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Original Research Paper

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A DEEP DIVE INTO NON-FUNGIBLE TOKENS (NFTs) AND ITS CORRELATION WITH THE PRICE OF BITCOIN AND ETHEREUM

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ABSTRACT NFT is the acronym used for Non-Fungible Token, the term non-fungible describes the non-interchangeable aspect of it, showcasing the characteristic of uniqueness. The term token explains how it is treated as a transferable digital asset (art, music, in-game item) stored on a blockchain with smart contracts used to keep record the ownership of it. In this paper, we aim to simplify the journey for anyone looking to understand this new technology by providing them a thorough overview which includes investigating the history of NFT, what brings it value, the technical details, the challenges it faces, the use cases, and finally analyzing a price interrelationship between the NFT market, Ethereum, and Bitcoin.

KEYWORDS : NFT, smart contracts, blockchain, price analysis

INTRODUCTION

The origin of the concept which led to the creation of today's NFTs can be traced back to 2012 when "colored coins" were being discussed in the bitcoin community. The idea of colored coins was simple yet novel, as we all know that bitcoins are fungible, that is, one bitcoin can't be differentiated from another. However, it was observed that by meticulously tracing back the origin of a particular bitcoin, it was feasible to distinguish it from others by assigning a 'color'. The use cases of this new concept included digital collectibles, community currencies, corporate currencies, smart properties, and issuing shares of a company. Through various research papers were written on it, including one from Vitalik Buterin, Ethereum's founder, the idea of colored coins didn't materialize due to the reluctance of the bitcoin community, but it certainly laid the foundation for NFTs.

Later in 2017 with the release of the new ERC721 token (Ethereum Request for Comment) on the Ethereum blockchain, NFTs got their first major traction, some of the most popular projects being Cryptopunks and Cryptokitties. The main idea of Cryptopunks revolved around creating a maximum of 10,000 characters on the Ethereum blockchain as a reference to the Cypherpunk community members who were among the first ones to experiment with an electronic peer-to-peer currency much before the formation of bitcoin. CryptoKitties was the first blockchain-based game where users could trade, breed, and collect virtual cats. The game got significant media attention and went viral, to the point that some of the rare collectibles were sold for more than 100,000$. It was due to successes like these that investors started giving attention and funding NFT projects.

In 2019, NFT marketplaces, or exchanges launched, the popular ones being Opensea.io and Rarible. Users could trade using smart contracts, allowing trustless transactions to happen securely, and a record of the ownership of the NFT is maintained on the blockchain. Further, the creator of the NFT gets royalties whenever it is re-sold to a buyer. With the features of scarcity, high liquidity, valid ownership, royalties to the creator, secure trustless transactions, and ease of exchange NFTs tend to have the potential to become intellectual properties. This is what ascribes value to it. As a result of which the artist Beeple was able to sell their digital art as an NFT for about $69 million and Twitter's CEO Jack Dorsey sold the first-ever tweet for about $2.9 million.

Even though NFTs have gained a lot of attention in a short period, one should not take it for granted, it is still in the initial stages of its development. There are many challenges yet to be overcome and many opportunities to be explored. Through this paper, we intend to provide a one-stop-shop for anyone looking to grasp this new concept by going through the overview of what an NFT is and how it is made, going into the technical details of it, explore the potential use cases, point out the challenges and lastly correlate the price action of NFTs and the active wallet addresses to the market price of Bitcoin and Ethereum.

We will do it in the following order.

- First, we will discuss the overall process of how an NFT is created/minted and traded.
- Secondly, we will define all the technical details of all the aspects involved in minting an NFT.
- Next, we will discuss the standard tokens used, various supporting protocols, and aspired properties.
- Next, we will analyze the security measures and highlight various threats and how these can be countered.
- Further, we will look at both the potential use cases and the various challenges faced.
- Finally, we will try to see if there is a correlation between the sales of NFTs and the active wallet addresses and the market price of Bitcoin and Ethereum.

How to create an NFT:

The process of creating and then trading an NFT can be a hectic one for a newcomer, here we will give an overview of the process. There are five main tasks involved.

- First, The actual creation of art, as in a photograph, digital art, audio file, and so on.
- The NFT creator uploads the file, writes a description and title, sets the percentage of royalty they desire on the resale.
- The owner then stores the data into the database of the exchange where they are listing their NFT, this database is outside the blockchain. The owner also has the option to store the data in the blockchain but it will require them to pay some gas fee.
- A transaction is sent to a smart contract, this transaction includes the signature of the owner and the hash of the NFT data.
- This is when the NFT is minted and the trading process begins, on the confirmation of the transaction by the smart contract the minting process completes. Meaning that now the NFT is stored at a unique address inside the blockchain forever.

The NFTs are stored on the blockchain, it is possible to maintain the record of the original owner of it, as the transactions are stored in blocks that are linked to the next block creating a long history that is immutable. Also, whenever an NFT is created or traded a new transaction interacts with the smart contract, after the validation of which the new owner details and the NFT metadata are added to the new block. Hence giving a secure property right to the owner.

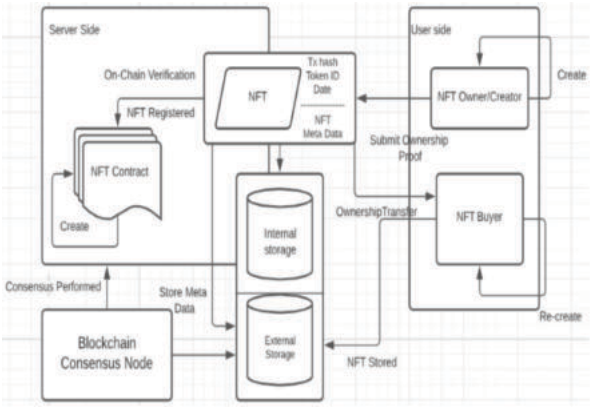

Figure 1: NFT System Architecture

TECHNICAL DETAILS

Here we will describe the underlying technologies which make up the foundation of the NFT system.

Blockchain - A blockchain is an immutable growing list of records linked together by cryptography, it is decentralized as it is managed by a peer-to-peer network of nodes for it to be ultimately used as a publicly distributed ledger. The origins of it trace back to 1991 when Stuart Haber and W. Scott Stornetta made a cryptographically secure chain of blocks whereby no one could tamper with the timestamps of the documents. Many improvements were added to it but it wasn't until 2008, the arrival of bitcoin, that blockchain had its first real-world application. Bitcoin solved the problem of double-spending which the earlier projects couldn't. There are various consensus mechanisms used by the blockchains such as proof of work (PoW), proof of stake (PoS), and many more, all having their pros and cons. There are many real-world use cases of a blockchain such as cryptocurrencies, smart contracts, decentralized finance, video games, supply chain, healthcare, domain names, and NFTs. Ethereum is the blockchain that hosts most of the NFT projects due to its ERC721 and ERC1155 standards which are more suitable for hosting NFTs and also due to the presence of solidity smart contracts on the Ethereum blockchain it is preferred. Some other honorable mentions are the Flow and Tezos blockchains.

Smart Contracts - The smart contract was first introduced in 1994, by the founder of BitGold, Nick Szabo. A smart contract is a block of code that can either be static or dynamic, containing the pre-agreed conditions made between the buyer and the seller on fulfillment of which the code executes automatically. Bitcoin supported very basic smart contracts via scrypt but with the advent of Ethereum with its solidity language more complex smart contracts are possible now, but it should be noted that these advancements come at a cost of less security and are prone to errors. The use cases of smart contracts are vast such as eliminating the middleman, being used as a payment channel, being used in decentralized applications (Dapps), and in the trading of NFT with the royalty being given to the creator, and so on.

Web3 Wallet - A web3 wallet is a tool to interact with web 3.0 applications, also known as the third generation of the internet. The Web3 wallet is capable of storing cryptocurrencies as well as crypto assets such as NFTs. Some examples of web3 wallets are Metamask and Trust wallet.

Address and Transaction - A blockchain address is just like an email address consisting of a fixed number of alphanumeric characters generated by a pair of public and private keys and is used as a unique identifier for the user to transfer or receive cryptocurrencies or crypto assets. In the case of sending a crypto asset or currency, the user has to prove the ownership of the corresponding private key and then send the asset or currency to another address with a valid digital signature.

Data Encoding - Converting data from one form to another is called data encoding. Usually, it is employed to compress in order to save disk space or to expand for better resolution. In most blockchains hex values are used to encode transactions. In essence, an NFT holder holds a true hex value signed by the creator. Hence solving the challenge posed by the process of cloning an NFT and claiming it to belong to themselves, because unless the owner doesn't have the original hex signed by the creator, they can't claim their right on that particular NFT, making it unique.

PROTOCOLS

A protocol is required to facilitate the storage and trade of NFTs efficiently and securely. A protocol is a decentralized ledger containing ever-increasing records, along with a peer-to-peer network for exchangeable transactions. There are a lot of blockchain protocols that support NFTs like Ethereum, Tezos, and Flow to name a few. The first NFT was built on Ethereum using the ERC721 standard, though Ethereum still uses the proof of work consensus (PoW) mechanism which results in high energy consumption, they are working toward moving to proof of stake (PoS), a consensus mechanism that has low energy requirements and is considered to be more ecofriendly. The other blockchain protocols mentioned above already use PoS and are catching up with Ethereum in terms of market share.

TOKEN STANDARDS

A token standard is required to define what the token can exactly do, it defines a set of properties and rules that a project must follow to be interoperable with the exchanges and the wallets. Different protocols have numerous standards and even within a protocol, there are further various standards. Here we will discuss the token standards of different protocols such as Ethereum and Tezos. Further, we will differentiate between the various tokens within these protocols.

ETHEREUM TOKEN STANDARDS

Ethereum has many token standards, the major ones are discussed below.

ERC-20 - It is the most used Ethereum based standard by most of the Ethereum based projects. ERC-20 tokens are also called "fungible" tokens as these tokens are interchangeable, that is, each token is worth the same amount as the other. Some examples of these are governance tokens and stable coins.

ERC-721 - This token standard is a non-interchangeable, one-of-a-kind asset. ERC-721 tokens represent a full asset that cannot be split, such as a certificate or tokenized item. Each ERC-721 token has its own set of contract values, such as information on the ownership and identity of a tokenized real-world asset such as a house. ERC-721s are strong in terms of immutability, ownership transparency, and security, despite their total flexibility in the creation of a token. ERC-721 tokens are frequently referred to as "non-fungible" since they are one-of-a-kind, and hence they are non-fungible tokens (NFTs).

ERC-1155 - The ERC-721 token standard is great in terms of being non-fungible but they prove to be slow and inefficient when it comes to transferring a collection of tokens at once. This is where the ERC-1155 token standard comes into play, created by Enjin, this standard provides unique digital NFTs that enable considerably quicker batch transfers of numerous tokens than ERC-721. With an emphasis on a true "multi-token"

approach, the ERC-1155 token standard is frequently referred to as a "next-generation multi-token standard."

Standard Name	Created Date	Use Cases
ERC-20	2015-11-19	Fungible token standard that provides basic functionality to transfer tokens, as well as allow tokens to be approved.
ERC-721	2018-01-24	Non-Fungible Token standard.
ERC-777	2017-11-20	Standard that defines all the functions required to send tokens on behalf of another address, contract or regular account.
ERC-1155	2018-06-17	A standard for contracts that manage multiple token types.

Figure 2: Ethereum token standards

Sources: https://crypto.com/university/article?category=crypto101&page=token-standards

TEZOS TOKEN STANDARDS

In Tezos, there are three token standards written in Tezos Interoperability Proposal (TIPZ) format, as described below.

TZIP #5: Financial Application 1 - Abstract ledger

FA1 (Abstract Ledger) did not have a specified interface at first. It was born out of the requirement for a simple abstract ledger that could be utilized as a component in applications that required a fungible asset concept. It meets the demand for minimum abstraction and matches identities with balances. FA1 does, however, have several drawbacks such as Contracts are not provided with any explicit method for recording incoming transactions. Further, Certain properties that are frequently sought when executing a contract are purposefully absent. And lastly, it does not state how additional contracts involving user funds should be handled.

TZIP #7: Financial Application 1.2 - Approvable Ledger

It is a new standard, designed to allow smart contract interactions. FA1.2 handles token transfers and spending authorization for tokens from other accounts. It is a similar version of the ERC-20. It performs token transfer procedures, implements permissions to spend tokens from other accounts, and connects identities with balances. Further, it can resist attack vector vulnerability, an issue faced by the ERC-20 standard.

TZIP #12: Financial Application 2 - Multi-Asset Interface

It was developed to keep Tezos developers from being reliant on token-specific standards. FA2 offers a single token contract interface that accommodates a broader range of token kinds and implementations. FA2 is token-agnostic, supporting both single- and multi-token contracts using a single standard. Batch operations are used at all entry points, allowing multiple token transfers and/or token kinds to be performed in a single atomic transaction. Developers must address typical factors, such as specifying the contract's token type, according to this standard.FA2 has some advantages such as, supports a broad range of token kinds and implementations by providing a standard for a uniform token contract interface. Offers token transfer semantics and supports a variety of transfer authorization regimes that are immune to the ERC-20 attack vector. FA2 supports a variety of standards, including ERC-20, ERC-721, and ERC-1155, although the most often used are ERC-20 (fungible tokens) and ERC-721 (non-fungible tokens).

SECURITY IN NFT

As we all know that the NFT ecosystem is still immature and there is a long way to go for it to fully mature. Hence, here we will be considering the security risks involved in the NFT space and highlight some of the defense measures to tackle them.

Re-entrancy attack - In computer science, a process is called re-entrant if it can be halted in the middle of its execution, initiated again and both runs can be run successfully without running into any error. This kind of attack by a hacker can lead to serious vulnerabilities. The DAO hack, in which $70 million worth of Ether was stolen, is the most prominent example of this. The hard fork of Ethereum Constantinople was just postponed after a re-entrancy issue was discovered during the final stage of the launch. There are several ways to stop this attack. Instead of using the call.value() function one should use the send() or transfer() function. The procedure is protected from the re-entrancy vulnerability if no internal state modifications occur following any transfer or an external function call inside it.

Blockchain-related issues - The possibility of a blockchain-based assault. For example, blockchains that use proof-of-work for block creation are known to be vulnerable to the so-called "51 percent attack," at least in theory, wherein some controlling the 51% of the hash rate of a particular blockchain can exploit that blockchain at will. Proof-of-stake systems are subject to various sorts of attacks, such as "fake stake attacks."

Spoofing - Spoofing is when a cybercriminal impersonates another person, company, or entity to carry out harmful activities by gaining authority. The attacker can use the authentication flaw to acquire the private keys of the original owner and then transfer the NFT to his wallet. The best practice to tackle this attack is by using a cold wallet as well as having a formal NFT smart contract verification.

Tampering - It is the act of a hacker changing the data with malicious intent. Even if NFTs are available on a blockchain, and changing the information after a transaction has been confirmed is very impossible. However, data kept outside of the blockchain might be tampered with, therefore it is suggested that a seller supply the NFT data as well as the hash data to the buyer at the moment of exchange.

Denial Of Service Attack - A denial-of-service (DoS) attack is a network attack in which a malicious attacker tries to disrupt normal operations to render a server inaccessible to its intended consumers. DoS impairs accessibility and disrupts the NFT service, which might be used by unauthorized users. The blockchain, fortunately, ensures that user actions are easily available. Legitimate users can utilize the information as needed, and data resources are not lost due to human error. However, DoS may be used to attack centralized web apps or raw data outside of the blockchain, rendering the NFT service unusable. A novel hybrid blockchain architecture was recently developed that uses two algorithms to solve availability problems utilizing a weak consensus mechanism.

Lost control over execution - Even fully functioning smart contracts may have hidden weaknesses created by malicious attacks. Because they are running on the network anonymously, we are left with no other way other than terminating them. Emergency Stop, which is the contract

owner's express stop option, is an excellent concept. This can disable a susceptible function (or an entire intelligent contract) that relies on it.

Information leakage - Information leakage occurs when data is made available to unauthorized people. In terms of state information and smart contract instruction codes, the NFT system is transparent, and any state and its changes are accessible to every observer. Malicious attackers can readily abuse the risk and transaction responsibility even if the user merely enters the NFT hash into the blockchain. As a result, rather than using simple intelligent contracts, we urge the NFT developer to employ sophisticated contracts that safeguard the user's privacy.

USE CASES

The use cases of NFTs are enormous, so here we will discuss a few and highlight their potential.

Digital art - Digital art was one of the earliest use cases of an NFT. The advantage which it possesses is the better revenue collection opportunity for the digital artists due to the feature of royalty, which is paid to the creator on every trade of the particular NFT. Moreover, it provides proof of ownership which ascribes value to it. There are numerous examples of successful NFTs sold as digital art the most popular being that of the artist Beeple who's digital art was sold for about $69 million at Christie's auction in march 2021.

Gaming - NFT has the potential to change the gaming industry as they can successfully monetize a player's time and facilitate the desired 'play to earn' dynamic. The economics of the game are designed in such a way that a good player is rewarded for being better at the game, the rewards are received in the form of in-game cryptocurrency. Further, the players can also create their types of NFTs such as in-game collectibles on re-sale of which they will receive a royalty. Some of the projects which have done this with the most degree of success are Axie Infinity, CryptoKitties, and Decentraland.

Collectables - As the fundamental property of an NFT is uniqueness and proof of ownership, NFTs are a great form of collectibles that also protect the owner from any copyright infringement. Some of the popular NFT which have ventured into this particular domain are NBA Top shots, where cards of the NBA players are sold as NFTs, and CryptoKitties where images of cats are sold as NFT, these can further be bred to create further unique CryptoKitties.

Fashion - Physical items such as wearables are attached to the blockchain via cryptography, for example, a jacket can be turned into an NFT, and the owner of it can be verified by scanning the QR code on the jacket.

Real estate – With the rising prices of real estate make it impossible for small investors to enter the real estate markets, but with the help of NFTs, various methods have been innovated where fractions of a real estate are purchased by tokenization, the information is stored on the blockchain which gives the investors the proof of ownership in a very secure way and with the help of smart contracts the property can be rented out and investors can earn a passive income according to their holdings and the rules of the smart contracts. Hence this breaks the barriers for the small investors interested in the real estate market.

Metaverse - The Metaverse is a shared virtual space for all types of digital activities. In general, a variety of techniques, such as augmented reality and the Internet, are used to construct the virtual world. The concept is from recent decades and has a great future due to blockchain's rapid expansion. Blockchain provides a decentralized environment for virtual online worlds. Participants in this blockchain-based alternative may have a variety of intriguing purposes, such as gaming, self-made arts, commercial products, and virtual properties (arts, land parcels, names, video shoots, wearables, and so on). The virtual economy is also available to users. Structures (such as offices) can be leased to others to collect a debt, create unique animals, and sell them for rewards. Decentraland, my neighbor Alice, and a few other blockchain-based projects are among the most notable.

CHALLENGES

Here we will describe the challenges or the pitfalls that the NFT ecosystem faces, these are the barriers that have to be overcome to grow further. These challenges range over various fields and are described below.

High gas price - This is the price that the users have to pay on any transactions that they make on a blockchain network, the gas price increases with the higher congestion in the network, which poses a major problem for the NFT exchanges, as it becomes not feasible to mint a collection of NFT. This fee is charged as every transaction related to the blockchain requires computation and storage resources.

Art Theft - This is a big pitfall of the NFT ecosystem as any user could steal someone else's artwork that hasn't been published on the blockchain yet and turn it into an NFT to claim its ownership.

Processing time - Whenever minting or exchanging NFTs transactions go through the smart contract which involves interaction with the blockchain, which currently has a low transaction per second, making the processing time-consuming and a bad user experience. Some of the new Proof of Stake (PoS) blockchains like Algorand have fixed this issue to quite an extent, but there is a long way to go.

Anonymity - Currently most of the NFT projects are based on Ethereum, Flow, and Tezos which do not provide total anonymity to their users. They provide pseudo-anonymity, where every transaction of every wallet address is visible to anyone, including the wallet balances. This information can be used by bad actors such as hackers to get access to some of these wallets. Though solutions like zero-knowledge proofs, multi-party signatures are already developed, but they haven't been implemented on most of these blockchains.

Carbon footprint - We live in a time where environmental impact and energy crisis are some of the biggest problems that our planet faces. In such a situation using computational resources to secure our digital art isn't seen as an important issue and it's even condemned for increasing the carbon footprint.

Legal issues - It has been observed that many of the NFT exchanges do not have a KYC (know your customer) policy. As it involves trading commodities and even cross-border transactions, it is important to know the regulatory stance of a country before investing any amount of money in the space. Also, as of now the sales of NFTs aren't considered as a taxable event, this can give rise to huge sums of financial scams in the system. Hence governments should consider regulating and taxing to protect its citizens from any potential danger.

Storing NFT off-chain - Currently what most of the NFT marketplaces are doing is that they store the digital art in a separate database which isn't a blockchain, as storing an image or video file takes a lot of block space and

computational resource and hence a huge gas fee which can eventually even congest the network, making the minting of NFTs a really expensive process for the users. So, to overcome this they only store a cryptographic hash as an identifier on the blockchain, which is tagged with the token. This process leads to a situation of lack of confidence among the users for the NFT marketplaces.

Intercorrelation with the price of Bitcoin and Ethereum

The data set used to perform this analysis dated from 08/17/2017 to 07/03/2021 and was collected from Kaggle.com. The data set comprised of daily observations of the total number of NFT sales, the active NFT wallet addresses which were involved with the trade of NFTs or held them, the price of Ethereum, the cryptocurrency mostly used to buy or sell an NFT, and the price of Bitcoin, the top most cryptocurrency. By using the multivariable correlation matrix method, the following observations were made.

The analytical method used a correlation coefficient, ranging from -1 to +1, which tells us how strongly the different variables are related to each other. A +1-correlation coefficient indicates a flawless positive correlation whereas a -1-correlation coefficient indicates a perfect inverse correlation.

Influence of Bitcoin on NFT Marketplace

We found out that the price movement of bitcoin did have some influence on the number of active NFT wallet addresses interacting with NFTs but had little to no influence on the total number of sales.

	BTC Price	Active NFT Wallets	Number of Sales
BTC Price	1		
Active NFT Wallets	0.544257746	1	
Number of Sales	0.012220539	0.749731028	1

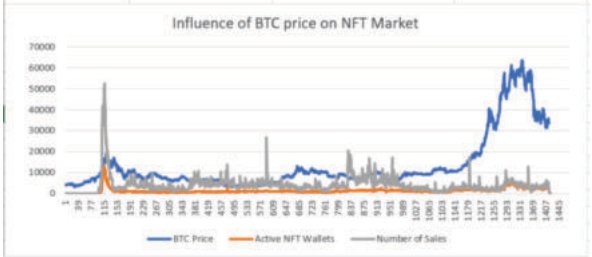

Figure 3 – Influence of Bitcoin's price on the NFT Marketplace

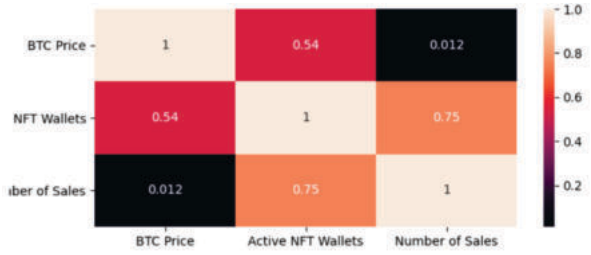

Figure 4 – Heatmap of Bitcoin's price influence on the NFT Marketplace

Influence of Ethereum on the NFT Marketplace

We analyzed that the price movement of Ethereum also had some influence on the number of active wallet addresses interacting with NFT, but it was noticed that this influence was lesser when compared to Bitcoin.

Further, it was found that the price of Ethereum was negatively correlated with the daily sales of the NFTs, which can be contributed to the fact that as Ethereum is the most widely used cryptocurrency for the trade of NFTs, an increase in Ether's price would mean an increase in the price of the NFT itself making it more expensive to buy and hence less reachable for the average buyers.

	Eth Price	Active NFT Wallets	Number of Sales
Eth Price	1		
Active NFT Wallets	0.420167745	1	
Number of Sales	-0.040717407	0.749731028	1

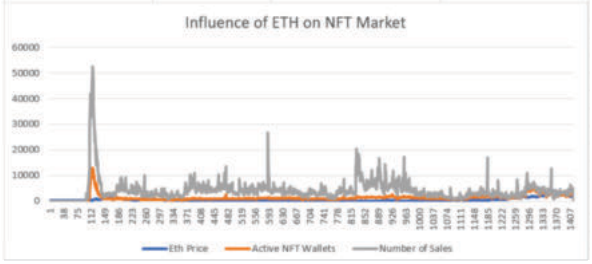

Figure 5 – Influence of Ethereum's price on the NFT Marketplace

Figure 6– Heatmap of Ethereum's price influence on the NFT Marketplace

CONCLUSION

To conclude, non-fungible token (NFT) is an exciting technology in the blockchain ecosystem. We discussed how to create an NFT and the mechanics which work in the background, like the blockchain, smart contracts, web3 wallets, and token standards. Further, we also discussed the state of security in the space, the potential vulnerabilities, the potential use cases which can transform industries, and the barriers which can hinder the progress. Lastly, we analyzed the influence that the change in prices of Ethereum and bitcoin can have on the NFT ecosystem as a whole. Overall, we can safely say that NFTs are a nascent asset class that has the potential to become an uncorrelated asset class in the future, when it matures, which is a highly desirable aspect for investors who are on the lookout for assets as a store of their monetary value.

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