The non-fungible token (NFT) market and its relationship with Bitcoin and Ethereum

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Abstract: Non-fungible tokens (NFTs) are transferrable rights to digital assets, such as art, in-game items, collectables or music. The phenomenon and its markets have grown significantly since early 2021. We investigate the interrelationships between NFT sales, NFT users (unique active blockchain wallets), and the pricing of Bitcoin and Ether. Using daily data between January 2018 and April 2021, we show that a Bitcoin price shock triggers an increase in NFT sales. Also, Ether price shocks reduce the number of active NFT wallets. The results suggest that (larger) cryptocurrency markets affect the growth and development of the (smaller) NFT market, but there is no reverse effect.

Keywords: NFTs; non-fungible tokens; cryptocurrency

1   Introduction

Prominent examples of *non-fungible tokens (NFTs)*, such as the artist *Beeple* selling a piece of digital art for $69 million (Christie's, 2021) or Twitter CEO *Jack Dorsey* auctioning off his first-ever tweet for $2.9 million (Valuables, 2021), show that NFTs have received mainstream attention. NFTs are unique certificates of authenticity on blockchains that are usually issued by the creators of the underlying assets. These assets can be digital or physical in nature. Fungible goods such as money or trade goods can be exchanged for goods of the same kind. By contrast, non-fungible items cannot be exchanged for a similar good because their value exceeds the actual material value. Examples from the analogue world include items of artistic or historical significance, or rare trading cards—all of which have a long history of trading in auctions and other marketplaces. In the digital world, it has so far been difficult to trade and auction non-fungible goods as their authenticity was hard to verify. NFTs now pave the way for the digitization and trade of unique values on the internet.

Within less than half a year (by May 16, 2021), hundreds of thousands of NFTs worth over $800 million were traded (NonFungible, 2021). Most of these referred to digital art, collectibles, music, in-game items or metaverses. Like cryptocurrency and other types of tokens, NFTs rely on blockchain technology and smart contracts as their digital infrastructure (Ante, 2021); however, they significantly differ from traditional cryptocurrencies such as Bitcoin or Ethereum

in other respects. NFTs serve not as a currency, a commodity or a technology but as an asset (Dowling, 2021a).

Besides the common technological infrastructure, NFT marketplaces such as *OpenSea* or *Rarible* furthermore use cryptocurrency, most commonly *Ether (ETH)*, as a payment and trading option, evidencing a close relationship between the cryptocurrency market and the NFT market. If users typically require cryptocurrency to buy NFTs, it is reasonable to assume that the cryptocurrency market has an impact on the smaller NFT market. Dowling (2021a) accordingly writes that anyone who is active in the NFT market recognizes the strong overlap between participants in these two markets. To access and use cryptocurrencies is a complex task; therefore, those who have mastered it are more likely to also participate in the NFT market.

There are few prior studies on the financial aspects of NFT markets. Nadini et al. (2021) map the NFT ecosystem based on sales and traded volume across different projects, stakeholders and other relevant characteristics. Dowling (2021b) examines the pricing behavior of a particular NFT project, *Decentraland*, which enables the trading of digital plots of land in a blockchain-based multiverse. In another study, Dowling (2021a) uses wavelet coherence analysis to identify any co-movement between the cryptocurrency and the NFT markets. He examines three major NFT submarkets (*Decentraland*, *CryptoPunks* and *AxieInfinity*), as well as the prices of Bitcoin and Ether. The results suggest that cryptocurrency pricing behavior can help understand NFT pricing patterns. Building on this, the aim of the present study is to investigate how the markets for NFTs and cryptocurrencies are related. We extract macro data on the Ethereum-based NFT market, more specifically the trading volume of all NFTs in USD and the number of blockchain wallets participating in the NFT market (sellers and buyers), and analyze how these relate to the pricing of Bitcoin and Ethereum using a cointegrated *vector autoregressive (VAR)* model, i.e. a *vector error correction model (VECM)*. This allows us to identify to what extent these markets influence each other, or co-move.

Our data on overall trading volume and users should permit a better understanding of the NFT phenomenon, with the existing research focusing on pricing aspects of NFT (sub)markets (Dowling, 2021a, 2021b). We aim to clarify what impact changes in the prices of Bitcoin and Ethereum have on the NFT market, which in turn helps to understand the impact or spillover effect of the (larger) cryptocurrency markets on the (smaller) NFT market. It seems likely that Bitcoin, as the market leader, drives the NFT market, as it does or did with respect to other cryptocurrencies (Kumar and Ajaz, 2019). We also hope to determine whether demand shocks in the NFT market affect the pricing of cryptocurrencies. The results contribute to lessons learned on the co-movement and spillover of blockchain-based markets or assets (Kumar and Anandarao, 2019; Moratis, 2021), and the use of on-chain data to assess blockchain-based markets and their efficiency (Ante et al., 2021). The data set and methodology are described below, followed by a presentation of the results and concluding remarks.

2 Data and methodology

Our dataset comprises 1,231 daily observations (January 01, 2018 to May 16, 2021) on the volume of NFT sales in USD, the number of blockchain wallets holding or interacting with NFTs on a particular day, and the prices of Ether (ETH) and Bitcoin (BTC) in USD. The first

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two metrics are collected from *NonFungible Corporation* (nonfungible.com) and cover data on the Ethereum blockchain only, which (historically) accounts for a majority of the NFT market. Price data (daily close) are collected from the cryptocurrency exchange *Bitfinex* (bitfinex.com). In line with Dowling (2021a), as cryptocurrency reference markets we use ETH, the most relevant currency for issuing and trading NFTs, and BTC, the largest and most significant cryptocurrency.

Figure 1 shows the extreme increase in the trading volume of NFTs since early 2021. For example, on the single day of May 03, 2021, over $100 million worth of NFTs were traded, and the daily average trading volume of the year to date is much higher than in previous years ($6.13 million, compared to $0.18 million in 2020, $0.07 million in 2019, and $0.10 million in 2018). The figure also shows that the number of wallets on the Ethereum blockchain holding NFTs has increased significantly. For example, in March 2021, over 5,700 different wallets held NFTs. The two metrics clearly illustrate the increasing relevance of NFTs, both in terms of market volume and the number of users, as proxied by the number of blockchain wallets. The two cryptocurrencies also peaked in 2021, at $63,537 (BTC) and $4,172 (ETH) respectively, having traded significantly lower prior to that. Descriptive statistics on the raw series, the log series and the log differences are presented in Table A.1.
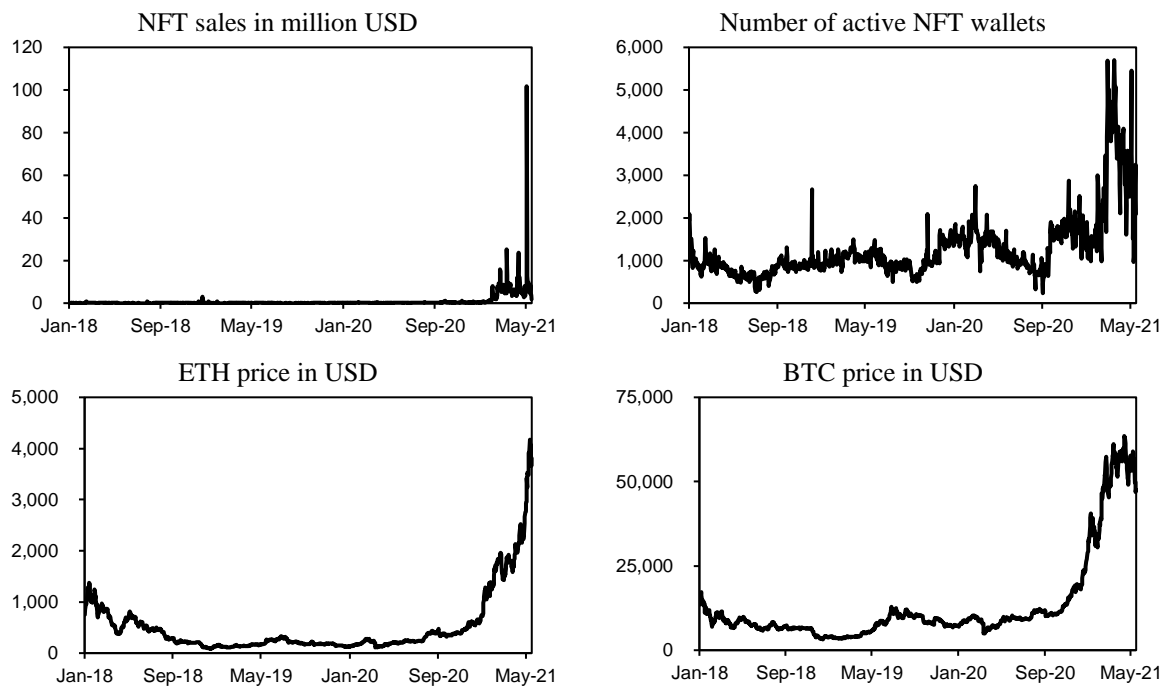
Figure 1. NFT and cryptocurrency market data..

To investigate the relationship between the NFT market and the cryptocurrencies, we propose a VAR framework, which can be used to structurally analyse the dependencies between several variables. Here, we model vectors of variables as depending on their own lags and the lags of other variables. With our four variables, the VAR model takes the following form.

$$\begin{bmatrix} NFT\ sales_t \\ NFT\ wallets_t \\ BTC\ price_t \\ ETH\ price_t \end{bmatrix} = a_0 + A_1 \begin{bmatrix} NFT\ sales_{t-1} \\ NFT\ wallets_{t-1} \\ BTC\ price_{t-1} \\ ETH\ price_{t-1} \end{bmatrix} + \cdots + A_4 \begin{bmatrix} NFT\ sales_{t-4} \\ NFT\ wallets_{t-4} \\ BTC\ price_{t-4} \\ ETH\ price_{t-4} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1,t} \\ \varepsilon_{2,t} \\ \varepsilon_{3,t} \\ \varepsilon_{4,t} \end{bmatrix} \qquad (1)$$

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a_0 is a vector of intercept terms and A_1 to A_4 are coefficients of a 4x4 matrix. The optimal number of lags—4 in our case—is identified by the Akaike information criterion (AIC). All four time series are stationary in their logarithmic form and all log differences are non-stationary (cf. Table A.2), making VAR a suitable method. Yet the Johansen test of cointegration (Johansen, 1991) indicates one cointegrating relationship (cf. Table A.3), thus making the VECM—the cointegrated VAR—our choice of model.

3 Results and discussion

In the following, we present two postestimation statistics to interpret the results of the cointegrated VAR. Table 4 lists short-run Granger causality test statistics that indicate whether a change in one variable precedes a change in another variable. The statistics are calculated for each combination of our dependent and independent variables. For example, the first line of results refers to the test whether all coefficients on 4 lags of NFT wallets as a potential predictor of NFT sales are zero. Since the p-value exceeds the significance threshold of 10%, we cannot confirm that NFT wallets Granger-cause NFT sales. NFT sales are, however, Granger-caused by the BTC price. Furthermore, NFT wallets are Granger-caused by the ETH price. BTC is not Granger-caused by any of the other variables, while ETH is Granger-caused by the BTC price. Accordingly, we find that NFT markets are influenced by cryptocurrency pricing, though Granger causality tells us nothing about the direction of these influences.

Table 4. Short-run Granger causality. The table shows short-run Granger causality test statistics for the VECM model.

Dependent variable	Independent variable	F-statistic	p-value
NFT sales	NFT wallets	3.92	0.270
	BTC price	10.32	0.016**
	ETH price	4.68	0.197
NFT wallets	NFT sales	6.25	0.100
	BTC price	1.22	0.747
	ETH price	13.09	0.004***
BTC price	NFT sales	1.89	0.596
	NFT wallets	11.86	0.603
	ETH price	5.53	0.137
ETH price	NFT sales	5.23	0.156
	NFT wallets	2.14	0.544
	BTC price	6.81	0.078*

*** $p < 0.01$; ** $p < 0.5$; * $p < 0.1$.

To understand that direction of influence, impulse response functions are shown in Figure 2. They depict how a standard deviation shock to one variable affects another variable over a period of 30 days. One impulse is placed in reach row and one response in each column.

Unlike with the VAR, impulse response functions of a VECM need not return to their mean value, as series are cointegrated in the long-run. We find that one-time standard deviation shock increases in the prices of BTC and ETH have positive effects on NFT sales. The effects level off at around 0.03% for BTC and around 0.015% for ETH. Bitcoin price shocks have a clear positive effect on the number of active NFT wallets. Surprisingly, the reverse effect applies to the ETH price. As expected, NFT sales and the number of NFT wallets are positively related. A 1% price shock of BTC has a negative short-term effect on the price of ETH. After about 5 days, the trend reverses, settling at a permanent effect of around 0.001%. An ETH price shock

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has a positive effect on the price of BTC (0.032%). Due to the existence of a long run equilibrium relationship between series, impulse response functions must be interpreted with caution for VECM models. They are helpful in interpreting the basic relationships between the variables, map short-run effects and complement the above results of the short-run Granger causalities.
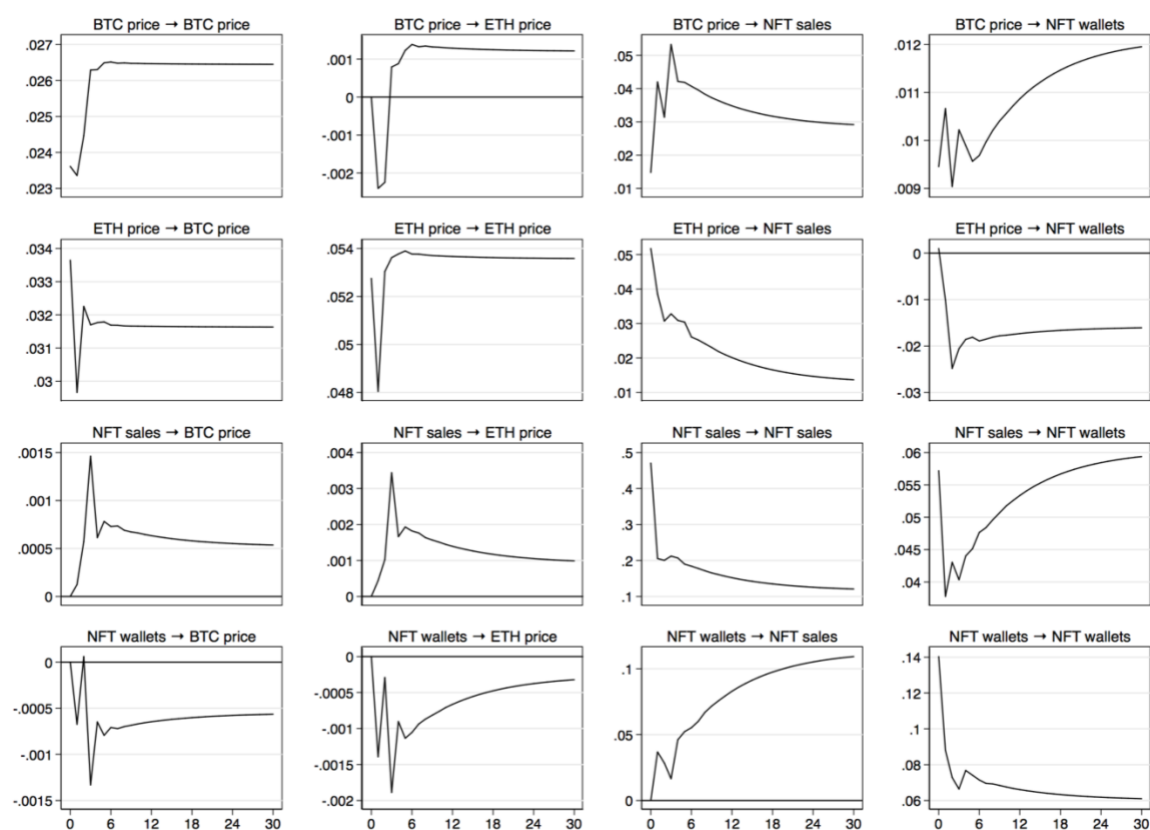
Figure 2. Impulse response functions. Impulse response functions based on the VECM with 4 lags are shown for a time horizon of 30 days.

4 Concluding remarks

This paper has analyzed the interplay between the cryptocurrency market and the NFT market, contributing to the emerging literature on the latter. In line with Dowling's (2021a) conjecture, we find that BTC and ETH pricing affects the NFT market, while the NFT market does not significantly influence the pricing of cryptocurrencies. It thus appears that the smaller NFT market is driven by the cryptocurrency market. This is plausible, as cryptocurrencies are the common currency for buying and trading NFTs. A drop in cryptocurrency value means lower purchasing power, which is likely to depress the NFT market. Conversely, when cryptocurrencies appreciate, investors tend to look for new or alternative investment opportunities. This is especially plausible in the context of ETH, the standard denomination of NFTs. While the impulse response function indicates such a relationship between NFT sales and ETH, we do not find a significant Granger causality between these metrics—yet we do so for BTC.

Our results contribute to research on spillover effects between blockchain-based markets of different sizes. For initial coin offerings (ICOs)—another market that is much small than cryptocurrency—Masiak et al. (2019) have shown that shocks in cryptocurrency pricing have

positive effects on market volume. Like NFTs, ICOs also typically rely on cryptocurrency for payment. Similarly, stablecoin markets are driven by the demand for cryptocurrency (Ante et al., 2020; Kristoufek, 2021). The question thus arises to what extent insights, issues and challenges from other blockchain-based markets can be transferred to the NFT market. This includes issues related to quality signaling in the context of token pricing or valuation (Fisch, 2019), investment returns (Domingo et al., 2020), or legal challenges (Hornuf et al., 2021).

A potential limitation of this study and at the same time an exciting challenge for future research is the topic of NFT wash trading. This is an issue that poses significant challenges to blockchain-based pseudo-anonymous markets and cryptocurrency markets (Cong et al., 2020; Le Pennec et al., 2021). In principle, an owner or creator can trade her own NFT transparently but anonymously by transferring it between two different addresses/wallets on the public blockchain infrastructure. This way, demand can be suggested, faked or inflated with the goal to attract future buyers. The legality of any such behavior is currently unclear. If it were to take place, this could— besides the evident investor protection challenges—bias the statistics on NFT sales and wallets and their interpretation used in this study. Accordingly, future research might analyze (large) NFT sales, the blockchain addresses involved, and transaction patterns to identify any wash trading.

We agree with Dowling's (2021a) main conclusion "that NFTs do appear to be a distinct (and exciting) new asset class". While the NFT market still seems to depend on the cryptocurrency market, specifically BTC, it may well mature over time. The question is to what extent this relationship will change once traditional marketplaces such as *eBay* allow trading of NFTs (against fiat currencies or stablecoins) (Reuters, 2021), established companies such as *Instagram* fully appreciate the potential of NFTs (Keely, 2021), or media firms like *Fox* launch their own NFT ventures (Khatri, 2021). In the future we may see NFT submarkets that are strongly related to cryptocurrency markets and others that are much more independent. The further development of the NFT market and its relationship to the cryptocurrency market thus holds plenty more research interest.

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Appendix

Table A.1. Descriptive statistics. Descriptive statistics for the raw metrics, log-transformed series and the logarithmic differences of 1,231 daily observations.

	Mean	SD	P50	Min	Max	Skewness	Kurtosis
Raw series							
NFT sales	780,199	3,644,778	78,349	14,591	102,000,000	485.80	18.59
NFT wallets	1,261	767	1,026	233	5,701	11.41	2.65
BTC price	13,139	13,458	8,818	3,281	63,537	7.78	2.43
ETH price	503	606	246	85	4,172	12.92	2.90
Log series							
NFT sales	11.73	1.44	11.27	9.59	18.44	5.64	11.73
NFT wallets	7.02	0.47	6.93	5.45	8.65	4.38	7.02
BTC price	5.80	0.83	5.51	4.45	8.34	3.07	5.80
ETH price	9.19	0.68	9.08	8.10	11.06	4.24	9.19
Log differences							
NFT sales	0.0021	0.5452	-0.0107	-3.4753	3.5531	11.0229	-0.0823
NFT wallets	0.0001	0.1637	-0.0037	-1.0603	1.1160	11.2118	0.0688
BTC price	0.0010	0.0413	0.0016	-0.4919	0.1789	21.0601	-1.4379
ETH price	0.0013	0.0533	0.0012	-0.5801	0.2331	15.8410	-1.2076

Table A.2. Unit root tests.

	Log series			Log differences	
	ADF	p-value		ADF	p-value
NFT sales	-1.593	0.4869		-17.219	0.0000***
NFT wallets	-2.452	0.1275		-16.536	0.0000***
BTC price	-0.011	0.9576		-12.264	0.0000***
ETH price	0.084	0.9650		-11.902	0.0000***

*** $p < 0.01$; ** $p < 0.5$; * $p < 0.1$.

Table A.3. Johansen cointegration test.

Hypothesized number of cointegrated vectors	Eigenvalue	Trace statistic	5% critical value	Maximum Eigenvalue statistic	5% critical value
0		64.48	39.89	30.04	23.80
1	0.0317	24.92	24.31	14.35	17.89
2	0.0124	9.63	12.53	2.13	11.44
3	0.0067	1.42	3.84	0.11	3.84

Declarations

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on request.

Conflicts of interest

Not applicable.

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Not applicable.

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About the Blockchain Research Lab

The Blockchain Research Lab promotes independent science and research on blockchain technologies and the publication of the results in the form of scientific papers and contributions to conferences and other media. The BRL is a non-profit organization aiming, on the one hand, to further the general understanding of the blockchain technology and, on the other hand, to analyze the resulting challenges and opportunities as well as their socio-economic consequences.

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