Non-Fungible Tokens: Blockchains, Scarcity, and Value

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Usman W. Chohan, MBA, PhD

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Abstract: Non-Fungible Tokens (NFTs) have garnered remarkable investor attention recently, with some NFTs securing selling prices that may have seemed unthinkable for a non-fungible virtual asset. This raises fascinating questions about "value" and "scarcity" with respect to blockchain technology, through a prism of non-fungibility of a digital asset, and this paper aims to draw attention to these questions insofar as they may shape an alternative space of blockchain development and exchange going forward.

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There is a category of blockchain-based virtual assets known as *non-fungible tokens* (NFTs) which have garnered incredible investor interest in a very recent and short period. NFTs are described by some as a craze, and by others as the future of digital art. Investors have expressed interest in various types of NFTs, with some being auctioned in the millions of dollars, despite in essence representing little more than code - but code to which a buyer has ascribed "value," despite questions of its comparative scarcity as a digital object. In December, 2020 the sale of NFTs were estimated at $12 million, but exploded to $340 million two months later in February, 2021.

Indeed, the rising success of certain NFTs raises fascinating questions about what "value" and "scarcity" might mean with respect to blockchain technology. The non-fungibility of a digital asset itself appears to have created an entire category of digital objects to which individuals would ascribe value; and while non-fungibility is a property that is tangential to the original premise of a distributed virtual ledger, it may come to represent a significant alternative space of blockchain development and exchange going forward. The purpose of this paper, then, is to draw attention to the questions of value and scarcity as they pertain to NFTs specifically, and to blockchain and digital assets more widely.

For the purposes of definition, a non-fungible token can be seen as a unit of digital information (token) that is stored on a blockchain and is not inherently interchangeable with other digital assets

(non-fungible). The term “fungible” derives from the economic and accounting literatures, and is defined as anything that is interchangeable with an identical or similar object. Traditional forms of currency, whether equivalent sums of paper money or identical units of precious metals, are fungible objects, and this is what helps them to serve as mediums of exchange, because they are understood to be of equal value. One can substitute a five-dollar bill with five one-dollar bills because both are fungible.

Assets that are commonly considered fungible are regulated commodities, common shares (stocks), financial options, and bills of money. By contrast, a non-fungible asset may be a person’s car, for example, since someone borrowing a friend’s car would not repay their debt to their friend by giving them another person's car. Collectible items such as baseball cards represent a traditional example of non-fungible assets, since each card would have unique attributes which enhance or diminish their value compared to other baseball cards. In the virtual realm, objects were originally thought to be difficult in terms of proving their uniqueness and distinguishability so that they could be considered “non-fungible.” Code is code: 1s and 0s that would be recreated and therefore fungible, at least to a large extent.

However, innovations driven by the digital distributed ledger system that underlies blockchain has allowed for the creation of ledger items that may not automatically be fungible. Although the major categories of blockchain technology, particularly cryptocurrencies such as Bitcoin, are indeed fungible, since one can exchange 1 Bitcoin for another (as well as for 100,000,000 Satoshis); there are cryptographic tokens which are not necessarily mutually interchangeable. These tokens are the NFTs which have attracted considerable investor interest for applications where value would be ascribed based on the uniqueness of a digital object.

The mechanism for NFT creation relies on uploading a file onto an NFT auction market,[1] where the file is recorded on the digital ledger as an NFT, and can thus be purchased or sold using digital currencies. While the creation of an NFT that represents a piece of art can be exclusive to an artist, they can nevertheless retain the copyright to the work and therefore reproduce more NFTs underpinned by the same piece of art. For this reason, a person who purchases an NFT does not gain necessarily possession of the original digital file, and therefore does not have exclusive access to the file.

This is part of what raises eyebrows among casual observers of NFT markets: that persons buying an NFT are not automatic owners of original objects, in fact they have no means of ensuring that the file is not reproduced or used by anybody else.[2] The origination problem, ever-present in other types of blockchain technology (such as smart contracts) is evident in the NFT space as well: anyone could in theory upload artwork onto an NFT, without proving that they are the original creator of the work. This creates an evident real-world risk that fraudulent actors will upload NFTs to auction markets by posing as the original owners, or creators, of objects of value.

The primary interest in NFTs emerges from uses that involve creating scarcity to ascribe value to code-built digital objects. An NFT can, for example, imprint a blockchain with a unique signature for the ownership of a digital asset. For creative works, including images and other objects that one would “autograph” in the physical world (i.e. collectibles), there is an evident use for ascribing unique ownership

[1] Some auction markets include Rarible, OpenSea, and KnownOrigin, but others are emerging as competitors in the field, based on the popularity of NFTs as a blockchain category.

[2] This point may become more contentious in the future if traditional sources of legal recourse become increasingly active in the NFT markets to enforce copyright ownership. However, this analog intrusion into the decentralized realm of blockchain would bring numerous challenges of its own. Nevertheless, it is foreseeable that lawyers would love to get in on the action in the NFT space.

on metadata through a cryptographic hash function. In other words, the distributed ledger technology helps to authenticate ownership of a digital asset that in the physical world would accrue to a single owner of a valuable real, material object.

In December, 2020 the sale of NFTs were estimated at $12 million, but exploded to so.ething along the lines of $340 million two months later in February, 2021. Naturally, one is predisposed to thinking of major pieces of art as exclusive objects for which buyers pay extraordinary premiums to hold on to them for their uniqueness. A similar avenue of ascribed value has emerged for digital art.

The recent popularity of NFTs is attributable in no small part to the purchase of digital artworks, particularly the piece created by Beeple titled *Everydays: The First 5000 Days*. At a Christie's auction in 2021, the NFT for this digital piece netted USD$69.3 million, which was a record sum that created much chatter in the auction industry. This led to a short boom for NFT artists who sought to upload their artworks into token formats for sale. Although by no means do all uploaded NFT artworks garner the interest of online buyers, there has nevertheless been a rush among virtual artists to enlist their works on NFT exchanges. This also raises interesting possibilities for artists to monetize their work in the digital age.

Aside from artwork, various digital collectible NFTs have also sold for comparatively high prices, such as a basketball-related NFT selling for $208,000;[3] and so have videogame-based NFTs. Oftentimes, videogame NFTs represent user-built in-game assets (as opposed to game developer assets), which can thus be traded for greater gameplay enjoyment. The NFT coding allows for the videogame assets to be traded

[3] This NFT was a Lebron James slam dunk NFT card sold on the NBA Top Shot Platform

on third-party platforms (e.g. online marketplaces) without the oversight or control of the videogame developers.[4]

Beyond visual artistic works, audio-centered creative works can also be tokenized as NFTs. In the early 2000s,there was an industry-wide fear that musicians would lose the ability to earn from their intellectual property the way that they did when audio cassettes or CD sales were the norm. Online platforms such as torrents caused even further concern that piracy would be rampant and musicians would be unable to earn. Although solutions such as Spotify offered a partial approach to online music monetization, this business model has not been as successful as comparable movie or TV show alternatives (e.g. Netflix). NFTs may be offer another *partial* mode of monetizing musical assets. In March, 2021 several well known musicians began to create NFT-based musical assets.[5]

There are numerous token standards that exist for NFTs. For example, the Ethereum ERC-721 standard of CryptoKitties was the first to be used for the NFT category, since it has an inheritable Solidity smart contract mechanism that allows developers to create new compliant contracts by importing it from a library (OppenZeppelin source library). The Ethereum ERC-1155 standard is another notable Ethereum variant that offers “semi-fungible” options and the potential to build ERC-721 assets. Aside from the Ethereum standards, Bitcoin Cash[6] and Flow (from the creators of Cryptokitties) also offer NFT-usable standards.

Although NFTs have struck the popular imagination with unique force after 2020, they represent an technological approach that has existed

[4] One such platform is Axie Infinity, which made a
[5] Kings of Leon, Lil Pump, and Grimes are but some of the major musicians who have already undertaken to tokenize musical output through NFTs.
[6] Bitcoin Cash has the Simple Ledger Protocol (SLP) which can be used to work with NFTs by minting a non-divisible token, in a supply of 1, without a minting baton. The SLP mechanism can also be used to sort various NFTs into larger groups.

for several years. The first non-fungible token example can be dated to 2015, when the tiled-map of Etheria was uploaded,[7] although the vast majority of its tiles remained unsold until the NFT frenzy of 2021. The second notable NFT was the pixelated pictures of Cryptopunks in 2017,[8] and the third was a similarly pixelated concept of MoonCatRescue, which also existed in 2017 but only caught attention in 2021.[9] Aside from these early projects, there were several marketplaces/exchanges for NFTs that had already raised capital before the 2021 NFT craze, including the Rarebits exchange in 2018 ($6 million investment), and Decentraland ($26 million raised in an ICO). From these earlier NFT concepts and platforms, today the craze has grown much larger, with a growing number of casual observers seeking to participate in the exchange, ownership, or creation of non-fungible tokens.

The ultimate questions of interest that NFTs raise regard those of value. How valuable is an NFT in reality? It is as valuable as people express a willingness to pay for it. In a decentralized, distributed, online market, it is the buyers and sellers that send signals about how much they desire a (digital) object. This is indeed the same for collectibles and objects of art, where enormous sums are dished out to acquire real, material objects, based on their perceived scarcity. But then two questions arise for NFTs: (1) are they really as rare as they are meant to be? and (2) does an "owner" of an NFT really "own" an object? This is where the skepticism regarding NFTs persists. In theory, there can be multiple NFTs created over an asset, claiming to be the "true" token representing an idea, image, or object. The

[7] Etheria is a three-dimensional map with a length-breadth extent of 33-by-33, with 457 hexagonal tiles on it that can be purchased and traded. Users can build structures on these tiles using Lego-style bricks.
[8] Cryptopunks is an assortment of pixelated characters ("punks") that can be purchased and exchanged.
[9] MoonCatRescue involves pixelated cat drawings, with the light-hearted plotline of rescuing cats from the moon and bringing them onto the Ethereum blockchain.

artificial scarcity still requires a marketplace that accepts that the tokens represent a "rare" thing.

The second point is even more contentious. An NFT does not necessarily offer "ownership" in a meaningful sense. The object represented by the token, as an image for example, can be distributed, reproduced, and viewed without exclusivity. Furthermore, if the initial tokenization of the NFT misrepresents the original owner, then the token will disseminate on a distributed ledger an inaccurate ownership.[10] Still worse, there is the risk of a *404 error* because, in truth, NFTs are a claim to an exclusive online location - but if the location to which the object's "ownership" refers itself has been relocated, then the NFT does not even provide the correct location of supposed ownership.[11] Further to this point, hacking and thefts of tokens, as with other cryptoinstruments such as coins and DAOs, still remains a concern. Supposed owners may peer into their wallets one day and find the code having been misappropriate, or having simply vanished.[12] Some NFT standards are more robust in maintaining the integrity of NFTs.[13]

The concepts of scarcity and value in a capitalist context are in part predicated on human notions of what is exchangeable capital and how much of it circulates for spending. The period in which NFTs have come to attention is one shaped by the economics of the coronavirus pandemic, with absurdly large amounts of stimulus money being printed in such a short time to stimulate economies when real, material

[10] This error is often omitted in discussions about the "garbage-in, garbage-out" risk of decentralized distributed ledgers: if they misrepresented real, material objects to begin with, then the blockchain is merely reproducing and disseminating an incorrect representation outwards.
[11] This 404 error has been reported by numerous NFT owners.
[12] This mystery-disappearance of tokens from wallets has also been reported by owners.
[13] For example, the Flow standard, created by the Cryptokitties team, ascribes resources within its standard that enforce important ownership rules through the type system: they can only have one owner, cannot be copied, and cannot be accidentally or maliciously lost or duplicated; at least for now.

activity has stalled.[14] In the West, at least, there is too much financial capital sloshing around relative to what can be produced and consumed, which is why governments are failing to generate inflation no matter how much their central banks expand their balance sheets.

Unfortunately, in some countries experiencing late stage capitalism, particularly the United States, the distribution of that surplus financial capital is extremely unequal, which means that an oligarchic economic class has too much nominal wealth relative to its requirements. This means that they can throw financial capital around on whimsical ideas, which in the context of coronavirus restrictions, means that virtual assets, whimsical as their existence might be, offer a curious avenue to spend surplus cash for the mere sake of it. NFTs are thus a new asset class, with various questionable precepts of value and scarcity, where money can be thrown for the sheer whim of saying that one owns a virtual claim to something that represents something else, and can be checked via a distributed ledger.

But NFTs are not necessarily an elitist preserve of whim. As with the Gamestop Short Squeeze, which involved small-scale investors experimenting with counter-hegemonic finance that challenged the behemoth of traditional finance, NFTs are a deployment of surplus capital to experiment with what might really be valuable for people. Gamestop itself may not have had the underlying profitability or cash flows to justify the surge in its stock price, but to the redditor battalion that bought into its shares and dismantled high-finance's short positions, a cherished videogame outlet was more "valuable" than the asset portfolios of remote banksters. Such groups of individuals are similarly exploring how their sensibilities of value can be made manifest in another domain (that is equally as "virtual" as stock equity), by creating boundaries of scarcity around virtual coding.

[14] For example, 40% of all US dollars in circulation today were created after the pandemic, through the unfettered expansion of the Fed's balance sheet.

There is thus an exploratory, counter-hegemonic element to virtual participants engaging with non-fungible tokens.

But perhaps the value of ownership should be framed not through a market or semi-market logic, but rather in terms of the "leisures of blockchains." NFTs offer a leisurely, creative, and interesting use of digital distributed tokens to represent objects that people find interesting. Their ascription of "value" and "scarcity" is but a leisurely exploration of what is possible in terms of digital objects that are treated as unique, non-fungible representations of things that are simply interesting to them. Indeed, it is categories of leisure that are most actively thriving in the NFT domain: music, sports, and visual art. By emphasizing the ability to make a quick buck through tokenizing objects, one detracts from the genuinely interesting idea that a decentralized mechanism can offer a public recognition of the specialty of an encoded object.[15][16]

There is a risk that NFTs might fade from wider public interest in the longer run, particularly if the contentious notions of value and scarcity that are purported by NFT owners are challenged too prominently; and also if a larger series of hacks and sabotage-activities of malignant actors occurs too frequently to preserve any confidence in NFTs as a store of value. These risks notwithstanding, the volume of interest in NFTs is certainly high as of this writing, and may even grow if a wider audience remains interested in tokenization of collectible categories represented through virtual mediums in a decentralized and distributed manner. NFTs may, in fact, come to represent an important alternate space of

[15] The early concept of Cryptokitties, for example, represents an exploration of a leisurely idea - that code can represent the human love for pets, made virtual and non-fungible for the sheer fun of having code represent cats.
[16] Etheria and Cryptopunks, the first and second NFTs respectively, can also be seen as leisurely in nature. Etheria involves building small structures using lego bricks on a three-dimensional map, while Cryptopunks comprise an assortment of pixelated characters.

blockchain development and exchange, beyond the realm of cryptocurrencies that have grown into significant prominence over the past decade. If this alternate space of NFTs grows at a pace and to an extent similar to cryptocurrencies, then it will constitute one more significant avenue of blockchain technologies, and further affirmation that the full extent of decentralized, distributed ledger technology has yet to be discovered. In other words, the “value” of blockchain has not been fully uncovered, and there is no “scarcity” of imaginative uses of blockchain technologies in the future.

References

1. Adhami, S., & Giudici, G. (2019). Initial Coin Offerings: Tokens as Innovative Financial Assets. In *Blockchain Economics and Financial Market Innovation* (pp. 61-81). Springer, Cham.
2. Baele, L., & Dodebier, D. (2017). Could cryptocurrencies contribute to a well-diversified portfolio for European investors?.
3. Ba, C. T., Zignani, M., Gaito, S., & Rossi, G. P. (2020, December). The Effect of Cryptocurrency Price on a Blockchain-Based Social Network. In *International Conference on Complex Networks and Their Applications* (pp. 581-592). Springer, Cham.
4. Bahrawy, A., Alessandretti, L., Kandler, A., Pastor-Satorras, R., & Baronchelli, A. (2017). Evolutionary dynamics of the cryptocurrency market. *Royal Society open science*, *4*(11), 170623.
5. Battagliola, M., Longo, R., Meneghetti, A., & Sala, M. (2020). Threshold ECDSA with an Offline Recovery Party. *arXiv preprint arXiv:2007.04036*.
6. Belotti, M., Božić, N., Pujolle, G., & Secci, S. (2019). A Vademecum on Blockchain Technologies: When, Which, and How. *IEEE Communications Surveys & Tutorials*, *21*(4), 3796-3838.
7. Benton, N., & Joyner, G. (2019). Making sense of blockchain. *Australasian Leisure Management*, (132).
8. Bianchetti, M., Ricci, C., & Scaringi, M. (2018). Are cryptocurrencies real financial bubbles? Evidence from quantitative analyses. *Evidence from Quantitative Analyses (February 24, 2018). A version of this paper was published in Risk*, *26*.
9. Boukamel, O., & Emery, Y. (2019). Les treize postulats de l'innovation publique: identification et discussion dans le champ de la santé. *Innovations*, (3), 15-41.
10. Cai, X., Zhao, X., Zhang, B., & Feng, G. (2019). Identifying multiple peer influences on smart contract adoption in blockchain user network. *Available at SSRN 3387794*.
11. Chodhury, N. (2019). *Inside Blockchain, Bitcoin, and Cryptocurrencies*. CRC Press.
12. Chod, J., & Lyandres, E. (2018). A theory of icos: Diversification, agency, and information asymmetry. *Agency, and Information Asymmetry (July 18, 2018)*.
13. Chuen, D. L. K., Guo, L., & Wang, Y. (2017). Cryptocurrency: A new investment opportunity?. *The Journal of Alternative Investments*, *20*(3), 16-40.
14. Chohan, U. W. (2017a). The decentralized autonomous organization and governance issues. *Available at SSRN 3082055*.
15. Chohan, U. W. (2017b). A History of Bitcoin.
16. Chohan, U. W. (2017c). The leisures of blockchains: Exploratory analysis. *Available at SSRN 3084411*.

17. Chohan, U.W. (2018). Oversight and Regulation of Cryptocurrencies: BitLicense.
18. Chohan, U. W. (2019a). Initial coin offerings (ICOs): Risks, regulation, and accountability. In *Cryptofinance and Mechanisms of Exchange* (pp. 165-177). Springer, Cham.
19. Chohan, U.W. (2019b). Are Cryptocurrencies Truly Trustless? *Cryptocurrencies and Mechanisms of Exchange*. Springer.
20. Chohan, U.W. (2019c). Cryptocurrencies and Inequality. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3322329
21. Chohan, U.W. (2020a). State-Sponsored Cryptocurrencies: The Diverse Motivations. CBRI Working Papers.
22. Chohan, U.W. (2020a). Some Precepts of the Digital Economy. CBRI Working Papers.
23. Chohan, U.W. (2021a). *Public Value and Digital Economy. Routledge*.
24. Chohan, U. W. (2021b). Counter-Hegemonic Finance: The Gamestop Short Squeeze.
25. Chohan, U. W. (2021c). Decentralized Finance (DeFi): An Emergent Alternative Financial Architecture. *Critical Blockchain Research Initiative (CBRI) Working Papers*.
26. Chohan, U. W. (2021d). Blockchain and the extractive industries: cobalt case study. *Available at SSRN 3138271*.
27. Desouza, K. C., Dawson, G. S., & Chenok, D. (2020). Designing, developing, and deploying artificial intelligence systems: Lessons from and for the public sector. *Business Horizons*, *63*(2), 205-213.
28. Fil, M., & Kristoufek, L. (2020). Pairs trading in cryptocurrency markets. *IEEE Access*, *8*, 172644-172651.
29. Gassner, M., & Lawrence, J. (2019). Fintech in Islamic Finance. *Fintech in Islamic Finance: Theory and Practice*, 1.
30. Gesso, C.(2020). Eco-Sustainable Metropolises: An Analysis of Budgetary Strategy in Italy‟s Largest Municipalities. *International Journal of Business Administration*. 11(2).
31. Huang, W., Meoli, M., & Vismara, S. (2019). The geography of initial coin offerings. *Small Business Economics*, 1-26.
32. Hrga, A., Benčić, F. M., & Žarko, I. P. (2019, July). Technical Analysis of an Initial Coin Offering. In *2019 15th International Conference on Telecommunications (ConTEL)* (pp. 1-8). IEEE.
33. Joo, M. H., Nishikawa, Y., & Dandapani, K. (2019). ICOs, the next generation of IPOs. *Managerial Finance*.
34. Jurgelaitis, M., Butkienė, R., Vaičiukynas, E., Drungilas, V., & Čeponienė, L. (2019). Modelling principles for blockchain-based implementation of business or scientific processes. In *CEUR workshop proceedings: IVUS 2019 international conference on information technologies: proceedings of the international conference on information technologies, Kaunas, Lithuania, April 25, 2019* (Vol. 2470, pp. 43-47). CEUR-WS.
35. Kim, M. S., & Chung, J. Y. (2019). Sustainable growth and token economy design: the case of steemit. *Sustainability*, *11*(1), 167.

36. Mann, T. J. (2019). Blockchain Technology-China's Bid to High Long-Run Growth. *Gettysburg Economic Review*, *11*(1), 5.
37. Marchesi, L., Marchesi, M., & Tonelli, R. (2020). ABCDE—agile block chain DApp engineering. *Blockchain: Research and Applications*, *1*(1-2), 100002.
38. Osborne, S. P. (2020). *Public Service Logic: Creating Value for Public Service Users, Citizens, and Society Through Public Service Delivery*. Routledge.
39. Oseni, U. A., & Ali, S. N. (Eds.). (2019). *Fintech in Islamic finance: Theory and practice*. Routledge.
40. Othman, A. H. A., Alhabshi, S. M., & Haron, R. (2019). The effect of symmetric and asymmetric information on volatility structure of crypto-currency markets. *Journal of Financial Economic Policy*.
41. Serada, A. (2020, September). Why Is CryptoKitties (Not) Gambling?. In *International Conference on the Foundations of Digital Games* (pp. 1-4).
42. Serada, A., Sihvonen, T., & Harviainen, J. T. (2020). CryptoKitties and the new ludic economy: how blockchain introduces value, ownership, and scarcity in digital gaming. *Games and Culture*, 1555412019898305.
43. Xie, Y., Holmes, J., & Dagher, G. G. (2020, March). ZeroLender: Trustless Peer-to-Peer Bitcoin Lending Platform. In *Proceedings of the Tenth ACM Conference on Data and Application Security and Privacy* (pp. 247-258).
44. Yilmaz, K. N., & Hazar, B. H. (2018). Predicting future cryptocurrency investment trends by conjoint analysis. *Journal of Economics, Finance and Accounting (JEFA)*, *5*(4).