

Executive summary

Challenges and objective of this analysis

Non-fungible tokens represent a technology that have gained a strong attention in the last years. This technology represents a unique digital identifier that cannot be copied, substituted, or subdivided, that is recorded in a blockchain which is used to certify ownership and authenticity. These characteristics, with transparency and scarcity led people to associate to it any type of file, such as images and videos, to sell online for cryptocurrency.

The first NFT has been minted in 2014 but public attention towards NFT has exploded only in 2021. The news about the digital works being sold for record sales of billions of dollars has instigated the curiosity of the people and led many scientists to study this phenomenon. Marketplaces raised in 2017, when important collections of NFT like CryptoPunks were released, and the market remained steady until 2021, when it saw a grow of 150 times more than it was eight months earlier. However, in May 2022 the NFT market was collapsing with to the so-called “crypto winter”, which led many platforms to bankrupt.

Because of these events, we are living a period of radical changes in the market of NFTs, where at first sight, now it seems that NFTs’ hype has fallen, but the hype cycle model testimonies that we are still in an early phase of the life of this technology, and they may acquire new functionalities.

Research on NFTs is still limited, and focuses mostly on technical aspects, but only a few deals with their marketplaces, which are interpreting their own way to allow artists to create and sell their digital content and collectors to buy them. Collections can be widely different, from sets of in-game objects to selection of art pieces.

This study aims to investigate possible directives for the development of NFT platforms and the browsing of NFT, through the analysis of the scenario of NFT marketplaces. In particular, a complete census of NFT marketplaces has been done, analyzing specific

variables related to the main gaps that emerged from a literature review, related to both technical and business aspects.

This research has provided an empirical analysis on NFT marketplaces and has identified business and technical models common to successful platforms. This has allowed for the identification of trends and directions of development of this technology, with substantial consequences for both entrepreneurs and enthusiasts.

Literature review

In the first part of this thesis, a review of the literature has been conducted. In particular, an historical background has been presented, to describe the main events that characterized the story of technology and the major projects that have been released.

Subsequently, the main properties and characteristics of NFTs have been listed, among which the most important are verifiability, transparency, availability, scarcity, tamper-resistance, usability, atomicity, and non-interoperability.

Following this, a technical analysis of this technology has been brought, with the description of the main components used to construct NFTs: the blockchain network, the smart contract, the address, the transaction and the data encoding. Afterwards it has been presented an analysis of the blockchains, with a comparison between the various standard protocol and consensus mechanisms used by the various blockchain networks. Then there is an illustration of the main characteristics that differentiate each blockchain. The differences between on-chain transactions and off-chain transactions and their implications are clarified, and finally the advantages and disadvantages of the most important blockchain networks have been described.

After the blockchains, the NFT marketplaces have been examined. The main components of the platforms have been discussed, with various real cases investigated further: the wallets, the purchase methods and the transaction costs (including the gas fee paid to the blockchain in order to mint an NFT, the commission fee owed to the platform and the royalty fee, a percentage of the secondary sales that goes to the

original creators). Subsequently, an in-depth analysis has been made regarding the governance of the platforms, which could be centralized or DAO, implemented through proprietary token that can have different utilities, among which the governance token allows their owners to participate in the vote for the future policies of the platform.

As a result of the literature review, the main gaps found in the scientific literature regarding blockchain and NFT marketplaces have been outlined.

It emerged a lack of framework of NFT marketplaces models. In addition, there are no studies that define which incentives each platform provides to the collectors and the main benefits they bring to the creators and sellers.

Regarding the technical aspects of NFT marketplaces and blockchains, many papers describe in-depth the technical functioning of its underlying algorithms, but no research has emerged that outlines the most common technical choices, such as the blockchain supported, the consensus mechanism adopted, and the governance established.

Methodology

The research objective and the research questions have been presented and the methods used for data collecting and variable classification are all discussed in the methodology chapter. Moreover, all the variables of the database have been defined and described extensively.

The variables introduced in the database have been chosen with the aim of addressing the main research gaps found in the literature. In particular, several variables have been introduced concerning the business models of NFT marketplaces and the incentives that they can offer. Some variables have also been introduced to study which technical elements NFT marketplaces have most commonly chosen to implement, with particular attention to the blockchains supported and the type of platform offered by new marketplaces.

The extraction of data on NFT marketplaces has been made in collaboration with the Blockchain and Distributed Ledger Observatory of Politecnico di Milano, which has also

provided the main sources from which collecting the data. Then, the main interviews to some ambassadors of important marketplaces have been reported.

The methodology for the empirical analysis itself has then been described, outlining the justification for the numerous investigations and incorporating the thought processes behind the outlier numbers.

Thus, this analysis aims to *describe the current ecosystem of NFT marketplaces*.

Starting from the objective of the research and the main gaps identified in the literature, the research questions that have been defined are the following:

What are the future directions of development in the NFT marketplaces? What will be the key to success in the NFT ecosystem?

Empirical analysis

The empirical analysis is divided in three main sections: the first part presents an overview of the main NFT marketplaces in the world during the last years. The analysis has then focused on business aspects, in particular investigating the main sectors in which platform operate, and the fees applied to the transactions; in the last section the analysis has addressed the technical aspect of the marketplaces, with particular focus on the blockchain supported and the governance adopted.

Overview of NFT marketplaces

The empirical analysis has been decided to start from a general overview of the NFT marketplaces that have been included in the census, showing the numbers and the volume sales during the years and in the World.

| Total marketplaces | Volume sales | Average | Median |
|---------------------------|---------------------|----------------|---------------|
| 100 marketplaces | 50 billion | 624 million | 10 million |

Table 1: total, average and median of volume sales of NFT marketplaces

The overview showed that the majority of the volume sales of \$50 billion USD has been influenced by only a few NFT marketplaces, which dominated the market in the last years. These includes:

- OpenSea, the most popular NFT marketplace
- Axie Marketplace, the NFT platform of the game Axie Infinity
- CryptoPunks, a collection of 10.000 rare NFT digital figures
- Magic Eden, the largest NFT marketplace on the Solana blockchain
- Blur, a new NFT marketplace and aggregator

The distribution of the NFT marketplaces have been investigated, from 2017 to 2022. In the first three of the years analyzed, there was not much interest in the NFT market and only a few marketplaces were born, including the collection CryptoPunks and the marketplace OpenSea, both launched in 2017. But only in 2020, many events such as the pandemic and the crypto popularity made the market experience a high growth that led to an NFT artwork sold for \$69 million USD. The peak arrived in the two years 2021-2022, when the market grew by more than 26.000%¹ in 2021 compared to 2020. Finally, in 2022, despite months of declining sales and falling prices during the second half of the year, the NFT sales volume in 2022 nearly matched the 2021 peak, generating around \$25 billion USD. Then, the so-called crypto winter caused by the collapse of Terra's LUNA and UST, with the downfall of the crypto exchange FTX, made the NFT market drop as well. In the end of the year OpenSea remained the leading marketplace for NFT trades, with Blur after it, the new rival that incentivized NFT trades with the promise of upcoming token rewards, while Solana continued its up-and-down pattern.

The geographical analysis showed that America is the most active country in NFT platforms, where around the 80% of the volume sales analyzed takes place. It is followed by Asian countries such as Singapore and China, which take the 18%. However, the countries have not still made a regulation for NFT, so taxes are applied differently.

¹ According to DappRadar

Business applications

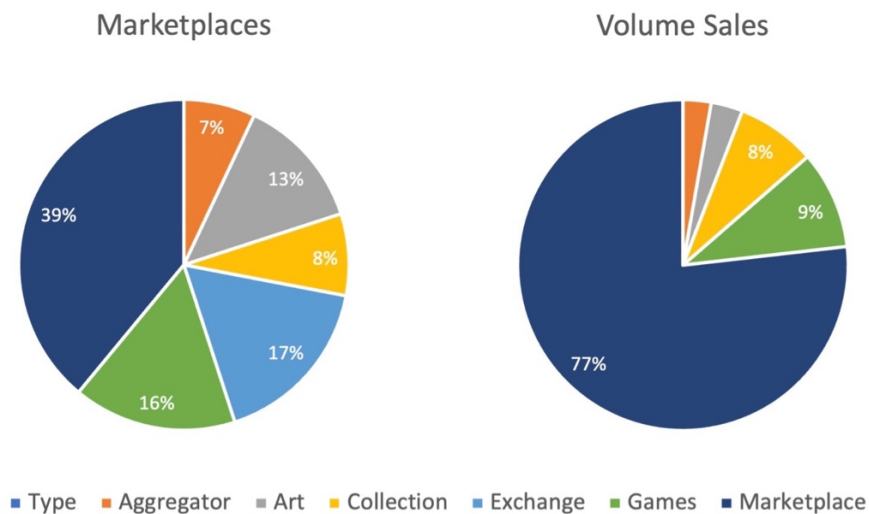


Figure 1: distribution of NFT marketplaces and volume sales by type

The marketplaces have been classified in six different classes:

- Marketplace: general NFT marketplace, open to everyone and many industries
- Gaming: platforms that sell NFTs used for gaming purpose
- Art: marketplaces that sell exclusive digital art collections
- Aggregator: platforms that browse NFTs from different platforms
- Collection: assortments of digital assets of the same style
- Exchange: the NFT marketplaces that belong to cryptocurrency exchanges

For each of these variables, the distribution of the number of NFT marketplaces and volume sales have been described and analyzed, in order to identify the most common and the most successful implementations, as shown in the following graph.

The category that saw the highest volume of sales is the open marketplace like OpenSea, where anyone can mint and sell NFTs. The gaming and art marketplaces are following, but aggregators like Blur are a new type of platform that is acquiring so much popularity lately and is radically changing the market.

Indeed, the commission fees collected by the platform for each transaction are set mostly to percentages under 1% but are getting set to zero in more and more marketplaces lately. The royalty fee, that is the percentage that goes to the original

creator of NFT during secondary sales, is usually set by the artist during the minting of the NFT, but a new trend is letting the buyer choosing the percentage of the transaction to send to the creator during the purchase. Most of the marketplaces offer three purchase methods: buying immediately the NFT for a fixed price; participate in an auction with a time limit; offer a bid, which can be later accepted or rejected by the seller. All of these can be done with cryptocurrency, but more and more marketplaces are implementing some auxiliary platforms such as MoonPay, that allow to buy NFTs with credit card. Finally, the majority of the marketplaces allow users to easily mint NFT directly on the platforms, without needing to have an advanced technical knowledge.

A focus on technological aspects

In the last section of this research, some more technical aspects have been examined. In fact, as reported in the literature review, the scientific papers on NFT are lacking in empirical analysis that examine how the technical elements are implemented in the various marketplaces. It has therefore been considered important to investigate the technological choices that the marketplaces analyzed have made, comparing the technical configurations adopted.

In particular, three aspects have been investigated: the blockchain platforms supported by NFT marketplaces, the implementation of a proprietary token and how they have been used in the governance, and the storage in which data about transactions are saved, whether on-chain or off-chain.

The majority of NFT marketplaces like OpenSea, do not support a single blockchain network, but they interface with various blockchains to provide their service, and this leads to a higher volume sale since they can reach a higher user base.

The blockchain that is supported by most of the NFT marketplaces is Ethereum, which has always been the most popular in this sector and last year has saw many improvements after the Merge and the transition from Proof-Of-Work to Proof-Of-Stake consensus mechanism. However, there are valid alternatives:

- BNB Chain, an Ethereum Virtual Machine that provides more efficiency

- Solana, the fastest blockchain supporting over 50.000 transactions per second
- Polygon, a blockchain that is compatible with ETH, allowing it to scale
- Immutable X, a layer 2 blockchain built on top of Ethereum

Subsequently, for each type of marketplace, the distribution of the blockchains have been analyzed, in order to identify the most popular blockchain networks for each industry.

Regarding the governance, the NFT marketplaces analyzed resulted to be split in two equal halves in centralized and decentralized organizations. However, the volume sales of centralized marketplaces were almost three times more than the ones of the DAOs. Centralized platforms are dominating now, but this may not persist, since the need for more neutral decentralized marketplaces is clear, as testified by the new entrant Blur. Decentralized aggregators are aiming to close this gap between centralized and decentralized market by offering better experiences. Subsequently, it was evidenced that decentralized platforms implemented DAO mainly through the introduction of a proprietary token, which can be used as a governance token to allow the owner to participate in the voting mechanism for future policies of the platform.

NFT marketplaces choose to save data whether:

- On-chain, directly on the decentralized ledger of the blockchain, which is updated every time a transaction occurs
- Off-chain, where an external storage is exploited for this purpose

The majority of the marketplaces resulted to save data in both ways, by saving the critical data on-chain, and the less relevant one on an external storage, in order to gain the advantages of both methods.

Regarding the standard supported by the platforms, the protocols supported the most were the ones offered by Ethereum:

- ERC-20, used for general tokens
- ERC-721, used for non-fungible tokens
- ERC-1155, which adds batch functionalities to ERC-721

Marketplaces that support different blockchains from Ethereum, offer different proprietary protocols which however are usually compatible with the Ethereum's ones.

Main findings and conclusion

The literature review has underlined the disruptive potential of NFT marketplaces technologies as well as the significant obstacles that still stand in the way of implementing distributed systems in current value chains, both from a technical and commercial perspective. In fact, there is still a great degree of uncertainty about the best choices to make when implementing an NFT marketplace in the real world.

The literature has identified NFTs as possible keys in technological innovation for the future of the metaverse, thanks to their proprieties that make them unique digital pieces that cannot be copied, nor substituted, nor subdivided.

The empirical analysis that has been carried out on NFT marketplaces had precisely the objective of providing information on the choices they have made, with the aim of identifying business and technical patterns common to successful platforms.

The most important findings that have been achieved are listed subsequently.

- The decentralized NFT marketplaces are growing. These are not popular at the moment, but they are closing the gap with the centralized platforms by offering a better experience to their customers. This can be reached with a simple and intuitive user interface and a faster registration that won't require to sign up a wallet in order to purchase NFTs. Moreover, mobile applications currently do not allow the users to purchase NFTs, but only to browse them.
- Aggregators are a new phenomenon that are changing the market, Blur overall. Indeed, its policies of nullifying the platform fees and making the royalty fees optional as the discretion of the buyer, have forced major players like OpenSea to review their policies in order to not lose their users.
- Ethereum is still the most popular blockchain network in this ecosystem, but other blockchains are offering faster transactions and better efficiency. For this reason NFT marketplaces seem to consider the Proof-of-Stake the best

consensus mechanism, which is supported by Ethereum. However, blockchains are introducing new consensus mechanisms, whether born from improvements of this one or done by scratch.

- Regulations that deal specifically with NFTs are lacking in the majority of the World. There are regulations about crypto assets that however exclude NFTs, which are not covered for topics like copyright and for which taxes application still result ambiguous.
- The future of this market is still uncertain, and it will be certainly influenced by the entrance of new important players, such as big tech companies like Amazon, which is expected to launch its proprietary marketplace in 2023, and the phenomenon of the metaverse.

This study has some implications for NFT artists, who are going to find a summary of the advantages and disadvantages provided by each marketplace, including the fees. The entrepreneurs will find interesting the insights regarding the business choices that the various platforms are making and can help them in taking technical choices such as the most suitable blockchain network for their purpose. NFT enthusiasts are going to be helped in the choice of the platform in which to make their investments.

However, the analysis of this thesis presents some limitations which may represent concrete opportunities for future research. For example, data about volume sales of NFT marketplaces that belong to cryptocurrency exchanges have been excluded from the database, since these could not be retrieved separately from the volume sales of the cryptocurrencies. Moreover, the inclusion of future platforms may change radically the statistics collected. Regarding the technical variables, the distribution of the tokens lacks a classification of their functionality. Finally, some individual areas may be interesting to be thorough, such as the fashion industry which is investing a lot in this technology, or the phenomenon of aggregators.