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# Risks inherent within various models of decentralised crypto networks

*A framework for an objective discussion about the level of decentralisation in crypto networks and risks to true decentralisation*

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**Abstract** Decentralisation is not a binary concept, but a spectrum. This paper presents a starting point for an objective discussion about the levels and risks related to decentralisation across ecosystem, consensus protocol, tokens and network distribution attributes for the largest networks of today — such as Bitcoin, Ethereum, Solana, Cardano, BNB Smart Chain, Polygon, Polkadot,

Uniswap, Compound, AAVE, Curve, MakerDAO and Lido. The paper argues that it is imperative to identify, mitigate, monitor, measure and manage risks for a successful decentralised network to meet its business objectives, and emphasises that the true degree of decentralisation and risks in the network are shaped by the strengths and weaknesses of the design, and further affected by market forces creating a wide range of operational, technological, financial, strategic, legal and regulatory, reputational and business risks, among many.

**Keywords:** *decentralisation, digital assets, risk management, decentralised autonomous organisations, DAOs, governance, centralisation, blockchain*

## **INTRODUCTION**

The crypto ecosystem prides itself on blockchain's unique distributed ledger technology, promising to make business models and processes more secure, cheaper, faster, inclusive and permissionless.

Frequently, the value of this inherent distribution of the blockchain is conflated with a discussion of 'decentralisation'. Yet distribution focuses on the architecture of a network, and decentralisation concerns decision-making power. Just because a network is distributed does not mean it is decentralised.

Excessive, centralised control over governance, economic, management, processing and legal attributes is not only a threat to operation, security and scalability but also an impediment to mass adoption of the technology. The degree of decentralisation across these attributes should be defined more explicitly in a spectrum and needs to be evaluated to capitalise on the benefits for the current and future participants in crypto networks. The true degree of decentralisation and risks in the network are shaped by the strengths and weaknesses of the design, and are further affected by market forces creating a wide range of operational, technological, financial, strategic, legal and regulatory, reputational and business risks, among many, that need to be managed. Introducing objective measures about the degree of decentralisation, especially with comparable examples from non-crypto fields, provides clarity and supports interest in the adoption of efficiencies that blockchain promises. Also importantly, the level of decentralisation within a network changes over time due to the gravity of market forces and emerging and changing risk profiles, illustrating the malleable nature of the concept. The paper explores

four different dimensions of centralisation for the largest crypto networks of today: ecosystem, consensus protocol, tokens and network distribution.

## **KEY TAKEAWAYS**

There are a number of key messages in the paper. First, decentralisation aims to share control and power with every individual participant of the network, reducing the level of trust and dependency on a central entity, eliminating a single point of failure. Second, decentralisation is not binary, but a spectrum. Third, a comprehensive risk management strategy must be employed in order to identify, mitigate (if not possible to eliminate during design and programming), monitor, measure and manage the risks facing the network and maintain the desired level of decentralisation. Fourth, neither Bitcoin nor Ethereum are fully decentralised across the dimensions of ecosystem, consensus protocol, tokens and network distribution. Fifth, since the end of 2021, mining pools for Bitcoin have increased significantly in centralisation. Sixth, the governance structures of decentralised finance (DeFi) through decentralised autonomous organisations (DAOs) are similar to decision making in traditional companies. However, since it currently comes with select stakeholders with concentrated voting rights to determine future actions, it is still far from realising the marketed level of decentralised collective decision making. Seventh, a decentralisation level is dynamic. The responsibility for designing and promoting a more decentralised ecosystem model lies with founding teams and investors at inception, and then follows adoption and market forces.

## BACKGROUND

Satoshi Nakamoto published a White Paper on 28th October, 2008, officially inventing the basis of a distributed register integrated into a cryptographic peer-to-peer system. Nakamoto's paper promised that Bitcoin would build a new layer of decentralised trust in response to the distrust in political and financial institutes stoked by the 2008 financial crisis, led by centralised governmental control and oligopolistic banking systems.<sup>1</sup>

Although the technology of blockchain reaches back to the 1990s, Bitcoin is the first decentralised network with a cryptographically-linked block design containing transactional data and a robust governance structure. The database of every transaction ever made on the Bitcoin network is transparent and immutable, and, more importantly, the governance and maintenance of the database is distributed. The most impressive innovation of the network is that participants do not need to know or trust each other to interact; the transactions can be automatically verified and recorded by the network's nodes through cryptographic algorithms without the involvement of any third party, central authority or human. Through solving mathematical puzzles, known as proof of work, the miners accurately validate the transactions and safeguard the ledger from tampering, even if some nodes are unreliable, dishonest or hostile, negating the need for a central governing body. When Bitcoin launched, ownership was concentrated in the inventor, Nakamoto, to help secure the network. However, since then, ownership has been changing hands over time.<sup>2</sup>

The shift from trusting people to trusting code has many more use cases than the decentralised digital store of value. As an irreversible and tamper-proof public record repository for documents, contracts, assets, liabilities and valuables, the blockchain can be used to merge information and instructions in several applications. The best examples today are smart contracts introduced by Ethereum in 2015 and used by multiple blockchains to execute pre-programmed automated processes and decisions.

Looking at the global ecosystem in July 2023, there are about 20,000 types of different blockchain-based digital tokens and networks with different functionalities and utilities.<sup>3</sup> Some of them are publicly accessible, such as Bitcoin and Ethereum,

allowing everyone to participate, and others are private, functioning in a closed ecosystem with a fixed number of participants. Many of the coins are modified or improved versions of Bitcoin or Ethereum, presenting alternative features, enhancements and use cases. Still, only a few of them can match the level of security of proof of work, which, unfortunately, comes with high electricity costs and environmental concerns for Bitcoin.

While decentralised networks introduce a new type of organisation, they are not immune to the wide range of risks that face traditional organisations across different industries. Risks faced by decentralised networks utilising blockchain technology include, but are not limited to, operational risks, technology risks, financial risks, strategic risks, sustainability risks, legal and regulatory risks, and reputational risks, among others. These risks play a role in affecting the level of decentralisation of the network.

One area that is covered in this paper is DeFi protocols. These protocols are centred on the creation of financial tools and services using smart contracts. They promote self-custody, empowering individuals to directly engage with lending, investing, staking, exchanging, and insurance protocols, thereby eliminating the need for intermediaries.<sup>4</sup> The decentralised distribution of voting power among network users is achieved by governance tokens allowing holders to directly participate in decision-making processes through majority voting techniques. DeFi protocols may similarly face many of the risks outlined above that have an impact on the DeFi protocol's decentralisation level (Figure 1).

The blockchain industry is still at an early stage of development, having been established by Bitcoin in 2008, becoming fully emerged with the launch of Ethereum in 2015, and significantly expanded by DeFi protocols in the summer of 2020 and non-fungible tokens (NFTs) in 2021.<sup>5</sup> Yet, these have strong potential to break hierarchical structures apart and challenge the conventional function of centralised institution control and intermediary authority. Many users believe conventional business workings will be replaced by blockchain-based services, creating decentralised and open-source platforms that better organise and advocate stakeholder interests and give

## DIGITAL ASSETS

### Store of value

#### Definition

A store of value is any commodity that would retain purchasing power over time or can be turned into an asset, including items such as stocks, bonds, real estate and intellectual property.

Utility for users: can be exchanged, saved or retrieved.

#### Selected Token



Bitcoin

### Financial Crypto Assets

#### Definition

Decentralised finance, or DeFi, uses emerging technology to remove third parties and centralised institutions from financial transactions. Stablecoins, software, hardware and applications are the components of DeFi.

Utility for users: access to voting rights, discounted transaction fees, exclusive coin offerings, and more.

#### Selected Tokens



MakerDAO



AAVE



Curve



Lido



UniSwap



Compound



Binance Coin

### Infrastructure / Smart Contract

#### Definition

Layer 1 – Underlying blockchain architecture, scaling solution (ie sharding) / Layer 2 – Lies on top of Layer 1, smart contract platform (ie decentralised applications, or dApps)

Range of functionality and utility: ie NFT marketplaces, Decentralised finance (DeFi).

#### Selected Tokens



Ethereum



Solana



Cardano



Polkadot



Polygon

Figure 1: Selected digital assets (July 2023)

individual users a voice.<sup>6</sup> If all of these promises hold, the distributed ledger technology is a logical complement to the internet and a fundamental building element to empower programmers and entrepreneurs to create an enhanced iteration of the World Wide Web, generally referred to as Web3. As the focus is placed on the value of blockchain, it is important to understand the degree of actual decentralisation among existing blockchains.

## DECENTRALISED VERSUS CENTRALISED SYSTEMS

To understand why decentralisation at a system infrastructural level is important, two network structures were compared and individual benefits identified. However, doing so requires distinguishing

between ‘decentralised’ and ‘distributed’. Even though a blockchain is inherently distributed in its architecture, it is not automatically decentralised in its decision making/governance.<sup>7</sup> A DAO leverages blockchain token ownership to allow anonymous participants with voting power to shape the project’s future development collectively. Compared to a centralised network, where stakeholders and identities are widely known, transactions within a DAO are opaque to the public, centralising the degree of trust in the network’s authorities (Figure 2).<sup>8</sup>

### Decentralised networks

#### Number of decision makers

The fundamental goal of blockchain is the decentralisation of registers with no control by any



**Figure 2:** Decentralised network

central authority. The data should be stored in a distributed ledger network so that no one has the authority to make adjustments without governance. The network is supposed to be open to every entity and maintained by a network of distributed computers, allowing no censorship of the system.

### *Power of decision makers*

Another factor of a ‘decentralised’ network is the number of decision makers. The more decision makers, the more decentralised the system becomes. Of course, decentralisation is also related to the power of the decision maker. If there are 1,000 decision makers and one has 90 per cent of the power, decentralisation will be limited. In the end, it is the distribution of power that counts. Power in decentralised systems is mapped by so-called consensus mechanisms, known as proof of work (PoW), proof of stake (PoS), and delegated proof of stake (DPoS).<sup>9</sup>

### *Power dynamic of decision makers*

In blockchain, the creator of a given token can specify various parameters in the creation process, which can, for example, influence the number of tokens available for a specific time period. Once the mechanism is in place, it cannot be altered or manipulated.



**Figure 3:** Centralised network

### *Advantages and disadvantages*

A purely decentralised system does not require trust in anyone else since every network member has their own data stored. These copies are instantly updated and shared with each entity, so no ‘data silo’ (common in centralised systems) can exist, having no risk of data being lost or incorrectly entered. Decentralisation reduces the vulnerabilities of a system and is less prone to failure and corruption, with a lower development cost. By optimising the distribution of resources, decentralisation can even improve performance and consistency, reducing the probability of catastrophic failures. Disadvantages of the network can be that performance decreases as the network grows, data is lost during transit and there are high maintenance cost due to deployment difficulties on multiple servers (Figure 3).

### **Centralised systems**

#### *Number of decision makers*

Centralised systems are physically under control and have a simple underlying principle, where the entire system consists of a central entity handling most of the functions (this entity is called a ‘master’), and

many client nodes synchronised with the global entity. The authority can easily impose its own will, which is an advantage for efficiency but also creates a single critical point of failure affecting the entire system. Central systems must work very efficiently for many users, and if the server is switched off, the whole system collapses.

### *Power of decision makers*

In most systems, a single central unit serves and coordinates all the other nodes in the system. All client nodes are highly dependent on this single authority. Checks and balances can be placed on the central authority but will never fully eliminate its power.

### *Power dynamic of decision makers*

The creator of the system can make adjustments at any given time without the consensus of participants; only one server node exists.

### *Advantages and disadvantages*

While a centralised distributed ledger significantly mitigates risk within highly regulated sectors such as financial services, it concurrently amplifies the security risk associated with a single central system. The secure management and servicing of server and client nodes are facilitated by their fixed locations. These servers operate on dedicated resources, utilising memory and CPU cores to maintain a stable and predictable network environment. The central authority holds direct control, enabling the prompt initiation of system updates. Given that there is only one machine requiring updates, this model allows for streamlined node detachment procedures, further enhancing system manageability.

## **PROOF OF WORK VERSUS PROOF OF STAKE**

Consensus mechanisms are used in decentralised networks to establish agreements among its users. They secure private information in the context of payment and currency systems and guarantee transactions' reliable, traceable and unalterable processing. PoW and PoS are the two main processes

on which blockchain technology is based. By definition, whether the network utilises PoW or PoS will have a significant impact on the specific technology risks faced by the network.

### **Proof of work**

Bitcoin relies on a PoW system. Miners are assigned a particular cryptographic puzzle, where the mining capacity depends on computational power. The miner who completes this puzzle fastest is permitted to add the appropriate block to the blockchain and is compensated with new tokens.

Depending on the size of its hash rate (the computing power required to mine a block), the network can be more decentralised or less. Other factors influencing the level of decentralisation can include how distributed the hash rate is among different entities and where these entities are geographically located, relying on countries' individual restrictions and regulations. History has already shown stressful examples that PoW networks are exposed to legal and regulatory risks in that, if mining operations are concentrated too heavily in individual countries, regulatory actions affecting mining in that country could potentially jeopardise the available computing power and, therefore, the security of the network.

### **Proof of stake**

The requirement for miners is eliminated in the case of PoS. The environmental concerns with PoW networks are not relevant for PoS networks and, therefore, the sustainability risks are significantly lower. Rewards for the work are not given to those who are the fastest to solve the puzzle, but, rather, on chance. A draw is held among all network participants and adding the block to the chain applies to whoever 'wins'. Today's networks use different mechanisms for staking distribution, often favouring big validator pools offering the highest stake. For example, with Ethereum, rewards are paid to encourage good conduct for affirming and proposing blocks, with punishments given for undesirable inaction or dishonesty. Crypto slashing is used as a PoS tool triggered by node's downtime and double signing. The 'slashers' (other node providers) can

unite and work together to confiscate the staked Ethereum of maliciously acting validators or kick out bad actors, ultimately being a threat, making the network more vulnerable to increased centralisation.

Decentralisation in PoS is determined by the count of stake pools or validators and distribution of token supply across validators. The more entities and (globally) distributed validating nodes a network has, the higher the decentralisation. A higher number of independent validating nodes would make it less likely for a group of nodes with shared interests to take control of the network. Furthermore, the share of circulating token supply staked to the network is relevant. The higher the percentage of token supply staked, the harder it is to disrupt the network, but staking power concentration can also be a security risk, thus, a small number of validators gaining majority control of the network. To secure decentralisation in the foundation phase of a network, the initial token or coin distribution should be evenly allocated among all participants. A disproportionate share of initial coins or tokens given to insiders creates concentration issues, the potential for collusion, and leaving control of the network development in the hands of a small controlling entity. Therefore, PoS networks may face significant strategic risks in the initial token economics design decisions. Networks should aim to design themselves in a way that minimises the risk of centralisation occurring based on these initial token distribution decisions. Accessibility through mining hardware and cheap electricity has become ever harder, and a high minimum stake, access fees and a long application process to become a network validator are detrimental to the decentralisation of a network.

## **BITCOIN AND ETHEREUM MINING AND DEVELOPMENT COMMUNITIES**

Bitcoin was the pioneer of the crypto industry, offering a scarce and secure alternative to traditional currencies and assets. There will never be more than 21m Bitcoins issued, making it the first finite digital resource, which, by design, cannot be copied or replicated. The last Bitcoin will be mined in approximately 2140.<sup>10</sup> It has gained vast interest from investors and the public, with the coin in 106m

digital wallets globally. As of July 2023, around 16,496 active full nodes (computers keeping a full copy of the blockchain) are distributed globally, making the network highly secure, having never been hacked since its existence.<sup>11</sup> A new block is closed about every 10 minutes and the top two validator pools control 53 per cent (33 per cent — Foundry USA, 20.3 per cent — AntPool) of the hash rate, which historically peaked at 230 exa-hashes (quintillion) per second.<sup>12</sup>

The constantly growing blockchain community wanted additional functionality beyond receiving, storing and transmitting Bitcoin; in 2013, five years after Bitcoin's founding, a team of innovators led by Vitalik Buterin launched Ethereum, offering more programmable flexibility in an open-source setting. Today, Ethereum has the largest developer ecosystem with approximately 5,835 monthly active contributors, with total commitments of 836 in the month of June 2023, well ahead of Bitcoin with 996 monthly active developers.<sup>13</sup>

Hundreds of apps have been built with Solidity, Ethereum's core programming language, which is Turing complete, meaning it can implement any form of computational reasoning or 'smart contracts'.

According to pre-set terms and conditions, smart contracts automatically execute transactions. They are decentralised but, like ordinary blockchain transactions, comparatively inefficient (in terms of latency and throughput) like centralised computing. For example, a decentralised application (dApp) is made up of multiple smart contracts interacting with one another, being highly secure through full transparency, compared to traditional financial software, where the code is governed and visible to authorities only.<sup>14</sup> The code is publicly accessible and replicated thousands of times in public ledgers that collectively make up the blockchain, where smart contracts do not need the trust engendered by individuals, nation-states or institutions. However, only a small number of people can analyse and verify smart contracts, making them similar to conventional financial systems, where consumers often rely on centralised organisations or individuals as auditors. This reliance on code exposes the network to a considerable amount of technology risks. Buggy or exploitable code could lead to significant negative consequences for the network

and a robust audit and risk management strategy must be employed to mitigate these risks. As of June 2023, there are about 646,127 active validators. A new block is closed in about every 12.15 seconds and the top four staking pools control 52.9 per cent of all Ethereum supply.<sup>15</sup>

## **DEVELOPMENT CONTROL**

The management of the code base of Bitcoin, through the file-hosting platform GitHub, is one of the most centralised aspects of the network. Only selected individuals named ‘core maintainers’, who are not officially specified, can edit the 646,000 lines of code, including protocols like the monetary cap and how transactions are processed. These individuals have access to a pretty good privacy (PGP) key used to sign or encrypt all forms of communication to the network.<sup>16</sup> Anyone can access the publicly stored code and propose changes, which are reviewed and verified by the maintainers. If changes prove to be beneficial for all network participants, they are signed with the PGP key and merged into the master branch as a new version, making them identifiable and transparent to the community. If a scenario plays out in which the PGP keys are leaked and malicious code is deployed to the network, the maintainers would create new PGP keys and ask the community to use an uncorrupted version of the code.

In 2018, a bug was detected by a core developer, allowing attackers to create new Bitcoin, inflating prices and causing distrust in the network among users. The developers decided to keep the bug a secret, fixed the bug, and urged users and miners to upgrade to the patched software. This highlights a vulnerability in the blockchain: if a maintainer successfully implements malicious code (hidden in an update but verified by the community) the next update would result in a contradiction in the code. If all maintainers holding the PGP keys unite to alter the code negatively, in theory the community could remove the maintainers and assign new ones. Past events have shown that if some community stakeholders have different motivations and disagree with the future development of Bitcoin, they can fork the blockchain and create adjusted versions of the code, ie BTC Cash or BTC Gold. This reliance

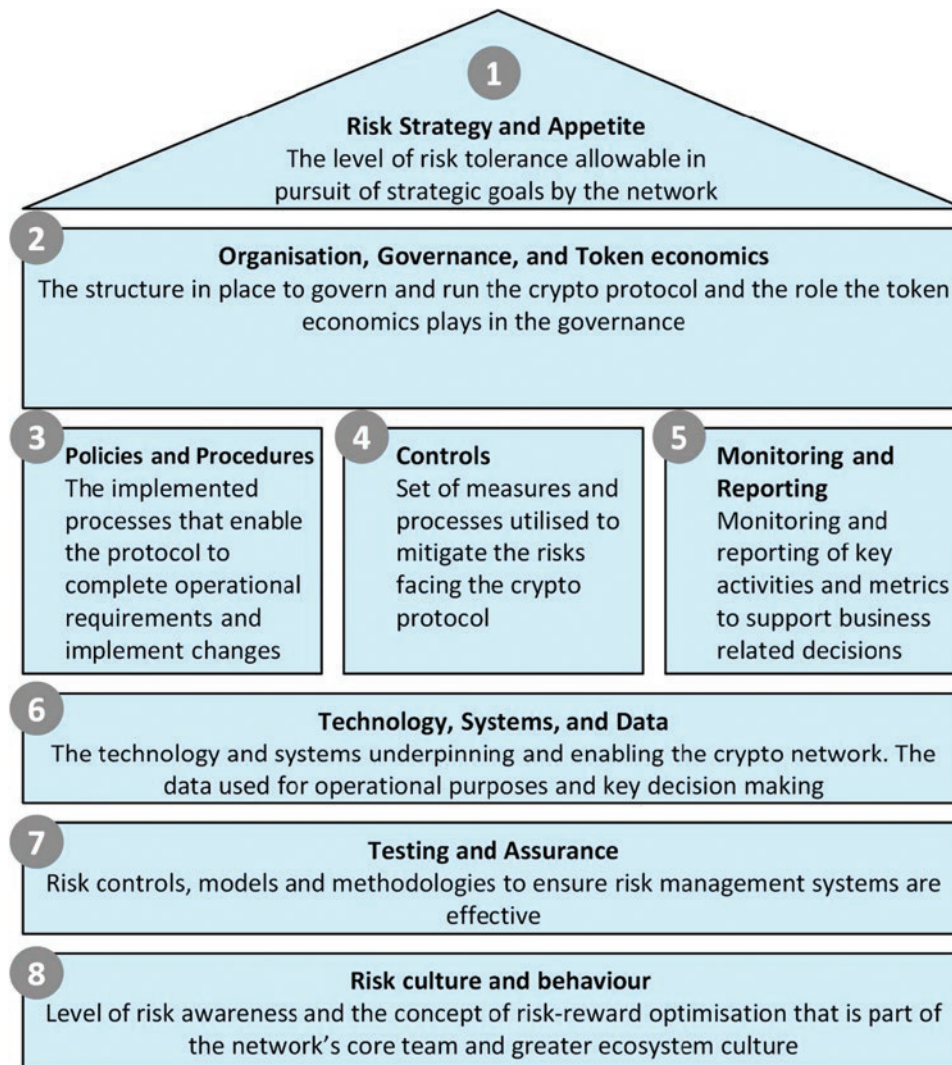
on individuals to control PGP keys highlights key-person risks and operational risks facing the network and its participants. Protocols must consider how to limit the operational risks associated with key management without hindering its ability to make operationally-necessary updates and changes.

In Ethereum, core protocol changes and development control are subject to a governance structure.<sup>17</sup> There is on-chain and off-chain governance. ‘On-chain’ means that proposed protocol changes are decided by a stakeholder vote (governance token holders) on the blockchain, often used in DAO structures. Ethereum uses ‘off-chain’ governance, meaning changes are discussed in an informal process in social discussions, and when the stakeholders reach a consensus, the changes are implemented. To make the protocol changes beneficial for all participants, each discussion involves: Ether holders, application users, application/tooling developers, node operators, Ethereum improvement proposals (EIP) authors (users who propose changes as Ethereum improvement proposals), validators and protocol developers, making the governance mechanism relatively decentralised. The protocol change, which should have been discussed in working groups beforehand, can be initiated by anyone in the community, proposing a core EIP (including the documentation of changes) that is presented, iterated and tested until it reaches a state where all stakeholders are satisfied with the future network adjustments and approved. The timeline is highly dependent on the individual proposal, spanning from days to years. Straightforward technical changes will be implemented quickly compared to trade-offs affecting different stakeholders. Each stakeholder can decide whether to implement the changes or not, maximising security and allowing no single entity to make malicious changes to the complete network.

## **RISK MANAGEMENT**

Crypto networks, as is the case with traditional organisations, must manage the risks facing the network. Traditional risk management frameworks can be leveraged by crypto networks, given that





**Figure 4:** Crypto networks enterprise risk management framework

they face many of the same risks as traditional organisations and need a comprehensive enterprise-wide risk management in place. However, the framework must also be significantly tailored to cover the novel components of a decentralised crypto network built on blockchain technology.

Figure 4 introduces a generalised crypto networks enterprise risk management framework that can be utilised to develop or assess a crypto network's holistic approach to risk management, starting with risk identification processes at the most granular level (including specifically how it manages the decentralisation risk it faces, which clearly helps to

reduce power concentrations with increased decentralisation but also creates new challenges for governance) all the way to articulating network level risk appetite in aggregate, and all necessary controls, monitoring, organisation, processes, technology, culture and governance in between.

## FOUR DECENTRALISATION DIMENSIONS

Decentralisation is the core promise of crypto networks. Yet, as explored in the previous sections, that decentralisation is not always inherent. There

are multiple qualitative and quantitative measurements with diverse dimensions to evaluate the decentralisation of blockchain networks. This paper presents four dimensions to consider the decentralisation levels: ecosystem, consensus protocols, tokens, and nodes and validators.

### **Ecosystem**

The network's value is directly related to its users and the unique addresses engaging in transactions. Within this dimension, the adoption of Bitcoin and Ethereum is analysed by active addresses and transaction amount over time and price, evaluating whether the network continues to grow, thus increasing decentralisation.

### **Consensus protocols**

Identifies some of the forces driving consensus power concentration in Bitcoin and Ethereum and compares centralisation in the top five smart contract networks with the help of the Nakamoto Coefficient.

### **Tokens**

Allocation of tokens across addresses over time is essential for a decentralised system, also affecting the governance structure of decentralised finance protocols through decentralised autonomous organisations. Bitcoin and Ethereum's token distribution are analysed and decentralised finance networks are compared to traditional companies with the help of the Herfindahl-Hirschman Index (HHI), using the Compound protocol as an example.

### **Network distribution**

Depending on countries' individual crypto policies, the global distribution of nodes and validators is important to guarantee a secure, efficient and censorship-resistant network. For this paper, a global overview of node and validator providers was created, examining the most significant threats and dependencies for Bitcoin and Ethereum.

These dimensions are affected by the different risks facing the network, including those mentioned

at the beginning of this paper. When considering the decentralisation level of the network, these risks must be evaluated to understand how this decentralisation might change based on a manifestation of these risks and the risk management strategies employed by the network to mitigate them. By utilising the crypto networks enterprise risk management assessment framework mentioned above, networks can seek to have the right framework to evaluate the risk posed to their network and develop mitigation strategies accordingly.

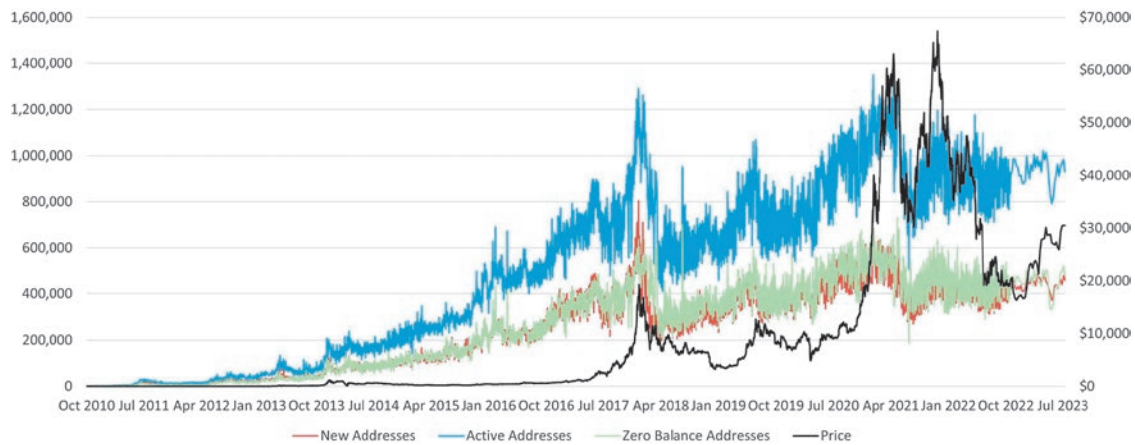
### **Ecosystem**

For Bitcoin the number of addresses and its price have been highly correlated over time. However, since the beginning of 2022, the number of addresses stayed constant, with prices vastly decreasing. Bitcoin adoption, by far at the highest levels of all coins, increased 113 per cent on average per year, contributing to the global crypto market growth of over 880 per cent in 2021, driven by Asia, Africa and Latin America, especially by individual investors.<sup>18</sup> In emerging markets, Bitcoin is used as an instrument for saving, money transfer or business transactions. In the US, the adoption rate was driven by investment interest and payment platforms, such as PayPal, which opened the crypto ecosystem to the wider population. Today, around 20 per cent of Americans hold cryptocurrencies, which is around 66 million people. Additionally, 36 publicly traded companies own Bitcoin, making up 1.107 per cent of total holdings globally.<sup>19</sup>

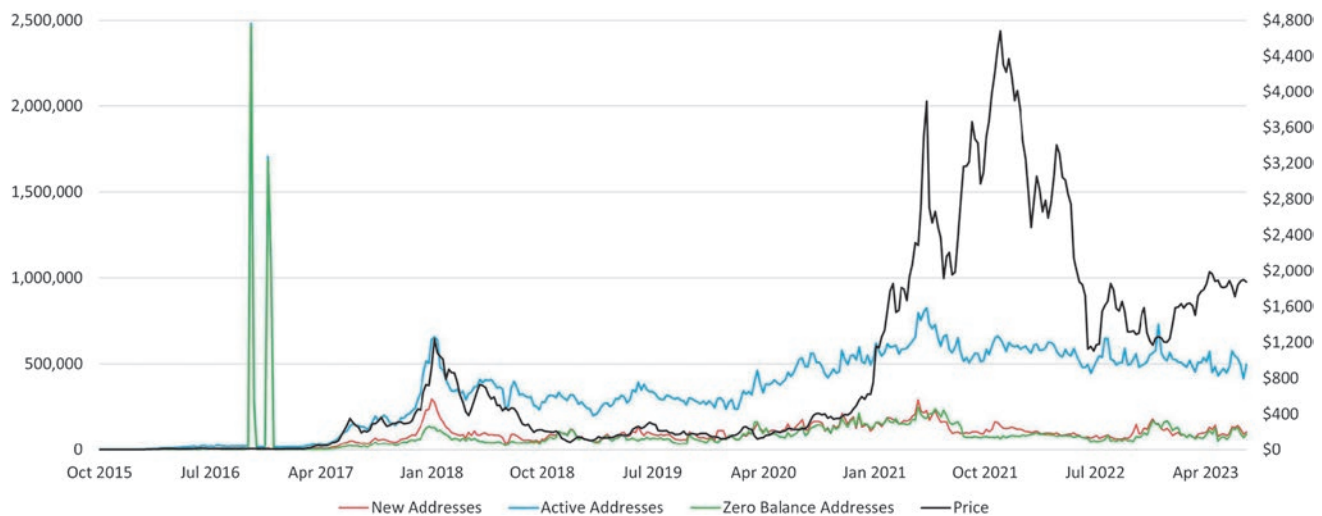
An overview of today's ecosystem of Bitcoin and Ethereum gives a holistic perspective on the usage by total active addresses in correlation to price and network transactions over time. Having more individual addresses results in higher decentralisation of the protocol.

### **Bitcoin: Account growth (total, active) over time versus price**

The green trajectory in Figure 5 signifies a consistent upsurge in the number of active addresses in the Bitcoin network, peaking at approximately



**Figure 5:** Bitcoin account growth: total, active versus price over time (July 2023)  
 Source: 'Into The Block' website, Oliver Wyman Analysis



**Figure 6:** Ethereum account growth: total, active versus price over time (July 2023)  
 Source: 'Into The Block' website, Oliver Wyman Analysis

one million addresses. This data illustrates a strong correlation between the proliferation of active addresses and the alteration in Bitcoin's price. A surge in price causes an increase in the quantity of addresses and the relationship is reciprocal. However, a divergence emerged at the onset of 2022 with the beginning of the bear market. Despite a significant plunge in price, the quantity of active addresses remained resilient. This persistence enhances the network's decentralisation, implying a shift among Bitcoin holders from transitory speculators to long

term investors, reinforcing Bitcoin's role as a store of value.

### Ethereum: Account growth (total, active) over time versus price

Mirroring Bitcoin, Ethereum's active addresses since launch in 2015 show a strong correlation with price, but have since displayed a plateauing trend from January 2021 onwards, marginally declining at approximately 500,000 addresses (Figure 6). This

contrasts with Bitcoin’s network adoption curve, which has demonstrated higher fluctuations. Since 2018, Ethereum’s active address count has been largely indifferent to price fluctuations, emphasising a robust and enduring community engagement and degree of decentralisation, confirmed by a consistent transaction volume, underlining the network’s enduring utility and usage, irrespective of market price volatility.

**Bitcoin network usage: Transaction frequency**

The frequency of Bitcoin transactions has historically exhibited a strong correlation with price, but has remained steady since mid-2021 (Figure 7). Despite a steep price decline at the onset of 2022 to approximately US\$20,000, the transaction frequency further decoupled, maintaining an average of about 250,000 transactions and briefly spiking to 500,000 transactions per second in March 2023. This trend can be interpreted as a testament to a consistent user base, correlating with the number of addresses, leveraging the network’s utility. The centralisation ratio has reached a state of equilibrium, with the majority of network activity relying on a fixed user base, inclusive of trading bots.

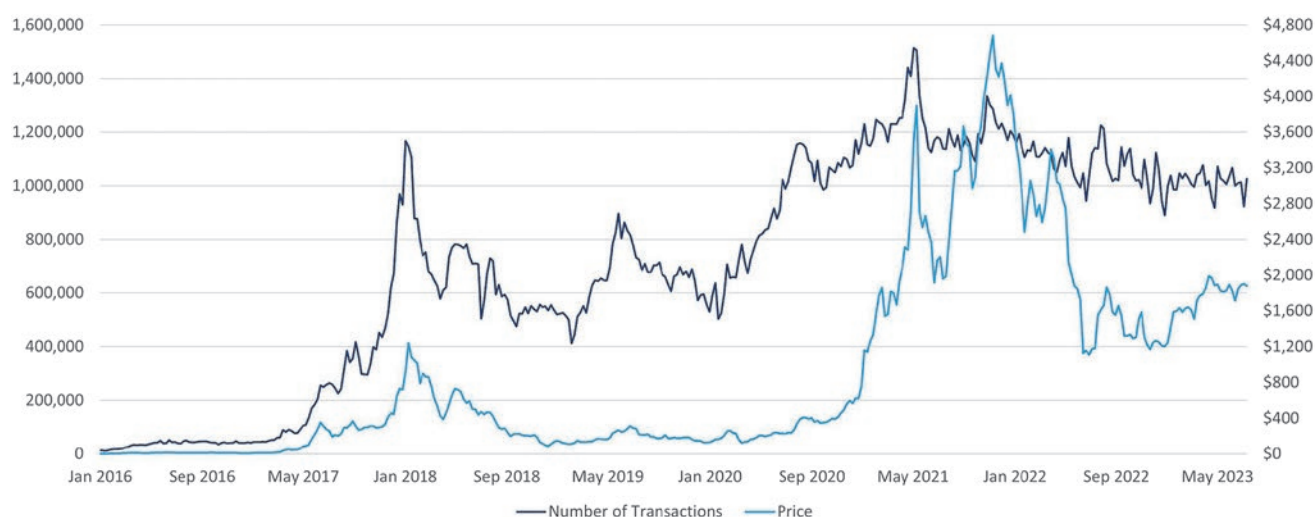
**Ethereum network usage: Transaction frequency**

The Ethereum network’s utilisation, as reflected by the number of transactions, has been incrementally evolving over time (Figure 8). However, compared to Bitcoin, Ethereum’s transaction activity has seen a slight decline after the price surge in March 2021, and it continues to linger below the long-term moving average. Presenting a strong dependency on price, standing in contrast to the utility and ecosystem development induced by second, third and fourth layer applications constructed on the network. The transition from PoW to PoS in September 2022 did not immediately catalyse a significant upswing in transaction activity. However, Ethereum staking shows consistent growth over the past three years, registering a 79.4 per cent increase since 2021, and accounting for 16.72 per cent of the total supply by 2023.<sup>20</sup>

The importance of network adoption and usage towards decentralisation highlights the reputational risk, among other risks, facing networks. It can be assumed that a better reputation is directly correlated to greater adoption and, in turn, a more decentralised network. Reputational damage will drive adoption away from the network and decrease its overall decentralisation. Networks should be evaluated for how their usage is changing over time



**Figure 7:** Bitcoin network usage over time (July 2023)  
 Source: ‘Into The Block’ website, Oliver Wyman Analysis



**Figure 8:** Ethereum network usage over time (July 2023)  
Source: 'Into The Block' website, Oliver Wyman analysis

to understand the risk the ecosystem poses to the network's decentralisation level.

## CONSENSUS PROTOCOLS

One of the main drivers of centralisation observed in public blockchains is the concentration of consensus power on a handful of entities. Testimony to this is the pseudo-oligopolistic dominance that mining and staking pools have established in Bitcoin and Ethereum, which poses significant security and censorship threats to these networks.<sup>21</sup>

Consensus power is determined by the share of the network's total computational power devoted to mining (hash rate) in PoW, and the number of tokens staked compared to the total locked up in PoS networks.

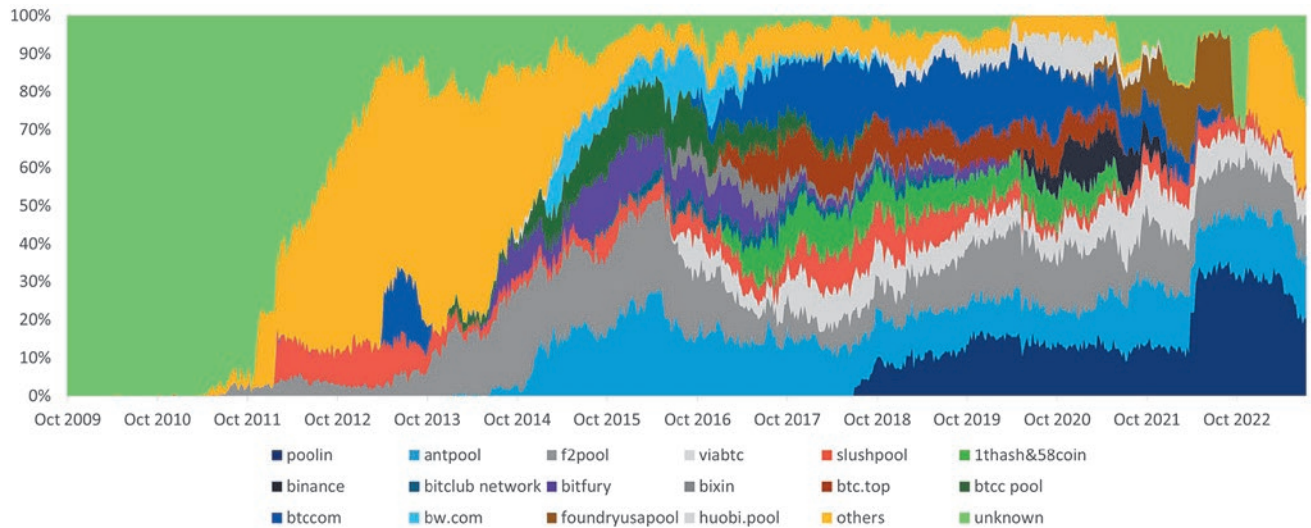
In Bitcoin, the rise of pooled mining has led to higher levels of consensus power concentration. Mining pools combine the hash rates of multiple miners over a network to increase the probability of finding a block, distributing rewards based on the amount of power each contributes. The substantial risk and profit-sharing benefits this option represents for miners made solo-mining a rare possibility.

Consolidating consensus power around a few centrally run mining pools introduces a single point of failure on networks. As of July 2023, a malicious agent would need to control the two largest mining

pools to disrupt the Bitcoin network. Such a concentration also constitutes a censorship risk to the network, with dominant mining pool operators able to decide what transactions are validated, redirect miners' hash rates to different cryptocurrencies, or ban mining operators.<sup>22</sup> This risk is partially offset by the ability of miners to leave and join pools in response to bad behaviour.<sup>23</sup>

Another source of centralisation in PoW networks that deserves particular attention is the concentration along the mining hardware supply chain. Limited competition in the manufacturing and distribution of specialised mining hardware could eventually weaken decentralisation, whereas having exclusive access to superior coin-specific mining equipment could tilt the balance in favour of a particular entity, enhancing control over the network and limiting wider participation. Large Chinese Bitcoin mining chip manufacturers such as Bitmain, MicroBT and Canaan have only recently started to be challenged by new players entering the space (American firm Intel unveiled its new Bitcoin mining chip in January 2022).

Figure 9 presents Bitcoin's hash rate distribution. Since the early days computational power has been taken up by mining pools. However, no pool consistently monopolised the hash rate production throughout the time between 2010 and 2023 (Figure 9).



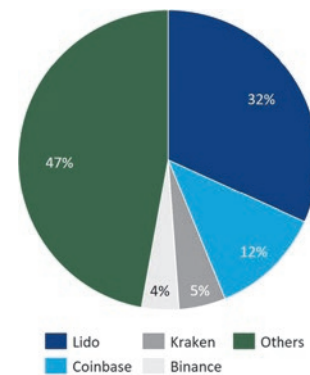
**Figure 9:** Bitcoin hash rate distribution over time (July 2023)  
 Source: 'Into The Block' website, Oliver Wyman analysis

The same stands for PoS networks, with small token holders often driven toward staking services, as they are unable to compete effectively for rewards against professional providers. In PoS, the greater the number of tokens stacked, the higher the chances of being chosen as a validator and, therefore, gathering rewards. By design, PoS algorithms tend to favour large stakeholders and staking providers, enabling them to grow more rapidly at lower costs, taking up larger profit margins, and eventually consolidating a position of power over the network.<sup>24</sup>

Ethereum, the largest PoS network in market capitalisation, has only four entities in control of almost 53 per cent of the consensus power — a staking pool (Lido: 31.7 per cent) and three centralised exchanges (Coinbase: 12 per cent, Binance: 5.2 per cent and Kraken: 4 per cent) (Figure 10).

Networks should be evaluated to understand the level of consensus power consolidation risk and how this has been evolving over time. In addition to the current levels of consensus power consolidation, the network should also be evaluated to understand the barriers to entry on setting up nodes or staking pools by reviewing the mining equipment supply chain and requirements around setting up a staking pool.

The Nakamoto Coefficient is one of the most common and uncomplicated methods to quantify



**Figure 10:** Ethereum: Top five validator distribution (July 2023)  
 Source: 'Dune' website, Oliver Wyman analysis

and compare decentralisation across blockchains. First introduced by Balaji Srinivasan in 2017, this metric combines the Gini coefficient and Lorenz curve, representing the minimum number of nodes that must be compromised to disrupt the network. The higher the value, the higher the decentralisation.

To calculate the Nakamoto Coefficient, first, it is necessary to determine the minimum control threshold of a network. In PoS blockchains, this equals to at least a third of voting power, which would be sufficient to prevent new blocks and transactions from being confirmed (Table 1).

**Table 1:** Nakamoto coefficient for the top five smart contract platforms by market capitalisation — July 2023

Network	Active validators	% tokens circulating supply staked	Nakamoto Coefficient	Minimum stake required to run a validator node	Lock-up period	Consensus algorithm
Ethereum	652,907	16%	2	32 ETH (~\$60k)	No withdrawals supported until the Shanghai upgrade	PoS
BNB Smart Chain	41	15%	14	10,000 BNB (~\$2.4m)	7 days	Proof of-staked authority (PoSA)
Solana	1,874	71%	32	1 SOL/day (~\$21)	5 days	PoS
Cardano	3,183	62%	34	-	None	PoS
TRON	27	42%	9	1 TRX (~\$0.1)	3 days	DPoS

Source: Oliver Wyman analysis

## TOKENS Ownership

In order to determine the adoption and distribution of tokens in a network, we considered Bitcoin's and Ethereum's total addresses by holding and time held, which reveals a high adoption of these networks over time based on an increase in total addresses.

However, these networks are not close to equal distribution among all participants, with the total supply in both networks very concentrated in a few addresses. In Bitcoin, this concentration is not a red flag since it relies on a PoW consensus mechanism, where the percentage of tokens held in accounts is not relevant to decentralisation of the network. As observed in the paper 'Blockchain Analysis of the Bitcoin Market' by Igor Makarov and Antoinette Schoar,<sup>25</sup> one-third of all Bitcoin supply is currently held by intermediaries (exchanges or institutes), where Binance, Coinbase, and Huobi demonstrate the highest measure of centrality within the Bitcoin network. They suggest that the majority of gains resulting from increased Bitcoin adoption are likely to accrue disproportionately to a small subset of named participants. This goes against Satoshi Nakamoto's initial idea of a ledger independent of intermediaries which cannot be easily manipulated by institutional and exchange players able to push the price up with speculative bets. Furthermore, a significant portion of Bitcoin's trading volume is attributed to cross-exchange flows.

These flows result from the presence of numerous non-integrated exchanges, independently owned and operating in parallel across various countries.

Ethereum, however, which moved from PoW to PoS, has an even higher concentration of total supply, with 53 per cent controlled by four validator pools in July 2023. This makes Ethereum vulnerable to manipulation threat. This concentration exists despite the initial token distribution of Ethereum, which allocated 80 per cent to public sale, including pre-launch sale or 'lock drop' allocations, 15 per cent to insiders such as venture capitalists and 5 per cent to a community governed grant pool.<sup>26</sup> Other blockchains with similar functionality, like Solana or Binance, have much higher concentrated insider ownership, with only around 50 per cent in each network allocated to public sale. The initial token economics of the network and the impact this has on who controls network tokens is crucial when understanding how decentralised the network is currently and how it can be expected to evolve over time.<sup>27</sup>

In Bitcoin, the average time a token is held in a wallet increased to 3.8 years, which is a sign of long-term investment by its users. Significant adoption was triggered by the price peak in 2018, and since then the adoption has been steadily increasing as observed by the number of wallets, although it is clear that each individual wallet address does not belong to one individual user; a single entity might manage numerous addresses, sometimes

even tens of millions. Many public entities, such as exchanges and online wallets, hold Bitcoin on behalf of other investors. When market participants deposit their Bitcoins with exchanges, these coins are often pooled together in one or a few addresses.

Looking at Bitcoin holdings distributions by wallet, it can be seen that:

- 43.56 million addresses, or 91 per cent, holding 0–0.1 Bitcoin.
- 4.23 million addresses, or 8.8 per cent, holding 0.1–10 Bitcoin.
- ~150,000 addresses, or 0.32 per cent, holding 10 to over 100,000 Bitcoin, a total of 82.08 per cent of total token supply worth US\$493.88bn (as of July 2023).<sup>28</sup>

Among the largest 1,000 clusters holding 2.8 million Bitcoin in 2020, approximately 0.4 million Bitcoin remained untouched since 2014, and 0.8 million since 2017. Similarly, for the top 10,000 clusters, roughly 0.9 million Bitcoin have not been transacted since 2014, and 1.6 million since 2017.

Ethereum holdings distributions by wallet:

- 95.22 million addresses, or 94.94 per cent, holding 0–0.1 Ethereum.
- 4.72 million addresses, or 4.7 per cent, holding 0.1–10 Ethereum.
- 352,000 addresses, or 0.35 per cent, holding 10 to over 100,000 Ethereum, a total of 95 per cent of token supply worth US\$226.08bn (as of July 2023) making Ethereum's price highly sensitive to 'whale' wallet transactions.<sup>29</sup>

## DECENTRALISED FINANCE VERSUS CENTRALISED FINANCE

Both DeFi and centralised finance (CeFi) have the potential to drastically alter how individuals interact with their financials. DeFi (such as MakerDAO or Compound) runs on a public immutable blockchain system, providing consumers digital assets with greater transparency and low transaction fees. These networks are accessible to everyone, but they are not yet functional enough to compete with more centralised options. Additionally, to successfully

engage with all services of DeFi applications, the customer requires some technical understanding of the blockchain mechanisms. Furthermore, the space is still entirely unregulated, offering risky services and no access to personalised support for consumers.<sup>30</sup>

CeFi applications, in contrast, are easier to use and more established. They provide familiar functionalities such as traditional exchanges, with high liquidity and direct customer support for assistance (such as Binance, Coinbase, Nexo). But CeFi also has downsides. When a provider goes bankrupt, users' crypto assets are lost, as seen with FTX or Celsius Network. Other disadvantages can be high trading or service fees and vulnerabilities to hacks or security issues.<sup>31</sup>

Although CeFi continues to dominate the market, DeFi is slowly growing and expanding with 6.6 million users in January 2023.<sup>32</sup> The adoption and total value locked is highly dependent on the Bitcoin having a cycle causing cyclical and volatile price movements. Today, in a bear market, a total of US\$40bn is invested in DeFi applications, much less than the US\$130bn invested in July 2022.<sup>33</sup>

Traditional finance is also slowly starting to see the value in DeFi, but problems such as risk of equity loss and regulatory issues are preventing scalability. FinTechs today are the early adopters, like Paypal and Revolut, and are offering their users their first way to interact with crypto currencies. Additionally, emerging third-generation blockchains are solving the challenges preventing scalability, making mass adoption more realistic.

## Decentralised finance token concentration

To assess token concentration, the HHI is used, a commonly accepted measure of market concentration. The HHI is often used before and after a merger and acquisition (M&A) transaction by the US Department of Justice to evaluate potential antitrust violations. It is calculated by squaring the market share of each competing firm and then adding the resulting numbers together. A market with an HHI of less than 1,500 is considered a competitive market, an HHI of 1,500–2,500 is moderately concentrated and an HHI of 2,500 or more is highly concentrated.



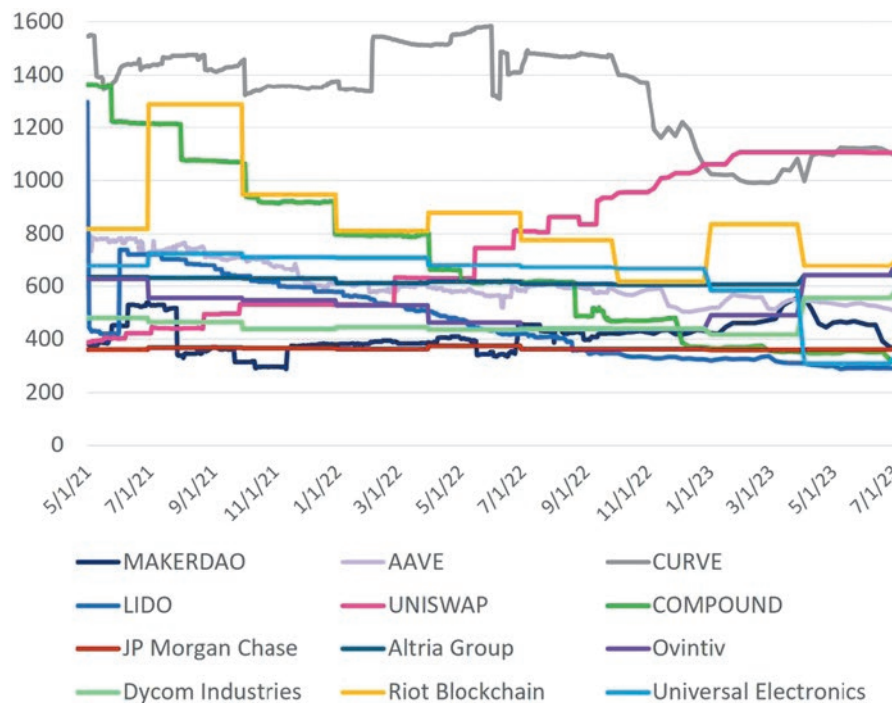
The governance tokens of selected DeFi applications (see Figure 11), in terms of total value locked, mostly do not seem to be highly concentrated when all wallets are considered independent (not considering that wallets could be related, having the same entities or intertwined entities behind them). Using the HHI, it is found that governance tokens are fairly distributed, as are the equity shares of traditional corporations. Dividing selected companies into three groups, these are:

- large cap companies having a market cap higher than US\$15bn dollars;
- medium cap companies with a market cap between US\$1bn and US\$15bn;
- small cap companies with a market cap lower than US\$1bn.

As of July 2023, Lido is the most decentralised network, having the lowest HHI at 290, followed by Compound (312) and MakerDAO (368).

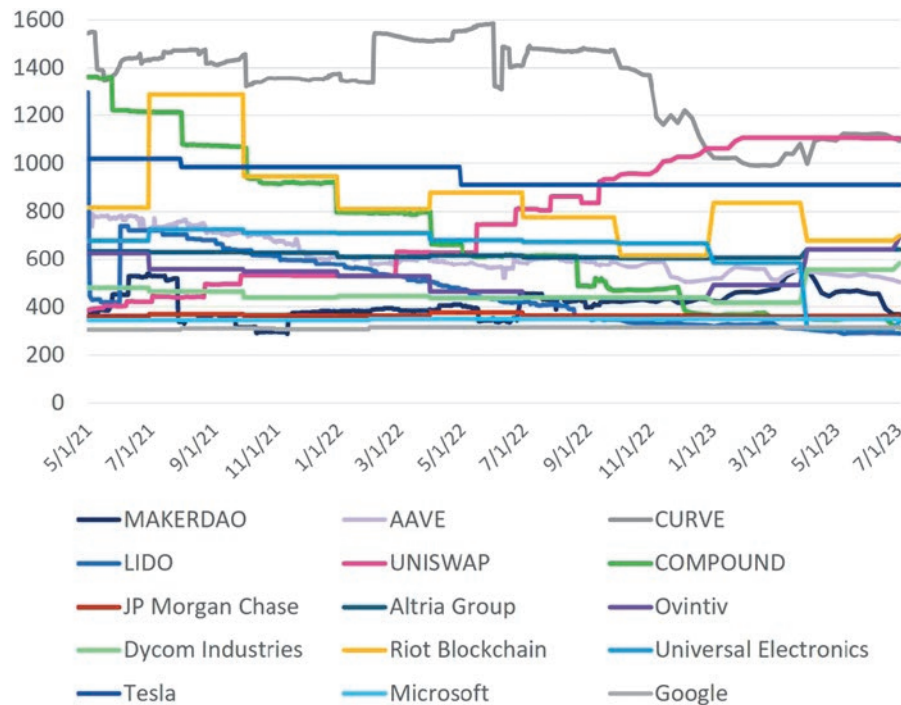
For traditional corporations, analysis show that mature and stable corporations such as Universal Electronics (341) and JP Morgan (365) with a market cap of US\$358bn have the highest distribution in share, followed by Dycom Industries (583), Altria Group (641) and Ovintiv (696), whereas low cap corporations such as Riot Blockchain (700), which can be more volatile in price swings, less liquid or thinly traded causing a bigger risk for investors, show a higher degree of centralisation (Figure 12).

Looking at big tech companies such as Google (314) and Microsoft (350), DeFi at first looks similar in governance tokens compared to share distribution. But taking a deeper look into Alphabet (Google), a centralised control through different share classes can be identified, ultimately allowing the two founders, through holding Class B shares — giving them ten ‘super-voting’ shares with one vote per share, to decide on every action the company takes, regardless of the opinion of other shareholders.



**Figure 11:** Herfindahl-Hirschman Index of selected DeFi networks and traditional corporations (July 2023)

Source: ‘Into The Block’ website, Oliver Wyman analysis



**Figure 12:** Herfindahl-Hirschman Index of selected DeFi networks and big tech companies (July 2023)  
 Source: ‘Into The Block’ website, Oliver Wyman analysis

## INTRODUCTION TO DECENTRALISED AUTONOMOUS ORGANISATIONS

A DAO, as the name implies, is an organisation that is decentralised, with no central government. Instead of being governed by a small team of executives like traditional institutes, the rules of a DAO are set in code and enforced by a network of computers. The rules are the same for everyone, regardless of which position they are in, and cannot be changed. There is no need for intermediaries, with the DAO tokenising governance democratically and not hierarchically. The users with larger governance token holdings have the highest decision-making power, which can lead to power struggles around the future development of the network. In DAOs, the user addresses of stakeholders are visible, but typically the real-life persons connected to the addresses are anonymous.

Since its establishment in 2016, ‘the DAO’ has served as one of the pioneering decentralised autonomous organisations utilised as an investor-directed venture capital fund with US\$150m worth of Ethereum. Over the years, the DAO ecosystem

has thrived. However, it is important to acknowledge the technological risks inherent to DAOs, particularly their reliance on code. This vulnerability was exemplified by the notable incident involving ‘the DAO’, wherein a substantial hacking event occurred, posing a threat to the very future of Ethereum itself. The community, however, learned from the experience and, in July 2023, there are approximately 12,727 DAOs with a combined treasury volume of US\$21.9bn with 6.9 million governance token holders. A conservative growth rate prediction estimates a collective treasury of US\$2tn in DAOs by 2025. The biggest DAOs by market cap are mostly layer 2: Arbitrum, BitDAO, Optimism and Uniswap.<sup>34</sup>

## DECENTRALISED FINANCE: DAO GOVERNANCE

DAOs have individual rules and processes in community voting, meaning their degree of decentralisation varies in terms of collective decision-making depending on protocol iterations

and advancements in features, rules or other parameters. In past years, DAOs have served as an experimental testing ground for various sandbox governance systems.<sup>35</sup> The different structures of DAOs are still at very early stages, and protocol founders often shift from an initial centralised foundation to a decentralised structure over time, trading off efficiency versus decentralisation. In the foundation phase of a protocol, development speed is crucial to bringing the concept to life. Team decisions must be made quickly and flexibly without polling all users through a decentralised process. DAO governance comes with operational risks, governance risks and legal and regulatory risks that must be managed and mitigated where possible. The governance policies put in place may have a significant impact on the network's ability to make and implement changes. Teams must balance the risk of making the governance process too simple, which could lead to buggy or errant code being uploaded, with too strict governance procedures that might render the network unable to evolve or respond to threats as required to stay relevant. Furthermore, depending on the level of decentralisation present, DAOs may run foul of securities laws, exposing themselves to significant legal and regulatory risk.

For example, Compound DAO's COMP token was entirely allocated to the development team, limiting the ability to propose adjustments to the protocol for users. Token distribution was made through liquidity mining and public sales, and whoever had the most capital to buy tokens had the most voting power in the DAO.<sup>36</sup> This limited the access, and later DAO governance, to a set number of investors, founders and users. Multiple decentralised finance projects have analysed this centralisation phenomenon and embedded new, more distributed token mechanisms to give people a chance to participate and contribute to a progressive decentralisation. This is referred to as a 'fair launch strategy', as stated in the Ethereum tokenomics.<sup>37</sup>

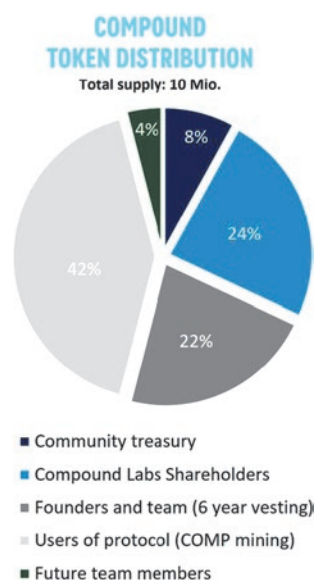
A bottom-up approach is starting to evolve within DAOs, where early and higher community responsibilities are promoted and new algorithmic governance mechanisms are helping start-ups launch without initial coin offerings or public sales. New

token lock-up mechanisms are implemented to improve price volatility and exclude speculators, fostering a community driven culture in the best interest of the collective DAO development.<sup>38</sup>

### Example: Compound

Compound, a financial borrowing and lending service, runs on the Ethereum blockchain. Compound's team defined a total token supply of 10 million (see Figure 13) and distributed the tokens between investors, founders and users to give every participant a chance to contribute to the network. Just over 4.2 million of these 10 million tokens will be distributed over a four-year period to Compound's users. Another 2.2 million tokens will be distributed to the founders and current team of Compound Labs, Inc., with a vesting period of four years. Almost 2.4 million COMP (the Compound token) will be distributed to Compound Labs, Inc. shareholders. The remaining 332,000 COMP tokens will be allocated to future team members, and 775,000 COMP will be reserved for community governance incentives.<sup>39</sup>

By passing a proposal through community governance, voters can increase or decrease the



**Figure 13:** Compound token distribution (July 2023)  
Source: 'Compound Blog' website, Oliver Wyman analysis

COMP emission rate over time. Addresses accredited with at least 25,000 COMP can create governance proposals directly, and with 100 COMP and community backing, users can create a new autonomous proposal. Anyone with COMP tokens can vote for or against a proposal, and, if successful, the proposal is locked and time queued.

To pass a proposal, the majority of DAOs in operation today employ ‘token-based quorum voting’, requiring a minimum number of voters (for example: a 30 per cent quorum, which means 30 per cent of voting power needs to vote). On Compound, the quorum is always set to 4 per cent of the total COMP supply.<sup>40</sup>

Once reaching this threshold, the decision with the most votes wins. The proposal fails if the required quorum is not met, or the proposal time runs out, which is equal to three days, assuming 15 seconds per block. Each voting result is documented on the blockchain and retrospectively transparently visible to everyone.

## DECENTRALISED FINANCE: DAO GOVERNANCE MECHANISMS

In Compound, the sum of all participants is the organisational owners. For instance, single users, communities or delegates can transparently make suggestions for protocol changes, debate and vote on implementing them. Compared to other protocols, proposals and changes are often decided on by core development communities or investors holding high token amounts. The user has the choice to cast a single vote or delegate their tokens (votes) to individuals with a shared interest. A governance action can be proposed by anyone with 1 per cent of COMP allocated to their address. Using this approach, governance is transparent and fluid, meaning that if a user disagrees with a delegate’s decision, they can easily assign their tokens to another delegate or vote independently, preventing the potential of vote counting being exploited or manipulated (Figure 14).<sup>41</sup>

In practice, most of the contribution to Compound’s voting mechanism comes from a core group, centralising the decision making. This is mostly due to low interest in participants who are not incentivised for active involvement. Looking at

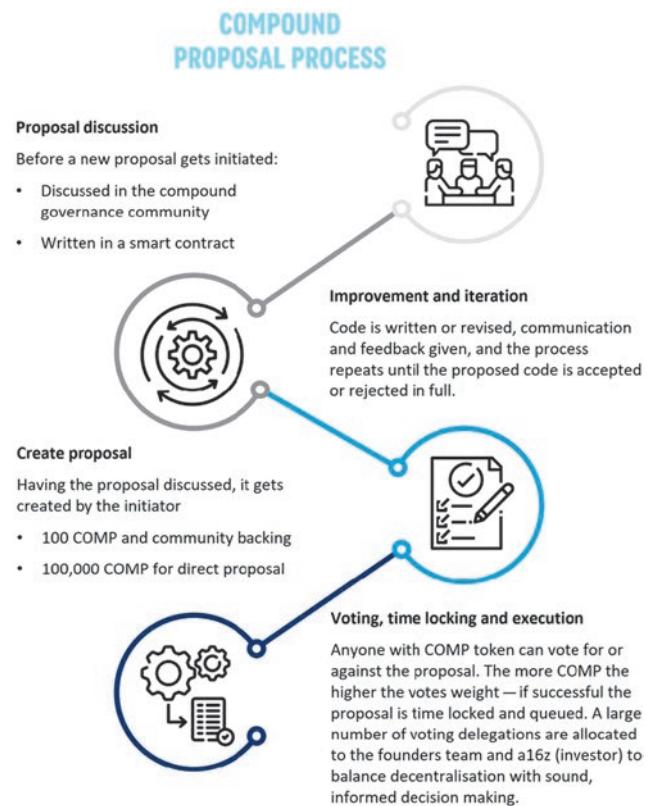
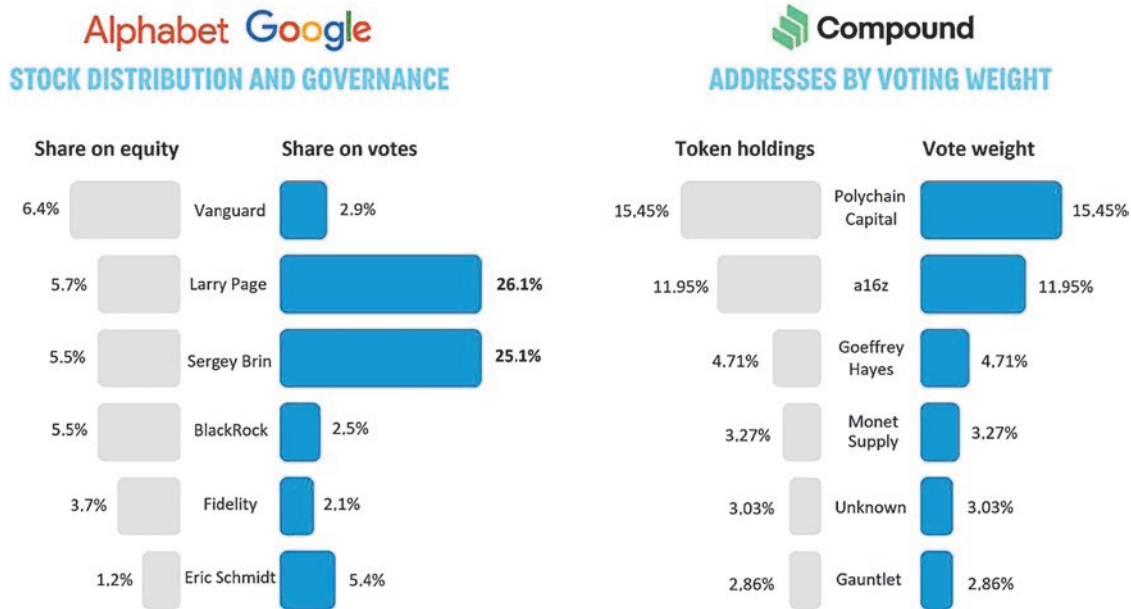


Figure 14: Compound proposal process (July 2023)

Source: ‘Compound Blog’ website, Oliver Wyman analysis

all four of the proposals in June and July 2023, individual voter addresses ranged from 18 to 66, delegating between 322,562 to 917,558 COMP<sup>42</sup> to each proposal. In all proposals, the largest voters account for significant voting power. Most proposals were initiated and programmed by key developers having a deep technical understanding of the protocol, thus limiting the community voting participation further to those with the technical background to understand the proposed changes.

This decentralised voting mechanism can be one of the biggest vulnerabilities in DAOs. If there is an error in the initial configuration of the smart contracts that conduct the voting, the entire DAO can be compromised. To provide a comparison between the decision making in traditional companies (eg Alphabet) and a DAO (eg Compound) by share on equity and share voting rights, see Figure 15. Although the two founders of



**Figure 15:** Comparison: Alphabet (Google) versus Compound stock/token distribution and governance (July 2023)  
Source: Oliver Wyman analysis

Alphabet own 11.2 per cent of total equity, their shares on voting rights are still 51.2 per cent,<sup>43</sup> giving them authoritarian decision-making. Meaning that, although Google has a lower HHI measuring the 'share on equity' than Compound and thereby is more decentralised, the 'share on votes', determining the governance is highly centralised. In Compound, investors and founders hold the equivalent equity in tokens to voting weight, making voting more distributed and accessible.

## NETWORK DISTRIBUTION

### Bitcoin node distribution

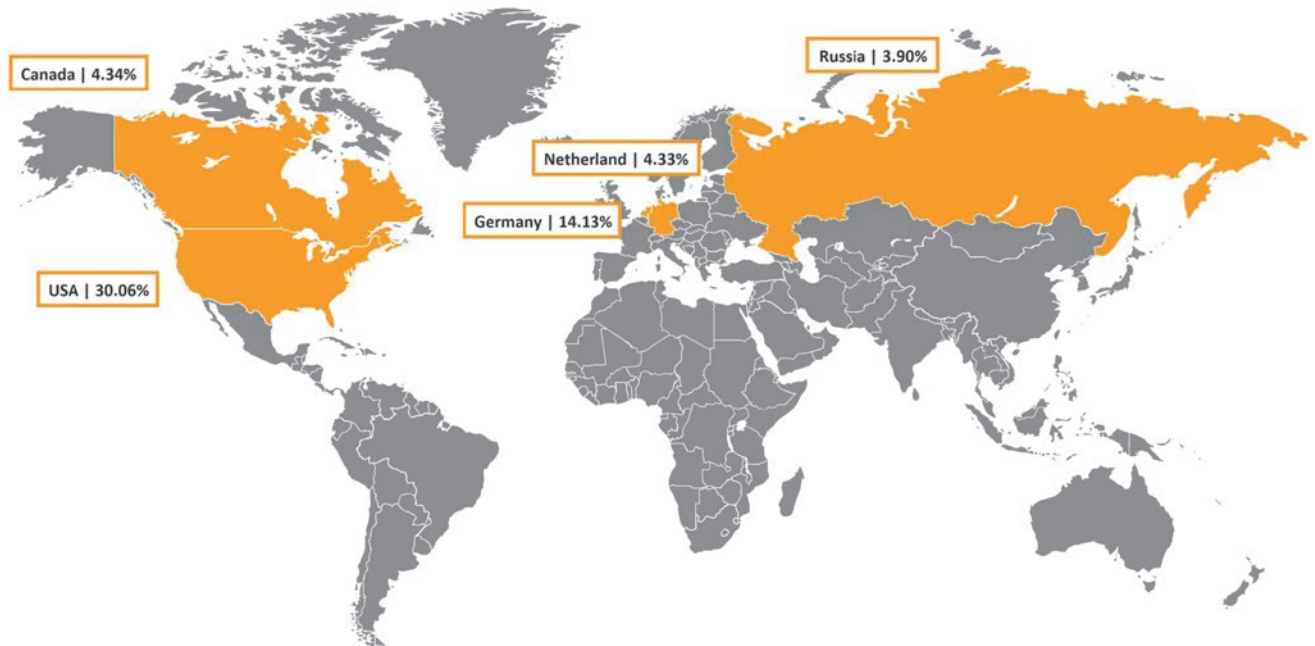
The Bitcoin full node is a programme that fully validates all transactions and blocks in the network. It can be downloaded and synchronised from anywhere on the planet and allows every user to validate each transaction and view the complete ledger through an average PC.

Bitcoin has a fairly decentralised global node distribution, with no country having a significant concentration of nodes. However, the number of nodes running on the same network has increased over time. In January 2023, 82 per cent (8,162 out of

14,838 nodes) of all nodes were routed through the private network provider TOR.<sup>44</sup> An outage to this provider could damage network efficiency.

Regulation from individual countries also plays an important role in the node distribution. For example, China banned crypto related transactions and mining, mostly due to the high energy consumption of PoW, resulting in a vast shift of node distribution to the US and Canada. Other countries doing the same would increase geographical centralisation. There is much discussion around the sustainability risks presented by Bitcoin mining operations. There is a further possibility that continued high energy use by Bitcoin of non-renewable energies could lead to additional bans in certain jurisdictions that further decrease the decentralisation of the network.

These kinds of actions have unintended consequences. For example, after China's ban, the percentage of renewable energy used for Bitcoin mining decreased globally (due to the use of hydro and solar energy in China). Centralisation in countries with the highest connection speeds could also occur because of the need for high broadband speeds to beat other miners (Figure 16).



**Figure 16:** Bitcoin top five: Global node distribution by country (July 2023)  
Source: 'Bitnodes' website, Oliver Wyman analysis

### Ethereum validator distribution

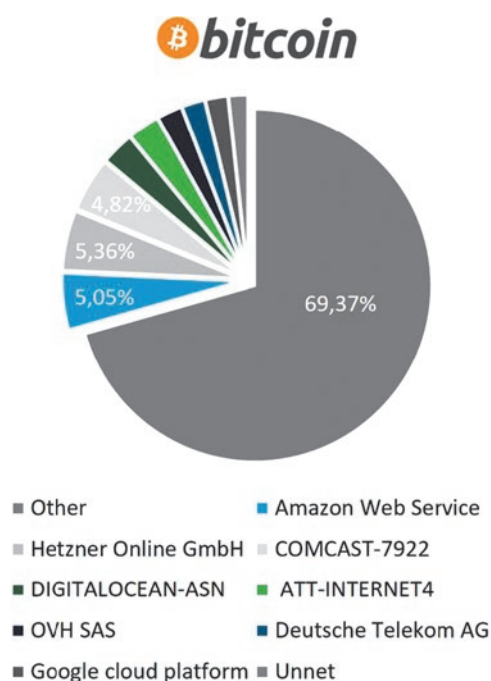
Ethereum's transition to PoS (646,127 validators) from PoW was motivated by several factors, including reducing energy consumption, enhancing network security and facilitating the implementation of new scaling solutions. The minimum stake required to run a validator node is 32 Ethereum (ETH). However, services such as Lido allow users to stake any amount of ETH, bypassing the need for the full 32 ETH deposit. This, along with other entities such as Coinbase, Kraken and Binance, has resulted in a large proportion of the total staked ETH being controlled by a few organisations. For example, currently 43.7 per cent of Ethereum's blocks are added by just two entities: Lido and Coinbase. Moreover, seven players own more than two-thirds of the stake on Ethereum's PoS network. While the PoS model has brought some improvements, it also seems to have potentially increased the concentration of power, prompting some in the community to express concerns about the level of centralisation. This situation might evolve over time as more participants join the Ethereum network and as the Ethereum community

might implement measures to prevent excessive centralisation.

In contrast to Ethereum, Solana or Cardano offers users the ability to hold on to the network's coins, only transferring the delegation rights to the staking pool, allowing flexible and permissionless withdrawing of the delegation. If the government of any state decides to censor transactions or take other policy actions, exchanges and other providers would exit staking, but with a cost, having their users Ethereum slashed, resulting in partial fund loss. This means that Ethereum is purely digitally created under strict parameters, controlled by its central planners.

### Bitcoin node hosting

Network security through node distribution depends on where the nodes are allocated and how high the number and dependency of cloud service providers are. As shown in Figure 17, Bitcoin's number of independent nodes is the highest in all blockchain networks, emphasising a solid distribution and low dependency on third-party providers. Networks



**Figure 17:** Bitcoin top ten ASNs nodes (July 2023)  
Source: 'Bitnodes' website, Oliver Wyman analysis

should continually monitor this distribution to identify any risk of concentration that may be occurring.

Crypto networks should seek to minimise the risk presented on each of these dimensions, in order to increase or maintain the decentralisation of the network. A similar framework can be applied to other dimensions that affect how decentralised the network is (Table 2).

For additional dimensions relevant for evaluating network decentralisation, a similar approach can be leveraged by identifying the relevant risk framework categories and risks, identifying the key risk management questions to evaluate the dimension on and developing design considerations that can mitigate the risks posed to the dimension.

## SUMMARY OF FINDINGS

Investors, organisations and traditional financial businesses that want to participate in the cryptocurrency ecosystem need to understand that decentralisation is a dynamic and multidimensional issue that must be deeply investigated. To increase

decentralisation, it is necessary to evaluate the governance structures, legal aspects, network distribution, centralisation of computing power, energy, infrastructure accessibility and token ownership distribution for each network and use case. Risk management strategies must be deployed by networks to manage the risks that affect network decentralisation and maintain the desired level of decentralisation in the network in line with the network's risk appetite (Figure 18).

Calculating HHI values across wallets, it can be seen that Bitcoin (56) is by far the most decentralised network and Ethereum (371) is moderately concentrated. Ethereum, for example, has an index similar to the asset concentration of shareholder holdings for stocks in big tech and traditional corporations (eg Microsoft, JP Morgan, Google, Altria), suggesting that the blockchain (other than Bitcoin) has not necessarily brought more decentralisation than traditional institutions in asset concentration for equivalent instruments. To put this in perspective with other fields, Bitcoin and Ethereum wallets are much less concentrated and much more competitive than most sports competitions, such as the US Open women's tournament (1,250), the US NBA (1,600), or the UK Premier League (2,750).

On the token dimension, Bitcoin has an HHI on wallet concentration of 56, while Ethereum has an HHI of 371. Looking at the overall trends, Bitcoin adoption confirms these numbers: since the emergence of Bitcoin, the number of addresses and the price have been highly correlated, but since the beginning of 2022, the number of addresses has remained constant, while the price has decreased significantly (Figure 19).

At the protocol level, the HHI for Bitcoin's overall hash rate distribution is about 1863. This level is considered highly concentrated by the US Department of Justice to evaluate potential antitrust violations. When the time series is reviewed, it is seen that Bitcoin's overall hash rate distribution was more decentralised until recently, after a clear concentration around a few mining pools started to emerge due to economies of scale.

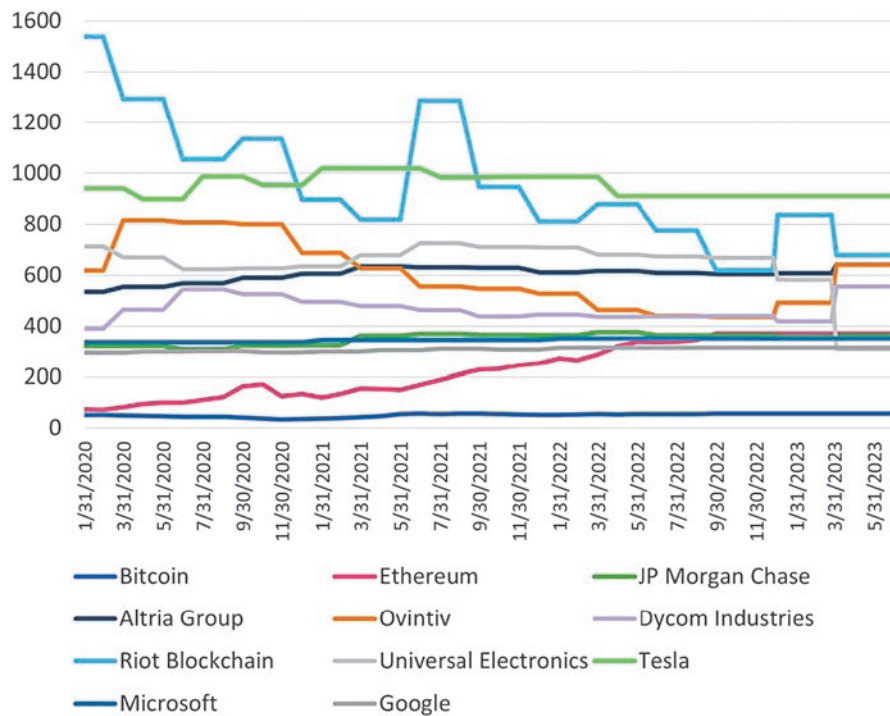
Consolidated consensus power in PoW (without fraudulent punishment for node operators) and PoS lies in a handful of centrally run mining or staking

Table 2: Key risk management considerations for the four dimensions of decentralisation (July 2023)

Dimension	Risk framework categories	Relevant risks (not comprehensive)	Potential risk management questions to evaluate	Potential design considerations
<b>Ecosystem</b>	<ul style="list-style-type: none"> <li>Risk strategy/appetite</li> <li>Organisation, governance, and token economics</li> </ul>	<ul style="list-style-type: none"> <li>Strategic risk</li> <li>Sustainability risk</li> <li>Legal and regulatory risk</li> <li>Reputational risk</li> </ul>	<ul style="list-style-type: none"> <li>Have the number of participants in the ecosystem, ie number of coin holders etc stayed the same, risen, or been decreasing over time?</li> <li>Who controls the consensus power?</li> <li>In PoW networks, who controls the mining hardware supply chain? Is there concentration/monopoly risk?</li> <li>What is the Nakamoto Coefficient of the network? How does this compare to similar networks?</li> </ul>	<ul style="list-style-type: none"> <li>Networks should seek to foster continued growth and network participation by encouraging developer activity and desirable use cases</li> <li>Networks should seek to decouple network usage and participation from token price</li> <li>PoW networks should enable ease of setting up a mining operation and allow easy transfers between mining pools</li> <li>Networks should facilitate companies to make mining equipment to limit the supply chain risk</li> <li>PoS networks should enable a relatively low barrier to entry to be a validator to decrease the risk of larger entities gobbling up consensus power</li> </ul>
<b>Tokens</b>	<ul style="list-style-type: none"> <li>Risk strategy/appetite</li> <li>Organisation, governance, and token economics</li> <li>Policies and procedures</li> <li>Technology, systems, and data</li> </ul>	<ul style="list-style-type: none"> <li>Operational risk</li> <li>Technology risk</li> <li>Financial risk</li> <li>Strategic risk</li> </ul>	<ul style="list-style-type: none"> <li>Does the network utilise PoW or PoS?</li> <li>Who controls the token supply?</li> <li>What was the initial token distribution mechanism implemented by the network?</li> <li>What is the HHI of token concentration in the protocol?</li> <li>Do the network's operational policies and procedures allow it to conduct operational activities in a timely manner in line with the protocol's risk appetite?</li> </ul>	<ul style="list-style-type: none"> <li>The initial token economics are critical for ensuring a decentralised distribution of tokens. The larger number of tokens available for public sale and the greater precautions taken to fairly offer these public tokens, the more decentralised the network is likely to be</li> </ul>
<b>Network distribution</b>	<ul style="list-style-type: none"> <li>Risk strategy/appetite</li> <li>Technology, systems, and data</li> </ul>	<ul style="list-style-type: none"> <li>Technology risk</li> <li>Strategic risk</li> <li>Sustainability risk</li> <li>Legal and regulatory risk</li> </ul>	<ul style="list-style-type: none"> <li>Does the network utilise PoW or PoS?</li> <li>What is the geographic distribution of nodes in the network?</li> <li>What is the distribution of cloud service providers utilised by nodes? What is the dependency on individual cloud providers?</li> <li>What is the geographic distribution of validators in the network?</li> </ul>	<ul style="list-style-type: none"> <li>The network should seek to foster participation from nodes across the globe and look to limit dependency on any one geography</li> <li>The network should monitor and stay abreast of regulatory headwinds and make decisions that ensure the network stays on the right side of regulatory decisions</li> <li>The network should monitor for a concentration of nodes being hosted from one or a few cloud providers and encourage distribution to other cloud providers if a concentration risk emerges</li> </ul>

Source: Oliver Wyman analysis





**Figure 18:** HHI on balance holdings by address of Bitcoin and Ethereum compared to big tech and other stock listed companies (July 2023)  
 Source: 'Into The Block' website, Oliver Wyman analysis



**Figure 19:** Bitcoin HHI on mining pools hash rate (July 2023)  
 Source: 'Into The Block' website, Oliver Wyman analysis

pools for single networks, allowing them to take control and harm the network. Looking at the distribution of nodes, Bitcoin is less concentrated overall, with the largest number of nodes (30.06 per cent) in the US and the rest fairly distributed in other countries. For Ethereum, regulatory changes in the US (ie Kraken exchange failed to register its staking as a service programme) is breaking up the highly concentrated staking centralisation of the past years, forcing Ethereum staking providers to move offshore (ie Lido is registered in the Cayman Islands) or potentially end their staking services.<sup>45</sup>

When it comes to governance token allocation, selected DeFi protocols that are considered among the most decentralised have relatively low HHI scores: Lido (290), Compound (312) and MakerDAO (368). However, the degree of decentralisation in governance token distribution is dynamic and changes, with increased or decreased centralisation through voting right token distribution over time. Uniswap, the largest decentralised exchange, has recently experienced an increased concentration of decision-making power, with large institutions accumulating governance tokens as prices fall. This highlights the financial risk posed to decentralised networks: as the price of the token decreases, the cost of a hostile takeover goes down. By tokenomics design, several networks have concentrations, and additional increases in concentration of tokens are usually attributed to vesting (insiders such as VCs, founders etc), which benefit addresses with high token holdings, further increasing an uneven and concentrated governance model.<sup>46</sup>

Attaining the right balance of decentralisation in a DAO's governance is crucial. High decentralisation fosters inclusivity, transparency and resistance to censorship, while excessive decentralisation poses challenges in decision making, coordination and accountability. Achieving complete decentralisation may not always be practical or desirable, considering regulatory requirements, scalability and coordination efficiency. Some DAOs adopt hybrid governance models to ensure efficiency and accountability. The optimal level of decentralisation depends on specific goals, organisational nature and participant preferences, evolving as the DAO grows and adapts.<sup>47</sup>

For a comprehensive discussion on decentralisation, there could be many other dimensions to

consider than the four presented above. However, the observations explained above strongly reveal that, while these select crypto network founding teams and investors put effort into creating some form of decentralised governance and management processes that are inclusive, transparent and dynamic, the voting power proxied by wallet sizes of most of the analysed crypto networks and DeFi applications are currently more centralised than ownership distribution of stocks in traditional companies. The risk management framework outlined in this paper has been applied specifically to the four dimensions discussed above, however, it can be expanded to any additional dimensions that should be considered.

The responsibility to design and promote a more decentralised ecosystem model lies with founding teams and investors at inception, and then follows adoption and market forces. Decentralisation needs to be continuously evaluated to capitalise on the promised benefits for the current and future participants of crypto networks.

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