The Rise of Decentralized Cryptocurrency Exchanges: Evaluating the Role of Airdrops and Governance Tokens

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Abstract

This paper introduces the most comprehensive data available to date on centralized and decentralized exchanges run off of distributed ledger technologies. First, we document the rapid growth in decentralized exchanges and their differences in volume and price dynamics from centralized exchanges. Second, motivated by these differences, we investigate the role of airdrops and governance tokens as mechanisms for expanding the base of users and driving up the value of an exchange. Our results suggest that both mechanisms are effective for expanding and strengthening networks, particularly for decentralized exchanges. We also exploit two event studies that suggest the growth in decentralized exchanges is not driven by speculation, but at least partially by value-creating cybersecurity benefits.

Keywords: Airdrops, Blockchain, Decentralized Exchanges, Decentralized Finance, Expectations, Smart Contracts.

JEL Codes: D82, D84, G29, L86

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1 Introduction

Between 2020 and 2021, the value of digital assets concentrated within decentralized finance (DeFi) grew from $670 million to $13 billion (Deshmukh et al., 2021). Furthermore, the number of user wallets grew from 100,000 to 1.2 million and the number of DeFi applications grew from 8 to over 200. Earlier this year, a famous economist and blogger remarked that the "killer app" for cryptocurrencies has "finally been found" in DeFi (Cowen, 2021). DeFi technologies leverage the blockchain—most frequently, the Ethereum blockchain—to enable users to exchange and borrow cryptocurrencies and even to obtain specialized insurance through peer-to-peer interchange without middlemen.[1] The primary contribution of this paper is to document the rise of decentralized exchanges (DEXs) and uncover plausible mechanisms behind the growth.

DEXs, like Uniswap, have fundamentally different architectures than centralized exchanges, such as Coinbase and Binance. Centralized exchanges require users to deposit currencies into "hot wallets," which are centralized repositories. The centralized exchange maintains private cryptographic keys which unlock these wallets. By contrast, DEXs are non-custodial: cryptocurrency remains in each user's wallet. DEXs perform transactions through smart contracts, computer programs which automatically execute when certain conditions are met. Since the operational footprint of many DEXs is reduced to the program code stored on a public blockchain, they often do not hold any legal identity. Therefore, unlike CEXs, they cannot interface with the banking sector and do not support trade between cryptoassets and conventional "fiat" currency.

Despite this limitation, DEXs have enjoyed meteoric growth.[2] Three principal rationales have

[1] See Iansiti and Lakhani (2017) for a broader discussion of blockchain technology for organizations and society.

[2] However, there is also a lot of concern about the role of speculation and fraudulent activity. For example, Cong et al. (2021) explore the incidence of "wash trading," which refers to strategies that exchanges may use to

been posited. First, proponents have claimed that, because cryptocurrencies are distributed in users' wallets and not stored in a hot wallet, DEXs are more private and more secure than centralized exchanges (Bowater, 2018). Second, because DEXs fiercely compete for business, they charge lower fees. This competitive landscape is likely to hold since DEXs are largely interoperable; users can move to other exchanges if they do not like a DEX's policies and practices (Cong and He, 2019; Alkurd, 2020; Boudjemaa, 2020). Third, because they operate on a global peer-to-peer network without formal registration in any jurisdiction, they can evade regulation and face lower compliance costs (Aspris et al., 2021). Unfortunately, empirically evaluating these theoretical predictions has been challenging due to an absence of reliable and sufficiently expansive data.

We address this gap in the literature by producing, to our knowledge, the most comprehensive dataset available covering both centralized and decentralized exchanges over time. Consider, for example, the rise of DEXs, relative to centralized exchanges, since 2019 (see Figure 1). We also explore the rise of DEX "governance tokens," or tokens that give users ownership that resembles shareholder rights for publicly traded firms. These governance tokens are often valuable assets and tend to appreciate in value as an exchange flourishes. Since its introduction in September of 2020, the governance token for Uniswap, the most popular DEX, has more than quadrupled in value. It is the eleventh biggest cryptocurrency asset by market capitalization.[3]

[INSERT FIGURE 1 HERE]

The second part of the paper estimates the difference in trading volume dynamics for centralized

fake transactions and create the perception of momentum to improve the ranking of the exchange, temporarily distort prices, and ultimately influence their market capitalization. Makarov and Schoar (2021) conducts a similar analysis for the Bitcoin market, arguing that only a minority of the transactions constitute illicit trades. Jahani et al. (2018) take an alternative approach, mining the textual content of posts on cryptocurrency discussion boards, finding that there is genuine "truth seeking" (versus hype) discussion around the more serious coins.

[3]Source: https://coinmarketcap.com/, August 31, 2021

and decentralized exchanges. Although centralized exchanges process larger volume overall, DEXs have a 8-9 percentage point higher growth rate in day-to-day exchange volume. Our estimates are robust to controlling for aggregate fluctuations in the demand for cryptocurrency, the trust rating of different exchanges, and the year that each exchange was established.

The third part of the paper investigates another potential mechanism driving DEX growth: the use of airdrops—that is, the distribution of a native exchange token or a governance token to current or potential users as part of a "digital asset giveaway." On one hand, airdrops reward early supporters who reap less value by backing a new DEX compared to an established one. Since DEXs begin with few users who generate lower volume, they accrue less revenue in transaction fees and cannot remunerate peer lenders as generously as established exchanges. Airdrops can also serve as marketing opportunities to reach users who are active in other DEXs to encourage them to experiment with another platform. On the other hand, airdrops can backfire, because they put governance tokens in the hand of individuals who do not believe in the long-term viability of the exchange and want to maximize their short-run returns. Moreover, airdrops may unintentionally signal that the tokens are lower quality, influencing expectations about the exchange's longevity.

Using a sample of 51 exchanges over time, we find that airdrops are positively associated with growth in market capitalization and volume, but these benefits are concentrated among DEXs and exchanges that offer governance tokens. In particular, DEXs that conduct an airdrop exhibit a 16.1 percentage point rise in their growth rate of their token's market capitalization (significant at the 5% level). We also find some evidence, although the estimates are not statistically significant at conventional levels, that DEXs who airdrop governance tokens experience higher volume growth than those who do not. These results suggest that airdrops may not only serve as marketing devices and sources for entrepreneurial funding, but also as a vehicle for ensuring that a DEX stays true to its values. By airdropping governance tokens, DEXs distribute control over an exchange's policies to some of the earliest adopters of DeFi, who are most skeptical of traditional financial institutions. Governance token holders ensure that a DEX stays true to its libertarian founding ethos; consequently, more users transact with DEXs who airdrop governance tokens.

Admittedly, these results are not causal. Some have suggested that the DEX growth is evidence of a bubble driven by rampant speculation. Other have posited that DeFi capitalizes on regulatory arbitrage: criminals use DEXs to hide their ill-gotten gains away from the prying eyes of the government. To investigate whether growth in DEXs can be tied to their inherent advantages, speculation or regulatory arbitrage, we conduct two event studies.

The first event we look at is the KuCoin breach in September 2020, where cybercriminals stole cryptocurrency located in the exchange's centralized hot wallet. This breach exploited a security flaw in centralized exchanges that isn't present in DEXs. Second, we examine the ramifications of a rare joint letter written by three US regulatory agencies, released in October 2019, that urged digital currency exchanges to adhere to regulations that proscribed financial institutions from abetting criminal activity. Many centralized exchanges responded to the letter by fortifying their compliance procedures, while DEXs largely resisted such measures. We find that growth in DEXs was not affected after the regulatory announcement, whereas DEX growth increased after the KuCoin breach. These results suggest that growth in DeFi is linked to the value-creating properties of DEXs (i.e., security benefits), rather than speculation or regulatory arbitrage.

Related Literature

Our paper contributes to an emerging literature on blockchain and DeFi (Yermack, 2017; Harvey et al., 2021). In particular, initial coin offerings (ICOs) have emerged as an effective tool for financing new ventures by offering unique tokens with the promise that they will operate as a medium for exchange to access the venture's future projects/services and/or governance. According to Catalini et al. (2018), blockchain startups have raised over $7 billion through ICOs, relative to $1 billion through traditional venture capital in the space. These tokens differ from equity in that they are not claims on future profits, but rather a flow of future revenues. Furthermore, Catalini and Gans (2019) provide a theoretical framework for valuing the benefits of token offerings over traditional venture financing, finding that there are some advantages for hybrid arrangements where ventures raise equity initially from a narrow group before going towards the public or accredited investors. Similarly, Cong and Wang (2021) explain how tokens (through smart contracts) provide a solution to a time inconsistency problem with investors, thereby providing an effective way of financing investment. Our results are also closely related with Chod and Lyandres (2020) who show that tokens can strictly dominate equity financing for information services startups where tokens can signal quality to outside investors and Howell et al. (2020) who show that ICOs predict firm performance and expansion. Besides the prospect for enabling greater funding for entrepreneurial ventures, there is also some evidence that smart contracts can reduce information asymmetries and promote competition, which could indirectly raise entrepreneurship (Cong and He, 2019).

Our paper is also directly related to the study of cyptocurrency exchanges. For example, Moore et al. (2018) study the emergence and closure of Bitcoin exchanges between 2010 and 2015, finding that higher-volume exchanges and those that derive their value from trading less popular currencies are less likely to close. Moreover, they show that experiencing a breach is highly predictive for whether the exchange closes. Similarly, Pieters and Vivanco (2017) show that governance structures surrounding Bitcoin matter for centralized exchanges, especially the inclusion of know-your-customer regulations that require consumers to provide identification to establish an account. Our paper is also closely related with Catalini and Tucker (2017) who conduct an experiment with Bitcoin, finding strong evidence of path dependence in the initial availability of technology among early adopters. In this sense, we build on an emerging literature that examines the effects of cryptocurrency design features on users and their growth.

Centralized and decentralized exchanges also differ in their market design. In particular, to avoid frequent updates and prohibitive transaction costs on the blockchain, Angeris and Chitra (2020) discuss the use of constant function market makers (CFMMs), which is an automated market maker rule that specifies what constitutes a valid trade. These CFMMs have emerged as a critical component of DEXs since they ensure that smart contracts can be credibly executed.[4] Relatedly, Harrigan et al. (2018) analyze the privacy risks of cross-chain airdrops, Wahby et al. (2020) design a privacy preserving airdrop approach where recipients are not publicly visible, and Frowis and Bohme (2019) explore the technical design space of airdrops on the Ethereum platform. Our paper relates with these design differences by examining how the use of airdrops and governance tokens might affect user engagement and market capitalization.

[4]Numerous publications explore the design space of Automated Marked Maker (AMM) based exchanges (Engel and Herlihy, 2021) and their use (Gudgeon et al., 2020; Lehar and Parlour, 2021; Qin et al., 2020; Lo and Medda, 2021). Automated market makers require less interactions than limit order book approaches and are thus cheaper to operate on decentralized ledger platforms. We are not aware of any study trying to assess success criterion of exchanges.

2 Background and Theoretical Framework

2.1 Decentralized Finance

The majority of the current data systems in finance are centralized, meaning they typically depend on a trustworthy third-party to decide if a transaction is legitimate. In contrast, distributed ledgers are designed to work without a single powerful party. This means all information stored and recorded in the ledger—often technically implemented as a blockchain data structure—is agreed upon between numerous independent parties (Bohme et al., 2015).

The consensus protocols leading to this agreement are mainly based on proof-of-work (POW) where record-keepers solve "moderately hard" mathematical problems to disambiguate potentially conflicting transactions and ensure that only legitimate transactions are added to the ledger. This technically enforced verification of records is in stark contrast to contract incompleteness in conventional markets where sellers are unable to charge prices that are contingent on the success of the goods or services: decentralized consensus mechanisms executed through smart contracts can allow for contracting and enforcement (Cong and He, 2019). However, smart contracts in DEXs are no panacea. Dating back to theoretical work by Shleifer and Vishney (1997), arbitrage opportunities can emerge in DEXs through a phenomenon called front-running. These are settings where arbitrage transactions are executed by "running in front of" other trades based on the information made public through the DEX (Daian et al., 2020).

2.2 The Value of Decentralization

There are several advantages of decentralized systems. First, decentralization means, by definition, that no single party has full control over the system. An ideal decentralized system would not require a dedicated supervisory authority as every user could convince herself that every transaction on the system is valid with respect to the rules laid down in a computer program open to everyone. While many practical systems fall short of this vision despite employing some decentralized technology (Böhme et al., 2020; Gencer et al., 2018), and empirical studies fail to identify decentralization as a strong driver of Bitcoin adoption (Abramova and Böhme, 2016), the structure of these decentralized systems can still provide users with greater autonomy.

Second, because decentralization removes private knowledge and compliance cost, decentralized exchanges promote greater competition. In centralized exchanges, information is not dispersed across a large population, so monopolies with third-party arbitrators emerge, controlling most, if not all, transactions. Furthermore, smart contracts can mitigate problems of time inconsistency that are endemic in venture financing: an entrepreneur can commit to one strategy, but conflicts of interest can emerge; the use of tokens enables commitment to a predetermined set of rules since the tokens only have value if the smart contract is executed on (Cong and Wang, 2021).

Third, since users have more autonomy under open and decentralized systems, they can copy and modify the computer program at any point in time (Reibel et al., 2019). This facilitates continuous improvement and ever improving efficiency. For example, the Sushiswap DEX is a copy of Uniswap's code adding reward mechanisms for users, which in some sense redistributes power from the operator to the users (Cryptopedia, 2021).[5]

[5]This pattern is known from cryptocurrencies: a clone of Zcash removing the "founders reward"—a cut 20% of

However, as in conventional finance, markets and platforms are network goods whose success is contingent on a critical mass of users (Economides, 1993). Unlike the technology, a user base cannot be copied. In the absence of technological leaps, attracting new users is the non-trivial part of establishing a decentralized platform. This applies to cryptocurrencies and DEXs alike.

2.3 Airdrops as Marketing Tools

Airdrops refer to a "marketing strategy" that involves sending small sums of new currencies (i.e., tokens) to active cryptocurrency traders in exchange for promotions (e.g., social media). By increasing awareness of new currencies, and consequently strengthened the base of active users. More recently, this practice has been adopted by DEXs and may help normalize them.

In 2010, Gavin Andresen, a Bitcoin developer, launched a thread on Reddit to give away five Bitcoin with the sole intent of driving greater interest and visibility towards it.[6] After the "Bitcoin faucet" demonstrated at least some success, others adopted the idea. In 2014, a new cyptocurrency tried to bootstrap its user base by giving its tokens to every active Bitcoin, Litecoin, and Dogecoin user (Harrigan et al., 2018). Airdrops became mainstream with the rise of Ethereum around 2016, which made it particularly easy for user to create their own cryptoasset, a so called token. At this stage, airdrops were increasingly given in exchange for social media services that drive visibility and momentum in the market. That is, in exchange for greater publicity, early users are rewarded with tokens (and encouraged to retain them) that may appreciate over time.

However, airdrops can also signal a currency's weakness. For example, investors could interpret the distribution of tokens as evidence that there are certain technological or design flaws in the

newly minted coins pocketed by the developers—has been launched shortly after the introduction of Zcash 2016.

[6] https://cointelegraph.com/news/reddit-reminisces-defunct-bitcoin-faucet-website-that-gave-away-19-700-btc-for-free

currency that would otherwise prevent them from attracting new users. Much like the theoretically ambiguous effects of coupons with physical goods, airdrops may not necessarily help the currency. Furthermore, airdrops can also get in the hands of "yield farmers:" highly speculative traders who are merely trying to maximize return and may not have the long-term welfare of the protocol in mind. These token holders may rapidly cash out after a run-up in the price of tokens, leading to volatility. We investigate whether airdrops can explain the growth in exchange volumes–or whether it is merely creating froth and increasing the volatility of the market.

2.4 Governance Tokens and Distributed Decision Making

Decentralized exchanges can avoid maintaining any legal identity, helping insulate them from regulation and enforcement actions. To gain user trust given the lack of a corporate body in charge of governance, they leverage distributed control mechanisms through smart contracts. Holders of exchange issued governance tokens can vote on decisions—e.g., adding or removing trade pairs, the fee and vote structure of the exchange, or whether or not to conduct an airdrop—much as common stock holders of a publicly traded company are empowered to vote on the firm's decisions.

Because of the potential benefits of avoiding a legal identity, all DEXs are implicitly expected to eventually issue governance tokens, although the timing varies. A critical governance question for decentralized exchanges relates to the initial distribution of governance tokens. A popular option is to reward early adopters with governance tokens relative to their contribution to the success of the exchange. However, some DEXs have opted to keep authority centralized in an exchange's incipient stages and to only later decentralize governance. For instance, Uniswap, which was founded in 2018, only airdropped its governance tokens in September 2020.

3 Data and Measurement

Our data-set is derived from *CoinGecko*, a popular data aggregation site for cryptocurrency and exchange data. We employ their API to collect information about exchanges and their associated tokens, acquiring information on a total of 477 exchanges that are listed on CoinGecko at the time of writing.[7] For every exchange we additionally obtain the daily trading volume. CoinGecko reports all volume and price data in BTC. We use daily price data acquired from *CoinDesk* to convert the BTC prices to USD using daily and monthly mid-point prices, as most cryptocurrency assets are highly volatile. Figure A.1 in Section A compares the time series trading volume for the full data versus the subset that have tokens.

Recall from Figure 1, which plots the log of the average trade volume per exchange for DEXs and centralized exchanges over time, that DEXs have a much more rapid growth rate in volume even though centralized exchanges trade a higher volume overall. Furthermore, Figure 2 plots the creation of new exchanges by year, showing that the bulk of DEXs emerged since 2020.[8] Table A.1 in Section A presents selected statistics for these DEXs and centralized exchanges. Furthermore, Figure A.2 plots the density function of exchange volume: while DEXs are still smaller than centralized exchanges, they are growing at a quicker pace.

[INSERT FIGURES 2 HERE]

To analyze the impact of exchange tokens and airdrops, we compile a list of exchanges that have an associated token. The list was created in a semi-automatic fashion. We first obtained the

[7] The list was fixed on the 15th of July, 2021. We plan to publish the data-set and code after publication.

[8] Since the year an exchange was established is not always available, we impute using the date that the first data point is available.

list of all tokens available on CoinGecko. Then, we match exchanges and tokens based on their name and symbol using a fuzzy text matching approach (Chang and Lampe, 1991). To avoid false negatives, we set the matching threshold conservatively such that we could remove false matches through a manual quality control process that mitigates the possibility of measurement error.

We also investigate whether a token was ever airdropped through an online search: we looked for airdrop announcements on exchange websites and blogs; popular news sources like *CoinDesk*, *CoinMarketCap*, and *CoinTelegraph*; and sites like Airdrop Alert, which informs crytocurrency traders about impending giveaways. Based on our research, we created a dummy variable which takes on the value of 1 if an exchange has offered an airdrop and zero otherwise. We record the date of an exchange's first airdrop so this variable is dynamic for our panels.

CoinGecko delineates tokens between *exchange tokens* and *governance tokens*. Exchange tokens are native to a particular DEX or centralized exchange; they are designed to increase that exchange's liquidity. Often, exchange tokens are awarded to particularly active users. By using exchange tokens, traders usually receive discounts on transaction fees. Governance tokens provide DEX users with many of the same benefits, but they also accord holders with voting power. In our analysis, we include two dummy variables: one that takes on the value of 1 if a token is an exchange token; and one that takes on the value of 1 if a token is a governance token.

Our data contains 73 exchanges, their associated tokens, and a classification of the purpose of the token according to CoinGecko. Some exchanges share the same token, e.g. the Uniswap token serves as token for three different versions of the Uniswap exchange listed on CoinGecko. To be able to assess the effect of governance tokens on the DEX ecosystem, we group together exchanges that use the same governance token into one entity. Table A.2 in Section A shows additional descriptive statistics of the governance data. Figure A.1 compares the distribution of the complete data-set against the filtered set with exchange tokens. Figure A.3 plots the time series trading behavior for the 7 largest DEXs and the six largest centralized exchanges.

4 Comparing Centralized and Decentralized Exchanges

To understand the difference in volume and price dynamics between centralized and decentralized exchanges, we consider regressions of the form:

$$y_{it} = \gamma DEX_{it} + \beta X_{it} + \rho y_{i,t-1} + \lambda_t + \varepsilon_{it} \tag{1}$$

where y_{it} denotes an outcome for exchange i in period t, DEX denotes an indicator for whether the exchange is decentralized, X denotes a vector of controls about the exchange, y_{t-1} denotes a one-day lagged value of the outcome variable, and λ denotes time fixed effects. We cluster standard errors at the exchange-level to allow for autocorrelation in our errors across time. We focus on two outcomes: logged volume and its growth rate.

Our primary concern in estimating Equation 1 is that γ might be biased downwards due to unobserved heterogeneity. For example, trading activity will tend to be lower in DEXs since they are newer. However, we address this concern by controlling for the date that the exchange was created, the trust rank, and by exploiting the panel structure of the data with an autoregressive component. The trust score is calculated by CoinGecko using a combination of several factors: (i) web traffic of the exchange, (ii) orderbook spread & +/- 2% depth, (iii) overall trading volume, (iv) trade frequency, and (v) outlier checks.[9] We also control for the year that the exchange was formed to purge variation that might stem from path dependence. Moreover, our inclusion of time

[9] https://blog.coingecko.com/trust-score-explained/

fixed effects purges aggregate variation, like federal reserve policy, that may affect the volume and price dynamics of both centralized and decentralized exchanges. Finally, the autoregressive component controls for some of the unobserved heterogeneity that could be present.

Table 1 documents these results under varying layers of controls. Starting with the raw volume differences in column 1, we see that DeFi exchanges have nearly 300% fewer trades per day. Controlling for the year that it was established linearly or through fixed effects brings the differences down to roughly 170% (columns 2 and 3). Trust rank, not surprisingly, enters negatively since a higher trust rank implies it is less trustworthy and, therefore, attracts fewer investors. However, both of these regressions contain a significant amount of unobserved heterogeneity, so column 4 controls for a one-day lag through an autoregressive component. We see a substantial drop—only a 5% difference in volume remains after controlling for the previous day's volume level.

To better understand the role of unobserved heterogeneity, we now consider comparable regression when the outcome variable is the day-to-day growth rate. Column 5 shows that DeFi exchanges grow 9.7 percentage points faster per day. Moreover, after we control for the trust score and age of the exchange, the coefficient remains statistically indistinguishable (column 6). Column 7 uses fixed effects on the age of the exchange, lowering the estimate slightly to 7.2 percentage points. These results are important since they show that, even when focusing on exchanges that were formed in the same year, DEXs grow faster than their counterparts. Finally, column 8 controls for an autoregressive component, generating a slightly higher coefficient of 8.1 percentage points. This could reflect negative selection into DEXs, i.e. the proliferation of low performing DEXs as the costs of starting new exchanges has declined over time.[10]

[10] We see slightly smaller estimates around 4.5% higher growth among DEXs when we winsorize the distribution of daily growth at the 3rd and 97th percentiles to remove otherwise extreme values. Moreover, our results are robust to estimating our sample with monthly, rather than daily variation. In column 6, we obtain a coefficient estimate of 0.146 with a p-value of 0.027. However, these less statistically significant estimates reflect our averaging

[INSERT TABLE 1 HERE]

Our results are also related with those from Moore et al. (2018) who examine closures of roughly 80 Bitcoin exchanges between 2010 and 2015. They find, for example, that higher-volume exchanges and that those derive their value from trading less popular currencies are less likely to close. They also show that experiencing a breach is highly predictive for whether the exchange closes. To the extent that decentralized exchanges also are able to maintain better security, we might be underestimating the growth and volume potential of the DEXs.

5 The Effects of Aidrops and Governance Tokens

As we discussed earlier, theoretical evidence highlights the role of decentralized governance tokens, which have increased dramatically in value, and airdrops in explaining the rising prominence of DEXs. First, governance tokens reward users with the authority to influence how the protocol develops, which is one of the major attractions of DeFi over centralized exchanges. Second, airdrops further reward early users with tokens, which can serve as a signal and generate momentum based on expectations of future growth (Chod and Lyandres, 2020).

To quantify the effect of these twin forces over our monthly sample of exchanges between 2018 and 2021, we consider panel regressions of the form:

$$y_{it} = \gamma DEX_{it} + \alpha a_{it} + \xi(DEX_{it} \times a_{it}) + \beta X_{it} + \lambda_t + \varepsilon_{it} \tag{2}$$

where y_{it} denotes the growth of the token's market capitalization or the exchange's volume over the course of month t, DEX denotes an indicator for whether the exchange is decentralized,

across observations and removal of some of the variation.

α denotes an indicator for whether the exchange had an airdrop, X denotes a vector of controls, and λ denotes year and month fixed effects. Like before, our vector of controls includes the exchange's trust rank, dummies on when the exchange was created (normalized to 2014), an indicator for distributing a governance token, and logged volume (when the outcome variable is market capitalization growth). When our outcome is market capitalization growth, we restrict the sample to observations where the exchange is strictly positive level of market capitalization. We cluster standard errors at the exchange-level to allow for autocorrelation in our errors across time.

Table 2 documents these results. In columns 1 and 2, we see no statistically or economically significant difference between centralized and decentralized exchanges—the indicator on DEX is insignificant. Moreover, in column 2, the indicator on airdrops is positive, but not statistically significant. However, in column 3, we see an economically large 16.1 percentage point increase in the monthly growth rate of market capitalization, which is statistically significant at the 10% level.[11] This result is meaningful: it demonstrates that airdrops tend to matter and manifest in higher market capitalization only when done from a DEX. (Moreover, if the regression is estimated in levels, we find that DEXs that do airdrops have roughly a 87% higher market capitalization, although it is not statistically significant at conventional levels.)

Motivated by the heterogeneity that we observe in column 3, we now allow for a heterogeneous effect of airdrops for exchanges that offer governance tokens in column 4. Although our estimate is statistically insignificant, we find that market capitalization growth is 11.8 percentage points higher among exchanges that offer governance tokens and conduct an airdrop. This is consistent with the view that governance tokens convey value to users. Similarly, in column 6 where the outcome

[11] These results can be somewhat sensitive to how the sample is winsorized, but they are qualitatively robust. For example, winsorizing at the top and bottom percentile produces a similar estimate, but it is not statistically significant at the 10% level.

is the growth rate of volume, the benefits of airdrops are also concentrated among exchanges that offer governance tokens with a 27.8 percentage point rise in the volume growth rate.

Turning to column 5, we focus on volume growth. Like the results in Table 1, columns 4 and 5 show that DEXs have higher growth in volume. These estimates are more noisy than those from Table 1, however, because we are working off of a smaller sample where we know whether the exchange has had an airdrop or not. While airdrops are associated with a 9.6 percentage point higher growth rate in volume overall, column 6 shows that airdrops have the greatest effect on growth when done from a DEX. In particular, DEXs that conduct an airdrop have a 7.3 percentage point higher growth rate of volume, although it is a noisy estimate that is not statistically significant at conventional levels. In sum, we find that airdrops are positively associated with growth in volume and there is suggestive evidence that they are most effective for DEXs.[12]

We also find that DEXs reap a greater benefit from airdropping governance tokens than, suggesting that there is another benefit to airdropping governance tokens which heretofore has been neglected in the literature. Decentralized airdrops are a means of distributing governance to early users who are committed to preserving the ethos and character of exchanges. DEX users are more likely to favor exchanges which have distributed governance rights.

[INSERT TABLE 2 HERE]

[12]While it is too early to say, in future work we will explore how the timing of airdrops and disbursement of governance tokens influences the dynamics of market capitalization and volume for different types of exchanges, along the lines of Catalini and Tucker (2017) who explore how the distribution of Bitcoin among early users affects the diffusion of the cryptocurrency.

6 Evaluating the Role of Speculation, Regulatory Arbitrage, and Security

Some have speculated that DEX growth is due to unchecked speculation and not their inherent characteristics. For example, Jay Powell acknowledged that the Federal Reserve's easy money policies had contributed to a "frothy" cryptocurrency market (Greifeld and Hajric, 2021). Other detractors, such as David Jevans, the CEO of blockchain analytics firm *CipherTrace* have argued that many users of DEXs are trying to evade reuglations and "launder money through the system." On the other hand, DEX evangelists like Uniswap CEO Hayden Adams, maintain that the growth of DEXs can be attributed to their "inherent advantages" over centralized exchanges, such as their better security and greater autonomy (Alloway and Weisenthal, 2021). Particularly as many investors look to cryptocurrency as a potential hedge to inflation, understanding more about the underlying drivers of DEX growth, and whether it is driven by regulatory arbitrage, is important to determine whether it may be more than a transient investment.

To investigate the drivers of DEX growth, we conduct two event studies, exploiting plausibly exogenous events that highlight the differences between DEXs and centralized exchanges. We investigate whether DEX growth accelerated in the wake of these events. Both of these events were generally unanticipated and reflect the dynamic and fast-paced cryptocurrency environment, giving us an opportunity to assess the potential drivers behind abrupt changes in growth.

The first event we examine is the breach of KuCoin in September 2020. Hackers discovered the private keys used to manage KuCoin's centralized hot wallets and stole $280 million in cryptocurrency (Hui and Zhao, 2020). The attack is emblematic of a key security flaw of centralized exchanges—money can be stolen if an exchange's private keys are discovered—that does not beset DEXs, which have non-custodial architectures that rely on smart contracts, not hot wallets.

We investigate whether the KuCoin breach accelerated the growth of DEXs relative to centralized exchanges. We conduct an event study, examining cryptocurrency exchange growth in the 10 days prior to and the 10 days after the public disclosure of the KuCoin breach:

$$y_{it} = \xi(DEX_{it} \times Post_t) + \zeta_i + \lambda_t + \varepsilon_{it} \tag{3}$$

where y_{it} denotes the volume growth rate of exchange i over the course of day t, ξ denotes the growth rate of DEXs in the period after (relative to before) the breach, and ζ and λ denote exchange and time fixed effects. Unlike before, our inclusion of exchange fixed effects purges all time-invariant heterogeneity across exchanges, isolating the effect of the events on decentralized versus centralized exchanges. We also present the results without these exchange fixed effects.[13]

Starting with column 1, Table 3 finds that the KuCoin breach increased DEX growth by 13 percentage points (pp) in our specification with time fixed effects but without exchange-level fixed effects. This coefficient is statistically significant at the 10% level. With time and exchange fixed effects in column 3, we estimate that the breach increased growth by 14pp; this coefficient is statistically significant at the 5% level. Based upon these results, we conclude that DEX growth has in part been driven by concerns about the cybersecurity of centralized exchanges.

The second event we study is a rare joint letter written by three US regulatory agencies, the Securities and Exchange Commission (SEC), the Commodity Futures Trading Commission (CFTC),

[13] We only examine volume growth for the 10 days before and the 10 days after the shock. This is for two reasons. First, cryptocurrency markets are heavily traded and react very quickly to new information (Bleher and Dimpfl, 2019). Second, compressing our pre- and post-periods reduces the chances that there is a concomitant shock that biases our results.

and the Financial Crimes Enforcement Network (FinCEN), which was released on October 11th, 2019. The letter urged digital currency exchanges to adhere to regulations that proscribed financial institutions from enabling money laundering and terrorist financing.

In response, many centralized exchanges imposed know-your-customer (KYC) standards, where they make a "reasonable effort" to verify that their clients are not engaging in illegal activity before they are allowed to open an account and complete transactions. However, because DEXs do not take custody of cryptocurrency assets and often lack order books, they are beyond the jurisdiction of many regulators. Furthermore, most governance token holders of DEXs have proved resistant to implementing KYC compliance checks. Consequently, a study by *CipherTrace* found that in October of 2020, a full year after this joint letter, 81% of DEXs had weak or no KYC practices. More than 50% of centralized exchanges—including a disproportionate share of the largest centralized exchanges— conducted KYC checks (CipherTrace, 2020).

Whether with or without time and exchange fixed effects, the joint letter had no differential effect on DEXs. One possibility is possible that DEX users feared that the letter portended greater regulatory scrutiny of all cryptocurrency exchanges. Another possibility is that regulatory arbitrage is not the primary driver behind crypto transactions. Our results suggest that growth in DEX adoption is due to the features of these decentralized institutions—greater privacy and security; more agency in determining the future of the exchange; an opportunity to share in the rewards of the exchange through airdrops—and not a desire to evade financial regulations.

[INSERT TABLE 3 HERE]

Our results have important implications for macroeconomic and monetary policy. In particular, we find little evidence that growth in DEXs is driven by regulatory arbitrage. Rather, the growth is largely explained by systematic differences in strategy (e.g., the use of governance tokens and airdrops) and security (e.g., avoiding the use of hot wallets). Attempts to counter the heightened demand for cryptocurrency through regulation or monetary policy would likely be ineffective.

Nonetheless, our analysis has several limitations. First, our time series is inherently limited to only a few years. Time will tell whether DeFi continues to grow and whether airdrops have positive effects on token market capitalization and exchange volume, but if central banks pursue more inflationary and volatile policies, it is likely that DeFi will only become more important and widely used. Second, our results are not fully causal. While we have controlled for the most obvious threats to identification, such as aggregate shocks (i.e., the overall upward trajectory of cryptocurrency) and the age of an exchange, full causality in this setting is not currently possible. In particular, the exchanges that conduct airdrops may be different from the exchanges that don't in unobserved ways that we cannot detect. Finally, the CoinGecko data might contain errors. They are self-reported by market participants via APIs, without the quality assurance of audited corporate disclosures let alone official statistics. While some peer review takes place, small exchanges and tokens may over-state their business without being discovered. Nonetheless, CoinGecko is currently the best data aggregator for cryptocurrencies and exchanges. Raw blockchain records, the alternative source of verified data used in technical measurement studies (e.g., Victor and Lüders (2019); Daian et al. (2020)), are insufficient to answer the research questions posed here.

7 Conclusion

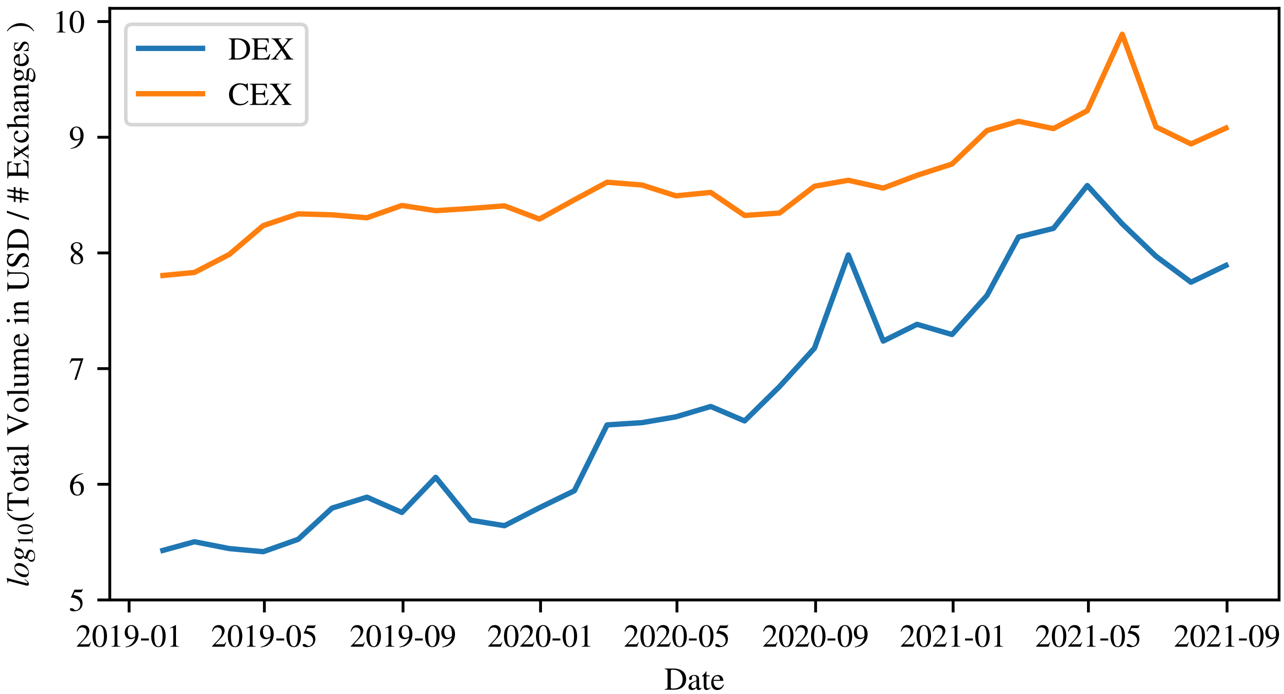
Decentralized finance has rapidly expanded over the past few years. Decentralized exchanges, a major application of DeFi, are beginning to surpass centralized exchanges in transaction volume, at least in terms of their growth rates. Drawing upon the full suite of distributed ledger technologies (DLTs) that arguably have transformational potential for organizations and societies (Iansiti and Lakhani, 2017), decentralized exchanges seem to offer at least four advantages over centralized ones: (i) fewer cybersecurity risks through incorruptible program code and the absence of "hot wallets," (ii) greater privacy through laxer or non-existent know-your-consumer (KYC) laws, (iii) lower fees and wider support for new coins and tokens that are often not supported by centralized changes, and (iv) greater user flexibility for those who do not like DEX policies and wish to switch. These advantages come with the downsides of somewhat less efficient market mechanisms, which leave users exposed to front-running attacks (Daian et al., 2020; Qin et al., 2020), and the lack of support for direct trades against conventional currencies.

Motivated by these differences, this paper provides the first comprehensive quantitative assessment of DEXs relative to their counterparts, by assembling the most comprehensive time series data available on exchanges between 2018 to 2021. Using the new data, we document that DEXs have experienced more growth than their centralized exchange counterparts, despite processing a lower volume of transactions, even controlling for differences in trust and age of the exchange. To understand this rapid growth, we investigate the role of airdrops, or the disbursement of tokens to existing and potential users, and governance tokens, finding that they are associated with growth in capitalization and volume primarily for DEXs. Furthermore, we examine whether these differences could be a result of regulatory arbitrage. Using an event study approach, we find that trading growth for DEXs increases following the KuCoin data breach September 2020, but there is no differential effect following the regulatory shock in October 2019. In sum, we provide the first comprehensive empirical evidence behind the rise of DEXs and the factors that fuel it.

Our paper nonetheless leaves many questions open for future research. First, how will different countries regulate DeFi? Since the smart contracts can be executed from anywhere and are fully interoperable, legal codes will have to catch up to technology. Second, what will the composition of the user base look like, particularly as the use of airdrops and governance tokens attract a possibly more diverse set of users? Third, how will organizations potentially adopt cryptocurrencies into their payment systems, and what benefits will these confer in heightened productivity and/or usability? Fourth, what new security risks might emerge with DEXs, particularly with the potential for front-running at scale? Only time will tell what the future will hold for DeFi, but our results here highlight its growth and the various factors at play.

Tables and Figures

Figure 1: Volume Across Centralized and Decentralized Exchanges, 2018–2021



Source: CoinGecko, 2019-2021. The figure plots the monthly logged (base 10) exchange-level average traded volume across centralized and decentralized exchanges from January 2019 to August 2021.

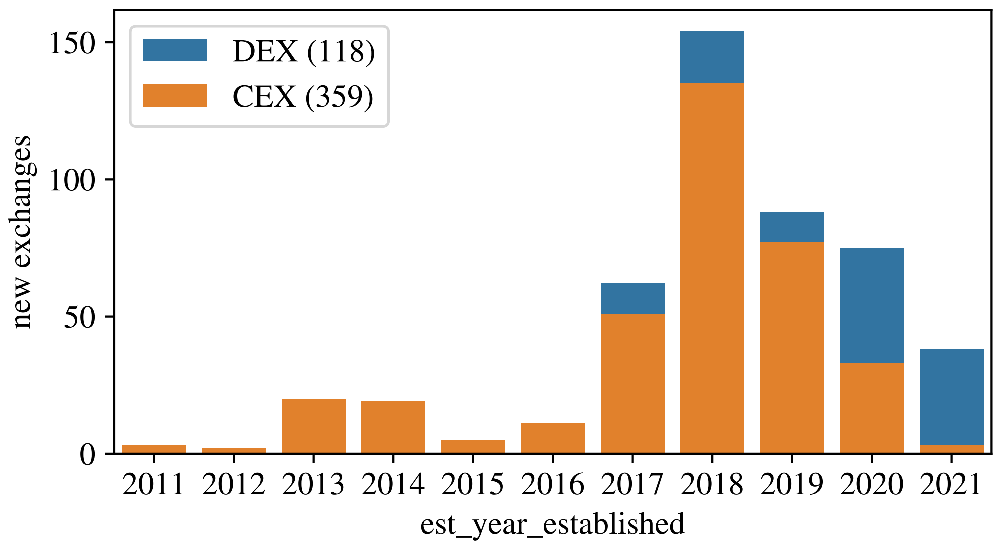


Figure 2: Number of newly established cryptocurrency exchanges per year. Decentralized is the dominant form since 2020. (2021 up until July.)

Table 1: Cross-sectional Differences in Volume Across Centralized and Decentralized Exchanges

	log(Volume in USD)				Daily Volume Growth			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Decentralized	-2.946***	-1.727***	-1.641***	-.050***	.097***	.090***	.072***	.081***
	[.428]	[.508]	[.486]	[.016]	[.019]	[.023]	[.024]	[.025]
log(Volume)$^{t-1}$				.973***				
				[.002]				
(Volume Growth)$^{t-1}$								-.126***
								[.005]
Trust Score Rank		-.016***	-.015***	-.000***		.000***	.000***	.000***
		[.002]	[.001]	[.000]		[.000]	[.000]	[.000]
Year Established		.146				-.013***		
		[.091]				[.004]		
Established in 2013			.187	.002			-.041	-.049
			[1.437]	[.038]			[.044]	[.049]
Established in 2014			.474	.010			-.072*	-.077
			[1.354]	[.035]			[.043]	[.048]
Established in 2015-16			.280	.007			-.090**	-.096*
			[1.524]	[.040]			[.045]	[.051]
Established in 2017			1.336	.036			-.111***	-.124***
			[1.359]	[.035]			[.037]	[.042]
Established in 2018			.518	.014			-.125***	-.139***
			[1.329]	[.034]			[.035]	[.040]
Established in 2019			.305	.009			-.083**	-.090**
			[1.367]	[.035]			[.037]	[.043]
Established in 2020-21			.784	.019			-.098**	-.105**
			[1.406]	[.037]			[.042]	[.047]
Constant	16.661***	-274.121	18.616***	.516***	.137***	26.384***	.169***	.190***
	[.219]	[182.971]	[1.281]	[.053]	[.007]	[8.532]	[.033]	[.038]
R-squared	.053	.260	.276	.959	.002	.005	.078	.100
Sample Size	295525	226364	270847	269423	285997	219247	261906	257317
Time FE	No	No	Yes	Yes	No	No	Yes	Yes

Notes.—Sources: CoinGecko, 2018-2021. The table reports the coefficients associated with regressions of logged (base 2) transaction volume on an indicator for whether the exchange is decentralized, a one-day lag of the outcome variable, the trust score rank, either a linear trend in the year the exchange was established or fixed effects on it (normalized to 2011-12), and day-of-the-year fixed effects. Daily growth in volume is winsorized at the first and last percentiles. Standard errors are clustered at the exchange-level and observations are unweighted. *** denotes significant at the 1% level, ** denotes significant at the 5% level, * denotes significant at the 10% level.

Table 2: Evaluating the Role of Governance Tokens and Airdrops

	Market Capitalization (Growth)				Volume (Growth)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Decentralized Exchange (DEX)	.005	-.026	-.136*	-.025	.082	.079	.029	.079
	[.035]	[.042]	[.073]	[.042]	[.094]	[.100]	[.142]	[.100]
Airdrop		.023	-.027	.008		.096*	.078	.068
		[.032]	[.036]	[.036]		[.056]	[.061]	[.056]
× DEX			.161**				.073	
			[.073]				[.137]	
Governance Token	.036	-.012	.011	-.078	-.009	.014	.024	-.136
	[.059]	[.060]	[.060]	[.090]	[.119]	[.106]	[.100]	[.160]
× Airdrop				.118				.278*
				[.086]				[.161]
log(Volume)		.015**	.014**	.014**				
		[.007]	[.007]	[.007]				
Trust Score Rank	-.000	-.000	-.000	-.000	.000	.000	-.000	-.000
	[.000]	[.000]	[.000]	[.000]	[.000]	[.000]	[.000]	[.000]
Established in 2017	-.016	.012	.048	.018	.122	.047	.062	.056
	[.016]	[.052]	[.050]	[.050]	[.097]	[.103]	[.105]	[.103]
Established in 2018	-.022	.017	.038	.023	.108	.070	.079	.084
	[.030]	[.046]	[.048]	[.047]	[.098]	[.100]	[.102]	[.101]
Established in 2019	.056**	.087**	.104***	.098**	.314**	.246*	.256*	.270**
	[.024]	[.035]	[.037]	[.037]	[.118]	[.124]	[.128]	[.126]
Established in 2020	.030	.057	.132**	.097	.329*	.281*	.313*	.366*
	[.064]	[.058]	[.059]	[.076]	[.180]	[.164]	[.186]	[.192]
R-squared	.11	.12	.13	.13	.07	.07	.07	.07
Sample Size	883	883	883	883	1265	1265	1265	1265
Year/Month FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes.—Sources: CoinGecko, 2018-2021. The table reports the coefficients associated with regressions of monthly growth in market capitalization and transaction volume on an indicator for whether the exchange is decentralized, an indicator for whether there is a governance token disbursed, indicators for whether the exchange had one air drop, an interaction between decentralization and airdrops, as well as an interaction of airdrops and governance token in columns 4 and 8, and a series of controls, including: logged volume (when the outcome is market capitalization growth), the trust rank, and dummies on the year the exchange was created (normalized to 2014). The growth rates are winsorized at the 1st and 97th percentiles. Our sample excludes observations where the market capitalization is zero. Standard errors are clustered at the exchange-level and observations are unweighted. *** denotes significant at the 1% level, ** denotes significant at the 5% level, * denotes significant at the 10% level.

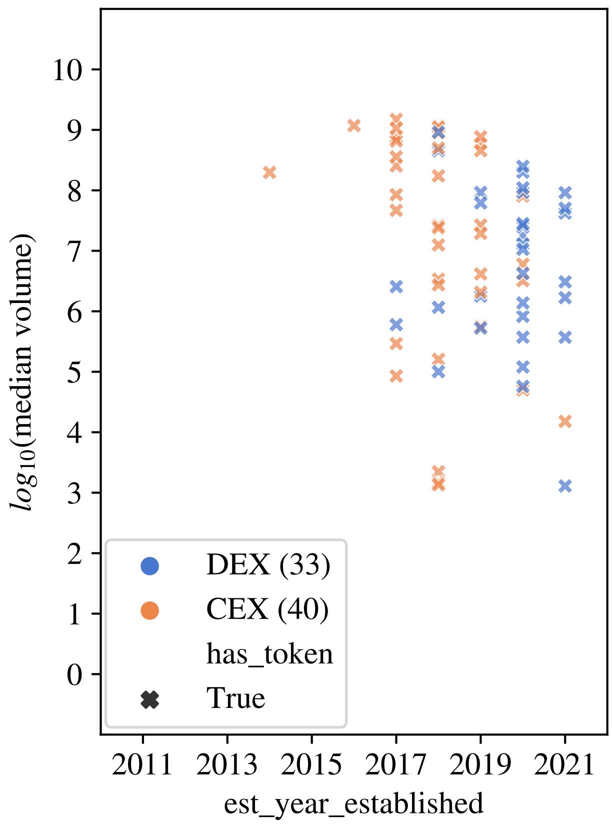
Table 3: Event Studies Investigating the Drivers of DEX Growth

	Daily Volume Growth					
	KuCoin 1	KuCoin 2	KuCoin 3	SEC 1	SEC 2	SEC 3
(Intercept)	0.19			0.21^{***}		
	(0.13)			(0.03)		
Post	0.01			0.05^{***}		
	(0.02)			(0.01)		
DEX	0.05	0.05		0.12^{***}	0.12	
	(0.08)	(0.07)		(0.02)	(0.07)	
Post*DEX	0.13	0.13	0.14^{*}	0.05	0.06	0.04
	(0.13)	(0.07)	(0.07)	(0.10)	(0.09)	(0.08)
Trust Score Rank	-0.01^{*}	-0.01^{*}		-0.00	-0.00	
	(0.01)	(0.01)		(0.00)	(0.00)	
Year Established Controls	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effects	No	Yes	Yes	No	Yes	Yes
Exchange Fixed Effect	No	No	Yes	No	No	Yes

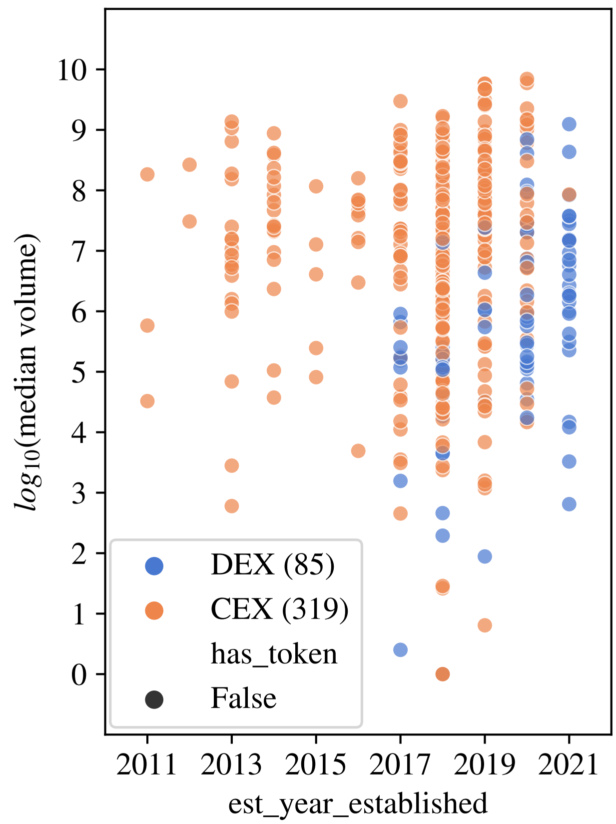
Note: —Sources: Coingecko, 2019-2020. The table documents the event study results associated with regressions of the daily trading volume growth on an indicator for whether the exchange is a decentralized exchange (DEX), an indicator for whether the day is on or after the specific event has happened, their interaction, and controls. The first shock we explore is the KuCoin breach, which highlighted a security flaw of centralized exchanges that does not plague decentralized exchanges. The second shock is a joint letter written by the SEC and two other U.S. regulators notifying centralized exchanges that they must follow customer compliance verification measures. We allow for a window of 10 days before and after the shock. We control for the trust score rank of the exchange, which measures the trust based on trading volume, orderbook spread, trade frequency, and more, computed by CoinGecko. Scale from 1-10 where 10 is the best. *** denotes significant at the 1% level, ** denotes significant at the 5% level, * denotes significant at the 10% level.

A Online Appendix

(a) Subset with token.



(b) Subset without token (not used).



(c) Complete data-set: (a) and (b) combined.

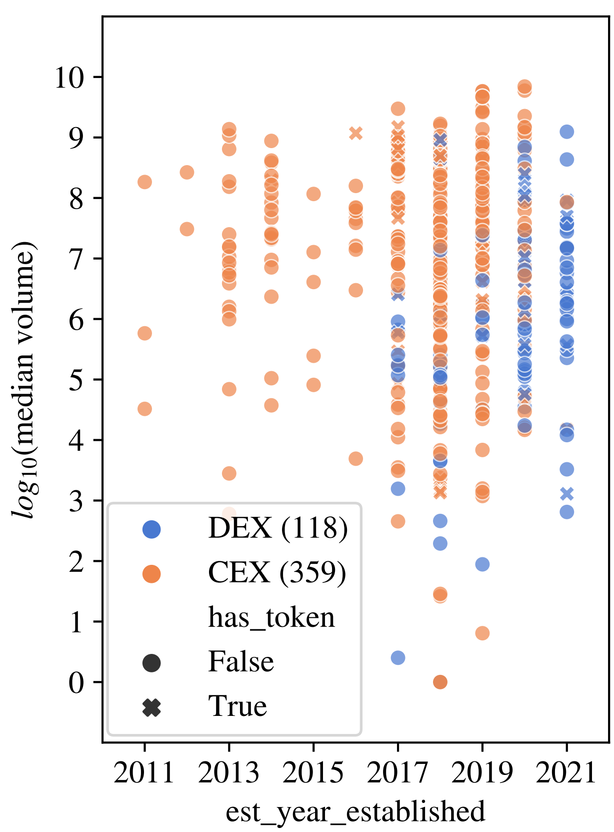


Figure A.1: Comparison of the Full Data & the Subset of Exchanges with Tokens

(a) Dezentralized Exchanges.

	trade_volume _median_usd	trust_score	trust_score_rank	year_established	est_year_established
count	118	46	113	81	118
mean	50 607 045	4.46	264.80	2019.26	2019.60
std	168 224 102	1.19	95.99	1.36	1.31
min	0	2	64	2017	2017
25%	147 319	4	189	2018	2018.25
50%	1 048 881	5	263	2020	2020
75%	19 672 570	5	338	2020	2020
max	1 243 651 994	7	437	2021	2021

(b) Centralized Exchanges.

	trade_volume _median_usd	trust_score	trust_score_rank	year_established	est_year_established
count	359	204	312	296	359
mean	291 970 784	5.93	201.17	2017.33	2017.60
std	827 981 806	2.21	133.87	2	1.94
min	0	1	1	2011	2011
25%	940 819	4	78	2017	2017
50%	19 394 148	6	187	2018	2017
75%	192 669 588	8	325	2019	2019
max	6 957 425 904	10	437	2021	2021

Table A.1: Descriptive Statistics on Centralized and Decentralized Exchanges

Notes.—Sources: Coingecko, 2018-2021. `trade_volume_median_usd` median daily trading volume in USD (until 2021-08-19). Note one exchange (elitex) did not provide volume data. `trust_score` a measure of trust based on trading volume, orderbook spread, trade frequency etc. computed by the CoinGecko. Scale from 1-10 where 10 is the best. `trust_score_rank` ranking of exchanges based on the trust score. `year_established` year in which the exchange was established. `est_year_established` same as year established but if no value is provided the exchange volume data is used to fill the year.

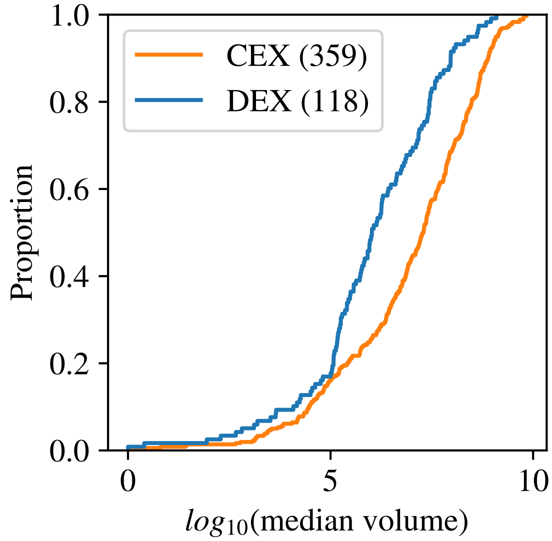


Figure A.2: CDF of exchanges by median exchange volume in USD. For the bottom 20 % of the exchanges, which trade less than 10k USD per day, the median trade volume is comparable between DEXs and CEXs. Differences are most pronounced for mid-size exchanges and amount to roughly one decimal order of magnitude. The gap narrows for the top exchanges.

Table A.2: Selected statistics of the curated list of exchanges with their respective token.

	centralized	cex_token	dex_token	exchange_-token	governance_-token	airdrop	token_name
count	73	73	73	73	73	73	73
unique	2	2	2	2	2	2	59
top	True	False	False	True	False	True	Sushi
freq	39	54	43	69	59	44	4

Notes.—Sources: Coingecko, 2018-2021. `cex_token` token is categorized as centralized exchange token. `dex_token` token is categorized as decentralized exchange token. `exchange_token` token is categorized as exchange token. `airdrop` indicates if a token conducted an airdrop. `token_name` Name of the token assigned to the exchanges, note that multiple exchanges share the same token in this data-set.

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Table A.3: Curated list of exchanges and their exchange token.

token_id	exchange	observations	centralized	airdrop	airdrop date	from date	to date	exchange established
0x	0x Protocol	47	False	False	–	2017-10-17	2021-08-01	–
1inch	1inch, 1inch Liquidity Protocol, 1inch Liquidity Protocol (BSC)	9	False	True	Dec-20	2020-12-25	2021-08-01	–
aave	Aave	11	False	True	Jan-18	2020-10-03	2021-08-01	2019
aax-token	AAX	17	True	True	Ongoing	2020-04-28	2021-08-01	2019
abcc-token	ABCC	38	True	False	–	2018-07-26	2021-08-07	2018
ac-exchange-token	ACDX, ACDX Futures	9	True	False	–	2020-12-04	2021-08-01	–
aurora-dao	Idex	44	False	True	Jan-21	2018-01-23	2021-08-01	2017
balancer	Balancer (v2), Balancer (v1)	15	False	False	–	2020-06-23	2021-08-01	2020
bancor	Bancor Network	51	False	True	Jan-20	2017-06-27	2021-08-01	–
bankera	Bankera	39	True	False	–	2018-06-05	2021-08-01	2018
beaxy-exchange	Beaxy	26	True	True	Mar-18	2019-07-11	2021-08-01	2017
bgogo	Bgogo	36	True	False	–	2018-09-19	2021-08-01	2018
bibox-token	Bibo, Bibox	44	True	True	Jan-21	2018-01-23	2021-08-01	2018
bilaxy-token	Bilaxy	29	True	True	Apr-19	2019-04-13	2021-08-01	–
bit-z-token	BitZ	38	True	False	–	2018-07-20	2021-08-01	2016
bitforex	Bitforex	37	True	True	Dec-18	2018-08-07	2021-08-01	2018
bitifex	Bitfinex	32	True	False	–	2018-12-11	2021-07-13	2014
bitmart-token	BitMart	37	True	True	Jun-20	2018-08-01	2021-08-01	2017
bitpanda-ecosystem-token	Bitpanda Pro	23	True	True	Jun-19	2019-10-04	2021-08-01	2019
bitsten-token	Bitsten	32	True	True	Jul-19	2019-01-04	2021-08-01	2017
bkex-token	BKEX	31	True	False	–	2019-02-15	2021-08-01	2018
btse-token	BTSE	18	True	False	–	2020-03-12	2021-08-01	2018
catex-token	Catex	31	True	True	Sep-19	2019-02-16	2021-08-01	2018
coinbene-token	CoinBene	39	True	True	Oct-18	2018-06-29	2021-08-01	2017
coindeal-token	Coindeal	22	True	True	Apr-20	2019-11-21	2021-08-01	2018
coinex-token	CoinEx	38	False	False	–	2018-07-04	2021-08-01	2017
coinmetro	CoinMetro	29	True	True	Apr-18	2019-04-24	2021-08-01	2018
coinsuper-ecosystem-network	Coinsuper	38	True	False	–	2018-07-31	2021-08-01	2017
coinzo-token	Coinzo	32	True	False	–	2019-01-24	2021-08-01	2018
compound-governance-token	Compound Finance	15	False	False	–	2020-06-16	2021-08-01	2019
delta-exchange-token	Delta Exchange	5	True	False	–	2021-04-01	2021-08-01	–
digifinextoken	Digifinex	37	True	False	–	2018-08-14	2021-08-01	2018
dmm-governance	DMM	15	False	False	–	2020-06-22	2021-08-01	–
dodo	DODO, Dodo BSC	12	False	False	–	2020-09-30	2021-08-01	2020
eterbase	Eterbase	32	True	True	Ongoing	2018-12-21	2021-07-01	2019
flex-coin	CoinFLEX	26	True	False	–	2019-07-30	2021-08-01	2019
ftx-token	FTX (Derivatives)	52	True	True	Ongoing	2019-07-30	2021-08-01	2019
futureswap	Futureswap	6	False	False	–	2021-03-25	2021-08-01	2020
hotbit-token	Hotbit	36	True	False	–	2018-09-13	2021-08-01	–
kyber-network	Kyber Network	47	False	True	Feb-18	2017-10-28	2021-08-01	2017
latoken	LATOKEN	47	True	True	Ongoing	2017-10-28	2021-08-01	2017
lcx	LCX Exchange	22	True	True	Dec-19	2019-11-22	2021-08-01	2020
leverj-gluon	Leverj	11	False	False	–	2020-10-27	2021-08-01	2019
loopring	Loopring, Loopring AMM	47	False	True	Jul-18	2017-10-30	2021-08-01	2020
mcdex	MCDEX	14	False	False	–	2020-07-13	2021-08-01	–
otcbtc-token	OTCBTC	37	True	False	–	2018-08-02	2021-08-01	–
perpetual-protocol	Perpetual Protocol	12	False	True	Apr-20	2020-09-09	2021-08-01	–
probit-exchange	ProBit	27	True	False	–	2019-06-07	2021-08-01	2017
quick	Quickswap	7	False	True	Oct-20	2021-02-15	2021-08-01	2020
resfinex-token	Resfinex	22	True	True	Jan-20	2019-11-28	2021-08-01	2019
sashimi	Sashimiswap	12	False	False	–	2020-09-10	2021-08-01	2020
serum	Serum DEX, SerumSwap	13	False	True	Nov-20	2020-08-11	2021-08-01	2020
sushi	Sushiswap, Sushiswap (Fantom), Sushiswap (Polygon POS), Sushiswap (xDai)	13	False	True	Sep-20	2020-08-28	2021-08-01	2020
switch	Switcheo	26	False	True	Nov-19	2019-07-06	2021-08-01	2018
topb	TopBTC	35	True	True	Jul-18	2018-10-23	2021-08-01	2017
unicly	Unicly	4	False	True	Jun-21	2021-05-18	2021-08-01	2020
uniswap	Uniswap (v3), Uniswap (v1), Uniswap (v2)	12	False	True	Sep-20	2020-09-17	2021-08-01	2018
zb-token	ZB	39	True	True	Jul-18	2018-06-28	2021-08-01	2017
ztcoin	ZBG	35	True	True	Aug-18	2018-10-30	2021-08-01	2018
		Σ 1610 μ 27.29 σ 13.33	**T: 36**	**T: 33**				

Notes.—Sources: Coingecko, 2018-2021. `observations`: number of month we have data for the token (market-cap and volume). `airdrop date`: Month and year in which the airdrop was conducted according to the announcements, ongoing if give-away is still ongoing. `from date` and `to date` Beginning and end month of the available token data. Data is aggregated monthly. `exchange established` the year the exchange was established.

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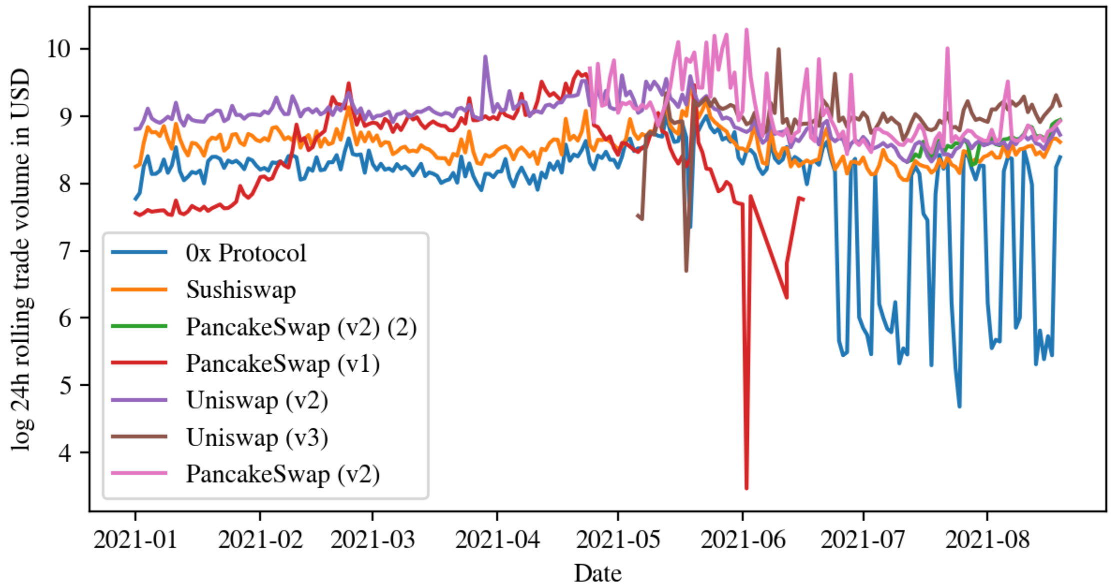
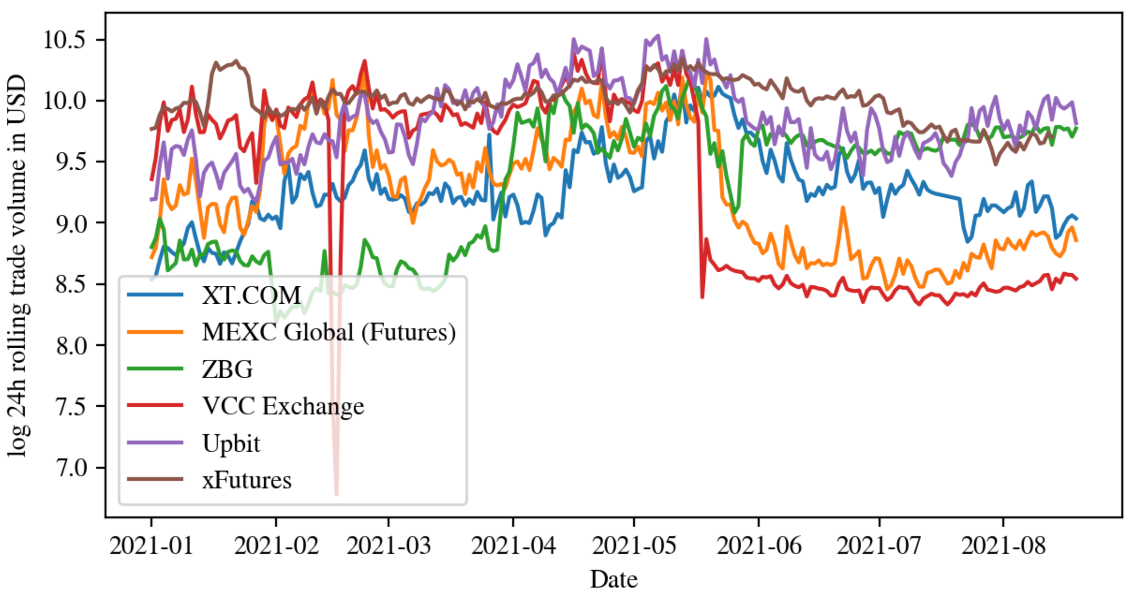


(a) Decentralized Exchanges.



(b) Centralized Exchanges.

Figure A.3: Time series of trading volume (24h rolling window, log-10) of the largest decentralized (top) and centralized (bottom) exchanges (by mean volume in the first half of 2021).