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NFTs and asset class spillovers: Lessons from the period around the COVID-19 pandemic

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ABSTRACT

In this paper, we analyze the connectedness between returns for non-fungible tokens (NFTs) and other financial assets (equities, bonds, currencies, gold, oil, Ethereum) during the period from January 2018 to June 2021. By using the Time-Varying Parameter Vector Autoregressions (TVP-VAR) approach, we show that the overall connectedness between the returns for financial assets increased during the COVID-19 period. Our static analysis shows that the behavior of the majority of NFT returns is attributable to endogenous shocks and only a small portion of this variation resulted from the impact of innovation in other assets. The results suggest that NFTs are mainly independent of shocks from common assets classes and even from their close relation, Ethereum. The dynamic analysis across time reveals that during normal times, NFTs act as transmitters of systemic risk to some degree, but during stressful times, their role shifts, and they act as absorbers of risk spillovers. This suggests that NFTs may have diversification benefits during turbulent times, as apparent during the COVID-19 crisis, and especially around the great March 2020 market plunge.

JEL Classification: C5; F3; G10; G12

1. Introduction

Over the last decade, cryptocurrencies have attracted the attention of the public, media, investors, and policymakers. There is a rapidly growing and evolving body of literature analyzing the financial properties of cryptocurrencies. A stream of those studies explores the spillover and connectedness within the cryptocurrency market and between cryptocurrencies and other financial assets (Baumöhl, 2019; Zeng et al. 2020; Aharon et al. 2021). It has already been shown that the COVID-19 outbreak substantially influenced the spillovers and connectedness among financial assets (Wang et al., 2021b; Bissoondoyal-Bheenick et al., 2021). Understanding connectedness is critical, as it lies at the core of risk measurement and management (Diebold and Yilmaz, 2014), providing important evidence to financial market participants.

In this paper, we explore returns' connectedness between non-fungible tokens (NFTs) and other financial assets, and the impact of the COVID-19 outbreak on this interaction. Financial markets have recently been experiencing the emergence and growth of the new phenomenon of NFTs, which are crypto assets that represent an intangible digital item, such as an image, characters, art, video, game

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item, or even a tweet. NFTs differ from cryptocurrencies in that NFTs are pure assets and their non-fungibility makes them unique (Dowling, 2021a). NFTs allow to develop the "provenance" of the assigned digital item by providing undebatable answers to such questions as who owns, owned, and created NFTs (Nadini et al., 2021). Most NFTs are powered by smart contracts on the Ethereum blockchain, which means that their ownership records cannot be modified, as they are secured by the Ethereum blockchain.[1] Traded items in the NFT market are categorized in collections based on their common features. Most collections can be classified in Art, Collectible, Games, Metaverse, Other, and Utility (Nadini et al., 2021). NFT sales volume across multiple blockchains reached almost 2.5 billion dollars in the first half of 2021, while the sales volume was only around 95 million dollars in 2020. Sports and collectible NFTs are the most popular categories in the first two quarters of 2021 (Howcroft, 2021).

In light of their very recent appearance, there is little literature on NFTs. Ante (2021) shows that Bitcoin and Ethereum prices affect the NFT market, although the NFT market has no effect on cryptocurrencies. Dowling (2021a) reports a limited volatility transmission between cryptocurrencies and NFTs and a further analysis documents a co-movement between the Ethereum and NFT markets. M. Dowling (2021b) finds that the NFT market is inefficient due to its early growth stage. Yet, we do not know how NFTs compare to other financial assets. How do NFTs correlate with other asset classes? Are there any spillovers to and/or from NFTs? We contribute to these initial NFT studies by analyzing the total connectedness, and especially the return connectedness, between NFTs and other financial assets (equities, gold, cryptocurrencies, currencies, oil, and bonds) using the Time-Varying Parameter Vector Autoregressions (TVP-VAR) model. To the best of our knowledge, this is a pioneer study exploring the spillover between NFTs and other financial assets.

Our static analysis implies that the majority of NFT returns are due to endogenous (own) shocks, while only a very small portion of the variation in NFT returns is attributable to the impact of innovation in other financial assets, during both pre-pandemic and ongoing pandemic periods. NFTs are largely independent of shocks from other asset classes. This has important implications for investors in portfolio construction. Our dynamic analysis verifies the potential diversification benefits that NFTs may offer. We uncover that NFTs were recipients of risk spillovers from the market plunge that occurred in around February 2018. In addition, during the COVID-19 crisis, and especially around the great plunge in financial markets during March 2020, NFTs acted as clear recipients of risk, much like other safe-haven assets, such as gold and the U.S. dollar.

2. Data

We included daily data of various assets (gold, equities, currencies, bonds, cryptocurrencies) having different levels of risk and return. Following Bouri et al. (2021), the sample included the MSCI World Index, gold, the PIMCO Investment Grade Corporate Bond Index Exchange-Traded Fund, the U.S. Dollar Index, Ethereum, crude oil, and NFTs. All the data was obtained from investing.com, with the exception of that for NFTs. Our NFT data comprised secondary market trades collected from https://nonfungible.com/. Following Dowling (2021a, M. 2021b), we calculated the mean value of transaction prices on a daily basis. Dowling (2021a, M. 2021b) focuses on sub-markets in the NFT market by using weekly and daily data. We relied on daily data, as our data included all trades in the NFT market, thus providing us with a higher number of observations for analysis. In addition, using data for the entire market can mitigate the issue of extreme volatility present in sub-markets.

Our data covers the period from January 1, 2018 to June 30, 2021. This period is determined by the availability of data on the NFT market, and includes the recent pandemic, which may have substantially influenced connectedness among financial assets. Consequently, we divided the data into the pre-COVID-19 period and the ongoing COVID-19 period. The cutoff date was set as January 13, 2020, in accordance with Bouri et al. (2021).[2]

3. Methodology

This section presents the dynamic connectedness procedure based on TVP-VAR method proposed by Antonakakis and Gabauer (2017) and originally provided by Diebold and Yilmaz (2009, 2012, 2014). Diebold and Yılmaz (2009, 2012, 2014) (DY) introduced a rolling-window VAR-based approach to provide various connectedness measures obtained from variance decompositions. Antonakakis and Gabauer (2017)[3] subsequently applied a time-varying parameter vector autoregressive model (TVP-VAR) based on a time-varying covariance structure as proposed by Primiceri (2005). The TVP-VAR(p) model can be represented as:

$$Y_t = \beta_t Z_{t-1} + \varepsilon_t, \ \varepsilon_t \mid \Omega_{t-1} \sim N(0, \Sigma_t), \tag{1}$$

$$\beta_t = \beta_{t-1} + \vartheta_t, \ \vartheta_t \mid \Omega_{t-1} \sim N(0, R_t). \tag{2}$$

The model presented in Eq. (1), and based on the Wold representation theorem, can be transformed to its moving average (VMA) representation as follows:

[1] Please see Kong and Lin (2021), Wang et al., 2021a) and Nadini et al. (2021) for a detailed explanation of NFTs and evaluation and trends of the NFT market.

[2] We also used March 13, 2020 as our cutoff point. The main results are essentially similar. The full results are available upon request.

[3] See Antonakakis and Gabauer (2017) for the advantages of using TVP-VAR and how it mitigates several shortcomings of the common VAR approach.

$$\mathrm{Y_t} = \sum_{j=0}^{\infty} \Theta_{jt}\varepsilon_{t-j}, \tag{3}$$

where Θ_{jt} is an $N \times N$ dimensional matrix.

To obtain the dynamic connectedness measures between the different variables, we use the time-varying parameters and variance-covariance matrices of the TVP-VAR model in Diebold and Yilmaz's measure of connectedness. As a result, the elements of the dynamic H-step generalized variance decomposition matrix $\mathrm{D_t^{gH}} = [\mathrm{d_{ij,t}^{gH}}]$ can be defined as:

$$\mathrm{d_{ij,t}^{gH}} = \frac{\sigma_{\mathrm{jj,t}}^{-1} \sum_{h=0}^{H-1} \left(e_i' \ \Theta_{h,t} \ \Sigma_t e_j\right)^2}{\sum_{h=0}^{H-1} \left(e_i' \ \Theta_{h,t} \ \Sigma_t \Theta_{h,t}' e_j\right)},$$

where $\sigma_{\mathrm{jj,t}}^{-1}$ is the j$^{\mathrm{th}}$ diagonal element of Σ_t. The normalized terms $\widetilde{\mathrm{d}}_{\mathrm{ij,t}}^{\mathrm{gH}} = \frac{\mathrm{d_{ij,t}^{gH}}}{\sum_{j=1}^{N} d_{ij,t}^{gH}}$ are used to determine the dynamic total directional connectedness, net total directional connectedness, and total connectedness as follows. The interconnectedness among the different variables is measured by the total connectedness index (TCI), and is calculated as:

$$\mathrm{C_t^{gH}} = \frac{\sum_{\mathrm{i},\ j=1,\ \mathrm{i}\neq\mathrm{j}}^{\mathrm{N}} \widetilde{\mathrm{d}}_{\mathrm{ij,t}}^{\mathrm{gH}}}{\sum_{j=1}^{N} \widetilde{d}_{ij,t}^{gH}} \times 100. \tag{4}$$

The directional spillover received by variable i from all other variables j, is measured as:

$$\mathrm{C_{i\leftarrow j}^{gH}} = \frac{\sum_{j=1,\ \mathrm{i}\neq\mathrm{j}}^{\mathrm{N}} \widetilde{\mathrm{d}}_{\mathrm{ij,t}}^{\mathrm{gH}}}{\sum_{i=1}^{N} \widetilde{d}_{ij,t}^{gH}} \times 100. \tag{5}$$

Similarly, the spillovers received by variable j from all other variables i, is calculated as:

$$\mathrm{C_{i\rightarrow j}^{gH}} = \frac{\sum_{j=1,\ \mathrm{i}\neq\mathrm{j}}^{\mathrm{N}} \widetilde{\mathrm{d}}_{\mathrm{ij,t}}^{\mathrm{gH}}}{\sum_{j=1}^{N} \widetilde{d}_{ij,t}^{gH}} \times 100. \tag{6}$$

To measure the net pairwise directional connectedness, we subtract the total directional connectedness to others from total directional connectedness from others. This can be considered as the influencing variable i has on the analyzed network. That is,

$$\mathrm{C_{ij,t}^{gH}} = \mathrm{C_{j\leftarrow i,t}^{gH}} - \mathrm{C_{i\leftarrow j,t}^{gH}}. \tag{7}$$

At last, the net pairwise directional connectedness is defined as:

$\mathrm{NPDC_{ij}^{gH}} = (\widetilde{\mathrm{d}}_{\mathrm{ji,t}}^{\mathrm{gH}} - \widetilde{\mathrm{d}}_{\mathrm{ij,t}}^{\mathrm{gH}}) \times 100$. If the value is greater than zero, this implies that variable i dominates variable j; otherwise, the latter dominates the former.[4]

4. Empirical findings

Table 1 reports the descriptive statistics for the variables of interest. Regardless of the period examined, NFTs and Ethereum, both belonging to the same blockchain technology family, are associated with the highest volatility as measured by the standard deviation. We also observe a heightened degree of volatility for all other assets. Notably, while the mean return of both NFTs and Ethereum was negative before the COVID-19 crisis, they shifted from losers to winners during the crisis, having not only positive mean returns, but also the highest ones of all the assets under analysis. We use the log first differences of each series to test for stationarity. In unreported results of ADF and Phillip-Perron tests, we reject the null hypothesis, confirming that the data is stationary at the 1% level.[5]

We note that although Fig. 1 shows a generally mean-reverting behavior, the outbreak of COVID-19 and the great plunge in financial markets during March 2020 is associated with relatively clear and pronounced spikes beginning around this period. However, while this pattern applies to Ethereum and other traditional assets, such as the USD index, gold, oil, and bonds, it is not apparent in the behavior of NFT returns. This may imply that the behavior of NFTs is perhaps atypical or different from the behavior of other assets or during the COVID-19 crisis as an exogenous event. It may also be the first indication of the diversification benefits of NFTs in terms of

[4] To address the potential issue of non-synchronous bias, we followed the procedure of Forbes & Rigobon (2002) and repeated our TVP-VAR examinations by employing rolling average of two days returns. The procedure has been recently employed by Akhtaruzzaman et al. (2021). The results are essentially similar and are available upon request.

[5] The findings are available upon request.

Table 1
Descriptive Statistics.

	Panel A. Full Period						
	January 1, 2018- June 30, 2021						
	Gold	**Equities**	**ETH**	**Oil**	**NFT**	**Bonds**	**USD Index**
Mean	0.0003	0.0004	0.0012	0.0008	0.0039	0.0009	−0.0000
Max	0.0363	0.0847	0.3574	0.3196	2.204	0.0681	0.0158
Min	−0.0589	−0.1044	−0.5896	−0.2822	−3.4703	−0.0508	−0.0169
S.D.	0.0088	0.0111	0.0647	0.0352	0.5649	0.0051	0.0036
Skewness	−0.6836	−1.5256	−0.9055	0.2372	−0.0526	0.0109	0.2190
Kurtosis	7.8379	24.2970	13.2164	30.1685	5.2468	66.0918	4.6410
J.B.	956	17,512	4072	27,934	191	150,598	109
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
	Panel B. Pre-COVID-19 Period						
	January 1, 2018- January 12, 2020						
	Gold	**Equities**	**ETH**	**Oil**	**NFT**	**Bonds**	**USD Index**
Mean	0.0003	0.0002	−0.0030	0.0000	−0.0007	0.0000	0.0001
Max	0.0244	0.0271	0.252	0.1369	2.2048	0.0060	0.0112
Min	−0.0216	−0.0317	−0.2781	−0.0823	−3.4703	−0.0071	−0.0104
S.D.	0.0066	0.0071	0.0587	0.0225	0.5684	0.0022	0.0032
Skewness	0.1272	−0.6874	−0.2440	0.0225	−0.2600	−0.3220	0.0115
Kurtosis	4.0868	5.2849	5.6671	8.5455	6.3417	3.5067	3.2053
J.B.	27	156	161	676	252	14	0.939
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.625)
	Panel C. COVID-19 Period						
	January 13, 2020 - June 30, 2021						
	Gold	**Equities**	**ETH**	**Oil**	**NFT**	**Bonds**	**USD Index**
Mean	0.0003	0.0007	0.0072	0.0022	0.0104	0.0001	−0.0001
Max	0.0363	0.0840	0.3574	0.3196	1.8816	0.0681	0.0158
Min	−0.0589	−0.1044	−0.5896	−0.2822	−1.8534	−0.0508	−0.0169
S.D.	0.0111	0.0155	0.0718	0.0490	0.5608	0.0075	0.0041
Skewness	−0.8485	−1.4095	−1.4815	0.1415	0.2485	0.0156	0.4000
Kurtosis	6.6032	16.9090	17.6944	18.9447	3.6144	35.0000	5.1813
J.B.	252	3166	3557	4026	9.890	16,129	85.46
	(0.000)	(0.000)	(0.000)	(0.000)	(0.007)	(0.000)	(0.000)

Notes: The table presents the descriptive statistics of the variables of interest. The reported values are the Mean, Max (maximum), Min (minimum), S.D. (standard deviation), Skewness, and Kurtosis moments of each variable distribution, the Jarque-Bera (1980) test and its significance (in Parenthesis) for the normality of each series. Panel A, B and C report the statistics for the full period (January 01, 2018- June 30, 2021), the Pre-COVID-19 period (January 1, 2018- January 12, 2020) and the COVID-19 period (January 13, 2020 - June 30, 2021), respectively. The total number of observations are 909, 527 and 382, for these periods, respectively.

portfolio construction.

The results reported at the top of Table 2 show that NFTs generally have weak correlations with the traditional asset classes, such as gold (+0.0268), equities (+0.0322), oil (+0.0585), bonds (+0.0427), and the USD index (−0.0004). The only exception is their correlation with Ethereum, which is slightly stronger (+0.1098), especially during the COVID-19 period (+0.1974), and may be predictable, as the price of NFTs is denominated in Ethereum units. However, the reported correlation levels mainly point to a weak relationship between NFTs and other assets, regardless of the examined period.

In order to facilitate a clearer investigation of the role that NFTs might fulfill in the context of systemic risk spillovers, we then tested the interactions of NFTs with other system variables using the novel TVP-VAR approach. The findings of the static analysis are summarized in Table 3. As done previously, we separate our investigation into the entire period, the pre-Crisis period and the ongoing COVID-19 period and thereafter.

We began with the static analysis in Table 3. We observe several interesting trends. First, consistent with earlier research, including the most recent studies (e.g., Adekoya and Oliyide 2021; Bouri et al., 2021; Wang et al., 2021b; Umar et al. Z. 2021), the overall connectedness between the various system variables increased during the COVID-19 period. The degree of system connectedness is obtained by dividing the total contribution FROM (which is also equal to the total contribution TO the system) by the number of system elements, which yields the Total Connectedness Index (TCI). Total Connectedness Index (TCI), as a measure of the systemic risk transmission, increases from 20.14 to 32.41, an increase of nearly 60% in the interdependence and connectivity of the assets under analysis. This suggests that during the ongoing COVID-19 period, nearly one-third of the variation in the system variables could be attributed to the mutual shocks in the examined system variables. Fig. 2, which uses a dynamic track of the total connectedness measure, also verifies this trend. The vertical axis presents the total connectedness index in percentage and reflects the portion of the variation which can be attributed, on average, to the interactions between the system variables. In the first quarter of 2018 (mainly

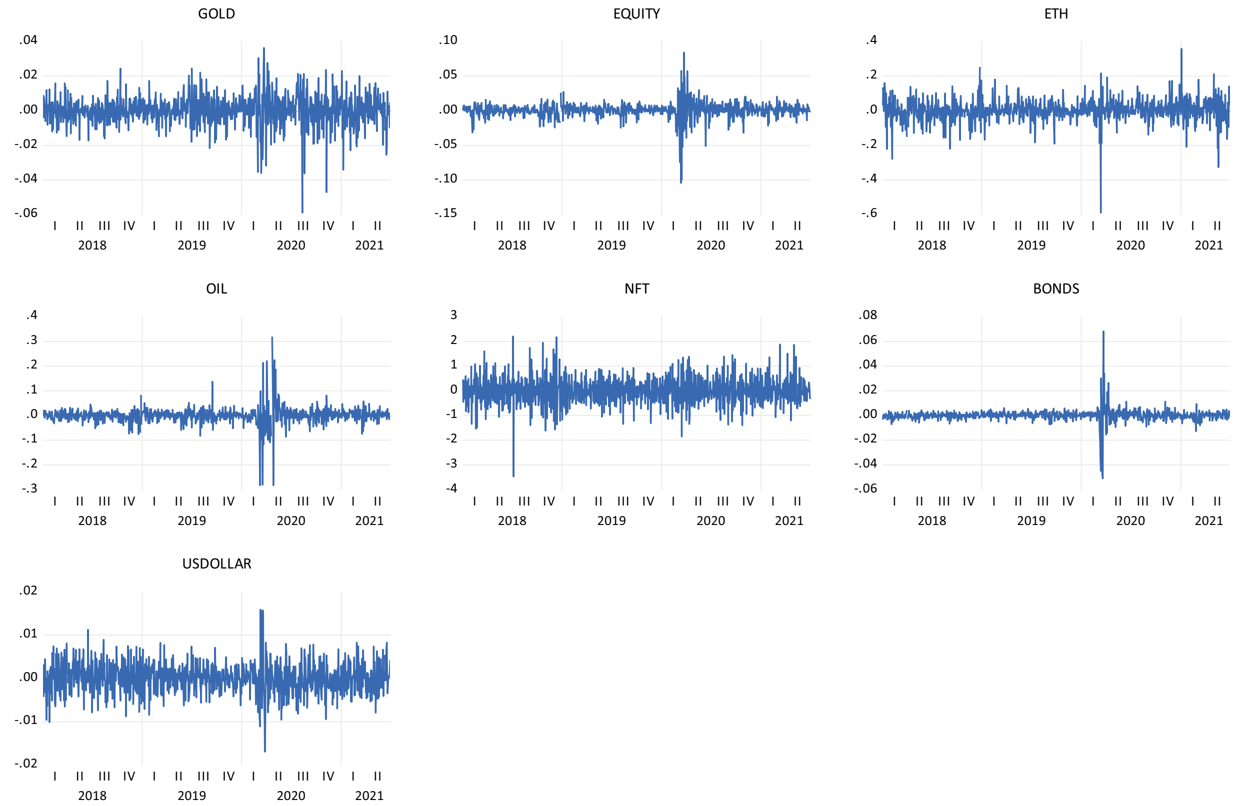

Fig. 1. Returns over the entire sample period Note: The graphs above present the log returns across time for each of the system variables. The sample period examined is January 1, 2018- June 30, 2021.

Table 2
Correlation Matrix.

	Panel A. Full period						
	Gold	Equities	ETH	Oil	NFT	Bonds	USD Index
Gold	1.000						
Equities	0.1053	1.000					
ETH	0.1303	0.2672	1.000				
Oil	0.0325	0.3035	0.0941	1.000			
NFT	0.0268	0.0322	0.1098	0.0585	1.000		
Bonds	0.2913	0.2476	0.1262	0.0648	0.0427	1.000	
US Dollar	−0.4625	−0.1244	−0.0507	0.0123	−0.0004	−0.2418	1.000
	Panel B. Pre-COVID-19 period						
	Gold	Equities	ETH	Oil	NFT	Bonds	USD Index
Gold	1.000						
Equities	−0.1025	1.000					
ETH	0.0528	0.0554	1.000				
Oil	−0.0358	0.3270	0.0283	1.000			
NFT	0.0375	−0.0524	0.0337	−0.0040	1.000		
Bonds	0.3691	0.0186	−0.0074	−0.0131	−0.0106	1.000	
US Dollar	−0.5552	−0.1102	−0.0290	−0.0478	−0.0118	−0.1284	1.000
	Panel C. COVID-19 period						
	Gold	Equities	ETH	Oil	NFT	Bonds	USD Index
Gold	1.000						
Equities	0.1858	1.000					
ETH	0.1859	0.3921	1.000				
Oil	0.0562	0.2972	0.1286	1.000			
NFT	0.0196	0.0910	0.1974	0.1032	1.000		
Bonds	0.2861	0.2953	0.1886	0.0785	0.0751	1.000	
US Dollar	−0.4093	−0.1373	−0.0651	0.0425	0.0132	−0.3100	1.000

Notes: The table above reports the pairwise correlations of the system variables. Panel A, B and C report the correlation matrix for the full period (January 1, 2018- June 30, 2021), the Pre-COVID-19 period (January 1, 2018- January 12, 2020) and the COVID-19 period (January 13, 2020 - June 30, 2021), respectively.

Table 3
Static Connectedness Tables.

	Gold	Equities	ETH	Oil	NFT	Bonds	US Dollar	FROM
	Panel A. Full period							
	Gold	**Equities**	**ETH**	**Oil**	**NFT**	**Bonds**	**US Dollar**	**FROM**
Gold	**63.92**	3.84	2.90	3.52	0.76	8.70	16.35	36.08
Equities	3.64	**71.01**	6.68	8.53	1.71	5.49	2.93	28.99
ETH	2.95	6.98	**82.13**	2.54	2.71	1.73	0.96	17.87
Oil	1.51	9.74	2.19	**83.02**	1.39	1.10	1.05	16.98
NFT	0.58	1.14	2.21	1.51	**93.82**	0.41	0.34	6.18
Bonds	8.51	3.65	1.67	2.31	0.66	**79.37**	3.84	20.63
USD Index	17.37	4.71	2.20	3.52	0.75	8.00	**63.44**	36.56
TO	34.56	30.05	17.86	21.93	7.99	25.43	25.48	163.29
In. own	98.48	101.06	99.99	104.95	101.80	104.80	88.92	**TCI**
NET	**−1.52**	**1.06**	**−0.01**	**4.95**	**1.80**	**4.80**	**−11.08**	**23.33**
NPDC	4.00	2.00	5.00	1.00	1.00	2.00	6.00	
	Panel B. Pre-COVID-19 period							
	Gold	**Equities**	**ETH**	**Oil**	**NFT**	**Bonds**	**US Dollar**	**FROM**
Gold	**62.93**	1.85	0.57	2.61	1.23	7.80	23.02	37.07
Equities	3.47	**77.23**	2.44	9.18	1.37	2.40	3.91	22.77
ETH	1.30	1.75	**91.39**	1.73	2.32	0.70	0.80	8.61
Oil	2.06	9.66	1.88	**82.63**	1.46	1.13	1.18	17.37
NFT	0.59	0.61	0.94	0.71	**96.59**	0.20	0.35	3.41
Bonds	10.06	1.19	1.14	2.00	1.05	**82.60**	1.96	17.40
USD Index	24.01	2.75	0.66	3.48	1.09	2.35	**65.66**	34.34
TO	41.50	17.82	7.63	19.71	8.52	14.57	31.22	140.96
In. own	104.43	95.05	99.02	102.34	105.11	97.17	96.88	**TCI**
NET	**4.43**	**−4.95**	**−0.98**	**2.34**	**5.11**	**−2.83**	**−3.12**	**20.14**
NPDC	2.00	5.00	3.00	3.00	0.00	4.00	4.00	
	Panel C. COVID-19							
	Gold	**Equities**	**ETH**	**Oil**	**NFT**	**Bonds**	**US Dollar**	**FROM**
Gold	**58.61**	7.30	7.63	5.09	1.07	11.81	8.49	41.39
Equities	4.58	**60.85**	11.98	11.69	2.75	6.64	1.53	39.15
ETH	6.65	12.26	**67.65**	1.81	4.24	5.73	1.66	32.35
Oil	1.59	13.55	2.24	**77.56**	1.31	1.13	2.63	22.44
NFT	0.59	2.49	5.73	2.02	**87.58**	1.32	0.29	12.24
Bonds	7.76	6.88	4.80	4.39	1.18	**67.55**	7.42	32.45
USD Index	10.22	6.85	5.09	4.35	1.06	19.15	**53.30**	46.70
TO	31.36	49.32	37.46	29.35	11.60	45.78	22.02	226.89
In. own	89.98	110.17	105.12	106.91	99.81	113.33	75.31	**TCI**
NET	**−10.02**	**10.17**	**5.12**	**6.91**	**−0.82**	**13.33**	**−24.69**	**32.41**
NPDC	5.00	1.00	2.00	2.00	3.00	2.00	6.00	

Notes: The table reports the connectedness measures between the system variables under a TVP-VAR forecast error variance decomposition. Panels A, B and C report the findings for the full period (January 1, 2018- June 30, 2021), the Pre-COVID-19 period (January 1, 2018- January 12, 2020) and the COVID-19 period (January 13, 2020 - June 30, 2021), respectively.

during February),[6] during which time the equity market experienced some of its largest daily point losses, and also during the second quarter of 2020, when the COVID-19 crisis erupted, there was an increase in the connectedness measure. This increase is much more conspicuous in the dynamic analysis than in the static analysis. However, these findings provide only a general illustration of the connectivity. It is therefore valuable to map the single role of each asset examined, focusing mainly on our targeted new asset class, the NFTs, around the time of such events.

According to Table 3, the majority of NFT return dynamics are due to endogenous shocks, and only a small portion of the variation in NFT returns is attributable to the impact of innovation in other system variables. The intrinsic variation in NFT returns reported in the diagonal equals to 93.82%, 96.59%, and 87.58%, in the full, pre, and ongoing COVID-19 periods, respectively. Even at the outbreak of the COVID-19 crisis and thereafter, there is only a small portion of systemic risk spillover which is determined exogenously to NFTs by interactions with other assets in the examined system, rather than internally by NFTs' intrinsic variation. This analysis again suggests that NFTs are mainly independent of shocks from the other asset classes investigated, including even Ethereum. Our findings are in line with Dowling (2021a) who documents a limited volatility transmission between cryptocurrencies and NFTs. Examining the NET row in the COVID-19 period that represents stress time, reveals that NFTs' role shifts to that of a receiver of shocks (−0.82), even though in the pre-COVID-19 period, their net role is that of a transmitter (+5.11) of shocks. This hints that NFTs might provide diversification benefits, especially during periods of crisis. Interestingly, NFTs' close relation, Ethereum, exhibits the opposite dynamic as do NFTs in the system. While in the pre-COVID-19 period, Ethereum acts as a NET receiver of risk spillovers (−0.98), during COVID-19 it shifts and acts as a transmitter of shocks (+5.12).

6 https://money.cnn.com/2018/02/05/investing/stock-market-today-dow-jones/index.html

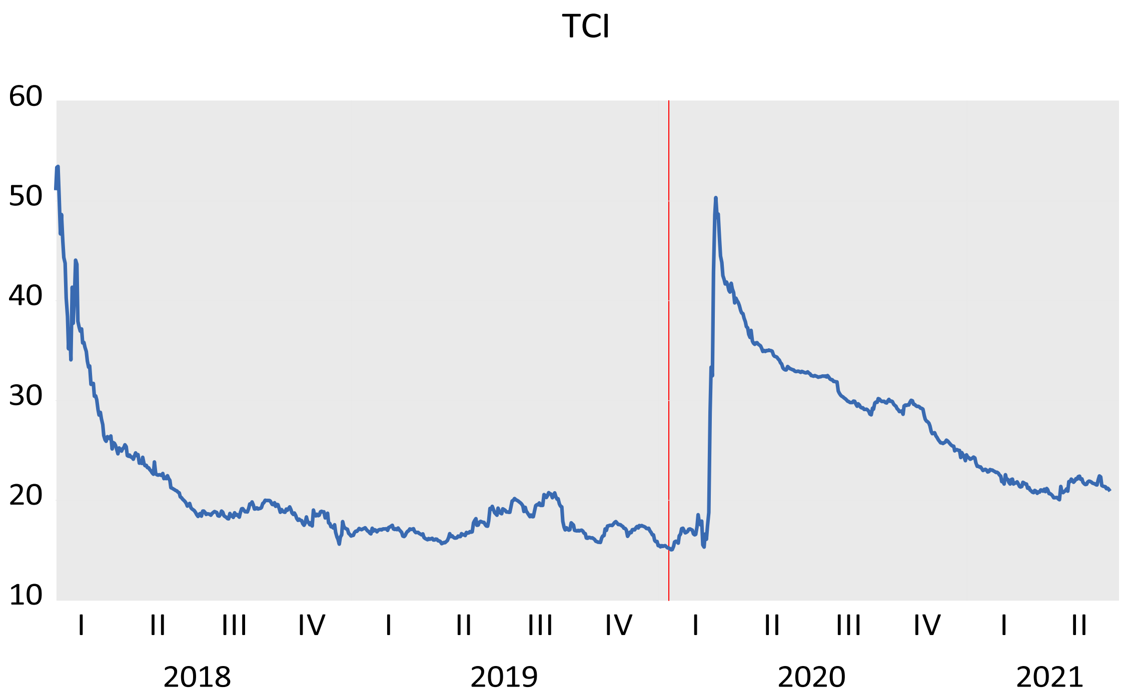

Fig. 2. Total Connectedness Index (TCI) for the whole period
Note: The figure depicts the dynamic connectedness of the variables of interest across time using a TVP-VAR approach with AR(1) based on the Bayes information criterion (BIC) criteria, and $h = 20$ for the decomposition of the generalized forecast error variance.

To further verify this and to more closely track the role of NFTs, we used a TVP-VAR dynamic analysis to observe the connectedness of NFTs across time. We divided our examinations in terms of how much of the variation FROM the system is absorbed by each variable (**Appendix A**) and TO the system (**Appendix B**). For brevity, we focus here on the result of the net effect of TO minus FROM, which is illustrated by the NET effect (Fig. 3).

The dynamic analysis reveals two main points at which the connectedness undergoes a substantial change during the first quarter of 2018, and around the COVID-19 period. When examining the 2018 period, we found that market crashes occurred several times, and especially during February 2018. Market participants were mainly concerned about future inflation and resulting interest rate hikes. We observe that during the first quarter of 2018, NFTs are receivers of risk spillovers. Ethereum also seems to act as a receiver in other periods of 2018, which was, in total, a bad year for investors. It appears that the fear of future inflation was fueled by shocks in the fixed income market (bonds), and was also triggered by rising oil prices at the time.[7] To summarize, the dynamic analysis can arguably provide initial empirical evidence for the diversification potential of NFTs.

Turning to our analysis of the period of COVID-19, we clearly see that NFTs act as a receiver of shocks. During this period, NFTs resemble other common and well-recognized safe-haven assets, such as the gold and the USD index, in their shock-absorbing features. It seems that NFTs, gold, and the USD index share similar effect on the rest of the system variables. That is, they have relatively low connectivity during normal times, but during the turbulent COVID-19 period they act as NET absorbers of systemic risk. Note however, that unlike the 2018 period, during the COVID-19 period, Ethereum seems to interact in the opposite way to NFTs, and is mainly a transmitter of risk spillovers. This underscores the significance of a performing dynamic analysis, which can reveal shifts in the role of variables as transmitters or receivers.

[7] For more information please see:https://www.cnbc.com/2018/02/05/why-the-stock-market-plunged-today.html, https://www.nytimes.com/2018/02/02/business/stock-market-interest-rates.html, https://money.cnn.com/2018/02/28/investing/stock-market-february-dow-jones/index.html.

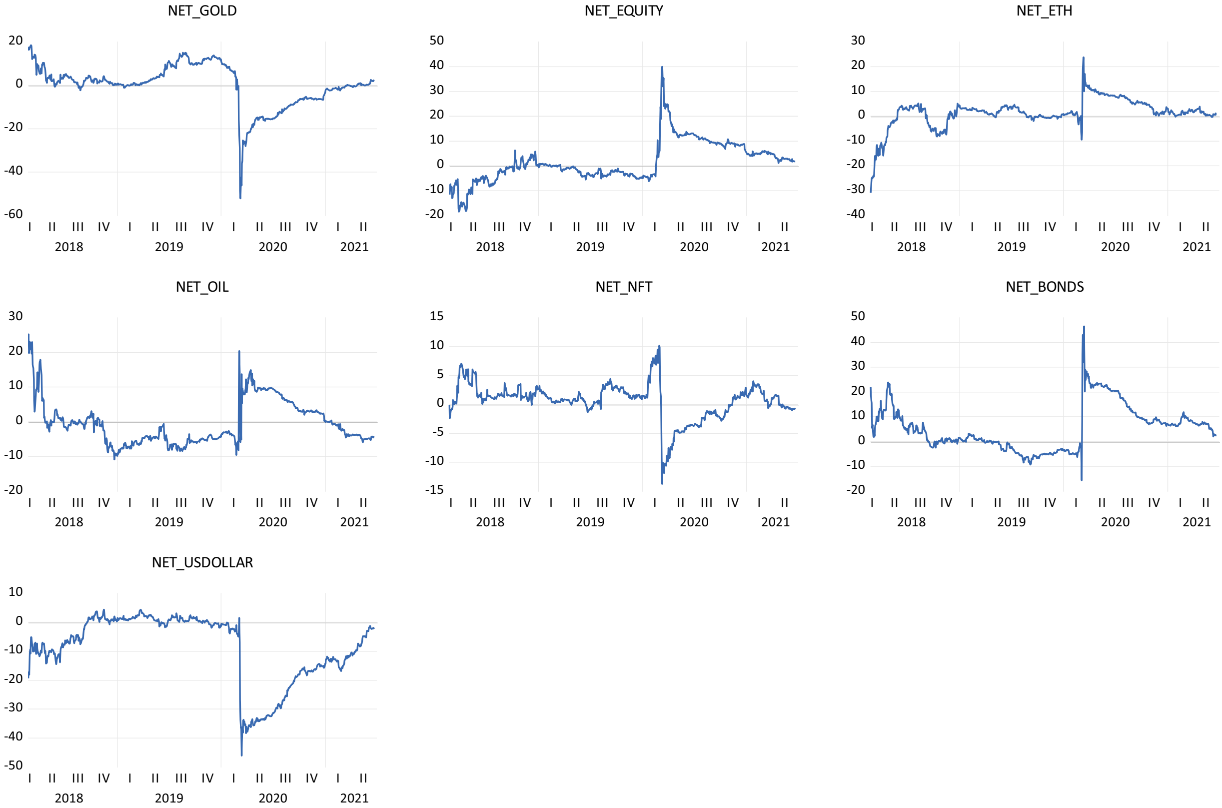

Fig. 3. Net Spillover Measurement
Note: The figures above depict the dynamics of the connectedness of each variable with the other system variables. The sample spans from January 01, 2018- June 30, 2021. Positive values imply that the variable acts as a transmitter of systemic shocks while negative value indicates that the role of variable is a receiver in terms of systemic risk shocks.

5. Conclusion

In this study, we present a first examination of the interconnectedness between NFTs, Ethereum, and common financial assets, namely, gold, bonds, equities, oil, and the USD index. Using the novel TVP-VAR methodology, we conduct both static and dynamic analyses. Both estimations hint at diversification or hedging benefits, which can be attributed to NFTs. The static analysis results show that NFTs have only weak interactions with the financial assets examined, while the dynamic analysis show that NFTs bear some similarity to gold and the USD index in terms of risk absorption during the COVID-19 crisis. NFTs also absorbed risk spillovers during the crashes in February 2018, when market fears of inflation and interest rates hikes were at their height. Surprisingly, while the price of NFTs is quoted in Ethereum crypto currency units, the two assets types present an opposite overall connectedness dynamic, particularly during the COVID-19 crisis.

Importantly, the results around the beginning of 2020 should be interpreted carefully, given that at this stage the market trade size was mainly much lower, compared to wake of trading on NFTs in early 2021.

In future research, our investigation could be extended to examine the connectedness of NFTs and Ethereum with respect to changes in different aspects of uncertainty captured by measures such as the Volatility Index (VIX), Economic Policy Uncertainty (EPU), the Consumer Confidence Index (CCI) and the Consumer Sentiment Index (CSI). Another approach would be to examine the volatility connectedness of NFTs with other cryptocurrencies.

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