CHAPTER 12

Categories and Functions of Crypto-Tokens

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12.1 Introduction

Tokenomics concerns the emergence, pricing, usage, and implications of digital currencies and crypto-tokens. The phenomenal growth (and decline) of cryptocurrencies and token-based financing, the U.S. Security and Exchange Commission (SEC)'s lawsuits against KIN foundation and Telegram, Libra's debacle at the hearing of House of Representatives, and China's introduction of Digital Currency Electronic Payment (DCEP) system all reflect the lightning speed of industry development. The recent Covid-19 pandemic and the associated quantitative easing policies further spurred the discussion of cashless payments. Yet we are just starting to understand the economics of using tokens. Tokenomics therefore constitutes a fast-growing area of academic research with important implications for the industry and policymakers.

Putting tokenomics in the broad scheme of advancement in FinTech and digital economy, we notice an increasing preference for forming peer-to-peer connections that are instantaneous and open, which is transforming how people work, interact, transact, and consume. Over the past decades, digital platforms and online networks have risen to the challenge and reshaped the

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organization of economic activities. Some of the most valued companies such as Amazon, Facebook, Google, and Tencent are all platform businesses in some sense. Even traditional firms such as General Electric are exploring ways to adopt platform thinking to spur growth and improve performance. Naturally, digital platforms and networks give rise to the "gig/sharing economy" wherein on-demand workers from different physical locations get instantaneous payments instead of long-term employment contracts, consumers demand fast digital payment options both online and offline, and central banks and regulatory bodies vie for control with private enterprises. Successful platforms rely heavily on payment innovations (e.g., Alibaba and eBay) as the lack of trust among anonymous agents constitutes a major obstacle for business exchanges, not to mention the general benefits electronic payments bring to the society overall.

More recently, instead of relying on financial systems that are often arranged around a series of centralized parties like banks and payments, clearing and settlement systems, blockchain-based crypto-applications attempt to resolve the issue by creating the financial architecture for peer-to-peer transactions and interactions, and reorganizing society into a series of relatively decentralized networks. By providing decentralized consensus, blockchains allow peers unknown to and distant from one another to interact, transact, and contract without relying on a single centralized trusted third party. The technology can potentially better prevent a single point of failure and concentration of market power (Cong and He 2019), but still face many challenging issues (Chen et al. 2019).

Even though not always necessary, a majority of blockchain applications entail the use of cryptocurrencies and crypto-tokens. In the past few years, thousands of cryptocurrencies have been introduced and many central banks are actively exploring cryptocurrency and blockchain for retail and payment systems. In addition, blockchain-based crypto-tokens have also emerged as a popular means for financing digital platforms and innovative startups. The total market capitalization of all cryptocurrencies peaked at $828 billion USD in 2017 and is at $240 billion USD at the dawn of 2020, with a total trading volume $8.8 trillion USD in the first quarter of 2020 alone. In what is known as Initial Coin Offerings (ICO), entrepreneurs sell "tokens" or "AppCoins" to dispersed investors around the globe. Despite the first ICO in 2013 raising a meager $500 thousand and the sporadic activities over the next two years, 2016 saw 46 ICOs raising about $100 m and according to CoinSchedule. In 2017, there were 235 Initial Coin Offerings. The year-end totals came in over $3 billion raised in ICO. In August 2017, OmiseGO (OMG) and Qtum passed a US$1 billion market cap, according to coinmarketcap.com, to become the first ERC20 tokens built on the Ethereum network and sold via an ICO to reach the unicorn status.

These trends lead to several general questions: What are these cryptocurrencies and tokens? What roles do tokens serve on platforms and in digital market places? Are they merely hypes and would disappear once investors' fever

recedes? What fundamental values do they carry? What roles does blockchain technology play? Finally, what are the regulatory implications?

We provide a comprehensive categorization of crypto-tokens as observed in practice or being designed. In addition, we describe early studies aiming to answer these questions, including discussions on using tokens including platform finance, user adoption, stable coins, and early liquidity creation, with legal and regulatory implications. We then suggest some future directions of tokenomics research.

12.2 Token Categories

Not all tokens are created equal. Several classifications have been proposed for crypto-tokens. "Security tokens" are mostly entitlements to future cash flows or returns the issuer generates, and are simply digital securities; "Utility tokens" usually carry the right to redeem a product or service on the platform; "work tokens" carry similar meaning, often used as licenses for developers to develop decentralized applications on the platform. However, while a majority of them are simply the required media of exchange and the "utility" comes from being able to interact with other users, no consensus has been reached on the proper classification of tokens. In fact, there is a lack of clarity, if not general confusion, in the media reference to these tokens.

To analyze the economics of using tokens, i.e., tokenomics, one has to first understand what tokens are. Interests in tokens surged with the development of blockchains in the past decade. Technically speaking, coins are cryptocurrencies native to each blockchain, and tokens could be derivative cryptocurrencies developed on top of a primary blockchain. That said, we are not interested in this technical distinction, neither are we restricting attention to blockchain-based tokens. Before we delve into the discussion, we recognize that cryptocurrencies that substitute fiat money have definitely garnered much media attention, and tokens are often backed by a specific startup company (in ICOs), or the technology of a platform (platform tokens), and assets of value can also be traded through tokens (e.g., Gold [HelloGold], oil [OilCoin], natural resource [El Petro]), for example, to lower the transaction costs of the underlying. Moreover, the key innovation of blockchain technology lies precisely in allowing peer-to-peer interactions in digital networks. A large fraction of tokens issued during ICOs in the past two years are indeed media of exchange on various platforms.

Generically speaking, tokens are contracts independent of identity and honored by some subset of participants in an economy. They have been long used on gaming platforms and social network apps. Although regulatory bodies such as the Securities and Exchange Commission (SEC) classifies tokens into security tokens and utility tokens, the actual classification is more nuanced based on how tokens derive value and function economically, which matters for how we should regulate their issuance and trading.

We now introduce the four major categories of tokens: The first category, perhaps also the best known, entails General Payment Tokens, which are what people have in mind when they discuss Bitcoin, Tether, Libra, etc. Here tokens are perceived as substitutes for fiat money or other liquid instruments such as treasury bills, and are used as monies. The valuation of such general payment tokens would be similar to how we value currencies. For example, money supply and velocity would be important determinants. Political considerations would also matter. A subset of general payment tokens also serve as store of value, if people perceive them as the "digital gold" due to the limited supply.

Second, digital platforms frequently "embed" tokens in their ecosystems, as Cong et al. (2018, 2019) point out. Such Platform Tokens are used as local means of payment on platforms that provide certain services or functions and constitute a majority of the ICOs in practice up till now. For example, Filecoin platform provides a marketplace and infrastructure for people with spare storage to meet up with people with the demand for storage. They then complete the transactions using Filecoin tokens. Users' demand for the platform depends on how efficiently the platform maintains data privacy and matching efficiency. The platform token-supply policy and the endogenous demand for using the platforms would jointly determine the token price. That demand also drives token prices because, for any given supply of tokens, the demand would jointly determine the token price. In a sense, General Payment Tokens are an extreme form of Platform Tokens, with the general economy being the platform.

The third category of tokens involves product tokens. It means the holder of a token can redeem from the issuer (or a service provider) a pre-determined quantity of product/service. This is very much like corporate coupons or discount vouchers used by retail stores or airlines. Such product tokens exist but are not very common. Yet they may enable the entrepreneur to figure out potential demand from the market (crowdfunding platforms in general have this function), or to pre-commit to certain price for their products as a way to compete in the market, as we discuss shortly. The pricing of tokens here, with rational agents, should simply be the pricing of the products, given that the exchange rate between the product/service and tokens are pre-set at some ratio. Note that platforms on which the pricing of goods and services in terms of nominal amount of tokens is done centrally by platform owners would exhibit both product token and platform token features because tokens are used as means of payment and at the same time serve as coupons for redeeming services or products at rates pre-specified by the centralized platforms.

Finally, the fourth category of tokens is cash-flow-based tokens. That is what regulators or practitioners typically have in mind when they talk about security tokens. The tokens entitle the holder to certain rights to future cash flows from a business. Such tokens are essentially security contracts and should be properly regulated under security law. The valuation of this type of token is also straightforward: discounting future cash flows to the present time would do the job. Such security tokens can be useful for entrepreneurs because they

can potentially contract on revenues rather than profit (as in equity contracts). There could also be contingencies written in smart contracts that affect token value. Lambert et al. (2020) discuss some examples.

Table 12.1 provides an illustration of how tokens in practice can be classified into the aforementioned four categories. More detailed classification can be found in Cong and Petruzzi (2018), in which the authors manually classify 648 tokens based on information obtained from articles and official websites/whitepapers, following the framework in this section. This information was collected up till May of 2019. Frequently sourced websites for further information included coinmarketcap.com, coincentral.com, and coincheckup.com which provided summaries of tokens' intended purposes, corporate background, and technology.

Table 12.1 Illustration of token classification scheme

Code	*Currency*	*Type of token*	*Information*
BNB	Binance Coin	Product	BNB can be used to pay for fees on the Binance exchange at a discount. Coins are burned to maintain stable price
BTC	Bitcoin	General payment	BTC is the original cryptocurrency. It is entirely peer-to-peer and lacks a central regulator
DOGE	Dogecoin	General payment	An inflationary coin with no cap on the number of coins that originated as a joke based off internet meme "doge"
ETH	Ethereum	Platform	Native token for the Ethereum platform for smart contracts, DApps, and tokens using the ERC20 standard
GAS	Gas	Product	A token distinct from NEO used to pay for operations on the NEO platform
KCS	KuCoin Shares	Security	An ERC20 token for the Kucoin exchange. Holders receive dividends from transaction fees and priority on the exchange
LTC	Litecoin	General payment	Inspired by BTC, LTC allows interblockchain exchange of different tokens through hashed timelock contracts
NEO	NEO	Platform	NEO token is used for governance of the NEO platform that has smart contracts, DApps and tokens using the NEP-5 standard
USDC	USD Coin	General payment	ERC20 stablecoin pegged to USD fully collateralized by USD reserves
XRP	Ripple	General payment	A centralized blockchain technology, XRP is intended for extremely liquid transactions for banks and payment providers

12.3 Economic Roles of Tokens

Besides the reasoning for using tokens that we occasionally read from media articles, early studies on tokenomics reveal several important roles tokens play on digital platforms or within digital ecosystems with native means of payments.

12.3.1 Token Embedding

First, we describe how in decentralized networks, it is natural and typically observed in practice to introduce native currencies and agents actually hold them—a phenomenon Cong et al. (2018) termed "Token Embedding."

In many existing blockchain applications, native coins are the required or favored medium of exchange. For example, it is cheaper to make international payments and settlements using Ripples (RXP) on the Ripple network; to make profit by providing validation services, OmiseGo (OMG) tokens are required as stakes on the OmiseGo blockchain; even though Ethereum platform allows other AppCoins and cryptocurrencies, many transactions and fundraising activities are still carried out using Ethers (ETH) because of the convenience and popularity.

Why do we need crypto-tokens in the ecosystem? Arguably, it is advantageous to adopt a standard unit of account in the ecosystem because it mitigates the risks of asset-liability mismatches if they are denoted in different units of account, which also leads to higher probability of default. Moreover, when agents in the economy meet and transact, it is hard to know all future partners' identities, and using a unit of account that is likely to be compatible with future potential trading partners can be useful.

That said, the standard unit of account does not have to be a native token. So why a native token or currency? It goes back to the question of trust. In the virtual economy, agents are likely from around the globe, and using any fiat money is subject to particular countries' legal and economic influences; moreover, to transact among parties unknown and non-trusting to one another, a crypto-coin relieves the concern of double-spending and misbehaving. Even with a centralized party operating the platform, it takes time to build trust and resources to maintain that transfers and transactions on the platform are reliable.

Other than these technical or convenience reasons for using platform tokens to facilitate trusted transactions, are there novel economic reasons why a platform should use its native tokens? After all, using other cryptocurrencies can also circumvent the trust issues.

The answer lies in incentive provision in a decentralized system. Mediating the exchanges using other cryptocurrencies means the incentives provided to miners, validators, users—contributors to the stability, functionality, and prosperity of the ecosystem—may be heavily influenced by fluctuations in those currencies that are not directly linked to the blockchain protocol or platform

quality. Moreover, native tokens can be directly linked to history of transactions and events on the blockchain, a feature other cryptocurrencies can ill-provide.

One example is Filecoin (FIL) which is used as the sole means of payment in the network marketplace to reward miners for block creation in the Filecoin consensus process. Another example is Basic Attention Token (BAT). As Strategic Coin explains in its BAT token launch research report, BAT functions as a medium exchange between users, advertisers, and publishers who participate in the Brave browser ecosystem. Advertisers purchase ads using BAT tokens, which are then distributed among both publishers and browser users as compensation for hosting the ads and viewing them, respectively. Arguably these platforms can use Bitcoins or Ethers, but then the incentive designs and the currencies are not directly linked, which as we discuss next does not allow the ecosystem to grow as quickly as in the case with native tokens.

12.3.2 Network Effects

User-base externality is an integral feature in decentralized systems, P2P systems, and many digital platforms. One obvious manifestation of the user-base externality is the network effect of participation. The utility of using cryptocurrencies also goes up when more people use them. Examples also include social networks and payment networks such as Facebook, Twitter, WeChat, PayPal, and OmiseGO.

Another form of user-base externality is in the initial launching of projects/platforms. Achieving a critical mass is crucial in platform business. Unikrn with UnikoinGold is the decentralized token for betting on e-sports and gambling, and Augur, a decentralized prediction market, both required a critical user base to take off.

While network externality is a static form of user-base externality, inter-temporal forms are also commonplace. The fact that a larger user base today helps improve the technology tomorrow, and a larger anticipated user base tomorrow encourages greater investments today are examples of how user base externality can play an inter-temporal role.

Filecoin the data storage network, Dfinity the decentralized cloud computation, marketplace such as overstock (and its ICO), and infrastructure projects such as Ethereum also exhibit user-base externality. Network effects are important for token valuation because, in a sense, token values capture the worth of the ecosystem, just like how currency strength reflects a country's dominance.

Among the earliest studies touching on the network effects, Cong et al. (2018) directly model network effects in platform adoption and token pricing, Li and Mann (2020) study how ICOs break up the investment games into sequential games and therefore coordinate the investors. Pagnotta and Buraschi (2018) characterize the demand for Bitcoins and the supply of hashrate to price Bitcoin, while allowing network effect among users. Sockin

and Xiong (2019) similarly consider both miners and users in a model of cryptocurrencies with platform fragility induced by the users' network effect.

While intuitively, users' network effects should be positive, once we consider the other side of the coin—consensus generation on blockchains—there could be negative network effects. For example, more transactions and users would imply they would not all be quickly recorded into Bitcoin blocks. The delays in finality may hinder adoption, as Hinzen et al. (2019) explore.

12.3.3 Adoption and User Base

Cong et al. (2018) show that tokens can accelerate the user adoption for promising platforms and reduce user base fluctuations, especially during the early stage of a platform's life cycle when users are endogenously adopting the platform. They enable early adopters to capitalize and benefit from the future prosperity of the platform. If a platform is improving over time, then future demand for it is high. That means future demand for its token is high, which drives up token price. Early adopters who hold tokens have an investment motive in addition to the usage value they derive, because they benefit from the token appreciation. This formalizes what practitioners typically coin "bootstrapping the community." Similarly, tokens precipitate demise for bad platforms.

Cong et al. (2018) also show a second role of tokens in stabilizing the user base. These roles of tokens are discussed for the first time and distinguish tokens from other securities people typically use. Whenever there is a negative technology shock to the platform, less people would adopt, implying that the room for increase in adoption in future goes up. The potential token appreciation from greater adoption in the future increases the investment motive of holding tokens token, buffering the reduction in token adoption due to the negative technology shock.

12.3.4 ICOs and Platform Finance

Over the past few years, issuing tokens has been a popular way of raising funds for startup projects. Initial coin offerings (ICOs), the sales of cryptocurrency tokens to the general public, to crowdfund in the technology and blockchain industries, have become a heatedly debated topic. On the one hand, ICOs seem to be fraught with frauds and regulatory arbitrage. On the other hand, the mechanisms involved also appear to be distinct from existing fundraising channels.

ICOs appeared in 2014 but before 2017 were very sporadic (Adhami et al. 2018). Momtaz (2020) finds that the volume of funds raised in ICOs represented $6 billion in 2017, which is only one fifth of the amount raised in Initial Public Offerings (IPOs) that year. Bourveau et al. (2018) identify 750 ICOs between April 2014 and May 2018 that collectively raised $13 billion by startups in 50 countries. Among recent studies, Howell et al. (2020)

reveal that the liquidity of ICO tokens depends on certification (VC backing), entrepreneurial experience and background, disclosure (white paper/Github code/budget plan), and incentive compatibility in terms of vesting, etc. Whether ICOs reach all-or-nothing funding targets also plays an important role (Cong and Xiao 2018), which is corroborated by Lee et al. (2018).

Lyandres et al. (2019) construct a comprehensive dataset of ICOs to study the determinants of ICO success, post-ICO returns, volatility and liquidity, and evolution of ICO-based ventures' social media activity and productivity. The authors empirically demonstrate that ICOs experience underpricing and post-ICO returns consistent with theories explaining the IPO market. Other studies such as Momtaz (2020) and Benedetti and Kostovetsky (2018) similarly document ICO underpricing.

Another common theme that emerges is that ICO success depends on code availability and the extent of disclosure and description (e.g., Adhami et al. 2018; Fisch 2018; Amsden and Schweizer 2018; Deng et al. 2018).

Among theoretical studies that analyze how platforms use tokens to finance platform development, Cong et al. (2019) stands out because the authors go beyond ICOs and examine the dynamic issuance and allocation of tokens. In such a dynamic model of platform economy, tokens are issued and used as means of payment among users, contributors, and founding entrepreneurs. Dispersed record-keepers, open-source developers, crowdfunders, etc., provide on-demand contributions to the platform in exchange for token compensation. In this regard, the use of tokens by digital platforms can be related to corporate finance, because the platforms have to manage the dynamic growth and investment of the ecosystem, as well as issuing tokens to gather financing and contributions from players within the ecosystem.

In Cong et al. (2019), entrepreneurs maximize their surplus by managing token-supply dynamics, subject to the conditions that users break even intertemporally and the markets for on-demand contributions are competitive. The authors characterize the dynamic token allocation strategy and its implications on user base dynamics, endogenous platform growth, the level and volatility of token price and their dependence on broader liquidity conditions. A key mechanism is the divergence between insiders' (entrepreneurs') token valuation and that of outsiders (users and contributors)—when the valuation wedge falls, the platform maximizes its growth by issuing more tokens to contributors; when it rises to an endogenously determined threshold, entrepreneurs optimally burn tokens out of circulation to stabilize token value.

Mayer (2019) and Gryglewicz, Mayer, and Morellec (2019) build on neo-classical dynamic valuation framework in Cong et al. (2018, 2019) to introduce speculators, agency issues, and cash-flow-based tokens. In particular, Mayer (2019) demonstrates that speculators and users both contribute to platform success and their investments are substitutes in some circumstances and complement in others. Gryglewicz, Mayer, and Morellec (2019) show

that token financing is generally preferred to equity financing, unless the platform expects strong cash flows or faces severe financing needs and large agency conflicts. Moreover, financing with both equity and tokens are not optimal.

Finally, several models explore product tokens or security tokens. Chod and Lyandres (2019), Malinova and Park (2018), and Catalini and Gans (2018) offer the earliest discussions. Gan et al. (2020) make suggestions on how to design "asset-backed" ICOs—including optimal token floating and pricing for both utility and equity tokens (aka, Security Token Offerings, STOs). Lambert et al. (2020) provide a systematic discourse of STOs. Other variants of ICOs, such as Initial Exchange Offerings (IEOs) and Initial Decentralized Exchange Offerings (IDOs) are still being developed and constitute interesting future research discussions.

12.3.5 Alignment of Investment and Consumption, and Crowd-Based Mechanisms

Another important observation in Cong et al. (2018) is that investors have both usage motive (using tokens as means of payment on a platform to conduct business activities) and investment motive (enjoying token price appreciation in anticipation of a platform's future prosperity). Such an alignment is absent in conventional settings and has very much to do with the crowd-based nature of token usage.

This point is fully highlighted in Lee and Parlour (2019): the fact that in crowdfunding financiers and consumers can overlap implies that the typical holdup problem between financiers and entrepreneurs can be mitigated. The liquid token market enables resale for the consumers' claims and helps fund long-term projects when consumers have short horizons. Goldstein et al. (2019) find similar impacts of alignments of financiers and consumers. What other forms of alignment exist and how tokens interact with them are just starting to be explored.

In addition to aligning consumers and financiers, crowd-based mechanisms can help with information aggregation. Catalini and Gans (2018) extend the demand aggregation function of crowdfunding to tokens. Bakos and Halaburda (2019) study how token tradability and broader crowdsourcing of due diligence affect the decision to use an ICO and demand discovery. Token tradability leverages that information and increases the amount that can be financed, thus enabling new ventures with higher development costs. Tsoukalas and Falk (2020) examine how blockchain-based platforms rely on token-weighted voting to efficiently crowdsource information from their users for a wide range of applications, including content curation and on-chain governance, harnessing the "wisdom" and "effort" of the crowd.

12.3.6 Commitments to Contracts and Token Policy

There are quite a number of papers discussing agency issues in ICOs or comparing ICOs to VC financing (e.g., Chod and Lyandres 2019; Malinova and Park 2018; Garratt and van Oordt 2019). They almost all explore tokens whose value is tied to the firm's revenue rather than profit, which either creates additional agency conflict or help to mitigate existing ones. Most of them treat the tokens as product tokens or security tokens that are cash-flow based. Even though currently most of the ICOs are either cryptocurrencies or platform currencies, the practice could change with the emergence of STOs.

More importantly, the ability to commit to sharing revenues reflects a distinguishing feature of the blockchain-based tokens: algorithmic commitment. Cong et al. (2019) discuss blockchain commitment at length. Smart contracting and the decentralized nature of many blockchain systems do enable commitment and automated enforcement of certain contracts. However, the commitment brought forth by blockchains is not panacea. The commitment space is limited and smart contracting can only incorporate limited contingencies as of now, not to mention that one needs oracles and the Internet of Things (IoTs) to feed signals onto blockchains. The venture, Quantstamp, is an example, which recently became embroiled in controversy when it did not adhere to a medium of exchange commitment for its platform for smart contracts and was accused of accepting other cryptocurrencies and US dollars for its services.

12.3.7 Valuation, Volatility, and Stablecoins

Creating coins or tokens that are stable in value has been the holy grail in the cryptocurrency industry, because only then cryptocurrencies can be used reliably as a store of value and unit of account. Tether, Libra, etc., use a collateralization mechanism, backing up the token value with other (basket of) assets. By using the tranche of other assets that is the least sensitive to information, the corresponding token price becomes stable. Tether claims to maintain 100% USD reserve as collateral to guarantee 1:1 exchange rate peg to USD. The Tether model necessarily entails the issuers to hold fiat money, which needs third party, like an auditing firm, to verify the reserve or depends on issuers' credibility. DAI similarly uses over-collateralization. By controlling the issuance of token bonds (another floating-rate cryptocurrency), Basis can moderate the price fluctuations of BaseCoins. These are not new discoveries by (financial) engineers, but mechanisms central bankers have contemplated for a long time. They are not perfect solutions, as central bankers have recognized earlier. Collateralization and tranching rely on reserving other assets and are subject to manipulation as was pointed out in Griffin and Shams (2020); open market operations still rely on the trust of a centralized party carrying out the operations.

These are in contrast with the mechanism in Cong et al. (2019), which shows that platform owners' endogenous token-supply policy moderates fluctuations in token price, making the token more stable. The authors highlight the role of the blockchain technology in enabling commitment to counter cyclical token-supply policies, and thus present a mechanism for stabilizing token values traditional centralized systems would not provide. The problem of creating a stablecoin is similar to the issue of maintaining an exchange rate peg. One potential advantage of stablecoin based on blockchains over fiat money is exactly that smart contracting potentially enables greater commitment to the dynamic token-supply policy. The policies written ex-ante with computer codes can help enforce the transfer of digital assets as well, once certain contingencies are met. Cong et al. (2019) and Routledge and Zetlin-Jones (2020) explore such blockchain-enabled commitment in creating stablecoins.

More fundamentally, one needs to understand the source of value of crypto-tokens in order to better understand token price volatility. To this end, Cong et al. (2018) provide the first dynamic pricing model of assets incorporating platform fundamentals, network externality, sources of price volatility, and user heterogeneity. The authors show that the value of tokens comes from the platform/network technology that they are associated with. For example, for a decentralized cloud computation blockchain on which users buy and sell spare computation power using the native tokens, token values come from users' demand for the platform. The authors highlight fundamental technological shocks for the platform and endogenous user adoption as sources of token return volatility. Therefore, they are not suitable as general payment money, but are instead a hybrid of money and investment asset without dividends (so returns come from capital gain and convenience flow), at least during the initial adoption stage.

Biais et al. (2019) also emphasize the fundamental value of Bitcoin from transactional benefits, and study the interaction among investors, miners, and hackers. Canidio (2018) touches on token price, but focus more on seignorage and agency issues in platform governance and ICOs. Pagnotta and Buraschi (2018), Canidio (2018), and Sockin and Xiong (2019) all identify multiplicities in token pricing, which could contribute to token price volatility. Saleh (2019) examines token price volatility and welfare in the context of proof-of-burn-based tokens, with an emphasis on the impacts of token-supply changes. Catalini and Gans (2018) examine the pricing of product tokens. Finally, cash-flow-based tokens can be valued using discounted cash-flow methods. And volatility in prices comes from fluctuations in the expected cash flows and discount rates.

12.3.8 Markets for Tokens and Regulatory Issues

A discussion of tokens would not be complete without discussing the markets for tokens, especially secondary markets that provide liquidity and discover

prices for tokens. Most of the earlier empirical studies focus on Bitcoin. For example, Makarov and Schoar (2020) state that the use of stablecoins like Tether instead of the corresponding fiat like USD can diminish the impact of capital controls. Market segmentation is also discussed by Shams (2020), who finds that the userbase is inherently tied to the investor base, resulting in amplification of demand shocks.

Liu and Tsyvinski (2018) and Liu et al. (2019) document basic risk and return patterns in the cryptocurrency markets. Lyandres et al. (2019) find that tokens behave like traditional securities. This is supported by evidence from Liu et al. (2019) who note that many of the known attributes of the equity market form successful long-short trading strategies for cryptocurrencies. However, the authors also find that Fama-French and Carhart four-factor models do not predict returns. In the same vein, Liu and Tsyvinski (2018) find the risk-return tradeoff of cryptocurrencies to be distinct from traditional assets, noting that returns are predicted mainly by investor attention and momentum. All of Liu and Tsyvinski (2018), Liu et al. (2019), and Shams (2020) confirm model predictions in Cong et al. (2018).

Several regulatory issues related to the issuance and trading of cryptocurrencies also warrant our attention. Our discussions on token categories and pre- versus post-launching the platform have direct implications on ICOs and Howey tests of token issuance (e.g., Cong et al. 2019). Mark Carney, the chairperson of the Financial Stability Board and the head of the Bank of England, warned that illegal manipulations such as wash trading, pump and dumps, and spoofing by bots are rampant in the secondary markets of crypto (Rodgers 2019).

In particular, unlike traditional markets, crypto exchanges, are largely unregulated. China banned all the crypto exchanges in 2017 and Japan issued licenses to 16 exchanges till now, but only less than 10 coins are allowed to be traded on these licensed exchanges. The United States has been exploring the optimal way to regulate cryptocurrency exchanges, with New York State's Bitlicensing leading the way. Singapore and Switzerland follow a strategy of incorporating cryptocurrency-related business into existing regulatory frameworks. However, for most of the countries, these token exchanges are still unregulated. Coinmarketcap lists over 300 token exchanges, about only around half have meaningful trading volume.

The centralized yet unregulated nature of crypto exchanges portends a high risk of manipulation. For example, Gandal et al. (2018) use transaction data leak from Mr. Gox to identify suspicious trading that impact Bitcoin price. Studies such as Cong et al. (2020) discuss how exchanges fake and inflate trading volume. Using universal statistical and behavioral principles, Cong et al. (2020) estimate that unregulated exchanges on average fake over 70% of the trading volume in late 2019, which amounts to over 1 trillion USD per month.

Speaking of market manipulations more generally, Foley et al. (2019) use transactions on Bitcoin blockchain and show that a significant amount of the

Bitcoin transactions are related to illegal transaction. Griffin and Shams (2020) investigate the trading activity of stablecoin Tether that is pegged to US dollar. The authors identify manipulative behaviors associated with the trading of Tether and Bitcoin. Li et al. (2019) analyze pump-and-dump trading in cryptocurrency markets.

Rather than comparing cryptocurrencies to the equity market, future studies may identify interesting patterns relating cryptocurrencies to currencies and commodities, given that general payment and platform tokens are essentially hybrid of money and investible assets. Regulatory issues arising from unique features of the cryptocurrency markets also warrant further examinations.

12.4 Looking Ahead and Future Research Directions

To conclude, we summarize the key takeaways from this introductory discussion of research about cryptocurrencies and tokens. We have categorized the major types of crypto-tokens and highlighted their distinguishing features. We next outline a few promising research directions on cryptocurrencies and the functions of digital tokens.

- Digital currencies are actively explored by central banks. A unified framework for analyzing digital currencies and electronic payments is yet to emerge. Obviously, exchange rate stability is important for digital currencies, as we mentioned earlier when discussing stablecoins. Beyond that, little is understood about how digital currency and electronic payments interact with fiat money and monetary policy, or about how they compete with one another. The distinction between account-based system and token-based system also likely matters for the implementation of digital currencies. Several recent articles such as Allen et al. (2020) provide the institutional background.
- It is useful to understand how tokens relate to Decentralized Finance (DeFi). In particular, how should people use tokens to manage platform growth, provide incentives in an open system, allocate cash and control rights, coordinate efforts, and mitigate agency issues? Can an autonomous system be designed that resolve the trust issue? What about auditability and data privacy issues in such digital networks? Bünz et al. (2018) and Cong et al. (2019) offer initial frameworks for further studies in this direction.
- While platform competitions have been discussed extensively in recent studies (e.g., Halaburda and Yehezkel 2013; Halaburda et al. 2018), how tokens reshape the competitive landscape and market power has just started to be explored. Although Gandal and Halaburda (2016) discuss cryptocurrency competition without necessarily invoking platforms, Lyandres (2019) offers one of the earliest discussions on the topic involving platform competition.

- It is important to clarify regulatory implications surrounding tokens, especially those related to informational issues and industry classification based on underlying functions and economic mechanisms. Manipulation issues in the cryptocurrency ecosystem continue constituting urgent problems for regulators and practitioners. Cong et al. (2020) explore these topics further.
- The design of community-based digital networks with digital tokens is just starting to be explored. Decentralization is a matter of degree, not a black or white dichotomy. A lot of the research has been devoted to cryptocurrencies on permissionless blockchains, but permissioned blockchain could achieve greater decentralization once we consider the tradeoffs involving scalability and net security. The roles of tokens on permissioned blockchains constitute an underexplored area of research.
- Further empirical studies of crypto assets may go beyond merely documenting stylized facts, which are constantly evolving in any case. We need to understand better whether crypto assets make a distinct asset class and empirically study the unique features. For example, network security in relation to token pricing is something other asset classes do not feature. Tokens' role in the staking economy is and is related to the concept of carry in other asset classes such as commodities or currencies (Cong et al. 2021).
- The token markets could also serve as testing grounds for traditional theories and industries. For example, due to the transparency and simple structure often present in cryptocurrencies at this stage of development of the industry, one may be able to test theories of retention, signaling, shock propagation across networks, etc. (e.g., Lee et al. 2018; Davydiuk et al. 2019; Schwenkler and Zheng 2020). We may also learn from the control/voting right allocation about voting system and crowd-based aggregation (e.g., Tsoukalas and Falk 2020).

This article by no means does justice in covering the fast-emerging literature on cryptocurrencies and digital tokens. Several survey articles including Halaburda et al. (2020) complement our discussion and provide additional sources of reference. Finally, a good platform for exploring the latest research is the Crypto and Blockchain Economics Forum (www.cber-forum.org).

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