6.2 billion around the world[3]; the total market capitalization of cryptocurrencies in 2018 is estimated at $211 billion.[4] Venture capitalists invested $3.9 billion in blockchain and crypto companies in 2018,[5] whereas well-known crowdfunding portals such as Kickstarter and Crowdcube raised a total of $3.4 billion and $483 million, respectively.

What is distinctive about this phenomenon is that ICOs rely on a digital, decentralized technology, the blockchain, that allows users to exchange assets directly and anonymously and with no intermediaries (Catalini & Gans, 2016). As per the opening quote by Brock Pierce, director of the Bitcoin Foundation, there is a shared belief that the blockchain is a revolutionary digital technology that will transform the way firms and users transact, and possibly, the way firms create value. For instance, ICOs can enable start-ups to raise large amounts of funding while limiting compliance and intermediary costs (Kaal & Dell'Erba, 2018; Sameeh, 2018). Also, the creation of digital currencies in an ICO allows funders to create a secondary market for their investments, offering a liquid asset that is, substantially, separated from the underlying business. These benefits explain why start-ups, as well as large firms, are increasingly embracing ICOs and conducting activities *via* blockchains. However, because of the decentralized nature of the blockchain technology, companies can have little control and influence over the system and, hence, limited ability to directly coordinate transactions and steer the value of their digital currencies (and assets). How do firms then leverage the blockchain and ICOs to raise money and grow the underlying value of the digital currency over time?

ICO projects can use existing or custom-made blockchain networks. Most projects use existing distributed ledger technologies, such as Ethereum, which is the leader blockchain platform network offering standardized tools for creating ICOs. Through interviews with professional operators,[6] we discovered that companies decide to create a digital currency linked to an existing blockchain because it gives access to a large network of users and is faster and cheaper than creating a proprietary blockchain *ex novo*.[7] Instead, when creating their own blockchain, companies need to create a network, attract "miners" (independent actors responsible for clearing transactions in the blockchain market), and pay for transaction confirmation: a complex process that can take several months to setup and require specialized, technical skills, network orchestration skills (to rally and coordinate multiple actors around the

[2] In this article, we use the term "digital currency" in a broad sense to refer to any type of digital asset that relies on blockchain technology and can be exchanged for other fiat or digital currencies on digital marketplaces. In our article, the term "digital currency" does not imply any particular intended usage. As will be explained in more detail in the following text, we divide digital currencies into "coins," which are based on their own blockchain technology and can operate independently, and "tokens" which depend on another party's blockchain technology to operate.

[3] CoinSchedule (2018).

[4] CoinMarketCap, All Cryptocurrencies (October 2018).

[5] Diar, Volume 2, Issue 39, Venture Capital Firms Go Deep and Wide with Blockchain Investments (October 2018).

[6] We had an interview with Stefano Ciravegna, CEO of Babylonia, a crypto exchange based in Singapore, and chief strategy officer (CSO) of Helbiz. Thanks to his daily experience with companies that are or want to be listed exchange we were able to collect very specific informations about the factors that companies really consider to make their ICO successful and how they deal with the strategic choice of the creation or not of an own blockchain.
We interviewed also Angelo Fasola, founder/chief executive officer of TrustMeUp, a platform of fundraising, who explained us the key role of their blockchain in their social funding project.

[7] The process behind the creation of a token on Ethereum is very straightforward, and a token can be created within 20 minutes. The code can be downloaded from Ethereum's website and then easily adapted along some parameters such as the total amount of tokens, how fast a block gets mined, and whether to implement a possibility to freeze the contracts in case of emergency (e.g., a hack) (Momtaz, 2018).

network), and substantive financial resources. We discovered through our interviews that companies may want to create their own blockchain because they can have more flexibility to design it around their core offerings for their specific business purposes, and for controlling and leveraging the data flow on the network: a critical aspect to enhance the quality and value of the core offerings and, most importantly, to coordinate actors and facilitate the emergence of complementary products and services by third-party firms.

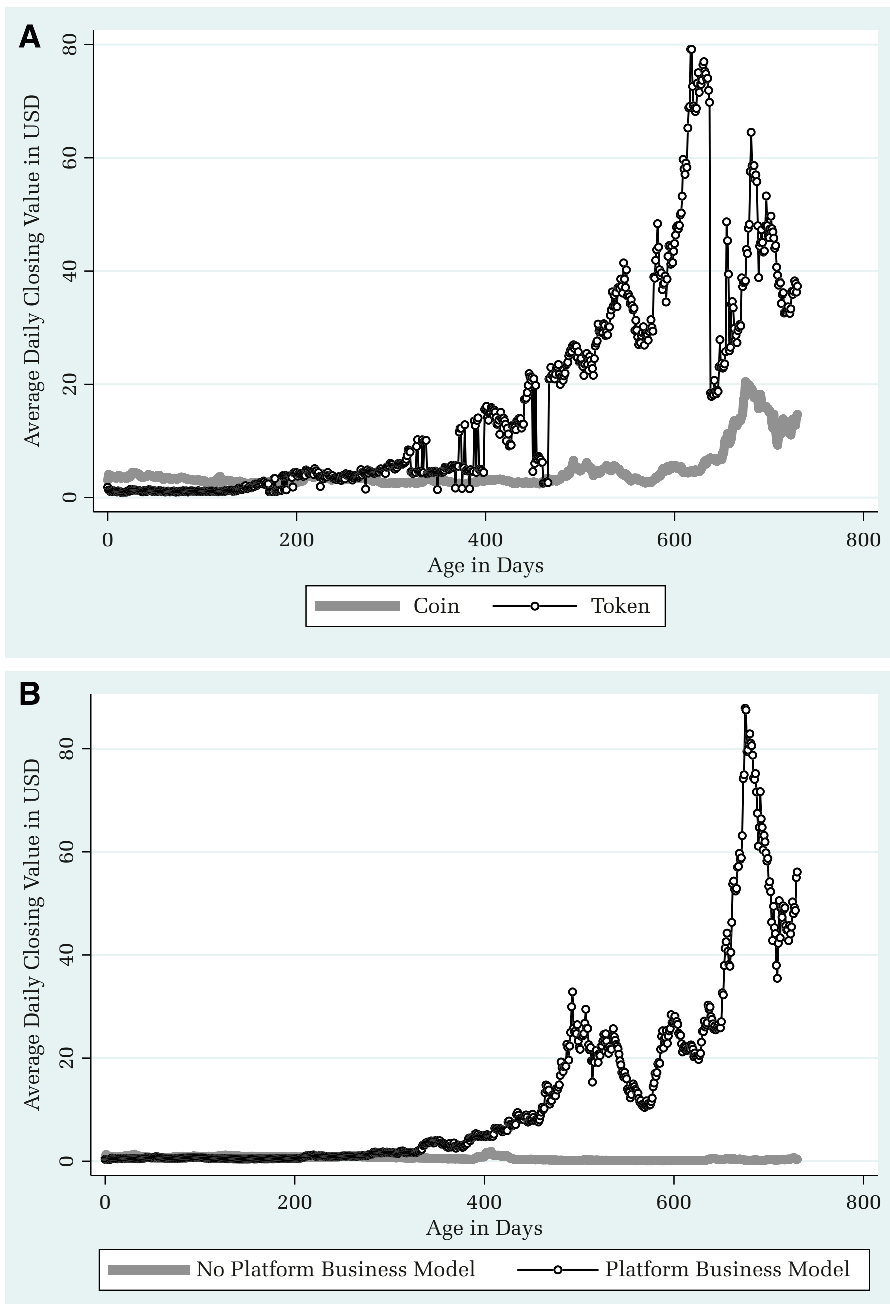
Although some of these aspects are peculiar to ICOs, the core strategic dilemma of leveraging the network and standardized tools of a third-party blockchain platform or building a proprietary specialized blockchain reminds of the classical trade-offs between technology systems with high degrees of modularity and those with "synergistic specificity" (i.e., with integrated, system-specific components) (Schilling, 2000). In fact, this trade-off is becoming increasingly the core of the strategic challenges that firms face in the wake of digital transformation across a number of sectors and emerging digital markets. With the increased digitization of the economy, we observe possibly a paradigm shift in the way firms innovate and manage their products to create greater value for the customer. Digitization brings about increased modularity in and across sectors, which allows disaggregating and reaggregating components in complex solutions by connecting their core products to other firms' products and services (e.g., Baldwin & Clark, 2000; Schilling, 2000; Yoo, Henfridsson, & Lyytinen, 2010). By doing so, firms can extend the range and scope of their product functionalities and create complementarities that enhance the consumption benefits and value for the final customer (Jacobides, Cennamo, & Gawer, 2018). Accordingly, firms are now presented with the challenges of how to connect their core offerings to other firms' offerings, within and beyond their core operating sector (Parker, Van Alstyne, & Jiang, 2017). Essentially, firms can either design their own specific technological infrastructures to facilitate this connectivity and shape and contain the complementarities among the connected products and services to create greater value for the customer or leverage standardized technological infrastructures managed by other firms. Both strategies entail trade-offs and require different management approaches and skills[8] (e.g., Cennamo, Ozalp, & Kretschmer, 2018; Rietveld, Schilling, & Bellavitis, 2019). The emergence of platform markets and ecosystems across an increasing number of sectors is a manifestation of this broader management paradigm shift ensuing from digitization (e.g., Jacobides et al., 2018; Yoo et al., 2010).

In this study, we focus on this core strategic tradeoff in the context of ICOs and blockchain technologies. We explore whether and when ICO projects and their digital currencies built on proprietary blockchain networks can outperform ICO projects built on third-party blockchain networks. In particular, we are interested in understanding the trade-offs that firms face in creating value with one or the other option, and how they affect performance. Our study relates more closely to the early work on the different business and technology nature of digital currencies (e.g., Amsden & Schweizer, 2018; Gans & Halaburda, 2015; Halaburda & Sarvary, 2016). We expand this body of knowledge by examining digital currencies' performance after the ICO, distinguishing between the type of digital currencies and the type of business model of the issuing firm. In particular, on the technology side, we distinguish between "coins," digital currencies that can operate independently through their own blockchain technology, and "tokens," digital currencies that rely on third-party blockchain infrastructures to operate (Amsden & Schweizer, 2018). On the business side, we distinguish between "platform-related" digital currencies, digital currencies that are related to a platform business (a platform on which users can exchange the digital currency for products or services provided by third parties or engage in peer-to-peer exchanges), and "non–platform-related" digital currencies that are not linked to any such platform business (e.g., Halaburda, 2016). Accounting for this business type distinction is important because the core trade-off we examine can be particularly pronounced for firms that want to create their own platform marketplace business. On the one hand, control over the technology infrastructure is critical to coordinate platform users and might thus require building a custom-made, proprietary blockchain. On the other hand, a large network of users is also needed to create value for the platform business; firms can leverage the existing user network of a third-party blockchain to launch and grow their platform business. We believe these are important questions to address to develop knowledge about the distinct mechanisms of value creation of these approaches and the managerial levers that firms have to influence these dynamics. We draw on the results of a longitudinal analysis of 345 digital currencies over a period of 2 years after their launch to find answers to these research questions.

[8] Network orchestration skills for designing the technological architecture to enable the creation of a market for complementary products and services and governing the relationships with third-parties therein (e.g., Cennamo & Santaló, 2019; Rietveld et al., 2019), and product system integration skills for designing products that can best integrate with and leverage third-party technological infrastructures (Boudreau & Jeppesen, 2015; Cennamo et al., 2018).

Initial examination of simple trends from the data reveals that, whereas tokens seem to reach higher value than coins as the digital currency matures in time (Figure 1a), platform-related digital currencies grow much larger in value over time than other digital currencies (Figure 1b). We discovered that the two types of digital currencies reflect different network effect dynamics and differ systematically in terms of performance. We find that, although leveraging a third-party blockchain network might help initially to successfully launch and grow the value of the currency, the value of these digital currencies (tokens) is also more volatile over time, largely influenced by high variations in the underlying value of the third-party blockchain network they are linked to. By contrast, the value of digital currencies that are related to a platform business grows larger over time and more steadily. We find that this is particularly the case when these currencies are linked to their own blockchain (i.e., for

FIGURE 1
Average Daily Closing Value Over Currency Age



coins). Also, we discovered that users hold more and for longer platform-related digital currencies, and that firms can positively influence the value of these currencies by pricing them more aggressively during the initial phase of the ICO (i.e., through strong "underpricing"). We uncovered some of the mechanisms underlying these findings, advancing some propositions about the distinct value creation dynamics and strategic trade-offs that firms face when launching their digital currencies on third-party or custom-made blockchains.

Our discovery makes an important contribution to the literature by clarifying the conditions under which to expect complementarities to arise between the type of business and the type of digital currency, revealing a theoretical intersection of demand-based complementarities (in this case, network externalities in the market for digital currencies) and firm-based complementarities (in this case, the type of a firm's business model). Essentially, our big discovery is that, paradoxically, to obtain the promised benefits of decentralized technologies (such as ICOs on blockchains in our context), firms need to centralize part of the technology system to retain control over critical strategic dimensions. The implications of our discovery go beyond our specific research context and might (to a certain degree) explain, for example, why in the context of another decentralized technology, the Internet, firms that have built proprietary, centralized platform technology systems on top of the Internet infrastructure are those that have captured most of the benefits of this technology. Our findings suggest that we should regard the ICO phenomenon not just in technological terms as an esoteric new digital technology but in light of the possible business paradigm shift that this technology can bring about; a new way for firms to create value. In this regard, this study represents an initial step to develop theory about the (theoretical) distinctiveness of the digital currency market based on decentralized blockchain technologies and how firms can leverage technology and business complementarities in such markets.

In the next section, we introduce the blockchain technology and the institutional framework of ICOs; define the two types of digital currencies, coins, and tokens; and discuss the main differences, shortly reviewing related existing studies as a way to ground the framing of our discovery. We then present our longitudinal analysis assessing the differential impact of the two types of digital currencies on value and underlying risk. We show a battery of tests, trying to identify the mechanisms behind these relationships. We conclude the article by discussing these mechanisms in the light also of their broader potential implications to other digitizing contexts.

THE ICOS AND DIGITAL CURRENCY PHENOMENON

Blockchain Technology and Digital Currencies

The digital currency market surpassed the barrier of $100 billion market capitalization (i.e., market price multiplied by the number of existing currency units) in June 2017, reaching the value of $211 billion in 2018.[9] The interest of the economic world in blockchain and "distributed ledger" technology arose because of the possibilities that this technology is expected to deliver (Catalini & Gans, 2016; Yuan & Wang, 2016). In a little less than a decade, blockchain technology has evolved from a by-product of Bitcoin's development to a forecasted $10 trillion market (Stevens, 2018)[10]; blockchain technology diffusion and its entrepreneurial applications increased tremendously, letting new decentralized and ownerless business models to emerge and, in some cases, to replace the need of trusted intermediaries. Blockchain could dramatically reduce the cost of transactions and, if adopted widely, reshape the economy (Iansiti & Lakhani, 2017).

Digital currencies rely on blockchain technologies to create a distributed system of certification and integrity on the Internet whenever payment transactions occur. This distributed system strikingly contrasts with the case of fiat money, where a central trusted party (namely, the central bank) guarantees the value of national currencies and banknotes (Adhami & Giudici, 2018). The phenomenon of digital currencies represents new market organizing principles that blend some of the characteristics of financial assets with the opportunities offered by new digital technologies, such as the blockchain. The blockchain is a digital, decentralized, distributed ledger (Pilkington, 2016), a file that records transactions between two parties efficiently and in a verifiable and permanent way.[11]

Bitcoin is the first application of blockchain technology; it is a digital asset designed to work as a medium of exchange (Barrdear & Kumhof, 2016; Nakamoto, 2008), a virtual currency system that eschewed a central authority for issuing currency, transferring ownership, and confirming transactions; users can send and receive native tokens, the

[9] CoinMarketCap.

[10] Mitch Steves is an analyst at RBC Capital Market: his interview with CNBC is available at https://www.cnbc.com/2018/01/03/one-stock-analysts-10-trillion-bull-case-for-cryptocurrencies.html (2018).

[11] All network nodes have a copy of the ledger, and no one has the sole authority to update it. Blockchains rely on hashing, a cryptographic system to transform any text of any arbitrary length into a theoretically irreversible fixed-length string of numbers and letters (the "hash") to provide security, accuracy, and immutability of the registrations.

"bitcoins," while collectively validating the transactions in a decentralized and transparent way.[12] After Bitcoin, a plethora of digital currencies have been created, and dedicated platforms emerged to exchange fiat money into cryptocurrencies and *vice versa*. Moreover, hundreds of large companies worldwide accept Bitcoin for their services, including Amazon, Bloomberg, Microsoft, PayPal, Subway, Target, and Tesla.[13] These "cryptocurrency and blockchain innovations" can be grouped into two categories: new (public) blockchain systems that feature their own blockchain (Ethereum, Peercoin, and Zcash), and apps/other that exist on additional layers built on top of existing blockchain systems (Counterparty and Augur).[14]

THEORETICAL BACKGROUND

Digital Currencies and ICOs

The rise of digital currencies and ICOs as a phenomenon has stimulated an increasing body of academic research. The ICO is a mechanism used by new ventures to raise capital by selling digital currencies to a crowd of investors, without involving any intermediaries. To some extent, ICOs are similar to the more traditional market-based funding mechanism of IPOs as they share the same logic. In both scenarios, the initiators are trying to raise funds and find investors who are willing to invest money in exchange for a stake in the company. Investors on the other hand are attracted by potential profits on their investment. Both ICOs and IPOs therefore differ greatly from the purpose of crowdfunding, where supporters want to realize a specific idea based on minor rewards or early access to a certain product or service (Ahlers, Cumming, Guenther, & Schweizer, 2015; Connelly, Trevis Certo, Ireland, & Reutzel, 2011; Megginson & Weiss, 1991). Compared with other forms of entrepreneurial finance such as crowdfunding or venture capital, liquidity is a defining feature that distinguishes ICOs (Howell, Niessner, & Yermack, 2018). In ICOs, investors can sell their assets immediately, as they are detached from the issuing firm and can be traded as standalone assets. Nonetheless, their value partly shapes with the ICO and can be affected by the underlying business of the issuing firm.

Broadly, most of previous empirical work on digital currencies and ICOs focuses on the determinants of a successful ICO, generally assessed as the extent a token is subsequently listed on an exchange (token tradability) and traded actively, and/or the total amount of money raised (Ahlers et al., 2015; Amsden & Schweizer, 2018). In an ICO, a tradable token is very important for both investors and venture founders as it enables founders to raise additional funds and investors to monetize their investments. Research on ICOs has been largely confined to explain the characteristics of ICOs and its market; that is, what it is. However, these studies do not reveal the extent to which ICOs and digital currencies differ in their functioning from other funding market mechanisms and the nature of such differences. Missing is an understanding of the managerial implications for entrepreneurs and organizations about what instruments are best suited for the distinct types of organizations, and how to best leverage ICOs. As a first step toward this direction, in our study, we focus on the digital currencies' value *after* they become tradable on exchanges, rather than the successful completion of the ICO *per se*. Thus, we focus on the digital currencies that have already gone through a successful ICO. Some analysis has considered the returns from ICOs. There is however no systematic analysis for instance on the differences, if any, between the distinct types of digital currencies. To the extent that scholars have considered the distinct types of digital currencies, they have tended to emphasize the distinct technical characteristics, and uses. But how does the distinct type of digital currencies impact on the underlying value creation for an entrepreneurial project? Are there systematic differences in the value creation mechanisms between the distinct type of digital currencies? What managerial levers do firms have to influence these dynamics, if any? We believe these are important questions to address if ICOs were to gain managerial relevance to firms, and not be confined only to an esoteric market.

Types of Digital Currencies

***Coins* versus *tokens*.** Digital currencies can be grouped into different categories depending on their

[12] The underlying technology is based on a public ledger, the blockchain, shared between participants and a reward mechanism in terms of Bitcoins as an incentive for users to run the transaction network. It relies on cryptography to secure the transactions and to control the creation of additional units of the currency, hence the term "cryptocurrency" (Vigna & Casey, 2015). Bitcoins, and other digital currencies, are generated by a "mining process" that solves a computational puzzle; the first miner that solves the puzzle earns the right to add his block to the blockchain (Decker & Wattenhofer, 2013). Bitcoin's protocol intentionally makes mining increasingly difficult, meaning that gaining control of most of the network is prohibitively expensive in terms of computational efforts (Eyal & Sirer, 2014).

[13] In 2017, the proposal for a Bitcoin Exchange Traded Fund (ETF) investment vehicle that would be easily accessible to retail investors was rejected by the SEC. Yet, other financial products, such as exchange traded notes (ETNs) (listed in countries such as Sweden that, in contrast to the United States, allowed such issuances) and contracts for difference (CFDs) (derivative products) that replicate Bitcoin's price performance, are available on the markets by brokers.

[14] CoinMarketCap (2018).

characteristics. In terms of the type of technology that they are based on, we can distinguish between coins and tokens. Whereas the terms "coin" and "token" are often used interchangeably, previous literature has increasingly followed a definition that sees them as two different things. For instance, Amsden and Schweizer (2018) base their work on a classification of digital currencies that is derived from the U.S. Securities and Exchange Commission (SEC) regulation. In this classification, digital currencies are grouped into different categories depending on blockchain technology, legal status, and purpose of usage. The categorization that is of most interest for this article is the one based on blockchain technology, which differentiates between coins and tokens. Therein, a coin is classified as a digital currency that "can operate independently," whereas a token is a digital currency that "depends on another cryptocurrency as a platform to operate." In other words, tokens are based on a third-party's blockchain platform technology connecting to and leveraging an existing network infrastructure, whereas coins are based on a firm's own blockchain that has been developed specifically for the firm's given business purposes. In this article, we follow the SEC-based classification adopted by Amsden and Schweizer (2018), differentiating our cryptocurrency in coins and tokens, as this is more standard and in line with the categorization of the many databases on ICOs.

Platform-* versus *non–platform-related. Digital currencies can also be categorized based on their business type. "Platform-related" digital currencies are primarily designed to support a platform business model (Halaburda, 2016), as a medium that users can exchange for complementary products or services on a specific digital platform.[15] Early examples of platform-related digital currencies include Amazon Coins or Facebook Credits, which can be exchanged for products or services on the respective platform (Halaburda, 2016). Other examples include *Filecoin*, a decentralized storage blockchain platform where the coins (*FIL*) can be earned by hosting files that lie on the unused storage of private hard drives, or *Trust Me Up*, a charity platform where the customers (i.e., donors) receive PassionCoins for their donation that can be spent on selected merchants that join the platform's network.

"Non–platform-related" digital currencies on the other hand are not linked directly to any platform business and are designed as a potential substitute for fiat currencies (Amsden & Schweizer, 2018; Halaburda, 2016). Much like traditional money, they are created to store value over time to allow for trading and exchange among users. Unlike platform-related digital currencies, they do not grant any direct access to a specific product or service available on a platform but can rather be thought of as a genuine type of currency, with the most prominent example being *Bitcoin*.

It is important to highlight that the two dimensions along which digital currencies can be distinguished (i.e., their technology type and their business type) are independent from one another. In other words, tokens can be either platform related or not, and coins can be platform related or not. The effect of different combinations of technology type and business type has not received scholarly attention as yet. But we believe this analytical angle can be very promising as it can reveal the potential trade-offs and complementarities between technology type and business type, and thus help to understand the performance of digital currencies.

POTENTIAL VALUE CREATION MECHANISMS

We lack theory on the different value creation mechanisms for the different types of digital currencies. Some studies have focused on the interaction between digital currencies and the platforms on which they can be used (Sockin & Xiong, 2018, Li & Mann, 2018, and Cong, Li, & Wang, 2018). Although informative on many aspects, largely, these studies focus on the differences between launching platform businesses with and without digital currencies. We draw on these studies' insights and our interviews with professionals from the field and analysis of specific cases[16] to identify the possible strategic

[15] Although Halaburda (2016) restricts the term "platform-related" digital currency to only those digital currencies that can be traded *exclusively* on the given platform, we use the term more broadly to refer to any kind of digital currencies that are linked to a platform, including the ones that can be traded both on the platform they are linked to and on online trading marketplaces.

[16] We analyzed five specific cases (Binance, Filecoin, Helbiz, Musicoin, and Trust Me Up), and we integrated our analysis with interviews from three of these cases. We had an interview with Stefano Ciravegna, CEO of Babylonia, a crypto exchange based in Singapore, and CSO of Helbiz. Thanks to his large experience with companies that are or want to be listed, we were able to collect very specific information about the factors that companies really consider when launching their ICO and how they deal with the strategic choice of the creation or not of an own blockchain. We interviewed also Angelo Fasola, founder/chief executive officer of TrustMeUp, who explained to us the key role of their blockchain in their social funding project. We had an interview with Richard Titus, CEO of Ark Advisors, a company that support firms through the tokenization and creation and sale of digital assets and securities, who confirmed that the choice of the cryptocurrency typology, related to the business model of the firm, is critical when a company decide to run an ICO.

trade-offs associated with each type of digital currency, and the potential value creation mechanisms that can be at play. We first discuss the pros and cons of building a custom-made blockchain network *versus* using a standardized blockchain platform such as Ethereum, and then relate these to the platform *versus* non-platform business model choice.

Table 1 summarizes the pros and cons of using an existing or custom-made blockchain network, offering also some stylized examples. Among the main benefits of using a third-party blockchain platform for creating digital currencies are the limited costs in terms of effort, skills, and money required compared with building a custom-made blockchain. In fact, it has been estimated that more than 80 percent of companies use the Ethereum blockchain platform, which is the market leader, to create their digital currency (EY, 2017); the process is standardized and it can take less than 20 minutes to create a digital currency (Momtaz, 2018). Because of its highly modular, decentralized structure, such a blockchain system can foster innovation (i.e., the creation of ICOs and new currencies in this case) by decentralizing decision-making on "hidden modules"—modules ("blocks" of code in our context) that integrate with the system but work independently of other modules (Baldwin & Clark, 2000). Users do not need to coordinate with each other and know how the other parts of the system work to be able to use the system and build their own modular extensions. Thus, modular systems can best respond to and meet heterogenous demands from the market by allowing for the creation of greater variety and configurations of solutions (Schilling, 2000). The promised benefits of the blockchain, that is, greater innovation and value potential, lower transaction costs, lack of centralized control, and "trustworthy" transactions (Burns & Moro, 2018; Kaal & Dell'Erba, 2017; Ofir & Sadeh, 2019), are directly related to the increased modularity of the technology, which allows for independent, diffused, and fragmented resources and inputs in the (blockchain) user network to be recombined in an increasing number of possible configurations. In our context, therefore, a large variety of heterogenous digital currencies can be created by leveraging the standardized tools of blockchain platforms such as Ethereum and its network of users, at (relatively) low costs and in large scale. However, there is a downside to its popularity; the blockchain network can be overloaded and congested, with the growing demand raising the cost of Ether and the cost to run ICOs on it. It has been reported that the increasing number of transactions on the Ethereum blockchain is associated with an increase in transaction costs[17] (EY, 2017). Also, because of the standardized and decentralized structure of the blockchain and the public nature of the ledger network, it offers firms very little flexibility over the rules of the blockchain, transactions, and control over data. As with any system with high degrees of modularity, its interfaces and core infrastructures need to be kept at a standardized level that guarantees high recombinatorial possibilities through mix and matching of a variety of components and applications (Baldwin & Clark, 2000; Constantinides, Henfridsson, & Parker, 2018; Schilling, 2000; Yoo et al., 2010). This might be problematic for companies that need to customize the blockchain network to their specific business needs. Helbiz, our opening example, is a case in point. They were able to build quickly a network of potential users for their platform, leveraging the existing user base on the Ethereum platform. However, while implementing their technological system, Helbiz faced two strong constraints for its business model. The lack of control over data prevented Helbiz from being able to effectively use the blockchain to verify the identity of people using their peer-to-peer system for the mobility services. This was particularly problematic because Helbiz would need that information to allow its technology system to securely unlock another user's car and make it available to the focal user. As in any peer-to-peer system like, for instance, Airbnb, the information about the identity of the user is critical for guaranteeing trust in the network and incent users to transact. Also, it was not possible for Helbiz to

[17] Each digital currency must be first converted in Ether, the Ethereum digital currency, before it can be exchanged against other digital currencies (e.g., Bitcoin) or dollars; each transaction must be validated by users in the network (the miners). With an increasing number of transactions, a larger number of "blocks" need to be created in the network to validate and clear the transaction. This is because each block on Ethereum has a size limit that determines how many transactions can fit in a block. Ethereum can increase the transaction size of blocks, but this will require an extra cost because the validation operations will require additional computational steps, and thus become computationally more expensive. Accordingly, with an increasing number of transaction demands (e.g., ICOs; currency exchange, and network usage) placed on the network, the costs of such transactions can increase either because greater monetary incentives will be required for miners to validate those transactions timely if the size limit of blocks does not change, or because they become more computationally expensive if the size limit of blocks increases to accommodate for greater demand.

TABLE 1
Pros and Cons of Building a Custom-Made Blockchain

Building a Digital Currency on an Own Blockchain	
Pros	**Examples**
Flexible control over what data are kept private and what are shared on the public ledger.	Helbiz, a company offering mobility services, decided to develop its own blockchain to exploit the data collection to increase the amount of services offered, in a logic of smart mobility.
Possibility to change the rules of a blockchain, revert transactions, and modify balances.	Filecoin is a decentralized platform for cloud storage that uses the peer-to-peer system to store and secure data on its blockchain. The own blockchain allows the company to act directly on the nodes approval, what data are shared and what are private, and controlling directly, and in case, reversing the validation of a block transaction. This guarantees a secure (although not irreversible) service to its custumers.
Cheaper transactions because only few nodes are needed for verification. Validators are known/lower risk of collusion.	Binance, one of the biggest cryptocurrency exchanges by volume, moved its native token Binance Coin from the Ethereum Blockchain to a new, own blockchain, to reduce the transaction fees and the volatility risk. Because Binance shifted to a private blockchain, the risk of collusion in trading has been reduced. The nodes approving the transactions are known, and it is possible to identify them in case of fraude.
Better privacy	The Filecoin blockchain verifies the transactions between clients and miners, and serves as a record of their legitimacy; it is a guarantee for the privacy in the business of data sharing.
Designed specifically for a given purpose, not a wide set of rules/ standards that need to be followed,	Musicoin, a music-streaming platform, built an own blockchain that supports the creation, distribution, and consumption of music in a shared economy.
Cons	
Typically owned by a single individual or corporation, making them centralized and less secure than public blockchains. Need to find miners that verify transaction.	Trust Me Up, a blockchain based fundraising platform, chose Optherium, a third-party blockchain to guarantee transparency and security in the transactions for its donors. Thanks to its decentralization, Optherium is less vulnerable to cyberattack, and transaction data cannot be manipulated by Trust Me Up to influence donors.
Limited network scale—network needs to be built over time.	Trust Me Up decided to rely on an external blockchain to connect globally all the actors involved in the projects (i.e., donors, sponsors, and merchants), reaching a relevant user base. Helbiz, after launching its currency through the Ethereum network, was able to raise $40 million in less than 1 month, and launched its first service in less than 1 year, leveraging the Ethereum network scale.
Requires more time and technical ability to build. More expensive to scale.	Helbiz started to move to a private blockchain 1 year after the ICO, even if it noticed problems with Ethereum set up before, because of the high entry costs of a private blockchain's development.

trace the route of the vehicles; only the point of departure and arrival was made available. This created problems in terms of insurance for the owners of the vehicle and for the company itself, which could not use this information to optimize their vehicles' locating and routing algorithm. Helbiz decided to build its blockchain network to customize it to its needs. Although increased modularity may be a substitute for interfirm coordination mechanisms in terms of the production process, it does not ensure that the objectives of the focal firm (e.g., specific content output and quality, and development trajectory of the technology) are met; coordination in product output might still be highly needed to achieve specific goals (Tiwana, 2008). Also, "some product systems achieve their functionality only through optimizing each of the components to work with each other" (Schilling, 2000: 316). In other words, parts of the system might still need to be specialized and centralized for the company to be able to better coordinate production and transactions, and enhance value creation opportunities. As advanced by Brusoni, Prencipe, and Pavitt (2001), integration of different parts of complex systems and coordination of actors might not happen automatically in decentralized, modular systems; superior information and knowledge over the overall system's functioning is required to best coordinate the actors and activities involved, and achieve optimized system integration.

A central actor, or "system integrator," must thus hold control over a core, specialized component of the system, which allows to secure the needed information and knowledge over the system's architecture. In this regard, Filecoin is a counter example of the benefits of control over data and rules offered by proprietary blockchains. Filecoin is a peer-to-peer platform for buying and selling storage space, where the blockchain verifies the transactions between clients and miners, and serves as a record of their legitimacy. Control over the blockchain and the user data allows Filecoin to shape the rules of the blockchain, revert transactions (if needed), modify balances, and accordingly guarantee the well functioning of its platform market. If a customer, for example, needs to modify the data shared and the storage required, and the miner (provider of storage) is not addressing the request after having received the coins, the blockchain administrator can act directly on the nodes that approved the transaction, deleting or modifying it.

The disadvantages of tokens (e.g., particularly the lack of control over the data and the rules of the blockchain) might be more problematic in the case of platform-related cryptocurrencies, where the digital currency is used both as a means to grow the underlying platform business network and as a means to coordinate interactions in the marketplace associated to the platform business. Platform business models differ from traditional value chain models in that value creation takes place by linking directly the demand side to the supply side rather than focusing on value creation on the supply side only (Massa, Tucci, & Afuah, 2017). Massa et al. (2017) argued that value on the demand side can be created by users either through their mere presence—for instance, on a platform (see Cennamo & Santaló, 2013)—or if they actively contribute to the innovation process (von Hippel, 2005). Business models are often seen as being essential to connect technologies to the market environment (Chesbrough & Rosenbloom, 2002), as they define the business value architecture; that is, how the configuration of the business activities relates to value creation/capture opportunities on the market. This is particularly relevant in many digital contexts that are characterized by strong network effects and in which the installed user base, as well as the entry time play an essential role in determining which firms will succeed (Schilling, 2002). Sockin and Xiong (2018) highlighted that digital currencies[18] have a dual role if they are linked to a platform business: they act as a membership fee to access the platform and as a service fee to compensate miners for providing clearing services on transactions. Because the firm does not control the underlying value of the token, which is linked instead to the third-party blockchain, it can be more difficult to use it effectively as a coordination mechanism to induce greater user adoption and greater participation by complement providers. The literature on two-sided platforms has largely documented the importance of pricing for platform adoption and growth (e.g., Evans, Hagiu, & Schmalensee, 2005; Parker & Van Alstyne, 2005; Rochet & Tirole, 2006). Cong et al. (2018) found that, in fact, there could be potential complementarities between the platform business growth and the associated digital currency's value. They argued that if users expect increases in future popularity of the platform, they are more likely to purchase the related digital currency and join the platform. Increased adoption in turn has a positive feedback effect on digital currency price and ultimately leads to accelerated platform adoption as investors also become customers, and *vice versa*. The authors also show that platforms with related digital currencies face less volatility in terms of user base than platforms without related digital currencies because of the positive expectations about user base growth in the future.[19] Thus, in the case of positive expectations, the value of the platform business can grow with the value of its associated digital currency, or can decrease in case of negative expectations. However, in the case of tokens, whose value is linked to the value of the blockchain's currency it is based on (e.g., Ethereum), there is not such one-to-one correspondence with the underlying value of the platform business, limiting its ability to act as coordination mechanism for platform adoption. Also, blockchains require that all transactions be verified cryptographically by independent miners that are rewarded for their validation job through digital currencies; this process requires a huge amount of computational energy because each block needs to be validated and can significantly slow down the transactions (Constantinides et al., 2018). This is particularly so on large, third-party blockchain platforms (such as Ethereum), where validation rules are standardized independently of the type of

[18] The authors refer to digital currencies as tokens.

[19] Also, according to Li and Mann (2018), ICOs of platform-related digital currencies can help mitigate to some extent the "chicken-and-egg" problem in platform adoption (see, e.g., Caillaud & Jullien, 2003; Rochet & Tirole, 2006). Initial participation of investors in ICOs can signal positive expectations about the future value of the platform business, hence the future value of the currency, and can thus trigger adoption by other users. In other words, the value of the digital currency associated with the platform business will convey relevant information to prospective users of the, possibly, "true" value of the platform business, and can thus shape their expectations about platform growth.

transaction and where a large and heterogenous set of transactions must be validated. Platform-related currencies can thus face a particular severe problem for the growth and scalability of their platform business, which largely relies on increased transactions' volume. Indeed, some authors have raised the concern that scaling platforms on third-party standardized blockchains appears to be a serious challenge (Constantinides et al., 2018). We aim to get a better understanding of the overall possible complementarities between the distinct type of digital currencies (i.e., the diverse technology type they are based on) and the distinct type of business (platforms *versus* non-platforms), and the implications for performance.

METHODS

Data

For our analysis, we used web-scraping techniques to collect data from three sources: *icorating.com*, *icobench.com*, and *coinmarketcap.com*. *Icorating.com* and *icobench.com* collect information related to the ICOs of digital currencies and allowed us to gather data on various characteristics of the digital currencies in our sample, such as their underlying business model, the amount of money they raised during the ICO, the quality of the project idea and founding team (as assessed by experts), and the level of attention that they attracted on relevant social media platforms. In addition, we gathered information on the daily trading performance of digital currencies over time from *coinmarketcap.com*. An overview over the variables that we use in this article and their source can be found in Table 2.

Author's voice:
What was the most difficult or challenging aspect of this research project?

The main variables of interest in our analyses are the daily closing value, trading volume, and weekly volatility of digital currencies. The daily closing value is the price in U.S. dollars that users have to pay for one unit of the digital currency and reflects the performance of the digital currency over time. Furthermore, we use the daily trading volume as an indicator of the extent to which users exchange a digital currency for other currencies or *vice versa*. Finally, the weekly volatility indicates how much the value of a digital currency varies over time and thus reflects the stability of a digital currency's value. Following the theoretical reasoning outlined earlier, we excluded 10 digital currencies that are marked as "Securities" in the "Type" field on *icorating.com*, as they share some of the characteristics of VC funding or crowdfunding (i.e., the digital currency essentially represents a share of a company) and do not fit into our classification of different business models. In addition, we also collected information on the digital currencies' age (*AgeInDays*), the amount of money that digital currencies raised during their ICO (*Raised*) and the extent to which digital currencies

TABLE 2
Variable Definition and Source

Variable Name	Definition	Source
Weekly Volatility	7-day standard deviation of daily logarithmic returns	coinmarketcap.com
Trading Volume	Trading volume in USD. For tokens, trading volume is first calculated in terms of underlying coin and then converted into USD	coinmarketcap.com
Closing Value	Daily closing value of the digital currency in USD	coinmarketcap.com
Platform Business Model	Dummy variable that takes the value of 1 if the digital currency is based on a platform business model (i.e., if the field "Product Type" on *icorating.com* contains the word "platform") and 0 if it is not based on a platform business model	icorating.com
Token	Dummy variable that takes the value of 1 if the digital currency is a token and 0 if it is a coin	coinmarketcap.com
Age (days)	Number of days since the digital currency was first traded	coinmarketcap.com
HypeScore	Parameter calculated by icorating.com "on the basis of the number of users on project pages on social media (Bitcointalk, Telegram, and Twitter) and other social activity metrics"	icorating.com
RiskScore	Parameter calculated by icorating.com to "determine the reliability of a project against aspects such as its team, the product, the existence of partners, and so on"	icorating.com
Raised	Amount of money raised during ICO	icorating.com
Rating	Evaluation of the quality of the product idea, vision, and the team behind the currency (combination of an automated assessment by the website and expert ratings)	icobench.com
Underpricing	Difference between first day opening price and first day closing price divided by first day opening price	coinmarketcap.com
BTC Value	Daily closing value of *Bitcoin* (*BTC*) in USD	coinmarketcap.com
ETH Value	Daily closing value of *Ethereum* (*ETH*) in USD	coinmarketcap.com

were initially priced less than their market value (*Underpricing*). For a subsample of digital currencies, we were able to collect the variable "*Rating*" from *icobench.com*. These ratings are a combination of an automatic evaluation performed by the website and ratings by experts, which evaluate, for instance, the quality of the product idea and the team behind the currency. From *coinmarketcap.com*, we were able to obtain information on the extent to which a given digital currency was able to attract interest on relevant digital media platforms (*HypeScore*) and on the extent to which its characteristics signal unreliability or even potential fraud (*RiskScore*).

In our analyses, we also control for the daily closing value of the two most prominent digital currencies—*Bitcoin* and *Ethereum*—to account for the potential spillover effect of their performance onto less prominent digital currencies. Summary statistics of our variables grouped by business type can be found in Table 3.

In total, our sample contains information on 335 digital currencies. We restrict our data to the first 2 years after the launch of a given digital currency. Given the young age of many digital currencies, we do not have the full 2 years of observations for all digital currencies in our sample. However, it is important to note that we do not have any periods in the life span of digital currencies for which we only have data on one type of digital currencies.

The composition of our sample in terms of business type and technology type can be seen in Table 4. Most of the digital currencies are tokens; that is, about 87 percent in our sample use a third-party blockchain platform (largely Ethereum) instead of custom-made blockchain infrastructures, which is in line with the general trend remarked elsewhere (e.g., EY, 2017). However, we do observe an almost even distribution between platform- and non–platform-related cryptocurrencies.

Analysis

We start with some descriptive analysis to examine potential differences in trends between platform-related and non–platform-related currencies. In particular, in Figure 2, we explore how the weekly volatility of different types of digital currencies evolves as their age increases. The underlying idea is that, if the value of the platform-related currency depends indeed largely on the underlying platform business dynamics, we should expect it to grow over time in tandem with the growth of the platform (for successful platforms), and thus show a more stable path in value. Instead, for non–platform-related currencies, we might expect greater volatility, particularly for those directly linked to other currencies, that is, tokens. We can see from the figure that the volatility of both types of digital currencies initially evolves along the same path. Over time, however, the volatility of platform-related digital currencies decreases significantly, whereas there is no such decrease for non–platform-related digital currencies.

TABLE 3
Summary Statistics

Variable Name	Observations	Mean	Standard Deviation	Min	Max
No Platform Business Model					
Weekly Volatility	26,145	.1171019	.106064	0	2.317356
Trading Volume	26,044	2,038,830	1.05e+07	0	5.40e+08
Closing Value	26,298	.8244001	4.285565	3.00e–06	89.11
Age (days)	26,298	159.0592	151.0602	0	730
Token	26,298	.7246178	.4467151	0	1
HypeScore	26,298	3.183664	.8579999	2	5
RiskScore	11,671	3.089624	.9801917	1	5
Raised	17,115	1.97e+07	1.59e+07	3,000	6.80e+07
Underpricing	26,298	6.443139	46.59278	–.2797519	353.3279
Rating	22,774	3.248626	.7154146	1.6	4.8
Platform Business Model					
Weekly Volatility	31,543	.1116692	.11058	.0009674	2.654866
Trading Volume	31,314	8,186,617	6.67e+07	0	2.88e+09
Closing Value	31,751	2.150857	15.35063	3.00e-06	401.49
Age (days)	31,751	141.1625	138.2364	0	730
Token	31,751	.8188089	.3851825	0	1
HypeScore	31,751	3.270952	.7325073	1	5
RiskScore	12,506	2.887254	.7326852	1	5
Raised	19,708	2.95e+07	5.94e+07	49,000	5.75e+08
Underpricing	31,751	.0978965	.419288	–.8703217	3.472603
Rating	24,563	3.340471	.6302642	1.8	4.7

TABLE 4
Sample Composition by Business Type and Technology Type

		Business Type	
		No Platform Business Model	Platform Business Model
Technology type	Coin	20	21
	Token	121	173

This suggests that the value of platform-related digital currencies becomes more and more stable over time than the more volatile value of non–platform-related digital currencies.

We expect this pattern to be reflected in more quantitative analyses as well. Results of a t-test that compares the volatility of the two types of digital currencies reported in Table 5 confirm that the average volatility of platform-related digital currencies is statistically significantly lower than that of non-platform digital currencies. Also, consistent with the value growth's path in Figure 1, the results of the t-test show that the closing value of platform-related digital currencies is significantly higher, statistically and economically (in terms of size effect), than the closing value of non-platform currencies. Taken together, these patterns provide preliminary evidence that digital currencies on average can reach higher value and grow more stable in value over time if they are linked to a platform business model, which might suggest that there could be indeed a reinforcing effect (i.e., a virtuous cycle) between the value of the currency and the value of the platform business.

Our starting assumption in the analysis is that these differences cannot be attributed solely to the different business type, but are driven, at least in part, by the underlying technological characteristics of the digital currency. For instance, we expect the potential reinforcing effect between currency value and platform value to be greater for coins than for tokens. Because the value of tokens is directly linked to the associated currency of the blockchain platform it is built on, it can be more volatile and disjoint from the underlying platform business dynamics because it is influenced to a large extent by the expectations of the market value of the third-party blockchain platform (e.g., Ethereum) rather than the focal ICO's business. Accordingly, we might expect tokens to be associated with higher volatility and potentially lower closing value on average than coins.

We also expect different types of digital currencies to be affected in different ways by the extent to which they manage to attract attention from potential users on relevant digital media platforms. Particularly in the case of platform-related digital currencies, strong user attention might trigger the typical indirect network effects dynamics of platform businesses, where initial hype around the platform by some actors can attract actors on the other side of the platform in a self-reinforcing way and lead to increases in the overall value of the digital currency over time. Instead, these dynamics are not present for non-platform digital currencies. A higher hype score might influence the initial value of the currency but, absent any complementarities between the underlying business and the currency's value, such as the indirect network effects in platform-related currencies that can reinforce users' expectations over time, the initial hype effect around the non-platform digital currency's value can quickly dissipate. In other words, the initial hype around the currency might have a short-lived effect for non-platform currencies and a more long-lasting effect for platform-related currencies because of the reinforcing effect between the user expectations of the currency value and the platform value.

To get a sense of whether these factors can indeed explain the differences that we observed, we run a set of panel regressions to analyze the relationship between our key variables of interest (i.e., *Weekly Volatility*, *Trading Volume*, and *Closing Value*) and some of the main characteristics of the digital currency. We regress each of our key variables of interest on *Token*, *HypeScore*, and *RiskScore*. In addition, we add time fixed-effects (γ_t) to control for confounding factors such as differences in the popularity of digital currencies over time (or market volume and liquidity).

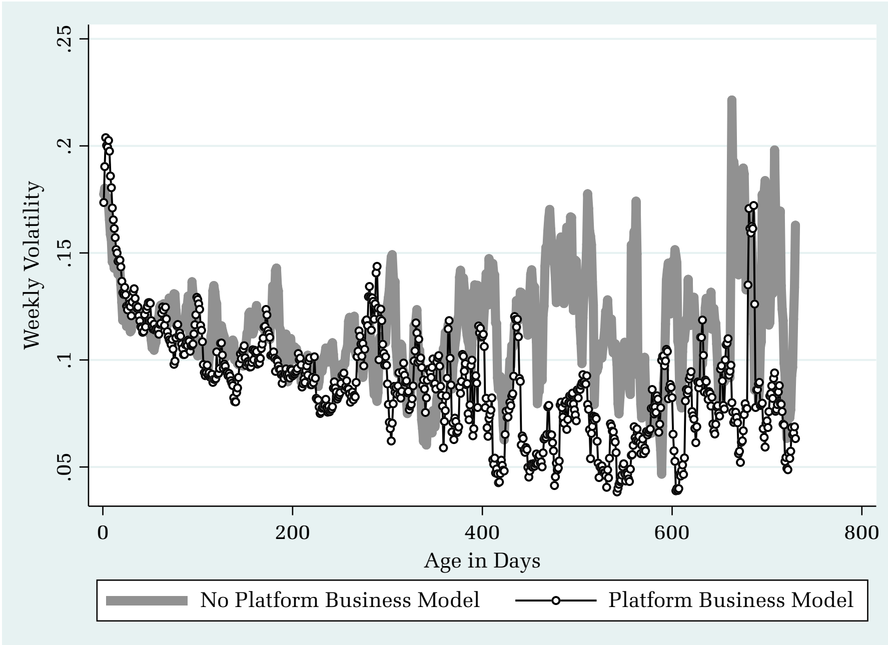
$$\text{Closing Value}_{it} = \beta_1 \times \text{Token}_i + \beta_2 \times \text{Hype Score}_i + \beta_3 \times \text{Risk Score}_i + \gamma_t + u_{it}.$$

We estimate this model using subsamples that either contain only digital currencies that are related to a platform business model or only non-platform digital currencies.[20] The results of this analysis are

[20] One concern might be that observations belonging to the same group might be correlated and require clustered standard errors. However, as shown in Abadie, Athey, Imbens, and Wooldridge (2017), this is not a concern when, as in our case, all clusters are represented in the data instead of only a subset of clusters of the population of clusters. Moreover, clustering adjustment might lead to too conservative and large errors in case of small-size samples; Angrist and Pischke (2008) suggest that having fewer than about 50 clusters can result in "biased standard errors and misleading inferences." For the coins group, we only have 20 platform-related and 21 non-platform related coins in our sample, which is well less than the suggested threshold value. The small size of the sample is one of the limitations of our analysis.

Author's voice:
How did the paper evolve and change as you worked on it?

FIGURE 2
Weekly Volatility Over Currency Age



presented in Table 6. The first two columns show that there is statistically significant negative relationship indeed between token (as opposed to coin) and the currency's closing value. All else equal, for non–platform-related currencies, the closing value of tokens is 0.703 USD lower (on average) than that of coins. The coefficient is statistically different from zero. For platform-related currencies, the closing value of tokens is 20.36 USD lower (on average) than that of coins, or 113 percent lower closing value than that of platform-related coins. This suggests that being tied do a third-party blockchain is particularly harmful in terms of currency's closing value for platform-related digital currencies. We use a seemingly unrelated regression (SUR) analysis[21] to test for statistical significance of the difference in these coefficients across the subsamples; the analysis confirms the significant differences across the subsamples.

It can also be seen that the hype score of platform-related digital currencies is positively related to their closing value. This suggests that digital currencies that manage to attract attention from users might indeed be able to activate reinforcing (indirect network) effects dynamics. By contrast, in line with our reasoning, we find no systematic relationship between the hype score and the closing value in the case of non–platform-related digital currencies, where indirect network effects are not present. We also find, as reported in columns (3) and (4), that token (i.e., being based on a third-party technological infrastructure) is positively associated with higher weekly volatility of non-platform digital currencies; but there is no effect for cryptocurrencies linked to a platform business model. This effect can be attributed to the fact that these digital currencies are not only affected by changes in their own value but, to a large extent, they are also influenced by variations in the value of the underlying cryptocurrency linked to the third-party blockchain platform.

Results in the last two columns also indicate that there is a negative relationship between token and the trading volume, and this is much larger in terms of size effect for platform-related digital currencies than for non-platform currencies (as also confirmed by the explicit comparison test *via* the SUR analysis). This finding suggests that tokens, in general, are traded less than coins, and this is particularly the case for platform-related business. One explanation for this result is that there might be higher transaction costs associated with tokens, as advanced by some in the industry (EY, 2017), that make exchanges more costly and thus less frequent. But this, alone, would not explain why we observe a much larger effect for

[21] This approach simultaneously estimates our two regressions (i.e., the regressions for platform and non-platform currencies) and therefore allows us to compute the covariance matrix between the coefficients from the two regressions (which would be zero in the case of separate estimation). We then test for statistically significant differences between the two coefficients. Results are not reported here but are available from authors upon request.

TABLE 5
T-Test Results

	No Platform		Platform		Difference = No Platform−Platform		
	N	**Mean**	***N***	**Mean**	**Mean**	**Standard Error**	***N* (Total)**
Weekly Volatility	26,145	.1171019	31,543	.1116692	0.0054***	0.0009	57,688
Trading Volume	26,044	2,038,830	31,314	8,186,617	−6,147,787.29***	417,373.4257	57,358
Closing Value	26,298	.8244001	31,751	2.150857	−1.3265***	0.0977	58,049

p-values in parentheses.
***p, .01

platform-related currencies. Another possible explanation is that users hold longer their tokens, either as an investment option or as a means of access to the platform network and its services in the case of platform-related currencies, which would explain why we observe a larger effect for these currencies.

Plausible underlying mechanisms. To get a better sense of the mechanisms behind these results, we ran an extended version of the model described earlier, in which we added not only the remaining variables of interest but also their interactions with currency age. This allows us to detect changes in the relationship between performance-related variables and the characteristics of the digital currencies.

Based on the reasoning described earlier, we expect to see significant differences in how our key variables of interest (i.e., *Daily Closing Value*, *Weekly Volatility*, and *Trading Volume*) evolve over time depending on the type of digital currency. In the case of platform-related digital currencies, we assume that to the extent that indirect network effects can take place and reinforce over time as more users adopt the digital currency and more products/services become available on the platform, we should observe lower volatility over time and higher value than non–platform-related digital currencies. In other words, if there are complementarities among the type of business, platform business, and the value of the currency in terms of reinforcing feedback effects in this case, we should expect the value of platform-related currencies to grow over time and be more stable. We also expect that the benefits from network effects should be triggered by factors that lead to strong user adoption, particularly in the early days of the life of a digital currency. For instance, a high value of *HypeScore* (i.e., a high amount of attention on social media platforms) and strong *Underpricing* (i.e., selling the digital currency below its market value at the time of release) should both have a positive effect on early user adoption and therefore boost particularly the value of platform-related digital currencies.

Table 7 shows the results of these tests for *Daily Closing Value* as the dependent variable. Consistent with our previous results, token is negatively related to the daily closing value of digital currencies, and the magnitude of this negative relationship is larger for platform-related currencies (the two coefficients are statistically different as confirmed by SUR-based t-test analysis). In principle, an alternative explanation for these results could be that *Token* and *Daily Closing*

TABLE 6
Regression Results: Main Variables

Dependent Variable	**Closing Value**		**Weekly Volatility**		**Trading Volume**	
Sample	**(1) No Platform**	**(2) Platform**	**(3) No Platform**	**(4) Platform**	**(5) No Platform**	**(6) Platform**
Token	−0.703***	−20.36***	0.0626***	0.0693	−2,576,368.1***	−48,104,573.0***
	(0.005)	(0.000)	(0.000)	(0.373)	(0.000)	(0.000)
HypeScore	−0.226**	2.247***	−0.0147***	−0.00510	957,603.9***	9,825,568.5***
	(0.018)	(0.000)	(0.005)	(0.855)	(0.000)	(0.000)
RiskScore	0.0258	−5.694***	−0.00259	0.0692**	127,203.5	−13,770,434.1***
	(0.799)	(0.000)	(0.640)	(0.015)	(0.659)	(0.000)
Constant	1.183*	33.07***	0.603***	0.526***	−894,590.1	39,572,733.7***
	(0.060)	(0.000)	(0.000)	(0.002)	(0.706)	(0.002)
N	11,671	12,506	11,600	12,416	11,655	12,493
R^2	0.0286	0.511	0.183	0.0208	0.123	0.391

p-values in parentheses.
$^{*}p < .10$
$^{**}p < .05$
$^{***}p < .01$

Value are both driven by systematic differences in other characteristics of the organization behind the digital currency, such as capabilities or resources. For instance, one might argue that less capable organizations create less valuable digital currencies and at the same time lack the capabilities needed to develop their own technological infrastructure. Although we cannot fully rule out this alternative explanation, we took some measures that alleviate this concern. More specifically, we included two variables in our model, *Raised* and *Rating*, that control for some of these potential differences. The variable *Raised* measures the amount of money that a given digital currency has raised during the ICO and allows us to rule out, at least in part, concerns that differences in financial resources of the organization behind the digital currency drive both their decision whether or not to develop their own digital infrastructure and also the value of the digital currency. Similarly, *Rating* is a combined "quality" evaluation of factors such as the team behind the digital currency and the product idea, which helps us alleviate concerns that differences in capabilities are the key driver behind differences in technological infrastructure and closing value.

Similar to the aforementioned figures, the results also show that the value of platform-related digital currencies increases much more with increasing age than the value of non-platform currencies. Again, we attribute this to the presence of the positive, reinforcing indirect network effects, that is, to the presence of complementarities between the value of the currency and the value of the platform business.

TABLE 7
Regression Results: Daily Closing Value

Dependent Variable	**Daily Closing Value**			
Sample	**(1) No Platform**	**(2) Platform**	**(3) No Platform**	**(4) Platform**
Age (days)	–	–	0.00478***	0.0671***
	–	–	(0.000)	(0.001)
Token	−1.950***	−12.40***	−2.823***	−4.547***
	(0.000)	(0.000)	(0.000)	(0.000)
TokenXAgeInDays	–	–	0.00177***	−0.0409***
	–	–	(0.000)	(0.000)
HypeScore	0.310***	0.658***	0.128***	0.755***
	(0.000)	(0.000)	(0.000)	(0.001)
HypeScoreXAgeInDays	–	–	0.00168***	−0.00163
	–	–	(0.000)	(0.476)
RiskScore	−0.00383	−2.919***	0.0473*	−1.443***
	(0.791)	(0.000)	(0.062)	(0.000)
RiskScoreXAgeInDays	–	–	−0.000194	−0.00253
	–	–	(0.319)	(0.315)
Raised	2.10e−08***	1.18e−08*	2.29e−08***	1.50e−08
	(0.000)	(0.057)	(0.000)	(0.141)
RaisedXAgeInDays	–	–	−9.97e−11***	−2.40e−10***
	–	–	(0.000)	(0.007)
Underpricing	−1.059***	17.11***	−0.252***	9.435***
	(0.000)	(0.000)	(0.000)	(0.000)
UnderpricingXAgeInDays	–	–	−0.00594***	0.00203
	–	–	(0.000)	(0.679)
Rating	0.194***	−1.485***	0.397***	−0.815***
	(0.000)	(0.000)	(0.000)	(0.001)
RatingXAgeInDays	–	–	−0.00169***	−0.00113
	–	–	(0.000)	(0.641)
BTCValue	0.0000437	−0.000188	0.0000446	−0.000176
	(0.348)	(0.565)	(0.310)	(0.579)
ETHValue	0.00117**	0.0148***	0.00118**	0.0149***
	(0.029)	(0.000)	(0.019)	(0.000)
Constant	−1.452***	12.57***	−2.086***	−0.795
	(0.000)	(0.006)	(0.000)	(0.866)
N	8,634	9,584	8,634	9,584
R^2	0.587	0.715	0.634	0.730

p-values in parentheses;
$^{*}p < .10$
$^{**}p < .05$
$^{***}p < .01$

Platform-related digital currencies are not merely used for trading purposes but are directly linked to the platform value, which is influenced by the number of users and the amount of products and services available on the platform and exchanged therein. The digital currency, in this case, is both a means to access the platform network and to exchange products therein. To the extent this is the case, as more users join the platform business network over time, and more products/services become available for it, the value of its associated digital currencies grows.

These indirect network effects dynamics typical of platform business models can also help explain the relationship between underpricing and currency value. Different theoretical models of platform businesses prescribe that firms should “subsidize” (i.e., lower the price even below marginal cost) their users initially to grow the network and activate the reinforcing virtuous circle between their users and complementary service providers. In the case of digital currencies, this can be achieved through the initial underpricing of the currency. For platform-related digital currencies, thus, underpricing should be especially beneficial as it encourages initial adoption of the digital currency by users and can thus activate the network effects that can then self-reinforce over time.

In Table 8, we report results of the same model estimation when using *Weekly Volatility* as the dependent variable. The results confirm the pattern that emerged from Figure 2; as the currency age increases, we see a stronger decrease in volatility of platform-related digital currencies than in that of non-platform currencies. Again, we attribute this finding to the stabilizing effect of the platform business that the digital currency is related to. In Table 9, we replicate the same model with *Trading Volume* as the dependent variable. It is important to highlight that *Trading Volume* refers to trading in exchange for other digital or fiat currencies and not to trading in exchange for products or services that might be available through a platform. The results confirm that token is negatively related to trading volume, suggesting that tokens are traded much less than coins, and this effect is much larger for platform-related currencies (again, the SUR analysis confirms the statistical significance of the coefficients’ difference across the subsamples). As we noticed, two plausible explanations can be in place. First, transaction costs associated with trading tokens are higher, and therefore users hold them longer before trading them, in expectation of larger gains in value. Although this might be plausible, it would not explain the striking difference between platform-related and non-platform currencies. In particular, we see that the effect over time disappears for non-platform currencies, whereas it is still present and significantly so (both statistically and economically) for platform-related currencies. We interpret this result as evidence of the second plausible explanation we advanced earlier: users hold longer their tokens in the case of platform-related currencies possibly to be able to use the platform network and services. Although we might not entirely exclude the possibility that part of the users might in fact hold the currency under the expectation that the platform value, and thus the currency value will grow larger over time, we think that this is less a plausible mechanism. For the platform value to grow over time, there must be growth in terms of transaction volume in the platform such that at least a substantive portion of users must be active users of the platform.

DISCUSSION

In the previous sections, we have presented analyses that help us advance our theoretical understanding of the drivers behind digital currency success. More specifically, we were able to shed some light on the drivers behind differences in the value of digital currencies by grouping digital currencies into different categories depending on their business type and technology type. Our analyses suggest that two factors play an important role in determining the success of digital currencies: the extent to which their business model allows them to benefit from indirect network effects and the extent these dynamics create reinforcing feedback (i.e., the degree of complementarity) between the business model and the underlying technological infrastructure.

Network Effects and Value Creation

The value of digital currencies that are not related to a platform business model is mainly driven by *direct* network effects—the more the users adopting the currency, the higher the potential value of the currency. Users often purchase these digital currencies for trading purposes, and the value of the currency is ultimately determined to a large extent by how many other users are interested in buying the currency, in the case of coins, or the collateral currency, in the case of tokens. The value of these digital currencies is therefore not linked directly to the

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What is the social relevance of your research?

TABLE 8
Regression Results: Weekly Volatility

Dependent Variable	**Weekly Volatility**			
Sample	**(1) No Platform**	**(2) Platform**	**(3) No Platform**	**(4) Platform**
Age (days)	–	–	−0.000738***	−0.00101***
	–	–	(0.000)	(0.001)
Token	0.0407***	0.161	−0.0280***	0.0731
	(0.000)	(0.107)	(0.000)	(0.450)
TokenXAgeInDays	–	–	0.000305***	0.000129
	–	–	(0.000)	(0.355)
HypeScore	−0.0123***	−0.0161	−0.0120***	−0.0324
	(0.000)	(0.518)	(0.000)	(0.163)
HypeScoreXAgeInDays	–	–	−0.0000103	0.0000633**
	–	–	(0.383)	(0.038)
RiskScore	0.0130***	0.125***	0.0150***	0.0879***
	(0.000)	(0.000)	(0.000)	(0.001)
RiskScoreXAgeInDays	–	–	−0.0000517***	0.0000319
	–	–	(0.006)	(0.321)
Raised	5.33e−11	−2.72e−09**	−5.48e−10***	−1.42e−09
	(0.747)	(0.013)	(0.000)	(0.191)
RaisedXAgeInDays	–	–	2.45e−12***	2.24e−12*
	–	–	(0.009)	(0.083)
Underpricing	0.0274***	0.224***	0.0149**	0.256***
	(0.007)	(0.000)	(0.023)	(0.000)
UnderpricingXAgeInDays	–	–	0.000149***	0.000187***
	–	–	(0.000)	(0.003)
Rating	0.0213***	0.0118	−0.00225	−0.000846
	(0.000)	(0.662)	(0.379)	(0.974)
RatingXAgeInDays	–	–	0.000177***	−0.0000445
	–	–	(0.000)	(0.165)
BTCclose	0.00000465	−0.00000320	0.00000459	−0.00000320
	(0.250)	(0.356)	(0.275)	(0.355)
ETHclose	−0.000145***	−0.0000854**	−0.000146***	−0.0000904**
	(0.002)	(0.047)	(0.002)	(0.035)
Constant	0.0841**	−0.177	0.149***	0
	(0.017)	(0.337)	(0.000)	(.)
N	8,588	9,518	8,588	9,518
R^2	0.362	0.0484	0.426	0.0855

p-values in parentheses;
$^{*}p < .10$
$^{**}p < .05$
$^{***}p < .01$

value of any business but depends mostly on trading-related factors. As we discovered, the value of these currencies may change drastically over time (i.e., being much more volatile) following changes in the interest of users for these digital currencies; this is particularly the case for tokens, where the value of the currency is influenced largely by the value of the third-party blockchain it is linked to. Firms, therefore, have little means to influence this value and are dependent to large extent on the value dynamics of the collateral value trading markets, which they do not control. Not only the value of these currencies is more volatile but is also significantly lower, over time, than the value that platform-related currencies can achieve. For these currencies, the value is driven to a much larger extent by *indirect* network effects—the value of the digital currency depends on the number of users adopting the currency, which in turn can largely depend on users' interest to trade the currency for products or services available on the associated platform network. In principle, users could trade these digital currencies for other digital currencies, much like in the case non–platform-related digital currencies. However, we find that tokens, in general, are traded less than coins, and this is particularly the case for platform-related business currencies. This finding indicates that users hold more and for longer period platform-related digital currencies and might suggest the existence of strong reinforcing feedback effects indeed for these currencies: users are interested in adopting the currency for trading within

TABLE 9
Regression Results: Trading Volume

Dependent Variable	**Trading Volume**			
Sample	**(1) No Platform**	**(2) Platform**	**(3) No Platform**	**(4) Platform**
Age (days)	–	–	−4,934.5	132,871.5
	–	–	(0.417)	(0.154)
Token	−4,016,693.9***	−32,413,852.1***	−7,139,124.7***	−12,702,084.9***
	(0.004)	(0.000)	(0.000)	(0.007)
TokenXAgeInDays	–	–	807.9	−145,206.6***
	–	–	(0.765)	(0.007)
HypeScore	811,354.3**	2,852,669.2***	447,296.0***	2,921,376.2***
	(0.050)	(0.000)	(0.000)	(0.008)
HypeScoreXAgeInDays	–	–	4,316.1***	−322.0
	–	–	(0.000)	(0.976)
RiskScore	1,301,605.0**	−7,374,340.9***	2,143,509.8***	−5,579,542.5***
	(0.024)	(0.000)	(0.000)	(0.000)
RiskScoreXAgeInDays	–	–	−3,610.1**	9,328.3
	–	–	(0.012)	(0.431)
Raised	0.164***	0.0905***	0.224***	0.115**
	(0.000)	(0.002)	(0.000)	(0.017)
RaisedXAgeInDays	–	–	−0.000276***	−0.000742*
	–	–	(0.000)	(0.076)
Underpricing	336,386.1	43,233,120.6***	3,909,703.7***	30,975,394.8***
	(0.849)	(0.000)	(0.000)	(0.000)
UnderpricingXAgeInDays	–	–	−25,771.9***	−24,566.5
	–	–	(0.000)	(0.287)
Rating	338,047.3	−3,471,324.1***	−1,575.9	−2,663,241.7**
	(0.601)	(0.000)	(0.994)	(0.026)
RatingXAgeInDays	–	–	3,513.4**	5,658.6
	–	–	(0.010)	(0.619)
BTCValue	447.7	1,677.5	425.1	1,693.4
	(0.114)	(0.264)	(0.191)	(0.257)
ETHValue	6,253.4*	28,343.8	6,891.3*	28,450.5
	(0.054)	(0.129)	(0.064)	(0.126)
Constant	−6,523,333.3	25,975,712.3	−11,807,147.7***	−377,446.6
	(0.118)	(0.218)	(0.000)	(0.986)
N	8,625	9,579	8,625	9,579
R^2	0.332	0.522	0.384	0.526

p-values in parentheses;
*$p < .10$
**$p < .05$
***$p < .01$

the platform (to a larger extent than exchanging the currency against other currencies). The more valuable products or services are available on the platform, the less likely users are to exchange the digital currency for another one. In other words, in the case of digital currencies that are related to platform business models, the value of the digital currency is instrumental to the value of the underlying business. One alternative explanation for why we observe lower trading volume for tokens could be attributed to higher transaction costs in the case of tokens, which might constrain their tradability, and not to the characteristics of the underlying business. However, this reasoning would not explain why we observe a strong difference in trading volume between platform-related and non–platform-related tokens. Also, it falls short in explaining why we find a large decrease in volatility for platform-related digital currencies. Our analysis instead might suggest that the reason behind this effect is related to the market dynamics on the platform which the digital currency is related to. To the extent that more users adopt the digital currency and more products and services become available for it, users of the digital currency would have greater incentives to hold their currency either because they want to benefit from its increasing value (ensuing from the growing value of the related platform business) or because they want to use the currency as means to access the platform's network and complementary offerings over time. Firms can further boost digital currencies' network effects if they engage in strategic actions such as underpricing or if they are able to attract significant attention on relevant social media platforms. Both these factors can increase interest and usage of the digital currency early on, and thus trigger the emergence of direct and indirect network effects. Ultimately, network effects drive the value of the digital currency as they increase the opportunities for exchange on the platform that the digital currency is based on. Anecdotal evidence for the importance of these network effects can be found in *Decentraland*, a blockchain-based virtual world where users can buy virtual land and engage in games and other applications using the *MANA* token. The initial strategy of the founders behind *Decentraland* included hosting a number of contests for developers and content creators,[22] which resulted in a strong user network and a cooperation with smartphone producer *HTC*.[23]

Complementarities Between Technology and Business Model

Based on our analyses, we propose that digital currency success does not only depend on the business type (i.e., whether it is platform based or not) but also depend on the extent to which the digital currency is able to exploit potential complementarities between its business type and its underlying technological infrastructure. More specifically, if digital currencies rely on the technological infrastructure provided by third parties instead of developing their own technological infrastructure, they face several limitations. On the one hand, interacting with potential users is only possible through the third-party technology, which poses potential constraints to the volume of transactions and thus the value of the currency. As we pointed out when assessing the pros and cons of using a third-party blockchain platform, although firms can leverage the large user base of the blockchain network, this popularity can also have negative externalities in the form of higher transaction costs and network congestion from the heavy use of the network by the large number of other users and businesses.

On the other hand, this negative effect can also be due to the standardized nature of the technological infrastructure of third-party blockchains that have not been developed specifically for the particular type of business of the firm and might cause a mismatch between business type and underlying technology, and constrain the potential value of the digital currency. Our finding of a stronger negative impact on the currency value for platform-related currencies using third-party blockchains indicates that these technological constraints are more problematic for digital currencies that are related to a platform business model. Instead, we found that platform-related currencies based on their own blockchain infrastructure perform better on different value dimensions.

By setting up and using their own blockchain, firms can design the technological infrastructure to the specific needs of the business, such as to create reinforcing feedback between the functioning of the infrastructure network and the functioning of the related market. In this case, a more integrated, centralized blockchain system with higher "synergistic specificity" (Schilling, 2000) can obtain greater functional utility and value for its users. A case in point is *Filecoin*, a custom-made blockchain where users can buy, sell, and use cloud storage of other users in the network using the native *FIL* coin from *Filecoin*. The blockchain is designed and managed by *Filecoin* to enable greater matching of users' buying–selling storage capacity and needs, and higher speed in the validation and completion of transactions. Also, *Filecoin* retains control and residual decisional power over the transactions in the network, such as to guarantee privacy (some of the user data that are exchanged are not displayed), which contributes to higher trustworthiness in the network and greater incentives for transacting. Control over the technological infrastructure can thus be strategic for keeping control over the rules for participation and transactions in the market. To the extent that firms can shape the technological infrastructure design to shape the market design, they can influence the market functioning to larger extent and boost the indirect network effect dynamics of platform businesses (to greater extent). Instead, when building the platform business on third-party technological infrastructures, steering the market development and boosting business growth might be more problematic because of the lack of control over the user data and the impossibility of shaping the rules of participation and engagement in the blockchain network. Such a decentralized blockchain system with high degree of modularity will be a poor fit to the specific needs of the focal firm for creating and running a platform marketplace business. A case in point of these problems is the cited example of *Helbiz* that decided to move its business from *Ethereum* to its own proprietary blockchain after facing challenges related to transaction costs and limited control over data, which prevented *Helbiz*

[22] https://www.coindesk.com/crypto/decentraland.
[23] https://sludgefeed.com/decentraland-surges-25-percent-on-htc-partnership/.

from exploiting possible reinforcing complementarities among its mobility services and from developing additional lines of businesses for third-party providers.

Ultimately, this suggests that the business model and underlying technology are strongly intertwined. Even though blockchain-related technologies are nowadays made available by various providers, it seems to be more beneficial for distributors of digital currencies to invest into the creation of their own specialized technological underpinnings, especially when the intent of the venture is to create its own platform business and marketplace. In other words, although blockchain technology is to a large extent based on the idea of decentralization, it still requires that specialized blockchain technologies are developed for each specific purpose (i.e., for each specific type of business model). Although technological advances related to blockchain have led to increasing decentralization and made it increasingly simple and potentially more democratic to access money to fund business initiatives, this evolution also has drawbacks. Often, the fact that ICOs provide investors with a liquid asset that is detached from the underlying business is cited as one of their main advantages. However, our analyses suggest that firms might need to centralize part of the decentralized blockchain network as way to retain control over some of the important technological and business dimensions (i.e., user data, rules of transactions, and blockchain validation) to ensure greater alignment between the value of their digital currency and the underlying business. This is particularly critical and valuable in the case of platform businesses.

Practical Implications

The patterns that we identified based on our analyses hold important practical implications as well. We have shown that, for entrepreneurs who want to attract long-term support by investors, it is important to design their business model in a way that allows them to benefit from network effects that unfold over time. Although blockchain technologies bring several advantages such as a reduction in the costs of capital raising, they also come with potential risks for entrepreneurs. More specifically, the creation of a secondary market for investments allows investors to take back their support more easily if they lose their interest in the business. Relying on ICOs and the underlying blockchain technology might therefore backfire and put start-ups at risk in the long run if they do not manage to sustain engagement by investors through their business model.

To fully release the potential benefits of a platform business model, we have argued that it is important to rely on blockchain technology that was developed specifically for the given purpose. At the same time, the development of such technologies generally requires significant investments upfront, which might be problematic for individuals who seek funding support from investors. A potential alternative might be to initially rely on blockchain technology developed by a third party and then develop specific blockchain technology for the given purpose at a later point in time (as in the case of *Helbiz*). In addition, this approach might stimulate continued investors' interest, even after the initial phases, and allow them to benefit from purpose-built blockchain technology when it is needed the most, that is, when the indirect network effects come into play with the growing underlying platform business.

Avenues for Further Research

The research presented in this article has allowed us to gain a better understanding of what might be some of the drivers behind digital currency success. At the same time, it has also highlighted some areas that require further investigations. For instance, it would be interesting to get a better understanding of the role of investors and their expectations. In our analyses, we use currency value as a key measure of interest, but we cannot disentangle the extent to which this value is driven either by the actual quality of the digital currency or by the extent to which the digital currency's characteristics match investors' expectations. A related aspect that merits further research relates to the organizations behind the digital currencies, that is, the start-ups or firms that launch them. Although we do observe several characteristics of the digital currencies, we cannot fully understand how these characteristics come about. More specifically, we need not only a better understanding of what drives a firm's decision to launch, for instance, a token or a coin, but also a better sense of the extent to which they consciously engage in strategic activities such as underpricing.

These questions are important also in the light of the potential implications of our discovery for other contexts that are undergoing the process of digitization with emerging digital markets, including IoT connected smart products (smart home, smart car…), financial services (fintech), healthcare services (meditech), or electric-vehicle–related services. In these sectors, we observe firms increasingly experimenting with a variety of new products, following basically the two approaches examined here—some are building and selling their products through third-party infrastructures, whereas others are trying to build their own infrastructures to promote their own and third-party offerings. It would be valuable to understand to what extent the trade-offs we identified in our context applies also to these settings and what are instead the differences and why. We might expect, for instance, in the context of IoT smart home–connected products, that firms building their own digitally enabled smart products may tend to connect and leverage existing technological infrastructures such as Google Home, Apple Home, or Amazon Alexa. Although this approach offers immediate benefits at low cost to firms from enhanced product connectivity and access to large user base, it might also constrain the potential value of these products in terms of the technical, specific functionalities. Being standardized platforms for any smart home product, there is a limited set of functionalities that these platforms can enable for the specific devise (e.g., alarm product systems can only be activated or disarm according to a given scenario preset by the customer, but other specific functions will need to be managed through their dedicated technological infrastructure). Consider also the case of electric-vehicles' services market. With the electrification of cars and mobility services in general, cars are increasingly becoming digitized and the new platform for services. In this scenario, controlling the data flow on the underlying technological infrastructure might become strategic to enable the creation of a service market and unleash value creation in the system. Understanding these dynamics may offer us also a new lens for understanding market power dynamics in digitized contexts where convergences of multiple and distinct markets makes market boundaries less a clear cut, a fascinating direction for future research.

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