Set in Stone: Analysis of an Immutable Web3 Social Media Platform

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ABSTRACT

There has been growing interest in the so-called "Web3" movement. This loosely refers to a mix of decentralized technologies, often underpinned by blockchain technologies. Among these, Web3 social media platforms have begun to emerge. These store all social interaction data (*e.g.,* posts) on a public ledger, removing the need for centralized data ownership and management. But this comes at a cost, which some argue is prohibitively expensive. As an exemplar within this growing ecosytem, we explore `memo.cash`, a microblogging service built on the Bitcoin Cash (BCH) blockchain. We gather data for 24K users, 317K posts, 2.57M user actions, which have facilitated \$6.75M worth of transactions. A particularly unique feature is that users must *pay* BCH tokens for each interaction (*e.g.,* posting, following). We study how this may impact the social makeup of the platform. We therefore study `memo.cash` as both a social network and a transaction platform.

CCS CONCEPTS

• Social and professional topics → User characteristics; **• Information systems → Social networks**; **• Networks → Network components**.

KEYWORDS

Blockchain-based social media, decentralization, memo.cash

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1 INTRODUCTION

In traditional centralized online social networks, users must trust service providers to enforce transparent policies and maintain continued operation. However, this trust has often been broken. For example, leakage of users' personal data happens regularly both *intentionally*, via resale of data to third parties [8], and *unintentionally* via hacking [21, 29]. Similarly, platforms inevitably run the risk of being shutdown, either because they become defunct (*e.g.,* MySpace) or because they face legal/policy actions (*e.g.,* Parler was blocked from the PlayStore).

Consequently, there has been a recent drive towards what is colloquially referred to as "Web3". This brings together a mix of technologies, largely underpinned by blockchain solutions, which attempt to offer decentralized equivalents of well-known services (*e.g.,* microblogs, video sharing). In such designs, there is no centralized entity to run the system. Rather, it is maintained by the participating individuals, removing the need (or ability) for any centralized management. Proponents argue that this helps protect Web3 platforms from censorship or large-scale takedown.

However, *decentralization comes at a cost.* Blockchain solutions can be computationally expensive, inefficient, and often rely on volatile token-based economies. One prominent example is `memo.cash`, a decentralized microblogging service built on the Bitcoin Cash (BCH) blockchain.[1] `memo.cash` writes all social data (*e.g.,* posts) onto the BCH blockchain, therefore requiring payments (in Satoshis) for each interaction. We argue that this may encourage new behaviors, whereby activities are shaped not only by social preferences but economic considerations too. To explore this, we present a first study of `memo.cash`, with the goal of understanding the interplay between economic factors and social activities.

We begin by presenting a characterization of `memo.cash` (Section 3). We observes approximately 1.1 million actions performed by 24k users between 2018 and 2021. We observe significant inequality among account: the top 1% of users control a remarkable 98.3% (USD \$30.4M) of all assets. This triggers us to investigate whether there is a potential relationship between users' posts and their financial wealth on the BCH blockchain (Section 4). We show that, indeed, wealthier user are also more socially active. We also find that their posts discuss more topics and share more URLs. Worryingly, 6.5% of these URLs shared are classified as malicious. As `memo.cash` is *immutable*, such posts can never be deleted. To overcome this, memo.cash allows users to locally "mute" each other. This serves as a form of moderation, allowing users to locally filter out any muted posts they do not wish to see. However, again, we find that this feature tends to be employed by wealthier users, suggesting that economic incentives may be dissuading poorer users from engaging in important moderation functionality. This is because even mute operations must be recorded as a transaction within

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[1]Bitcoin Cash (BCH) is one of the 10 most important cryptocurrencies [24], with a market capital estimated over 2.36 billion USD in 30/09/2022.

the blockchain, thereby incurring a fee. This tight integration between social activities and transactions leads us to examine the wider transaction network by inspecting the underlying blockchain records (Section 5). We show that users appear to use `memo.cash` as an entry point, before widening their transactions to other services. Our key contributions are:

(1) To the best of our knowledge, we perform the first large-scale analysis of a social platform built of a blockchain, covering 317.8K posts and 2.57M user actions.
(2) We show that monetary (BCH) wealth has a relationship with various user interactions. As users must pay transaction fees for all social actions, this leads to wealthier users being more proactive. We argue that this may risk embedding traditional economic inequalities into such platforms. For example, we show that poorer users are less likely to engage in the `memo.cash` moderation system. Indeed, we find a positive correlation (0.49 of Pearson Coefficient) between users posting frequency and transaction frequency.
(3) We explore common topics discussed in the platform and the content exchanged. Given the platform is immutable and content cannot be deleted, we explore the risk of unmoderated material spreading. We find a significant presence of malicious URLs (6.5% of URLs). The (financial) cost associated with moderation actions, means that less wealthy users are potentially more exposed to these risks.
(4) We shed light on the transactions made within the platform. We show that `memo.cash` is tightly coupled with wider BCH financial transactions. A significant volume of money is exchanged between users (USD $6.75M), largely via "tipping" for posts. We further explore the transaction network to identify central users who, if removed, would have a significant impact on the overall system. This raises questions regarding how decentralized `memo.cash` really is.

2 MEMO.CASH: PRIMER

We start by providing a brief primer on `memo.cash`.

Overview. `memo.cash` is an onchain social network that stores its data on the Bitcoin Cash (BCH) blockchain. The creator of `memo.cash` describes it as "both a protocol and a front-end application". Client applications can therefore read/write transactions to interact with the social network. Specifically, every time a user interaction takes place, the data is recorded as a transaction in the BCH blockchain. It is stored in the `OP_RETURN` field of a BCH transaction [27]. The `OP_RETURN` field can be thought of as the "memo" field on a cheque. Thus, it is used to store all related data, including posts, replies and likes. This means the data is permanent and uncensorable. To enable content moderation, `memo.cash` also allows users to "mute" each other (see Section 4.3). This is akin to blocking on traditional centralized platforms, whereby the front-end will hide posts from muted users. Importantly, even mutes are recorded on the blockchain, therefore giving full vantage into the network. To facilitate access to the service, `memo.cash` also operates a web-based front end, allowing people to access the service without understanding the underlying blockchain technology.[2]

[2]https://memo.cash/blog/introducing-memo

Table 1: Dataset description

Users	Content	Transactions
user id*	user-post content	BTC user id
user name	#comments	transaction id
profile description	#favourites	#inputs & #outputs
user activities*	#stars	Txn amount
following users*	rewards[3]	Txn Fee
followers*		
mute receivers*		
mute issuers*		
topics followed		
tokens held		

* includes creation/action time.

Users and social actions. Anyone can create an account on the platform. Once an account is created, a 20 byte wallet address is created in the BCH blockchain. Alternatively, a user can import their existing BCH wallet while signing up. This allows the users to use their existing funds to perform any social actions. Each action is associated with a cost.

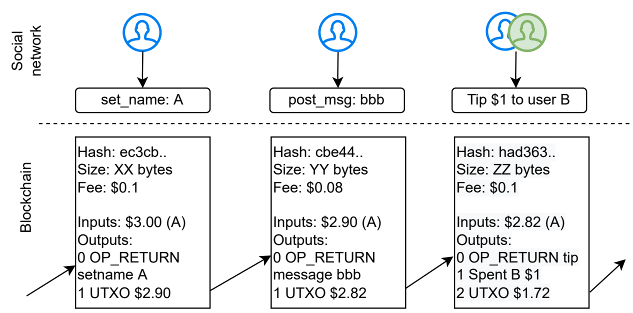

Figure 1: Overview of memo.cash's storage using BCH records.

Funds and transactions. Once the user makes an action, this gets recorded on the BCH blockchain as a transaction. A transaction is made of three main components (*i*) input: the address(es) sending the amount; (*ii*) output: the address(es) receiving the amount; and (*iii*) the actual amount. Further, there is a data store part in the transaction, allowing to store an immutable note/memo associated with the transaction. Due to this, it is necessary for users to pay a small amount (1 Satoshi/byte) when recording an action on the blockchain. In practice, this means that any action costs a minimum of 560 Satoshi.

Figure 1 shows a simple example of how the actions on the social network and transactions on the blockchain network occur. User A, who has just joined the platform, has set the profile name. Assuming the fee for setting name is $0.1 and the user has $3 balance in their wallet, the input is taken as $3 with outputs as opcode for setting the name and the remaining balance as UTXO. The remaining balance is used to create a user post and then to tipping user B.

3 DATASETS & TERMINOLOGY

3.1 Data Collection

We have developed a crawler to collect the data publicly available on `memo.cash`. A summary of the data is presented in Table 1.

User Data. We first extract all user identifiers listed on the platform.[4] For every user, we then collect their profile information,[5] followers,[6] and associated metadata (listed in Table 1).

Content Data. Next, we gather all the public posts listed on their profile. This includes the post text, alongside associated metadata: timestamp, number of likes, number of stars and its earnings. Note, earnings come from financial "tips" that other users gift for a particular post.

Transaction Data. All social actions within `memo.cash` are stored within the BCH blockchain as transactions. The transaction data includes things like transaction category and transaction fee. We therefore gather the entire set of transactions associated with any account that has posted on `memo.cash`. From this, we then induce a transaction graph. Users of `memo.cash` are represented in the network by nodes, and any transactions between two users are indicated by links.

Summary. The data spans approximately three years from Apr 2018 (when the platform was created) to Oct 2021. During this period, we discover 24.02K users joining the platform, making 317.8K posts and performing 2.57M blockchain transactions through their social activities. In summary, our data covers three parts: (*i*) user information, consisting of all user data; (*ii*) content information, consisting of all posts; and (*iii*) transaction information, consisting of all transactions within the underlying BCH blockchain (as shown in the Table 1).

3.2 Definitions

We describe here the key terminologies used across the paper.

Action. This refers to all social actions performed by the user on the platform. This includes posting, following, and muting others. An exhaustive list of actions and the number of bytes for these actions are given in Table 5 in the Appendix.

Satoshi. A satoshi is the smallest denomination of the Bitcoin Cash cryptocurrency. It is therefore the minimum transaction that can be recorded on the blockchain. It is a hundredth of a millionth BCH (at the time of writing 1 BCH roughly equals $110.4).

Transaction. A transfer of value from one address on a network to another is referred as transaction. In `memo.cash`, user actions result in transactions being written to the BCH blockchain (as they are stored in the memo field of the transaction).

Social Graph. A social graph is built using the follower relationship. Each node represents a `memo.cash` user and a directed edges denotes a followership on `memo.cash`.

Transaction Network. Each node represents a `memo.cash` user and one directed edge means a transaction from one `memo.cash` user to another.

Wallet Balance. `memo.cash` accounts are associated with a Bitcoin Cash wallet that can store Satoshi. The wallet balance represents the total number of Bitcoin Cash (Satoshi) a user holds. Incomes primarily comes from deposits and transaction income from others (*e.g.,* users can "tip" money for another person's post).

3.3 Data Overview

In contrast to prior social networks, `memo.cash` directly integrates economic incentives into posting and interaction behaviors. Hence, we provide an overview of the user in terms of their wealth and activities.

Wallet Balance. We first measure the economic status of the users via their wallet balance (measured in Satoshi). `memo.cash` accounts are associated with a Bitcoin Cash wallet that can store Satoshi. The wallet balance represents the total amount of Bitcoin Cash (Satoshi) a user holds.

We see that the top 1% of users own 98.3% (approximately USD 30.4M) of all assets. To quantify the balance distribution, we compute the Gini Coefficient: A value of 0 indicates a perfectly equal distribution of income or wealth among a population whereas 1 represents perfect inequality. We discover a highly skewed distribution: 0.998. The Gini coefficient thus demonstrates the significant disparity in user wealth in the `memo.cash` system. This is particularly relevant, as `memo.cash` requires each transaction to be paid for (a 1 satoshi/Byte transaction fee, based on the bytes needed for each action in Table 5).

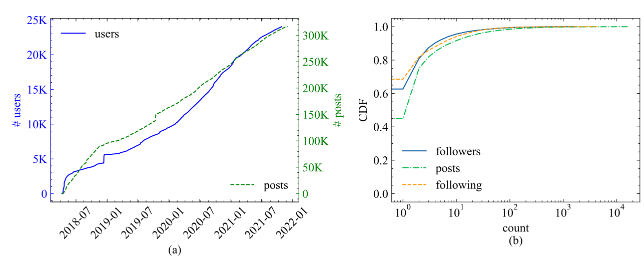

Figure 2: (a) User creation date with total number of users in `memo.cash`. (b) Distribution of per-user attributes

Growth of Users. We next study the platform's evolution, in terms of posts and user counts. We begin by looking at the join dates of the users. Figure 2a presents the growth in users and posts across the lifetime of `memo.cash`. We see that user growth has been 15.8% during the initial 3 months but thereafter mostly linear. It is not until a year later that a total of 39.4% of users joined the site, showing a steady take off of the platform. Similar behavior has been exhibited for user posts. This shows that individuals are experimenting with this new kind of social platform, and it has gained some interest (largely from the blockchain community).

In addition, we describe how active these users are. Figure 2b plots the distribution of social activities per user. We include the number of followers, followings, and posts per user. The utility of `memo.cash` as a social platform for some individuals is rather constrained: There are 62.7%, 68.6%, and 44.9% of users, respectively, who do not have *any* followers, following, and posts.

[3] as accumulated mainly through tips
[4] https://memo.cash/profiles
[5] https://memo.cash/profiles/<username>
[6] https://memo.cash/profiles/following/<username>

Impact of Wallet Balance. Recall, that every action on `memo.cash` comes at an expense of 1 satoshi/byte. We conjecture that this may reduce users' willingness to perform social actions. Hence, we test if a user's wallet balance has a relationship with the number of social actions a user undertakes. We see that users with higher wallet balances *do* have more followers (0.46 Spearman correlation), followings (0.32), transactions (0.54), post (0.34), and activity (0.54). This demonstrates that users who have a larger balance are more likely to be active on `memo.cash` and gain more attention. Further, users with a higher wallet balance have gained more tips (0.40 Spearman correlation) through posting posts. As a result, a user's wallet balance arguably serves as a proxy for their popularity on the platform.

4 CONTENT CHARACTERIZATION AND USER MODERATION

In this section we look into the content aspects of the `memo.cash` users: their posts, URLs and moderation activities. Across these axis, we are keen to understand how these factors might be related to economic wealth within the platform.

4.1 Post topics

Each post in `memo.cash` can be tagged with specific topics by the publisher. To enable the discovery of content, each user can then follow a particular topic to explore postings that fall under that area. This provides an insight into the key discussion areas. We find 977 unique topics in total, with only 11.9% of them being recently discussed in the 30 days before the date of our crawl.

Topic Followers & Posts. Out of 24,024 `memo.cash` users, 1,994 users follow at least one topic, and these 1,994 users follow a total of 6,516 topics. In sum, users have posted 328,685 posts, of which 17.7% of posts are tagged with a topic. From these, 127 unique topics are tagged by more than 50 posts. These 127 prevalent topics make up a total of 89.4% of the posts that have been specifically tagged.

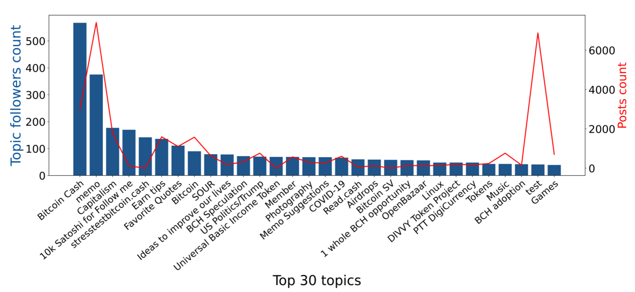

Figure 3: The number of followers for the top 30 topics. The line depicts the number of posts per topic.

In order to see which topics are most popular, we list the top 30 topics in Figure 3. We illustrate the number of followers and posts for each topic — these account for 46.8% of the total number of followers. Figure 3 also depicts the number of posts per topic. These represent the majority of user interests. The most popular topics are associated with economics (Bitcoin Cash 28.4%, memo 18.8%, Capitalism 8.9%). This follows a similar pattern to the number of followers (Spearman coefficient of 0.51). Yet we see certain outliers. For example, whereas 18.8% users follow "memo", only 12.7% posts are on this topic. Unsurprisingly, the largest outlier is the "test topic", which has 11.8% of posts but just 2.1% followers.

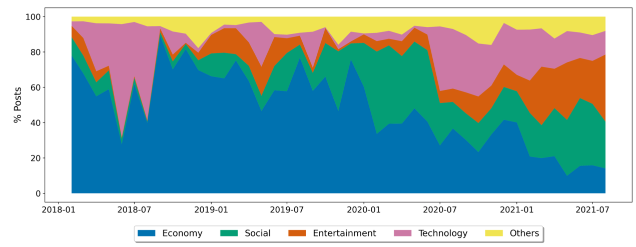

Figure 4: The percentage of posts per topic over time.

Topic Posting Across Time. We next seek to examine how the themes posted on the platform have changed over time. To assist in this, we extract all topics that are tagged in over 50 posts (127 topics). We then group these topics into five categories: *Economy*, *Social*, *Entertainment*, *Technology*, and *Others*.

Figure 4 plots the percentage of posts tagged with the five topic categories over time. We see that in 2018, the proportion of posts in the five categories exhibit a striking imbalance. In the last 4.5 years, the posts in the *Economy* category have decreased sharply from 77.3% to 16.8%. In parallel, the posts in the *Social* category have increased from 6.4 to 24%. Similarly, posts in the *Entertainment* category have increased from under 8% to 17.1%. This suggests that `memo.cash` is expanding from a platform solely focused on Bitcoin to a wider discussion forum. This is perhaps more indicative of a wider Web3 takeup, and highlights the growing media attention around associated platforms.

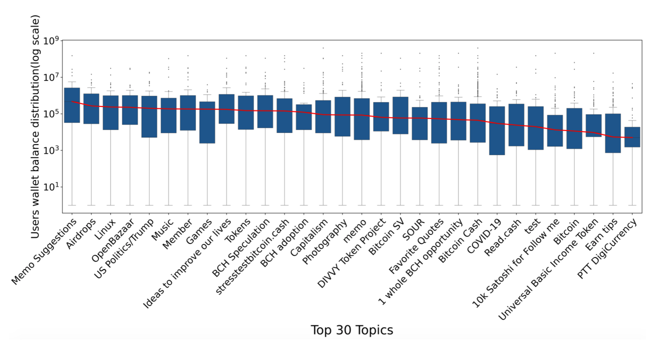

Figure 5: The wallet balance distribution among each topic's followers. Sorted by median value.

Wallet Balance and Following Topics. In order to observe the relationship between users' wallet balances and the topics they follow, we present Figure 5. This displays the distribution of wallet balances for each of the top 30 topics' followers. Indeed, we observe that users following these different topics have differing wealth. 20 of the top 30 topics are related to the BCH blockchain (such as Memo Suggestion and Tokens). Interestingly, users who follow these 20 topics are wealthier than users who have followed non-economic related topics. Users who follow these 20 economic-related topics have 5.4×10^6 (mean) and 21,936 (median) Satoshis, respectively. In contrast, users who only follow the remaining 10 non-economic related topics have wallet balances of only 1.5×10^6 (mean) and 546 (median) Satoshis, respectively. It is hard to draw strong conclusions from this, yet it is likely that users more active in discussing these Bitcoin related topics, are similarly more active in accumulating BCH wealth.

4.2 URL Characterisation

We observe that users regularly share URLs. This is particularly pertinent for `memo.cash`, as they clearly offer a window to external (centralized) services off-chain.

Overview of URLs. 28.2% of posts include at least one URL. Note, before analysis, we expand any shortened URLs.[7] Of the 92,853 URLs posted, 91,651 (98.7%) are long and 1,202 (1.3%) are shortened. Overall, these are hosted by 7,987 unique domains, with the top 10 domains cover 65.6% of URLs.

To examine the specifics of how these well-known domains are shared, we list the top 10 most popular domains of shared URLs in Table 3. We also list the number of interactions these posts receive from other users (*e.g.,* likes). We see a number of sites commonly observed on other mainstream portals. For example, Twitter and Reddit.com stand out as influential. Twitter occupies the highest percentage of likes (15.23%), stars (19.48%), comments (16.36%) and users (13.14%). Perhaps more noteworthy is the set of domains less commonly observed on mainstream portals. The domain that receives the most tips is read.cash, a decentralized blogging platform.[8] We observe other top-scoring decentralized services such as open.lbry.com, a blockchain-based video sharing site (significantly outranking YouTube, which is ranked 39th). This highlights a growing and interconnected Web3 ecosystem, albeit one that continues to interlink with more mainstream centralized platforms. We conjecture that this split may widen as more Web3 platforms emerge.

Presence of Malicious Domains. One particular worry is that, because `memo.cash` posts are immutable and cannot be deleted, malicious URLs could propagate without moderation. To test this, we use the VirusTotal API to examine the 7,987 unique domains that make up the long URLs, to see if they are malicious. We find that 6.5% of URLs are flagged as malicious by at least one malware engine within VirusTotal. For the subsequent analysis, we term these "malicious".

In order to understand the influence of publishers who publish content on the platform with malicious URLs attached, Figure 6 compares the number of posts and followers of individuals who have shared malicious URLs and those who have not published malicious URLs. Users who have shared at least one malicious URL have significantly more followers (mean 59) and posts (mean 334). In contrast, users who have never shared a malicious URL have an average of 7.3 followers and 25.7 posts, respectively. This

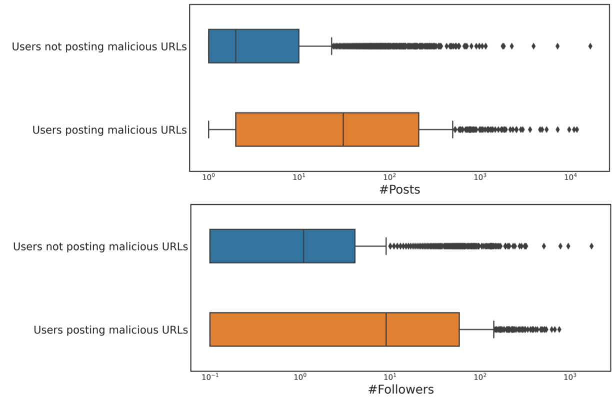

Figure 6: Comparison of followers and posts from users who post and do not posting malicious URLs.

indicates that users who have shared malicious external resources have greater social reach. The fact that the content is persistent and immutable means that these shared URLs continue to be visible today. Note, to overcome this, `memo.cash` allows individual users to mute each other; in Section 4.3, we explore this topic further.

Wallet Balance and Posting Malicious URLs. We next conjecture that richer users may share more posts, as these users are generally more active. We therefore measure the relationship between user's wallet balance and the number of malicious URLs they post. We find a Spearman correlation of 0.44, which indicates that wealthier users indeed share more malicious URLs. However, this is driven by the fact that richer users have the resources (and motivation) to post a larger number of URLs in general. Indeed, if we correlate wealth with the *fraction* of malicious URLs shared by users, it drops to 0.08.

4.3 User Moderation

As an immutable platform without any central administration, `memo.cash` does not have any moderators. Indeed, the above results show that a non-negligible number of malicious URLs are shared. To address this, `memo.cash` offer a *mute* feature, which allows users to block each other.

User Moderation. We first measure how many days after the user's creation, they start to receive mutes or mute other users. Figure 7 shows the results. Users are binned into their account creation dates, as depicted on the X-axis. The Y-axis depicts the number of days between the account creation date and when an account is first muted (or mutes another). The size of the point indicates how many users fall into that bin. We see that the majority of users are muted by others shortly after they create their account. Amongst 1,189 users who receive mutes on `memo.cash`, around 756 (63.6%) received their first mute within 30 days. This result perhaps reflects that most of the muted users are quickly identified by others, as their platform behaviour are accessible to others. Interestingly, we also note that 3.5% of the 1,189 users who have received mutes, have not posted anything, replied to any other users' posts, followed or

[7] We consider all URLs shortener on this list: https://github.com/boutetnico/url-shorteners/blob/master/list.txt
[8] Recall that users can tip each other for posts in Satoshi. Here, we sum the tips for all posts that mention each domain.

Table 3: Domain popularity of shared URLs in the posts. We rank by the rewards earned from post interactions.

domain	likes (%)	stars (%)	comments (%)	users (%)	earnings (satoshis)	page description
read.cash	5.05	6.31	7.01	7.58	**68.15 M**	decentralised blogging platform
twitter.com	**15.23**	**19.48**	**16.36**	**13.14**	37.27 M	centralised microblogging service
memo.cash	4.54	6.12	6.69	9.03	24.36 M	decentralised microblogging platform
reddit.com	13.10	5.25	5.51	6.54	8.67 M	centralised social news aggregation and discussion website
gitlab.com	0.18	0.10	0.11	0.32	7.51 M	provider of hosting software development, commonly open-source projects
open.lbry.com	1.19	1.65	0.44	0.79	6.14 M	video-sharing website using blockchain-based file-sharing system
github.com	1.71	1.99	1.63	3.73	5.67 M	similar to gitlab.com
imgur.com	1.14	1.51	3.02	10.27	5.55 M	image sharing and image hosting centralised service
memberapp.github.io	0.51	0.63	0.42	0.44	5.38 M	Bitcoin Cash blockchain browser
whotipped.it	1.06	0.68	0.25	0.16	3.69 M	stats of memo.cash earnings

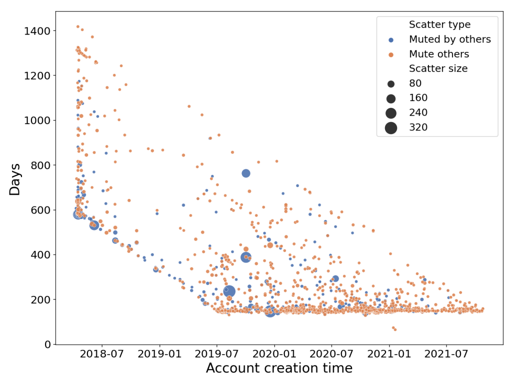

Figure 7: The length of time taken for users to start issuing (or receiving) mutes. Users are binned into their account creation dates (X-axis). The Y-axis depicts the number of days between the account creation and when an account is first muted (or mutes others). Size of the point indicates that number of users that fall into that bin.

unfollowed anyone, or added a profile description. This suggests that there may be exogenous reasons for muting users.

Wallet Balance and Moderation. As before, users must pay Satoshi when performing a mute. We conjecture that this may impact the willingness of some users to engage with this moderation model. As before, we compute the Spearman Coefficient between the number of mutes and wallet balance per user. We find a weak correlation (0.37), which suggests that richer users do moderate more. This may pose wider challenges to the Web3 community.

5 ON-CHAIN TRANSACTION NETWORK

A unique feature of `memo.cash` is the use of blockchain transactions to record all data. This provides a unique opportunity to understand user transactions, both within and outside of `memo.cash`

5.1 Overview of Transactions on `memo.cash`

Transaction Distribution. We hypothesize that some users may rely on `memo.cash` more for managing financial transactions. Thus, we look at the distribution of users' transactions and social actions. Note, that each social action is also recorded as a transaction. The remaining set of transactions the transfer of tokens (*e.g.,* for "tips").

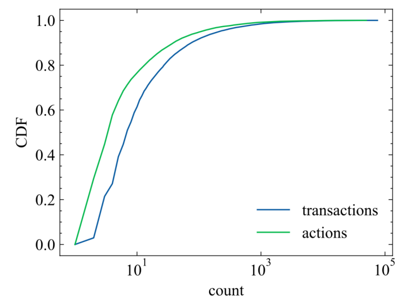

Figure 8: The CDF distribution of transaction and actions.

Figure 8 presents the CDF of number of social actions[9] and transactions made by individual users. Note, the distribution of transactions include all social actions too, which are recorded as transactions in the blockchain — the remaining transactions are transfers of Satoshi. Overall, we see 2,567,179 transactions. Both operations are clearly important, with a subset of highly active users; for example, 25.5% of users perform over 10 social actions, and 37.3% perform over 10 transactions. This demonstrates `memo.cash`'s importance as a platform for BCH transactions, as well as its social functions. That said, there is again a highly skewed distribution: The top 1% of users (by number of transactions) contribute 62.83% of all transactions, with the top user contributing 2.94%.

Transaction Types. Knowing that the quantity of transactions varies greatly between users, we next examine the types of transactions. On `memo.cash`, there are 28 distinct transaction types (excluding "null" and "unknown"). Hence, we first quantify each type of transaction and the total Satoshis for each type of transaction. Figure 9 plots the transaction types and the total number of transactions for each. The most frequent transaction type, accounting for 27.52% of all transactions, is "memo-like," with 706,470 transactions. In contrast, "set-alias" with just 37 transactions, is the least common. Additionally, we see that popular transaction types like "memo-like," "memo-reply," "memo-message," "topic-message," and

[9]Recall, the term "action" refers to all user social interactions on the platform, including posts, likes, replies, and mutes (but excludes sending Satoshis).

“memo-follow” are all related to users’ social behaviour: In sum, these make up 52.06% of all transactions.

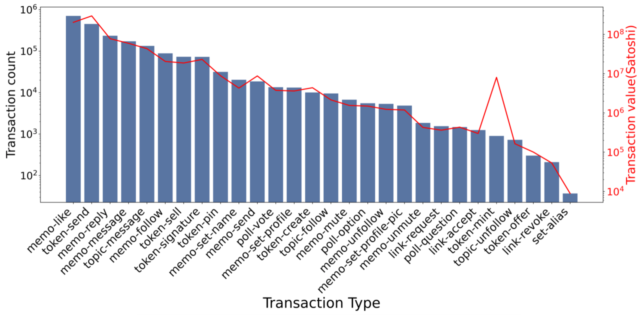

Figure 9: The number of transactions per type. The line depicts the sum value of each transaction type in Satoshi.

Transactions outside of memo.cash. We are next curious to understand the initiaters and targets of the transactions. Specifically, we observe a surprising number of recipient wallet identifiers that are not `memo.cash` users. We therefore divide the transactions initiated by `memo.cash` users into three categories: (*i*) Memo.cash users to memo.cash users (81.6%); (*ii*) Memo.cash users to non-memo.cash users (12.7%); and (*iii*) Memo.cash users to *both* memo.cash and non-memo.cash users (5.7%). The latter occurs because there are transaction outputs that include both wallets associated with `memo.cash` and other BCH-based services.

Figure 10 represents the counts for the above three types of transactions over time. This reveals interesting trends. While transactions between `memo.cash` users are steadily declining, more and more users are initiating transactions with users outside the platform (on the wider BCH blockchain). For example, in July 2018, the average daily transaction volume was 1,879, with a per-user average of 1.48. Three years later, in July 2021, the volume of transactions between `memo.cash` users decreases to an average of 554.5 per day, while the volume of transactions between `memo.cash` users and on-chain users increases to an average of 66.4 per day. Initially, we thought this might indicate a more general decline in user activity. However, closer inspection shows there is a parallel growth in the third category of transaction between memo users and *both* `memo.cash` and non-memo.cash users. This suggests that users may interact first within `memo.cash`, but later diversify their interactions to include both sets. This suggests an interesting form of ‘lock-in’, where users engaging in the social parts of the service steadily increase engagement with other parts.

5.2 Memo.cash Transaction Network

The transaction graph represents the direct interactions between users. Hence, we are curious to better understand its structural properties.

Network Centrality. We first examine centrality, which gauges the importance of each user. Figure 11 depicts the distribution of the four centrality metrics. We see that the betweeness, Eigenvector and degree centrality distributions are all highly skewed. For example, 42% of users have a betweenness centrality of 0. This suggests that

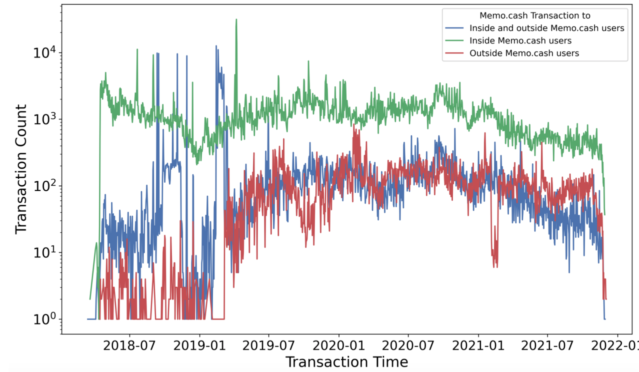

Figure 10: Number of transactions over time.

a small portion of users dominate the transaction graph. This may raise questions related to the true level of decentralization within `memo.cash`. In contrast, the closeness distribution is far wider, with the majority of users falling between 0.05 and 0.35. These findings demonstrate the small-world nature of the `memo.cash` transaction network. We therefore next inspect the resilience of the graph to the users leaving the system.

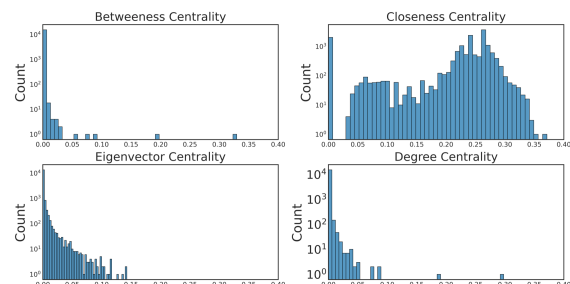

Figure 11: The distribution of centrality values for the transaction network.

Network Resilience. We conjecture that the above results may inadvertently create a single point of failure among the user graph. We therefore test the resilience of the transaction network by removing the top users and computing two metrics: (*i*) the size of the Largest Connected Component (LCC), which represents the largest subset of users, between whom transactions have flowed; and (*ii*) the number of disconnected components, which reflects the number of isolated communities retaining internal connectivity for exchanging funds. We repeat this process iteratively removing the top 1% of remaining users, and re-computing the metrics. For context, we also calculate the same statistics for the follower graph.

We start by looking at the transaction graph properties *before* removal, as summarized in Table 4. The largest weakly connected component comprises 86.8% of users. This suggests that (transitive) transactions have occurred across the majority of users. Figure 12 present the LCC and SCC in the graph when iteratively removing the top 1% of remaining users (for both the transaction and followership networks). Both the social graph and the transaction graphs

Table 4: Summary of transaction graph properties.

# Nodes	#Directed Edge	# Undirected Edge	# WCC	# Largest WCC	# SCC	# Largest SCC
15,416	83,572	72,683	1,710	13,388	12,135	3231

show a certain amount of robustness. When the top 3% of the users are removed, 29.1% and 23.9% of the users remain in the LCC of the social graph and the transaction graph, respectively. This indicates that both the social graph and the transaction graph are highly vulnerable to the loss of prominent users.

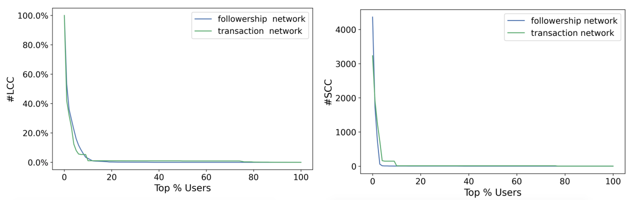

Figure 12: Impact of removing users from the followership and transaction graphs. Each iteration (X-axis) represents the removal of the remaining 1% of the highest degree nodes.

6 RELATED WORK

Decentralised Social Networks. Prior works have extensively analyzed online social networks, *e.g.,* their network structure [3, 9, 33, 35] and moderation activities [7, 13–15, 19, 31, 37, 41]. However, there has been limited attention paid to decentralized social media platforms. For example, there have been studies looking at key architectural components [28, 38, 39], management [6], privacy & security [40] and user interface design [12]. More recently, there have been studies looking at federated decentralized social networks [5, 11, 22, 23, 30, 36]. `memo.cash` is rather different. In contrast to the federated networks, all social interactions are recorded on-chain. To the best of our knowledge, this paper offers the first study of a Web3 blockchain-based immutable social platform.

Blockchain Measurements. One of the major ideologies behind Web3 is to achieve the decentralization of power. Blockchain is the main technology proposed in the Web3 community for attaining such a goal. Zarrin *et al.* discusses blockchain in detail and its applicability to the future Internet [44], as well highlighting trends and challenges. Primarily, there have been two groups of blockchain measurements: (*i*) the application frontier, studying or proposing applications built upon blockchains; and (*ii*) the blockchain frontier, studying specific underlying blockchain technologies. Examples of the first category include applying blockchain in the financial sector to tackle trust problem with investors [43], 5G and IoT applications [20] and studying the applicability in carbon credit market (see [42] and references within). Examples of the second category [32] include measurements of structural properties of the Ethererum network [10]. Our work lies in the intersection of these frontiers and aims to study a social networking application built using blockchain.

Blockchain-based Social Media. On chain social networking applications such as `memo.cash`, Steemit [2] and SocialX [1] are gaining popularity. They utilize cryptocurrency to incentivise users to share content and prevent malicious behaviors. Li *et al.* [34] presents an empirical examination of the platform and dissects the reward/consensus mechanism in Steemit. Guidi *et al.* [18] study the social graph structure of the platform. Further, to overcome the privacy challenges in native blockchains, recently there have been various proposals to bring together blockchain and social media applications [4, 16, 26]. We argue `memo.cash`, as a use case, is representative of other blockchain based social media. For instance, Steemit and Sapien operate in a similar fashion to `memo.cash` [17, 25]. Furthermore, `memo.cash` works similarly to other Bitcoin Cash-based social media, such as noise.cash, Member.cash, and Read.cash. Thus, we provide the first study into `memo.cash`, offering insights into the interplay between social and economic factors in these Web3 environments.

7 CONCLUSION

This paper has explored the recent drive towards so-called "Web3". The Web3 community brings together a mix of technologies, largely underpinned by blockchain solutions that attempt to offer decentralized equivalents of well-known platforms (*e.g.,* microblogs, video sharing). This introduces a number of new concepts, *e.g.,* the integration of economic incentives (and constraints) into platform use. As an exemplar of the Web3 movement, we have studied `memo.cash`—a immutable blockchain-based social media platform. Our main goal was to understand the interplay between economic factors (wallets and transactions) and social activities (posts and social relationships).

Our work revealed an active system, experiencing growth in terms of both users and posting (Section 3). A unique feature of `memo.cash` is the need for users to *pay* for social interactions (due to the associated fee for writing to the blockchain). We observed significant inequality among account wealth: the top 1% of users control a remarkable 98.3% (USD $30.4M) of all wallet assets. This led us to investigate whether there is a relationship between users' posts and their financial wealth on the BCH blockchain (Section 4). We find that wealth *does* correlate with various actions, confirming a risk that Web3 principals may embed traditional economic inequalities within our online social spaces. Another inherent feature of `memo.cash`'s design is immutability. We found evidence that this could cause challenges. For example, we identified a range of malicious URLs being shared (now unable to be removed). Due to economic inequalities, we argue that `memo.cash`'s moderation strategy falls short, with evidence that poorer users mute less than richer counterparts. Finally, we examined the wider transaction network (Section 5), showing that there was a surprising degree of centralization. Our findings offer a new evidence base for researchers working in Web3, and flag key risks that must be considered. In the future, we plan to look at other platforms such as read.cash and noise.cash. We are particularly keen to look at their dissemination of harmful content, and associated challenges with content moderation.

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A APPENDIX

name	action	bytes
Set name	<name>	1-217
Post memo	<message>	1-217
Reply to memo	<tx_hash> <message>	32 1-184
Like / tip memo	<tx_hash>	32
Set profile text	<text>	1-217
Follow user	<address>	20
Unfollow user	<address>	20
Set profile picture	<url>	1-217
Post topic message	<topic_name> <message>	1-214 1-[214-len(topic_name)]
Topic follow	<topic_name>	1-214
Topic unfollow	<topic_name>	1-214
Create poll	<poll_type> <option_count> <question>	1 1 1-209
Add poll option	<poll_tx_hash> <option>	32 1-184
Poll vote	<poll_tx_hash> <comment>	32 0-184
Mute user	<address_hash>	20
Unmute user	<address_hash>	20
Send money	<address_hash> <message>	20 1-194
Sell tokens Spec	<input/output_1>... <input/output_n>	
Token buy offer Spec	<list_sale_hash> <input/output_1>... <input/output_n>	30
Attach token sale signature Spec	<sale_offer_hash> <signature_1> <input/output_n>	30 72 72
Pin token post	<post_tx_hash> <token_utxo_hash> <token_utxo_index>	30 30 1
Link request	<address_hash> <message>	20 1-194
Link accept	<request_tx_hash> <message>	30 1-184
Link revoke	<accept_tx_hash> <message>	30 1-184
Set address alias	<address_hash> <alias>	20 1-194

Table 5: List of actions in `memo.cash`