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# Key Innovations and Emerging Developments in Digital Assets and Decentralized Finance – A Primer

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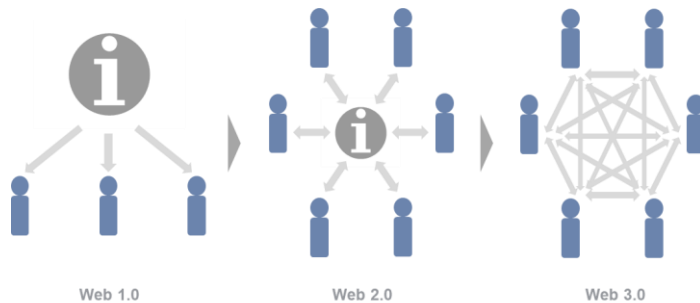
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# Key Innovations in Digital Assets

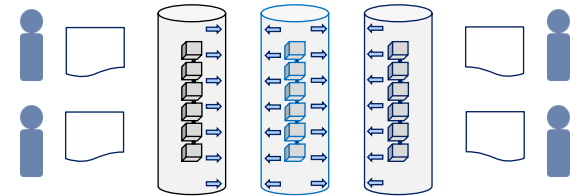
Innovations in the digital asset ecosystem have the potential to fundamentally transform financial services, with investment interest expanding

## Open Source, Decentralized Innovation



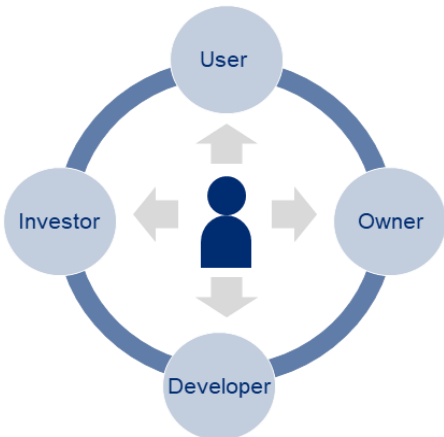
- **Peer-to-peer** digital asset ecosystems are built on **code created and maintained by investor-developer communities** and available broadly
- The combination of participants storing and controlling data and automated software programs “smart contracts” is creating a **Web 3.0 competitive paradigm of widely-distributed data and capabilities**

## Blockchain-based Building Blocks & Distributed Architectures



- **Shared transactional ledgers** and **programming rules on how to execute processes in code** remove the need for a central intermediary and signal a previously impossible level of automation
- **Composability** enables plugging new protocol building blocks into new financial applications, with innovation occurring at an exponential pace

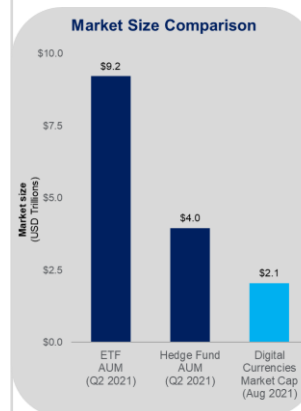
## New Models of Retail Participation



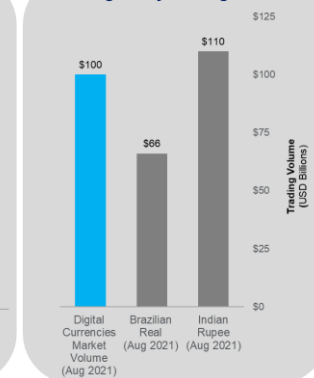
- Innovation is occurring outside of the investment industry, **driven by retail investors**. In 2020, retail investors represented approximately 2/3 of Bitcoin ownership<sup>1</sup>
- Individuals **act as users, managers, and economic owners of decentralized financial applications** built on “protocol” platforms

## Investment Interest Growing at Fast Clip

### Expanding Size of the Crypto Realm



### Average Daily Trading Volume

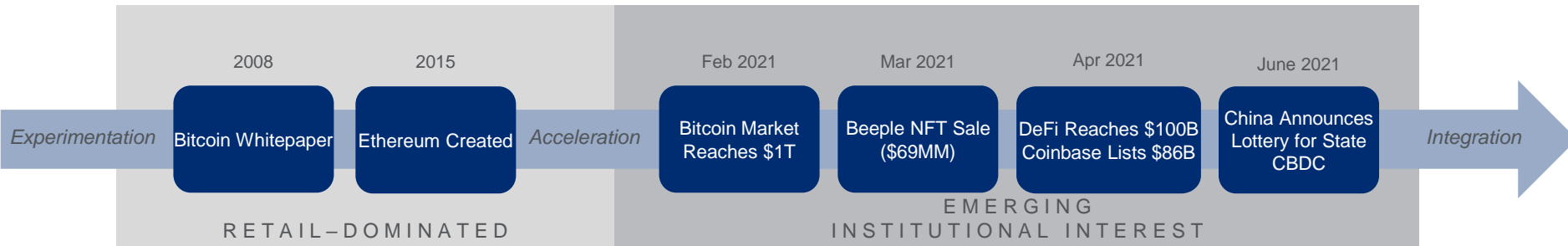


- **Bitcoin market cap surpassed \$1T in February 2021**. Trading volumes in digital currencies became comparable to those in some emerging market currencies<sup>2</sup>
- Robinhood reported **6 million new crypto traders** in the first 2 months of 2021 vs. a monthly average of ~200,000 in 2020<sup>3</sup>

# Key Milestones and Envisioned Progression

While the cryptocurrency ecosystem is still young, it has grown and evolved at a rapid pace, being now viewed as a standalone investible asset class by a growing number of institutional investors

## Evolution of the Digital Assets Landscape



### Emergence of New Models of Financial Participation

- **Bitcoin's Roots in the Cypherpunk Movement:** The identity of Satoshi Nakamoto is not known but ideas encapsulated in the Bitcoin whitepaper align to those espoused by a group of developers committed to cryptography being used to preserve sovereignty and privacy on the internet<sup>1</sup>
- **Peer-to-Peer Networks Begin to Gain Ground with Retail Investors:** By 2018, Bitcoin Blockchain wallet users had reached 20 million<sup>2</sup>

### Increased Professionalization of the Digital Asset Ecosystem

- **Institutional Investment in Bitcoin Accelerates:** Investment in Bitcoin grows as mainstream investors are drawn to Bitcoin's digital scarcity feature
- **Crypto Market Infrastructure Resemble Traditional Financial Services:** The digital trading infrastructure moves from vertically integrated and retail-oriented to specialized and institutional-grade
- **Moving Beyond Bitcoin:** More institutions begin to track and experiment with digital asset opportunities beyond Bitcoin and threading into decentralized finance
- **Future Integration with Traditional Finance:** Models currently experimented within the peer-to-peer digital realm might cross-over into traditional financial services

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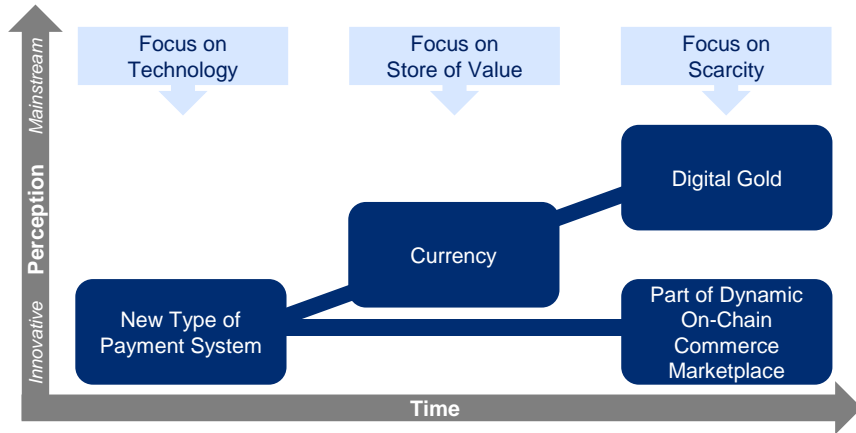
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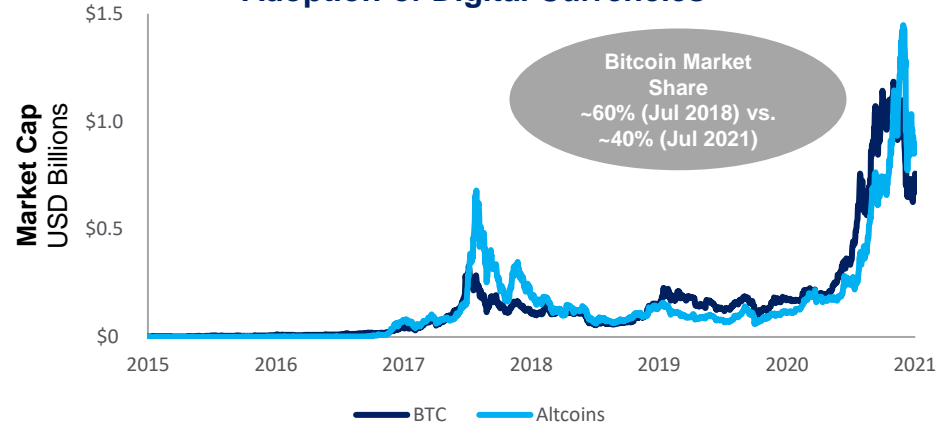
# Bitcoin as Point of Origin

Bitcoin is largely seen as the point of origin for the emergence of the crypto realm, with its role evolving from payment system to currency to possible store of value

Evolution in the Role of Bitcoin



Bitcoin Continues to Dominate Adoption of Digital Currencies



- **Peer-to-Peer Payment System:** The Bitcoin transaction network does not rely on mint or trusted parties. New coins are generated through proof-of-work by Bitcoin miners, preventing double spending
- **Unique Ability to Engineer Digital Scarcity:** Bitcoin’s source code only allows for the creation of 21 million coins, of which ~18.7 million are already in circulation. Inflation is “algorithmically controlled” through the size of the block reward to miners, which fell from 50 to 6.25 over the last 10 years<sup>1</sup>
- **Superior Traits vs Gold:** Bitcoin can be fractionalized down to 1/100,000,000th of a unit and is stored digitally<sup>2</sup>

**Factors driving Bitcoin adoption:**

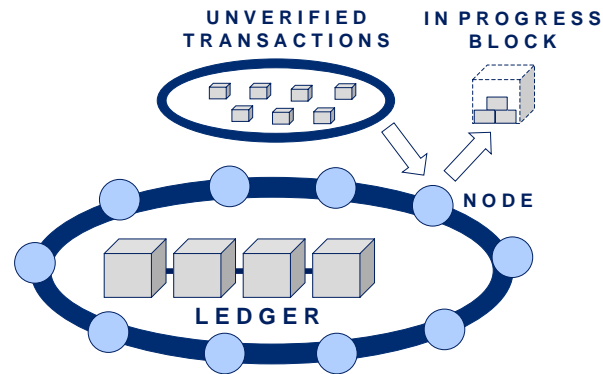
- **Expansionary Macro Environment:** Rising inflation concerns due to massive government debt issuance, overloaded alternative markets with ~\$3T in dry powder favored adoption in 2020.<sup>3</sup> MicroStrategy holds over ~\$3B in Bitcoin and a recent call with the CEO in early February drew over 1,400 companies; Tesla added ~\$1.5B in reserves, raising prospects for more tech company uptake<sup>4,5</sup>
- **Growing Use of Bitcoin as Medium of Exchange:** Major payment networks PayPal, Visa, and Mastercard are creating pathways to use Bitcoin in merchant payments, though Bitcoin’s transaction throughput is 5 per second vs. Visa’s ~24,000 per second<sup>6,7,8,9</sup>

Footnotes & Sources in Appendix

# Transaction Verification via “Proof of Work” (POW)

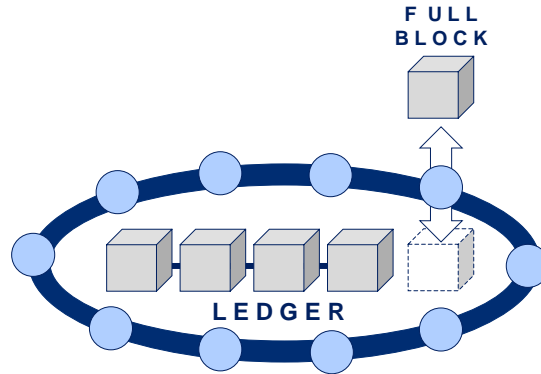
While traditional payment systems rely on a central intermediary, the Bitcoin blockchain adds and confirms transactions by incentivizing “miners” to solve mathematical problems

## Transaction Verification



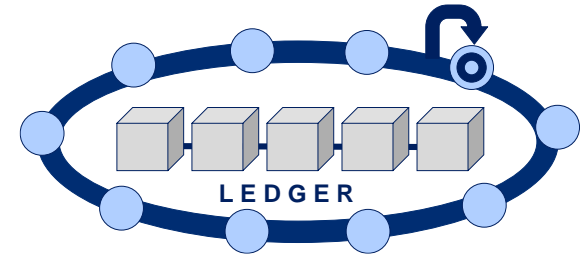
- **Transaction Verification:** All transactions ever completed on the network are stored and linked to each other, and every network participant can see the entire ledger. Any user (node) in the network can access the pending transaction queue and verify transactions in order to build their own “block”

## Mathematical Challenge



- **Cryptographic Challenge:** To add their block to the chain, the user must solve a complex mathematical problem and submit it to the network. As more miners compete to add new blocks to earn the reward, the network makes the problem harder. Originally, users could mine using their personal laptops whereas today it requires specialized chips and massive data centers

## Reward



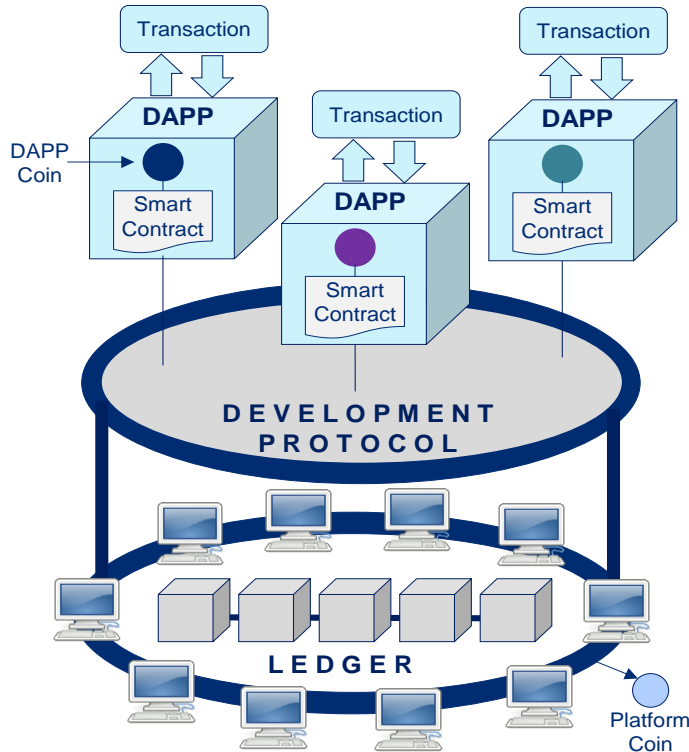
- **Rewards for Miners:** In order to get paid, other users must verify the accuracy of the work done by the miner. Cryptography makes it far easier to confirm the content of a block after the puzzle has been solved. The network creates new bitcoins to reward the miner, but the inflation reward gets cut in half every 210,000 blocks<sup>1</sup>



# Ethereum Blockchain Opens New Use Cases

The key innovation brought by the Ethereum blockchain is that it functions as a de facto software development platform given its smart contract architecture

## Ethereum Emerges as Decentralized Software Development Platform



- The Ethereum blockchain is often compared to “**The World’s Computer**”, enabling anyone to run and secure the network by contributing computing power to secure a node and thereby creating a decentralized internet infrastructure<sup>1</sup>

### Platform and Currency

- **The Ethereum Platform:** Similar to an App Store, the decentralized blockchain-based platform offers open development protocols that allow for the creation of specialized financial and non-financial applications
- **The Ether Currency:** Any transaction executed on the network is paid in Ether, Ethereum’s native coin

### Key Applications

- **Decentralized Applications (Dapps):** Dapps are applications built on a peer-to-peer network like Ethereum and utilize smart contracts to operate autonomously. Users pay to record transactions in the platform coin. Some Dapps also require users to buy utility tokens to access services provided by the applications

### Enabling Technologies

- **Blockchain:** Distributed ledger that records transactions across several computers
- **Smart Contracts:** Programmable pieces of code that provide services to Dapp users autonomously without the need for an intermediary or human interaction
- **Oracle Networks:** Specialized Dapps scan on-chain data and off-chain APIs, databases, and content sources to identify and deliver the data that the smart contracts require to execute

Chart Source: Citi Business Advisory Services

1. “Ethereum, Smart Contracts, and the World Computer”, Vinay Gupta, ConsenSys, October 21, 2015, <https://consensys.net/blog/news/programmable-blockchains-in-context-ethereum-smart-contracts-and-the-world-computer/>



# Comparison of the Bitcoin and Ethereum Network

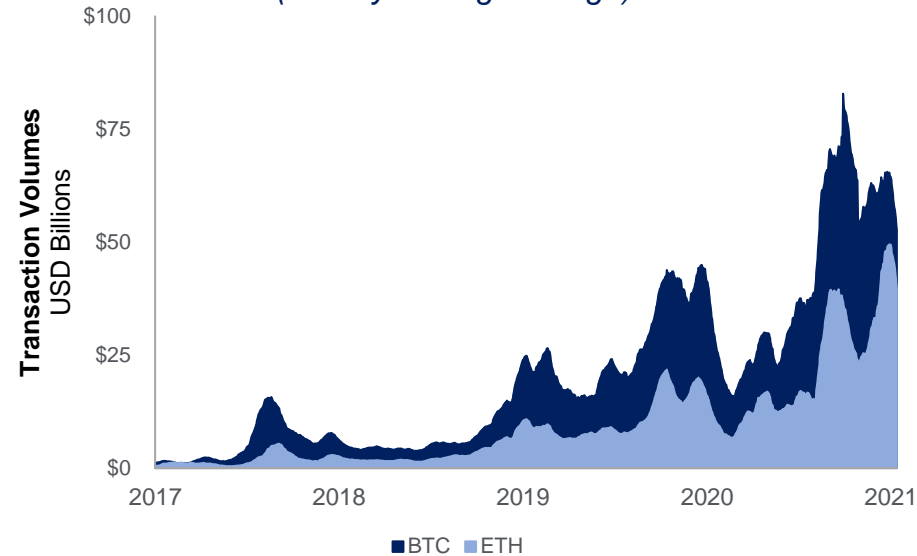
While both networks leverage blockchain technology, the Bitcoin network has remained largely transaction-focused, while Ethereum is used to build a new decentralized marketplace

## Key Features of the Bitcoin and Ethereum Blockchains

	Bitcoin	Ethereum
<b>Creation</b>	2008	2014
<b>Purpose</b>	Decentralized store of value	Decentralized applications
<b>Issuance Policy</b>	Disinflationary	Linear
<b>Supply Cap</b>	Yes (21 million)	No
<b>Block Reward</b>	6.25 coins	2 coins
<b>Transaction Throughput</b>	5-7 per second	10-15 per second
<b>Consensus Mechanism</b>	Proof of Work	Proof of Work (transition to Proof of Stake in process)

- **Different Purposes Drive Different Features:** Ethereum was inspired by the Bitcoin blockchain, but its overarching goal to build a development platform for decentralized applications resulted in a series of key differences, including facilitating programmability and a faster transaction throughput
- **Ethereum as Platform of Choice for Decentralized Commerce:** To create, host, and utilize Dapps, users pay “gas fees”, which represent the unit of computational effort to process a transaction on Ethereum

## Ether Transaction Volumes Approach Those of Bitcoin (30 Day Rolling Average)



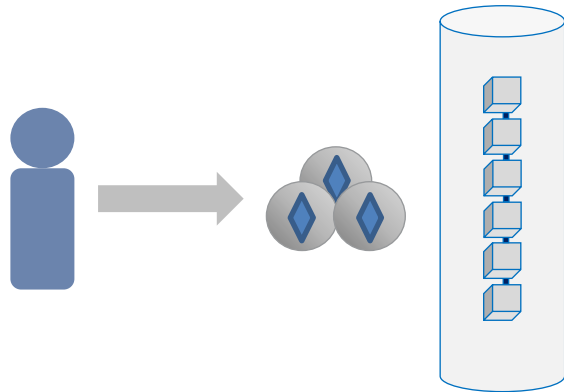
- **Ethereum Gaining Market Share:** Ether has gone from 0% market share to ~18% between 2014 and mid-June 2021. Transaction volumes grew ~3x from the end of 2019 to mid-June 2021 as applications built on top of the Ethereum platform motivate broad-based adoption<sup>1</sup>
- **Dapps Built on Ethereum Surge:** In June 2021, there were over 2,800 Dapps vs. fewer than 250 in 2017<sup>2</sup>

Footnotes & Sources in Appendix

# Transaction Verification via “Proof-of-Stake” (“POS”)

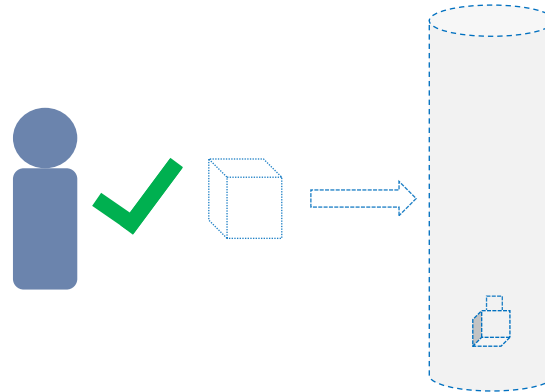
Ethereum is currently in the process of transitioning to a proof-of-stake consensus mechanism, whereby staking, or depositing, Ether is akin to mining under the proof-of-work approach

Staking



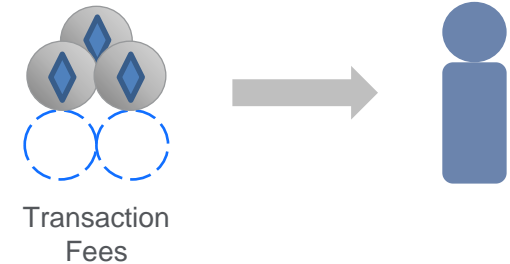
- **Staking:** In order to be a part of the Proof of Stake verification process, users must first stake a portion of their native coin holdings with the network. The probability of validating a new block is dependent on the amount of the token that is staked by each user. The minimum amount of cryptocurrency required to participate in the staking process is typically high – for ETH2, it stands at 32 ETH<sup>1</sup>
- **Delegation:** Individuals with lower amounts of cryptocurrency available can “delegate” staking to “staking pools” and receive rewards in proportion to the overall liquidity provided<sup>2</sup>

Verification



- **Verification:** Validators are selected based on the amount of cryptocurrency staked. Those who are selected attest proposed blocks, which are then added to the ledger. When a certain level of attestations has been reached, the transaction is recorded onto the ledger. Those who validate malicious blocks will lose a portion or all of their staked tokens in a process called “slashing”<sup>3</sup>

Reward

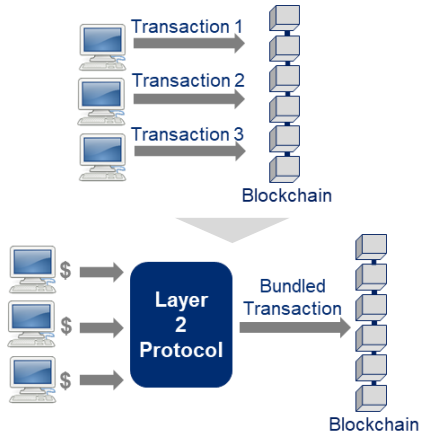


- **Rewards:** Verifiers receive rewards for aggregating transactions into blocks along with checking other validators’ work. These rewards consist of transaction fees and are disbursed in proportion to each validator’s stake in the validation pool<sup>4</sup>

# Varied Solutions Target Infrastructure Improvements

Initiatives underway to improve on the limitations of existing blockchain platforms might further encourage adoption of such technology building blocks

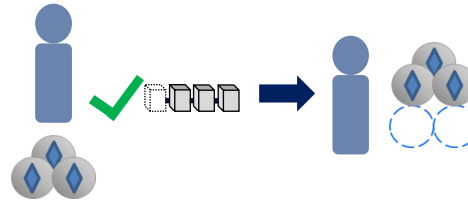
## Scaling “Layer 2” Solutions



- **“Layer 2” Solutions Improve Throughput:** Tech improvements built on top of the Bitcoin or Ethereum blockchain aim to address shortcomings such as the speed with which such networks can process financial transactions – solutions such as Ethereum Plasma look to increase the number of transactions per second to 2000-4000, while the Lightning Network can decrease Bitcoin settlement time by over 10x<sup>1,2,3</sup>

## ETH 2.0 Platform Upgrade

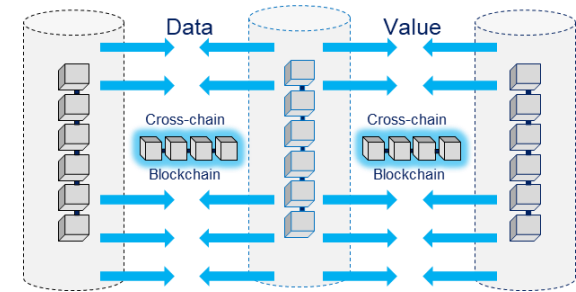
### Proof-of-Stake Validation Process



The Ethereum platform’s most significant architectural update to date is set to be completed by 2022, addressing 3 key gaps that have limited the platform’s use:

- **Scalability:** By leveraging a new “sharding” technology “to better disperse data processing and utilizing innovations in Layer 2 solutions, the ETH 2.0 platform may be able to process 100,000 transactions per second, improving fit for high-speed financial markets<sup>4,5</sup>
- **Security:** The updated protocol can disincentivize attacks by automatically destroying coins staked by malicious actors<sup>6</sup>
- **Sustainability:** Transition to a proof-of-stake transaction verification approach could reduce energy intensity by ~99.9%<sup>7</sup>

## Alternative Blockchain Platforms



While relatively early-stage, protocols are emerging as an alternative approach to building Dapps and transacting on Ethereum altogether:

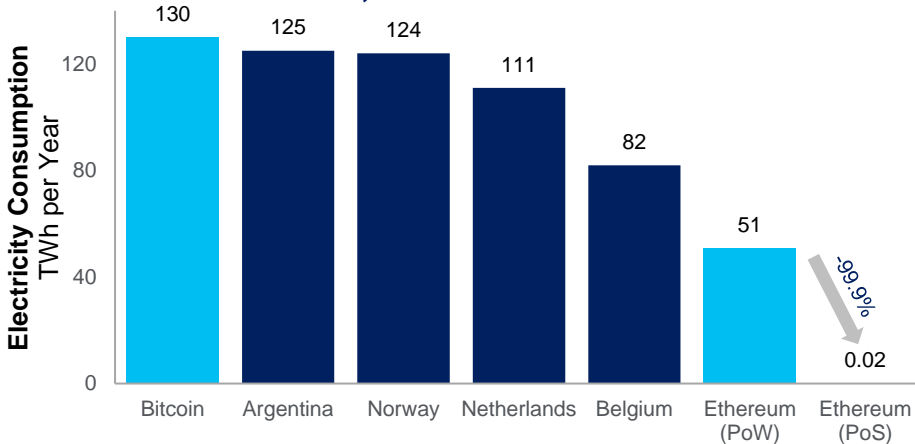
- **Cardano:** Operates smart contracts to build Dapps, but utilizes a proof-of-stake transaction verification approach<sup>8</sup>
- **Polkadot:** Enables the transfer of any type of data or asset including tokens across different blockchains<sup>9</sup>
- **Avalanche:** Seeks to build bridges between permissioned blockchains and decentralized Ethereum applications<sup>10</sup>
- **Binance Smart Chain:** Is compatible with the Ethereum infrastructure but improves on its speed, focusing chiefly on trading applications<sup>11</sup>

# Energy Usage Considerations

The energy intensity of crypto mining sparks growing concerns but a variety of initiatives aim to mitigate negative impact from high energy usage

## Crypto Mining Raises Environmental Concerns

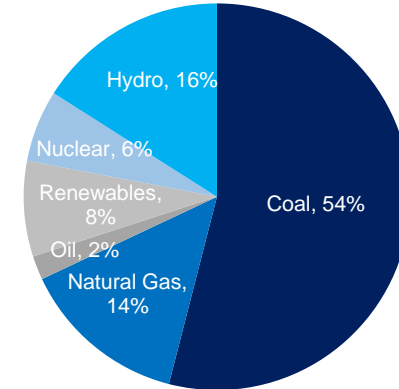
Annualized Electricity Consumption of Bitcoin, Ethereum, and Select Countries



- Bitcoin’s Substantial Energy Usage Seen as Adoption Roadblock:** PoW cryptos make up ~68% of total crypto market cap as of July 12, 2021.<sup>1</sup> One Bitcoin transaction uses ~80% of the energy consumed by one million Visa transactions.<sup>2</sup> However, miners usually use excess electricity in scarcely populated areas, and Bitcoin was found to consume less than half of the energy of gold mining and the top 100 banks’ data centers<sup>3</sup>
- Ethereum Consumes Less Energy:** Ethereum mining consumes ~1/3 of Bitcoin’s annual energy consumption, as it sets the average time to mine a block at 10-19 seconds compared to Bitcoin’s 10 minutes<sup>4,5,6</sup>

## Initiatives to Address High Energy Usage

Estimates of Energy Use for Bitcoin Mining



### Improve Present-day Energy Consumption:

- Shift to Renewable Energy Sources:** As of April 2020, over 60% of PoW mining occurred in China, being mainly powered by coal. As China bans crypto mining, miners might disperse to regions leveraging renewable energy, such as Iceland<sup>7,8,9</sup>
- Offsetting Crypto’s Carbon Footprint:** In May 2021, One River Asset Management has filed with SEC to launch a carbon-neutral Bitcoin ETF which uses carbon credit purchases to offset its holdings’ environmental impact.<sup>10</sup> Wrapped, a joint project by Tokensoft and Anchorage, announced the launch of eBTC, a carbon-neutral Bitcoin-backed asset<sup>11</sup>

### Re-architect the Platform to Use Less Energy:

- Transition to PoS Architecture:** The 2022 transition to the PoS model is expected to reduce Ethereum’s energy consumption by up to 10,000 times<sup>12,13</sup>

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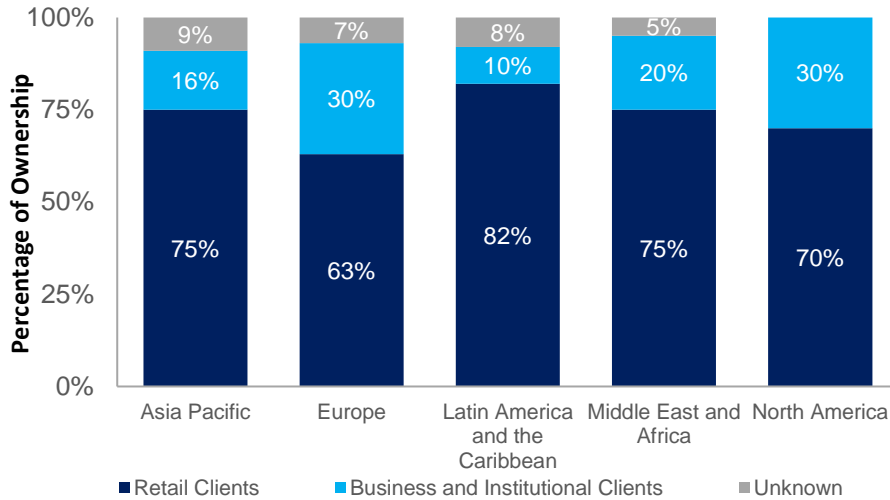
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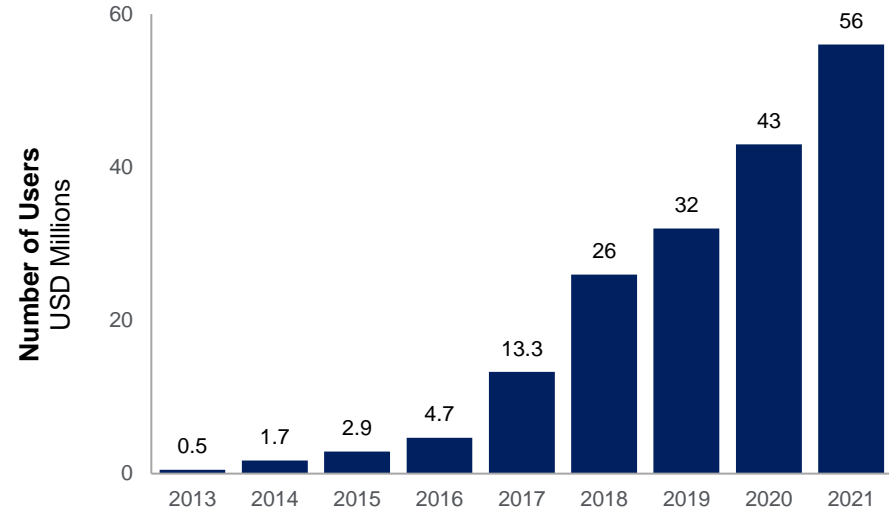
# Retail Participants Drive Activity in the Crypto Domain

Digital currencies emerged as a retail-dominated asset class, with more retail-oriented banking and investment offerings reaching the market

**Retail Dominates Bitcoin Ownership (2020)**



**Growth in Number of Coinbase Users**

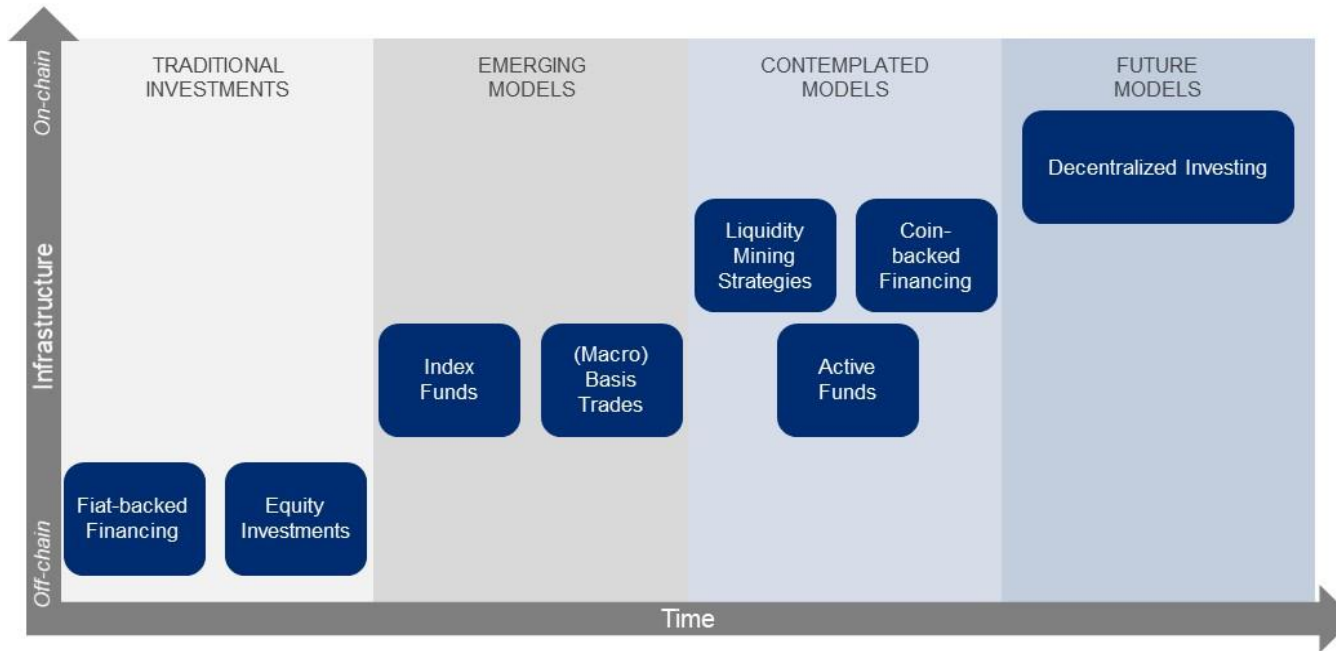


- Crypto Retail Banking Services:** Anchorage was the first crypto entity to receive a federal charter in January 2021; Kraken and Avanti were licensed as state-chartered digital banks in 2020<sup>1</sup>
  - Wealth Drives Crypto Investment Offerings:** Morgan Stanley and Wells Fargo began to offer crypto exposure to HNW clients via Bitcoin funds, while WisdomTree partnered with Gemini to include crypto within model portfolios<sup>2,3</sup>
  - Platform-as-a-Service Might Broaden Industry Adoption:** NYDIG partnered with FIS to provide custody, execution, and compliance tools as a service to financial institutions<sup>4</sup>
  - Rapid Growth of Users:** Coinbase saw its user base increase by ~65% since March 2020 as ~13 million users were added in Q1 2021 alone<sup>5</sup>
  - View of Bitcoin as Investment Prompts “HODL”-ing:** While Bitcoin was historically viewed as a speculative investment, after the 2018 crash, more individual investors began to hold Bitcoins as a potential store of value
  - Ownership Remains Concentrated:** ~38% of total bitcoin supply owned by those with at least 500 coins, but only ~23% held by investors with under 50 coins<sup>6</sup>
- Retail participation in the digital asset ecosystem faces excessive leverage – up to 100X, high market volatility – after reaching \$63,314 on April 15, the price of BTC declined 41% to \$37,332 by May 31, and lack of financial advice and regulatory oversight<sup>7,8</sup>

# Participation Models for Investment Managers

A growing share of mainstream institutional investors are seeking exposure to digital assets via traditional investment rails or passive offerings; future models might evolve to include more active offerings

Range of Participation Models for Investment Managers



Participating in digital assets markets requires a significant **operating model change**, including:

- 1) Adoption and understanding of **new technologies and infrastructure**
- 2) Capturing and developing new **investment insights** which leverage **on-chain data sets**
- 3) Acquiring **specialized investment expertise** (public markets *plus* VC-like investment experience *plus* cryptography knowledge)

Fiat-based enterprise-level financing or equity investments in companies with crypto exposure

Funds tracking the price of digital assets and trading spot and futures access instruments

Expansion into active investment strategies across protocol coins and yield farming strategies on emerging lending protocols and decentralized exchanges

Decentralized fund management models (e.g., TokenSets, Enzyme) with democratization of fund creation, automated rebalancing, full-visibility reporting



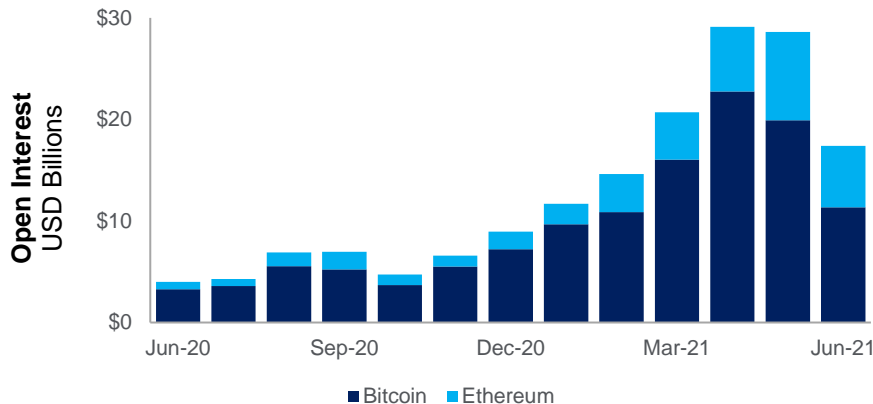
# Developments in Access Products and Derivatives

To date, most institutional investors have accessed the crypto market through a set of regulated investment structures that obviate the operational complexity of holding digital currencies directly

**Grayscale Bitcoin Trust AUM**



**Aggregated Open Interest of Bitcoin and Ethereum Futures**



## Crypto Access Products

- **Access Products Provide Price Exposure with No Operational Complexity:** In May 2021, total AUM of crypto exchange traded products reached ~\$59B globally, and total AUM of Grayscale’s various funds peaked at ~\$52B.<sup>1,2</sup> Competitor products are emerging, including from CoinShares and 3iQ each with a total of ~\$3.5B in AUM as of May 2021.<sup>3,4</sup> Besides access products, a small subset of retail investors are utilizing on-chain markets (e.g., Synthetix) for synthetic price exposure to cryptocurrencies
- **Diversified Offerings Emerge:** Grayscale and Bitwise offer funds backed by tokens including Filecoin (data storage), BAT (advertising), MANA (virtual reality), UNI (exchange)<sup>5,6</sup>
- **Established Players Enter the Space:** Invesco announced the creation of two ETFs with ~85% crypto-linked equities. Guggenheim filed an amendment to be able to gain Bitcoin exposure via the Grayscale Bitcoin Trust<sup>7,8</sup>

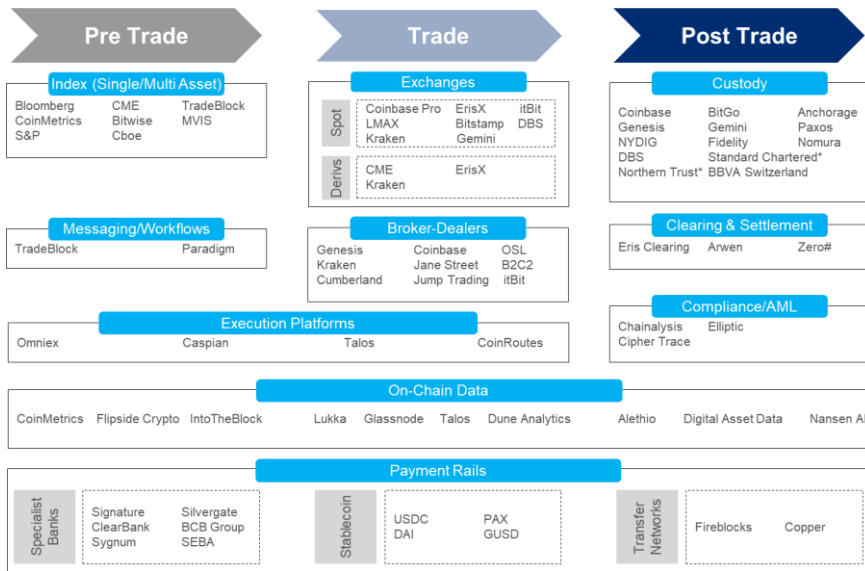
## Derivative Contracts

- **Greater Retail Participation Pushes Exchanges to Launch More Products:** Cash-settled futures volume have grown consistently, while physically-settled ones failed to gain traction. In June, the CME’s open interest reached ~\$1.5B, ~11% of the total global open interest of ~\$13B.<sup>9</sup> CME also launched Ether Futures and Micro Bitcoin Futures at 1/50 of the size of a regular contract to provide additional granularity to trading and risk management strategies<sup>10</sup>

# Trading Infrastructure is Maturing

The crypto market infrastructure is beginning to mirror traditional market infrastructure with defined pre trade, trade, and post trade services

## Institutionalization of Crypto Investing Ecosystem



## Professionalization of Trading Ecosystem

- **Exchange Enhancements:** Trading APIs based on FIX-protocols, execution algos, and risk analytics are included in “pro” offerings; co-location services are emerging to facilitate HFT and quant strategies. Development Bank of Singapore (DBS) announced plans for a crypto exchange in late 2020<sup>1</sup>
- **OTC Dealing Desks:** OTC execution has evolved from voice or chat to APIs, and now the overwhelming majority of spot trades are done electronically<sup>2</sup>
- **Hedging and Risk Management:** Crypto exchanges, such as OkEx, Binance, Bybit, and Huobi are adding derivatives offering. CME has also launched cash-settled Bitcoin futures in December 2017 and Ether futures in February 2021<sup>3,4</sup>
- **Prime Brokerage:** Aggregation of execution, clearing, and settlement and custody in a single wallet with specialized algos to offer “best execution” across fragmented liquidity pools; Reg T margin financing
- **On-chain Data:** On-chain data brings a unique level of transparency as every trade is added to the blockchain ledger
- **Data Governance and Compliance:** 3rd party data providers have developed internal policies and procedures and undergone SOC2 audits; new services such as performing “purity” tests on individual coins and assigning risk ratings are emerging as new best practices
- **Custody:** Multi-party computation (MPC) cryptography for custody ensures there is no single point of failure and that a complete private key is not held in any location at any one time. MPC helps reduce complexities of key management across different blockchains. BNY Mellon (2021)<sup>5</sup>, Northern Trust, Nomura, Standard Chartered, BBVA, and DBS announced plans to enter the space (2020)<sup>6,7,8</sup>

- **Investing Infrastructure Develops around Traditional Investing Lifecycle:** As more institutional investors begin to trade cryptocurrencies a supporting ecosystem is developing to mirror the traditional securities lifecycle

\* Announced, not launched. \*\* Some firms provide additional services than those listed above

Footnotes & Sources in Appendix

# On-chain Data Enables New Insights

The transparency of on-chain data can augment investment managers' portfolio and risk management capabilities with the ability to construct novel indicators

## Network Health

- **Circulating Supply:** Monitor cryptocurrency supply and level of liquidity, given minting rates and readily accessible supply
- **Active Addresses:** Track the growth in the number of market participants although one person can have multiple addresses
- **Hash Rate:** Measures the total computational power of miners for a proof-of-work blockchain, as indicator of the platform's overall security<sup>1</sup>

Helps assess the overall security of the blockchain, adoption rates, and the market dynamics of a particular cryptocurrency

## Behavioral Insights

- **Wallet Labelling:** Analytics providers are using trading patterns to infer and label addresses and examine how their purchasing patterns can be leading indicators for coin performance or changing market regimes (e.g., Nansen labels 85 million wallets to track the flow of Ether, stablecoins, and altcoins)<sup>2</sup>
  - Transferring coins from wallets to exchanges is typically viewed as a bearish indicator
  - Risk and compliance use cases to detect patterns associated with high-risk activities, outlier transactions, or OFAC-sanctioned addresses
- **"Smart Wallet" Tracking:** Follow wallets with profitable strategies

A wealth of behavioral indicators render possible a more nuanced understanding of the impact of market participants' behavior on crypto markets

## Broad Market Intel

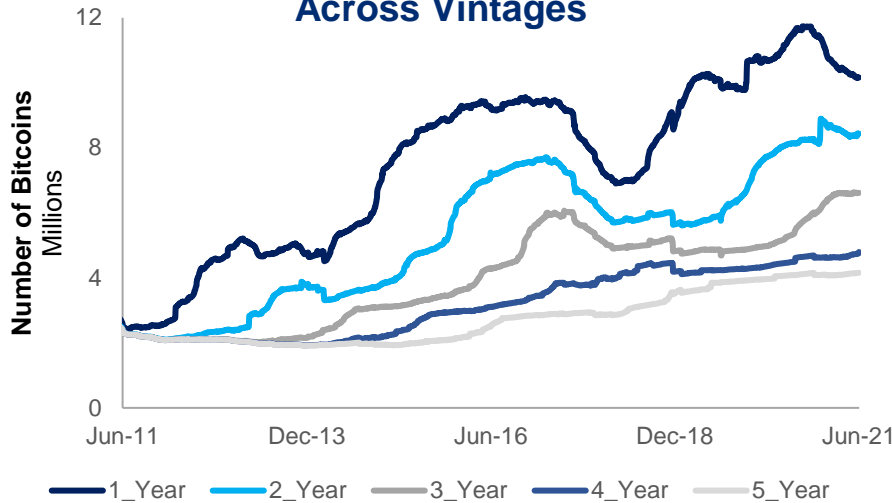
- **Relative Holding Period:** Data providers like Coin Metrics can track broader market trends like investment duration among wallets
- **Spent Output Profit Ratio:** Shows if investors are selling at a profit or loss by looking at the price of a specific crypto when a transaction was made into the wallet and out of the wallet<sup>3</sup>
- **Relative Unrealized Profit:** Utilizes price information of crypto when a transaction was made into a wallet and calculates the extent of unrealized gains in a market relative to a cryptocurrency's market cap<sup>4</sup>

Provides information on investor sentiment and composition, offering insight into potential future price movements and relative assessments across tokens

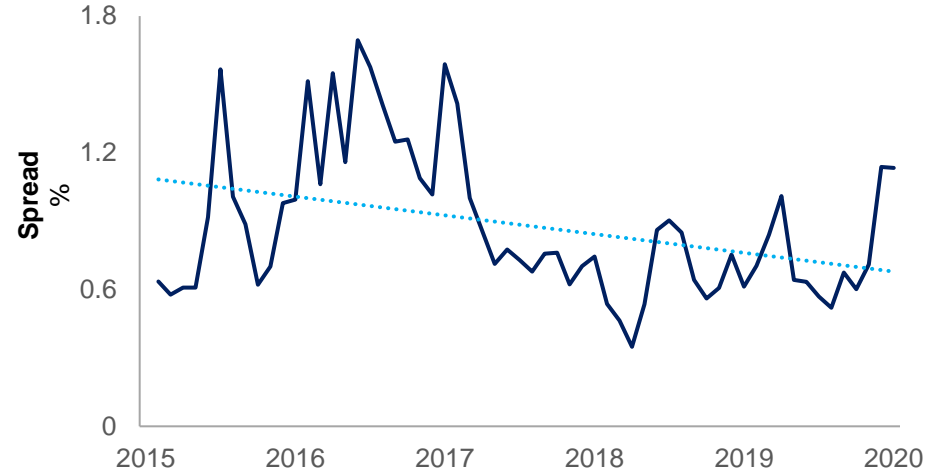
# Institutionalization Improves Market Structure

As larger institutional investors begin to trade digital currencies, there are early indications of improved market liquidity and depth

### Growth in Stationary Bitcoin Holdings Across Vintages



### Illustrative Bitcoin/USD Spread for 100 Bitcoin



## Increased Holding Size and Period

- **Larger Holding Size:** The number of investors that hold over 1,000 Bitcoin is growing, indicating more institutional players are entering the space<sup>1</sup>
- **Longer Holding Period:** Bitcoin is no longer seen simply as a short-term speculative play but rather as a long-term portfolio diversification tool. The percentage of Bitcoin not switching hands has increased across periods of one to five years, with over 4 million Bitcoin representing over \$152B (based on current pricing) that has not moved in over 5 years<sup>2</sup>

## More Advanced Execution Options

- **Record Flows to OTC Desks:** In early 2020, Bitcoin OTC trading volumes were already estimated to be around \$20B/day before the rally really got underway<sup>3</sup>
- **Narrowing Spreads:** OTC spreads for crypto trades have tightened from ~50-200 bps to ~5-10 bps on an 8 figure trade<sup>4</sup>
- **Emergence of Algos, Trade, and Risk Analytics:** Sophisticated analytics, smart routing, and algos are emerging to provide best execution

Footnotes & Sources in Appendix

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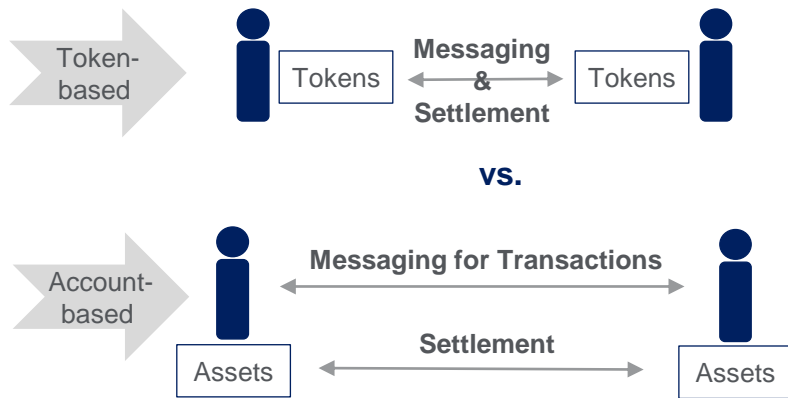
**Experimentation with New Payment Rails: Stablecoins and Central Bank Digital Currencies**

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# Digital Money as Alternative to Electronic Money

Digital money, which leverages a token-based structure, enables the asset and the transaction information to move in one data package, leading to real-time settlement

## Token-based System vs. Account-based System



- **Token Money as Digital Bearer Instrument:** Token-based money leverages digital signatures, while account-based forms are based on double entry bookkeeping. Paying with the former requires verifying that the token is authentic, while paying with the latter necessitates identity verification. The wallet is the investor’s unique “key” that matches the owner to the wallet address on the token issuer’s blockchain
- **Tokens Facilitate Simultaneous Messaging and Settlement:** Blockchain can move both the asset and the transaction information simultaneously in one data package. This is in contrast to traditional payment systems like SWIFT which operates as a messaging system to send the transaction information but not the actual value

## Digital Money vs. E-money

	Digital Money	vs.	Electronic Money
Form	Fiat-linked or Cryptocurrencies		Fiat-linked
Structure	Token-based		Account-based
Technology	Central Database or Blockchain		Central Database
Examples	Bitcoin, Ether, USDC		Electronic store of monetary value (e.g., PayPal), Commercial bank money

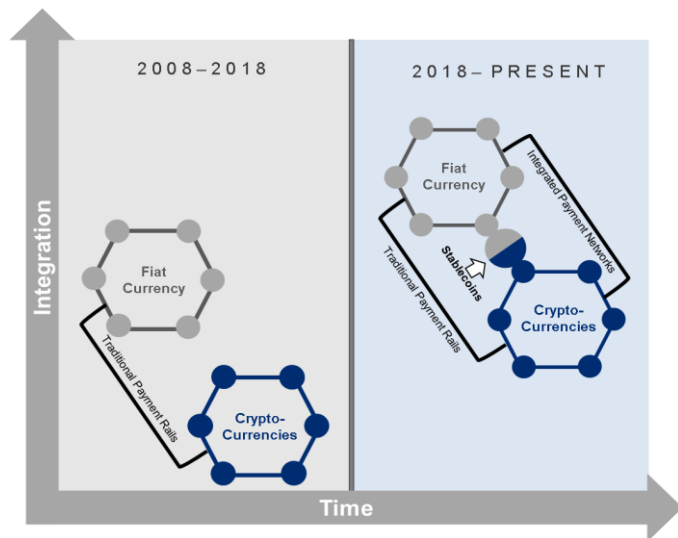
- **Digital Money can Utilize Permissionless or Permissioned Infrastructure:** Digital currencies exist on an an open “trustless” blockchain infrastructure, but central bank digital currencies which are digital versions of fiat money, would circulate in a closed, trusted ecosystem<sup>1</sup>
- **E-Money is “Traditional Money” with Digital Storage:** E-money (e.g., Google Pay, Stripe, AliPay) functions as an electronic store of monetary value issued by regulated institutions stored on a computer system<sup>2</sup>

Left Chart Source: Citi Business Advisory Services. Right Chart Source, 1 and 2: “Citi GPS: FUTURE OF MONEY: CBDCs, Crypto and 21st Century Cash”, Ronit Ghose and others, Citigroup, April 15, 2021, <https://ir.citi.com/6kaLOQ3DM84cUKeGSN0Vh2aTe7bi%2F%2BYrozLZ%2FuyAz5OHKIII0RFdq2LkPxTRKvFdnKelEwDGV9c%3D>

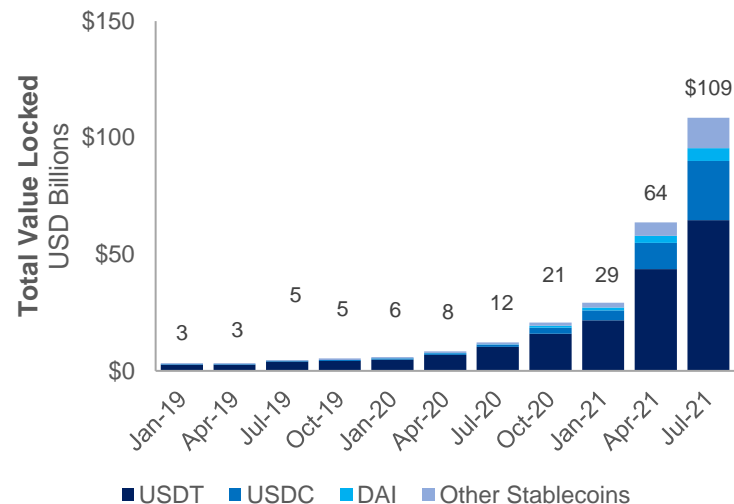
# Stablecoins Provide New On and Off Ramps

New types of collateral-backed cryptocurrency offerings help address volatility concerns by pegging the value of a cryptocurrency to a more stable reference asset

## Evolution of Fiat to On-Chain Payment Options



## Growth in Stablecoin Volume Accelerates



- **Regulatory Guidance Allows Banks to Issue and Transact Stablecoins:** In Jan 2021, the OCC authorized national banks and federal savings associations to make and accept payments in stablecoins<sup>1</sup>
- **More Favorable Capital Rules:** Unlike digital currencies, stablecoins are viewed as token-based representations of traditional assets – as such, the Basel Committee recommended their inclusion in the existing capital framework to the extent they demonstrate they are fully-backed by fiat reserves, along with bonds, loans, deposits, equities, and commodities<sup>2</sup>
- **Uncertainty Remains:** Tighter regulation proposed under the STABLE Act (US) and Markets in Crypto Regulation (EU)<sup>3</sup>

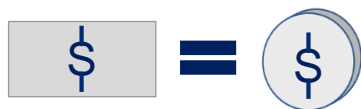
- **Make-up of the Stablecoin Market:** Tether (USDT) is currently the largest stablecoin with a market cap of ~\$62.6B; USD Coin, issued by Coinbase and Circle, has seen a ~6x growth in total value locked since the start of 2021.<sup>3</sup> Overall, total value locked in stablecoins reached a record during the Bitcoin sell off in May and June 2021<sup>4</sup>
- **Payments Players Seen Entering the Space:** PayPal is reported to be working with a third-party partner to launch its own stablecoin<sup>5</sup>
- **Key Concerns in Adoption:** Risks center on amount and type of reserves, which might impede ability to redeem at par, lack of FDIC insurance, and contagion from being held as collateral in DeFi<sup>6,7</sup>



# Stablecoin Approaches

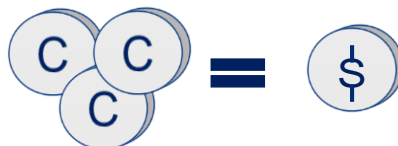
There are multiple methods to create a stable peg between the target asset and the stablecoin, ranging from 1:1 fiat collateralization to crypto-backed collateralization to no collateralization at all

## Fiat-Backed Stablecoins



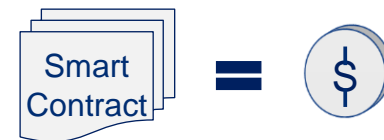
- Mint coins that are equal to the amount of the collateral deposited into the holding account and then burn such coins when they are redeemed and the currency is removed
- Examples: Tether/USDT, Paxos, TrueUSD, and Gemini Dollar

## Cryptocurrency-Backed Stablecoins



- Peg their value to the fiat currency itself and can utilize a 1:1 collateral ratio, but other cryptocurrency-backed stablecoins also look to peg their value to a stable asset such as the USD. These coins will over-collateralize and algorithmically balance the collateral to stay in line with the target asset
- Examples: DAI and Synthetix

## Non-Collateralized Stablecoins (Algorithmic)



- The algorithm charged with maintaining the peg to the stable asset increases the supply if the coin falls too far below the target or decreases the supply if the value rises too much
- Examples: Ampleforth, defiDollar, and Frax<sup>5,6</sup>

Overview

Considerations

- Although a 1:1 fiat peg reduces the chance of high volatility and fiat-backed stablecoins have a decreased chance of being hacked as no collateral is held on the blockchain, there is counterparty risk as a trusted party is needed to store the collateral<sup>1,2</sup>

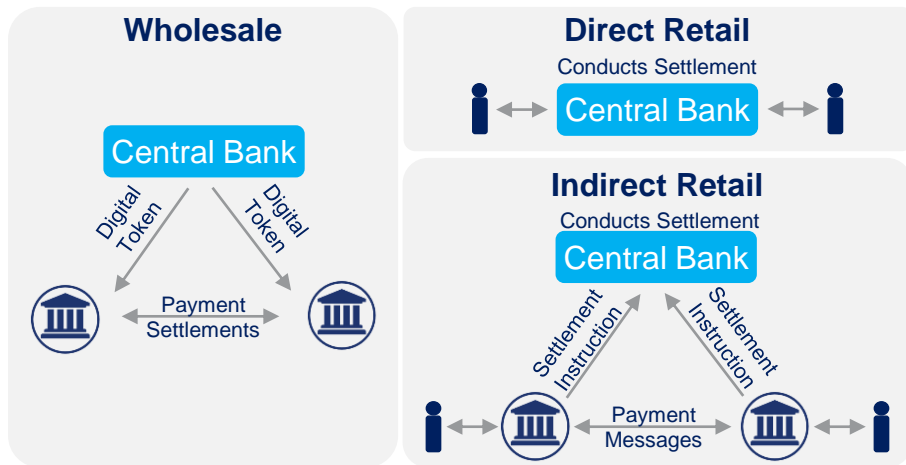
- Both the collateral and the coins are fully on the blockchain, enabling faster transaction speeds. There are no custodial requirements and there is no need to audit holdings as they are all transparent. However, this is a more complex instrument and it may provide less stability in the case of cryptocurrency volatility<sup>3,4</sup>

- Concerns about inadvertently amplifying directional momentum through the method of balancing the stablecoin based solely on supply and demand remains an obstacle in this model

# Emergence of Central Bank Digital Currencies (CBDCs)

A growing number of central banks are piloting the development of CBDCs as a way to improve their countries' monetary and payment rails

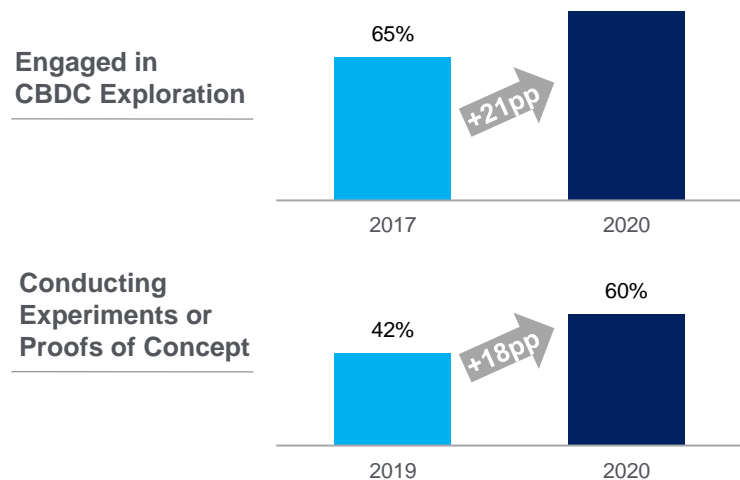
## Main Models of CBDCs



• CBDCs can be categorized into two main models:

- **Wholesale CBDC System:** Used for interbank payments and settlements with the goal to improve payment efficiency. Often compared to a Real-time Gross Settlement system built on distributed ledger technology (DLT)<sup>1,2</sup>
- **Retail CBDC System:** Serves as an alternative to cash and e-money. Commercial banks, firms, and individuals could all participate. Central banks may issue CBDCs to retail individuals directly or interface with those via commercial banks which then distribute it to each individual's accounts (indirect model).<sup>3</sup> More pilots are currently exploring setting up a retail CBDC system than a wholesale one

## Central Banks' Engagement in CBDC Development

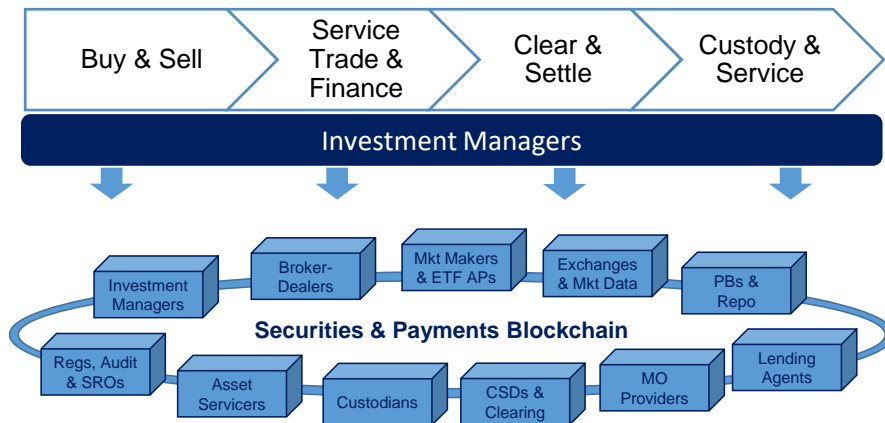


- **Accelerating Exploration of CBDCs:** In response to private payment networks such as Diem, a majority of national and supra-national monetary authorities are exploring CBDCs; despite 3 in 4 central banks expressing uncertainty or concern about legal authority to issue CBDCs, ~14% are progressing to pilots or development<sup>4</sup>
- **China in Advanced Trials of Digital Yuan (“DCEP”):** While not based on blockchain, as of November 2020, ~\$300MM equivalent of DCEP had been transacted across ~12,000 use cases.<sup>5,6</sup> A trial awards citizens coupons to take metro transportation.<sup>7</sup> Second-stage trials were launched in Hong Kong to evaluate cross-border applications<sup>8</sup>
- **US and EU Efforts are Earlier Stage:** The Boston Fed is partnering with MIT to study the practical implications of CBDCs, while the US Digital Dollar Project launched five pilot programs to test use cases in May 2020, and the EU has formed a task explore a digital Euro<sup>9,10,11</sup>

# Modernizing Traditional Financial Infrastructure

Blockchain technology has the chance to transform financial infrastructure which could lead to vast improvements in public markets, private markets, and the payments ecosystem

## Traditional Investment Lifecycle With Legacy Infrastructure



- **Initiatives to Facilitate Simultaneous Payments Underway:** Tokens combine payment and message movement into one transaction, with efforts underway to streamline existing payment rails. Monetary Authority of Singapore is exploring using DLT to improve payment and security settlement via Project Ubin<sup>1</sup>
- **Real Time Payments May Force Synchronization in Settlement Infrastructure:** Having real-time settlement of payments at an atomic transaction level and maintaining the sequential and multi-step securities processing approach would magnify system risks and friction, likely leading to an eventual alignment

## Blockchain-based Payments and Security Processing Initiatives

### • Payments

- **Project Stella:** Joint initiative between the ECB and the bank of Japan to research using DLT for payment and security delivery<sup>2</sup>
- **Partior:** JPMorgan, DBS, and Temasek launched a new tech company to develop a blockchain platform to digitize commercial bank money on the back of Project Ubin sponsored by the Monetary Authority of Singapore<sup>3</sup>

### • Public Markets

- **PilotR:** EU-led program to experiment with securities market infrastructure based on DLT<sup>4</sup>
- **Project Helvetia:** Swiss SIX digital exchange performed a proof of concept for exchanging whole CBDCs for the settlement of tokenized assets<sup>5</sup>
- **Project Ion:** A DTCC initiative to explore using DLT to increase the speed and reduce the costs associated with equities settlement from T+2 to T+1<sup>6,7</sup>

### • Private Markets

- **Project Whitney:** DTCC initiative to create a new infrastructure to facilitate private market transactions using tokenization and public blockchains<sup>8</sup>

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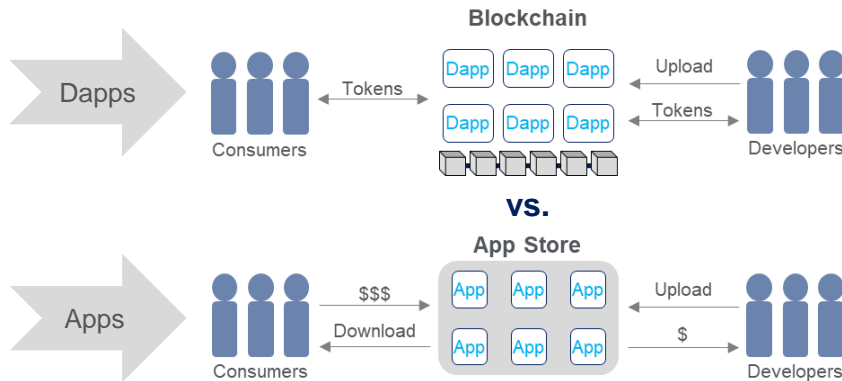
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# Decentralized Applications (Dapps)

Dapps, applications built on top of a decentralized infrastructure, are giving rise to new economic participation and governance models

## Dapps vs. Apps



**Dapp-issued Tokens Generate Network Effects:** Each Dapp requires users to pay for services in the platform coin (e.g, ETH). Some Dapps (e.g., Compound and Aave) also issue their own tokens, which entitle token owners to either claim a service or participate in the governance and growth of the Dapp

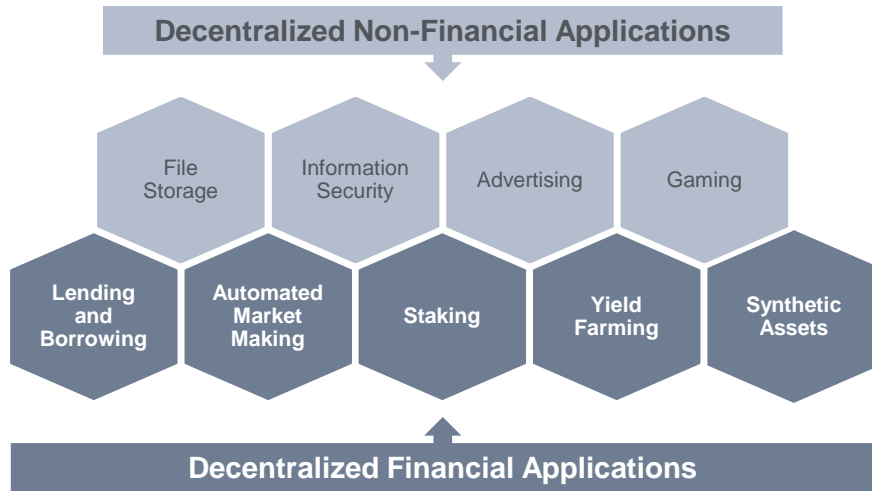
- **Dapps Enable a Wide Variety of Financial and Non-Financial Applications:** Dapps perform a similar function to regular apps, but are built on top of a peer-to-peer platform instead of being hosted by a corporate platform<sup>1</sup>
- **The Majority of Dapps are Built on Ethereum:** Most Dapps leverage the ERC-20 code standard that enables standardization and interoperability within the Ethereum architecture, defining and automating the implementation of development policies and rules. Notably, alternative development platforms (e.g., Cardano, Polkadot, Avalanche) are emerging to improve speed and security. Certain protocols (e.g., Binance Smart Chain) are specializing in financial applications<sup>2</sup>

**Some Dapps Evolve to Become Decentralized Autonomous Organizations (DAOs):** DAOs are organizations run according to rules set by algorithms, and for functions that cannot be accomplished by code alone, they are governed and administered by the members of the organization. Individuals join the organization by purchasing the governance token issued by the DAO or are invited into the DAO through the award of tokens. For example, MakerDAO is well-known lending and borrowing project governed via the DAO construct

# Emergence and Growth of Decentralized Finance (DeFi)

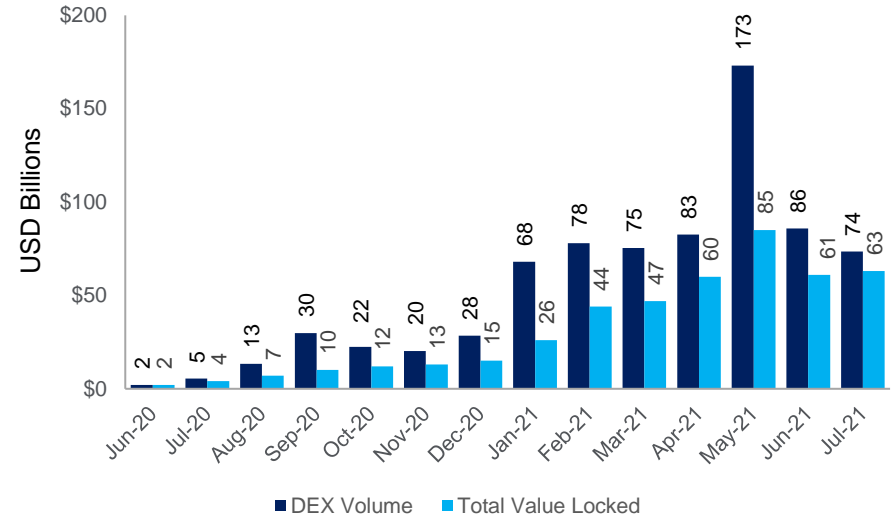
The joint emergence of development platforms and Dapps is allowing for a completely new peer-to-peer marketplace of financial services to take shape

## Emergence of Decentralized, Peer-to-Peer Economy



- DeFi Takes Shape as Peer-to-Peer Platforms Aim to Reinvent Financial Marketplaces:** Decentralized autonomous financial networks have emerged to emulate traditional financial functions and services and build net new capabilities or extend interactions to individual investors previously only available to institutions. As of September 2020, over 95% of the Ether staked in decentralized applications was directed to DeFi apps<sup>1</sup>

## Growth in DeFi Activity



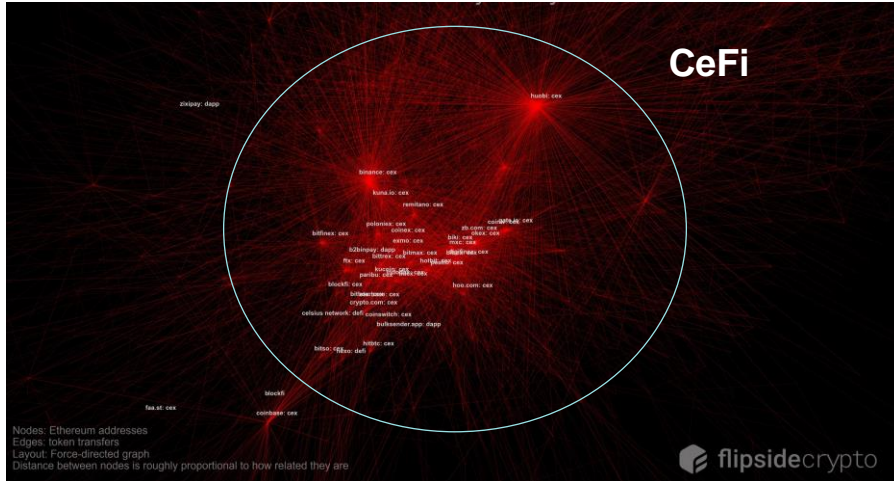
- DeFi Growth Accelerates Post-2020 “DeFi Summer”:** Total Value Locked (TVL), which measures the value of coins posted as collateral into applications run by smart contracts, indicates that DeFi increased by over 60x YoY through May 2021<sup>2</sup>
- Decentralized Exchanges Capture Increased Volumes:** As of June 2021, trading volume on DEXs increased 40x since June 2020.<sup>3</sup> Trading volume reached an all-time high in May 2021 due to the surge in crypto volatility<sup>4</sup>



# More Financial Activities Shift to the Decentralized Realm

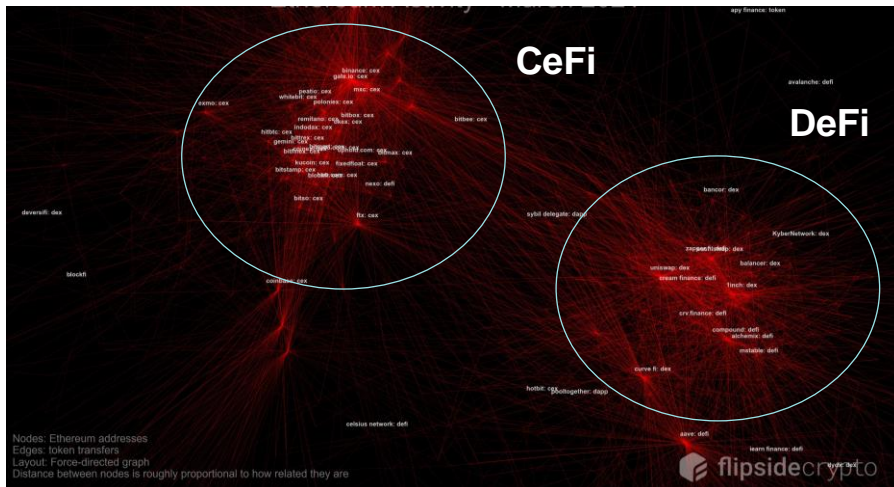
Network analysis points to a growing share of transactional activity moving from centralized financial marketplaces to the decentralized realm

Ethereum Activity – May 2020



- **Pre-2020 Transactional Activity Concentrated on Centralized Exchanges:** Prior to 2020, Ether transactions primarily took place on centralized finance (CeFi) platforms such as Coinbase, Huobi, and Binance, signaling that market participants largely viewed Ether as an investment
- **More Financial Activities Shift to Decentralized Platforms:** An expanding menu of distributed financial applications is capturing growing retail and institutional interest with the Ethereum platform underlying growth in DeFi apps including automated market makers, lending and borrowing protocols, derivatives markets, and others. In April 2021, DeFi accounted for ~40% of the Ether moved on the Ethereum blockchain YOY, significantly above the 7% over the previous 12 months.<sup>1</sup> As of May 2021, almost 23% of the total Ether supply was held by smart contracts and not individual or institutional wallets<sup>2</sup>

Ethereum Activity – March 2021



- **Broader Adoption of Peer-to-Peer Models:** The number of DeFi users on the Ethereum blockchain increased ~50% in Q1 2021, reaching over 1.75 million users.<sup>3</sup> In May 2021, Ether trading volumes surpassed \$600B, ~60% more than Bitcoin volumes<sup>4</sup>

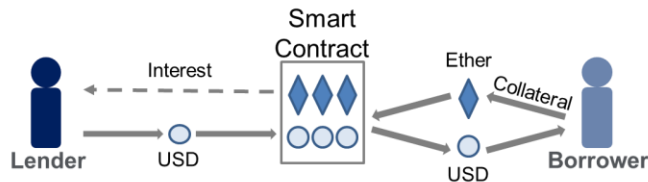
Footnotes & Sources in Appendix



# Variety of DeFi Models Expanding

While many DeFi models emulate traditional financial services, others create new models of financial engagement

## Lending and Borrowing

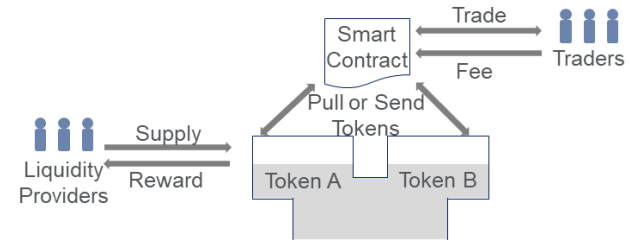


Peer-to-peer network facilitating lending and borrowing is akin to traditional financial services except with **smart contracts acting as the intermediary and holding collateral until the loan term has ended.**

Two parties located anywhere in the world can enter an automated lending agreement<sup>1</sup>

- **Overcollateralization:** Lending is usually over-collateralized (often 150-200%) to account for volatility<sup>2</sup>
- **Flash Loans:** Hyper quick uncollateralized loans with capital returned within one transaction block

## Decentralized Exchanges



**Peer-to-peer cryptocurrency exchanges** operate without a central intermediary

- **Order Book Model:** Functions according to a traditional order book model
- **Automated Market Maker Model (AMM):** Creates a market through liquidity pools. Liquidity providers are incentivized to put assets in the pool to create stronger liquidity for less liquid markets. AMMs use a formula to set prices instead of relying on buyers and sellers<sup>3</sup>

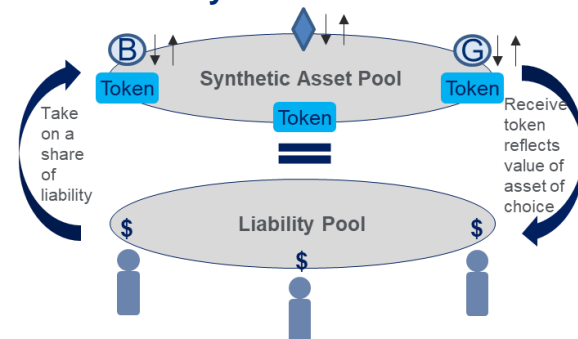
## Yield Farming



The model whereby **users deposit coins in the liquidity pool of different protocols to receive a portion of the fees charged by protocols.** Yield farmers move their crypto around the DeFi lending and borrowing ecosystem in search of higher yields<sup>4</sup>

- **Liquidity Mining Approaches:** Protocols can also distribute a separate token which can enhance users' yield beyond earned fees. Yield farmers can use leverage to enhance returns

## Synthetic Assets



**Exposure to crypto currencies and even popular stocks** like Google and Tesla

- Users can purchase tokens which can be staked on the platform in exchange for receiving a multiple of the dollar value of the underlying asset. The collateralization ratio can be more than 6x<sup>5</sup>

# Digital Token Taxonomy

Mapping the emerging digital token ecosystem highlights five key categories of tokens critical for participating in the digital realm

## Digital Token Classification and Use Cases

### New Assets

#### Payment Tokens

Serving as **unit of account and medium of exchange**, payment tokens facilitate transactions on the blockchain network. They are often viewed as currencies, though sometimes also attributed additional purposes such as store of value

Examples: Bitcoin, Bitcoin Cash, Litecoin

#### Non-fungible Tokens

Tokens that **represent the ownership of a unique digital asset** and register that ownership on the blockchain

Examples: Bepple art token, NBA TopShots

#### Utility / Facilitative Tokens

Utility tokens are **used to access products or services provided by a Dapp**. Purchasing such tokens is typically required by the Dapp in addition to covering platform transaction costs via platform tokens

Examples: Uniswap, Aave, Synthetix

### Operate With Dapps

#### Governance Tokens

Governance tokens **provide protocol users the ability to vote on changes to the underlying protocol**. Some utility tokens also provide governance rights

Examples: MKR (MakerDao), COMP (Compound)

#### Platform Tokens

**Means of payment for using a network's developer tools** and its user base computational power to build new applications on top

Examples: Ethereum, Cardano, Solana

*Altcoin growth has significantly outpaced that of Bitcoin year to date with the price of popular altcoins like ETH and ADA growing over ~215% and ~691% respectively compared to BTC price growth of ~18%<sup>1</sup>*

1. "Global Cryptocurrency Charts", CoinMarketCap, Accessed July 6, 20201, <https://coinmarketcap.com/charts/>

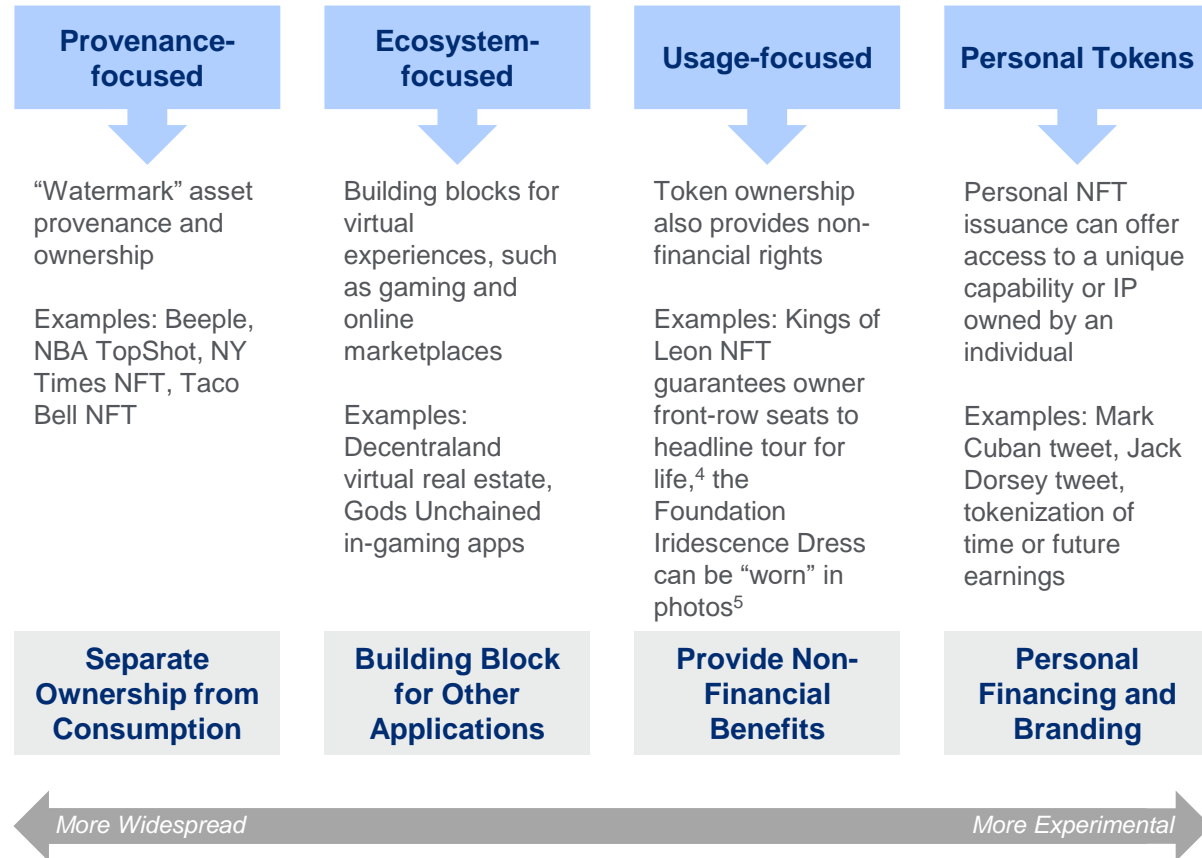
# Non-fungible Tokens (NFTs) as New Way to Create Assets

Though tracing back to 2017, NFTs have seen a surge in 2021 leading many to view the rise in experimentation as a signpost for expanding the definition of what constitutes an asset

## Overview and Key Developments

- **Unique digital assets**, which cannot be swapped for other assets and whose ownership and other associated rights are embedded into a distributed ledger infrastructure
- NFTs generated ~ **\$1.5B in transaction volume in Q1 2021, with 91% of projects focused on art or collectibles**<sup>1,2</sup>
- Three protocols are typically used: Ethereum (token standards ERC721 and ERC1155), Flow (Dapper Labs), and Wax
- The largest marketplace is currently OpenSea, with other marketplaces including Rarible, Nifty Gateway, and Zora
- Emerging attempts at **fractionalization of NFTs** (e.g., Niftex) or at **displaying physical versions** (e.g., Superchief Gallery in NYC<sup>3</sup>)

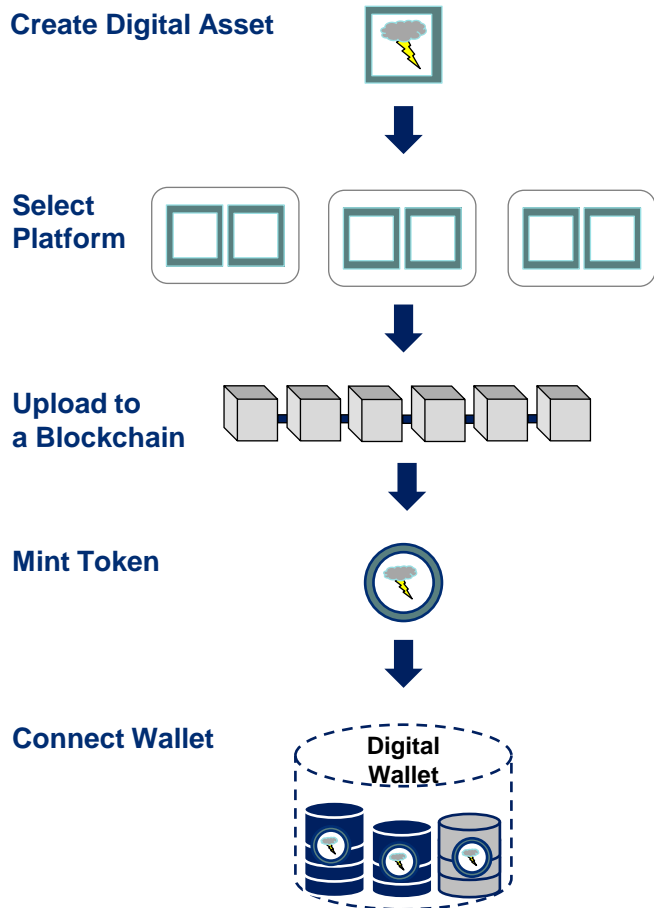
## Spectrum of NFTs



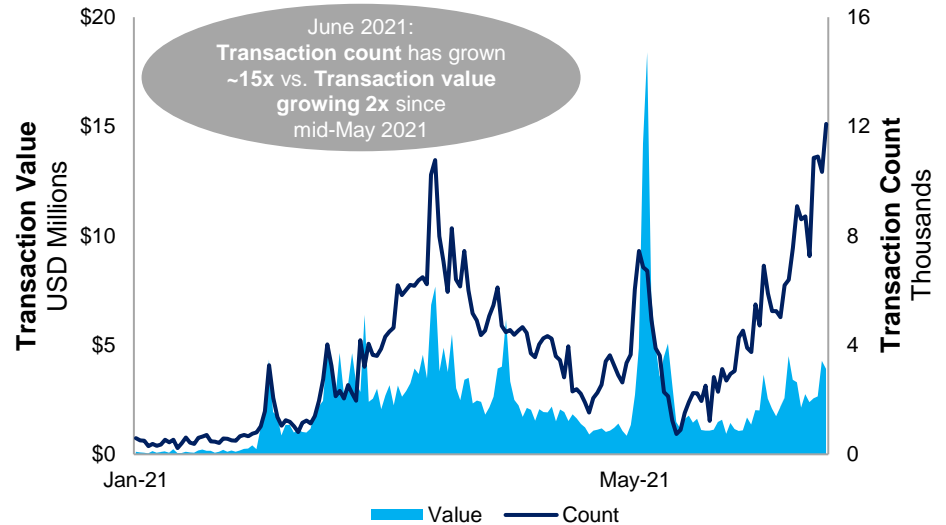
# NFTs See More Adoption

In addition to the potential for price appreciation, characteristics such as ease of issuance, subsequent traceability, and accompanying utilization rights, are driving adoption

## Issuing a Non-Fungible Token (NFT) is Easily Accessible



## Growth in Transaction Number vs. Value of NFTs on OpenSea Marketplace

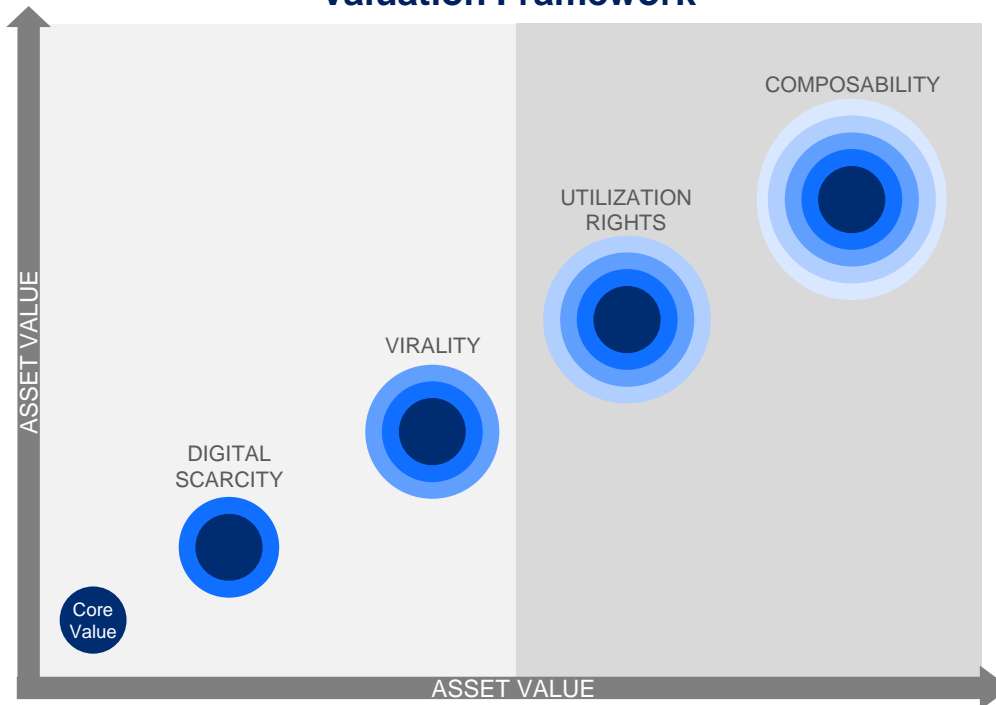


- Growth in Number of NFT Transactions Could be Leading Indicator for More Mainstream Adoption:** The NFT transaction count on prominent NFT marketplace OpenSea in June 2021 surpassed the rally in May 2021, while transaction volume recovered to only ~20% of the May level.<sup>1,2</sup> Gaming- and art-related NFTs such as Axie Infinity and CryptoPunks largely accounted for the increased transaction count.<sup>2,3</sup> Additionally, traditional companies such as American Express are incorporating NFTs in their rewards programs which might further adoption<sup>4</sup>

# New Digital Asset Valuation Framework

Using crypto-economy models, investors may update their valuation approach to incorporate new attributes that are critical to valuing and trading digital exposures

## Developing a New Digital Asset Valuation Framework



## New Attributes Factor In Valuation Analysis

- **Digital Scarcity:** Proprietary assets are likely to be seen as more valuable and assets tendered in the digital realm should be unique
  - **Virality:** The continued exchange or growing utilization of the asset amplifies the value, generating more interactions, data, and community interest
  - **Utilization Rights:** The ability to establish ownership of an asset brings with it an ability to retain or grant utilization rights embedded in smart contracts
  - **Composability:** Inspired by DeFi protocols, this refers to the ability to expand the usage of an asset beyond its originating network and make it interoperable and portable, thus enabling it to be utilized across multiple domains
- **Network Value Increases Asset Value:** Asset value increases with greater network usage and vice versa, due to the accumulation of digital exhaust and community effects

# DeFi Advantages and Risks

While DeFi models could support automation and transparency in financial services, significant concerns remain around leverage and complexity, both reinforcing regulatory uncertainty

## Advantages

- **Programmability:** Smart contracts enable an unprecedented level of automation, bringing the potential to streamline not just individual processes but also whole functions
- **Composability:** DeFi's open-source architecture allows protocols and applications to utilize each other's code and interact with each other more easily. This enables a Lego-like functionality where protocols can be stacked on top of one another to create new products and services. Participants can therefore move and deploy capital easily across platforms
- **Transparency:** As DeFi operates on the blockchain infrastructure, all information including pieces of code, data on previous transactions, and flows are available to market participants, opening the potential for better monitoring, surveillance, and compliance process. As an example, collateral can be tracked real-time, as it is held on-chain

## Risks and Challenges

- **Lack of Regulatory Clarity:** Regulatory uncertainty and fragmentation remain key concerns across the institutional community
- **Concerning Levels of Leverage and Limited Liquidity:** Market participants cite sub-optimal liquidity and significant leverage as critical roadblocks. Debt levels can be extremely high, with some crypto exchanges allowing up to 100x leverage on futures contracts<sup>1</sup>
- **System Complexity Amplifies Systemic Risks:** As Dapps and protocols are closely interconnected, including owing to the composability features, there is a higher risk that a technology or financial shock to one part of the system might reverberate through the system and negatively impact applications unexpectedly. For example, a major pullback in the price of Ether could have a significant effect on the entire DeFi system as most DeFi applications depend on the price of Ether. This would also cause DAI to be under-collateralized, which would in turn stress additional financial applications as many DeFi applications also rely on the supply of the DAI stablecoin<sup>2</sup>

## Footnotes



# Additional Footnotes

## Key Innovations in Digital Assets

Top Left Chart Source: Citi Business Advisory Services

Bottom Left Chart Source: Citi Business Advisory Services

Top Right Chart Source: Citi Business Advisory Services

Bottom Right Chart Source: ETF AUM (Q2 2021), Citi Business Advisory Services' analysis of Broadridge Global Market Intelligence; Hedge Fund AUM (Q2 2021) Source: HFR Industry Reports © HFR, Inc. Q2 2021, [www.hfr.com](http://www.hfr.com); Digital Currencies Market Cap (Aug 2021), CoinMarketCap, Accessed Aug 24, 2021, <https://coinmarketcap.com/charts/>; Digital Currencies Market Volume (Aug 2021), CoinMarketCap, Accessed Aug 24, 2021, <https://coinmarketcap.com/charts/>; Brazilian Real (Aug 2021), Bloomberg based on BIS, Accessed Aug 24, 2021; Indian Rupee (Aug 2021), Bloomberg based on BIS, Accessed Aug 24, 2021

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## Emergence of Central Bank Digital Currencies (CBDCs)

Left Chart Source: “Citi GPS: FUTURE OF MONEY: CBDCs, Crypto and 21st Century Cash”, Ronit Ghose and others, Citigroup, April 15, 2021, <https://ir.citi.com/6kaLOQ3DM84cUKeGSN0Vh2aTe7bi%2F%2BYrozLZ%2FuyAz5OHKIII0RFdq2LkPxTRKvFdnKelEwDGV9c%3D>

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Chart Source: Citi Business Advisory Services

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## **Emergence and Growth of Decentralized Finance (DeFi)**

Left Chart Source: Citi Business Advisory Services

Right Chart source: DEX Trading Volume, Accessed August 24, 2021, <https://duneanalytics.com/queries/4424/8622>; DeFi TVL; Accessed August 24, 2021, <https://defipulse.com/>

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Top and Bottom chart source: Proprietary analysis provided by Flipside Crypto published with their permission

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Top Left Chart Source: Citi Business Advisory Services

Top Right Chart Source: Citi Business Advisory Services

Bottom Left Chart Source: “The Yield Farming phenomenon - Lending Crypto to earn interest”, Blockchain Simplified, July 27, 2020, <https://blockchainsimplified.com/blog/the-yield-farming-phenomenon-lending-crypto-to-earn-interest/>

Bottom Right Chart Source: Citi Business Advisory Services

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Left Chart Source: Citi Business Advisory Services

Right Chart Source: NFT Transaction Value and Count on OpenSea, Dapp Radar, Accessed June 22, 2021 <https://dappradar.com/>

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