TOO CENTRALIZED TO FAIL?
A BITCOIN NETWORK ANALYSIS

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Abstract: As the title provocatively suggests, in this article we explore empirically and question on the basis of research outcomes the implications of one of the most distinctive features of Bitcoin as a digital currency: the positively advertised de-centralization of its network and the often derived claim of egalitarianism alleged to the peer-to-peer system. In order to assess degrees and trends of network de-centralization we follow two tracks. First, we analyze a snapshot of BTC transactions taken in October 2020, basing our explorations on a subset of the "crypto_bitcoin" dataset publicly available on Google Cloud Platform and applying some of the more relevant network analysis tools, like degrees and prestige. Then we extend the analysis to the overall Bitcoin system, tracing the structural transformations it has witnessed over time with regard to the hash-rate distribution. Through a longitudinal comparison, we come to show that the number of competitors in the network have decreased over time, reducing the initial outright pluralism of the actors in the system, and gradually melting down into "special nodes", whose power has grown over time. Such centralization trends, together with the China-centered geographical distribution of the major mining pools, might have had important implications for Bitcoin success as well as they might for its future.

Keywords: Bitcoin, network analysis, de-centralized network, mining pools, prestige.

INTRODUCTION

"To the Moon": this is the answer experts and traders in crypto-currencies nowadays are ready to give, when asked about where the Bitcoin price is going to go. By the time of writing the present work, the BTS/USD reference ratio has in fact surged almost every day, trespassing the psychological threshold of 30.000$ by the end of the year, to soon reach new

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Fig. 1. *BTC/USD price variations over 5 years.*

Source: https://finance.yahoo.com.

historic peaks over 40.000$. In a breath-taking rally between December 2020 and January 2021, the Bitcoin price has almost doubled its price, reaching the huge capitalization amount of about 800 billion US dollars.

Whatever the reasons that might have sparked this impressive increase – some ascribe it to its possible hedge-function against the risk of inflation in a time when central banks worldwide are keeping interest rates low to counterbalance the economic turmoil of the COVID-19 pandemic, others to new massive investments by institutional investors – Bitcoin is not new to such sudden swings (in both directions!). Extending the analysis of price variation over a five-year span, in fact, one can verify that volatility has always been a Bitcoin hallmark (and to somebody, one of its severe drawbacks).

Notwithstanding such volatility, and a few "black moments" like the first semester of 2018, when some critics were fast to forsee its coming end, Bitcoin seems to have remained attractive over time as a "reserve currency", as well as a profitably tradable asset (the more so after 2017, when some high-leverage derivatives of cryptocurrency have been developed). Neither, seems this success to a standstill yet, whithin the landscape that Luciano Gallino (2011) has crytically described as "Finanzcapitalism"[1]. While dedicated literature abounds in explanations for such success (Ametrano 2016; Capoti et al. 2015; LaMarsch 2017), few have linked this

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notable resilience to two distinctive features of Bitcoin: 1) its presumed totally trustless mechanism; 2) its network structure and evolution over time. With regard to the first point, some sociological studies have already questioned critically the actual role that trust plays in dygital currencies (Dodd 2017; Corradi, Höfner 2018), also showing the "double embeddedness" of Bitcoin in trust relationships (Corradi 2018). As to the second point, while historical network analysis studies are piling up (among the more recent, the forthcoming historical analysis by Nerurkar et al. 2021, that covers the entire existence of Bitcoin), trends of centralization within the network have already been highlighted (Beikverdi, Song 2015). Shi (2016) has convincingly pointed at a centralization process regarding mining pools, and Javarone and Wright (2018), comparing bitcoin and Bitcoin cash networks, have found proofs, in both cases, of mechanisms like the "fittest-get-richer" one. Nonetheless, still some confusion seems to linger between the concepts of distributed and decentralized networks[2], a key distinction that must be preliminarily clarified. Figure 2 might be of help.

In the case of Bitcoin, this confusion can derive from the overlapping between the underlying blockchain mechanism (which is based on the distributed ledger technology and its alleged peer-to-peer system[3]) and the connectivity patters resulting from the accomplished transactions, with their topological properties and dynamics that can be studied empirically. Moreover, the peer-to-peer system at the base of distributed networks is sometimes misconceived as a warrant of egalitarianism, a misunderstanding probably rising from the fact that in a peer-to-peer system, by protocol (first described by Nakamoto 2008), "all nodes lie at the same level. So that there is no place for privileged actors, as, for instance, banking institutions in classical financial networks" (Javarone, Wright 2018).

In the present work, accordingly, we maintain the two levels distinct (the protocol and the real structural pattern) to focus on the actual degrees and processes of de-centralization concerning the Bitcoin network. We follow two different empirical tracks: on the one hand, we consider a snapshot of the

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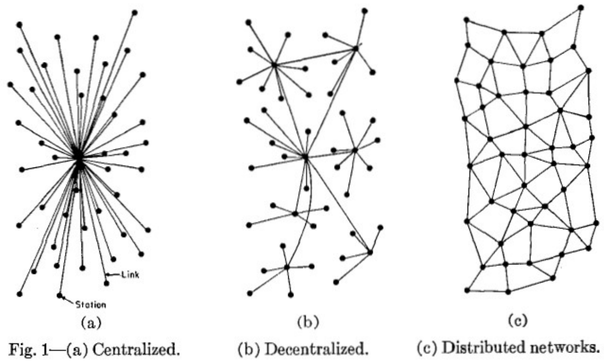

Fig. 2. *Representations of centralized, decentralized and distributed networks.*

Source: https://steemkr.com/decentralization/@hsalbert/j4snz.

Bitcoin newtork applying some of the key tools of network analysis to a subset of the "crypto_bitcoin" dataset publicly available on Google Cloud Platform; on the other hand, we extend the analysis to the overall Bitcoin system, comparing three snapshots of the hash-rate distribution and tracing the structural transformations it has witnessed over time with regard to the competition among mining pools. As it will become clear at the end, the two tracks are complementary in showing that the positively advertised de-centralization of its network and the often derived claim of egalitarianism alleged to the peer-to-peer system are empirically unsound, both at the micro and at the macro levels. In the conclusive remarks, we finally highlight the possible link between Bitcoin ongoing success and the multiple trends towards centralization that seem to affect the Bitcoin network.

TRACK ONE: STRUCTURAL ROLES IN THE BITCOIN'S TRANSACTIONAL NETWORK

To evaluate the level of centralization of the Bitcoin blockchain we started our analysis from an empirical study based on the simplest form of connection between two (or more) addresses: transactions. As individuals move funds between wallets, they effectively build a "transactional web" that can be described through network analysis techniques.

The Bitcoin dataset in analysis has been extracted from the "cypto_bitcoin" transactions dataset publicly available on Google Cloud Platform through the use of the Big Query Tool. Considering the enormous size of the dataset (580 million rows at the time of writing) and the computational restrictions for a local machine, we have limited the extraction to 16,000 rows filtered on the month of October 2020[4]. Each row contains an input, the address from which the transaction started, and an output, the target of the flow. Similar approaches involving the analysis of a blockchain subset have successfully been conducted in other papers. For example, in 2018 Javarone and Wright investigated a Bitcoin dataset composed by 7000 nodes to comprehend the general behavior of the Bitcoin network through the use of network analysis (Javarone, Wright 2018); another recent example is the upcoming paper by Nerurkar, P., Patel, D., Busnel, Y., Ludinard, R., Kumari, S., Khan, M.K (2021: 10) who have adopted a similar "Wallet_address:START_ID" to "Wallet_address:END_ID" format to analyze transactions at a row-level.

While in social networks nodes usually identify real human beings, with links representing different kinds of relationships (such as friendships, affiliation, and others), in this application each address is displayed as a node and directional ties visualize the transactions that have occurred between said addresses. Moreover, being the blockchain addresses public, every transaction (nodes and links) can be verified on dedicated websites[5].

Though the resulting dataset may seem small when compared to the entire blockchain, it is capable of telling a story about a region of the complex Bitcoin network by highlighting certain structural properties that could also be carried out to the bigger scale of the blockchain, namely potential concentration of resources, control, or, in general, centralization phenomena. Most importantly, this analysis provides a method which could be replicated not only for subsets of the Bitcoin's database, but for all blockchains.

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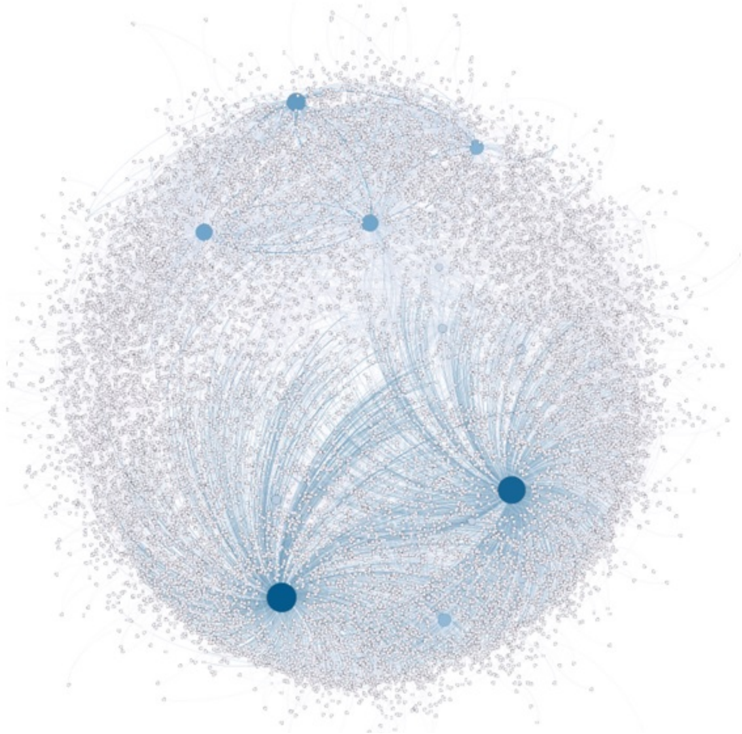

Fig. 3. *BTC Transactions Network, degree visualization. Authors' original rendering.*

The 16,000 rows BTC dataset has been analyzed through Gephi[6], an open-source and freeware software which provides useful tools for network analysis. The dataset reports 15278 nodes and 14989 ties, with an average degree of 0.981. Degree is the simplest network analysis indicator: the degree of a node is the number of its connections Average degree is calculated as number of total ties divided by number of total nodes. Therefore, each node should, on average, be connected to another one. However, as shown in figure 3, not all nodes display a similar number of connections.

In the graph nodes have been represented as bigger and darker (on a scale from white to dark blue) depending on their degree. The vast majority of the network's nodes have a very low degree, as 95 per cent of nodes have a degree ranging from 1 to 4. In other words, these addresses have traded BTC very few times and could be owned by individuals who are not extremely active on the blockchain.

On the contrary, we also identify four high-degree addresses in the northern side of the network and two in the southern. These nodes display a very high number of connections, making them the protagonists of this network. Such addresses seem to belong to individuals who trade BTC not only on a daily basis, but even much more often.

Considering one of those, the node at the very northern side of the network located on the periphery[7], reports 376 connections, with 222 incoming and 154 outgoing as shown in table 1.

Through further investigation in the wallet transaction history, we were able to discover that this address has traded tens of thousands of times during its lifetime making it very likely to be identified as a BTC "merchant". Further evidence to this claim comes from recent studies that have labeled high-degree nodes as "gambling hubs, exchanges, pools, mixers", referring to the total number of transactions in which the address has participated as an indicator of its role (Nerurkar et al. 2021: 21). For the node in analysis this definition is especially fitting since it also has high structural importance: it allows for flows to be channeled into it and be redistributed to other areas of the network.

A quite peculiar behavior was observed for the two high-degree nodes located in the southern part of the network, as their degree is equal to their out-degree. In practice, this means that they both only display outgoing connections. Though this phenomenon seems unusual, it can be explained in different ways. The first possibility is that these nodes could have been used to redistribute a certain amount of BTC to several accounts. This can happen for different reasons, which usually refer to two circumstances: risk sharing, obtained by moving funds on several addresses, and traceability reduction. This option does not seem very likely in the case in analysis, as the sender address has not equally divided its funds among the 600 target addresses. Furthermore, the blockchain is fully traceable by its nature and hiding the real target address among several hundreds of others can only slow down the process of verification.

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Tab. 1. *BTC Network statistics for six of the most relevant nodes.*

Node Id	In-degree	Out-degree	Degree	Eigenvectory Centrality
bc1q7cyrfmck2ffu2ud3rn5l5a8yv6f0chkp0zpemf	0	659	659	0.0
bc1q3tm6meq2709xjtslqalrrz7l9lc5u7nfhzxpp0	0	608	608	0.0
3G5hBoSmASwMR1aK7SfVaR7hXr1nZPgUBe	222	154	376	0.747
3479gSjwpQXmw2PtuDqyTRqLk5b8e1KLJi	194	145	339	0.7145
3GfWyoYqUYPCQBtCN7UvzRF1QPKQExL79V	254	81	335	1.0
39EKjvDK6UEkpaBcLVbBen1M4dhh2iE9Lq	214	64	278	0.9231

The second option we have considered is the so called "dust attack"[8], a methodical action that aims at revealing the real identity of addresses owners. Dust attacks are based on the assumption that users tend to use all of their addresses for similar purposes, sometimes paying for goods or services with a combination of their wallets. The attacker sends a very small amount of cryptocurrency to several targets and tracks the flow of said "dust" along the blockchain. This kind of attack exploits the traceability of the system for malicious goals such as targeted phishing, blackmailing and extortion.

With reference to the two nodes in analysis, we have identified a list of over 500 addresses who have joined the "dust attack"[9]. Attacks of this kind are an example of vulnerability in the "pseudo-anonymity" of the blockchain, though the victim is able to defend its identity by simply freezing the "dust amounts" in the wallet. So far, we have only considered the number of connections for these key actors in the network.

Even if the results obtained up to this point already allow a distinction in roles in the network, other sophisticated indicators can assess the quality of the connections. To better understand the structural roles of the addresses contained in this network we have computed the Eigenvector centrality statistic (also called "prestige" or "eigencentrality"). According to Newman we can think of Eigenvector centrality as a sum of scores assigned to connected nodes, each having a different value depending on the score of its neighbors (Newman 2010: 171). In other words, it measures the "prestige" of a node by looking at how well-connected it is to other individuals who themselves are well-connected. In social networks a person reporting high "prestige" would usually display connections to other relevant subjects, such as popular and influential individuals.

The application of the Eigenvector centrality statistic to the Bitcoin environment allows us to identify addresses which not only trade with many nodes, but also do that with structurally important ones. As shown in figure 4, the previously described nodes now display extremely different prestige values: the ones located in the southern side of the network have a very low prestige (shown as light color), while the four nodes in the northern part have the highest prestige values of the network. Intuitively, because the first nodes only reported outgoing transactions towards addresses which did not start new connections with other important nodes the prestige value cannot be high, because the quality of their connections is low. As theorized by Wasserman and Faust: "the prestige of an actor increases as the actor becomes the object of more ties, but not necessarily when the actor itself initiates the ties. In other words, one must look at ties directed to an actor to study that actor's prestige." (Wasserman, Faust 1994: 174). On the contrary, having the function of "brokers" who both display incoming and outgoing transactions towards many nodes, the four nodes in the northern side (visualized in dark-purple) conduct the network flows and act as structurally important addresses. Besides the four most visible nodes, other individuals with high prestige values (above 0.5) are also linked to this well-connected area if the network. They can be identified by following the purple ties in figure 4 and mostly belong to the same region of the network.

Thus, different behaviors can be observed in this blockchain region. In the case involving the nodes located in the northern side of the network, individuals acted in a way which recalls the "small-world" structure: a few centralized actors were engaged in many incoming and outgoing activities, functioning as intermediaries for many addresses. On the contrary, in the southern side of the network a peculiar event was observed: in a sophisticated and coordinated way two addresses redistributed their entire balance to hundreds of nodes.

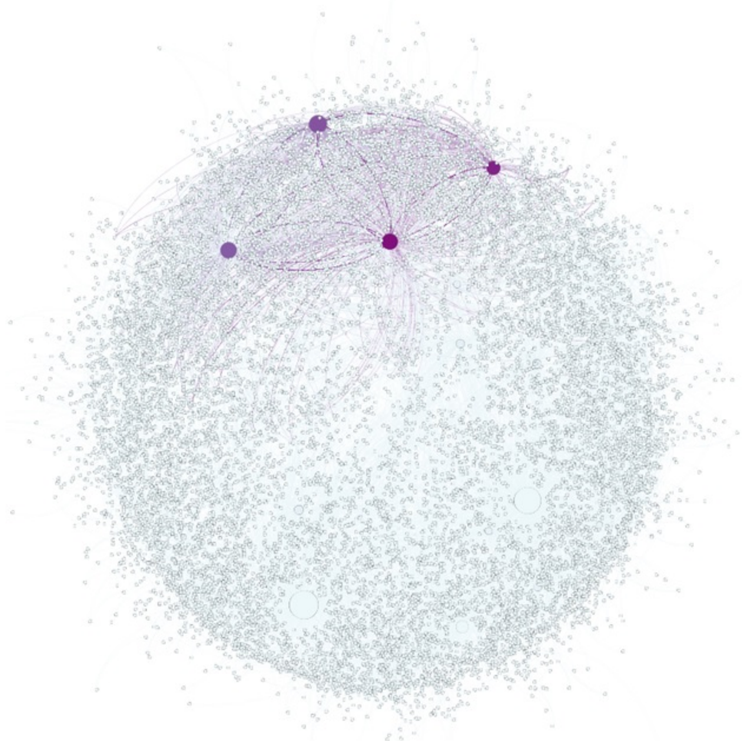

Fig. 4. *BTC Transactions Network, prestige visualization. Author's original rendering.*

Consequently, thanks to the use of network analysis, we were able to identify communities with very different purposes. According to Newman, "a way in which a network breaks down into communities can help us to understand how a system is structured" (Newman 2010: 9), therefore we deem this step of primary importance in studying the behavior of the Bitcoin's blockchain. The observed tendency to centralization that characterized this small part of the Bitcoin network appears to be an emerging trait of the entire blockchain, to the point of questioning the alleged "de-centralization" and "egalitarianism" of Bitcoin.

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TRACK TWO: A COMPARISON OF HASHRATE AVERAGE DISTRIBUTION OVER TIME

Bitcoins can be bought (and sold) on Bitcoin Exchanges (like Coinbase), or they can be "mined", using, instead of simple pickaxes, hash power to solve a computational puzzle (also called a "proof of work"). Bitcoin mining is "the process of verifying bitcoin transactions and recording them in the public blockchain ledger. In blockchain, the transactions are verified by bitcoin users, so basically the transactions have to be verified by the participants of the network. Those who have the required hardware and computing power are called miners"[10]. Such power is usually measured in hashrate. The hashrate is a 64-digit hexadecimal number; it measures how much power the Bitcoin network is consuming to work properly. So hashrate is a unity of measurement, that tells us what the computational power of a hardware is, or of the overall network (for instance, a hash rate of 10 Th/s tells us that the network is able to solve a trillion calculations in a second).

Except than from the very beginning, in 2009, when bitcoin mining could be performed by single individuals, nowadays it can only be undertaken by high-powered computers, able to solve increasingly complex algorithmical problems[11]. Since bitcoin mining is essentially "guesswork", finding the "right" answer is a matter of time and consequently of computational power (the greater the hash-rate the higher the probability to perform the proof of work successfully). While already in 2013, bitcoin miners started to use computers designed specifically for mining cryptocurrency, called Application-Specific Integrated Circuits (ASICs), nowadays bitcoin mining is so competitive that it can only be done profitably with the most up-to-date ASICs. Moreover, mining pools have definitively overcome "solo mining", and the majority of blocks are mined by "mining pools", sharing costs and profits[12], rather than by individual miners. In any case, by solving computational problems, "miners" are rewarded with new bitcoin (not unlike when gold is extracted from the ground) and they make the bitcoin payment network trustworthy and secure by verifying its transaction information. Hence, bitcoin mining is not only a profitable

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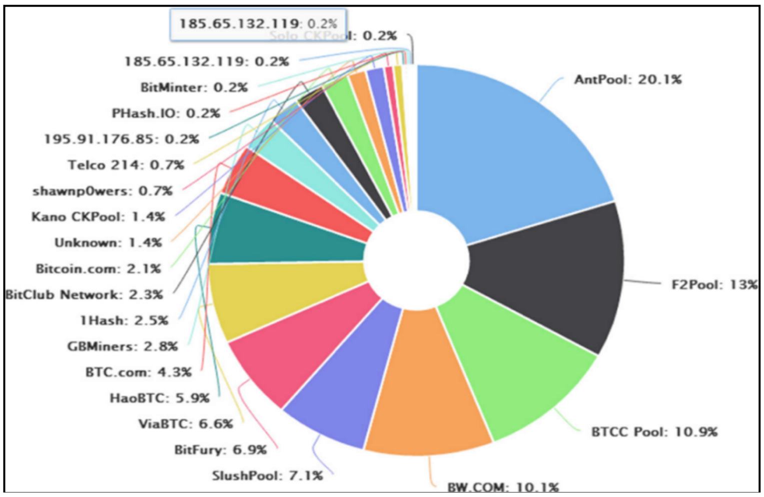

Fig. 5. *An estimation of hashrate distribution amongst mining pools (Shi, 2016).*

job, but it still remains essential to maintain the ledger of transactions upon which bitcoin is based.

Despite the internal "schism" occurred in August 2017, when a group of miners initiated a hard fork, leaving the bitcoin network to create a new currency (Bitcoin Cash)[13], the hash power average distribution among mining pools is comparable over time. A first snapshot of such distribution was already considered by Shi (2016), from whose work comes the following figure.

Juxtaposing this snapshot with another one, that I personally took by middle March 2018, it is easy to see that the number of competing mining pools was significantly higher in 2016 than in 2018.

As figure 6 shows, in 2018 there was one bigger mining pool (BTC.com), which alone owned more than 18 per cent of the overall computational effectiveness, followed by four main competitors (AntPool, ViaBTC, SlushPool and BTC.TOP, with shares ranging from 12,4 per cent to 11,6 per cent). 13 other mining pools shared the remaining hashrate. Finally, the hashrate performed by "unknown mining pools"[14] was still limited

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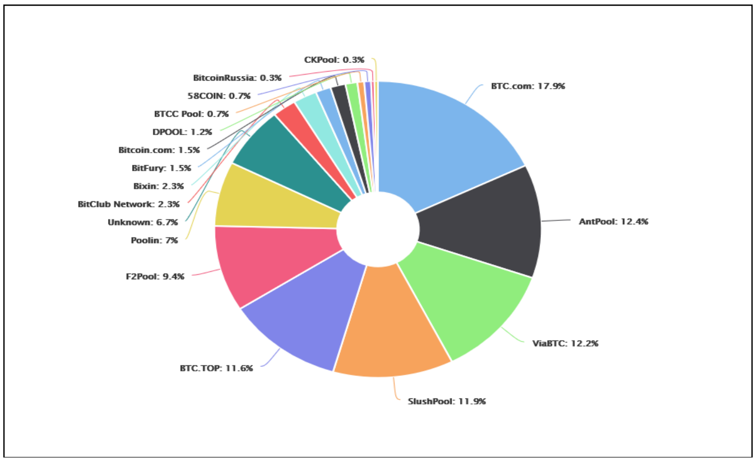

Fig. 6. *An estimation of Hashrate distribution (4 days av., 8-12/09/2018).*

Source: https://blockchain.info/pools.

(8,7 per cent), especially when compared to the current picture. A snapshot of the present situation (figure 7, together with tab. 2), shows very important changes.

First, the percentage of "unknown" mined blocks has soared up to 30 per cent of the total hash rate distribution, an evidence that would deserve further inquiry[15]. At the same time, the picture clearly shows that the struggle over the hashrate distribution has new winners and it has almost erased smaller mining pools from the battlefield. Some previously fierce competitors are almost defeated (see for instance BTC.com, which was the major mining pool in 2018, while today holds less than 1 per cent of the total hashrate; or ViaBTC, that has lost more than 5,8 percentage points); others are keeping their position pretty steady (this is the case of AntPool, although the latter has lost almost 3 percentage points) or even improving it (the case of F2Pool, passing from 9,4 per cent to 17,29 per cent). There are also brand new incoming protagonists: Huobi.com, holding more than 10% of the total and 1Thash%58COIN with about 8 per cent.

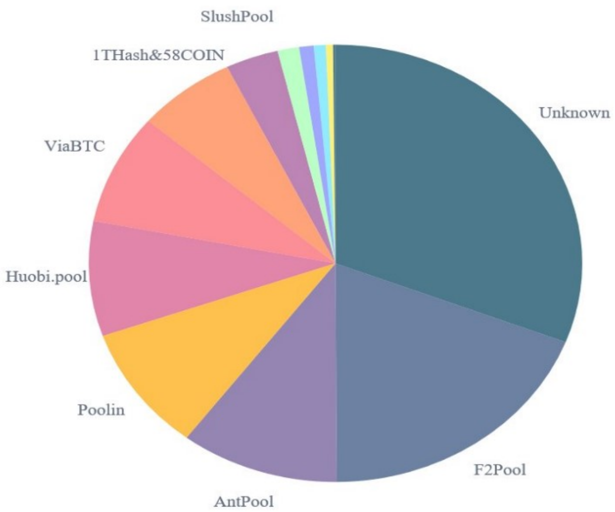

Fig. 7. *An estimation of Hashrate distribution (4 days av., 28-31 December 2020).*

Tab. 2. *Author's calculations from data retrieved at: https://blockchain.info/pools.*

Mining Pool	Mined Blocks	% of Hashrate
Unknown	200	30,07518797
F2Pool	115	17,29323308
Huobi.pool	72	10,82706767
Poolin	62	9,323308271
AntPool	60	9,022556391
1THash&58COIN	51	7,669172932
ViaBTC	43	6,466165414
SlushPool	28	4,210526316
BTC.TOP	17	2,556390977
OKExPool	6	0,902255639
BTC.com	4	0,601503759
WAYI.CN	4	0,601503759
NovaBlock	3	0,45112782
TOTAL	665	100

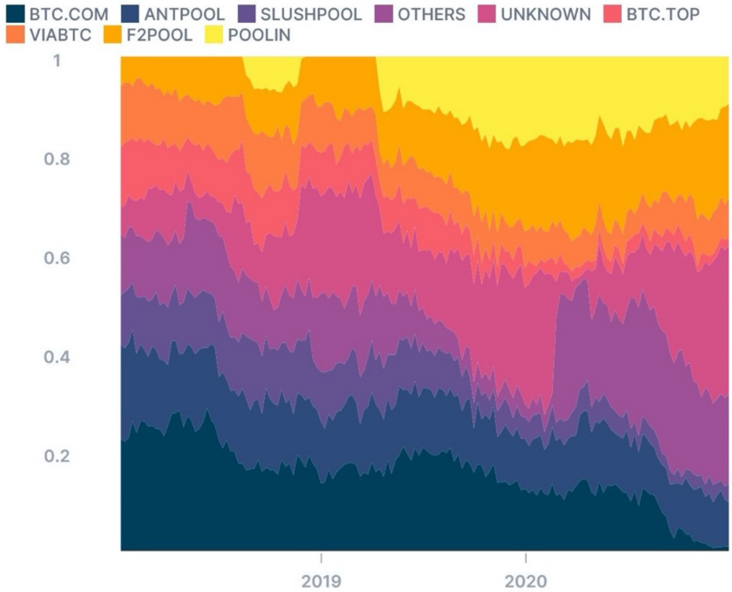

Fig. 8. *A comparison of the Hashrate distribution on a three-year-timespan (2018-2020).*

Source: https://blockchain.info/pools.

Figure 8, displaying a comparison of hash rate distribution among mining pools over a three-years timespan (2018-2020), confirms that the overall picture results dynamic and in constant change over time with regard to its actors, who alternatively lose and win shares of the total hashrate distribution, being sometimes removed from the battlefield and substituted by new comers (notable the peak in the number of "Others" in the spring of 2020, whose role, however, screwed as suddenly as it emerged).

To conclude, the comparison of the proposed snapshots over more than a four-year time span suggests that the average hashrate distribution is undergoing a process of centralization in fewer, fiercely competing, mining pools, whose number is progressively, even though slowly, reducing. Moreover, about 81 per cent of the mining pools are based in China (like Poolin, F2pool, Antpool, Via BTCm BTC.top etc), hinting at a clear geographical centralization. If, on the one hand, the tendency towards centralization reflects the increasing computational difficulties and the energy-consuming levels necessary to perform the proof of work – for instance pushing small pools to merge into bigger ones – on the other hand, it hints at a possible threat: it should not be forgotten, in fact, that a concentration of hashrate superior to 51 per cent of the total would eventually allow a potentially disruptive attack to the network[16]. Until that time, however, this process of centralization seems to provide stability to the regular functioning of the bitcoin network, assuring that the proof of work keeps going to be performed, to the benefit of the overall system. In other words, it might well be that, contrary to its technological protocol, it is the centralization in few, strongly competing mining pools, rather than the system decentralization, that finally preserves Bitcoin from failure.

CONCLUSIVE REMARKS

Along the two empirical tracks we have explored in this paper we have collected some evidences of centralization shifts towards few(er) central exchanging nodes and towards stronger mining pools located in China. Although these proofs deserve more extensive investigations, they already seem to suggest that the unreflective advertisement of Bitcoin as a distributed, decentralized – and apparently trustless – network has hindered its real developments, in the direction of higher degrees of centralization. It is now time to provide some interpretation of these tendencies.

On the one hand, the network analysis carried out at the micro level on a snapshot of the bitcoin transactions has shown that there are a few nodes that hold higher degrees of prestige, becoming special "hubs" for incoming and outgoing transactions. As such, these "merchants" or "exchanges" play a key role in the network, showing that actually some actors (like Coinbase) are more trusted – or at least relied on – than others as to their exchanging capacity, affordability or reliability. On the other hand, the comparison of hashrate distribution over

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time in the network (the macro level) shows that the growing technological and energetic costs that must be faced while mining bitcoins – not only a profitable activity, but also a key condition for Bitcoin functioning – have generated a battlefield where the struggle for survival (and thriving) becomes progressively harsher. As a consequence, not only the mining pools tend to merge in bigger ones, but new competitors enter the battlefield defeating others, or being defeated on their turn. At this point it should be clear that these features make the Bitcoin system more similar to any non-digital and non-cryptographically organized market, where no exchange can occur without trust and where competition in a limited resources environment creates power-differences and inequalities. Consequently, it might be reasonable to think that the enduring success of Bitcoin could be ascribed more to its increasing resemblance to a financial market, than to its presumed innovative and even disruptive structure.

NOTES

[1] It should be stated from the beginning that the authors share Luciano Gallino's critical analysis of the role that finance has acquired to the detriment of "real" economy (2011). The authors believe that Bitcoin is yet but another, although technologically advanced, phenomenon of speculative frenzy. Nonetheless we think that its existence and development are sociologically interesting, and as such worth studying. More detailed arguments about the speculative nature of Bitcoin and its presumed disruptive character as trustless currency are to be found in Corradi (2019).

[2] In an attempt to clarify this point, Javarone and Wright write: "nowadays, a number of services and platforms are based on distributed networks. In particular, one of the major benefits of distributed networks is given by the partition of a computational workload among multiple nodes, so that each one can perform an autonomous processing. As result, at a global level, a distributed network allows to implement the so-called 'parallelcomputing'.When this kind of network is not controlled by a (or a few) central unit (e.g. a node that coordinates the whole system, or a part of the network), it can be also defined as 'decentralized'" (2018: 1).

[3] As we suppose well known, the Blockchain technology has spread far beyond the realm of Cryptocurrencies. For an overview of its multiple applications see Romano and Schmid (2017).

[4] The extraction query is filtered in SQL language as follows: WHERE block_timestamp_month = "2020-10-01". This column contains all months covered by the dataset in the format "yyyy-mm-01".

[5] www.blockchain.com or www.btc.com, among many, allow to search transactions or addresses and, potentially, verify each row of the dataset.

[6] About Gephi: https://gephi.org.

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[7] Address number: 3G5hBoSmASwMR1aK7SfVaR7hXr1nZPgUBe.

[8] Also called "dusting attack". The term refers to the low amount of currency transmitted, so small that it can be compared to a "trace of dust".

[9] An example of "dust attack" for one of the two nodes in analysis can be viewed at the following link: https://www.blockchain.com/it/btc/address/bc1q3tm6meq2709xjtslqalrrz7l9lc5u7nfhzxpp0.

[10] https://www.simplilearn.com/bitcoin-mining-explained-article.

[11] The difficulty level of the most recent block as of December 2020 is more than 18 trillion. The difficulty level is adjusted every 2016 blocks, or roughly every 2 weeks. That is, the more miners there are competing for a solution, the more difficult the problem will become. The opposite is also true. If computational power is taken off from the network, the difficulty adjusts downward to make mining easier.

[12] The amount of new bitcoin released with each mined block is called the "block reward". It is halved every 210,000 blocks (about every 4 years). In 2009, it was 50. In 2013, 25; in 2018, 12.5, and in May of 2020, it was halved to 6.25. At this rate, the total number of Bitcoin in circulation will reach a limit of 21 million (fixed by protocol), making the currency potentially more valuable over time. This system will continue until around 2140. At that point, miners will be rewarded with fees for processing transactions paid by network users.

[13] The schism, that started as a controversy upon a solution to scaling, resulted in a new currency, called "bitcoin cash" (BCH). On 8 January 2021, Bitcoin Cash is valued at about $448 to Bitcoin's roughly $38,000.

[14] On this regard the website authors comment: "A large portion of unknown blocks does not mean an attack on the network, it simply means we have been unable to determine the origin".

[15] Some hunches are jet already possible: it could be that this variance in the proportion of unknown hashrate dealers is due to the increasing role of new Chinese companies entering "the market" of mining just for the time necessary to gain some profit, before turning to other cryptocurrencies.

[16] In fact, once a certain mining pool surpasses the threshold of 51% of the network's mining hashrate it is able to halt, control and manipulate the process of validation of some (if not all) payments between users. While for the BTC blockchain this would probably require collusion between several mining pools, the event is not entirely impossible. For instance, other cryptocurrencies (such as Bitcoin Cash in May 2019 or Ethereum Classic in January 2019) have suffered this kind of attack. For more details on this point see Tasca (2015).

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