Journal of Business Research 158 (2023) 113673

Contents lists available at ScienceDirect

Journal of Business Research

journal homepage: www.elsevier.com/locate/jbusres

Impact of social metrics in decentralized finance

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ARTICLE INFO

Keywords:
Decentralized Finance
DeFi
Cryptocurrencies
User-generated content
Investor attention
Twitter
Social indicators
Uncertainty

ABSTRACT

In our study, we have evaluated the impact of tweets, social indicators, uncertainty, and attention indices on the selected variables calculated from a pool of 51 decentralised finance entities. In so doing, we have identified some evidence that returns are impacted by tweets, but not by social indicators that appear to be more relevant for volatility. We have further confirmed that the S&P500 Index negatively influences cryptocurrency returns, which means that these two asset classes are substitutes. Uncertainty and attention indices are relevant in determining returns and the alternative measurement of volatility. However, they remain insignificant for illiquidity and our initial volatility choice.

1. Introduction

Cryptocurrencies are a topic of considerable interest for investing and academia alike (Corbet et al., 2019). Unprecedented returns (Chuen et al., 2017) and the promise of changing the value interchange paradigm (Angelis & Da Silva, 2019) represent its primary lures. Meanwhile, the blockchain use cases, technology, companies, and projects have begun exploding in popularity in recent years. In fact, the area is transforming so quickly that most investors—especially retail investors, which constitute the majority in crypto—cannot follow the tremendous information available. This represents one of the main reasons for the category-learning behaviour (Peng & Xiong, 2006) in cryptocurrencies. This investment behaviour in a context of limited attention leads to the process of more sector-wide information than the token's project information.

During the brief history of cryptocurrencies, several trends had gained the attention of investors, resulting in prices soaring in the beginning and then falling after the excitement has run its course. In 2017, for instance, initial coin offerings (ICOs) were the main attraction to the blockchain area (Piñeiro-Chousa et al., 2021). This offered a way to finance digital projects through a token emission thanks to the promise of use, equity, or governance with those tokens. In time, however, this ICO frenzy was followed by a period of price downturn across the entire crypto ecosystem called 'crypto winter'.

In the summer of 2020, some projects started to gain a great deal of traction and attention due to the possibility to trade, lend, borrow, and insure, all without an intermediary—that is, in a decentralised manner (Piñeiro-Chousa et al., 2022b). This became the so-called 'DeFi summer'. Soon, decentralised finance (DeFi) became a category of its own (Corbet et al., 2021a), with specialised websites making it possible to follow the performance of these specific assets and even crypto ETFs such as the Defi Pulse Index (DPI). The total value locked (similar to bank deposits) in all DeFi projects went from USD 1 billion in June 2020 to USD 247 billion in December 2021 (Stepanova & Eriņš 2021). Other trends, such as non fungible tokens (NFTs), the metaverse, and crypto-gaming were part of this period of considerable price increases in most crypto tokens, usually called a 'bull run'. This study focusses on the main DeFi project returns during this period, analysing these returns as a category from the cryptocurrency area.

Indeed, Peng and Xiong (2006) claim that categories emerged for optimising investor attention. Since cognitive resources are limited and investment possibilities widespread, investor psychology tends to involve category-based behaviour. At the time of writing, there are tens of thousands of cryptocurrencies according to coinmarketcap.com and approximately-two thousand DeFi cryptocurrencies according to defillama.com. These impressive numbers, along with the speed of creation and sometimes even destruction of cryptocurrencies, make this investment scenario rather extreme in terms of investor attention. For this reason, we consider studying the relation between social measures and volatility an interesting topic to investigate.

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https://doi.org/10.1016/j.jbusres.2023.113673
Received 16 June 2022; Received in revised form 6 January 2023; Accepted 10 January 2023
Available online 27 January 2023

The short track record of most DeFi protocols, the rapidly changing nature of crypto assets, and all of its associated risks (Gudgeon et al., 2020), make investing in this category difficult and information the key to understanding market behaviour. Social networks—primarily Twitter—have also become the public square for conversations, news, and debates, as well as a highly important source of research thanks to sentiment analysis and other such tools (Bollen et al., 2011; Piñeiro-Chousa et al., 2022b). The importance of user-generated content in cryptocurrencies also goes beyond traditional finance thanks to the lack of official information from authorities along with the explosive nature of the cryptocurrency ecosystem.

COVID19 has become present in almost every human activity since its consideration as a pandemic in March 2020. In fact, the stock market and the main cryptocurrencies suffered a crash at that moment (Liu et al., 2020), losing the safe haven property from the perspective of equity index investors except for stablecoins such as Tether (Conlon et al., 2020). Investor attention to the stock market during the COVID19 pandemic has also been studied by Smales (2021), using Google Search volume as a proxy for investor attention. It is almost impossible to separate the COVID influence from any study, including in the financial and economic area in most countries (Zhang et al, 2020). As for this study, the big March crash is not included, because DeFi projects were born or became popular later. However, it is important to keep the context of this study in mind—namely, recovery from the COVID crash and the frenzy of the 'crypto bull run'; more research will be needed in new contexts.

Lucey et al. (2022) proposed the Cryptocurrency Uncertainty Index (UCRY), which features two versions: policy and price. In this study, we utilise several social indicators and recreate the price index of uncertainty. Amihud (2002), meanwhile, introduced the illiquidity ratio, a means of scaling absolute values by trade volumes. Florackis et al. (2011) proposed an illiquidity variable, which helps to reduce the size bias. We utilises these variables in this study to search for relations with returns and volatility.

Piñeiro-Chousa el al. (2022b) conducted a preliminary study of the relation between 13 DeFi projects and some social indicators and financial indexes using a Logic-Probit model. In this study, we increase the number of DeFi projects to 51, increase the time range, and use a panel-data model. Furthermore, we contribute to the extant body of knowledge by including the large group of sufficiently liquid DeFI products and examining the impact of social metrics such as Twitter, market expectations, and a range of indices relevant for cryptocurrency markets (Lucey et al., 2022; Wang et al., 2021a, and Wang et al.,2021b). Finally, we do not examine returns alone, but also explore liquidity and illiquidity measures, which enables us to explore the nature of the selected variables' impact.

In the following chapter, we include a discussion of relevant research papers, which is followed by the methodology section and results. Finally, we end the paper by providing concluding remarks, along with the relevant discussion and managerial implications.

2. Literature review

2.1. Blockchain and smart contracts

Since the publication of the Bitcoin whitepaper by Satoshi Nakamoto (2008), and especially since the publishing of the Bitcoin software in 2009, a new investment asset has appeared with few competitors in history in terms of growth (Chan et al., 2019). In turn, this crypto-punk dream of a currency without a central government has led to an appealing investment asset, full of risks (Grant & Hogan, 2015) with important energy consumption (Corbet et al., 2021b), and with financial properties endless debated. Indeed, the COVID19 pandemic was a period of drastic falls and rises for Bitcoin and the stock market alike, going deeper into the debate of safe-haven, hedge instrument, gold comparison, market correlation, and more (Mariana et al., 2021).

Nakamoto's innovation represented the beginning of a decentralisation trend based on blockchains, which was followed by others attempting to improve technicalities. To this end, Buterin (2014) published the Ethereum whitepaper describing a blockchain intended to provide fully computational properties to a blockchain. Soon after, the Ethereum software was created, allowing anyone to run a code in a decentralised manner, better known as a smart contract (Ante, 2021). In this way, Ethereum democratises access to blockchain features using smart contracts.

Some general use cases of smart contracts include the following:

- Creating web applications called 'dapps' (decentralised applications) or web3 (the concept of a new era in the web; Gray, 2021).
- Creating, trading, and custody of new tokens (Lee, 2019), along with some nuances, also known as cryptocurrencies.
- Creating and managing self-sovereign identity (Liu et al., 2020) to interact with blockchains and other users.
- Funding projects launching an ICO (Bellavitis et al., 2021), the crypto equivalent of an initial public offering (IPO) on the stock market but unregulated and its crypto and regulated version security token offering (STO)
- Creating organisations called decentralised autonomous organisations (DAOs) (Diallo et al., 2018), which allow the coordination of groups of people with truthful votes and more.
- Registering and trading property in non-fungible tokens NFTs; (Kong & Lin, 2021) with the possibility to add conditions to future trades and uses.

The main property of smart contracts is they will be executed under any circumstance. As such, when a smart contract is deployed on a blockchain, not even the owner can stop it or change its behaviour. In this way, no human interaction is necessary; anybody can use it, since it fulfils the contract. The three main implications of this include decentralisation, being permissionless, and composability. As for the lack of central authority, this reduces transaction costs, monopoly costs, and benefits from network effects (Catalini and Gans, 2020). Furthermore, it removes the arbitrariness, because anybody can use the contract without permission, and the network's interoperability enables creating new uses comprising several other smart contracts. These differences from traditional digital services have since popularised the term 'protocol' in favour of 'service'. Someone must provide the service, but a protocol is just an open description and an open-source implementation on a blockchain.

Meanwhile, the smart contract approach is not without risks (Grant & Hogan, 2015). As an incredibly novel technology, the possibility of an error or even on-purpose malfunction is more common than in traditional digital products. In fact, the scarce or non-existent regulation mixed with anonymity represents an attraction for negative behaviours. However, the unstoppable condition of smart contracts has another side. If there are new circumstances, or even if both parties agree on stopping the agreement, this is still not possible. In summary, the removal of a central authority does not come without costs and risks, but these are rather different compared to the traditional ones. In this way, decentralisation opens a new model of digital applications that coordinate information and value among humans.

2.2. Decentralised finance, a new category

When smart contract meets financial services, decentralised finance (DeFi) appears. This represents a new paradigm of financial services offered by open protocols defined in smart contracts and running over a blockchain (Piñeiro-Chousa et al., 2022a). As a result, these services are more interoperable, borderless, and transparent (Chen & Bellavitis, 2020). Furthermore, DeFi does not rely on intermediaries; instead, it is based on open protocols and decentralised applications (Schär 2021).

The DeFi stands opposed to the traditional approach, called centralised finance (CeFi), in which an entity such as a bank provides access to the financial service. Recently, however, another concept in between these two methods has emerged: centralised decentralised finance (CeDeFi), in which a company facilitates and extends the service provided by DeFi protocols (Scharfman, 2022). Together, these three concepts create a framework defined by the existence or non-existence of a middleman acting as a service provider or facilitator. This forms the meaning of the words 'centralised' and 'decentralised', and it possesses profound implications (Bernhard et al., 2021).

As a visual analogy, traditional finance would be an opaque office that offers a service regulated by the government, whereas decentralised finance is a large glass box with a machine inside that anyone can examine and interact with under immutable rules. One particularly interesting DeFi feature concerns its composability, which makes it possible to use several protocols in cascade or even as part of a new protocol, since they are permissionless (Katona, 2021). The parts of DeFi anybody can compose are popularly called 'money legos'. Following the previous analogy, to compose in the traditional finance, one needs the permission of each actor of the chain, and those actors can eventually revoke their availability. However, in DeFi, one can use one machine and then another and another, or one can even create a new glass box machine that transparently uses other glass box machines for its purpose.

The definition of which services could be listed under the DeFi category remains under discussion (Corbet at al., 2021a). There is currently neither clear and common taxonomy, nor a subcategorisation. Furthermore, the boundaries of what is and is not DeFi remain far from a consensus. That said, most authors agree with the general idea of new financial services built from scratch over blockchain technology without a middleman. However, joining two fuzzy terms such as 'decentralised' and 'financial' makes the definition even more complicated and a matter of perspective.

The financial nature of cryptocurrencies and their decentralisation could make any token fall under the DeFi category. In fact, because all of them can be used for payments, any transaction in a blockchain asks for a fee that must be paid with the blockchain token. Indeed, some blockchains offer the possibility to stake tokens to secure the blockchain, with the user being rewarded with a yield. In turn, though, this raises the question of whether that implies that all blockchains are DeFi. It could be argued that they are, but if we assume blockchains and cryptocurrencies are decentralised networks of value, these features are common to all the crypto ecosystem and do not create a subcategory. In other words, decentralisation and financial service must be a heavy part of the protocol.

The novelty of the area and the technical difficulties involved make the definition process even more difficult. In order to gain perspective, we compare the subcategorisation of DeFi projects from three authors in Table 1 below and two DeFi data provider services in Table 2:

In the research of Chen and Bellavitis (2020), they explain the promises, limits, and a list of major business models in the DeFi space. While not a proper subcategorisation, this brings a rather wide perspective to the realm of decentralised finance. From the authors' perspective, most cryptocurrencies are part of DeFi, including any payment system or even the fundraising process such as the ICOs (Domingo et al., 2020). The fourth category, decentralised contracts, is where most of the undoubtedly DeFi projects are located.

Table 1
Services considered DeFi by several authors. Source: Own elaboration.

Chen & Bellavitis (2020)	Schär (2021)	Piñeiro-Chousa et al. (2022a)
Decentralised:	Asset tokenisation	Decentralised stablecoins
Currencies	Decentralised exchange protocols	Lending-borrowing
Payment services	Decentralised lending protocols	Decentralised exchanges (DEX)
Fundraising	Decentralised derivatives	Asset management
Contracts	On-chain asset management	Funds
		Decentralised derivatives
		Synthetics
		Insurance

Table 2
Categorization of DeFi by two main online data providers. Source: Own elaboration.

Defipulse	DefiLlama
Yield Generator	Dexes
Asset Management	Lending
Wallets	Bridge
Assets	CDP
Interfaces	Yield
Stablecoins	Liquid Staking
Options	Algo-Stables
Derivatives	Services
Scaling	Derivatives
Infrastructure	Yield Aggregator
Payments	Cross Chain
Insurance	Reserve Currency
Decentralised Exchange	Payments
	Insurance
	Privacy
	Options
	Synthetics
	Indexes
	Launchpad
	Staking
	RWA
	NFT Lending
	Farm
	NFT Marketplace
	Gaming
	Prediction Market
	Oracle

Schär's (2021) paper provides a rather interesting conceptual model of technical layers that makes DeFi possible. Afterwards, he describes several types of protocols that help us understand the author's view of DeFi. He further mentions lending, derivatives, exchange, and asset management, which are subcategories often used in the cryptocurrency online data providers, as we can see later in this article.

The chapter from Piñeiro-Chousa et al. (2022a) describes several categories along with the lead project or projects in each category. They utilise white papers to define the economic mechanism behind the protocols, and from this, they attempt to generalise for the whole category. They largely coincide with Schär's view, but they split derivatives into synthetics, funds, and derivatives in general. Furthermore, they also add insurance, which is an area that is not as heavily used and explored as others in DeFi, and it is also controversial due to the difficulty of the decentralised assessment. Of course, all these services must be provided in a decentralised manner. The chapter also mentions the Oracles, not as part of DeFi, but as an important piece along with the smart contracts.

Other authors express similar perspectives and subcategorisations as Piñeiro-Chousa et al. (2022a), such as Popescu (2020), Zetzsche et al. (2020), and Werner et al. (2021).

At the moment of writing this paper, two major DeFi data providers are available. On the one hand, Defipulse.com provides data solely from Ethereum protocols, and as mentioned in the Introduction, they utilise the DeFi Pulse Index (DPI), which they describe as 'a capitalisation-weighted index that tracks the performance of decentralised financial assets across the market'. On the other hand, Defillama.com provides data from more than one hundred blockchains, with Ethereum as the leader at 63 % of the total funds. Apart from providing several metrics, such as the total value locked, they have also categorised the protocols.

Defipulse features 13 categories, some of which are similar categories or subcategories to those previously referred by the authors. However, others came from protocols that help the ecosystem but are not purely financial, such as infrastructure, scaling, interfaces, or wallets.

Defillama includes 27 categories, ordered from more to less total value locked and includes a brief explanation that can be checked online. A large number of categories came from splitting the previous one into some more detailed alternatives. For instance, instead of asset management, they define yield ('Protocols that pay you a reward for your staking/LP on their platform'), liquid staking ('Rewards/Liquidity for staked assets'), yield aggregator ('Protocols that aggregated yield from diverse protocols'), and farm ('Lock money in exchange for their token'). They also add multichain categories such as bridge, which are protocols that enable moving tokens from one blockchain to another, as well as new trends such as privacy ('Protocols that have the intention of hiding information about transactions'). Also of note is that they further include oracles or even gaming, which seems far removed from academic definitions.

In summary, it appears difficult to develop a perfect definition with clear boundaries, but from the different granularity of subcategories, a common general view emerges from academia and data providers.

To fully consider the DeFi assets a category, more studies are required concerning the relation of price movements and whether these tokens behave technically in similar ways. To this end, Corbet et al. (2021a) conducted a study of DeFi token prices and their relationship with Bitcoin (main crypto asset), Ethereum (main smart contract asset), and Google trends (a measure of investor attention). They found that investor attention represented the main driver, and DeFi behaved as a category in that sense. More studies such as this are decisive for fully considering DeFi as a category, because this brings the investment perspective that completes the conceptual category presented in this paper.

As a final note, it is important to remember that we are in the early years of a new technology that promises to change the financial sector as we know it. Indeed, it started as one of the most frenzied periods of investment, valuations, and conceptual advancements in the financial sector.

DeFi trust, risk, and challenges.

Trust represents a key value in any business, but in financial businesses specifically, this becomes even more crucial. Accordingly, the 2008 crisis was, beyond simply an economic crisis, the result of a loss of confidence in the financial system and the institutions behind it (Uslaner, 2010). Actually, Bitcoin was considered as a response to said crisis. The main idea involved the creation of a trustless and permissionless currency with no central bank or institution that holds any power over the currency, no bank or institution that requires permission to use the currency, and no opaque third-party system to verify transactions. Kowalski et al. (2021) checked the importance of blockchain technologies with the trade finance industry using in-depth interviews. They determined that it improves the security of the transactions, facilitates expressions of benevolence, enhances efficiency, and increases the predictability of trading partners. Smart contracts are specific technology that enables extending the Bitcoin idea of a trustless and permissionless currency to a trustless and permissionless application for any purpose. When that purpose is applied to the financial category, we speak of DeFi, a type of service in which trust is especially relevant.

In the book of Harvey et al. (2021), besides providing a complete DeFi explanation, they also discuss seven risks that face DeFi, as follows:

1. Smart-contract risk
2. Governance risk
3. Oracle risk
4. Scaling risk
5. DEX risk
6. Custodial risk
7. Regulatory risk

The first six comprise endogenous crypto risks, most of which are related to technical issues, which are quite relevant in the actual, but not technically mature, stage. The last constitutes an exogenous risk, as explained further below:

Since blockchain represents a novel technology, and some applications replicate traditionally highly regulated services, making law accommodation a key topic for the technology's present and future. Indeed, part of the ecosystem comprises legal companies under legal regulations, and part of the ecosystem consists of decentralised entities that are difficult if not impossible to regulate. The exchanges offer an effective example of the regulated companies that are performing the intermediation from the traditional world to the crypto world (Johnson, 2020); as such, they can suffer the regulations yet earn the rewards from an early position and the intermediary job. This can be seen either as a risk for DeFi, because it relays at some point in centralised entities (exchanges) under legal and governmental obligations, or as an opportunity to maintain control of some problems in DeFi, such as scams, money laundry, or other illegal activities. The compliance with the regulation and the avoidance of criminal activities represent challenges that DeFi will face in its near future (Wronka, 2021). In the decentralised crypto world, 'code is law', but in the real world, 'law is law'; in this tension from the centralised real world to the decentralised crypto world, the legal constraints seem to play a key role, as demonstrated by the Tornado Cash case of 2022.

Stablecoins are cryptocurrencies with prices pegged to an external currency, typically the US dollar. This is accomplished in a centralised fashion using an external entity that guarantees each minted coin has collateral in US dollars such as USDT, USDC, and BUSD. This is also performed in a decentralised manner using different methods such as collateral debt positions (e.g. DAI), elastic supply (e.g. Ampleforth), or any form of collateral or bond (e.g. Basis). Saengchote (2021) describes the stablecoin state and the flows of total value locked in the different protocols, following incentives such as yield farming. Total value locked represents a popular means of measuring the deposits of a protocol and also conveys a measure of its importance (Stepanova & Eriņš, 2021). Katona (2021) digs into one of the main features of DeFi, its composability, also phrased as the 'Money Lego' system. Beyond this, Saengchote (2021) also mentioned the importance of the DeFi's composability and its relation with stablecoins. In terms of risks, stablecoins possess the risk of losing the peg, either from problems in the entity supporting it (e.g. doubts about Theter fully backed USDT) or the algorithm that generates it (e.g. the crash of Terra and its stablecoin UST (Briola et al., 2023)). Apart from the technical risk of a smart contract failing, DeFi also suffers a highly specific and wide risk of stablecoin malfunction that could deeply impact the ecosystem thanks to the aforementioned composability (Briola et al., 2023).

In such a new scenario, playing with large amounts of money using highly novel and barely regulated technologies, the challenges are tremendous and the limits are not yet known. The concept of the technical frontier of pseudonymous agents that interacts with algorithms is explored by Harwick and Caton (2020). Furthermore, they also discuss the integration of real-world identities. Besides most authors exploring the limits of Defi, this topic appears to be more relevant in a more mature context.

2.3. Asset correlation, spillovers, and the impact of COVID19

Crypto assets in general, as well as new ones like DeFi assets, are difficult to valuate and suffer from high volatility. One approach for studying the returns behaviour involves comparison with other assets, searching for correlations and spillovers. Bação et al. (2018) searched for information transmission between cryptocurrencies and bitcoin as the main asset and found correlation. Beneki et al. (2019) further identified relations in volatility between Bitcoin and Ethereum. Yousaf and Yarovaya (2022), meanwhile, studied the transmission in returns and volatility between NFTs, DeFi assets, oil, gold, Bitcoin, and S&P 500. Charfeddine et al. (2020) researched the correlation between traditional assets and crypto assets. More broadly, Chen et al. (2022) studied the volatility spillover effect between Internet finance and banks. However, most of these studies have been conducted during the COVID19 pandemic, which is a rare event that interferes with the normal behaviour of almost any human activity.

The importance of other topics that influence financial assets has been studied from multiple perspectives, such as corporate social responsibility (Ghanbarpour & Gustafsson, 2022), business strategy (Cao et al., 2022), marketing capabilities (Angulo-Ruiz et al., 2014), or debt financing (Giaretta & Chesini, 2021). Ye et al. (2022), for instance, determined that financial technology is a driver of poverty alleviation in China. Technical and social innovation such as crowdfunding (Gil-Gomez et al., 2021), crowdlending (Ribeiro-Navarrete et al., 2022), or open innovation approaches have also offered a means to finance long before DeFi. Sustainability, meanwhile, represents another topic that affects finance performance (Lee & Suh, 2022) and innovation (Hao et al., 2022), which will subsequently influence DeFi evolution as well.

Due to the extreme situation in 2020, 2021, and partially 2022, most authors have directly studied the pandemic effects. As one example, Bouri et al. (2021) explored the tail risk spillover over the global financial markets relation between assets during COVID19′s extreme stock conditions. Fuming et al. (2022) studied the increased use of Internet financial services during the pandemic by micro and small-sized enterprises (MSEs), which could represent the start of a culture change in terms of the use of digital financial services. Chemkha et al. (2021), meanwhile, explored the highly studied topic of bitcoin and gold as a safe-haven, but in this case, during the pandemic. Umar et al. (2021) researched the relation between the COVID19 information and the impact on cryptocurrencies and fiat currencies.

This study suffers from the same unprecedented context of a pandemic that locked most of the world population at home and created a long period of social distance. However, the relation with other assets that suffer the same context can offer insights into how each asset behaves under real stress tests.

2.4. User-generated content, sentiment analysis, investor attention, and uncertainty

Since the Internet's broad adoption, investors have profoundly changed how they access information, which has gone on to severely influence their investment behaviour and, consequently, returns (Agarwal et al., 2019). The news also plays an important role in investor perception of the world; even now, in a highly novel topic such as central bank digital currencies (CBDCs), Wang et al. (2021b) discovered that news indexes remain linked to several assets in different ways. However, the news is currently losing its monopoly of investor attention in favour of user-generated content such as social media, blogs, forums, and messaging applications. The Wallstreetbets case can be considered a paradigm of the power of an Internet forum based on user-generated content and the community paradigm (Bradley et al., 2021).

Twitter is also an essential information source in this area with years of research on either its influence in the stock market (Bollen et al., 2011) or the cryptocurrency market. Advancements in natural language processing, such as sentiment analysis, also play a crucial role in assessing the massive amount of textual data involved. Even with an inevitable error, they can measure qualitative intentions in the text, especially in short texts such as tweets (Agarwal et al., 2011).

In this context of vast amounts of information and investors' limited time, attention becomes even more scarce and valuable. Accordingly, the relationship between price volatility and investor attention has been deeply studied *(*Dimpfl & Jank, 2016; Smales, 2021; Vlastakis & Markellos, 2012*)*. Al Guindy (2021) explored this relationship for cryptocurrencies, as well, using information from Twitter as in this study. Peng and Xiong (2006), meanwhile, illustrated that limited investor attention promotes sector-wide investor research and reduces firm-specific information consumption. To date, however, there remains no research on DeFi asset class.

In view of the discussion related to Twitter and social metrics, we propose the following:

H_{1a}: Positive social metrics have a positive impact on returns while simultaneously increasing liquidity and reducing the volatility of DeFi.

Lucey et al. (2022), Wang et al. (2021a), and Wang et al. (2021b) have created the Cryptocurrency Uncertainty Index (UCRY), Central Bank Digital Currency Uncertainty and Attention indices (CBDCUI and CBDCAI), Index of Cryptocurrency Environmental Attention (ICEA), and Non-Fungible Token Attention Index (NFTAI). They further utilise the Lexis-Nexis news as a source to calculate uncertainty and attention levels. We also include the Arouba-Diebold-Scotti business conditions index in order to examine the impact of the overall business sentiment and not only the indices created based on the data related solely to the cryptocurrency market. In view of the initial findings provided by Smales (2022), for some of these indicators, we claim the following:

H2a: Less uncertainty and more attention in cryptocurrency indices, along with improving business conditions, increase DeFi returns, reduce volatility, and increase liquidity.

3. Methodology

In our study, we select the largest and most liquid DeFis. Due to constraints imposed by the weekly data frequency, we initially selected variables with at least 360 observations until November 2021. From the resulting list of 80 crypto products that comply with this requirement, we have excluded products with incomplete data series. Due to illiquidity and the lack of public interests at any stage of their life cycle, 29 DeFis have also been excluded. Otherwise, the conversion of daily into weekly data would be imprecise and our analysis rendered incorrect.

For the list of selected DeFis, we examine returns, calculated as follows:

$$R = log\left(\frac{lnR_t}{lnR_{t-1}}\right)$$

Where R_t is weekly return at time t, and R_{t-1} is the weekly return from the end of the preceding week. Apart from the absolute value of returns being used as a volatility proxy, we follow Smales (2022) and also apply the Perkinson (1980) approach that emphasizes the difference between high and low prices:

$$Volatilityhl = \frac{1}{4ln2}(lnH_t - lnL_t)^2$$

Amihud (2002) further proposes the illiquidity ratio, wherein the absolute value of returns is scaled by the trade volumes that vary across cryptocurrencies due to their size, following, and utmost importance for crypto investors. In order to reduce this size bias, we introduce an illiquidity variable suggested by Florackis et al. (2011). The turnover ratio TR_t provides a standardised and less size-biased variable:

$$Illiquidity = \frac{|R_t|}{TR_t}$$

In order to examine the impact of market sentiment on returns, volatility, and illiquidity, we examine the following panel regression:

$$R_{i,t} = \alpha + \beta\sum_{j=1}^{3}\Delta twitter_{j,t} + \gamma\Delta pricescore_{i,t} + \delta\sum_{k=1}^{2}\Delta social_{k,t,} - + \theta\sum_{l=1}^{4}control_{l,t,} + \varepsilon_{i,t} \text{ eq.1.}$$

Where $\Delta twitter_{j,t}$ includes the weekly change in the number of tweets related to the respective crypto product), the weekly change in the number of followers related to the pertinent tweet posts ($\Delta tweetfoll_t$), and the weekly change in the number of likes on a relevant social post $(\Delta tweetfav_t)$. The $\Delta pricescore_{i,t}$ includes the weekly change in the average price scores derived from technical analysis. It is back-tested, and the best trading approaches are obtained via a range of technical analysis tools to create this indicator. It ranges from 1 (very bearish) to 5 (very bullish). The social aspect is captured by $\Delta social_{k,t}$, which includes the weekly change in social impact $\Delta socialimp_t$, calculated by the AI and based on the scrutinising of public and private domains on social media networks, and $\Delta socialcont_t$ (i.e. the weekly change in the number of social contributors who are unique people discussing the selected crypto product). Finally, $\sum_{l=1}^{4} control_{l,t,}$ captures the weekly changes in the S&P 500 Index, VIX, gold returns, and the difference between yields on 10-year and 2-year notes.

When examining how selected uncertainty and attention indices influence returns, volatility, and illiquidity, respectively, we apply the following model:

$R_{i,t} = \alpha + \beta \sum_{j=1}^{6} \Delta uncertainty_{j,t} + \gamma \sum_{k=1}^{4} control_{k,t,} + \varepsilon_{i,t}$ eq.2.

Where $\sum_{j=1}^{6} \Delta uncertainty_{j,t}$ includes a weekly change in $\Delta ucry_t$ that evaluates the uncertainty of cryptocurrency policy (Lucey et al., 2022); a weekly change in $\Delta cbdcui_t$ and $\Delta cbdcai_t$, which are central bank digital currencies uncertainty and attention indices, respectively (Lucey et al., 2022); the change in the index of cryptocurrency environmental attention $\Delta icea_t$ (Wang et al., 2021a); variations in the non-fungible tokens attention index $\Delta nftai_t$; and ultimately, weekly changes in the Aruoba-Diebold-Scotti business conditions index. Control variables are the same as in eq. 1.

4. Results

In the first panel-data analysis, we have allowed for both fixed and random effects, but the ultimate decision regarding the model's suitability was determined by the Hausman test. In Tables 1 and 2, we have included the estimations of both models. Except for *Volatilityhl*, the fixed effects were more relevant in the estimation process. When selected variables have been regressed on the weekly returns of 51 DeFis, the number of observations equals 4,102 in eq.1 and 4,148 in eq.2, respectively. The same values have been applicable to all other estimations in Tables 1 and 2, and the reason for this discrepancy concerns the inability to calculate some values due to the lack of relevant data in the first set of sentiment variables. F-statistics across all estimations are statistically significant. The adjusted R^2 is the highest when variables are regressed on returns (0.136 and 0.074, respectively).

The changes in the weekly number of tweets, followers, and the number of 'likes' produce a statistically significant impact on returns. In contrast, so-called 'social variables' do not have any relevance. It is also important to note that the weekly change in price scores is relevant to some degree (at 10 %). Simultaneously, control variables, such as the changes in the S&P500 Index, VIX, gold prices, and yield differences, remain statistically significant. The coefficient estimate for the S&P500 index is negative, which confirms the use of cryptocurrencies as an alternative for traditional stocks, and an increase in the yield differential negatively influences cryptocurrency returns. These results may be influenced by the sample period in our study, which largely covers the COVID-19 period. The second part of the analysis implies that all uncertainty and attention indices are relevant in determining returns, except for $\Delta cbdcui$. We then proceed with the volatility analysis, since some indicators may be more relevant for persistency in volatility rather than returns. For example, tweet followers, price score, and social impact are more accountable for volatility. Surprisingly, change in VIX becomes irrelevant, which indicates that anxiousness in the crypto market is transferred more from social networks than established traditional markets.

Table 3 Panel A.

$\Delta tweets_t$ includes the weekly change in the number of tweets related to the respective crypto product; $\Delta tweetfoll_t$ is the weekly change in the number of followers related to the pertinent tweet posts; $\Delta tweetfav_t$ is the weekly change in the number of likes on a relevant social post; $\Delta pricescore_{i,t}$ includes the weekly change in the average price scores derived from technical analysis; $\Delta socialimp_t$ includes the weekly change in social impact calculated by the AI and based on the scrutinising of public and provide domains on social media networks; $\Delta socialcont_t$ is the weekly change in the number of social contributors who are unique people discussing the selected crypto product; $\Delta ucry_t$ evaluates the uncertainty of cryptocurrency policy; $\Delta cbdcui_t$ and $\Delta cbdcai_t$ are a weekly change in central bank digital currencies uncertainty and attention indices, respectively; $\Delta icea_t$ is the change in the index of cryptocurrency environmental attention; $\Delta nftai_t$ is the non-fungible tokens attention index; and weekly changes in the Aruoba-Diebold-Scotti business conditions index are captured by $\Delta ADSindex$. Finally, control variables include changes in S&P 500 Index, VIX, gold returns, and the difference between yields on 10-year and 2-year notes.

*p-value ≤ 10 %, ** p-value ≤ 5 %, *** p-value ≤ 1 %.

	Return	Return	Volatility	Volatility
Constant	−0.025	0.02***	0.07***	0.137***
	(-1.15)	(5.95)	(4.01)	(57.13)
Δtweets	0.048***		0.033	
	(4.41)		(3.83)	
Δtweetfoll	0.022***		0.016***	
	(3.46)		(3.23)	
Δtweetfav	0.037***		0.003	
	(7.11)		(0.73)	
Δpricescore	0.039*		0.05***	
	(1.92)		(3.12)	
Δsocialimp	0.007		0.016**	
	(0.75)		(2.07)	
Δsocialcont	−0.013		-0.011	
	(-1.4)		(-1.58)	
Δucry		−3.555***		1.989
		(-9.89)		(7.20)
Δcbdcui		−0.595		1.745
		(-1.08)		(4.14)
Δcbdcai		2.297***		−2.235
		(3.28)		(-4.16)
Δicea		1.366***		-0.858
		(3.30)		(-2.69)
Δnftai		−1.233***		0.959
		(-3.17)		(3.21)
ΔADSindex		0.045**		-0.033
		(2.06)		(-2.00)
ΔS&PIndex	−0.324*	−0.211	-0.303**	-0.203
	(-1.71)	(-1.08)	(-2.01)	(-1.35)
ΔVIX	−0.273***	−0.284***	-0.004	0.005
	(-9.44)	(-9.40)	(-0.16)	(0.20)
Δgold	0.607***	0.535***	-0.371***	-0.5***
	(3.42)	(2.83)	(-2.63)	(-3.44)
Δ10_2_dif	−0.146***	−0.109	0.184***	0.156***
	(-5.36)	(-3.84)	(8.52)	(7.12)
Adjusted R2	0.136	0.074	0.066	0.061
F Stat	63.376	32.842	28.430	26.401
Suitable model	fe	fe	fe	fe

In Table 4, we have included results for the alternative measurement of volatility and illiquidity. While the coefficient estimates of uncertainty and attention indices have remained largely significant for the alternative volatility measurement, the weekly change in the number of tweets becomes a significant determinant. In addition, the change in VIX still remains statistically insignificant, implying that even the variation in volatility measurements still renders volatility in the mainstream market rather insignificant. Finally, when including the standardised illiquidity measurement in our study, the Adjusted R^2 becomes rather low, and many variables become insignificant, including the control ones. We also find some evidence that the price score positively influences illiquidity, while the social impact reduces it.

Table 4 Panel B.

$\Delta tweets_t$ includes the weekly change in the number of tweets related to the respective crypto product; $\Delta tweetfoll_t$ is the weekly change in the number of followers related to the pertinent tweet posts; $\Delta tweetfav_t$ is the weekly change in the number of likes on a relevant social post; $\Delta pricescore_{i,t}$ includes the weekly change in the average price scores derived from technical analysis; $\Delta socialimp_t$ includes the weekly change in social impact calculated by the AI and based on the scrutinising of public and provide domains on social media networks; $\Delta socialcont_t$ is the weekly change in the number of social contributors who are unique people discussing the selected crypto product; $\Delta ucry_t$ evaluates the uncertainty of cryptocurrency policy; $\Delta cbdcui_t$ and $\Delta cbdcai_t$ are a weekly change in central bank digital currencies uncertainty and attention indices, respectively; $\Delta icea_t$ is the change in the index of cryptocurrency environmental attention; $\Delta nftai_t$ is the non-fungible tokens attention index; and weekly changes in the Aruoba-Diebold-Scotti business conditions index are captured by $\Delta ADSindex$. Finally, control variables include changes in S&P 500 Index, VIX, gold returns, and the difference between yields on 10-year and 2-year notes.

*p-value ≤ 10 %, ** p-value ≤ 5 %, *** p-value ≤ 1 %.

	Volatilityhl	Volatilityhl	Illiquidity	Illiquidity
Constant	0.006**	0.008***	0.132	0.289***
	(2.56)	(24.73)	(1.03)	14.80
Δ*tweets*	0.003***		0.057	
	(3.10)		(0.90)	
Δ*tweetfoll*	0		0.04	
	(0.34)		(1.07)	
Δ*tweetfav*	-0.001		0.021	
	(-1.42)		(0.71)	
Δ*pricescore*	0.001		0.247**	
	(0.33)		(2.08)	
Δ*socialimp*	0.001		-0.095*	
	(1.48)		(-1.70)	
Δ*socialcont*	-0.002*		-0.05	
	(-1.69)		(-0.93)	
Δ*ucry*		0.235***		-0.213
		(6.76)		(-0.10)
Δ*cbdcui*		0.079		3.657
		(1.49)		(1.15)
Δ*cbdcai*		-0.088		−1.491
		(-1.29)		(-0.37)
Δ*icea*		-0.094**		-0.249
		(-2.35)		(-0.10)
Δ*nftai*		0.086**		1.25
		(2.27)		(0.55)
Δ*ADSindex*		-0.007***		-0.14
		(-3.54)		(-1.12)
Δ*S&PIndex*	-0.021	-0.012	-0.44	-0.043
	(-1.09)	(-0.66)	(-0.40)	(-0.04)
Δ*VIX*	0	0.001	-0.098	-0.042
	(0.00)	(0.50)	(-0.58)	(-0.24)
Δ*gold*	0.015	0.008	−1.661	−2.27**
	(0.86)	(0.43)	(-1.60)	(-2.07)
Δ*10_2_dif*	0.001	-0.003	0.772	0.679***
	(0.27)	(-0.96)	(4.86)	(4.10)
Adjusted R2	0.005	0.023	0.013	0.009
F Stat	22.702	9.469	5.490	3.902
Suitable model	re	fe	fe	fe

5. Concluding remarks and discussion

In our study, we have evaluated how sentiment variables, in their broadest sense, influence the selected variables calculated from a pool of 51 decentralised finance entities. In so doing, we have identified some evidence that returns are influenced by tweets, the number of followers, and favourable comments of pertinent social comments. Since the market capitalisation of DeFis in our sample is small, their relevance from the investment perspective appears to be strongly supported by any social media outreach. These findings partially support our H_{a1} hypothesis, since we do not find any support for reduced illiquidity or volatility. We do find some support for increased volatility when there is an increase in weekly changes in the number of tweets or followers, which implies that social media attention leads to greater uncertainty. Furthermore, since crypto investors exhibit more herding behaviour during positive market movements (Ballis & Drakos, 2020; Kaiser & Stöckl, 2020) a rise in volatility could be justified. We have also confirmed that the S&P500 Index negatively influences cryptocurrency returns, which means that these two asset classes are substitutes, and greater volatility in the US market negatively influences DeFis' returns. Positive weekly changes in gold returns positively influence returns and reduce volatility and illiquidity in the cryptocurrency market. Finally, the negative coefficient estimate for the yield differential implies that a steeper yield curve negatively influences crypto returns, since any positive market outlook for the mainstream market may not be good news for investments in DeFis that could be viewed as an alternative market when major investments are expected to underperform. It is also possible that these results are specific to the COVID19 pandemic period, and further studies in the post-pandemic period could offer alternative insights.

When examining H2a, we find support for the claim that increased regulatory uncertainty reduces returns and increases volatility. The relevance of environmental attention is also supported by higher returns and lower volatility, which fully supports our initial claims. The attention to central bank digital currency positively influences returns, but we cannot find any evidence for links to volatility or liquidity. Non-fungible tokens' attention reduces returns and increases volatility, which fully contradicts our initial claim. Finally, the ADS index increases return and reduces volatility. Based on the examination of a range of crypto indices, we can claim that environmental issues and regulatory uncertainty exert a major influence on the cryptocurrency markets, whereas central bank digital currencies are of secondary importance. Unsurprisingly, non-fungible tokens that offer unprecedented advantages for ownership in the digital realm could be still viewed by market participants as highly speculative at this stage, and its relevance for the crypto markets offers contradicting results.

From the managerial perspective, our findings are important because they indicate that, in setting up investment strategies, DeFis could be viewed as an alternative to traditional assets, and it is advisable to limit the portfolio exposure in order to control for negative returns during market reversals. Social media exposure is also relevant for targeting returns, but it is not a useful tool in limiting volatility and reducing illiquidity. When analytically examining the crypto world, it is recommendable to pay attention to the progress in the regulatory realm as well as the reduction of the environmental footprint that cryptomarkets have nowadays. Examining trends in non-fungible tokens and in establishing central bank digital currencies could be of secondary importance when targeting specific returns or limiting volatility and illiquidity.

The results in our study could be impacted by the time period in question, which largely includes the COVID19 pandemic. Therefore, for further research, it is recommended to include data outside of the pandemic. Another constraint concerns our requirement to include converted daily and weekly values in a single study. Future research could instead limit themselves to fewer and higher frequency variables.

CRediT authorship contribution statement

Juan Pineiro-Chousa: Writing – review & editing, Supervision, Methodology, Conceptualization. **Aleksandar Sevic:** Writing – review & editing, Methodology, Conceptualization. **Isaac González-López:** Writing – review & editing, Methodology, Conceptualization.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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