

Digital Asset Market Evolution

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The market for digital assets has evolved since its inception in 2009. Its rapid proliferation in 2016–18 was followed by significant downward corrections in 2018–19. The Article evaluates the central stages of the evolution of the market in digital assets and the affected market participants. It presents and compares market data for initial coin offerings, equity offerings, and initial exchange offerings in blockchain and digital-asset startups. The author examines data trends and their underlying causes in the evolution of the market for digital assets. Particular emphasis is placed on the emerging market for Decentralized Finance (DeFi) and its role in the evolution of digital assets. The article examines data to evaluate the feasibility of a DeFi market evolution in the decentralized market infrastructure environment of the early 2020s.

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I. INTRODUCTION

The market in digital assets continues to evolve. The emergence of the Bitcoin protocol in 2009¹ inaugurated and gave rise to the market in digital assets.² Its rapid proliferation in 2016–18 was followed by significant downward corrections, called the “crypto winter” of 2018–19. The continuing creation of digital assets and the funding for the creation of digital assets is subject to ongoing market changes and changes in investor priorities.

Digital assets can be narrowly defined and broadly defined. Narrowly construed, digital assets are instantiated through computer code and depend on so-called consensus computer algorithms to trigger and validate a transaction in a given digital asset. Broadly construed, digital assets can include virtual assets such as video games in the broadest sense, and items sold in video games can be virtual assets. Virtual assets do not necessitate a consensus algorithm that validates the transaction or provides a level of security.

For the purposes of this article, digital assets are defined broadly. Digital assets cover all types of virtual and electronic assets, regardless of how they are otherwise named or categorized by regulatory agencies, including cryptocurrencies, security tokens, utility

1. See Satoshi Nakamoto, *Bitcoin: A Peer-to-Peer Electronic Cash System*, BITCOIN.ORG, 1–8, <https://bitcoin.org/bitcoin.pdf> [<https://perma.cc/72J7-J553>] (explaining how bitcoin worked upon its release in 2009).

2. The market for virtual assets predates the market for digital assets. In the gaming industry, the acquisition of virtual assets for purposes of game advancement was a common occurrence almost since the inception of online gaming. Yet, such virtual gaming assets could not initially be freely traded in a liquid market. By contrast, the digital asset market allowed free consumer access with limited liquidity in digital assets.

tokens, virtual assets, virtual collectibles, stablecoins, altcoins, among others. Digital assets can be distinguished from stock because stocks are not inherently digital and have strong ties to the world of hard assets. Bitcoin is a purely digital asset because it only exists in the virtual world.

Blockchain technology has enabled the emergence of the digital asset market.³ The digital asset market was possible through a form of upgrading the internet era with decentralized technology and cryptocurrencies.⁴ Blockchain technology⁵ allows securities offerings and stock transfers with all the characteristics of a physical stock transfer, yet the blockchain-enabled stock transfer is completely digitalized and virtual. Much of the media attention has centered on the uses of decentralized technology to support the issuance and trading of Bitcoin and other cryptocurrencies.⁶ Blockchain technology offers a number of attractive features to potential issuers of traditional securities who wish to experiment with digital assets. Benefits to issuers, and to those who process trades in the offering after-

3. Marco Iansiti & Karim R. Lakhani, *The Truth About Blockchain*, HARV. BUS. REV. (Jan.–Feb. 2017), <https://hbr.org/2017/01/the-truth-about-blockchain> [<https://perma.cc/B2PH-UT48>].

4. William Mougayar, *The Blockchain is the New Google*, TECHCRUNCH (May 11, 2016, 7:30 PM), <https://techcrunch.com/2016/05/11/the-blockchain-is-the-new-google/> [<https://perma.cc/6UKE-Z9LG>] (excerpting WILLIAM MOUNGAYAR, *THE BUSINESS BLOCKCHAIN: PROMISE, PRACTICE, AND APPLICATION OF THE NEXT INTERNET TECHNOLOGY* 14–15, 17–19 (2016)); Dinis Guarda, *Over 50 Bitcoin and Blockchain Thoughts and Quotes You Need to Read*, TRADERSDNA, <http://www.tradersdna.com/bitcoin-and-blockchain/over-50-bitcoin-and-blockchain-thoughts-and-quotes-you-need-to-read/> [<https://perma.cc/U4DG-NAG4>]; PEGASYS INC., *THE FUTURE OF FINANCIAL SERVICES: A GLOBAL STUDY OF 500 SENIOR BANKING AND INSURANCE EXECUTIVES BY COGNIZANT, MARKETFORCE AND PEGASYS* 6, 28–30 (2016), <https://www.pega.com/sites/pega.com/files/docs/2016/Jan/the-future-of-retail-financial-services-study.pdf> [<https://perma.cc/FL47-2U8H>]; John Naughton, *Is Blockchain the Most Important IT Invention of Our Age?*, GUARDIAN (Jan. 24, 2016, 4:00 PM), <https://www.theguardian.com/commentisfree/2016/jan/24/blockchain-bitcoin-technology-most-important-tech-invention-of-our-age-sir-mark-walport> [<https://perma.cc/Z25T-NX4J>]; Michael Crosby et al., *BlockChain Technology: Beyond Bitcoin*, SUTARDJA CTR. FOR ENTREPRENEURSHIP & TECH. 3 (2015), <http://scet.berkeley.edu/wp-content/uploads/BlockchainPaper.pdf> [<https://perma.cc/4GGU-EQ47>]; Kyle Torpey, *Why the Bitcoin Blockchain Is the Biggest Thing Since the Internet*, NASDAQ: BITCOIN MAG. (Apr. 19, 2016, 9:32 AM), <http://www.nasdaq.com/article/why-the-bitcoin-blockchain-is-the-biggest-thing-since-the-internet-cm608228> [<https://perma.cc/EC77-4ZBW>]; Carrie Kirby, *Andreessen at CoinSummit: Bitcoin Today Is the Internet in 1994*, COINDESK (Apr. 24, 2014, 10:57 AM), <http://www.coindesk.com/marc-andreessen-balaji-srinivasan-discuss-bitcoin/> [<https://perma.cc/LW54-YP57>]; Rich Daly, *Blockchain: Wall Street's Most Game-Changing Technology Advance Since the Internet*, FORBES (July 11, 2016, 6:00 AM), <https://www.forbes.com/sites/richdaly/2016/07/11/blockchain-wall-streets-most-game-changing-technology-advance-since-the-internet/?sh=de7f8104d87e> [<https://perma.cc/B6L4-E4C2>].

5. A blockchain is a shared digital ledger or database that maintains a continuously growing list of transactions among participating parties regarding digital assets—together described as “blocks.” The linear and chronological order of transactions in a chain will be extended with another transaction link that is added to the block once such additional transactions are validated, verified, and completed. The chain of transactions is distributed to a limitless number of participants, called nodes, around the world in a public or private peer-to-peer network. The technology provides significant opportunities and applications in peer-to-peer interactions and transactions in a decentralized network where all participants are equal, and verification and validation of each transaction are provided by all parties in the network through the blockchain technology.

6. See Jen Wiczner, *Uber Co-Founder and E*Trade Alum Launch No-Fee Cryptocurrency Trading*, FORTUNE (July 25, 2018, 7:26 AM), <http://fortune.com/2018/07/25/cryptocurrency-bitcoin-free-trading-voyager/> [<https://perma.cc/3VJ4-ESSL>] (reporting on Voyager offering no-fee trades on cryptocurrency); Nika Goddard, *How Does a Cryptocurrency Exchange Work*, BESTTECHIE (Aug. 17, 2018), <https://www.besttechie.com/how-does-a-cryptocurrency-exchange-work/> [<https://perma.cc/7G7J-GDGS>] (explaining what cryptocurrency is and how to start trading online).

market, include lower issuing, operating, and administrative costs.⁷ In the securities trading context, blockchain could provide indisputable proof of current ownership of “digital securities,” any transaction in those shares, and the resulting changes in ownership of the shares, in a form that is available to multiple securities market participants (e.g., investors, brokers, regulators).

The nascent digital asset market presents an opportunity for the establishment of a new asset class that attracts mainstream investors. The global consensus record of information and transactions that is enabled through blockchain technology enables the much-needed transparency in finance. At the beginning of the 2020s, investors in the digital asset market range from retail to institutional, as well as exchanges, broker dealers, investment banks, custody providers, IT firms, and other players in the ecosystem. Yet, blockchain technology opens global access to finance, including in areas of the world where the banking system is not readily available and the unbanked constitute large parts of the population.⁸

The funding sources for digital asset startups have an impact on the digital asset market. Since 2016–17, the funding sources for digital asset startups and blockchain startups moved from equity funding to initial coin offerings (ICOs), to equity offerings, and initial exchange offerings (IEOs), just to return back to equity funding in the early 2020s. Because equity investments in blockchain startups make it less likely and less necessary for the respective startups to issue digital currencies, at least as a funding source, the market for digital currencies and the total volume of issued digital currencies are likely to recede when the funding market moves from ICOs back to equity funding.

The emerging market for DeFi has the potential to impact the overall digital asset market. Proponents of DeFi often claim that DeFi involves the development of an upgraded monetary system built on public blockchains.⁹ The expected customer base of such an upgraded and distinguishable monetary system could involve the 1.7 billion unbanked individuals plus the crypto communities of the western hemisphere. In the early 2020s, most DeFi applications are built on open-source networks such as Bitcoin and Ethereum, which enable such decentralized applications (Dapps) to disintermediate financial activities via permissionless and censorship-resistant blockchains.¹⁰

7. Several large securities trading and brokerage institutions have already started to experiment with trading over the blockchain. These institutions include BTL energy, Barclays, and a joint project between IBM and Northern Trust. Several other industry groups have been established to date to develop and launch blockchain-based initiatives that are potentially relevant to the securities industry (e.g., R3, EEA, etc.). Each entity has taken a different approach to the issuance of securities over the blockchain; however, none of these trades have been subject to SEC or CFTC regulation. The existing projects also are not subject to an environment in which the prices must be posted real-time to a public (retail) market.

8. See, e.g., Michele Chandler, *Mobile Banking Takes Off in Nigeria*, STAN. GRADUATE SCH. BUS. (Jan. 24, 2012), <https://www.gsb.stanford.edu/insights/mobile-banking-takes-nigeria> [https://perma.cc/V749-JZSV] (detailing how mobile phones in Africa are revolutionizing transaction services); Cade Metz, *Why Bitcoin Will Thrive First in the Developing World*, WIRED (Feb. 2, 2016, 8:00 AM), <https://www.wired.com/2016/02/why-bitcoin-will-thrive-first-in-the-developing-world/> [https://perma.cc/V9TA-ZKCC] (noting that in Nigeria, for example, banking transactions are readily executed over mobile phones because no infrastructure exists for consumer banking). Donations and aid to third world countries can finally be provided without the interference of suboptimal bureaucratic organizations that do not allocate the aid as intended by the donor.

9. Connor Blenkinsop, *Decentralized Finance, Explained*, COINTELEGRAPH (Oct. 7, 2019), <https://cointelegraph.com/explained/decentralized-finance-explained> [https://perma.cc/47HR-PPVL].

10. *Id.*

Normatively, this Article points out that the expected growth rate of the DeFi, according to diverse sets of estimates, is substantial enough to call into question the long-term viability of the decentralized technology infrastructure without core infrastructure improvements. The author provides a case study to illustrate the possible shortcomings of the existing DeFi infrastructure.

II. DIGITAL ASSET MARKET

Throughout history, evolving markets were subject to evolution and de-evolution cycles.¹¹ The nascent market for digital assets is no exception. The emerging market for digital assets follows a similar evolution and de-evolution pattern. Since its inception in 2009, the rapid proliferation of the digital asset market in 2016–18 was followed by significant downward corrections in 2018–19 (called the “crypto winter”).¹²

Digital assets and decentralized cryptocurrencies are different from fiat currencies. Key differences include what their respective values attach to, the supply level, and the respective storage methods. The value of fiat currency, once backed by gold, is tied to the trust citizens have in their country’s economy, government, and central bank. In theory, decentralized cryptocurrencies, such as Bitcoin, are different. They are often designed with a fixed supply to be anti-inflationary. Cryptocurrencies can be stored and transferred without any central entity involvement. They are designed to bypass existing financial intermediaries.

1. Bitcoin vs. Altcoins

The evolution of digital assets¹³ started with Bitcoin, the first digital asset, launched in 2009.¹⁴ Bitcoin’s blockchain consensus mechanism, Proof-of-Work, uses a 256-bit signature secure hash algorithm that was first designed by the NSA to solve computationally investment puzzles that validate transactions and create new blocks.¹⁵

11. See generally José Albuquerque de Sousa et al., *Nascent Markets: Understanding the Success and Failure of New Stock Markets* (Nov. 17, 2016) (unpublished manuscript) (available at https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2870392 [<https://perma.cc/R6YZ-ANF7>]) (studying fifty-nine nascent stock markets since 1975 in their first forty years).

12. See generally Michael J. Casey, *Crypto Winter Is Here and We Only Have Ourselves to Blame*, COINDESK (Dec. 4, 2018, 6:17 AM), <https://www.coindesk.com/the-crypto-winter-is-here-and-we-only-have-ourselves-to-blame> [<https://perma.cc/B2TF-JTF5>] (describing how the crypto bubble has burst).

13. *Crypto Glossary*, COINMARKET CAP, <https://coinmarketcap.com/glossary/> [<https://perma.cc/DM2R-EQ7D>]; Zvezdin Besarabov & Todor Kolev, *Predicting Digital Asset Market Based on Blockchain Activity Data 1* (Oct. 15, 2018) (unpublished manuscript) (available at <https://arxiv.org/abs/1810.06696> [<https://perma.cc/QUK2-ZL2B>]); Luis P. de la Horra et al., *The Drivers of Bitcoin Demand: A Short and Long-Run Analysis*, 62 INT’L REV. FIN. ANALYSIS 21, 24 (2019); Gianluca Elia et al., *Digital Entrepreneurship Ecosystem: How Digital Technologies and Collective Intelligence Are Reshaping the Entrepreneurial Process*, 150 TECH. FORECASTING & SOC. CHANGE 1, 2 (2020) (quoting Klaus Schwab, *The Fourth Industrial Revolution: What it Means, How to Respond*, WORLD ECON. F. (Jan. 14, 2016), <https://www.weforum.org/agenda/2016/01/the-fourth-industrial-revolution-what-it-means-and-how-to-respond/> [<https://perma.cc/P3UM-TPZY>]); Lanouar Charfeddine et al., *Investigating the Dynamic Relationship Between Cryptocurrencies and Conventional Assets: Implications for Financial Investors*, 85 ECON. MODELLING 198, 201 (2020).

14. See Nakamoto, *supra* note 1, at 1–8.

15. *Proof-of-Work*, COINMARKETCAP, <https://coinmarketcap.com/alexandria/glossary/proof-of-work-pow>

Bitcoin's design prevents double spending,¹⁶ a situation where a sum of money is illegitimately spent more than once.¹⁷ Bitcoin had no financial backing or intrinsic value and no centralized issuer or controller¹⁸ and facilitated peer-to-peer transactions.¹⁹ Bitcoin was first traded in 2010.²⁰ The Bitcoin whitepaper published by Satoshi Nakamoto outlined the technical foundations and blockchain technology underlying Bitcoin.²¹ Each Bitcoin represents a transaction that is registered on a public open ledger.²² In order for a new transaction to be added to the block, it must be approved by the miners. The transaction is then linked to a chain comprising all the previous blocks—that is how the blockchain is formed. Any changes to the data on a blockchain are made by consensus among all members of the decentralized network, thereby eliminating the need for an intermediary between the originator and recipient.²³ In its limited supply by design and growing marginal production cost, Bitcoin resembles a commodity.²⁴ Bitcoin has a maximum supply of 21 million units.²⁵ “Bitcoin’s monetary base is pre-programmed to grow at a predictable, decreasing rate that will reach zero in 2140.”²⁶

The success of Bitcoin has inspired the introduction of other digital currencies, called alt-coins.²⁷ A coin is a cryptocurrency that can operate independently; a token is a digital unit that provides to its holder access and use of a larger cryptoeconomic system with no independent store of value but instead holds utility value.²⁸ Altcoins have grown to represent as much as 60% of cryptocurrency market capitalization.²⁹ Between 2014 to mid-2017, approximately seven cryptocurrencies launched per week while roughly the same number of cryptocurrencies were abandoned at the same time.³⁰ As of May 2017, approximately 1,500 cryptocurrencies had been introduced to the market, 600 of which were actively traded at that time.³¹ As of October 2018, the cryptocurrency market

[<https://perma.cc/75K7-FREJ>].

16. *Crypto Basics*, COINMARKETCAP, <https://coinmarketcap.com/intro-to-crypto/what-are-cryptocurrencies/> [<https://perma.cc/UKK3-6QC8>].

17. *Double Spending*, COINMARKETCAP, <https://coinmarketcap.com/alexandria/glossary/double-spending> (last visited Feb. 18, 2021).

18. Besarabov & Kolev, *supra* note 13, at 1.

19. de la Horra et al., *supra* note 13, at 24.

20. Bernard Marr, *A Short History of Bitcoin and Crypto Currency Everyone Should Read*, FORBES (Dec. 6, 2017, 12:28 AM), <https://www.forbes.com/sites/bernardmarr/2017/12/06/a-short-history-of-bitcoin-and-crypto-currency-everyone-should-read/#7e009f593f27> [<https://perma.cc/XYS7-6KNK>].

21. Charfeddine et al., *supra* note 13, at 201.

22. *Id.*

23. Besarabov & Kolev, *supra* note 13, at 1.

24. See de la Horra et al., *supra* note 13, at 24 n.12.

25. Adrian Cheung et al., *Crypto-Currency Bubbles: An Application of the Phillips-Shi-Yu (2013) Methodology on Mt. Gox Bitcoin Prices*, 47 APPLIED ECON. 2348, 2348 (2015).

26. de la Horra et al., *supra* note 13, at 23.

27. Cheung et al., *supra* note 25, at 2349.

28. *Coin*, COINMARKETCAP, <https://coinmarketcap.com/alexandria/glossary/coin> [<https://perma.cc/G6QA-GD7H>]; *Token*, COINMARKETCAP, <https://coinmarketcap.com/alexandria/glossary/token> [<https://perma.cc/3C6W-5UD6>].

29. Charfeddine et al., *supra* note 13, at 201.

30. Abeer ElBahrawy et al., *Evolutionary Dynamics of the Cryptocurrency Market*, ROYAL SOC'Y OPEN SCI. 1, 3–4 (2017), <https://royalsocietypublishing.org/doi/pdf/10.1098/rsos.170623> [<https://perma.cc/T367-DCPL>].

31. *Id.* at 2.

consisted of more than 212 coins and tokens,³² which jumped to over 5,300 cryptocurrencies as of April 2020.³³

The second most important cryptocurrency in terms of market capitalization after Bitcoin is the Ethereum network's token Ether, which launched in 2016.³⁴ As of October 2018, an average daily transaction count for Bitcoin was 200,000 and 500,000 Ethereum.³⁵ Ethereum expanded on Bitcoin's blockchain technology by providing a mechanism to execute program logic in each transaction, thereby enabling a wider variety of use cases.³⁶ Ethereum stores computer codes powered by the computing power going into the network formed by its connected computers, representing Ethereum's currency, Ether, which allows its holders to use the resources provided by the network to run their applications.³⁷

New tokens can either be launched on the Ethereum network, which can encourage wider adoption of the new token, or can essentially be created from scratch on an independent blockchain. An independent blockchain runs its own network with its own technology and protocol and starts from a Genesis Block, also called the zero block, "[t]he first block of data that is processed and validated to form a new blockchain . . ."³⁸ The benefits of building a new chain include its high flexibility in design. The main drawback of creating a new chain is gaining user adoption and associated network effects and economies of scale. A token that runs on Ethereum can be attractive for consumers because they often meet standards such as the ERC-20 token and Ethereum Improvement Proposals. ERC-20 tokens satisfy a common list of rules defining interactions between tokens, including transfer between addresses and data access.³⁹ Ethereum Improvement Proposals "describe standards for the Ethereum platform, including core protocol specifications, client [application programming interfaces], and contract standards."⁴⁰

Since its inception in 2009, with the invention of Bitcoin, until around January 2017, the digital asset market was dominated by one digital currency, namely Bitcoin. This dominance in the market for fungible cryptocurrencies lasted from around 2009 to 2011. On April 15, 2011, the first known alternative coin to Bitcoin, known as "alt-coin," was created. With the introduction of altcoins, Bitcoin's market dominance in fungible cryptocurrencies slowly eroded. In the aftermath, between 2017 and 2019, the alt-coin market proliferated significantly.

32. Charfeddine et al., *supra* note 13, at 199.

33. See *Crypto Glossary*, *supra* note 13 (defining words related to cryptocurrency).

34. Marr, *supra* note 20.

35. Charfeddine et al., *supra* note 13, at 200.

36. Besarabov & Kolev, *supra* note 13, at 1.

37. Charfeddine et al., *supra* note 13, at 201.

38. *Genesis Block*, COINMARKETCAP, <https://coinmarketcap.com/alexandria/glossary/genesis-block> [<https://perma.cc/QWA3-UUSP>].

39. *ERC-20*, COINMARKETCAP, <https://coinmarketcap.com/alexandria/glossary/erc-20> [<https://perma.cc/TE4E-SHWB>].

40. *Ethereum Improvement Proposals (EIP)*, COINMARKETCAP, <https://coinmarketcap.com/alexandria/glossary/ethereum-improvement-proposal-eip> [<https://perma.cc/52M9-5LC7>].

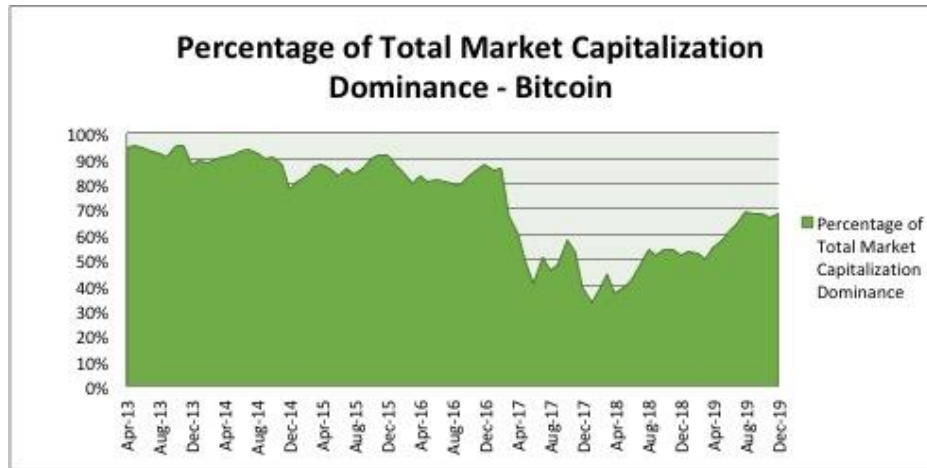


Figure [1]: Source: coinmarketcap.com. Note: 100% dominance assumed until April 15, 2011 (creation of first known altcoin). Linear interpolation from April 15, 2011, to April 28, 2013 (the date of coinmarketcap.com's first Bitcoin data point).

Figure 1 highlights that at the end of 2014, with the instantiation of smart contracting in the Ethereum ecosystem and the ETH currency, the market for digital assets started to diversify and proliferate substantially. As a result, as demonstrated in Figure 1, from 2016 to 2017, Bitcoin's market share dropped dramatically. New alt-coins emerged almost weekly, leading to over 2000 fungible cryptocurrencies in circulation in late 2018.⁴¹

41. *List of Cryptocurrencies*, WIKIPEDIA, https://en.m.wikipedia.org/wiki/List_of_cryptocurrencies [<https://perma.cc/TEU2-C8HR>].

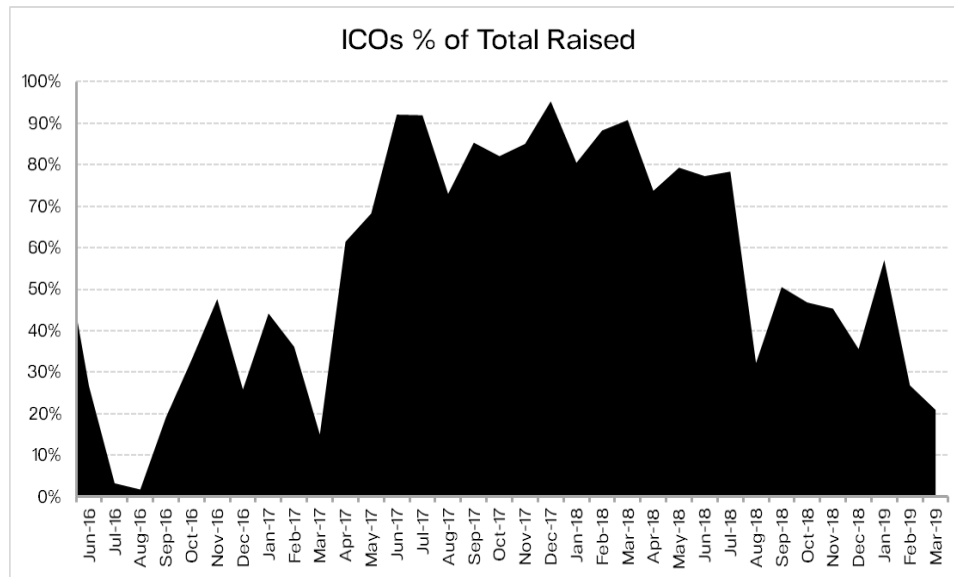


Figure [2]: ICOs % of Total Blockchain Funding. Sources: Coindesk (Jan. 2016–Dec. 2016), <https://www.coindesk.com/ico-tracker/ico-rating.com> [<https://perma.cc/LSK7-HW93>] (Jan. 2017–Mar. 2019), <https://icorating.com/statistics/market/> [<https://perma.cc/J5AG-AXSG>].

The ICO market provides evidence of the increasing maturity of the fungible alt-coin market. Figure 2 shows that the ICO market (% of ICOs of total amount raised by blockchain startups) reached its peak from March 2018 to June 2018. Figure 2 highlights that the percentage of ICOs in relation to total fundraising of blockchain startups dropped from 80% to around 35% in August 2018 and only marginally recovered between September 2018 and February 2019 at around 40% to 50% before dropping to 20% in March 2019. By implication, Figure 2 shows that other funding vehicles, such as venture fundraising, became more important for the blockchain industry in August 2018.

2. Initial Coin Offerings

With the emergence of alt-coins in April 2011 (Figure 1), e.g., coins that provide an alternative investment opportunity other than Bitcoin, public token sales also known as ICOs became possible. The first ICO was conducted by Mastercoin in July 2013.⁴²

ICOs evolved rapidly and receded equally quickly. After Satoshi Nakamoto established the use case for blockchain technology for cryptocurrencies in 2008,⁴³ it was not until 2012 that the first ICO materialized. However, the exponential growth of ICOs since 2015 culminated in ICO fundraising outperforming venture capital financing of crypto start-ups in the second quarter of 2017.⁴⁴ Following its rapid proliferation and

42. *Initial Coin Offering*, WIKIPEDIA, https://en.wikipedia.org/wiki/Initial_coin_offering [<https://perma.cc/7WAF-5WSB>].

43. Nakamoto, *supra* note 1, at 2–8.

44. Alex Sunnarborg, *ICO Investments Pass VC Funding in Blockchain Market First*, COINDESK (June 11,

market exuberance, ICOs receded equally quickly lockstep with the depreciation in the value of Bitcoin in early 2018.

The emergence of ICOs changed the funding landscape for digital asset startups and other startups dramatically and in many ways inaugurated the rise of the digital asset market. ICOs provided unprecedented liquidity and efficiency for capital formation while minimizing transaction costs. While ICOs historically had allowed primarily crypto startups, financial technology start-ups, and the crypto community to raise funds, in 2018, legacy businesses with established services and products increasingly used ICO fundraising to finance their business activities.

A major attractive feature that contributed to the success of ICOs was their apparent ability to avoid regulatory costs associated with fundraising. Issuers of ICOs often assumed that ICOs allowed the issuer to circumvent the usual requirements associated with issuing securities. Such requirements include a full slate of federally mandated securities disclosures, the registration of securities, as well as the application of the 1933 and the 1934 Act with all of their regulatory implications. The issuer of tokens in an ICO in effect disintermediates all of the otherwise required intermediation in issuing securities, which is typically provided by investment bankers, accountants, and lawyers. For the issuer, the disintermediation and the presumed lack of applicable rules meant that, regardless of the stage of the company—many only had a simple ten-page whitepaper listing their idea and the remnants of a team that promised to implement the idea, they were able to approach possible investors directly and sell directly to the market. Of course, for many U.S. issuers of tokens in ICOs this presumption became in retrospect a fallacy that should haunt them in the aftermath of increased SEC enforcement actions of ICOs in late 2019.⁴⁵

ICOs' comparative advantage over other means of capital formation consisted mainly of their cost-effectiveness that helped offset the complex and unpredictable economic dynamics in the crypto marketplace. Unlike other means of capital formation, ICOs allowed promoters to avoid sacrificing equity for financing. Instead, ICO promoters could use the proceeds from an ICO exclusively for product development. ICOs provide low barriers to entry for a diverse body of investors and thus increase the diversity and the heterogeneity of start-up funding. ICOs created unparalleled efficiencies for capital formation. ICOs enabled borderless online sales with far fewer points of friction. ICOs enable the promoters to bypass the typical legal, jurisdictional, and business hurdles by directly marketing to a worldwide pool of investors.

ICOs provided unparalleled liquidity for all of their constituents. Global cryptocurrency exchanges provided significant continuous access to trading ICO tokens which allows for significant liquidity at the earliest possible time in the lifecycle of the underlying business. ICOs provided liquidity to investors much faster than any other form of capital formation. ICOs also allowed venture capital funds to capitalize on existing profits much earlier while avoiding long, complex, and time-intensive processes leading up to an IPO, acquisition, or similar late liquidity event in the lifecycle of the business.⁴⁶

2017, 5:59 AM), <https://www.coindesk.com/ico-investments-pass-vc-funding-in-blockchain-market-first> [<https://perma.cc/QP5C-85RD>].

45. *Cyber Enforcement Actions*, SEC (Feb. 18, 2021), <https://www.sec.gov/spotlight/cybersecurity-enforcement-actions> [<https://perma.cc/Y875-ASV9>].

46. The risks and rewards of tokens differ from those of equity. Unlike token ownership, equity typically conveys a right to dividends. In the case of bankruptcy, equity owners have some residual claims on the assets of

Finally, promoters could obtain the earliest possible liquidity from their token reserves simultaneously with the financing for their product launch.

ICOs had disruptive effects on finance. ICOs provide low barriers to entry for a diverse body of investors and thus increase the diversity and the heterogeneity of start-up funding. Through borderless online sales, ICOs were directly marketed to a worldwide potential pool of investors, bypassing the typical legal, jurisdictional, and business hurdles in traditional venture capital financing.⁴⁷ Moreover, ICOs benefited from limited accreditation standards, as well as from multiple global cryptocurrency exchanges that provide continuous access to trading.⁴⁸

The ICO market had multiple distinguishing features from the venture capital market in 2017. A core distinguishing feature was the ICO market's ability to grant the earliest possible liquidity to investors and issuers alike. Yet, as the ICO market evolved, not only did the market for digital asset investments revert back to the venture investment model, the remaining ICOs that coexist with venture investments in digital assets became also substantively very similar to venture investments. The similarity was most clearly visible when examining the lockup periods required in ICOs between 2018 and 2019. Most ICOs during that period required a one to three-year lockup period for their investors. Accordingly, the ICO market in 2019 is very similar to the venture market in the sense that neither of these markets offer early liquidity to investors and issuers.

The fee structure of ICOs evolved during 2017–19 and created a perhaps even higher cost structure than IPOs. Many ICOs in 2017–18 had a staggered discount structure for private sale investors of up to 50% for the very earliest investors, which tapered off to 30%, 20%, 10%, and so forth for any following investors. A similar, yet less significant, discount window was available for public sale investors once the public ICO had started. Considering these steep discounts to incentivize the earliest possible investments, the cost structure of ICOs is arguably significantly higher than the cost structure of an IPO. In the IPO context, on average, companies incur an underwriter fee equal to 4–7% of gross proceeds, plus an additional \$4.2 million of offering costs directly attributable to the IPO.⁴⁹ While the offering (legal) cost for an ICO is substantially below the IPO offering cost, anecdotal evidence suggests the cost would be at around \$250,000 depending on the jurisdiction and legal team involved. The discounted offering of tokens in ICOs is substantially higher on average than the IPO underwriting fee of 4–7%.

the company. Unlike IPOs, where companies sell stocks via regulated exchange platforms, ICOs sold digital coupons, so-called tokens that did not generally confer ownership rights, to early investors in so-called private sales and later to the public via unregulated or exempt exchange platforms. In an IPO, the user receives a share of ownership in the company. They usually have rights to the profit in the form of dividends, rights to company direction in the form of shareholder voting, etc. Similarly, in an ICO, the user receives a token that allows use of the token's features. Unlike IPOs, successful ICOs do not require the support of a reputable banking institution as underwriters and remove the associated fees for the issuer. Similar to the ownership right itself as in the IPO, a token offers discounts on cryptocurrency before they hit the exchanges once the ICO is launched and, together with the stake in the company, a right to vote on future decisions. Similar to different classes of stock with different rights in an IPO, some ICOs provide for different categories of participations (or levels of membership): voting member, founding member, third party service provider member, and asset gateway member.

47. *Id.*

48. See Sunnarborg, *supra* note 44 (mentioning the limited regulatory framework surrounding ICOs).

49. *Considering an IPO? First, Understand the Costs*, PRICEWATERHOUSECOOPERS, <https://www.pwc.com/us/en/services/deals/library/cost-of-an-ipo.html> [https://perma.cc/V86G-J6ST].

3. Venture Capital

Despite the disruptive effects of ICOs, venture capital funds could also benefit significantly from participation in the ICO market which in turn propelled the market for digital assets forward during the ICO boom years. While the ICO market also was a competitor to venture funding via venture capital funds, the business model of venture capital funds could benefit from the early liquidity provided by cryptocurrencies in ICOs.⁵⁰

ICOs disrupt the traditional business model of venture capital funds, an asset class that has traditionally played a crucial role in financing highly innovative start-ups. ICOs display several core characteristics that make them preferable for many start-ups to the traditional venture capital funding model. ICOs provide unprecedented efficiency for capital formation in start-ups. ICO promoters and their developers are not forced to sacrifice their equity in the project in exchange for the funds they raised.⁵¹ ICOs allow crypto start-ups, financial technology start-ups, and increasingly legacy system innovators, and the Ethereum developer community, among others, to fundraise directly in the crypto community for their activities and projects, bypassing both banking and non-banking entities (i.e., venture capitalists) as well as their services and the associated cost. ICO promoters can use the proceeds from an ICO exclusively for product development. In the second quarter of 2017, ICO issuances exceeded venture capital financing of start-ups for the first time,⁵² with \$210 million invested in ICOs versus \$180 million invested into start-ups via traditional venture capital funds.

Capital formation via ICOs disrupts the traditional hierarchies in venture capital. Traditional venture capital funds typically only allow a smaller group of elite investors to invest in highly innovative projects generally unknown to the investing public.⁵³ By contrast, ICOs provide a much more inclusive option for all investors. ICOs increase the diversity and the heterogeneity of start-up funding.⁵⁴ Because of the low barrier to entry and the borderless nature of the online token sale, ICOs allow small investors from all over the world to invest.⁵⁵ In contrast to traditional venture capital financing, the inclusive elements of ICOs in combination with increased efficiencies, significant simplification, and better timing render ICOs the faster and overall preferable alternative for fundraising by startups.⁵⁶

The disruption of legacy finance by ICOs has triggered attempts by venture capital funds to capitalize on the source of disruption within the existing business model to benefit from its advantages.⁵⁷ Venture capital funds can benefit from the early liquidity provided by cryptocurrencies. In the existing venture capital model, venture capital funds invest

50. See Lionel Laurent, *Want to Be a VC? Just Flip a Bitcoin*, BLOOMBERG OP., <https://www.bloomberg.com/gadfly/articles/2017-04-18/ beating-vc-funds-is-as-easy-as-flipping-a-bitcoin> [https://perma.cc/2XX5-8E7B] (Apr. 18, 2017, 1:25 AM) (explaining how early liquidity of virtual currency can benefit venture capital funds).

51. *Id.*

52. See Sunnarborg, *supra* note 44 (showing the growth of ICO issuances).

53. Dinis Guarda, *Blockchain, Cryptoeconomics, ICOs*, INTELLIGENT HQ, <https://www.intelligenthq.com/blockchain-cryptoeconomicsicos/> (last visited Feb. 22, 2021).

54. This may potentially increase volatility due to panic sales of unexperienced investors.

55. Guarda, *supra* note 53.

56. Sunnarborg, *supra* note 44.

57. Laurent, *supra* note 50.

significant amounts of money in the hope of finding the next unicorn start-up. This investment process is subject to long, complex, and time-intensive processes leading up to a very late liquidity event in the form of an IPO or acquisition. By contrast, ICOs provide liquidity to investors much faster and allow venture capital funds to capitalize on existing profits early.⁵⁸ Venture capital funds who invested in crypto start-ups gain access to much earlier liquidity via ICOs by converting their cryptocurrency profits into Bitcoin or Ether through any of the cryptocurrency exchanges and can thereafter transfer into fiat currencies via online services such as Coinsbank or Coinbase.⁵⁹ Venture capital funds have financial incentives to invest in blockchain startups and cryptocurrencies. Cryptocurrencies created by blockchain start-ups generate investment returns that cannot be matched by legacy investments. For example, several cryptocurrencies such as Ether, Monero and NEM increased in value by 2,000% in 2017-18,⁶⁰ and Litecoin more than 900% in 2017-18.⁶¹

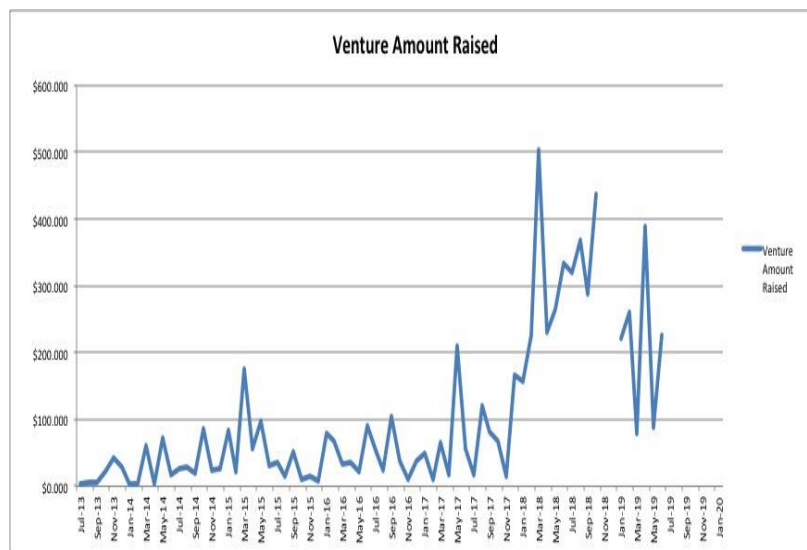


Figure [3]: Evolution from 0 to 900 Bil Mkt Cap in Digital Assets.

Because equity investments in blockchain startups make it less likely and less necessary for the respective startups to issue digital currencies, at least as a funding source, the market for digital currencies and the total volume of issued digital currencies are likely affected by the choice of funding method.

4. Initial Exchange Offers

Initial exchange offers (IEO)⁶² evolved as a response to the near disappearance of the

58. Kastelein, *supra* note **Error! Bookmark not defined.**

59. COINBASE, <https://coinsbank.com/> (last visited Feb. 18, 2021); COINBASE, <https://www.coinbase.com/> (last visited Feb. 18, 2021); Kastelein, *supra* note **Error! Bookmark not defined.**

60. See COINBASE, <https://www.coinbase.com/> (price at July 3, 2017) (for the cryptocurrencies' worth).

61. See COINBASE, <https://www.coinbase.com/> (price at July 3, 2017) (for Litecoin's price).

62. See, e.g., Benjamin Vitáris, *What Is an Initial Exchange Offering (IEO) and How It Differs from ICO?*, CRYPTOPOATATO (June 24, 2020), <https://cryptopotato.com/what-is-an-initial-exchange-offering-ieo-and-how-it-differs-from-ico/> [<https://perma.cc/KY6E-W7C2>] (describing IEOs).

ICO market in January 2019. The cryptocurrency exchanges were most affected by the negative trends in ICOs and sought a remedy. The IEO was born. In an IEO, the cryptocurrency exchange acts as a screening device for token offerings. In an IEO, the issuer no longer interacts with investors directly. Rather the exchange screens the token offering by the issuer and investors buy the tokens through the exchange that listed the token offering.

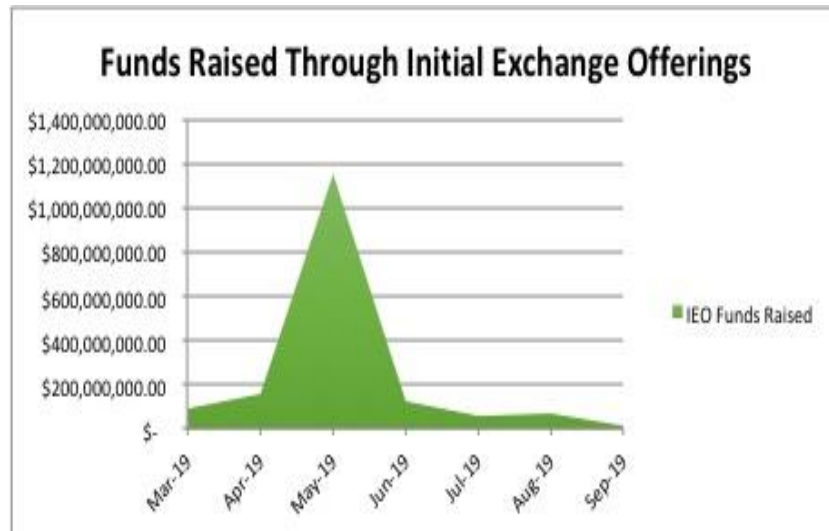


Figure [4]: Demonstrates that IEO fundraising was a temporary phenomenon with primary market acceptance from April to June 2019.

5. DeFi

In the aftermath of the ICO boom and bust, the decentralized finance community continued to expand financial products and services that are based on digital assets. This continuing expansion and these attempts to disrupt existing legacy finance via decentralized finance products gave rise to what became known as Decentralized Finance (DeFi).

The historical evolution of DeFi begins in early 2018. It was then that the teams behind Set Protocol, 0x, Dharma, and DyDx started working together to build an alternative financial system. The teams hoped they would be able to address the fairness, transparency, and equity issues that afflict the existing system.⁶³ As it evolved, the DeFi movement became an open community for decentralized finance platforms to work toward these goals together to achieve open-source interoperability, collaboration, and transparency.⁶⁴ Telegram and Reddit channels were subsequently created, followed by meetups and soon conferences called “DeFi Summits.” In the early 2020s, DeFi’s total value had risen to ~US\$500M.⁶⁵ DeFi applications became more robust and the community started launching second-generation protocols. DeFi became the leading sector of the cryptocurrency market.⁶⁶ Any FinTech project can become part of the DeFi community if it builds a service

63. WTF, *Story of DeFi: How It Started, Where It Stands Now, DeFi Definition Revisited*, MEDIUM (Oct. 23, 2019), <https://medium.com/wtf-dao/story-of-defi-how-it-started-where-it-stands-now-defi-definition-revisited-628fc3bab308> [<https://perma.cc/NGM8-LTDJ>]. The name “DeFi”, short for decentralized finance, has similarities with the ideas of “defy”ing something and is, by itself, a reference to a challenge to the existing financial system. *Id.*

64. *Id.*

65. *Id.*

66. Product Protocol, *The History of DeFi*, MEDIUM (Dec. 11, 2019), <https://medium.com/@product-protocol/the-history-of-defi-f6e11a3c2d6e> [<https://perma.cc/3GAG-8UUC>].

for or is based on blockchain, based on general standards and is compatible with other DeFi projects, and fulfills these principles.⁶⁷

The Ethereum platform enabled the evolution of DeFi. Ethereum enables an open financial system with little to no involvement from financial institutions.⁶⁸ So far, in the early 2020s, Ethereum is the leading DeFi platform for smart contracting and is used by the overwhelming majority of DeFi protocols.⁶⁹ Transactions on the Ethereum blockchain are valid, meaning network participants (“nodes”) verify, validate, and audit transactions before and after they are executed.⁷⁰ Such transactions are immutable, no third party can reverse a transaction,⁷¹ and verifiable through a smart contract.⁷² Ethereum’s network technology can thus eliminate the need for intermediaries in financial transactions and expand transaction possibilities by increasing the scope and efficiency of peer-to-peer transactions through distributed trust and decentralized platforms.⁷³ Less intermediary involvement reduces transaction costs, broadens financial inclusion, empowers open access, encourages permissionless innovation, and creates new business opportunities.⁷⁴

Evolving DeFi platforms keep increasing the financial products and portfolio of services for network participants. For example, DeFi platforms include prediction markets, distributed corporate governance, and trade finance.⁷⁵ Banking services have also employed blockchain technology in order to mitigate credit risk for exporters and importers.⁷⁶ DeFi platforms allow users to convert fiat currency into a stable currency, store stable currency in an interest-bearing account, and use future contracts to hedge against financial uncertainty. DeFi platforms go beyond traditional banking and financial services. Parties in the supply chain can view inventory records and effect payments in real-time and could facilitate a seamless system of lending and repayment using smart contracts.⁷⁷

Despite its impressive gains, the evolution of DeFi platforms depends on higher levels

67. *Id.*

68. *Decentralised Financial Technologies: Report on Financial Stability, Regulatory and Governance Implications*, FIN. STABILITY BD. (June 6, 2019), <https://www.fsb.org/2019/06/decentralised-financial-technologies-report-on-financial-stability-regulatory-and-governance-implications/> [<https://perma.cc/8C9Q-ZNB8>].

69. *See generally* Tom Shaughnessy et al., *Decentralized Finance (DeFi) Thematic Insights*, DELPHI DIGITAL (Mar. 2019), <https://www.delphidigital.io/defi> [<https://perma.cc/PX2M-QTP4>] (providing additional insights on DeFi).

70. Mark Fenwick et al., *Legal Education in the Blockchain Revolution*, 20 VAND. J. ENT. & TECH. L. 351, 366 (2017).

71. Shaughnessy et al., *supra* note 69, at 3.

72. ARVIND NARAYANAN ET AL., *BITCOIN AND CRYPTOCURRENCY TECHNOLOGIES: A COMPREHENSIVE INTRODUCTION* 64 (2016).

73. *See* Lin William Cong & Zhiguo He, *Blockchain Disruption and Smart Contracts*, 32 REV. FIN. STUD. 1754, 1754 (2019) (describing how blockchain technology increases smart contracts’ efficiency).

74. *See* FIN. STABILITY BD., *supra* note 68 (detailing the benefits of minimized intermediary involvement).

75. *See* SATYAJIT BOSE ET AL., *THE FINANCIAL ECOSYSTEM* 304 (2019) (discussing three potential applications to sustainable finance).

76. *Id.* at 305.

77. *See* Peter Lee, *Trade Finance on Blockchain Moves to Full Commercial Production*, EUROMONEY (May 23, 2018), <https://www.euromoney.com/article/b18b63t1m85nd0/trade-finance-on-blockchain-moves-to-full-commercial-production> [<https://perma.cc/PE4M-DVQW>] (reporting on a successful soybean trade using the R3 Corda platform); Rui Wang et al., *Blockchain, Bank Credit and SME Financing*, 53 QUALITY & QUANTITY 1127, 1136–39 (2019) (discussing the development of smart contracts).

of stability in its products and the market for digital assets overall. The evolution of the DeFi market and its new monetary system depends on the stability of DeFi products and digital assets. The stability and adoption of DeFi are undermined by the instability of most cryptocurrencies.⁷⁸

a. Decentralized Exchanges (“DEXs”) & Protocols

A key feature of the DeFi community is its ability to make decentralized protocols available for the benefit of its users. For example, several DeFi protocols enable decentralized peer-to-peer token exchanges (DEXs).⁷⁹ In the early 2020s, DEXs include EtherDelta, IDEX, 0x, Kyber Network, Uniswap, Ren, and the Bancor Network. Protocols can serve as liquidity reserves to other protocols⁸⁰ and parties can even create custom dark pool DEXs.⁸¹

DEXs have several key characteristics. DEXs can facilitate “swaps,” where trades are conducted directly against smart contract token reserves and prices are determined using a conversion formula. Or DEXs can be similar to a traditional, centralized exchange. Trades can either be settled “on-chain,” wherein trades are finalized and ownership transferred directly on the blockchain, or off-chain where trades are finalized and ownership transferred in a third-party system.⁸² DEX order books can be held in a smart contract directly on the blockchain or a third party can operate the exchange’s order books. Finally, liquidity can either be pooled in smart contracts directly on the blockchain or off-chain, where multiple third-parties aggregate order books to pool liquidity. The majority of DEXs are swap, settle on-chain, pool liquidity on-chain, and either do not include order books or have off-chain order books. Some protocols have their own token, used for governance, paying fees, or determining conversion rate for token swaps (some even give users stake, upon which users can gain a yield from transaction fees).⁸³ For example, Uniswap, a protocol that has approximately 25,000 ETH and \$USD 7.1 million in pooled liquidity, does not have its own token.⁸⁴

b. Lending and Borrowing

Lending and borrowing of digital assets is one of the most common services DeFi protocols make available to their users. The loan market in the existing centralized financial system is ripe for disruption by DeFi DApps. The 1.7 billion unbanked in the world have very limited access to the loan market because they typically cannot provide the basic documentation required by centralized banking institutions. This excludes the unbanked entirely from the value creation that would be possible if they had access to loans. DeFi platforms grant the unbanked access to the loan market by disintermediating existing

78. See Yan Chen & Cristiano Bellavitis, *Blockchain Disruption and Decentralized Finance: The Rise of Decentralized Business Models*, 13 J. BUS. VENTURING INSIGHTS 1, 6 (2020) (describing current limits to DeFi).

79. E.g., BANCOR, <https://www.bancor.network/> [<https://perma.cc/CX5N-EH4T>].

80. E.g., Uniswap Protocol (@Uniswap), TWITTER (Feb. 5, 2019, 10:26 AM), <https://twitter.com/UniswapExchange/status/1092821767134035968>.

81. E.g., REN, <https://renproject.io/> (last visited Feb. 19, 2021).

82. Shaughnessy et al., *supra* note 69, at 5.

83. E.g., 0X, <https://0x.org/> (last visited Feb. 19, 2021).

84. Shaughnessy et al., *supra* note 69, at 4.

banks. DeFi DApps connect borrowers and lenders in peer-to-peer networks directly. They allow the unbanked to use digital assets as collateral for loans and require often much less documentation than traditional banking institutions.

Users have a few different options for decentralized lending and borrowing through protocols built on Ethereum. The most popular lending platforms include MakerDAO, Compound, and Dharma. MakerDAO is a lending protocol that allows users to post ETH as collateral to borrow against. Users of MakerDAO can open a collateralized debt position to borrow against on MakerDAO by posting ETH.⁸⁵ MakerDAO accounts for almost 90% of the total USD value locked in DeFi projects.⁸⁶ As a lending platform, Maker remained resilient even as the price of ETH, the asset it lends against, lost much of its value over the course of 2018. MakerDAO's token, Dai, remained stable in early October 2019 by keeping pegged to within 2% of 1 USD while other cryptocurrencies experienced major volatility.⁸⁷

Compound is a platform launched in September 2018 that enables decentralized money markets that have dynamic interest rates that float in real-time as market conditions adjust.⁸⁸ Compound is a smart-contract system that acts as a credit market and accumulates tokens in a liquidity pool through which users can lend or borrow cryptocurrency.⁸⁹ Compound is a money market protocol with floating interest rates based on market conditions.⁹⁰ Users supply assets to the protocol and can either earn interest or borrow from the protocol and pay interest, as long as the user's supply balance remains one and one-half times the user's borrow balance. Users held over \$24,000 worth of assets held as collateral on Compound v1.

Compound released the second generation of their protocol in May 2019⁹¹ that includes granular risk modeling, more asset gateways, and governance improvements.⁹² Projects on Compound v2⁹³ include Zerion,⁹⁴ a portfolio monitoring and management tool for open finance, and Oryn,⁹⁵ a decentralized margin trading platform. Compound stores almost 15% of all Dai, one of MakerDAO's two tokens, and Dai is the most borrowed asset on Compound.⁹⁶

Dharma is a platform for building lending products on Ethereum.⁹⁷ Dharma is a

85. MAKERDAO, <https://makerdao.com/en/> [<https://perma.cc/6HS2-E7JX>].

86. DEFI PULSE, <https://defipulse.com/> (last visited Feb. 16, 2021).

87. *Dai in Numbers: Momentum Report Q3*, MAKERDAO BLOG (Oct. 8, 2019), <https://blog.makerdao.com/dai-in-numbers-momentum-report-q3/>.

88. *We're Compound Labs*, COMPOUND, <https://compound.finance/about> (last visited Feb. 16, 2021).

89. MAKERDAO BLOG, *supra* note 85.

90. COMPOUND, *infra* note 91.

91. See Robert Leshner, *Compound v2 is Live*, COMPOUND (May 23, 2019), <https://medium.com/compound-finance/compound-v2-is-live-157db0b7cfc8> [<https://perma.cc/V7JH-X23A>] (stating that a new version of the protocol has been released).

92. Robert Leshner, *Our Plan to Create Compound v2*, COMPOUND (Mar. 18, 2019), <https://medium.com/compound-finance/compound-v2-fe4b1fb62abb> [<https://perma.cc/64M4-X6JR>].

93. *Id.*; Leshner, *supra* note 91.

94. ZERION, <https://zerion.io/> [<https://perma.cc/J3JM-3N2M>].

95. OPYN, <https://opyn.co/#/> [<https://perma.cc/R99Z-YVYY>].

96. Leshner, *supra* note 91.

97. Sam Scarpino, *Dharma Platform: Your Impact-First Technology Partner*, DHARMA PLATFORM (Jan. 2019), https://dharmaplatform.com/wp-content/uploads/2019/01/Dharma-Platform_Your-Impact-First-Data-Management-Partner-1.pdf [<https://perma.cc/9C2T-WJPL>].

platform for building decentralized lending products and facilitates peer-to-peer crypto lending, directly from each user's personal wallet.⁹⁸ One such product is Dharma Lever, which provides instant margin loans for traders using ETH-based assets. This platform facilitates peer-to-peer crypto lending, directly from each user's personal wallet, by allowing each party of the loan to be discoverable. Borrowers can customize their loan terms including asset type, collateral, and duration. Lenders set a risk profile by specifying their desired loan terms. Borrowers receive principal instantly after they lock up collateral in a smart contract.

The remittance market is similar to the loan market with regards to the potential for disruption by DeFi Dapps. The existing remittances market requires migrant workers who wish to send part of their income across borders to their families in their home countries to pay significant fees. DeFi Dapps often offer the same service for significantly lower fees.

c. Trading

The trading of digital assets is another significant market segment of DeFi Dapps. Several DeFi protocols enable derivatives, margin trading, and prediction markets on Ethereum. Users can trade margins and derivatives,⁹⁹ lend margins,¹⁰⁰ and can be issued short or long ERC-20 tokens representing the payouts of the contract, which can be exchanged or posted for sale.¹⁰¹ Augur operates as a decentralized futures market on Ethereum.¹⁰² Because there is no intermediary, operation costs are reduced, which can maximize the societal benefit-cost ratio of improved forecasts.¹⁰³ The decentralized prediction market allows users to bet on, or create a market for, the outcome of any event, ranging from political elections to sports.¹⁰⁴

III. DIGITAL ASSET MARKET EVOLUTION

Several factors have contributed to the evolution and de-evolution of the market in digital assets. First and foremost, among those factors is the persistent legal uncertainty that afflicts the market for digital assets. Regulators around the world have struggled with a coherent approach to regulating digital assets. For example, in the context of ICOs, only a very small minority of countries have banned ICOs and cryptocurrencies altogether. Regulatory efforts in the context of digital assets have included attempts at regulating cryptocurrencies, regulating DLT, mandating compliance programs, regulating ICOs, regulating exchanges, securities regulation, prohibition of exposed financial institutions, and government guidance discouraging consumer participation.¹⁰⁵

98. DHARMA PLATFORM, <https://dharmaplatform.com/> [<https://perma.cc/QRC9-SEY4>].

99. DYDX, <https://dydx.exchange/> [<https://perma.cc/JHF7-CN9J>].

100. BZX, <https://bxz.network/> [<https://perma.cc/EE3S-SW3N>].

101. DAXIA, <https://www.daxia.us/> [<https://perma.cc/VY6B-9WV7>].

102. AUGUR, <https://www.augur.net/> [<https://perma.cc/3EA5-MXQ7>].

103. Jack Peterson et al., Augur: A Decentralized Oracle and Prediction Market Platform (V2.0) (Feb. 3 2018) (unpublished manuscript) (available at <https://arxiv.org/abs/1501.01042> [<https://perma.cc/SCT4-WN36>]).

104. Shaughnessy et al., *supra* note 69, at 14.

105. Wulf A. Kaal, *Initial Coin Offerings: The Top 25 Jurisdictions and Their Comparative Regulatory Responses (as of May 2018)*, STAN. J. BLOCKCHAIN L. & POL'Y (June 23, 2018), <https://stanford-jblp.pubpub.org/pub/ico-comparative-reg/release/2> [<https://perma.cc/D3C7-PH6B>].

Other factors that influenced the evolution of the market in digital assets included the changes in the market for ICOs. ICOs morphed from mostly unencumbered direct fundraising, albeit not regulatorily supported, to more restricted fundraising efforts. Such restrictions were mostly voluntary by token issuers in anticipation of regulatory scrutiny. For example, in 2018 and 2019 lockup of ICO token investments became the norm. In an effort to curtail the market frenzy of 2017 and 2018, many ICOs required their investors to hold the tokens for one to three years before selling. Moreover, the ICO fee structure, typically offering large discounts, up to 30%, for early investors, was in many ways more expensive for issuers, especially in comparison with the fees charged by investment banks in an initial public offering of stock. Underwriter fees charged by investment banks could range from 4–7% of gross proceeds, plus an additional \$4.2 million of offering costs directly attributable to the IPO.¹⁰⁶

Finally, the market maturity and investor experience continue to play a role in the evolution of the market for digital assets. Immature markets, such as the market for digital assets in 2020, often cannot attract institutional investors and venture capitalists that have sufficient operating experience in that market. Without significant operating experience, investors are less likely to make successful decisions in the market for digital assets, especially in an environment of market turbulence. This, in turn, can limit institutional investor access at scale, which is only partially offset by possible profit margins attainable in such emerging markets.

The market for digital assets is continuously evolving. Yet, despite the significant growth, as illustrated in Figures 3 and 4, the immaturity of the digital asset market in combination with its volatility make the direction of its evolution less certain.

1. Market Volatility

The fundamental value of an asset is the present value of the payoffs taking into account all available relevant information.¹⁰⁷ Bitcoin can be hard to value as it does not have any clearly identifiable cash flows nor is it even clear what its nature is.¹⁰⁸ Bitcoin is a medium of exchange used by a number of businesses, but it arguably fails as a store of value and as a unit of account because of its volatility and lack of intrinsic value.¹⁰⁹ Bitcoin's speculative and affinity value is based on the spin of technological mystery in the mining.¹¹⁰ When Bitcoin derives its value from being a speculative commodity, it can be said to be bound to be characterized by bubbles.¹¹¹

The continual rise in the Bitcoin price accompanied by volatility has led the investment industry and media to claim the Bitcoin market is characterized by bubbles that could “burst any time.”¹¹² Yet, the literature is conflicted regarding whether Bitcoin in fact experiences bubbles.¹¹³ An asset bubble represents an extreme price acceleration that

106. PRICEWATERHOUSECOOPERS, *supra* note 49.

107. Cheung et al., *supra* note 25, at 2350.

108. *Id.*

109. *Id.*

110. *Id.*

111. *Id.* at 2351.

112. Cheung et al., *supra* note 25, at 2348.

113. See, e.g., de la Horra et al., *supra* note 13 (saying no price bubbles are experienced); Cheung et al., *supra* note 25.

cannot be explained by the underlying fundamental economic variables.¹¹⁴ A bubble exists when the price of an asset diverges persistently from fundamentals.¹¹⁵ In order to experience price bubbles, a financial asset needs to possess some kind of fundamental value from which to deviate.¹¹⁶ Bitcoin may have been in a bubble phase in late 2017.¹¹⁷ The collapse of the Mt. Gox exchange, the biggest Bitcoin exchange at the time, provides at least some evidence that there were indeed bubbles in the market.¹¹⁸ However, the Bitcoin market continually recovers.

Price volatility of digital assets is a particular concern among investors. Both Bitcoin and Ethereum have seen large increases in returns, at times exceeding 100% day-to-day.¹¹⁹ Between mid-July 2010 and December 2017, Bitcoin's price increased from \$0.09 to over \$19,000.¹²⁰ Bitcoin's price increased by 122% in 2016 and 1360% in 2017.¹²¹ Between mid-December 2017 and October 1st 2018, Bitcoin's price decreased by 65%¹²² and fell to nearly \$6,500.¹²³ Before Ethereum's first trading day on August 7th, 2015 until October 1st, 2018, its price increased from \$1.33 to \$228.96 USD.¹²⁴ Ethereum's price increased significantly between 2015 and 2018 and decreased between January to October 2018.¹²⁵

The interconnectedness of digital assets exacerbates price volatility. Major events in one cryptocurrency can cause unexpected fluctuations in others.¹²⁶ For example, major events in Ethereum have caused surges in Litecoin and other cryptocurrencies.¹²⁷ Ethereum, Ripple, Litecoin, and Nem surged several thousand percent in price in 2017.¹²⁸

Price explosivity represents an asset with exponential price growth.¹²⁹ Market participants can exploit evidence of co-explosivity in the cryptocurrency market by switching from one digital asset to another.¹³⁰ Bitcoin price explosivity is the least dependent on the price explosivity of other cryptocurrencies.¹³¹

Media can impact price and increase digital asset volatility. Around October 2011, the dependence between Bitcoin and the S&P 500 decreased slightly, parallel to Greece and the tripartite committee formed by the European commission European Central Bank and international monetary fund discussion of the Eurozone debt crisis.¹³² During the March

114. Elie Bouri et al., *Co-explosivity in the Cryptocurrency Market*, 29 FIN. RSCH. LETTERS 178, 178 (2019).

115. de la Horra et al., *supra* note 13, at 24.

116. *Id.*

117. Shaen Corbet et al., *Cryptocurrencies as a Financial Asset: A Systematic Analysis*, 62 INT'L REV. FIN. ANALYSIS 182, 183 (2019).

118. Cheung et al., *supra* note 25.

119. Charfeddine et al., *supra* note 13, at 199.

120. *Id.* at 202.

121. Bouri et al., *supra* note 114, at 178.

122. Charfeddine et al., *supra* note 13, at 202.

123. *Id.* at 199.

124. *Id.*

125. *Id.* at 200 fig.1, 202 tbl.1.

126. Besarabov & Kolev, *supra* note 13, at 2.

127. *Id.*

128. Bouri et al., *supra* note 114, at 178.

129. *Id.* at 179.

130. *Id.* at 182.

131. *Id.* at 181.

132. Charfeddine et al., *supra* note 13, at 209.

2013 Cyprus debt crisis, the dependence between the S&P and Bitcoin rose.¹³³ A steady stream of good news between October 27, 2015, and November 7, 2015 led to a price jump of more than 70% in Bitcoin.¹³⁴ The media reporting of a “widespread hoax” about the founder of Ethereum led to a temporary plummet and loss of \$4 billion from Ethereum’s market capitalization.¹³⁵ Media reporting of cyber-security incidents in digital asset exchanges routinely affects BTC and ETH prices.

2. *Funding Source Volatility*

Figure 5 illustrates the changing nature of funding sources for digital asset startups. Figure 5 shows an overall trend towards ICO funding that was over time eroded and seemed to favor venture capital funding in the blockchain industry. Figure 5 shows that from March 2017 to June 2018, ICOs were the overwhelmingly dominant fundraising tool for the blockchain industry. Yet, Figure 5 also shows that in October 2018 and a few months thereafter, venture investments in the blockchain industry were more than competitive with ICO investments and reversed a prior trend of ICO dominance in blockchain investments.¹³⁶

133. *Id.*

134. Bouri, et al., *supra* note 114, at 180.

135. Besarabov & Kolev, *supra* note 13, at 2.

136. Several examples of blockchain startups that used both token fundraising and equity fundraising illustrate the overall market shift from ICOs to venture investment up until March 2019, as demonstrated in Figure 5. Examples of blockchain startups that have issued both equity and tokens include Ampleforth, Enigma, Filecoin, Omise, Unikrn, Alchemy, and Audius, among several others. These examples demonstrate the market shift from ICOs to venture investment. The shift is a natural evolution of the market for digital assets after the ICO market deteriorated.

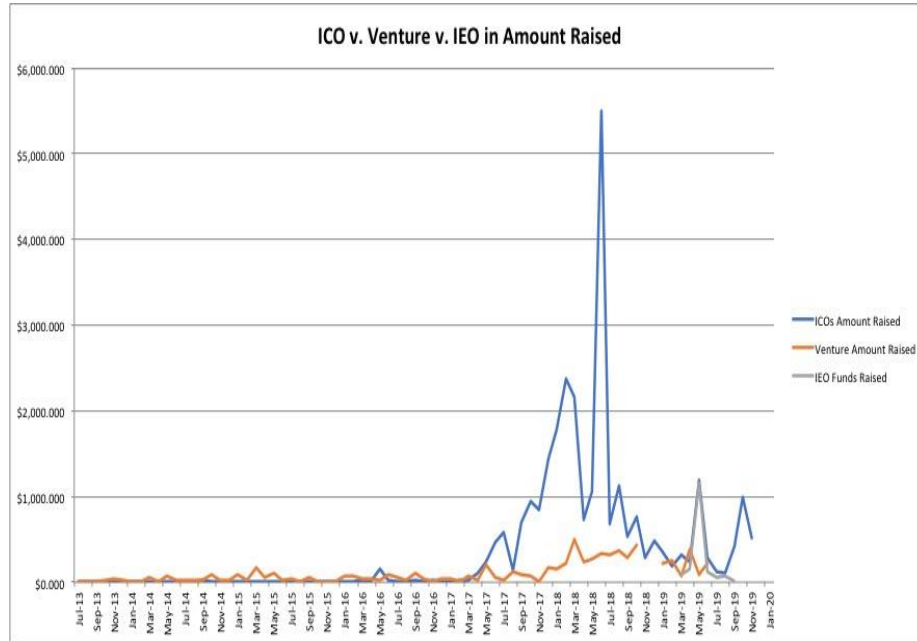


Figure [5]: Combined ICO v. Venture v. IEO in Amount Raised; Sources: Coindesk (Jan. 2016–Dec. 2016), <https://www.coindesk.com/ico-trackericorating.com> [<https://perma.cc/K5A6-ENT4>] (Jan. 2017–Mar. 2019), <https://icorating.com/statistics/market/> [<https://perma.cc/2HDS-8CWG>].

In the aftermath of the shift from ICO funding to venture funding of digital asset startups, initial exchange offers became a new venue for funding for a short time frame, e.g. from March to July 2019, as illustrated by Figure 5. The data examined for Figure 5, while incomplete, suggests that the attractive features of ICOs have the potential to continue to drive some issuers and investors to engage in that market, even though perhaps in less traditional jurisdictions until the main jurisdictions clarify the regulatory framework as it pertains to ICOs.

Several factors help explain the volatile nature and changing funding preferences in the market for digital asset startups. Such factors include but are not limited to the lacking market maturity, challenges for early stage investments, ICO lockups in 2018 and 2019, the high fee structure of ICOs, as well as the ongoing regulatory uncertainty, among several others that are beyond the scope of this Article.

3. Challenges for Early Stage Investors

The market for digital assets creates challenges for early stage investors. Venture capital funds and other early stage investors that wish to participate in the market for digital assets struggle to gain access to industry expertise in digital assets. It is difficult to distinguish core expertise in digital assets. Since its inception, the digital asset industry has evolved in silos of information and expertise, making it more difficult for early stage investors to gain access to a broad spectrum of engineering and technology insights.

Early stage investing in digital assets is a relationships business. It is key for early

stage investors in digital assets to be part of a core network of early stage experts in the industry. After an initial investment in a digital asset startup, novice early stage investors in digital assets can increase their learning curve very quickly and start developing industry expertise and a core network in the industry. The early stage investment helps investors develop skills that help avoid investments in digital asset companies with questionable management teams or fraudulent technology, among other issues to be avoided. Without access to a network of core expertise, early stage investments in the digital asset industry are rarely successful.

Without access to experienced decentralized system architects, legacy investors and venture capitalists struggle to navigate the market for digital assets. During the early days of the digital asset evolution a very limited amount of people had relevant experience with the technical and market aspects of digital assets. Very few were able to build cryptocurrencies that attempted to solve incentive issues and create tokens that were compatible with the incentives' design in order to enable participants in the network to act non-opportunistically and align their utility and economic incentives in systems with anonymous actors. The anonymity in decentralized networks requires a special skillset for system architects who know how to navigate the limitations in system design that is associated with anonymity. Only very few architects have figured out how to create system solutions in ways that overcome the challenges of anonymous and autonomous systems. That skillset is still very rare in the early 2020s.

Legacy investors and venture capitalists often do not have sufficient operating experience in digital assets. In addition to decentralized autonomous and anonymous networks with incentive-compatible design systems, venture capitalists and crypto hedge funds require key expertise in helping their portfolio on the operating side. A key skill that contributes to portfolio companies' success is the ability to hire engineers and run technical teams. The most successful digital asset investors are able to use their network to help their portfolio companies successfully hire technical talent.

Venture companies that do not have a strong background in community building can be disadvantaged in the digital asset market. In the digital asset space generally, and more specifically in the context of ICOs and token design, it is essential to have some expertise in open-source software and the associated community building. Incentive designs for open-source software contributions can also play a large role.

Technical decentralized designs take a long time to reach maturity. Because of the community building aspect and the built-in experimentation with design features, decentralized network design can take much longer than other technical network designs. The cryptocurrency market in the early 2020s is still afflicted with questionable designs, as well as legal and ethical issues. Many top projects in 2020 are still afflicted by technical issues that have not been ironed out. Because the market has been so hype driven, technical experience has not added significantly to overall market development and maturity. Several indicia suggest that this can change over time.

4. Regulatory Uncertainty

In the early 2020s, the digital asset space is still plagued by many issues that undermine its evolution. Such issues range from blatant fraud, unreliable data, poor liquidity, to hacking attacks, among many others. Many digital assets are traded on trading platforms with inadequate infrastructure to support proper asset valuation, trading,

settlement, and custody. The regulatory uncertainty for investors in digital assets is substantial because regulators have not provided sufficient guidance at the beginning of the 2020s. These combined factors undermine the evolution of the digital asset market.

Bitcoin has been controversially accused of being used in illegal business activities, which exacerbates regulatory resistance.¹³⁷ The issue of anonymity, which can contribute to issues such as money laundering and general misappropriation of funds, has deterred major banking corporations from conducting business with crypto traders, undermining the reputation of these new financial products.¹³⁸

Regulatory underdevelopment and the associated regulatory uncertainty have significantly affected the ICO market in 2018 and 2019 and continue to afflict the market for digital assets. Regulators have been evaluating possible risk factors associated with ICOs since the inception of the ICO market. For example, the People's Republic of China has taken a firm stance against ICOs, banning them entirely.¹³⁹ This ban also applies to the offering of coins and the exchanges used to trade coins.¹⁴⁰ The official Chinese stance is that ICOs hurt the market because of potential deception and fraud.¹⁴¹ The PRC recognizes that such problems have been widespread nationally.

In the context of ICOs, regulators have been evaluating possible risk factors associated with ICOs since the inception of the ICO market. Regulators are particularly motivated by several ICO risk factors for retail investors. Unlike shareholders in the traditional corporate infrastructure who are able to vote for or against directors or to nominate directors, ICO investors have no control over the promoters whatsoever. Token holders typically invest in the future promise of an idea or future infrastructure product associated with the platform they invest in without having access to a tangible underlying product. Capped ICO raises evolved in an attempt by the crypto community to address the uncertainty for investors about the valuation of the underlying platform in cases of uncapped raises. However, capped ICO raises create significant incentives for investors to attempt to get in first, raising the likelihood of retail investor frenzy. Moreover, the lack of mandatory disclosures for ICOs leads many promoters to make irregular or no disclosures about the platform as time passes, leading to a significant lack of transparency in the ICO market. Promoters can also alter the smart contract to change ICO sales rules mid-course during an ICO.

Regulatory efforts can take several forms but appear to involve some of the following approaches or permutations thereof: regulating ICOs, regulating cryptocurrencies, regulating DLT, mandating compliance programs, regulating exchanges, securities regulation, the prohibition of exposed financial institutions, and government guidance discouraging consumer participation. In attempts to address these risk factors to protect the investing public, most regulators around the world attempt to use existing laws to regulate cryptocurrencies or wait to see how other countries react to the crypto evolution.

Several initiatives attempt to address the existing regulatory shortcomings in the market for digital assets. Both established industry players such as Fidelity, State Street,

137. Cheung et al., *supra* note 25, at 1.

138. Corbet et al., *supra* note 117, at 187–88.

139. 关于防范代币发行融资风险的公告 [Notice on preventing the financing risk of the issuing of tokens], CHINA BANKING REG. COMM'N (Sept. 4, 2017), <http://www.cbrc.gov.cn/Chinese/home/docView/BE5842392CFF4BD98B0F3DC9C2A4C540.html>.

140. *Id.*

141. *Id.*

ICE (Bakkt), CME, as well as new entrants to the space such as Chicago's ERIS-X, Seed-C, and OFN have sought to mitigate the challenges faced by digital assets. The overall effect, while mostly positive, is still ad-hoc and haphazard, and does not address the broader, deeper problems inherent in the system such as AML/KYC, money transfer, and money-laundering.

In the early 2020s, the regulatory framework for digital assets is severely lacking and outdated. The U.S. Securities and Exchange Commission (SEC) and the U.S. Commodities and Futures Trading Commission (CFTC) govern different parts of the spectrum and have not been clear in defining how existing regulations can be interpreted for use in the digital assets space. The best feedback from them is often determined from cases they have brought against industry participants. Other regulators such as FINCEN and the New York State Department of Financial Services (NYSDFS) BitLicense, are focused on more distinct aspects of the ecosystem.

The regulatory uncertainty in the market for digital assets is curtailing the growth of the industry. Many investor classes—from retail to the largest institutions—are hesitant to participate in the market because of the regulatory uncertainty. In the case of retail investors, the market is too volatile and operationally insecure to justify investments. While larger institutional players face the same issues, they are also limited by their fiduciary responsibility to their clients, which limits the type of risk they can be exposed to. Compounding these challenges is the lack of stable custody solution(s) that are recognized by the regulators.

In the early 2020s, over twenty bills in Congress attempting to address various aspects of crypto/digital assets/blockchain await deliberation before the U.S. Congress. While some are directly related to financial services, they are broad in scope and do not always address the key areas that we might be concerned about as a trading community. These bills cover a variety of subjects including the use of crypto to avoid U.S. sanctions, for human trafficking and terrorist use, how to best use blockchain for analysis and tracking of all sorts of regulatory violations, and lastly, how to manage the new digital assets within the existing legal and regulatory framework.

In the futures and options markets, established exchanges (and some new ones) abide by the existing regulations and are closely surveilled by the CFTC to ensure broad compliance. Unfortunately, this sector is an anomaly. Other sectors that involve ICOs and Crypto Tokens of all kinds (e.g., valid Security Tokens), have gray areas, or in many cases are being squeezed into antiquated legal and regulatory frameworks. Some of the regulations which are being applied are over eighty years old or are not tailored to the needs of innovative, electronic, and digital assets.

5. Cyber Security

Since its inception, cyber-security incidents have afflicted the digital asset community. In 2014, the biggest cryptocurrency exchange, Mt. Gox, went bankrupt¹⁴² when \$400 million of NEM customer deposits were reported to have been stolen from the exchange. In December 2017, hackers stole approximately \$70 million worth of Bitcoin from a digital currency trading platform based in Slovenia.¹⁴³ In January 2018, \$530 million were hacked from CoinCheck.¹⁴⁴ Some indicia suggest that cyber-security incidents contribute to the volatility of the digital asset market as consumers withdraw instantaneously their assets from an exchange that has been affected by a cyber-security incident, among other reasons for this relationship.

6. Crypto Economics

The evolving field of crypto economics has a foundational impact on the design of evolving digital assets. Crypto-economics and token design often require tough decisions that have long-term effects on projects. In the interest of longevity and business impact, token design and crypto economics need to be understood as an iterative process. Design features of a token go hand-in-hand with the underlying technology choices and decentralized infrastructure choices. The combination of design features and underlying technology, in turn, are affected by the macro and micro-economic choices that affect the respective token ecosystem. Ultimately, the crypto-economic design has to allow for data collection and experimentation, which enables optimal design choices as information asymmetries are minimized. Because it is an iterative process, design choices unfold as shortcomings in initial design materialize through network growth. It is important to get the basic design parameters of a token design right in order to be able to build on top and make appropriate choices as the ecosystem evolves. Data collection and flexibility in core design parameters are essential because prior crypto-economic assumptions often materialize as suboptimal in the light of network growth and changing user and consumer preferences. The creation of new network organs and DAOs that fulfill emerging new requirements are often inevitable to adapt to network changes that are generated by network growth, including growth in new and emerging markets.

Experimentation is an integral part of crypto-economics which drives the evolution of digital assets. Emerging decentralized economic incentive designs allow unprecedented economic experimentation. As blockchain-based emerging technologies mature and evolve, incentive designs in decentralized systems provide unparalleled opportunities for experimentation with economic models, stability mechanisms, and policy tools. That experimentation, in turn, enables a heightened community understanding of what systems can be operational and are worth developing further and building on top of. The economic experimentation in crypto-economics and associated decentralized architectures may enable the creation of new tokenized economic ecosystems and entirely new economies. Each of these new economies has a computational infrastructure that is created with the design of a currency and can have unique monetary and fiscal policies and regulations that,

142. Charfeddine et al., *supra* note 13, at 202.

143. Corbet et al., *supra* note 117, at 188.

144. *Id.*

in turn, drive innovation in system design and in digital assets at large.

7. *Coins of Two Realms*

The market in digital assets evolves through the evolution of digital coins of two realms. The two core realms for the coin evolution are the public and the private realm. While attempts to create a public realm of coins would not exist without the evolution of the private realm of coins and the ongoing experimentation in private coins and the associated innovation and growth, it is possible that the public realm of the coin evolution could attempt to impact or even preempt the private coin development and use. For example, some central banks may attempt to censor the use of non-centrally issued digital currencies.¹⁴⁵

a. Private Realm

In the private realm, coins are developed through private and not public initiatives. Since the invention of the Bitcoin protocol in 2009, the development of the cryptocurrency market is largely driven by private initiatives and experimentation with coin design and crypto economics. Token models and their design and incentive optimization within their design are constantly evolving and enable experimentation and innovation for cryptocurrency designs and decentralized infrastructure products.

Privately designed and issued cryptocurrencies enable the essential experimentation with design features and architecture. Because the economic experimentation inherent in crypto economics continuously generates new token models and incentive designs for tokens in an effort to determine which systems, architecture, and designs can survive, experimentation and innovation is built into the evolution of decentralized systems and digital assets.

In the evolution of digital assets and cryptocurrencies, cutting-edge innovation and associated decentralized infrastructure was mostly generated by private initiatives. The development of the Bitcoin protocol, for instance, was only possible through the volunteer efforts of the open-source community and the altruistic devotion of the core Bitcoin developers who believed in the mission and vision of decentralized assets. By contrast, other major initiatives, such as Ethereum, among others, were initiated by volunteer efforts in the open-source community but funded through ICOs and venture capital.

Innovation in cryptocurrency designs is not only materializing in start-ups but also in existing legacy businesses. Banks and other legacy businesses that may fear possible disruption of their business model started to experiment with decentralized cryptocurrency designs. Many cryptocurrency exchanges are creating their own stable cryptocurrencies.¹⁴⁶ J.P. Morgan was one of the first established banks to introduce a stable cryptocurrency

145. Sina Motamedi, *Will Bitcoins Ever Become Money? A Path to Decentralized Central Banking*, TANNU TUVA INITIATIVE (July 21, 2014), <https://tannutuva.org/2014/will-bitcoins-ever-become-money-a-path-to-decentralized-central-banking/> [<https://perma.cc/V98D-K6FU>].

146. Jeff John Roberts, *Cryptocurrency Exchanges Back \$32 Million Stable Coin Project*, FORTUNE (Aug. 29, 2018, 8:54 AM), <http://fortune.com/2018/08/29/cryptocurrency-exchanges-back-32-million-stable-coin-project> [<https://perma.cc/8RZF-XGK7>]; Julie Verhage, *Crypto Exchange Coinbase to List Stable Coin Backed by Circle*, BLOOMBERG (Oct. 23, 2018, 11:00 AM), <https://www.bloomberg.com/news/articles/2018-10-23/crypto-exchange-coinbase-to-list-stable-coin-backed-by-circle> [<https://perma.cc/Y5YD-8K2T>].

backed one-to-one by JPM's fiat currency reserves.¹⁴⁷ Perhaps most notoriously, Facebook is developing a stable cryptocurrency in an attempt to break into the financial services business.¹⁴⁸

b. Public Realm

The public realm of the coin evolution is largely defined by emerging central bank digital currencies (CBDCs). CBDCs are in the public realm in the sense that they are subject to central bank control. Factors that render CBDCs subject to central bank control include central banks' oversight of payment systems, monetary policy, and central banks' supervisory responsibilities for financial risks to issuers of electronic money.¹⁴⁹ Most importantly, central banks own the seigniorage, that is, the difference between the value of the CBDCs it creates and the cost to produce and distribute it. Because of automation, among many other factors, the cost of production of CBDC is a fraction of the fiat money production cost, making the seigniorage of CBDCs that much more significant. While central banks have been debating CBDCs since 2016, more concrete proposals and concerted efforts for the development of CBDCs began in 2019.

CBDC can be rather broadly defined. CBDC can be defined as any electronic fiat liability of a central bank that can be used to settle payments, or as a store of value.¹⁵⁰ CBDCs can also be defined as an electric form of central bank money that can be exchanged in a decentralized manner enabling transactions to be processed without the need for a central server, directly between the payor and a payee without the need for a central intermediary.¹⁵¹ A CBDC would be legal tender under the law, including a requirement to pay taxes with them.¹⁵² The central bank would have exclusive authority to create and destroy ledger entries.¹⁵³ CBDCs could act as a highly effective form of money and promote true price stability, as the real value of CBDCs could be easily held stable over time.¹⁵⁴ Universally accessible, interest-bearing, account-based CBDCs could be used for monetary policy purposes in much the same way that central bank reserves are still used

147. Michelle F. Davis & Alastair Marsh, *JPMorgan to Use Digital Coin to Speed Up Corporate Payments*, BLOOMBERG (Feb. 14, 2019, 3:28 PM), <https://www.bloomberg.com/news/articles/2019-02-14/jpmorgan-to-use-cryptocurrency-for-payments-business-cnbc-says> [https://perma.cc/6ACY-DLZH].

148. Sarah Frier & Julie Verhage, *Facebook is Developing a Cryptocurrency for WhatsApp Transfers*, *Sources Say*, BLOOMBERG (Dec. 20, 2018, 6:35 PM), <https://www.bloomberg.com/news/articles/2018-12-21/facebook-is-said-to-develop-stablecoin-for-whatsapp-transfers> [https://perma.cc/JG6T-UKBH]; Nathaniel Popper & Mike Isaac, *Facebook and Telegram Are Hoping to Succeed Where Bitcoin Failed*, N.Y. TIMES (Feb. 28, 2019), <https://www.nytimes.com/2019/02/28/technology/cryptocurrency-facebook-telegram.html> [https://perma.cc/3KH3-TGHX].

149. Sean Craig et al., *Implications for Central Banks of the Development of Electronic Money*, BANK FOR INT'L SETTLEMENTS 1, 4 (Oct. 1996), <https://www.bis.org/publ/bisp01.pdf> [https://perma.cc/642B-3PBD].

150. Jack Meaning et al., *Broadening Narrow Money: Monetary Policy with a Central Bank Digital Currency 1* (Bank of England, Staff Working Paper No. 724, 2018), <https://www.bankofengland.co.uk/working-paper/2018/broadening-narrow-money-monetary-policy-with-a-central-bank-digital-currency> [https://perma.cc/KR6X-F4YQ].

151. Morten Bech & Rodney Garratt, *Central Bank Cryptocurrencies*, BIS Q. REV., Sept. 2017, at 55, 55.

152. Motamedi, *supra* note 145.

153. JP Koning, *Fedcoin*, MONEYNESS BLOG (Oct. 19, 2014, 1:28 PM), <http://jpkoning.blogspot.com/2014/10/fedcoin.html> [https://perma.cc/J85W-PQFV].

154. Meaning et al., *supra* note 150, at 2 (citing Michael D. Bordo & Andrew T. Levin, *Central Bank Digital Currency and the Future of Monetary Policy*, (Nat'l Bureau of Econ. Rsch., Working Paper No. 23711, 2017)).

in the early 2020s.¹⁵⁵

Several historical factors help explain the increasing engagement of central banks with CBDCs. At the end of 1995, the central banks of the G10 countries began studying the development of electronic money and the various policy issues it raises.¹⁵⁶ The BIS surmised that e-money could conceivably gain ground in the European Union between the proposed start of the Monetary Union in 1999 and when notes and coin denominated in Euros were likely to become available in 2002. During that transition, e-money and notes and coin denominated in national currencies such as Euros could be used interchangeably.¹⁵⁷ In 2017, several central banks announced that they were exploring or experimenting with distributed ledger technology and the prospect of central bank crypto or digital currencies.¹⁵⁸ By contrast, Denmark announced that CBDCs would not improve upon their existing payment solutions.¹⁵⁹

Progress toward CBDCs accelerated in 2020. Central banks increasingly recognized the limitations of cash in the banking systems. In 2020, almost 90% of US dollars were not physically held.¹⁶⁰ Worldwide, only 8% of currency exists as physical cash.¹⁶¹ Moreover, because central banks' reserve balances only exist in electronic form and are liabilities of the central bank, this renders them, in a sense, a digital asset already issued by a central bank which can be easily combined with a CBDC.¹⁶² In January 2020, the World Economic Forum released a CBDC policy-maker toolkit.¹⁶³ The central banks of Canada, England, Japan, Switzerland, and Sweden joined the European Central Bank, in forming a think-tank to create a central bank digital currency.¹⁶⁴ A Deutsche Bank analyst estimated a group of central banks representing one-fifth of the world's inhabitants would issue central bank digital currency (CBDC) in the next three years.¹⁶⁵ The Reserve Bank of Australia reported it started exploring an Ethereum-based interbank settlement system

155. Meaning et al., *supra* note 150, at 2.

156. Craig et al., *supra* note 149.

157. *Id.* at 3 n.5.

158. Bech & Garratt, *supra* note 151.

159. Kirsten Gürtler et al., *Central Bank Digital Currency in Denmark?*, DANMARKS NATIONALBANK (2017), <https://www.nationalbanken.dk/en/publications/Documents/2017/12/Analysis%20-%20Central%20bank%20digital%20currency%20in%20Denmark.pdf>; see also Ole Bjerg, *Designing New Money: The Policy Trilemma of Central Bank Digital Currency*, (June 2017) (unpublished manuscript) (available at <https://research.cbs.dk/en/publications/designing-new-money-the-policy-trilemma-of-central-bank-digital-c> [<https://perma.cc/4922-FNBK>]) (describing how CBDCs will interact with existing forms of money).

160. David B. Black, *Who Needs Cryptocurrency FedCoin When We Already Have a National Digital Currency?*, FORBES (Mar. 1, 2020, 4:06 PM), <https://www.forbes.com/sites/davidblack/2020/03/01/who-needs-cryptocurrency-fedcoin-when-we-already-have-a-national-digital-currency/> [<https://perma.cc/2JWQ-E9WK>].

161. *Id.*

162. See e.g., BANK FOR INTERNATIONAL SETTLEMENTS: COMMITTEE ON PAYMENTS AND MARKET INFRASTRUCTURES, DIGITAL CURRENCIES 17 (2015) [hereinafter DIGITAL CURRENCIES]; Black, *supra* note 160.

163. *Central Bank Digital Currency Policy-Maker Toolkit*, WORLD ECON. F. (Jan. 22, 2020), <https://www.weforum.org/whitepapers/central-bank-digital-currency-policy-maker-toolkit> [<https://perma.cc/L3UC-NSMW>].

164. Osato Avan-Nomayo, *Major Central Banks Form CBDC Think Tank*, BITCOINIST (Jan. 21, 2020, 9:59), <https://bitcoinist.com/major-central-banks-form-cbdc-think-tank/> [<https://perma.cc/BTH9-D4S5>].

165. Mike Dolan, *Pandemic Shock May Hasten Central Bank Digital Cash*, REUTERS (Apr. 9, 2020, 1:01 AM), <https://www.reuters.com/article/global-markets-column/rpt-column-pandemic-shock-may-hasten-central-bank-digital-cash-mike-dolan-idUSL5N2BX7AC>.

using a central bank-issued digital token.¹⁶⁶ The central bank of the Netherlands also started considering developing a CBDC.¹⁶⁷

CBDC and fiat currency have several common denominators and are susceptible to similar problems.¹⁶⁸ Both are means of payment, form a unit of account, and a store of value.¹⁶⁹ Currency use, whether centrally-issued fiat cash or privately issued digital currency, is based on trust. Users of a given currency need to have faith in its value and its issuer.¹⁷⁰ Both have value because the issuing bank guarantees the holder that they will always be able to redeem it.¹⁷¹ Hyperinflation undermines trust in either currency retaining its value over time.¹⁷² A bank run generates a demand for redemption that exceeds supply, the threat of which also undermines trust.¹⁷³ Losses caused by security breaches are “borne by issuers or system operators.”¹⁷⁴

CBDC mitigates several risks in the technology-based shifting of economies. As economies become increasingly technology-focused, consumers become more reliant on mobile-payment systems.¹⁷⁵ Because of this transition process, less cash is in circulation.¹⁷⁶ In the case of a crisis or system failure, market participants may attempt to fall back onto cash as a form of financial security. A CBDC would be another way for market participants to shift their holdings into official digital money in central-bank-authorized mobile wallets, similar to cash but without the conversion problems associated with digital assets to fiat conversion.¹⁷⁷

CBDC can take two essential forms. CBDC can be for retail use and institutional or wholesale use.¹⁷⁸ CBDCs for retail customers are a consumer-facing payment instrument for relatively low-value transactions, in the form of checks, credit transfers, and direct debits and card payments.¹⁷⁹ Retail CBDCs provide consumers with, presumably, low-cost access to an account with the central bank. The peer-to-peer element of CBDCs provides

166. *Submission to the Senate Select Committee on Financial Technology and Regulatory Technology*, RSRV. BANK OF AUSTL. (Dec. 2019), <https://www.rba.gov.au/publications/submissions/payments-system/financial-and-regulatory-technology/> [<https://perma.cc/PYQ2-N3B>].

167. Mathew Di Salvo, *Dutch Central Bank Wants ‘Leading Role’ in Digital Currency Development*, DECRYPT (Apr. 21, 2020), <https://decrypt.co/26260/dutch-central-bank-leading-role-digital-currency-development> [<https://perma.cc/7AVC-K3Y3>]; Andy Pickering, *Netherlands Central Bank Supports a Digital Euro*, BRAVE NEW COIN (Apr. 23, 2020), <https://bravenewcoin.com/insights/netherlands-central-bank-supports-a-digital-euro> [<https://perma.cc/YFB2-UEWN>].

168. Motamedi, *supra* note 145.

169. Cecilia Skingsley, *Sveriges Riksbank, Should the Riksbank Issue E-Krona?*, Speech at FinTech Stockholm 2016, Berns 2 (Nov. 16, 2016) (transcript available at <https://www.bis.org/review/r161128a.pdf>) [<https://perma.cc/6GH8-DURN>].

170. Motamedi, *supra* note 145.

171. Skingsley, *supra* note 169, at 3.

172. *Id.* at 2.

173. Motamedi, *supra* note 145.

174. Craig et al., *supra* note 149.

175. *China Aims to Launch the World’s First Official Digital Currency*, ECONOMIST (Apr. 23, 2020), <https://www.economist.com/finance-and-economics/2020/04/23/china-aims-to-launch-the-worlds-first-official-digital-currency> [<https://perma.cc/4A2B-WQRQ>].

176. *Id.*

177. *Id.*

178. Bech & Garratt, *supra* note 151, at 56; *see also* WORLD ECON. F., *supra* note 163, at 6 (describing costs/benefits of CBDC uses using these categorizations).

179. Bech & Garratt, *supra* note 151, at 56 n.4.

retail consumers with the “anonymity features that are similar to those of cash but in digital form.”¹⁸⁰ “By contrast, wholesale [CBDC] payments are large-value and high-priority transactions, such as interbank transfers” with restricted-access using digital settlement CBDC for wholesale payment applications.¹⁸¹ “Interbank settlements typically take place on the books of the central bank.”¹⁸² Transactions and wholesale payments that “occur in wholesale systems are visible to the central operator.”¹⁸³ According to the BIS, “the case for wholesale CBCCs depends on their ability to improve efficiency and reduce settlement costs.”¹⁸⁴

As a stable cryptocurrency, CBDC has several competitive advantages because of its centralized design. A CBDC could function as a central bank for cryptocurrencies, which would arguably mitigate cryptocurrency volatility, lack of policy coordination, and vulnerability to bank runs.¹⁸⁵ Some startups provide services to allow customers to easily transact in regular cryptocurrencies instead of building their own protocols. Currently, most of these bitcoin transaction facilitator “banks operate with 100% reserve ratios because they record [users’] ownership” of cryptocurrencies on the official blockchain.¹⁸⁶ Implementing a CBDC could arguably provide the public with an innovative and cheap payment option that would be more stable than a privately-issued cryptocurrency.¹⁸⁷

Central banks’ policy making is enhanced with CBDC. Universally accessible, interest-bearing, account-based CBDC could be used for monetary policy purposes in much the same way as central bank reserves.¹⁸⁸ “[C]entral bank could adjust [the CBDC-fiat] exchange rate in order to conduct monetary policy.”¹⁸⁹ Central banks are particularly interested in the effect of monetary policy of electronic money “on the demand for money aggregates and on the formulation of monetary policy.”¹⁹⁰

Central banks’ CBDC-based policy making increases the requirements for the underlying network protocol. For example, if a central bank forks the Bitcoin protocol in order to have a workable technology platform for CBDC, the central bank could retain discretion to set and adjust the block mining reward. In theory, increasing the block reward can be seen as loosening monetary policy, and vice-versa, similar to the way central banks use fiat interest rates. If the central bank chose to replace cash with CBDC, it could then charge a negative interest rate on deposits to bypass the zero lower bound.¹⁹¹ If the

180. *Id.* at 56. The anonymity feature of CBDC is of course largely debated and depends on the instantiation through the central bank. A risk exists that the central bank may be able to remove anonymity to supervise CBDC payment flows.

181. *Id.* at 56 n.4.

182. Craig et al., *supra* note 149, at 7 n.10.

183. Bech & Garratt, *supra* note 151, at 56.

184. *Id.* at 56–57.

185. Motamedi, *supra* note 145.

186. *Id.*

187. Koning, *supra* note 153.

188. Meaning et al., *supra* note 150, at 3.

189. Motamedi, *supra* note 145.

190. Craig et al., *supra* note 149, at 6.

191. Marilyne Tolle, *Central Bank Digital Currency: The End of Monetary Policy As We Know It?*, BANK UNDERGROUND (July 25, 2016), <https://bankunderground.co.uk/2016/07/25/central-bank-digital-currency-the-end-of-monetary-policy-as-we-know-it/> (citing Miles Kimball, *How and Why to Eliminate the Zero Lower Bound: A Reader’s Guide*, CONFESSIONS OF A SUPPLY-SIDE LIBERAL (Sept. 30, 2013), <https://blog.supplysideliberal.com/post/62693219358/how-and-why-to-eliminate-the-zero-lower-bound-a>

exchange rate were fixed at 1-1, there would no longer exist a distinction between the two. If a CBDC were remunerated at the same rate as central bank reserves, they would be interchangeable.¹⁹² Moreover, in order to be able to conduct monetary policy with CBDC, the underlying network protocol would have to enable the central bank to adjust the money supply at will. The protocol would need to allow the central bank to be the lender of last resort, that is, to have access to an unlimited supply of the CBDC.¹⁹³ Unlike capped supply token issuances by private parties, central banks can create an unlimited supply of CBDC for themselves by announcing a future transaction block with a corresponding one-time reward amount. To make this work in the respective technology platform, central banks can, in theory, solve the block themselves (or use a system that does not even require that) and announce the updated official blockchain to the network, and claim the reward themselves. Adjusting the block reward is a more natural way to conduct monetary policy because it affects every transaction in the economy.¹⁹⁴

CBDC can play a major role in optimizing settlement. Settlement is a common agreement that a transaction has taken place.¹⁹⁵ Traditional central bank settlement systems can take up to three business days to settle a single transaction.¹⁹⁶ These timing requirements for existing settlements create regulatory and system risk issues, especially counterparty risk, among many others. Central bank money is the ultimate settlement asset because banks use central bank reserves as the medium of exchange when settling residual amounts and netting out transfers between parties who bank at different banking institutions.¹⁹⁷ Unlike traditional electronic money, which requires a central entity that operates a ledger to which everyone in the system connects, CBDC can employ digital ledger technology, which can function well without a central body.¹⁹⁸ CBDC-based settlement may no longer require a central ledger held by a central body if banks could agree on changes to a common ledger in a way that does not require a central record keeper and allow each bank to hold a copy of the distributed common ledger.¹⁹⁹

Given the substantial benefits offered by CBDC, the People's Bank of China ("PBOC") was among the first major central banks to study a sovereign digital currency.²⁰⁰ China has been moving away from cash for the last decade and has over 890 million mobile payment users²⁰¹ who cumulatively made over \$20 trillion worth of payments in 2019

[<https://perma.cc/LC22-GDLY>].

192. *Id.*

193. Motamedi, *supra* note 145.

194. *Id.*

195. DIGITAL CURRENCIES, *supra* note 162.

196. Alexander Kroeger & Asani Sarkar, *Is Bitcoin Really Frictionless?*, FED. RESRV. BANK N.Y.: LIBERTY ST. ECON. (Mar. 23, 2016), <https://libertystreeteconomics.newyorkfed.org/2016/03/is-bitcoin-really-frictionless.html> [<https://perma.cc/PWJ9-P5F5>].

197. Tolle, *supra* note 191.

198. DIGITAL CURRENCIES, *supra* note 162.

199. *Id.*

200. Zhou Xin, *China's Sovereign Digital Currency 'Progressing Well', Central Bank Says, But Still No Launch Date*, S. CHINA MORNING POST (Jan. 5, 2020, 2:30 PM), <https://www.scmp.com/economy/china-economy/article/3044727/chinas-sovereign-currency-progressing-well-central-bank-says> [<https://perma.cc/5LTJ-CPQE>].

201. Zen Soo, *People's Daily Article Calls for Mobile Payments Companies to Tighten Consumer Protection Measures*, S. CHINA MORNING POST (Aug. 10, 2018, 2:05 PM), <https://www.scmp.com/tech/enterprises/article/2159104/peoples-daily-article-calls-mobile-payments->

alone.²⁰² Using traditionally issued banknotes, the promotion of the yuan's use internationally and in cross-border payments was stalling in 2016 which became a primary motivation in creating a nationally-owned CBDC in China. The PBOC first established a research institute to study this issue in 2016.²⁰³ Moreover, China perceived privately-issued cryptocurrencies as a threat to financial security and a challenge to their capital account controls.²⁰⁴

China has been using a centrally controlled cryptocurrency known as Digital Currency Electronic Payment (DCEP) since 2020.²⁰⁵ China's four largest commercial banks began internal tests in April 2020.²⁰⁶ In their testing program, the four commercial banks pass DCEP on to consumers, with the goal of replacing cash in all transactions.²⁰⁷ Pilot schemes for the digital currency are being conducted in four cities—Shenzhen, Suzhou, Xiong'an, and Chengdu.²⁰⁸ The Xiangcheng district of Suzhou has put the currency to use in May 2020 by paying half its travel subsidies given to public sector workers in digital form.²⁰⁹ The PBOC released a list of nineteen local businesses that will test the digital currency in small transactions including hotels, convenience stores, a stuffed bun shop, a bakery, a bookstore, a gym, as well as American chains including Starbucks, McDonald's, and Subway.²¹⁰

In contrast to its DCEP, China's CBDC would be a digital form of China's centrally issued fiat currency. The China digital currency would be tightly controlled by the government rather than built on pure blockchain technology.²¹¹ The central bank could track all digital cash in circulation and use coding to control how the money is used.²¹² PBOC planned to make the coins available through four state-owned banks as well as online payment platforms operated by China tech giants.²¹³ The coin was intended for primary use in online retail transactions but the goal was to accelerate its use internationally

companies-tighten [<https://perma.cc/4PAW-G3D7>].

202. Shaurya Malwa, *China's Digital Currency Goes into Play at McDonalds and Starbucks*, CRYPTOSLATE (Apr. 24, 2020, 12:01 PM), <https://cryptoslate.com/chinas-digital-currency-goes-into-play-at-mcdonalds-and-starbucks/> [<https://perma.cc/VF2X-XNU6>].

203. See Frank Tang, *China Has 'No Timetable' for Launch of Its Digital Currency, Says Central Bank Governor*, S. CHINA MORNING POST (Sept. 24, 2019, 8:30 PM), <https://www.scmp.com/economy/global-economy/article/3030120/china-has-no-timetable-launch-its-digital-currency-says> [<https://perma.cc/7DKX-JR4R>] (describing the plan to utilize a sovereign digital currency to alleviate the issue of stalling domestic currency).

204. Xin, *supra* note 200.

205. See Frank Tang, *China's Sovereign Digital Currency Plan in Doubt with Concerns Raised About Wider Application*, S. CHINA MORNING POST (Jan. 13, 2020, 10:15 PM), <https://www.scmp.com/economy/china-economy/article/3045887/chinas-sovereign-digital-currency-plan-doubt-concerns-raised> [<https://perma.cc/4ZAG-TMES>] (describing the PBOC's plan to deploy their sovereign digital currency).

206. ECONOMIST, *supra* note 175.

207. Tang, *supra* note 205.

208. Karen Yeung, *China's Digital Currency Takes Shape as Trials Begin With Travel Subsidies and Communist Party Fees*, S. CHINA MORNING POST (Apr. 19, 2020, 6:41 PM), <https://www.scmp.com/economy/china-economy/article/3080594/travel-subsidies-party-fees-chinas-digital-currency-takes> [<https://perma.cc/7NEC-J7FU>]. See also Tang, *supra* note 205.

209. Yeung, *supra* note 208.

210. Tang, *supra* note 205.

211. *Id.*

212. ECONOMIST, *supra* note 175.

213. Tang, *supra* note 203.

and counter the aforementioned capital challenges posed by privately-issued cryptocurrencies such as Bitcoin.²¹⁴ As such, China's CBDC/yuan is not intended for speculation and no backing will be required.²¹⁵ The CBDC/yuan would have the same legitimacy as yuan banknotes and, in time, replace them to a large extent.²¹⁶

China's engagement in CBDC has a competitive element to the US dollar that impacts the evolution of digital assets. In its competition with the US dollar for the world's reserve currency, China has maintained strict capital controls and bans domestic internet access to Google and Facebook.²¹⁷ As such, the launch of Facebook's Libra could threaten the use of the digital yuan internationally.²¹⁸ In response to Facebook's plan to launch its Libra digital currency in June 2019, the People's Bank of China stepped up its plan to launch a sovereign digital currency.²¹⁹ China had feared that Facebook's Libra could extend the US dollar's dominance in international payments. In Facebook's Libra, the US dollar would constitute over 50% weight in the basket of currencies backing Libra's value. American businesses account for a majority of the twenty-eight founding members of the consortium that will back the Libra cryptocurrency.²²⁰

The central banks of Canada, Sweden, France, and the United States are also exploring CBDC. For example, the Bank of Canada has been exploring the possibility of clearing and settling large-value payments using DLT since before 2015.²²¹ Canadian businesses have been exploring the possibility of clearing and settling large-value payments using DLT.²²² Yet, in May 2017, the Bank of Canada found that blockchain was not mature enough to run a national interbank payment system.²²³ The year-long "Jasper" trial was tested on Ethereum and Corda. While Ethereum would make the wholesale payment system more resilient but would be costly and raised privacy issues, Corda was able to address the cost and privacy concerns but made the system less resilient.²²⁴ The Bank of Canada is working to modernize the technology behind existing payment systems and is studying whether it might make sense to issue a digital version of bank notes.²²⁵

214. *Id.*

215. Cissy Zhou, *China's New Digital Currency "Isn't Bitcoin and is Not for Speculation"*, S. CHINA MORNING POST (Dec. 22, 2019, 6:00 PM), <https://www.scmp.com/economy/china-economy/article/3043134/chinas-new-digital-currency-isnt-bitcoin-and-not-speculation> [<https://perma.cc/SDP4-3AHX>] (citing SHANGHAI SEC. NEWS).

216. Tang, *supra* note 203.

217. *Id.*

218. *Id.*

219. Tang, *supra* note 205.

220. Tang, *supra* note 203.

221. Rod Garratt, *CAD-coin Versus Fedcoin*, R3 REPS. 1, 1 (Nov. 15, 2016), https://www.r3.com/wp-content/uploads/2017/06/cadcoin-versus-fedcoin_R3.pdf [<https://perma.cc/3BBY-JM5X>].

222. *Id.* The pilot project was called CAD-coin, although the bank did not plan to use that name because it suggested a central bank digital currency, which the Bank of Canada was not promising in 2015.

223. Solarina Ho, *Canadian Trial Finds Blockchain Not Ready for Bank Settlements*, REUTERS (May 25, 2017, 10:52 AM), <https://ca.reuters.com/article/businessNews/idCAKBN18L26M-OCABS> [<https://perma.cc/VRB5-D4K8>].

224. *Id.*

225. *See generally Cross-Border High Value Transfer Using Distributed Ledger Technologies*, ACCENTURE (2019), <https://www.mas.gov.sg/-/media/Jasper-Ubin-Design-Paper.pdf> [<https://perma.cc/BE3A-96NN>] (proposing a new system for cross-border payments); Stephen S. Poloz, *Big Issues Ahead: The Bank's 2020 Vision*, BANK OF CAN. (Dec. 12, 2019), <https://www.bankofcanada.ca/wp-content/uploads/2019/12/remarks-121219.pdf> [<https://perma.cc/CBU9-Y7U5>].

In Sweden, the Central Bank / Riksbank officially considered developing an e-krona in 2017 in response to its growing cashless system.²²⁶ In December 2019, the Riksbank expounded on their e-krona project in two reports published in September 2017 and October 2018.²²⁷ Riksbank focuses on safety and efficiency.²²⁸ E-krona would be released to the general public as a digital complement to cash.²²⁹ In February 2020, the Riksbank announced a pilot project in partnership with Accenture aimed at developing a proposal for a technical solution for an e-krona.²³⁰ The pilot project is expected to run until the end of February 2021.²³¹

In France, the Governor of Banque de France announced its intent to begin testing a CBDC targeted at institutions with a timescale during the first quarter of 2020.²³² France's central bank is calling for applications to experiment with the use of a digital euro issued for interbank settlements.²³³ In 2021, France's central bank called the experiment a "success" and indicated that more would follow.²³⁴

In 2015, the Federal Reserve Bank of St. Louis endorsed the idea of transferring the large-value payment system in the United States, Fedwire Funds, to a distributed ledger so that it would eliminate its dependence on centralized processors and increase its resiliency. This idea came to be known as Fedcoin, a proposal that emphasizes the product over the philosophy—creating a stable and dependable digital currency delivering Bitcoin's practical advantages even though it does away with Bitcoin's philosophy by involving a central bank.²³⁵ Fedcoin's value would be tied to the US dollar at a one-to-one exchange rate.²³⁶ On September 30, 2019, Congressmen Hill and Foster wrote to Federal Reserve

226. *Riksbankens E-Krona: 14 March 17 Project Plan*, SVERIGES RIKSBANK (Mar. 14, 2017), https://www.riksbank.se/globalassets/media/rapporter/e-krona/2017/projektplan-e-kronan_170314_eng.pdf.

227. *E-Krona*, SVERIGES RIKSBANK (Dec. 13, 2019), <https://www.riksbank.se/en-gb/payments—cash/e-krona/> [<https://perma.cc/SLU6-C86F>].

228. *Id.*

229. *Id.*

230. *Id.*; *The Riksbank to Test Technical Solution for the E-Krona*, SVERIGES RIKSBANK (Feb. 20, 2020), <https://www.riksbank.se/en-gb/press-and-published/notices-and-press-releases/notices/2020/the-riksbank-to-test-technical-solution-for-the-e-krona/> [<https://perma.cc/KP8U-VMFM>]; *The Riksbank's E-Krona Pilot*, SVERIGES RIKSBANK (Feb. 2020), <https://www.riksbank.se/globalassets/media/rapporter/e-krona/2019/the-riksbanks-e-krona-pilot.pdf> [<https://perma.cc/ALX4-FKXU>].

231. Mike Orcutt, *Sweden is Now Testing Its Digital Version of Cash, the E-Krona*, MIT TECH. REV. (Feb. 20, 2020), <https://www.technologyreview.com/2020/02/20/906146/sweden-riksbank-ekrona-blockchain/> [<https://perma.cc/VW5P-F2BF>].

232. *France Plans to Test Institutional CBDC in 2020*, LEDGER INSIGHTS (Dec. 2019), <https://www.ledgerinsights.com/france-plans-test-institutional-cbdc-central-bank-digital-currency/> [<https://perma.cc/G6AL-9B2U>] (citing Nessim Aït-Kacimi & Raphaël Bloch, *La Banque de France Va Expérimenter Un Euro Digital en 2020*, LES ECHOS (Dec. 4, 2019), <https://www.lesechos.fr/finance-marches/marches-financiers/la-banque-de-france-va-experimenter-un-euro-digital-en-2020-pour-les-institutions-financieres-1153659#xtor=CS1-3046> [<https://perma.cc/L6EB-DFLM>]).

233. *Call for Applications – Central Bank Digital Currency Experimentations*, BANQUE DE FR. (Apr. 24, 2020), <https://www.banque-france.fr/en/financial-stability/market-infrastructure-and-payment-systems/call-applications-central-bank-digital-currency-experimentations> [<https://perma.cc/TKY3-8GQV>].

234. Press Release, La Banque de France, La Banque de France réalise avec IZNES une expérimentation de monnaie numérique de banque centrale à des fins de règlement interbancaire (Jan. 1, 2021), <https://www.banque-france.fr/communiqu-de-presse/la-banque-de-france-realise-avec-iznes-une-experimentation-de-monnaie-numerique-de-banque-centrale>.

235. Garratt, *supra* note 221, at 4.

236. *Id.*

Bank Chairman Jerome Powell encouraging the Federal Reserve to take up the project of developing a USD digital currency.²³⁷ In March 2020, bills were proposed to the U.S. Senate and House proposing US CBDC. The Senate bill²³⁸ was introduced by Sen. Sherrod Brown (D-Ohio).²³⁹ The House bill²⁴⁰ was introduced by Rep. Paul Gosar (R-AZ).²⁴¹ Mentions of a digital dollar were even included in a coronavirus-related relief bill before the U.S. House, which have since been scrubbed.²⁴²

Finally, while many opportunities are presented by CBCD, many open questions still need to be addressed to enable CBCD to evolve. For example, it is still largely unclear in 2020 what technology would be deployed in a CBDC system and the extent to which it could be decentralized, if at all.²⁴³ Similarly, it is still unclear what type of entities would exist in a CBDC system and how they should be regulated.²⁴⁴ Anti-money-laundering, anti-terrorism financing, anti-tax evasion, and know-your-client protocols are needed for sovereign digital currencies that involve cross-border use.²⁴⁵ CBDC could have wide-ranging impacts on payment systems, the privacy of the transactions, private sector innovation, deposits held at commercial banks, financial stability of making a risk-free digital asset more widely available, and the transmission of monetary policy.²⁴⁶ These and many related questions have to be worked out to understand how CBDC may evolve and what impact they will have on the evolution of digital assets.

8. Convergence of Asset Classes

Digital assets and traditional investment via fiat currencies are becoming increasingly intermingled. Investors have access to a growing global network of digital asset exchanges. As of February 2020, more than 250 digital asset exchanges were operational globally with twenty-seven digital asset exchanges in the United States.²⁴⁷ The digital asset market records more than \$37 billion transactions daily.²⁴⁸ However, the majority of digital asset

237. Letter from French Hill, Congressman, & Bill Foster, Congressman, to Jerome Powell, Fed. Reserve. Chairman (Sept. 30, 2019) (on file with authors).

238. Banking for All Act, S. 3571, 116th Cong. (2020).

239. Nikhilesh De & Zack Seward, *US Senate Floats 'Digital Dollar' Bill After House Scrubs Term from Coronavirus Relief Plan*, COINDESK (Mar. 26, 2020, 11:42 AM), <https://www.coindesk.com/us-senate-floats-digital-dollar-bill-after-house-scrubs-term-from-coronavirus-relief-plan> [https://perma.cc/CGG4-LRLT].

240. Crypto-Currency Act of 2020, H.R. 6154 116th Cong. (2020).

241. Kollen Post, *US Congressman Introduces Crypto-Currency Act of 2020*, COINTELEGRAPH (Mar. 9, 2020), <https://cointelegraph.com/news/us-congressman-introduces-crypto-currency-act-of-2020>.

242. See Nikhilesh De, *'Digital Dollar' Stripped from Latest US Coronavirus Relief Bill*, COINDESK (Mar. 24, 2020, 3:44 PM), <https://www.coindesk.com/digital-dollar-stripped-from-latest-us-coronavirus-relief-bill> [https://perma.cc/725E-B928]; Nikhilesh De, *House Stimulus Bills Envision 'Digital Dollar' to Ease Coronavirus Recession*, COINDESK (Mar. 26, 2020, 4:09 PM), <https://www.coindesk.com/house-stimulus-bills-envision-digital-dollar-to-ease-coronavirus-recession> [https://perma.cc/3WSU-PG7L].

243. DIGITAL CURRENCIES, *supra* note 162, at 17.

244. *Id.*

245. Tang, *supra* note 203.

246. DIGITAL CURRENCIES, *supra* note 162, at 17.

247. BTCS Inc., *BTCS Expands Business Model with Development of Digital Asset Data Analytics Platform*, GLOBENEWSWIRE (Feb. 3, 2020), <https://www.globenewswire.com/news-release/2020/02/03/1978781/0/en/BTCS-Expands-Business-Model-with-Development-of-Digital-Asset-Data-Analytics-Platform.html> [https://perma.cc/QK6K-27W9].

248. *Id.*

exchanges lack detailed performance metrics. One of the first publicly traded companies in the United States focused on digital assets and blockchain technologies began developing a digital asset data analytics platform in mid-2019 in order to improve the sophistication of digital asset holdings and performance.²⁴⁹ Consumers can aggregate their portfolio holdings into a single seamless platform by connecting multiple digital asset exchanges and wallets, enabling them to view and analyze performance risk metrics at near-real time as well as potential tax implications.²⁵⁰ Users can also share their trade history with other platform users, consistent with the community focus of decentralized finance and blockchain technology.²⁵¹

A portfolio of both conventional and digital assets can maximize investor profits.²⁵² The dependence between digital and conventional assets is very weak although sensitive to external shocks and events.²⁵³ The co-movement between the returns of cryptocurrencies and S&P 500 became steady between 2011 and 2013.²⁵⁴ In 2015, the co-movement between cryptocurrencies and the S&P became extremely volatile.²⁵⁵ These different regimes in the dependence between cryptocurrencies and S&P 500 are closely related to various economic and financial events.²⁵⁶ The average dependence between Bitcoin and the S&P 500 is negative.²⁵⁷ The average dependence between Ethereum and the S&P 500 is positive.²⁵⁸

Regulatory uncertainty is holding back the development of convergence of asset classes. In March 2017, the SEC rejected the first BTC exchange-traded funds, saying the underlying Bitcoin market was too manipulable, volatile, and resistant to surveillance.²⁵⁹ “In March 2018, the SEC issued dozens of subpoenas for information requests to companies and advisors centered on ICOs and the structure of the sales.”²⁶⁰ Most recently in February 2020, the SEC again rejected a bid for a Bitcoin-based ETF.²⁶¹ SEC Commissioner Hester M. Peirce published a dissent to the most recent decision arguing that the Commission applies a “unique, heightened standard” to digital assets, thereby

249. *Id.*

250. *Id.*

251. *Id.*

252. Charfeddine et al., *supra* note 13, at 210, 211–15 (for calculations of optimal weights, hedging ratios, and hedging effectiveness of portfolios combining digital and conventional financial assets).

253. *Id.* at 210.

254. *Id.* at 209.

255. *Id.*

256. *Id.* at 209 figs.14 & 15.

257. Charfeddine et al., *supra* note 13, at 209.

258. *Id.*

259. See Simon Chandler, *A Brief History of the SEC's Reviews of Bitcoin ETF Proposals*, COINTELEGRAPH (Apr. 1, 2019), <https://cointelegraph.com/news/a-brief-history-of-the-secs-reviews-of-bitcoin-etf-proposals> [<https://perma.cc/J52B-E3ZT>] (providing the history of BTC exchange-traded funds); see also Self-Regulatory Organizations; Bats BZX Exchange, Inc.; Order Disapproving a Proposed Rule Change, as Modified by Amendments No. 1 and 2, to BZX Rule 14.11(e)(4), Commodity-Based Trust Shares, to List and Trade Shares Issued by the Winklevoss Bitcoin Trust, Exchange Act Release No. 34-80206 (Mar. 10, 2017), <https://www.sec.gov/rules/sro/batsbzx/2017/34-80206.pdf> [<https://perma.cc/VQ26-9BGM>] (discussing the same).

260. Corbet et al., *supra* note 117, at 187.

261. Nikhilesh De, *SEC Rejects Latest Bitcoin ETF Bid*, COINDESK (Feb. 26, 2020, 4:47 PM), <https://www.coindesk.com/sec-rejects-latest-bitcoin-etf-bid>; Order Disapproving a Proposed Rule Change to Amend NYSE Arca Rule 8.201-E, 85 Fed. Reg. 12,595 (Mar. 3, 2020).

impeding institutionalization and innovation.²⁶²

Some countries' regulators have been even harsher on digital assets. The Chinese government has altogether explicitly banned cryptocurrency from use by financial institutions and businesses.²⁶³ The Chinese Central bank issued a warning regarding the need to enforce rules on money laundering and foreign exchange, which led to major Chinese cryptocurrencies exchange halting withdrawals.²⁶⁴ China wants to completely eradicate cryptocurrencies by blocking access, "although Chinese investors have been among the biggest actors in the cryptocurrencies markets."²⁶⁵ In January 2018, financial regulators in South Korea began to cooperate with Chinese and Japanese authorities on new rules for cryptocurrency trading.²⁶⁶ After a related news release, "cryptocurrency prices fell with Bitcoin experiencing losses in excess of 50% in one month."²⁶⁷

9. DeFi Evolution

DeFi products and markets are constantly morphing and will be subject to continuing evolutionary trends as core decentralized infrastructure products become more viable while others devolve.

a. Growth Estimates

Figures 6 to 11 provide an overview of the evolving DeFi market and its separation from the overall market in Ethereum transactions. Figure 6 highlights the difference between the overall ETH transfer count and the total value locked in ETH of DeFi transactions. Figure 6 suggests that the DeFi marketplace is evolving so far not in terms of growth of the total number of transactions on the Ethereum network but in terms of the total value of the transactions.

262. Hester M. Peirce, *Dissenting Statement of Hester M. Peirce in Response to Release No. 34-88284; File No. SR-NYSEArca-2019-39*, U.S. SEC. & EXCH. COMM'N (Feb. 26, 2020), <https://www.sec.gov/news/public-statement/peirce-dissenting-statement-34-88284>.

263. Cheung et al., *supra* note 25, at 2356.

264. Charfeddine et al., *supra* note 13, at 209.

265. *Id.* at 202.

266. Corbet et al., *supra* note 117, at 187.

267. *Id.* at 187 n.2.

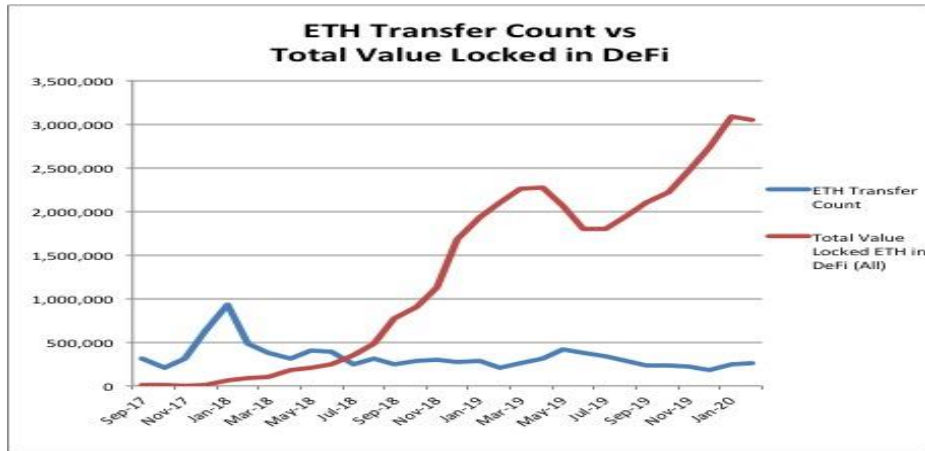


Figure [6]: Source: glass node and defipulse (ETH Transfer Count—the total amount of transfers. One transaction can trigger one or more transfers. Only successful, non-zero transfers are counted, Source explains TVL (total value locked) is calculated by pulling the balance of ETH and ERC-20 tokens held by each protocol’s underlying smart contracts. The data shown is the data from the 15th of each month, “All” was directly from the website—not generated).

Figure 7 further explains the trend illustrated in Figure 6 above in terms of other transaction measures. Figure 7 illustrates that the value of the ETH transfer volume depreciated from 9/1/17 to 5/1/18 lockstep with the withering away of the ICO market, Bitcoin value and is associated with the emergence of the so-called crypto winter. In its aftermath, finance professionals have started to develop more and more Ethereum based financial products which gave rise to the birth of DeFi and are illustrated by the total value locked of ETH in DeFi (All).

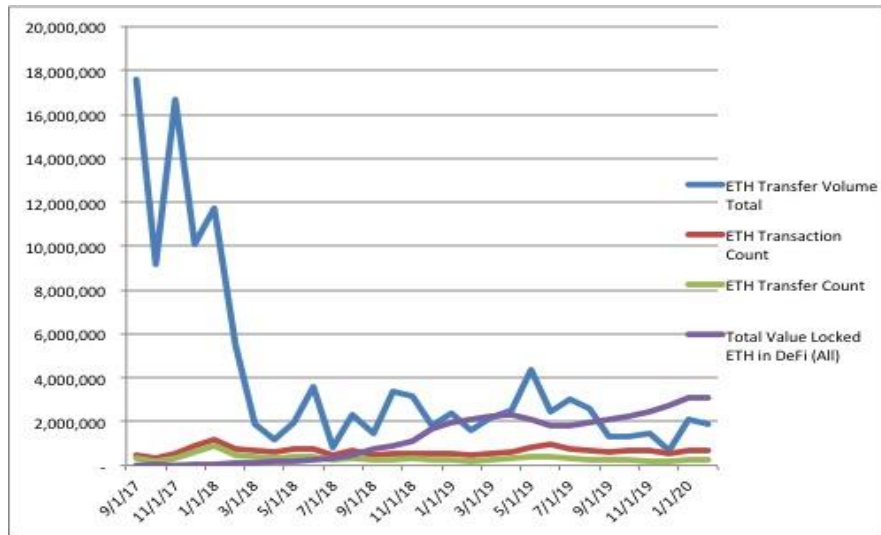


Figure [7]: Source: Glass Node for ETH data and DeFi Pulse (Glass Node—ETH Data, Source defines “Transfer Volume Total” as the total amount of coins transferred on-chain. Only successful transfers are counted, Source defines “Transaction Count” as the total amount of transactions. Only successful transactions are counted, Source defines “Transfer Count” as the total amount of transfers. One transaction can trigger one or more transfers. Only successful, non-zero transfers are counted, DeFi Pulse—TVL, Source explains TVL (total value locked) is calculated by pulling the balance of ETH and ERC-20 tokens held by each protocol’s underlying smart contracts. The data shown is the data from the 15th of each month, “All” was directly from the website – not generated).

Figures 8 to 11 further illustrate the breakdown of the increase in value locked in DeFi transactions as illuminated in Figures 6 and 7 above. In particular, Figure 7 shows that DeFi lending before the breakout of the COVID-19 pandemic generated the majority of value locked in DeFi transactions. Some evidence exists that the market deleveraged most of the lending value as margin calls forced DeFi lenders to deleverage during the pandemic.

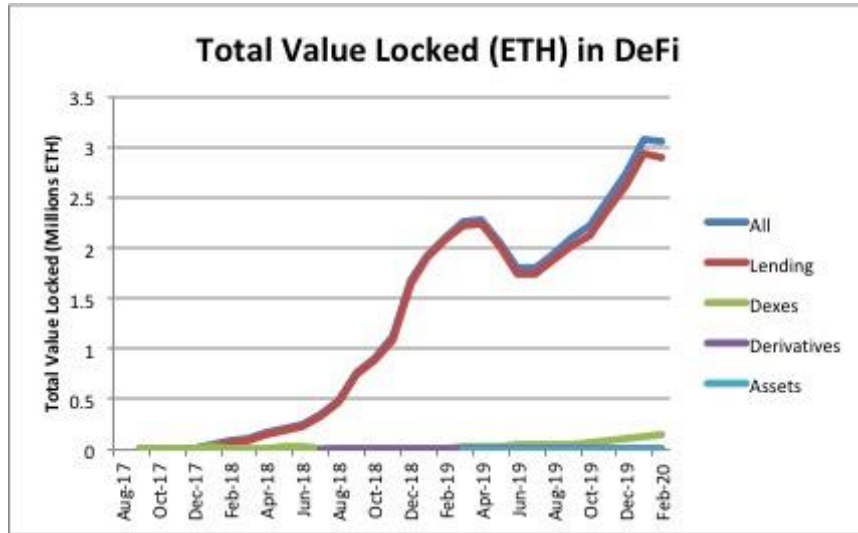


Figure [8]: Source: DeFiPulse.com (Source explains TVL (total value locked) is calculated by pulling the balance of ETH and ERC-20 tokens held by each protocol’s underlying smart contracts. The data shown is the data from the 15th of each month.).

Figures 9 and 10 illustrate which ethereum-based protocols generate a proportion of the overall DeFi transactions.

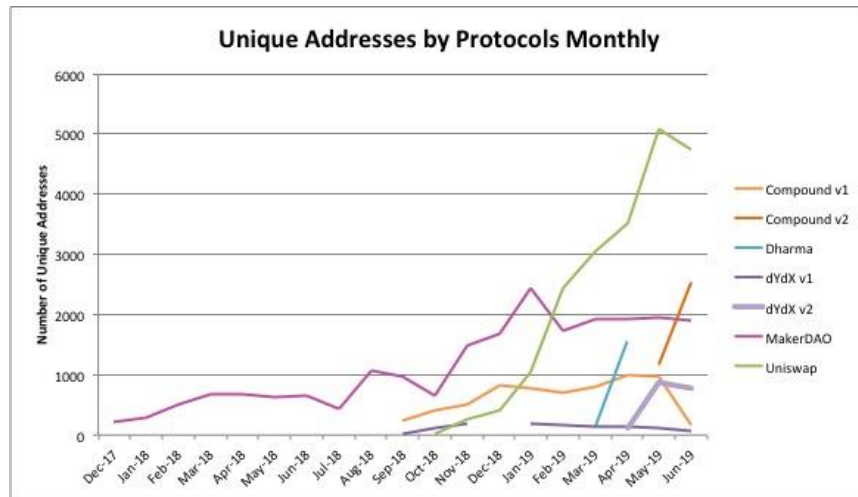


Figure [9]: Source: Bloxy—Lending Protocols Dynamics Comparison (Source categorized the graphs under Decentralized Protocols analytics, Value Analysis. This category was lending protocols dynamics comparison. Graphs titled “Monthly Cumulative Locked Amount, Unique addresses by Protocol” and “Unique Addresses vs Locked Amount by Protocols Monthly”).

Figure 10 highlights the important role MakerDao, a key stable coin, plays in the DeFi market. The locked dollar amount associated with the unique address for MakerDAO constitutes the overwhelming majority of all unique addresses and associated dollar amount

of DeFi transactions.

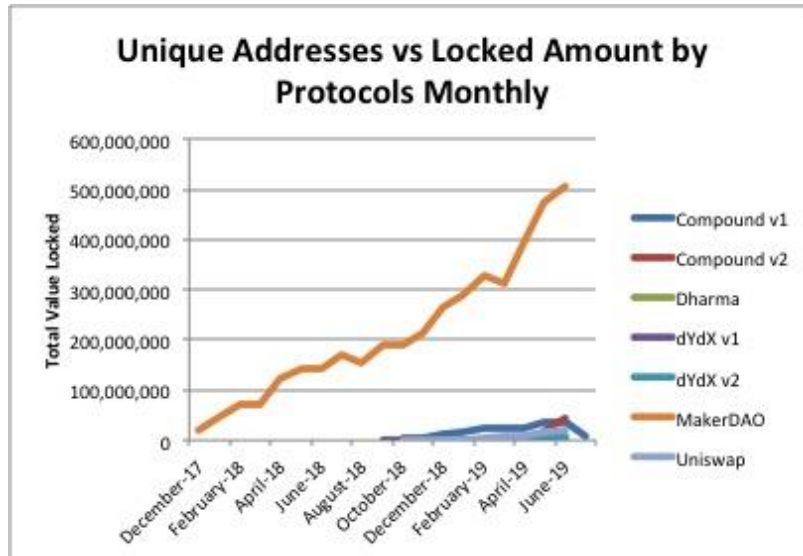


Figure [10]: Source: Bloxy—Lending Protocols Dynamics Comparison (Source categorized the graphs under Decentralized Protocols analytics, Value Analysis. This category was lending protocols dynamics comparison. Graphs titled “Monthly Cumulative Locked Amount, Unique addresses by Protocol” and “Unique Addresses vs Locked Amount by Protocols Monthly”).

Figure 11 further illustrates the power of DeFi transactions in the Ethereum transaction universe. As Figure 11 shows, smart contract calls constitute a very significant proportion of the ETH transfer count. This appears to be support for the proposition that DeFi financial products built into Ethereum smart contracts play a significant role in the development of the Ethereum network and will likely continue to play that significant role at an increasing scale.

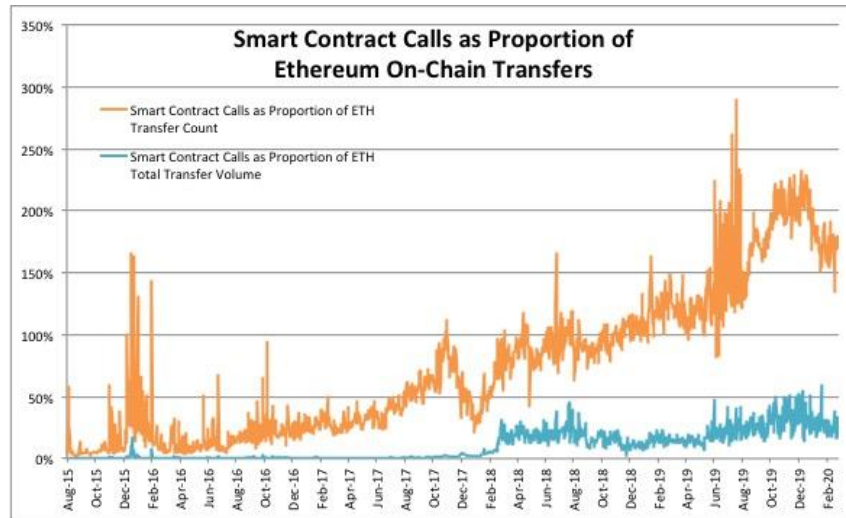


Figure [11]: Source: Bloxy (Proportions obtained by dividing value for monthly smart contract calls by the ETH value, Smart contract call data—Source categorized the graphs under Decentralized Protocols analytics, Value Analysis. This category was Smart Contract Calls, Daily. Graph titled Dynamics of smart contract calls (external only). The data for smart contract calls in the above was generated by taking the monthly sum for contract calls, ETH Transfer Count—the total amount of transfers. One transaction can trigger one or more transfers. Only successful, non-zero transfers are counted, Source defines “Transfer Volume Total” as the total amount of coins transferred on-chain. Only successful transfers are counted).

b. Growth Factors

DeFi’s growth rate, illustrated in Figure 11, and expected growth rate, illustrated in Figure 12, provide an early impression of what the digital asset market could morph into. Some of the core features of DeFi provide benefits that have significant comparative advantages over existing legacy finance and FinTech businesses.

Several factors contribute to DeFi’s growth rates and foreshadow the possible evolution of the market for digital assets. At the beginning of the 2020s, DeFi has started to capitalize on its core features to expand into existing legacy businesses. DeFi’s decentralized payment networks facilitate online and offline commerce with low-cost, secure, instant, and global payments. Low transaction costs benefit consumers as well as merchants by enabling profit maximization and reducing barriers to entry for new business models, such as micropayments. Several examples illustrate the crossover of DeFi into the more mainstream financial commerce. For example, Square, a centralized payment platform, may incorporate Bitcoin Lightning Network into its payment services.²⁶⁸ Ripple is at the forefront of decentralized payment networks and has partnered with financial

268. Leigh Cuen, *Square CEO Jack Dorsey Says Bitcoin’s Lightning is Coming to Cash App*, COINDESK (Mar. 27, 2019, 1:33 PM), <https://www.coindesk.com/square-bitcoin-jack-dorsey-lightning-cash-app> [<https://perma.cc/P7PS-EAA8>].

institutions such as MoneyGram to improve the efficiency of cross-border money transfers.²⁶⁹

A. Decentralization

Most of the comparative advantages of DeFi derive from its decentralized features. DeFi is efficient, more decentralized than any other financial solution, and borderless. In theory, because of its higher degree of decentralization in finance, DeFi can protect against monopolization, censorship, mutability, and counterparty risk. The decentralized nature of DeFi transactions makes it less likely that a single node or entity can monopolize the network and exclude others from participating, allowing broad access to the benefits of network effects.²⁷⁰ It also facilitates easy and instantaneous value transfer without regulatory intermediaries as it is less reliant on a central bank or government.²⁷¹

The decentralized nature of DeFi Dapps via blockchain technology also enables unparalleled transparency. The transparency offered by the technology allows parties in the supply chain real-time access to inventory records and payments can be effected in real-time. The real-time transparency enhancements could facilitate a seamless system of lending and repayment using smart contracts.²⁷² In turn, DeFi's transaction transparency has the potential to expand the scope and scale of transactions, protect transacting parties, and facilitate a quick response to financial crises and promote financial inclusion and innovation.

DeFi can promote financial inclusion. Because DeFi transactions are typically open-source, fully transparent, and permissionless. Anyone with an internet connection can access it. Polycentric governance structures can help achieve communication and consensus between the full set of participants.²⁷³ The underlying programming for DeFi projects is publicly available under a creative commons copyright license and allows nonprofit usage of open-source code.²⁷⁴ Self-custody via encrypted wallets removes costly intermediation that can give the unbanked an opportunity to participate in value creation. DeFi instruments can help secure and grow the life savings of citizens living in unstable countries, such as Venezuela. In DeFi's financial alternative, individuals can convert their fiat (government-backed) currency into a stable cryptocurrency ("stablecoin"), store the stablecoin in an interest-bearing account, and use futures contracts to hedge against financial uncertainty. By converting fiat currency into cryptocurrency, migrant workers and refugees can recover their funds even if their property is confiscated while fleeing their home country.

The emerging interoperability of DeFi Dapps further enhances the benefits of DeFi's decentralization. The interoperability of DeFi transactions could provide further benefits

269. *Ripple Announces Strategic Partnership with Money Transfer Giant, MoneyGram*, RIPLE: INSIGHTS (June 17, 2019), <https://ripple.com/insights/ripple-announces-strategic-partnership-with-money-transfer-giant-moneygram/> [https://perma.cc/2WAY-63SE].

270. Gur Huberman et al., *An Economist's Perspective on the Bitcoin Payment System*, 109 AEA PAPERS & PROC. 93, 93 (2019).

271. See SAIFEDEAN AMMOUS, *THE BITCOIN STANDARD: THE DECENTRALIZED ALTERNATIVE TO CENTRAL BANKING* xvi (2018) (discussing the advantages of decentralization).

272. Wang et al., *supra* note 77, at 1136; Lee, *supra* note 77.

273. BOSE ET AL., *supra* note 75, at 287.

274. Shaughnessy et al., *supra* note 69, at 3.

for the evolution of the digital asset market. At the beginning of the 2020s, DeFi is still largely relegated to the use of one dominant platform. 87% of all publicly funded DeFi projects have been built on Ethereum.²⁷⁵ Further enhancement of the interoperability of DeFi would increase value flow seamlessly across different services and borders. Interoperability as envisioned by Cosmos and Polkadot,²⁷⁶ would mean that different blockchains can be interconnected, allowing for enhanced interoperability and increased value flow.

B. Disintermediation Beyond FinTech

DeFi upgrades financial disintermediation above and beyond FinTech. Financial institutions connect market participants and build trust by serving as an intermediary, thereby reducing transaction costs.²⁷⁷ Financial technology is increasing efficiency by serving as an intermediary and taking up these roles. Financial technology (FinTech) can further reduce transaction costs by expanding transaction scope and empowering peer-to-peer transactions that disintermediate. In existing centralized forms of financial technology, disintermediation users are still dealing with a technology company as an intermediary instead of a financial institution.²⁷⁸ Accordingly, centralized financial technology disintermediation is incomplete and allows for further improvements. DeFi attempts to provide such decentralized financial solutions.

DeFi is more efficient than existing financial intermediation, including FinTech. Its superior efficiency can be traced to its extensive reliance on code and automation that remove large parts of the human element and the associated errors and inefficiencies. The entry and exit of network participants are possible at comparatively low costs, which increase efficiency gains.²⁷⁹ Distributed ledger technology has the potential to allow participants to make joint investments in shared infrastructure without assigning market power to the platform operator, helping increase the efficiency of operations.²⁸⁰

DeFi can help increase competition and accelerate the pace of financial innovation beyond FinTech. DeFi's permissionless and open-source nature creates an environment that promotes innovation above and beyond FinTech. Decentralized financial applications and platforms publicly share their core technologies through permissive open-source licensing.²⁸¹ Since the early days of digital assets, the permissionless open-source environment allowed the developer community to freely build and experiment with new applications.²⁸² The DeFi framework allows users to combine different protocols to create

275. Chen & Bellavitis, *supra* note 78, at 3.

276. POLKADOT, <https://polkadot.network/> [https://perma.cc/VXA5-8XGR]; COSMOS, <https://cosmos.network/> (last visited Feb. 27, 2021).

277. Chen & Bellavitis, *supra* note 78, at 1.

278. *Id.*

279. BOSE ET AL., *supra* note 65, at 287.

280. Christian Catalini & Joshua S. Gans, *Some Simple Economics of the Blockchain*, 9–10 (Nat'l Bureau of Econ. Rsch., Working Paper No. 22952, 2019).

281. Chen & Bellavitis, *supra* note 78, at 2–3; Shaughnessy et al., *supra* note 69, at 3.

282. Henry Chesbrough & Marshall Van Alstyne, *Permissionless Innovation*, 58 COMM'NS ACM 24, 24–26 (2015); Vint Cerf, *Remarks at the Digital Broadband Migration: The Dynamics of Disruptive Innovation*, 10 J. ON TELECOMM. HIGH TECH. L. 21, 28 (2012).

new financial products and services.²⁸³

DeFi can scale up savings flows between investors and issuers without having to go through a highly centralized global or national financial ecosystem. DeFi can enable the formation of communities of different types of investors extending beyond geographical boundaries to finance local public goods. These alliances can operate as conduits for financing and feedback between small responsible investors and issuers.²⁸⁴

C. Counterparty Risk Management

DeFi has the potential to address the issue of counterparty risk and associated regulatory concerns. A large part of the regulatory infrastructure that pertains to legacy systems revolves around issues concerning counterparty risk. Yet, the existing regulatory infrastructure is still mostly a patchwork of solutions that has not fully addressed the issue of counterparty risk. DeFi has the potential to address these shortcomings. DeFi reduces counterparty risk because there is no need to trust a third-party intermediary to custody funds or validate transactions.²⁸⁵ Because DeFi transactions are typically stored and recorded on a public blockchain, DeFi's transaction transparency can expand the scope and scale of transactions as well as protect transacting parties. Transactions recorded on public ledgers that can be easily viewed and verified,²⁸⁶ can expand the scale and scope of transactions.²⁸⁷ Transparency is further enhanced because DeFi is typically built with open-source code, the system is auditable by external parties.²⁸⁸ Finally, counterparty risk that materialized in past financial crises may be addressed by DeFi's public records of all historical transactions. Financial crises that involve issues of counterparty risk management may be less likely in a DeFi environment.²⁸⁹

D. StableCoins

Since 2019, stablecoins have become a staple in the emerging DeFi market. The total volume of stable cryptocurrencies relative to the rest of the cryptocurrency market is growing consistently.²⁹⁰ The growth of stable cryptocurrencies can largely be traced back to attempts to combine the utility and benefits of cryptocurrencies and blockchain technology with remedies for the existing fluctuation and volatility in the cryptocurrency

283. See generally ERIK BYNJOLFSSON & ANDREW MCAFFEE, *THE SECOND MACHINE AGE: WORK, PROGRESS, AND PROSPERITY IN A TIME OF BRILLIANT TECHNOLOGIES* (2014) (describing how the technology works).

284. See BOSE ET AL., *supra* note 75, at 283 (discussing the impact of self-organizing behavior by small investors and issuers).

285. Shaughnessy et al., *supra* note 69, at 3.

286. Chen & Bellavitis, *supra* note 78, at 3–4.

287. Marc-David L. Seidel, *Questioning Centralized Organizations in a Time of Distributed Trust*, 27 J. MGMT. INQUIRY 40, 40–43 (2018).

288. Shaughnessy et al., *supra* note 69, at 3.

289. Andrew W. Lo, *Reading About the Financial Crisis: A Twenty-One-Book Review*, 50 J. ECON. LITERATURE 151, 174 (2012).

290. The google search results for “blockchain” were exceeded by “stablecoin” in mid-2019. Mason Nystrom, *2019 Was the Year of DeFi (and Why 2020 Will be Too)*, CONSENSYS (Dec. 5, 2019), <https://consensys.net/blog/news/2019-was-the-year-of-defi-and-why-2020-will-be-too/> [<https://perma.cc/WQJ5-R4SU>].

markets.²⁹¹ The growth data suggests that demand for products that help manage the volatility inherent in other crypto assets is likely to continue to increase.²⁹²

The emergence of stablecoins in the DeFi infrastructure is accompanied by changes in the legacy banking environment. Cash and bank notes are gradually losing ground to other payment systems.²⁹³ Cash usage in the United States, the United Kingdom, the Netherlands, Sweden, Finland, Canada, France, among other industrialized nations, “has fallen well below [50%] of total transaction volume.”²⁹⁴ Most significantly, in Northern Europe, as few as one in every five transactions is made in cash.²⁹⁵ The end of technological life cycles of legacy systems and associated emerging trends in payment systems necessitate central banks’ enhanced examination of cryptocurrency solutions.²⁹⁶

The renaissance in privately issued stablecoins is, in part, triggered by evolving non-cash alternative needs of existing central banks. Central banks in countries with rapidly declining cash usage²⁹⁷ are subject to the most pressure to find solutions for bank-note alternatives. The cost of cash is also afflicting the existing cash system. In the United States, transacting in cash costs the consumer around 200 billion dollars annually—about \$637 per person.²⁹⁸ The cost of cash is primarily associated with counting, managing, storing, transporting, guarding, and accounting for bank notes.²⁹⁹ The theft of cash alone costs U.S. retail businesses losses around \$40 billion annually.³⁰⁰ The poor and those with less access to institutions bear a disproportionate share of the costs of using cash.³⁰¹

291. Stablecoin, BINANCE ACAD., <https://www.binance.vision/glossary/stablecoin> [<https://perma.cc/6AX5-PP22>].

292. *Can JPM Coin Disrupt the Existing Stablecoin Market?*, BINANCE RSCH. (Mar. 1, 2019) at 4, <https://research.binance.com/en/analysis/jpmcoin> [<https://perma.cc/2TTW-EGJD>].

293. See generally KENNETH S. ROGOFF, *THE CURSE OF CASH* (2016) (analyzing the decline of cash systems); Jonathan Brugge et al., *Attacking the Cost of Cash*, MCKINSEY & CO. (Aug. 20, 2018), <https://www.mckinsey.com/industries/financial-services/our-insights/attacking-the-cost-of-cash> [<https://perma.cc/JN36-6V4C>] (discussing the same).

294. “Germany, Japan, and Austria stand apart as wealthy countries where consumers maintain a strong preference for cash at the point of sale, despite universal availability of electronic payments instruments and the broad adoption of electronic transfers for recurring payments.” Brugge et al., *supra* note 293.

295. *Id.*

296. Bech & Garratt, *supra* note 151, at 66.

297. Brugge et al., *supra* note 293.

298. *Id.*; Bhaskar Chakravorti & Benjamin D. Mazzotta, *The Cost of Cash In The United States*, INST. FOR BUS. GLOB. CONTEXT 7 (Sept. 2019), <https://sites.tufts.edu/digitalplanet/files/2020/06/Cost-of-Cash-US.pdf#:~:text=On%20aggregate%2C%20the%20cost%20of,States%20is%20%24200%20billion%20annually.&text=Consumers%20spend%20approximately%2028%20minutes,point%20where%20they%20access%20cash.&text=Consumers%20invest%20considerable%20time%20and%20money%20in%20managing%20their%20personal%20finances> [<https://perma.cc/492J-DK99>].

299. See Aleksander Berentsen & Fabian Schär, *The Case for Central Bank Electronic Money and the Non-case for Central Bank Cryptocurrencies*, 100 FED. RSRV. BANK ST. LOUIS REV. 97, 97 (2018), <https://files.stlouisfed.org/files/htdocs/publications/review/2018/04/16/the-case-for-central-bank-electronic-money-and-the-non-case-for-central-bank-cryptocurrencies.pdf> [<https://perma.cc/MF3Y-ACG6>] (emphasizing that cash is a physical object).

300. Will Yakowicz, *Cash Costs U.S. Businesses \$40 Billion a Year*, INC. (Sept. 20, 2013), <https://www.inc.com/will-yakowicz/dealing-with-cash-costs-american-businesses-55-billion.html> [<https://perma.cc/6BWN-9YW3>]; Chakravorti & Mazzotta, *supra* note 298, at 27.

301. Yakowicz, *supra* note 300.

E. DAO Prospects

Most of the applications and uses of digital currencies are improved and expanded with well-functioning and well-governed decentralized autonomous organizations (DAOs). A DAO is “[a]n organization that is run through rules encoded in smart contracts.”³⁰² In May 2016, a crowdfunding campaign began using a DAO, operated on Ethereum, and set the record for the largest crowdfunding campaign in history with \$120 million worth of Ether raised.³⁰³ DAOs help upgrade digital assets across the spectrum of applications and uses. This includes digital assets that can be used as mediums of exchange, speculation,³⁰⁴ and payment rail for non-expensive cross-borders money transfer, in addition to their non-monetary uses such as time stamping.³⁰⁵ Additional use cases of DAOs “include financial transactions, secure voting, autonomous organizations, company management, freedom of speech networks, online games, crowdfunding, and speculation.”³⁰⁶

DAOs are organizations that run through rules encoded in smart contracts.³⁰⁷ Smart contracts “are executed when the conditions embedded in them are recognized as being met by the network.”³⁰⁸ Ethereum’s more flexible programming language, Solidity, enables the development of smart contracts³⁰⁹ in conjunction with Ethereum’s Virtual Machine (EVM), upon which every Ethereum node runs to maintain consensus. EVM is Turing-complete, meaning that it can perform calculations that any other programmable computer is capable of, enabling “execution of code exactly as intended.”³¹⁰ This is the unique feature of the Ethereum network that enables smart contracts and a high level of flexibility in digital innovation, which makes the platform attractive to developers.

Regulatory uncertainty is holding back the development of DAOs and the optimization potential of DAOs for digital assets. The DAO claimed to be a crowdfunding contract and made unregistered offers and sales of DAO tokens in exchange for Ether.³¹¹ However, the SEC began an investigation and determined that, although the DAO claimed to be a crowdfunding contract, it did not meet the SEC’s requirements for a Regulation Crowdfunding exemption because the DAO is neither a broker-dealer nor a funding portal

302. *Decentralized Autonomous Organizations (DAO)*, COINMARKETCAP, <https://coinmarketcap.com/alexandria/glossary/decentralized-autonomous-organizations-dao> [<https://perma.cc/PQT3-SQZD>].

303. Charfeddine et al., *supra* note 13, at 209.

304. Angela Rogojanu & Liana Badea, *The Issue of Competing Currencies: Case Study—Bitcoin*, 21 THEORETICAL & APPLIED ECON. 103, 105 (2014); Paola Ceruleo, Bitcoin: a rival to fiat money or a speculative financial asset? 26, 49 (2014) (Masters thesis, Libera Università Internazionale Degli Studi Sociali) (on file with LUISS Guido Carli).

305. Rogojanu & Badea, *supra* note 304, at 105–06, 110; Robleh Ali et al., *The Economics of Digital Currencies*, BANK OF ENGLAND: Q. BULL., 2014 Quarter 3, at 276, 276, 280.

306. Besarabov & Kolev, *supra* note 13, at 1.

307. *Decentralized Autonomous Organizations (DAO)*, *supra* note 302.

308. Charfeddine et al., *supra* note 13, at 201.

309. *Decentralized Autonomous Organizations (DAO)*, *supra* note 302.

310. *Ethereum Virtual Machine (EVM)*, COINMARKETCAP, <https://coinmarketcap.com/alexandria/glossary/ethereum-virtual-machine-vm> [<https://perma.cc/JNH3-J552>].

311. Press Release, Sec. & Exch. Comm’n, SEC Issues Investigative Report Concluding DAO Tokens, a Digital Asset, Were Securities (July 25, 2017) (citing SEC. & EXCH. COMM’N, RELEASE NO. 81207 REPORT OF INVESTIGATION PURSUANT TO SECTION 21(A) OF THE SECURITIES EXCHANGE ACT OF 1934: THE DAO (2017)).

registered with the SEC and the Financial Industry Regulatory Authority.³¹² In July 2017, following this investigation, the SEC issued an investigative report stating that virtual coins or tokens may be securities and subject to securities laws, depending on the facts and circumstances, including the economic realities of the transaction. The SEC stated that federal securities laws apply to those who offer and sell securities in the United States, regardless of whether the issuing entity is a traditional company or a decentralized autonomous organization, regardless of whether securities are purchased using fiat or virtual currency, regardless of whether they are distributed in certificated form or through distributed ledger technology. Federal securities laws provide disclosure requirements and regulatory scrutiny aimed at investor protection.³¹³

c. Growth Limitations

DeFi is subject to several growth limitations that may undermine its evolution. It is crucial for decentralized finance technologies to be market-driven rather than novelty-driven. Moreover, DeFi technologies need to be both user-friendly and useful for users.

At the beginning of the 2020s, DeFi was not sufficiently user friendly. Anyone who ever interacted with metamask, myetherwallet, or scatter, among other core DeFi user interfaces, can attest that dealing with public and private keys requires levels of technical know-how most lay users do not possess. As with most innovative technologies, the digital asset market also resulted from a technology push rather than a market pull.³¹⁴ Rather than focusing on the usefulness and user-friendliness of new platforms, developers were inspired by technical advancement and started experimenting with new possibilities of the technology to try to discern how to make a profit from their product experimentation.³¹⁵ Market pull may evolve if and when the DeFi technology infrastructure is more developed. With a sufficiently developed technology infrastructure, it will be possible for consumer adoption to drive the innovation of new decentralized financial technologies rather than technical novelty.

DeFi platform technologies often have a limited product market fit. The reliance on code in the market for digital assets over human judgments resulted in a focus on products that predominantly rely on automation, ignoring the human element in financial transactions. Because DeFi relies on code rather than human judgment, DeFi products often do not leverage human knowledge and subjective judgment, which limits the potential value of the technology. DeFi technologies are most effective when analyzing inputs that can be objectively recorded and verified. However, human interactions with business are often too complex to be fully codified objectively. By excluding all non-objective information from the product analysis, all available information may not be fully utilized which limits the efficiency and potential usefulness of DeFi.

312. *Testimony on "Virtual Currencies: The Oversight Role of the U.S. Securities and Exchange Commission and the U.S. Commodity Futures Trading Commission" Before the S. Comm. On Banking, Hous., & Urban Affs.*, 115th Cong. (Feb. 6, 2018) (testimony of Jay Clayton), <https://www.banking.senate.gov/imo/media/doc/Clayton%20Testimony%202-6-18.pdf> [<https://perma.cc/24E4-M4XB>].

313. *Id.*

314. Richard Partington, *How the Wheels Came Off Facebook's Libra Project*, *GUARDIAN* (Oct. 18, 2019, 9:42 AM), <https://www.theguardian.com/technology/2019/oct/18/how-the-wheels-came-off-facebook-libra-project> [<https://perma.cc/MFV6-K6YW>].

315. *Id.*

DeFi lacks a clear regulatory framework which makes its adoption and consumer confidence uncertain. There is insufficient or non-existent regulatory guidance, court decisions, and uncertainty over applicable jurisdiction. Lack of regulatory recognition of blockchain technology is problematic not only for users but for developers. A clear regulatory framework is needed to support reasonable innovation. Courts' perception and treatment of blockchain technology are uncertain because they have not reviewed, assessed, or scrutinized the uses and applications of blockchain technology. Human intervention is needed to settle legal disputes, even involving smart contract transactions, and is even helpful to create regulatory certainty.³¹⁶

Accountability in DeFi can be a concern. "Without central entity involvement, who should be held accountable for potential wrongdoing can become unclear. Who do you resort to for help? When problems arise, no central party can take actions to freeze transactions, fix problems, and restore normal operations."³¹⁷ At the beginning of the 2020s, crypto custody solutions to store cryptocurrencies either lacked transparency, safety, or liquidity.³¹⁸

Finally, DeFi can be vulnerable to fraud and untested financial innovations,³¹⁹ non-existent links to physical/traditional assets,³²⁰ and limited on-chain throughput.³²¹

d. DeFi Infrastructure Case Study

In the early 2020s, the DeFi technology infrastructure was insufficiently developed to support DeFi growth estimates and growth potential. To truly fulfill its potential, the DeFi infrastructure development necessitates significant tradeoffs between scaling, security, and levels of decentralization. The trade-off between transaction approval speed and immutability has the potential to undermine the DeFi infrastructure in the long run.³²² Achieving broad consensus among key stakeholders to implement major upgrades is costly and often challenging.³²³ All information must be distributed to all parties publicly, then validated through distributed consensus, and stored, a process that requires a great deal of computational power.³²⁴ Creating consensus requires increase costs of prepping, processing, and storing information.³²⁵ On the other hand, fewer computational checks for consensus increase the risk of collusion attacks that could change the record.³²⁶ The

316. See Reggie O'Shields, *Smart Contracts: Legal Agreements for the Blockchain*, 21 N.C. BANKING INST. 177 (2017) (making the point a human touch is still required in smart contracts).

317. Robert Palatnick, *Governing DLT Networks: Distributed Ledger Technology Governance for Private Permissioned Networks*, DTCC 1 (Sept. 2019), <https://perspectives.dtcc.com/articles/governing-dlt-networks> [<https://perma.cc/TK99-B4MK>].

318. Cdx, <https://cdxproject.com/> [<https://perma.cc/T5PJ-EYXR>].

319. Chen & Bellavitis, *supra* note 78, at 6.

320. Shaughnessy et al., *supra* note 69, at 3.

321. *Id.* at 3.

322. BOSE ET AL., *supra* note 75, at 304.

323. Akhil Kumar et al., *Is Blockchain a Silver Bullet for Supply Chain Management? Technical Challenges and Research Opportunities*, 51 DECISION SCIS. 9 (2019).

324. Eric Budish, *The Economic Limits of Bitcoin and the Blockchain*, (Nat'l Bureau of Econ. Rsch., Working Paper No. 24717, 2018), https://www.nber.org/system/files/working_papers/w24717/w24717.pdf [<https://perma.cc/UDZ4-U3NY>].

325. Kumar et al., *supra* note 323.

326. BOSE ET AL., *supra* note 75, at 304.

flipside of the transparency offered by DeFi is the competing interest of user privacy, plus associated processing costs to achieve privacy.³²⁷

A specific example that may raise concerns with regard to the DeFi infrastructure development is the case of CryptoKitties. Cryptokitties is a game of digital collectibles on the Ethereum blockchain.³²⁸ In one of the earliest attempts to apply blockchain technology to gaming, CryptoKitties allows players to breed, purchase, and sell virtual cats of different origin. Significantly, CryptoKitties is one of the first instantiations of true digital assets that create an inherent value for its users. In December 2017, the game's popularity slowed down the Ethereum network by causing an all-time high in a number of transactions.³²⁹

Figure 12 illustrates that in early December 2017 the Ethereum network experienced significant delays in transaction processing which was in part caused by the CryptoKitties DApp.

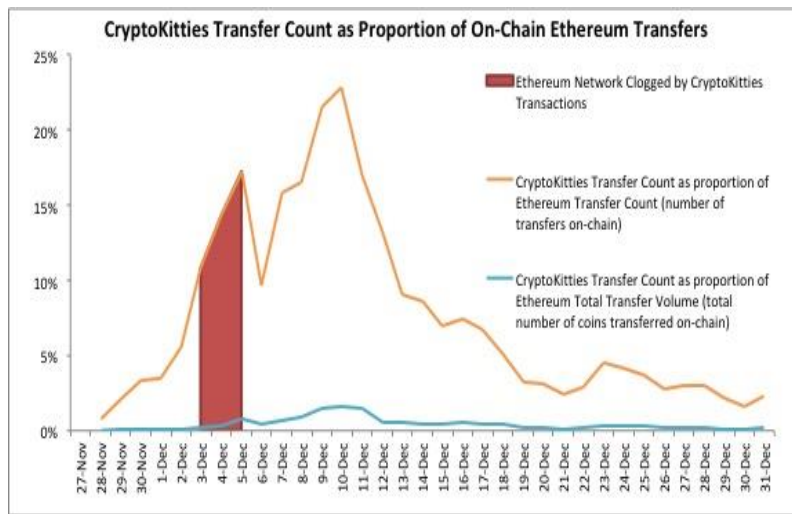


Figure [12]³³⁰ Source: GlassNode, Bloxy.info. Proportions were obtained by dividing value for CK transfer by the ETH value (the source titles this data “CK Transfer Count” with no further explanations, and ETH Transfer Count as the total amount of transfers). One transaction can trigger one or more transfers, and only successful, non-zero transfers are counted. “Transfer Volume Total” is defined as the total amount of coins transferred

327. Chen & Bellavitis, *supra* note 78, at 6.

328. *CryptoKitties*, WIKIPEDIA, <https://en.wikipedia.org/wiki/CryptoKitties> (last visited Feb. 16, 2021).

329. *CryptoKitties Craze Slows Down Transactions on Ethereum*, BBC NEWS (Dec. 5, 2017), <https://www.bbc.com/news/technology-42237162> [<https://perma.cc/6WUN-E99L>].

330. *Id.*

Why does it matter if CryptoKitties is slowing down Ethereum? According to ETH Gas Station, the CryptoKitties game accounts for over 10% of network traffic on Ethereum. As traffic increases, transactions become more expensive to execute quickly. “The real big issue is other major players looking for alternatives to Ethereum and moving to different systems,” Mr Hileman said. “There’s definitely an urgency for Ethereum to try and address this issue.”

Id. (quoting Garrick Hileman from the University of Cambridge).

on-chain (only successful transfers are counted).³³¹

A comparison of ETH transfer count and CryptoKitties transfer counts in Figures 11 and 12 suggests that the CryptoKitties effect on the Ethereum network could have larger implications if the Ethereum network and expected transaction volume continue to grow.

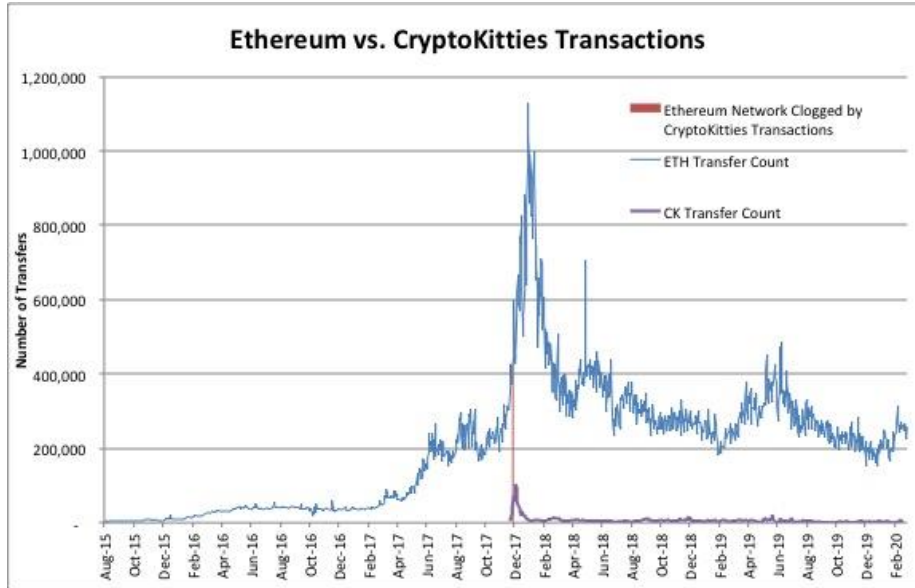


Figure [13]: Source: GlassNode, Bloxy.info (CK transfer—source titles this data “CK Transfer Count” with no further explanation, ETH Transfer Count—the total amount of transfers. One transaction can trigger one or more transfers. Only successful, non-zero transfers are counted).

In light of the network capacity issues illustrated by the CryptoKitties shutdown in Figures 12 and 13, the expected growth rate illustrated in Figures 10 and 11 could mean that the Ethereum network will continue to experience network shortages and throughput issues unless the Ethereum infrastructure is upgraded to deal with the expected volume of transactions. Of course, correlation is not causation and many other factors could call the DeFi technology infrastructure into question.

331. *Id.*; see also Joon Ian Wong, *The Ethereum Network Is Getting Jammed up Because People Are Rushing to Buy Cartoon Cats on Its Blockchain*, QUARTZ (Dec. 4, 2017), <https://qz.com/1145833/cryptokitties-is-causing-ethereum-network-congestion/> [<https://perma.cc/3UNF-MYGC>]. *Coin Metrics' State of the Network: Issue 27*, COIN METRICS (Nov. 26, 2019, 12:00 AM), <https://coinmetrics.io/coin-metrics-state-of-the-network-issue-27/> [<https://perma.cc/58EW-59LX>].

In late 2017, CryptoKitties burst onto the scene causing ERC-721 (non-fungible token) transactions to reach over 80,000 per day. But after a brief frenzy, CryptoKitty trading died off, and ERC-721 transactions have not topped over 25,000 per day since CryptoKitties notoriously caused blockchain congestion, and caused ETH fees to spike.

COIN METRICS, *supra*.

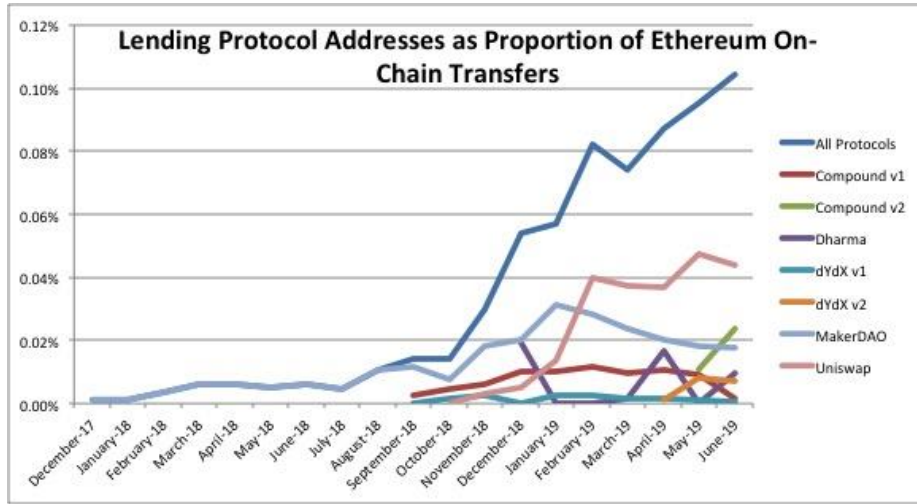


Figure [14]: This proportion was obtained by dividing address number by ETH transfer count. Lending protocol dynamics are from the circle data above. Here, ETH Transfer Count means the total amount of transfers. One transaction can trigger one or more transfers. Only successful, non-zero transfers are counted.

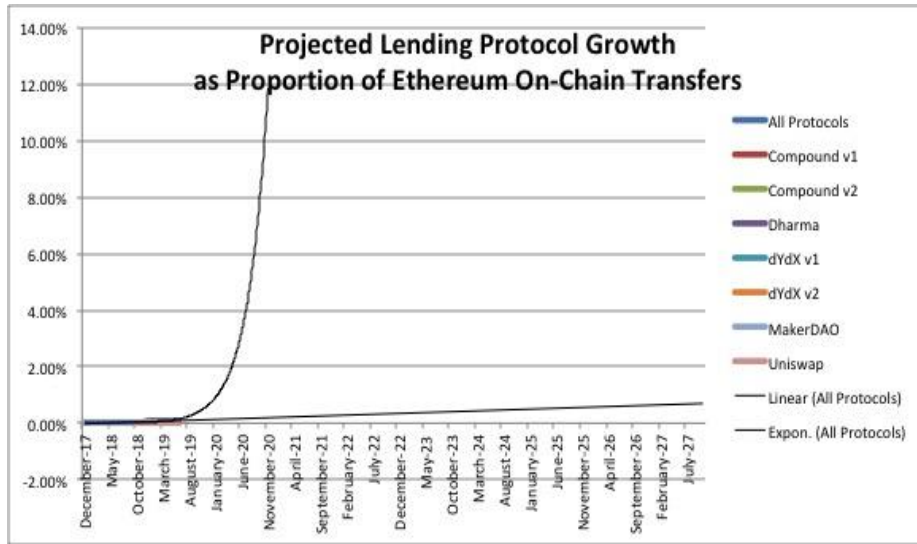


Figure [15]: This is the same graph as immediately above, adding in projections using linear and exponential growth models for the “all protocols as proportion of ETH on-chain transfers” data.

IV. CONCLUSION

The evolution of the market for digital assets can be traced to many factors. This Article examined some of the most prevalent factors. The market trends and factors that affect the market in digital assets are constantly changing. It remains to be seen if the digital asset market can evolve further without key decentralized infrastructure upgrades. All projects that make contributions to decentralized infrastructure engage in the much-needed experimentation that pervades the market for digital assets and enables its evolution.