

NON-FUNGIBLE TOKEN (NFT) MARKETS ON THE ETHEREUM BLOCKCHAIN: TEMPORAL DEVELOPMENT, COINTEGRATION AND INTERRELATIONS

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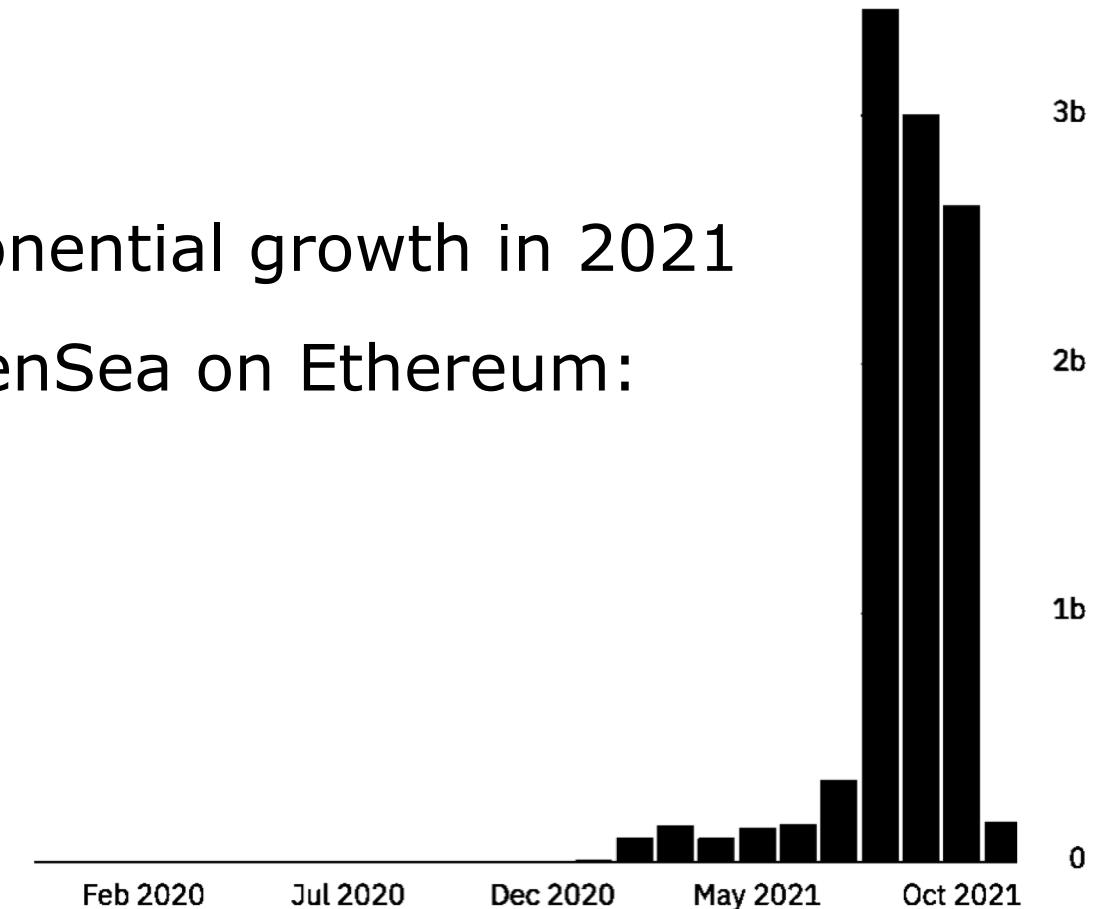
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Introduction

- Non-fungible tokens (NFTs)
 - Tokens (i.e., smart contracts) on blockchains that represent unique items
 - Digital assets (e.g., a digital picture)
 - Real-world assets (e.g., a physical piece of art)
 - Each NFT represents a unique value that cannot be fully replaced by a different NFT
 - One Bitcoin is fully interchangeable with another Bitcoin
 - NFTs may relate to similar items (e.g., the same type of trading card) but will always be unique (e.g., by having a unique identifier)

Introduction

- NFT markets experience(ed) exponential growth in 2021
- Example leading marketplace OpenSea on Ethereum:
 - \$2.6b traded volume in Oct 21
 - 1.4m NFTs sold in Oct 21
 - 293k users in Oct 21
 - 620k users all-time



Monthly traded volume on NFT marketplace OpenSea in USD (Ethereum blockchain)
Source: <https://dune.xyz/queries/3469/6913>

Introduction

- Numerous high profile NFT sales
 - Firms are adopting NFTs as part of their strategy
 - Celebrities and artists use NFTs to monetize content and to interact with their community
- NFTs experience miscellaneous adoption
- However, the phenomenon is still largely unexplored

Beeple sold an NFT for \$69 million

Through a first-of-its-kind auction at Christie's

WORLD | News

Quentin Tarantino will sell 7 never-before-seen clips from 'Pulp Fiction' as NFTs

The Margin

McDonald's put a McRib NFT on the menu for \$20 — here's how to get one

Twitter is reportedly working on a blockchain-linked 'Collectibles' tab to showcase user's NFT collection

Some random examples from media.

Research question

How do NFT markets (causally) relate to each other?

- Various stakeholders with different need for risk management and market understanding (e.g., NFT owners, issuers, intermediaries, base-layer infrastructure)
- NFT projects focus on very different application areas (e.g., art, gaming, collectables, etc.)
- Comparatively older and arguably “unsuccessful” projects are revived by the market. Therefore, it can be assumed that markets influence each other
- How did the field evolve over time?
- If economic variables (NFT sales, trading volume or users) of projects are interrelated, this could have significant implications for strategic decisions in terms of investment, market entry or collaboration with potential competitors.

Goal: Contribute to the understanding of NFT markets by analyzing causal relationships between NFT (sub-)markets.

Data and methods

- Data from *nonfungible.com*, a leading data source for NFTs on the Ethereum blockchain
- Analysis of the largest, “most relevant” markets
 - At least \$10 million in NFT traded volume as of May 19, 2021
→ 14 NFT projects/platforms fit this criteria
- Extraction of daily “macro” data of these projects
 - Number of NFT sales
 - USD spent in NFT sales
 - The number of unique blockchain wallets (=a proxy for users)

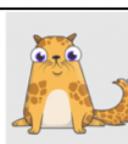
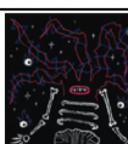
Data and methods

- Description, summary and visualization of the NFT markets to gain a basic understanding of their scope
- Analysis of short-term and long-term interactions as well as causal relationships between the 14 NFT projects
- *Vector error correction model (VECM) to*
 - calculate short-run Granger causalities between the individual NFT projects and
 - visualize their (long-run) relationships via *impulse response functions (IRFs)*.

Results

- NFT projects show very different patterns
 - CryptoPunks has 9.4 sales per day, CryptoKitties 2,250.8
 - CryptoPunks have a mean USD volume of \$236,000, Axie Infinity \$17,000
- Different use cases, sectors and characteristics

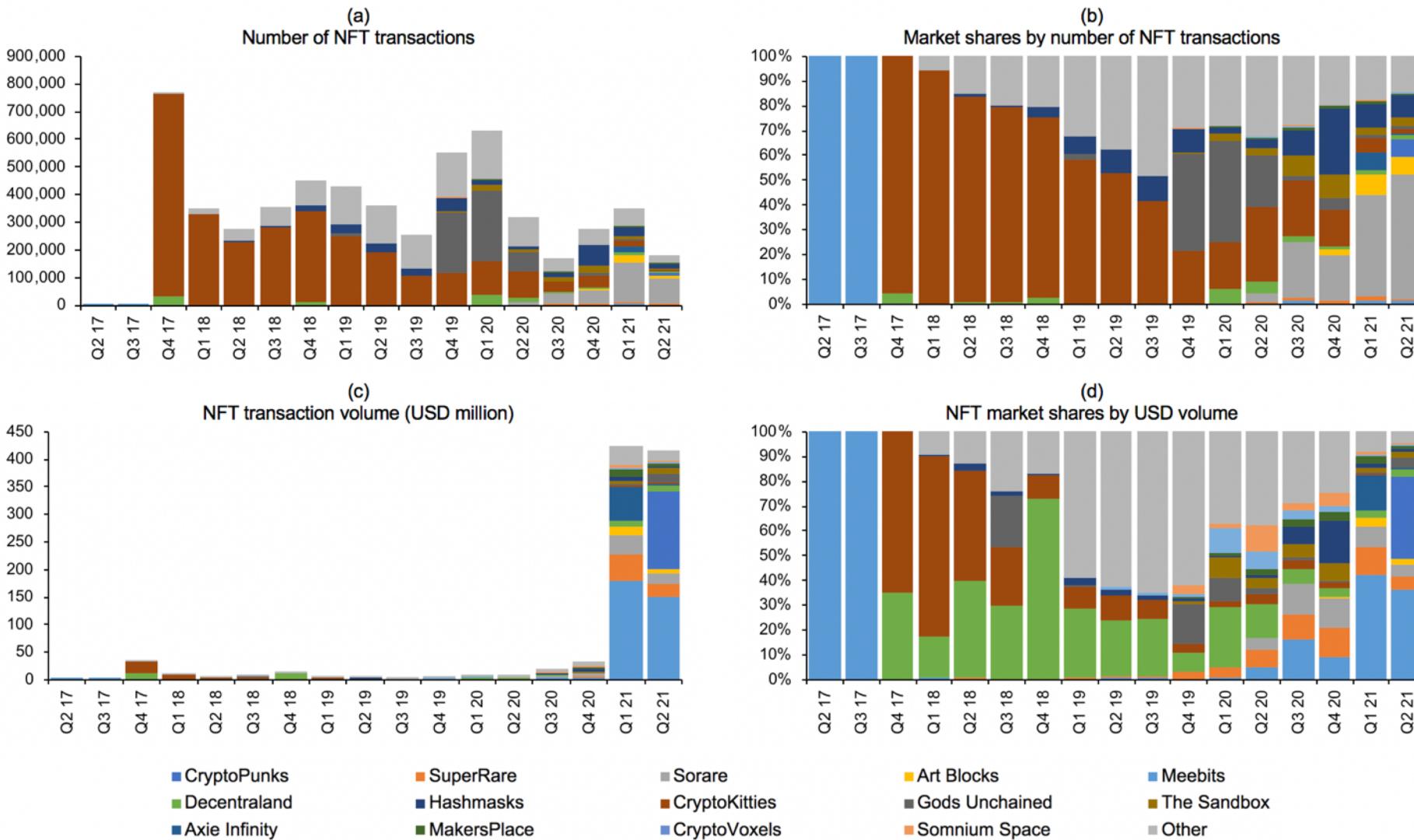
NFT market	Days recorded	NFT sales			NFT volume			NFT wallets		
		Mean	SD	Max	Mean	SD	Max	Mean	SD	Max
CryptoPunks	1,428	9.4	24.4	329	0.236	1.139	21.200	10.0	21.4	234
Decentraland	1,329	93.6	399.0	6,573	0.045	0.156	2.872	36.3	76.7	1,406
CryptoKitties	1,276	2,250.8	4,270.4	52,451	0.034	0.165	2.436	442.5	1,078.7	12,867
Axie Infinity	1,190	276.0	285.8	2,269	0.017	0.043	0.340	135.9	183.9	1,092
SuperRare	1,144	19.3	25.6	152	0.068	0.234	2.692	27.1	35.0	202
CryptoVoxels	1,080	8.1	12.6	101	0.009	0.029	0.409	7.2	7.1	49

Project	Sector	Launch	Example
CryptoPunks	Collectibles	Jun 17	
Decentraland	Metaverse	Sep 17	
CryptoKitties	Collectibles	Nov 17	
Axie Infinity	Collectibles, Game	Feb 18	
SuperRare	Art	Apr 18	
CryptoVoxels	Metaverse	Jun 18	

This CryptoPunk, a “simple JPG” on the web, sold for \$1.3 million in March 2021.

Note: Shortened to only six NFT projects under consideration. The others include MakersPlace, Gods Unchained, Sorare, Somnium Space, The Sandbox, Art Blocks, Hashmasks and Meebits. The full sample, descriptions, examples and statistics are provided in the [working paper](#).

Results



Results

- Specification of the empirical model
 - Test for unit roots (Augmented Dickey-Fuller test) → drop non-stationary data series (11 remaining)
 - Test for cointegration → use VECM, as series are cointegrated
- Calculation of short-run Granger causality (below for NFT sales)

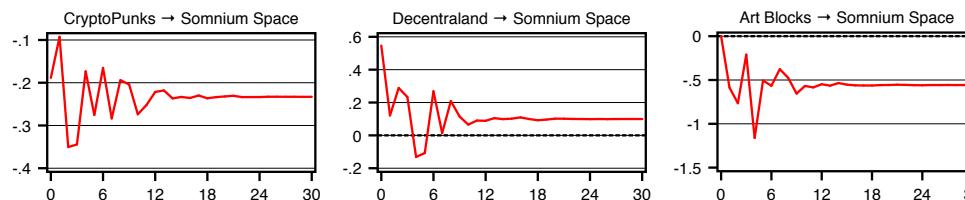
Project	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
(1) CryptoPunks	-	2.37	12.48***	1.21	5.97	18.06***	2.15	7.48*	12.91***	9.24**	1.86
(2) Decentraland	6.39*	-	2.74	1.25	10.34**	0.40	7.64*	1.09	9.19**	3.99	8.49**
(3) CryptoKitties	7.65*	1.04	-	2.39	1.92	0.12	2.74	4.29	6.02	4.72	16.12***
(4) Axie Infinity	1.44	1.64	1.64	-	2.12	0.88	1.25	1.61	0.67	0.60	4.29
(5) SuperRare	4.03	2.40	4.48	5.42	-	1.22	0.60	5.38	1.99	0.81	0.73
(6) CryptoVoxels	9.30**	2.06	1.68	1.53	3.32	-	1.60	1.02	4.60	4.67	5.87
(7) MakersPlace	3.50	1.43	5.55	4.46	0.08	4.01	-	2.88	1.46	0.60	3.10
(8) Gods Unchained	0.03	4.50	7.60*	7.33*	5.71	3.41	6.58*	-	0.15	0.70	2.95
(9) Somnium Space	6.14	2.32	10.80**	6.96*	13.06***	14.89***	4.75	13.72***	-	3.21	20.79***
(10) The Sandbox	3.14	1.25	3.86	0.92	0.75	5.69	7.60*	2.09	5.58	-	1.15
(11) Art Blocks	2.70	3.31	6.54*	3.50	0.99	2.00	4.54	2.76	12.57***	3.55	-

Results for the metrics NFT trading volume and unique wallets can be found in the [working paper](#).

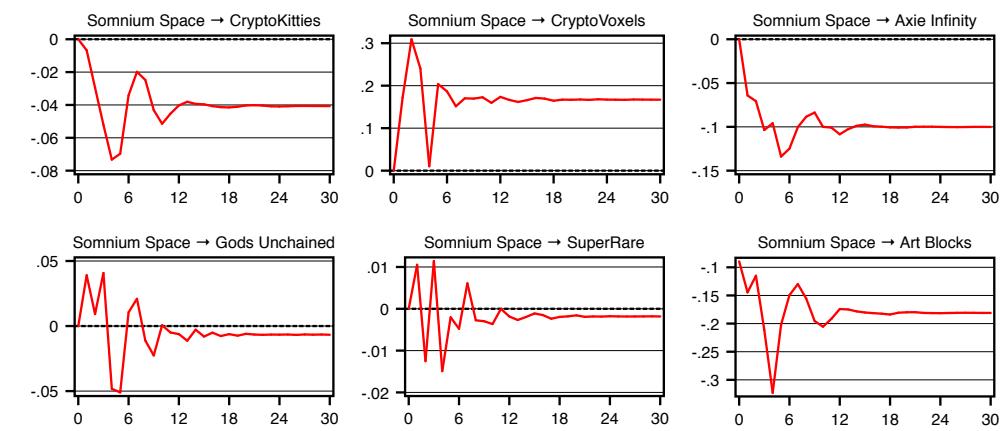
- *Example:* Somnium Space Granger-causes six other projects and is Granger-caused by 3 other projects (direction of causal connection is unclear).

Results

- Next step: Visualization of impulse response functions to assess direction of short- and long-run causal relationships:
- Examples for trading volume metric where *Somnium Space* is Granger-caused by another project or is Granger-causing another project:



- Increases in *CryptoPunks* and *Art Blocks sales* have both short-run and long-run negative causal effects on *Somnium Space*
- *Decentraland* sales positively impact sales of *Somnium Space* (both metaverses)



- Increases in *Somnium Space* sales negatively impact sales of *CryptoKitties*, *Axie Infinity* and *Art Blocks*
- Effect is positive for *CryptoVoxels*
- *Gods Unchained* and *Super Rare* results are mixed (long-run relationship is close to 0)

This is done for all relationships where significant Granger causality are identified.

Conclusion

- A comprehensive overview of the development and interrelations of major NFT markets on the Ethereum blockchain
- The NFT market has already experienced several peaks, including the great success of *CryptoKitties* (from late 2017) and the market boom that began in 2021 in the form of an extreme growth in trading volume.
- Results and visual analysis indicate that the NFT market should be viewed and evaluated from diverse angles (revenue, activity, users).
 - Metrics are highly dependent on the underlying use cases
- NFT markets are driven by other NFT markets
 - NFT projects with widely diverging content can despite those differences have a significant positive or negative impact on each other
 - This is a relevant information for NFT owners, issuers, intermediaries and infrastructure providers
- Still lots of shortcomings and uncertainty (e.g. wash trading, legal certainty, copyright etc.)



Thank you for your attention!

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