Prof. Dr. Mark Wahrenburg
Chair of Banking and Finance
Goethe University Frankfurt
Supervisor: Dr. Sasan Mansouri

Bachelor Thesis

NFT Art, an Investment Alternative for Everyone?

Submitted on 10 November 2022 by:

Viktor Fendesak
Student ID: 6978534
Economics and Business Administration
Theodor-W.-Adorno Platz 3
60323 Frankfurt am Main
E-mail: viktor.fendesak@stud.uni-frankfurt.de

Abstract

In the past century, alternative investments, like fine arts, were restrictive and mostly accessible to a few individuals. Enhanced by the ensemble between art and stock market prices, growing wealth was mainly a privilege for the wealthy. The era of decentralization and Non-Fungible Tokens (NFTs) makes diversifying portfolios with art investments possible for everyone connected to the internet. This work analyses historical transactions of such investments and shows that NFT art has portrayed investment opportunities for budgets of all sizes. Although the observed returns exhibit high volatility, this new technology can be a tool making art suitable for the portfolios of the mass. The aim is to provide potential investors with an overview of the historical profitability of NFT art investments. The analysis operates a hedonic approach on hundreds of thousands of trades by comparing log-returns with various trade features.

Contents

List of Figures

List of Tables

List of Abbreviations

ETH　　　Ether, the native currency of the Ethereum blockchain

Etherscan etherscan.io, the leading data provider for the Ethereum blockchain

NFT　　　Non-Fungible Token

OpenSea　opensea.io, a major decentralized NFT exchange on the Ethereum blockchain

USD　　　US-Dollar

1 Introduction

Alternative investments are non-traditional assets that are used to either drive additional profits or bring diversification into investment portfolios, as described by Anson, Fabozzi, and Jones (2011). Art is such an instrument and acts as a store of value. In the past, art investments used to be an investment alternative mainly for the wealthy. Auctions taking place in big cities like New York or Paris create obstacles to becoming an art investor. One either needs to be lucky to get invited or needs the money to pay the costs to get to the auction. As a result, art was not part of the average investment portfolio. An easily accessible, affordable, and fast way of trading ownership of art pieces was lacking. Traditional fungible assets, like common stocks, already have a standard way of trading them. The blockchain technology illustrates a potential solution to the problems of traditional art investing. With smart contracts on the Ethereum blockchain, a new standard of trading ownership could be introduced. The solution, Non-Fungible Tokens (NFTs), creates the required trust in ownership of unique items and facilitates trading the ownership. Additionally, the decentralization aspect brings transparency, security, and equal opportunities into the world of art. This leads to the central question. Does the resulting new asset class, NFT art, depict an investment alternative for everyone? Of course, everyone is an exaggeration and can not mean everyone in this world. In this context, the term everyone is limited to everyone looking for new investment opportunities. To include as many potential investors as possible, this work incorporates art pieces costing even less than $100. The results of this analysis are meant for both institutional and retail investors and shall provide a first overview of NFT art profitability. As the outcome of the analysis will show, the new asset class NFT art exhibits similar investment characteristics as traditional art.

This work is structured as follows. First, the new NFT technology will be introduced. Second, as a benchmark, traditional art investments will be described. In the next step, the combination of both art investments and NFT technology, NFT art, will be exemplified. The main part is the analysis of real-world data, beginning with describing the data set. The most interesting part will then be the breakdown of profitability in regard to trade features like the timestamp, holding period, trade frequency, liquidity in the market, and the initial NFT price. Analyzing the initial cost of an NFT art makes it possible to answer if it's an alternative for everyone, the broader mass. This work does not try to predict any future NFT art prices. Its purpose is to provide an overview of the profitability and, eventually, the according risks. In the end, the resulting advantages and disadvantages of NFT art investing will be faced in order to answer the central question.

2 Literature Review

2.1 Understanding NFTs

To analyze the characteristics of NFT art as an investment alternative, it is essential first to understand the underlying basic mechanics, such as blockchain. Therefore, the following part will summarize individual parts of NFTs.

2.1.1 Blockchain

Gomber et al. (2017) describe a blockchain as a sequence of data packages (blocks). Each block consists of messages containing information about transactions. This sequence is an ever-growing list maintained by a decentralized network of servers. The network uses a mechanism to reach a consensus on the transaction validation within each new block. Cryptographic hash algorithms make it hardly impossible to manipulate a blockchain. Nakamoto (2008) presented the first concept of a peer-to-peer network for electronic payments using a blockchain known today as Bitcoin. The presented draft for payment processing using a blockchain made third- parties, like banks, unnecessary. With this new concept, the required mutual trust when making transactions is replaced by blockchain technology. Over the past years, a variety of blockchains evolved. They can differ in purpose, functionality, or even in the used hash algorithm. The two blockchains with the largest market caps have been for years, and still are, Bitcoin and Ethereum. Measured in US-Dollar (USD), the native tokens of both blockchains have a combined market cap of more than \$500bn, according to cryptowat.ch on 20 October 2022. It is not necessary to fully understand the technical mechanics of how those blockchains work. As a potential NFT investor, it is important to know that anyone can see the full contents of the historic blocks of a blockchain (Chen, Cong, and Xiao, 2021, p. 4-5). This is crucial when comparing traditional art investing with NFT art investing. Regarding security, participants can check previous transactions and recognize potentially invalid transactions, and thus, there is no incentive to validate fraudulent transactions. In order to motivate the network for the validation process, transaction fees incur for each transaction on the blockchain (Chen, Cong, and Xiao, 2021, p. 12-13). The resulting costs are often called gas fees and are paid by the user triggering the transaction. These transaction fees can be volatile and depend on the units of the data size gas, used as explained by Buterin et al. (2019) and visualized in figure 1. Gas fees increase when more people use applications that run on top of a blockchain's network. The more users use the blockchain, the higher the gas fees will be. This is caused by the competition of the

users for the space available in the next block. The process of writing a digital item to the blockchain is also a transaction and is called minting. According to OpenSea, 2022b minting establishes an unchangeable proof of authenticity and ownership.
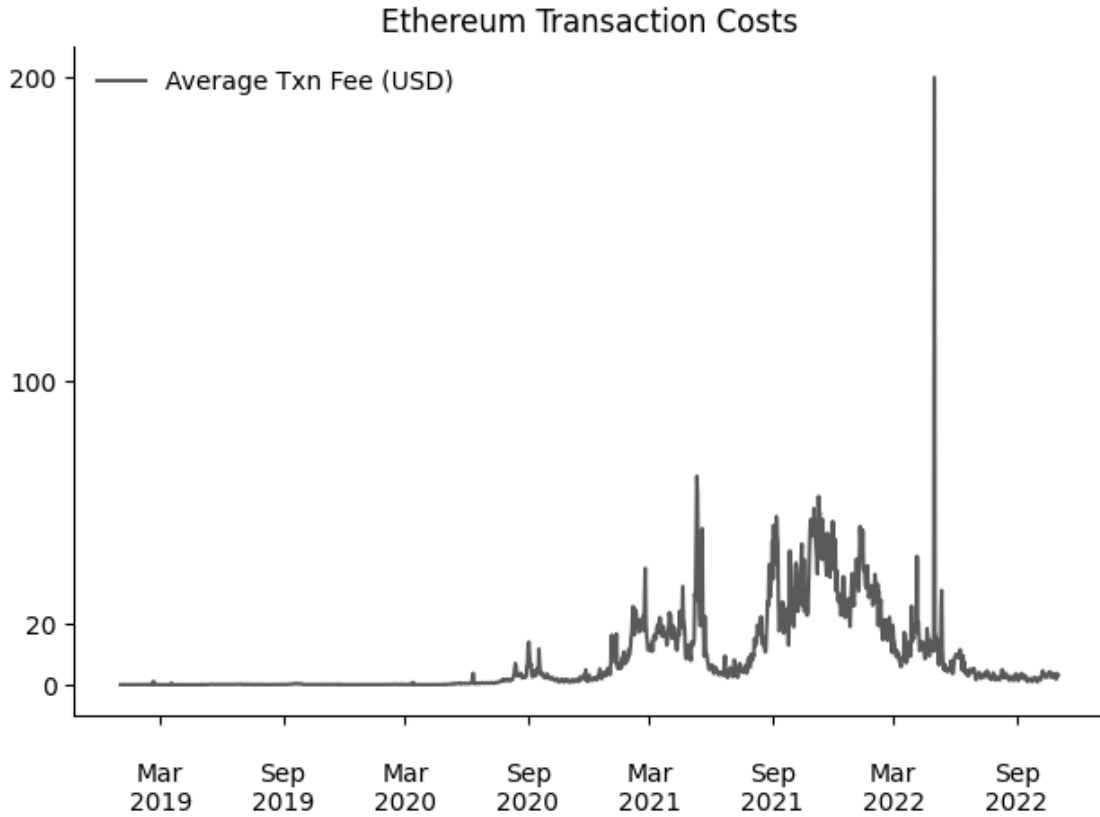
Figure 1   Average Daily Transaction Fees on Ethereum Blockchain

Source: etherscan.io

2.1.2 Fungible and Non-Fungible Tokens

NFTs represent ownership of unique items, as initially described by Entriken et al. (2018). They enable the tokenization of art, collectibles, or even real estate. The following paragraph briefly explains what tokens are and how NFTs differ from cryptocurrencies.

With the introduction of the Ethereum network by Buterin (2014), a platform emerged with built-in Turing-complete programming language, allowing for the creation and execution of various complex smart contracts. Smart contracts are codes that automatically execute the predetermined content of an agreement, such as transferring cryptocurrency, once the terms of the agreement are met (Alharby and Moorsel, 2017, p. 127-128). Smart contracts are one of the reasons why Ethereum is the most popular blockchain for decentralized applications. Smart contracts also have their memory

and account balance and can no longer be changed once connected to the blockchain. Transactions are sent to the unique contract address, the public key. After successful validation by the network, the account balance of the contract is updated. There are different standards for different types of assets, so-called tokens, on the Ethereum blockchain. ERC-20, defined by Vogelsteller and Buterin (2015) is the standard for tokens on the Ethereum blockchain that have an identical value and are exchangeable. The result is ether (ETH), the native currency of the Ethereum blockchain, introduced by Buterin (2014) and further explained by Wood (2022). The standard for the opposite, tokens on the Ethereum blockchain that have an identical value and are therefore exchangeable, is ERC-721. It is equivalent to the ERC-20 standard, but for distinguishable and unique tokens, which are not exchangeable, defined by Entriken et al. (2018). ERC-721 is supposed to be an open-source standard describing how to build NFTs on the Ethereum blockchain. NFTs, in general, are typically embedded in such a blockchain, provided the blockchain has the required functionalities. Wang et al. (2021) wrote that the concept of NFTs originally came from the Ethereum blockchain with the aim of distinguishing tokens with unique attributes. It is questionable if the concept of NFTs emerged from the Ethereum blockchain. The white paper of so-called Colored Coins from Rosenfeld (2012) already presented a similar construct where real-world assets can be embedded in the Bitcoin blockchain as non-fungible tokens. However, this idea has not caught on in practice. In order to interact with a blockchain and transfer cryptocurrency, a public key and a private key is required. The public key is the address to which the assets are allocated on the blockchain, comparable to a bank account number. The private key makes it possible to instruct transactions from one address to another address. Anyone with access to this private key, typically consisting of a sequence of randomly generated words, has access to the assets of the address on the blockchain. It is, therefore, essential to keep this private key safe. So-called wallets store the keys to the address of a blockchain. This wallet makes it possible to receive and sell cryptocurrency or NFTs. OpenSea (2022d) describes how such a wallet can be set up in order to become an NFT investor, see opensea.io/learn/what-is-crypto-wallet.

2.1.3 Purpose of Use

There are different types of NFTs. Table 1 shows the available categories on opensea.io, a major decentralized NFT exchange on the Ethereum blockchain (OpenSea). NFTs facilitate ownership of digital media like web domains, photography, or music. The gaming industry has also started to introduce trading of unique items in the form of NFTs. Additional to the functionality of proofing ownership, many NFT collections like PROOF Collective invite to an exclusive club when buying one of their

limited NFTs. Real-world assets like houses were already sold as an NFT, although some doubt the legal authenticity. The first NFT-based real-estate purchase could be executed within six seconds, as Etherscan shows. Once legal questions are solved, NFTs have a revolutionary character in terms of speed and convenience. More and more Web 2.0 companies build Web 3.0 applications and begin using NFT in their business. A recent example is the company Meta (2022) introducing NFTs to their social media application Instagram.

Category	Example Collection
Art	Autoglyphs
Collectibles	Bored Ape Yacht Club
Domain Names	ENS: Ethereum Name Service
Music	SAN Origin
Photography	Women Unite - 10k Assemble
Sports	The NFTeams
Trading Cards	Parallel Alpha
Utility	Consortium Key
Virtual Worlds	Decentraland

Table 1   NFT Categories

Source: opensea.io

2.2   Traditional Art Investing

This work focuses on the NFT category art. In order to understand this new asset class, it is helpful first to get a basic understanding of traditional art investing. The following paragraph briefly explains how art pieces have performed as investments in the past.

Art has been an alternative investment for many centuries. However, research on art investments has been rare. First studies by Anderson (1974) have examined paintings as an investment from 1780 to 1970. Their results show that art investments, on the one hand, can provide a positive annual return. On the other hand, the risk-adjusted return is less attractive when compared with other investment alternatives. Existing literature quantifies the profitability of traditional art investments by creating an index of art prices. Anderson (1974) first used the mean-variance approach to portfolio theory to approximate that the total return must be similar to another equally risky asset. They concluded that the price of a painting depends on the artist's reputation, the year it was sold, and the size of the painting. Risk return ratios of paintings can be compared with those of common stocks. Lower risk-return ratios may be due to the consumption value of the art. Constructing an art index comes with a problem.

Since the asset class is less liquid than common stocks, for example, art pieces might be sold for high prices on the primary market, but investors can not sell their art on the secondary market due to a lack of demand. This distorts the profitability of art investments. Further studies from Goetzmann, Renneboog, and Spaenjers (2011) still used a similar approach in 2009. By constructing an art index, they analyzed the impact of equity markets and top incomes on art prices. Results showed a positive correlation between the art index, the stock market, and the wealth of the wealthy. The wealth data used for their analysis rely on income tax data of the top 0.1% income share. Their results strongly suggest a long-term relationship between top incomes and part prices. In their words, "it is indeed the wealth of the wealthy that drives art prices".Rennebog and Spaenjers (2012) have studied the investment performance of traditional art with a more recent and more extensive data set than previous work has done. The analyzed data set ranges from 1957 to 2007. They came to a similar conclusion that alternative investments in art can result in high returns but come with high risk. Art critic Robert Hughes (1984) describes art prices as an investment with an irrational and manipulable desire concerning the prices. A little teaser on NFT art: a regression on NFT art in appendix A.2 underlines this description of art prices by showing no significance. This is one of the reasons why this work focuses on analyzing the historic NFT art profitability instead of trying to predict prices.

2.3 Alternative Investment: NFT Art

Typical alternative investments are real estate, fine arts, wine, or collectibles, mainly used to diversify investment portfolios. As the studies from the previous section portrayed, art investing had been a privilege where mostly wealthy investors added art pieces to their portfolios. This shows the need for a better accessible and less restrictive way to invest in art. The new asset class NFT art is a potential solution, combining the new technology with traditional art. The following paragraphs provide an overview of this new asset class, enabling alternative investments for the broader society.

2.3.1 Market Places and Participants

The most famous marketplaces for NFT art are Nifty Gateway, Rarible, OpenSea, or the centralized exchange Binance. OpenSea as the most prominent decentralized exchange on the Ethereum blockchain, will be the focus of this work. According to itself, OpenSea was created in 2017 and is, therefore, one of the first NFT marketplaces. OpenSea believes that in the future, almost everything which can be owned will be embedded on a blockchain. It says from itself that trust and safety are their priority,

and inclusion and diversity are a big part of this marketplace. Possible blockchains on OpenSea are, at the time of writing: Arbitrum, Avalanche, Ethereum, Klaytn, Optimism, Polygon, and Solana. This work focuses on Ethereum transactions since it has the longest history of data and the above-described ERC-721 standard. To be able to trade NFT art, there must be artists within this new world. On OpenSea, anyone having a crypto wallet can mint their digital art and become a creator. Due to the pseudonymity of blockchain technology, only the wallet addresses are visible of the market participants. Within the past years, new communities emerged, discussing trends in NFT art. Most of the discussions on NFT art happen on the social media platform Twitter and the chatting application Discord; see discord channel members on discadia.com. This work will call the visible wallet addresses buying NFT art investors, although it is possible for one investor to use different wallets. Similar to the artists, the pseudonymity of the blockchain makes it hard to tell much about the investors themselves. However, it is possible to say something about investors based on their trade behavior. As the data in the next chapter will show, most of the sales from the sample happen on the same day of the purchase. This is already a sign of bots, or at least a sign of investors not being interested in consuming the art as Anderson (1974) described it. In times of artificial intelligence automatically generating art and machine learning-driven bots automatically buying and selling digital assets, it is thinkable that a whole NFT-art-bot-bubble emerges. The analysis of this work will show that addresses executing many transactions do not automatically generate more profits than addresses with fewer transactions. A market driven by bots can be highly manipulative and pose a severe risk to potential NFT art investors. It is up to the NFT marketplaces like OpenSea to regulate the use of bots. Admittedly, it might be in favor of marketplaces when bots create more trading volume, causing more fees.

2.3.2 Costs and Taxes

Next to gas fees applying to every transaction on the blockchain, costs for buying or selling NFTs can be creator earnings and a marketplace fee. According to OpenSea (2022c) creator earnings are set by the creator of the NFT. This allows the artist to profit from further reselling of his art pieces. The marketplace fee on OpenSea amounts to fixed 2.5% of each NFT sale price. According to Taulli (2022) NFTs are treated as property by the Internal Revenue Service (IRS) of the United States of America. The regulation of taxes on profits from NFT trades still needs to be clarified. The situation in Germany looks similar, where cryptocurrencies and NFTs are seen as objects according to Winheller and Schwendemann (n.d.). There, a distinction is made as to whether the seller also created the art object or not.

2.3.3 Becoming an Investor

Buying NFT art requires a wallet, as described above. One of the most common online wallet providers is MetaMask which can be accessed on metamask.io. This wallet provider is open source and offers a browser extension that can directly link to the marketplace, for instance, opensea.io. Next, the desired art piece must be available in the preferred marketplace. To be able to interact with the blockchain and buy an NFT, one needs to own cryptocurrency like ETH. Opening an account on a central crypto exchange allows one to change fiat money like USD into cryptocurrency and transfer it to the created wallet. The current biggest central exchanges are binance.com and coinbase.com, requiring a KYC process and exchange fees. This implies that investing in NFT art also means taking cryptocurrency exposure into account. Finally, once selected an art piece and connected the wallet to the marketplace, the NFT can be bought. On OpenSea, NFTs can be either bought directly or acquired through an auction. A more detailed instruction on buying NFT art is described by OpenSea (2022a). Requiring no KYC process implies the risk of money laundering or other criminal activity. After Wang et al. (2021), it is up to the government to regulate the business of NFTs. Anti-money-laundering algorithms improve, and criminals can be caught once illegal money turns back to fiat money. Selling an NFT is similarly straightforward. Once the wallet containing the NFT is connected to the marketplace, one can just put the art piece on sale for either a desired price or a timed auction, described by OpenSea (2022c).

2.3.4 Exisiting Work on NFT Art Profitability

Existing work on NFT art profitability, like from Kong and Lin (2021), analyzed the single collection Cryptopunks, one of the most significant NFT collections in history. They find that NFT trades of the collection Cryptopunks can achieve high rates of returns. These high returns are accompanied by high volatility resulting in a Sharpe ratio similar to traditional art and similar to the technology common stock index, the NASDAQ. Cryptopunks is not in the data sample because the data source for this work, etherscan.io, the leading data provider for the Ethereum blockchain (Etherscan), does not provide data for this specific collection. However, answering the central question of NFT art as an investment alternative for everyone is not possible when only looking at one collection costing at several minimum tens of thousands USD. The expectation for the results of this work is that a more diverse range of NFT art collections still perform well and achieve similar results. The significant advantage of this new asset class is that it is less restrictive. This hypothesis will be analyzed in the following chapter.

3 Analysis

The previous chapters introduced the world of NFTs, traditional art investing, and finally, the combination of both: NFT art investing. This chapter puts the theory into practice. Analyzing historic NFT art investments provides insights that are especially relevant for potential investors considering entering the NFT art market. The analysis begins with describing the available data and preparing it for deeper analysis. In the next step, the profitability is broken down in detail. By comparing contiguous transactions, the analyzed profitability represents realized returns by actual trades and thus ensures practical relevance. At the end of the analysis part, the from the data induced advantages and disadvantages will be faced.

Note: data gathering, data clean-up, and analysis were all independently performed using python. All graphs included in this work were created independently and by own calculation, with the use of the described data. The according to code can be found on github.com/vfcapital/bachelor-thesis.
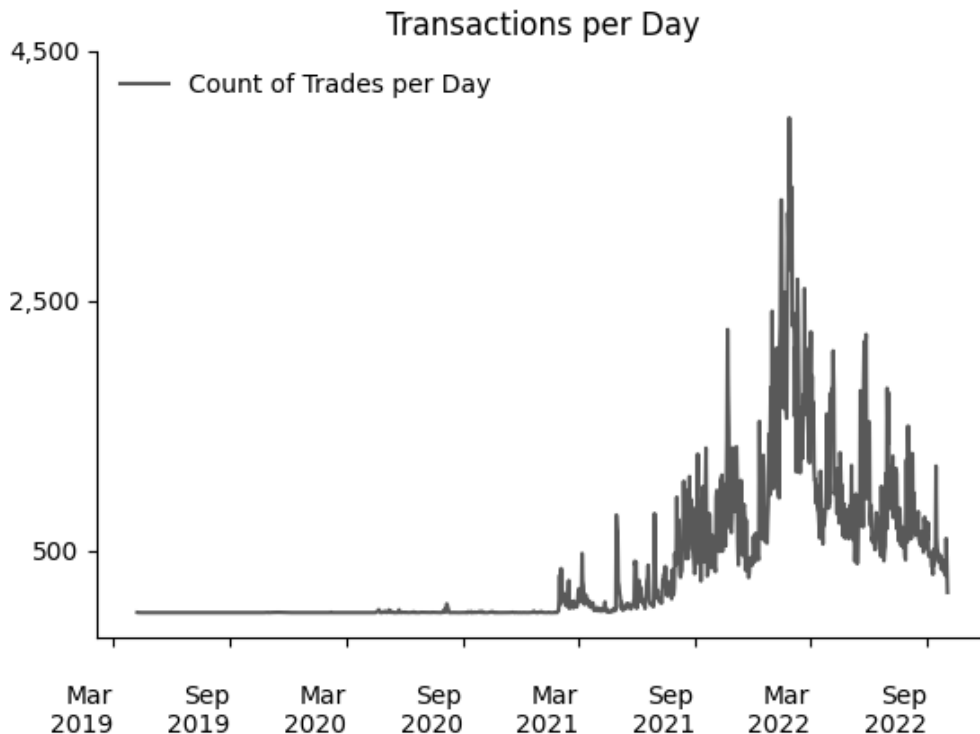

Figure 2   Transactions per Day

Source: Own calculation

3.1 Data Description

This section describes the data used to analyze NFT art investments' profitability. First, it needs to be decided which NFTs are being included in the analysis. As a basis, this work chose the top 100 art collections from OpenSea, as of 01 October 2022, 11:00 am CET. OpenSea is one of the major exchanges when it comes to minting and trading ERC-721 tokens on the Ethereum blockchain; see erc721.org. The top 100 collections ranking is selected by all-time trade volume measured in Ether, the native currency of the Ethereum blockchain (ETH) and filtered by the NFT subcategory "art." Data were retrieved for the period from 01 January 2019 to 03 October 2022. This might seem like a short time when compared to data sets of traditional art, where several centuries of historical investment transactions can be analyzed. As the previous chapter mentioned, NFTs and their ERC-721 standard were first published in 2018. Hence, much more extended periods are just not possible. Looking at the finally retrieved data in the following section of the analysis, one will notice that most of the NFT art trades took place in late 2021; see figure 2.

Count of Collections	89
Count of NFTs	164,195
Count of Transactions	437,173
Median Transaction Count per Collection	4,443
Median NFT Count per Collection	1,814
Min. Total Volume per Collection	$14,695.95
Median Volume per Collection	$5,921,004.73
Mean Volume per Collection	$21,092,742.05
Max. Volume per Collection	$967,988,903.95

Table 2   Total Transaction Volumes per Collection

Source: Own calculation

The transaction count distribution of the analyzed data set raises questions about potential selection issues. An argument against such issues is that the selected top 100 collections are composed of all-time transaction volume and therefore contain the most important NFT collections. The collection in the data set with the lowest transaction volume is called "SUPERPLASTIC: SUPERGUCCI" with a total volume of $14,695.95. This relatively low all-time transaction volume also indicates that essential NFT art collections are included in the data set. For comparison, the collection with the highest overall transaction volume is "BoredApeYachtClub," with a total of $967,988,903.95. More metrics on the data can be extracted from table 2.The data contains primary as well as secondary market transactions since both types are possible on the OpenSea exchange. Additionally, the data contains only

actual successfully settled trades, or at least marked as such on Etherscan. Etherscan retrieves its data directly from the Ethereum blockchain, ensuring high data quality. It turns out that after the data set clean-up, only 89 of the 100 initially retrieved collections remain. A final count of $n = 437,173$ transactions within the past 3.5 years remaining. Comparing to Rennebog and Spaenjers (2012) who analyzed 1,078,482 sales within 50 years, this final count might be a good representation of the overall NFT art market.

	Purchase Prices	Sell Prices
Count	272,978	272,978
Total Value	$901,219,605.94	$1,486,589,361.26
Median	$971.97	919.58
Mean	$3,301.44	$5,445.82
Std. Dev.	$15,354.35	$30,731.75
Min. Value	$0.01	$0.01
Max. Value	$1,554,677.10	$2,907,016.00
Min. Value Collection	OGCR	AVASTAR Token
Max. Value Collection	BoredApeYachtClub	BoredApeYachtClub

Table 3   Trade Prices Overview

Source: Own calculation

While retrieving the data for this work, a strong pattern has been recognized for many collections. Most of the transactions of each collection happened on the first days of trading. This pattern induces the behavior of NFT investors, who are always looking for the following hyped collection. This can also be shown in numbers. Across all collections, 5% of all transactions happen on the first day after the first trade was made. 51.30% of all transactions of each collection happens within the first ten days. This displays a cluster risk in terms of liquidity. Investors might not be able to sell their art pieces anymore because the crowd has moved on to the next hyped collection. Another potential issue with the data set could be survivorship bias. Only the well-performing collections might be included in the analysis, causing an upwards bias, as Goetzmann, Brown, et al. (1992) exemplified. This potential issue is countered by the nature of how a blockchain works. Every transaction settled on the blockchain stays on the blockchain and can not be reverted. As long as OpenSea did not manually remove any collection from the top 100 art collections of all time transaction volume, the list is complete. The only collection missing is Cryptopunks. NFT collections that are not traded anymore and lost their complete attraction to investors are included in the analysis.

The following paragraph describes the clean-up process. It is vital for achieving reliable results and avoiding unnecessary errors in the calculation. The clean-up is

	Profits	Holding Period in Days
Median	3.45%	12.00
Mean	881.10%	39.35
Std. Dev.	77,026.77%	61.10
Min. Value	-100.00%	0
Max. Value	30,641,460.00%	1,110
Min. Value Collection	Crypto Janky	0xmons.xyz
Max. Value Collection	BoredApeYachtClub	Autoglyphs

Table 4   Trade Profits Overview

Source: Own calculation

applied to all initially fetched 775,592 transactions for analyzing profits afterward. The remaining 89 collections can be looked up in the appendix A.1. The raw data contains the following columns:

Transaction Hash, Timestamp (inclusive milliseconds), Transaction Action Type, Buyer Wallet Address, Collection Name, Token ID, NFT Type, Quantity, ETH Price, USD Price and Marketplace

First, a unique NFT identifier is created by merging the collection name with the token id. The token id is collection-specific and not a unique identifier across collections. Next, some sanity checks are being run on the data. First, to ensure that the marketplace is for all the same OpenSea. Another check ensures the NFT type equals the Ethereum standard ERC-721. The transaction action type has to be "bought," excluding transactions where the investor won the auction but the trade did not settle. All transactions having a buy price of $0 are excluded from the data set. This might seem controversial to some. Giving away NFTs for free to some selected investors is a marketing strategy used by a few collections. Potential investors should not rely on such special treatments. The resulting profits from such transactions would bias the final results by increasing the mean profits significantly. The amount of such transactions is still low compared to the total count of transactions. Hence, they are excluded. The following check filters out a much higher number of transactions. To calculate realized profits, at least two continuous transactions are required per unique NFT id. NFTs only having exactly one transaction in the whole data set will be excluded from the profit analysis. Additionally, checks on potential duplicated transactions are performed. It is possible having multiple transactions with the same transaction hash. This happens on OpenSea when an investor buys multiple NFTs and pays them in one transfer. On the other hand, multiple transactions where transaction hash and NFT id are identical are assumed to be errors in the sample.

Once the clean-up is done, 437,173 transactions remain in the data set, where actually realized profits can be calculated from. The profit calculation is done by first sorting the table by NFT id and timestamp. Afterward, the transactions from each unique NFT, unequal to the particular first transaction of each NFT, are shifted up to the prior transaction, resulting in a new table. This new table represents continuous trades, including the price of the buy and the following sell transaction. This makes it possible to calculate actually realized profits. Both the profit resulting from the buy and sell ETH prices and from the USD prices are calculated. By having both metrics, the impact of ETH measured in USD could be analyzed separately from the plain change in the value of the NFT itself. The profit is calculated using log returns:

$$\Pi_C = \ln\left(\frac{P_{C(t)}}{P_{C(t-1)}}\right) - F \tag{3.1}$$

where

$$\Pi_C : \textit{log-return of the trade, calculated using the prices measured in currency } C$$
$$C : \textit{either ETH, or USD}$$
$$P_{C(t)} : \textit{sell price denoted in currency } C$$
$$P_{C(t-1)} : \textit{buy price denoted in currency } C$$
$$F : \textit{Marketplace Fee}$$

The final table of the trade profits contains the following columns:
Unique NFT ID, Number of Trade for Unique NFT ID (restarting with "1" for every NFT), Purchase Timestamp, Sell Timestamp, Holding Period, Purchase Price in ETH, Sell Price in ETH, Log Return in ETH, Purchase Price in USD, Sell Price in USD, Log Return in USD, Collection Name, Seller Address, Buyer Address, Purchase Hash, Sell Hash

3.2 Analysing NFT Art Trades

The final data set consists of 89 NFT art collections covering 164,195 unique NFTs and 272,978 trades with information on their profitability. Descriptive statistics of the trades data set can be extracted from table 3 and 4. This work can now start diving into the profitability of NFT art investments.
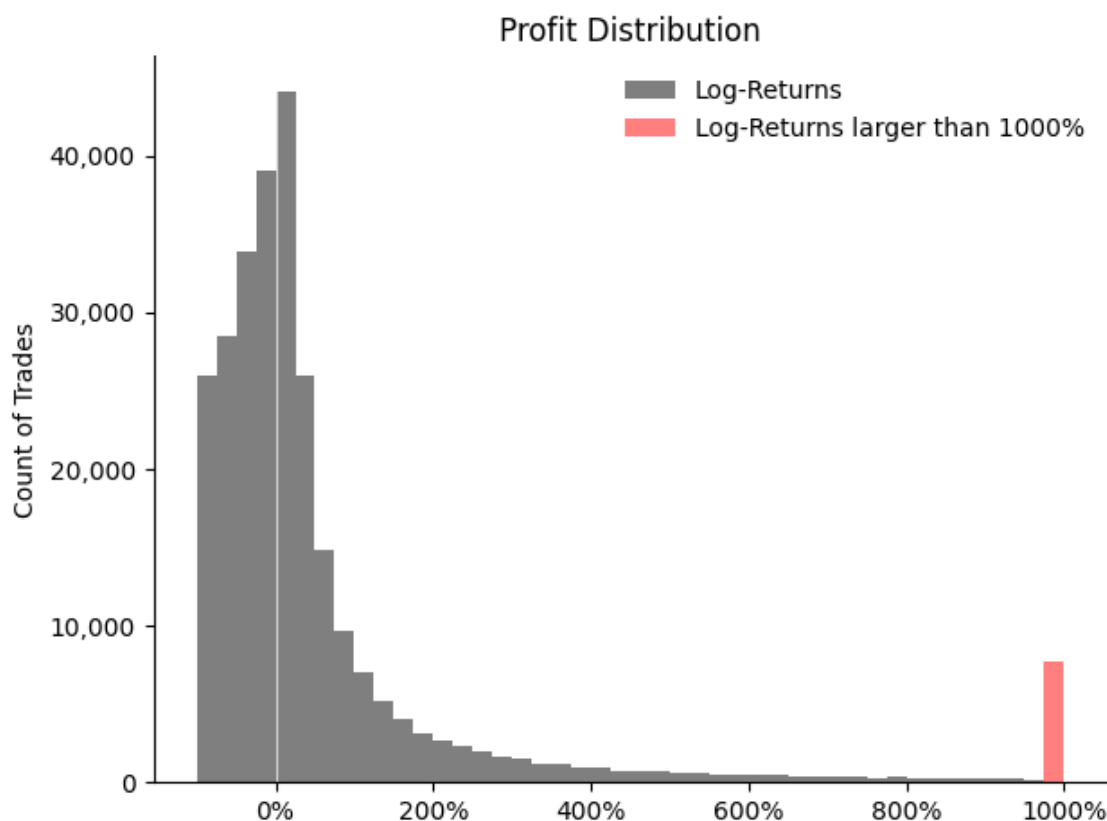
Figure 3   Profit Distribution

Source: Own calculation

3.2.1 Profit Distribution

Let's start by looking at the returns distribution in figure 3. This histogram shows
the count of each profit bucket on the y-axis. The x-axis represents the profit buckets
in percent, calculated using the equation (3.1) with C = USD and F = 2.5%. The dis-
tribution shows typical characteristics of log-normal distributed returns. All returns
exceeding 1000% are clipped into the last bin, marked in red. Trades resulted in log-
returns of more than 1,000% makes up a small relative amount, with 0.4%. It might
look like the majority of trades have a profit of less than 0%, but in total, 52.20% of
the trades were profitable in absolute values. Figure 4 splits up this profitability of
investors and shows its distribution. More precisely, it shows the count of investors
who bought an NFT and sold it for a log-return in terms of USD on the y-axis. The
x-axis reflects the buckets of returns.

When looking at the price history of ETH in figure 5 and comparing it to when all
these transactions happened in figure 5, one could argue that this was due to exchange
rate risk. The ratio of profitable trades, measured in C = ETH, is 53.81%, almost the
same as profits calculated using the USD prices. When comparing the log-returns
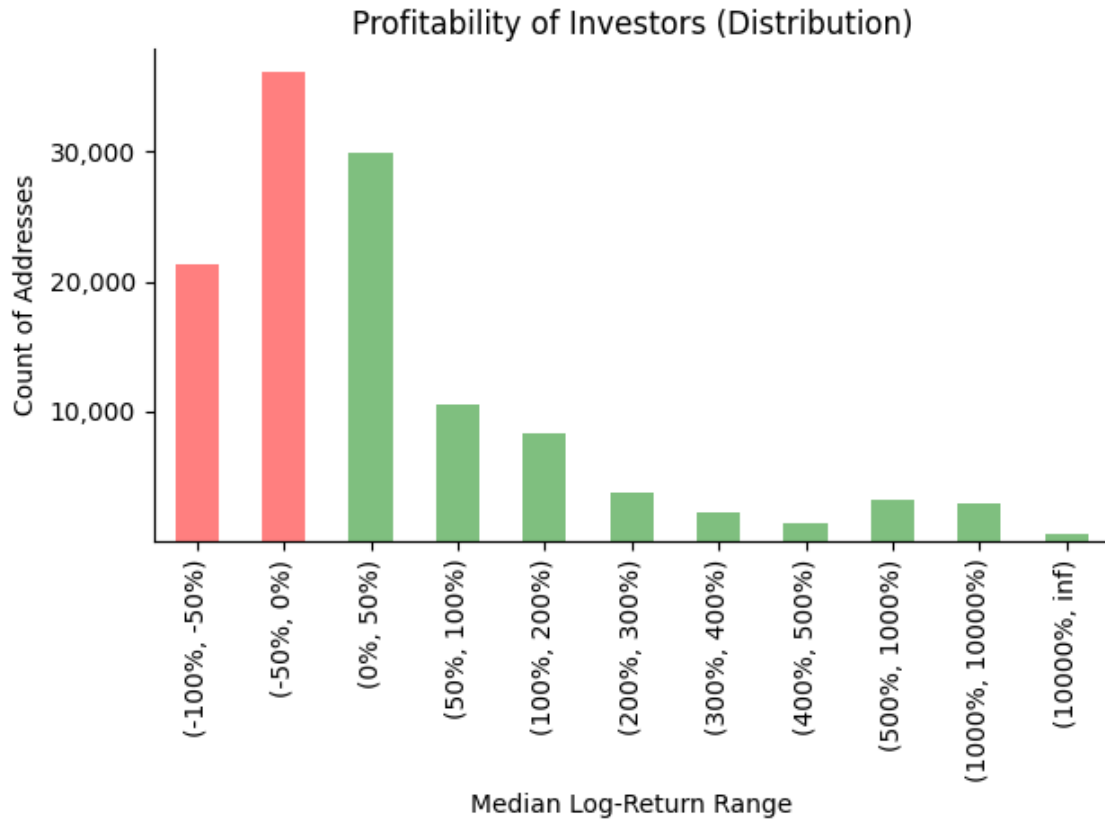
Figure 4   Profitability per NFT Art Investor

Source: Own calculation

calculated using ETH with those computed using USD, the profits using USD are, on average, 81.49% higher. This divergence is caused by some huge outliers. The median difference between the USD profit and the ETH profit is -0.3%, almost equal to zero, as figure 6 shows. These differences are simply calculated by subtracting the profits using C = ETH from the profits using C = USD. As this plot of differences in ETH and USD profits shows, on average, both profits are equal. To make comparability easier, the following hedonic approach of analyzing NFT art's profitability uses the profits measured in USD. This comes in favor of potential investors who are not yet active in the world of blockchain and NFTs who do not think in terms of cryptocurrency. Or at least not yet.

Outliers have been checked on plausibility manually on Etherscan. In the differences figure 6, the highest dot at the top reflects the following trade. An investor with wallet address "0xf2e4a3639b7dc9c7084ae59f7c511a9a1f807d1e" bought on 15 September 2020 the NFT with id 271 from collection "Autoglyphs" for 0.005263 ETH, which was worth $1.92 back then. The investor has held the NFT for 228 days. In the meantime, the ETH price took off, as figure 5 shows. Also, the NFT hype began in terms of the count of trades, as figure 2 shows. The investor sold the NFT on the same marketplace

Figure 5   Price History ETH

Source: coinmarketcap.com

where it was bought initially, OpenSea. The final price was 90 ETH, as the data of transaction hash "0x68e1d83758aa4fe8d54eaa33f4dd46e13db2efeededff0c38d0095e6576e41ab" confirms. With the booming NFT market and the increase in ETH prices, the in-
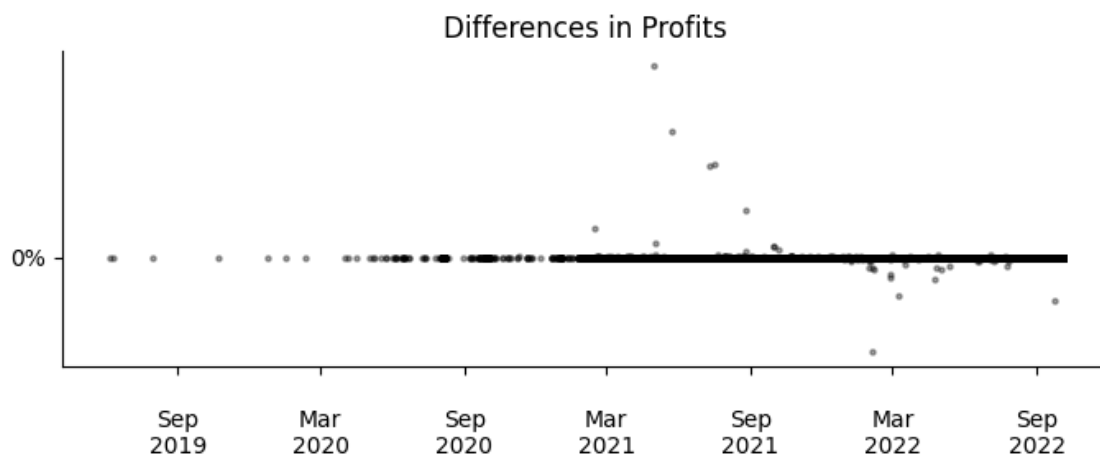

Figure 6   USD Profits vs. ETH Profits
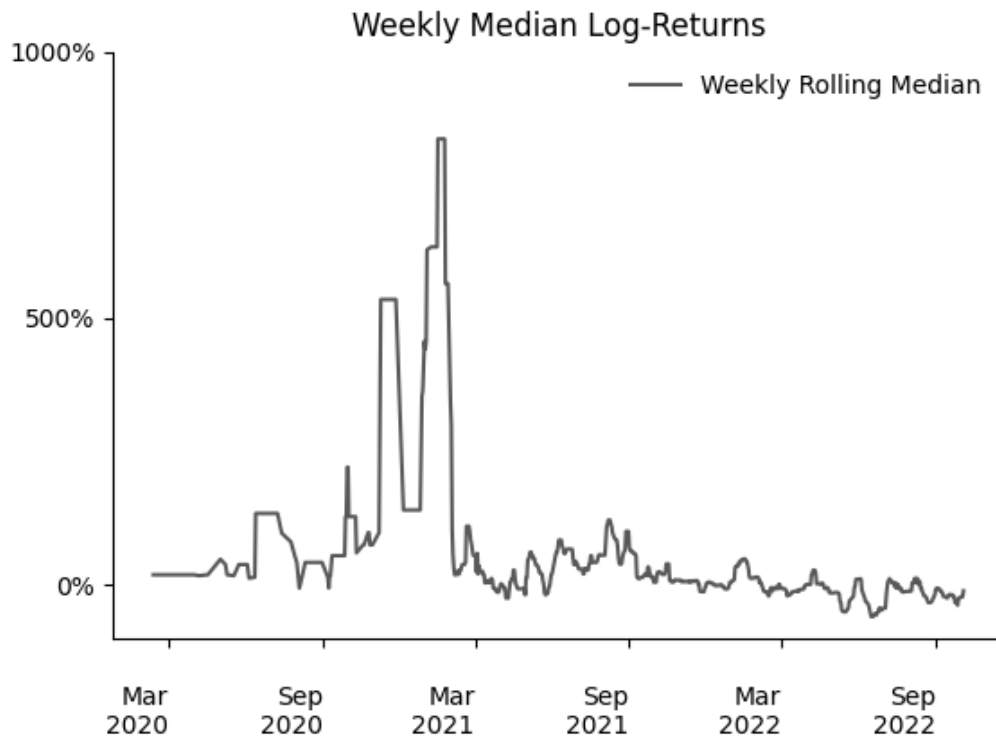
Source: Own calculation

16

Figure 7   Weekly Rolling Log-Returns

Source: Own calculation

vestor achieved an extraordinary profit of 13,817,712.5%. However, such outliers are still rare. Because of that, this work uses median values instead of arithmetic means, avoiding biases.

Figure 7 provides an overview of the rolling weekly median log-returns. The seven-day median includes fewer upside spikes in returns than the daily median. Avoiding just a handful of days in the sample distorts the whole picture of profitability. This graph indicates how the NFT art market went through a period of hype at the end of 2020 and the beginning of 2021. The median trade achieved profits between 100% and 900%. This period of huge profits is followed by median log-returns settling at around 100% in mid-2021. These numbers are relatively large compared to stock market trades, for example. At the time of writing, the weekly median log-returns evened at around 0% profit. This indicates that it is now harder to make profits from NFT art investments. Since these numbers do not include the underlying holding period of each trade, figure 7 does not tell much about the overall profitability of NFT art investing. Therefore it is necessary to dig deeper and break down the components of the trades.
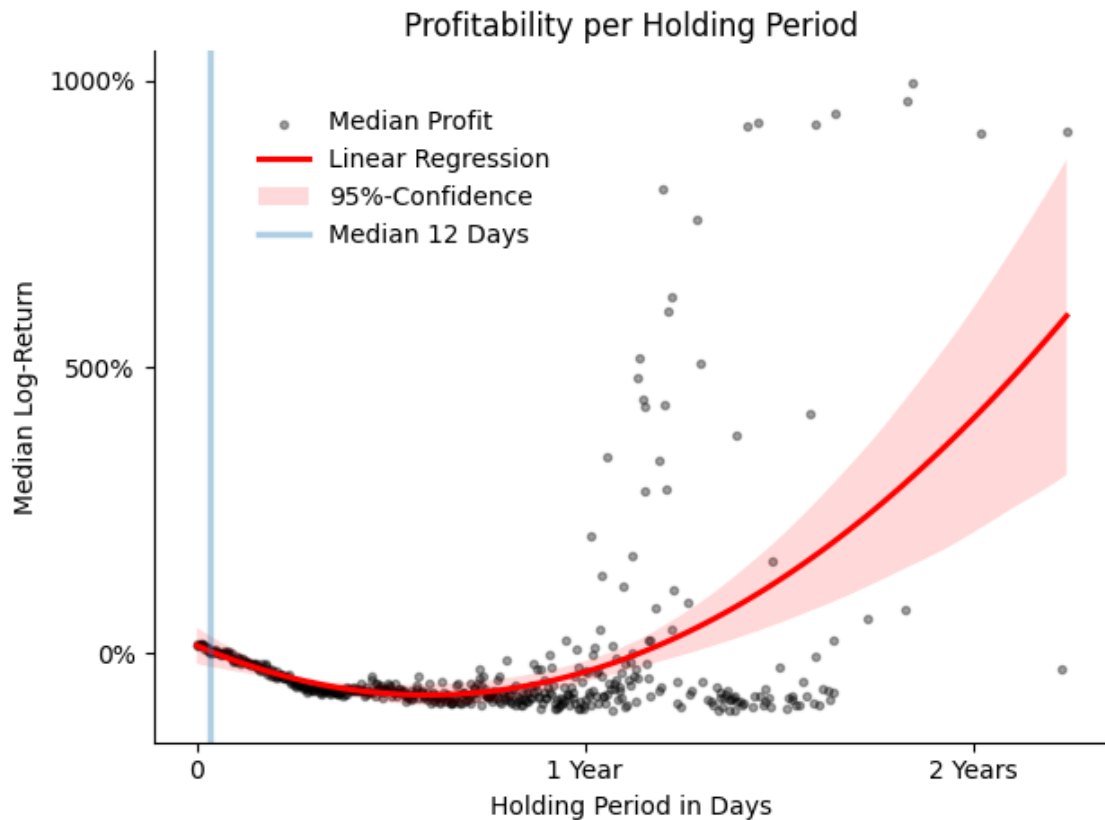
Figure 8   Profitability per Holding Period

Source: Own calculation

3.2.2 Holding Period

Figure 8 does precisely that. It shows the median log-return of each holding period in terms of days. To exemplify, the graph only shows median log-returns of 1,000% or less. The median of all holding periods in the data set is 12 days. Looking at figure 8, this number might seem small, but it represents a crucial investor behavior. For 11% of all trades, the purchase and the sale happened on the same day. The median profit of intraday trades is positive with a median profit of 11% and a mean profit of 1,167%. Many collections experience a big hype, even before the art is released. Additionally, the amount of NFTs issued per collection is limited. Those two factors can lead to investors who were lucky enough to buy an NFT of the freshly released collection directly selling the piece on the secondary market. This trading strategy adds up relatively often because the median log-return for a holding period of zero days is positive. It appears from figure 8 that the mid-range holding period results in negative median log-returns. This indicates that holding NFT art for just several months was not profitable in the past. In the long term, a holding period of one year or longer results in spiking median return profits. These spikes might be explainable

by the relatively short time of existence of the NFT technology. The data set started in early 2019 when the count of trades and median returns of NFT art began to rise at the end of 2020. On top of the rising NFT hype, as explained above, the exchange rate of ETH took off simultaneously. Early investors from 2019 hence profited from both hypes. Trades that did not take off exhibit negative median returns. In the long run, there are not many trades in the mid-profit range. This "all or nothing" pattern is typical for alternative investments in general and points out that NFT art might not be as comparable to investments like common shares or bonds. Such relationships will be described in more depth at the end of this analysis and are visualized in figure 14 and 15.

Another part of the holding period graph (figure 8) is a linear regression of the second order. Holding periods within one year seem to fit this quadratic behavior even though many data points are not in the 95%-confidence interval. Many data points being in the 95%-confidence interval would indicate that the profit could be predicted by the expected holding period. The Pearson correlation coefficient between the profit and the holding period is 0.01, suggesting a low correlation. Table 5 in appendix A.2 shows a regression in the profits using the holding period, the initial purchase price, and the ETH/USD price as the explanatory variables. The model was trained by randomly splitting the data into 70% train and 30% test data sets. The quality of the regression can be quantified by the metric $R-squared$ measuring the share of variance from the regression model explaining the variance of the actual test values. The results of this regression using Statsmodels by Seabold and Perktold (2010) show a $R-squared$ of zero, meaning these explanatory variables do not explain the behavior of the NFT art profits. Searching for potential drivers of NFT art prices in more detail is not part of this work.

3.2.3 Liquidity

Figure 9 provides an overview of the total monthly turnover across all NFT art transactions for the last two years. Comparing this graph with the weekly median log-returns from figure 7, it appears that liquidity and profits do not perfectly match. According to the liquidity spike in march 2022, the median log-returns should be higher during that time. Drawing the conclusion from higher liquidity follows higher demand but does not necessarily result in higher returns. Besides the difference in the development of those two graphs, the absolute change in total turnover had dropped significantly. It compares the time of the big NFT hype at the end of 2021 and the beginning of 2022. In march 2022, the total transaction volume of NFT art in the data set added up to almost half a billion USD, at which the total turnover in September 2022 only added up to 8 million USD and 13,311 trades. As figure 9
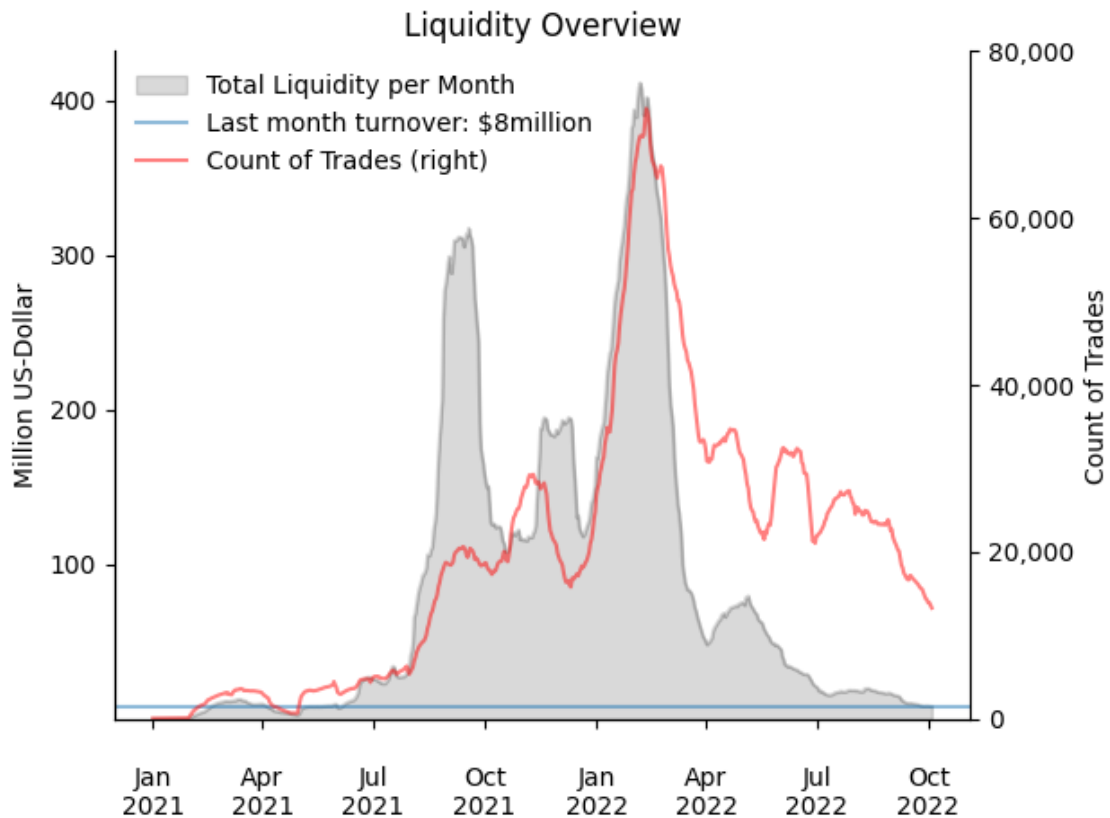
Figure 9   Liquidity of the NFT art market

Source: Own calculation

visualizes this reduction in NFT art market activity, it is notable that the count of trades decreased less than how the total liquidity has dropped. This indicates that the prices of NFT art have dropped significantly after the described hype.

The founder of index funds John C. Bogle (2010), compares short-term investing with long-term investing. He strongly suggests avoiding short-term trading in general. Combining the factors holding period and liquidity, this work analyses the trade frequency within the NFT art market and its potential influence on the resulting returns. First, the trade frequency per collection is broken down. The floor price is the lowest price an NFT per collection was sold for. The number of trades per collection compared with the floor price is negatively correlated, shown by the Pearson correlation coefficient being -0.36. This makes sense if assuming equally distributed liquidity. Lower-priced NFT art collections are traded more often. In practice, the data set of this work shows that trade counts are not equally distributed over the initial price. Therefore it is worth looking at the profitability per trade counts. Figure 10 shows the median log-returns per count of trades per collection. As the linear regression in this graph suggests, the count of trades per collection has a relatively low but positive impact on the median log-return. The relatively small slope can

be interpreted as the count of trades only having a small impact on log-returns and is not an important indicator for potential investors. On the other hand, from the positive slope, it can be concluded that a higher trade count might lead to higher liquidity and, therefore, a greater demand for that collection.
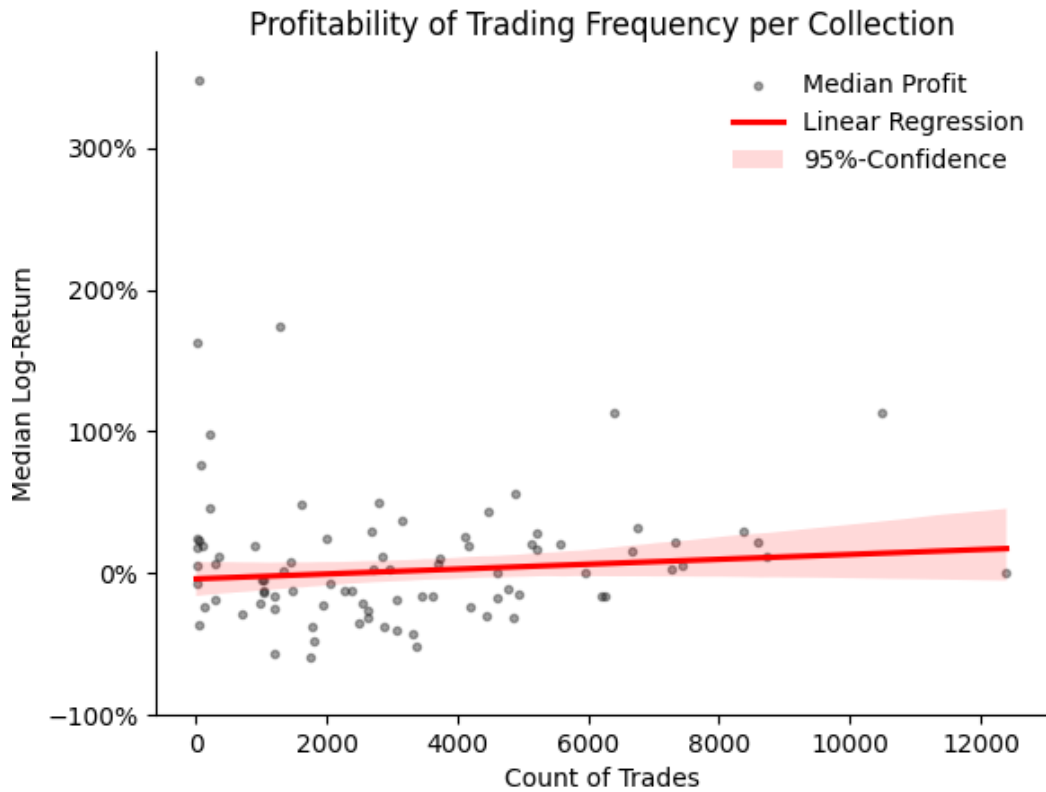

Figure 10   Trade Frequency per Collection

Source: Own calculation

Among the trades per collection, the frequency of trades per investor and the resulting profitability is relevant for potential investors. As Keim (2003) already analyzed for the stock market, chasing trends can be costly and inefficient. This work does not expect potential investors to implement complex momentum strategies like Keim (2003) explained. More straightforwardly, the count of trades per investor can be compared with the resulting median log-returns. A possible expected outcome would be that more trades imply more expertise of the investor within the NFT art space. The additional expertise is assumed to achieve higher returns. Figure 11 visualizes this comparison. Looking at the scattered median profits, no evident trend can be observed. Adding a linear regression line to the graph shows a slightly negative trend. This finding is underlined by the fact that most investors, having traded less than 100 times, achieved positive median returns. Considering this historical data, it can

be desirable to focus on qualitative factors like the art itself when it comes to NFT art investing.
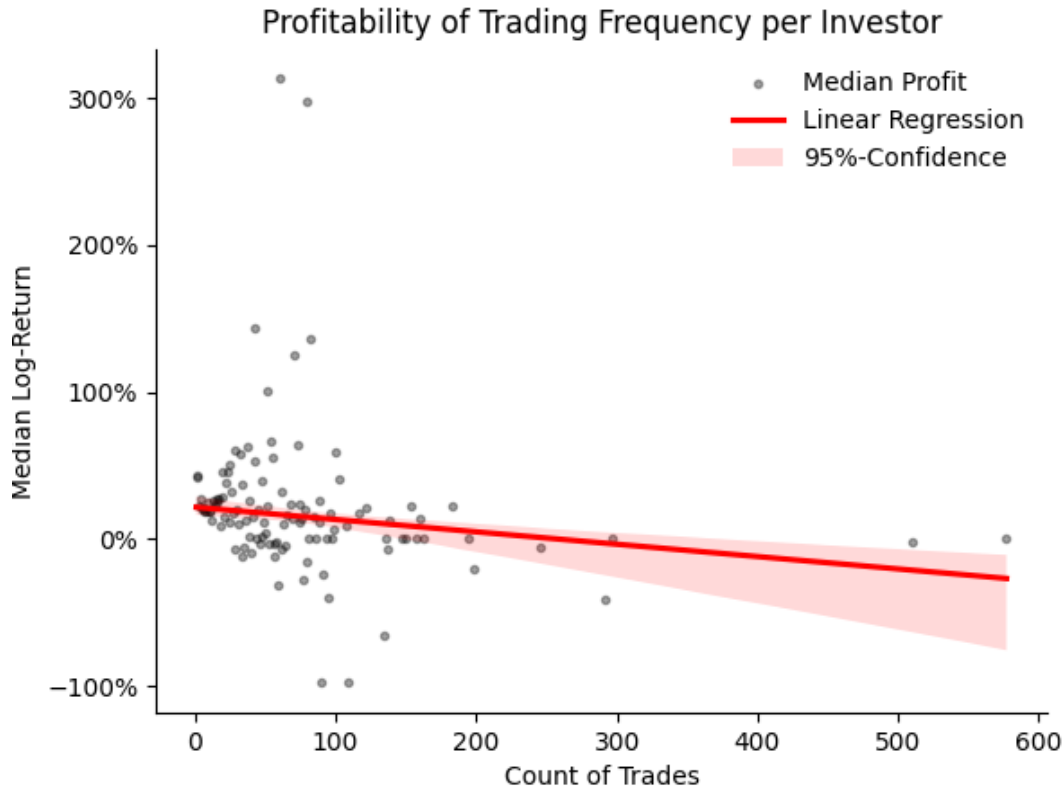

Figure 11   Trade Frequency per Investor

Source: Own calculation

3.2.4 Risk and Return

The following part analyses the profitability of trades having different initial purchase price sizes. To answer the central question, "NFT art, an investment alternative for everyone?" it is crucial to tell whether comparably affordable NFT art is profitable or not. If historically lower-priced NFT art had been unattractive in the past, potential investors might not want to invest in those assets, and vice versa. At the end of this analysis, potential investors with relatively little money should have a first overview of whether this new asset class is an investment alternative. For measuring profitability, this work follows Rennebog and Spaenjers (2012) by mainly looking at the reward-to-volatility relationship measured by the Sharpe ratio.

The Sharpe ratio first introduced by Sharpe (1998) is a practical way to measure the performance of an asset using historical data. It is calculated by subtracting the risk-free rate, usually the U.S. treasury bill, from the historic return of the asset and then
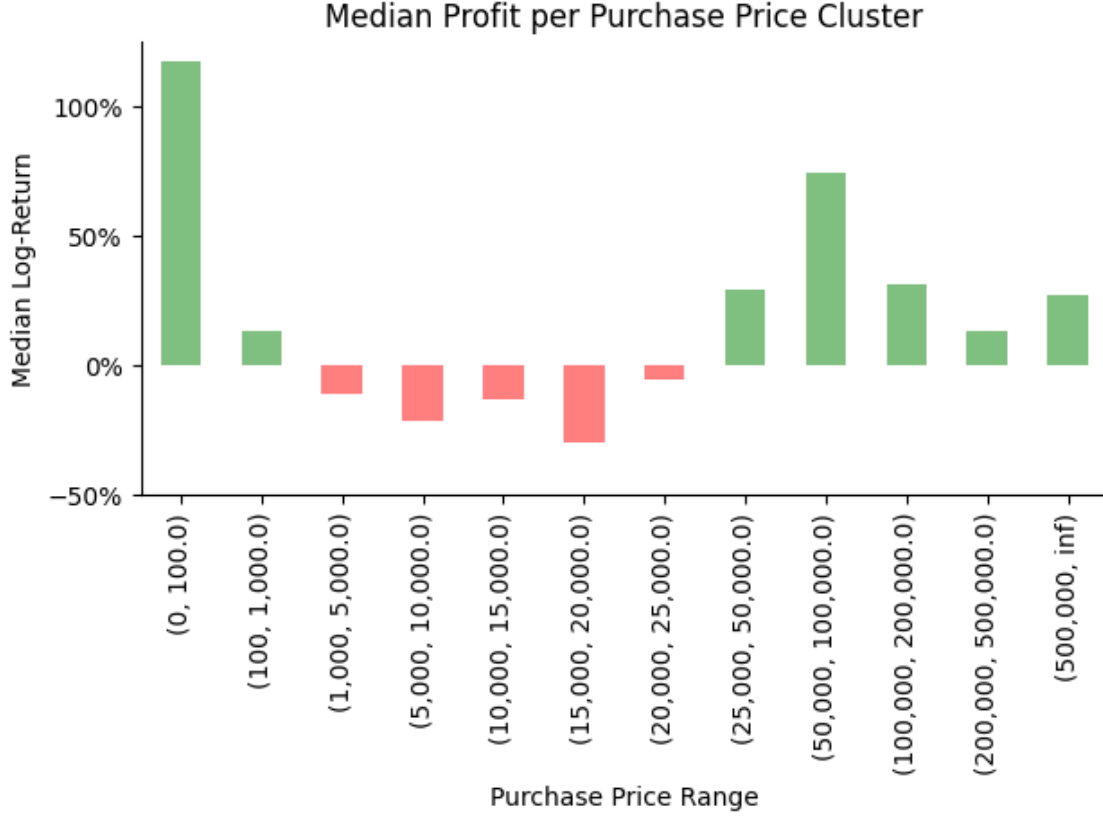
Figure 12   Profitability per Purchase Price Range

Source: Own calculation

dividing it by the volatility, measured by the standard deviation. For this work the return of the asset is the median log-return, for the risk-free rate, the 10-year treasury yield is used, which is quoted around 2% at the time of writing; seetreasurydirect.gov. Accordingly, the standard deviation of the log-returns is used.

$$SharpeRatio = \frac{R_p - R_f}{\sigma_p} \tag{3.2}$$

where

R_p = return of portfolio or asset

R_f = risk-free rate

σ_p = standard deviation of the portfolio or asset

and $SharpeRatio \in \mathbb{R}$

What is affordable NFT art? According to the Governors of the Federal Reserve System (September 2020) the conditional median value of all financial assets held by families in the United States rose 3% to \$25,700 in 2019. To find an appropriate
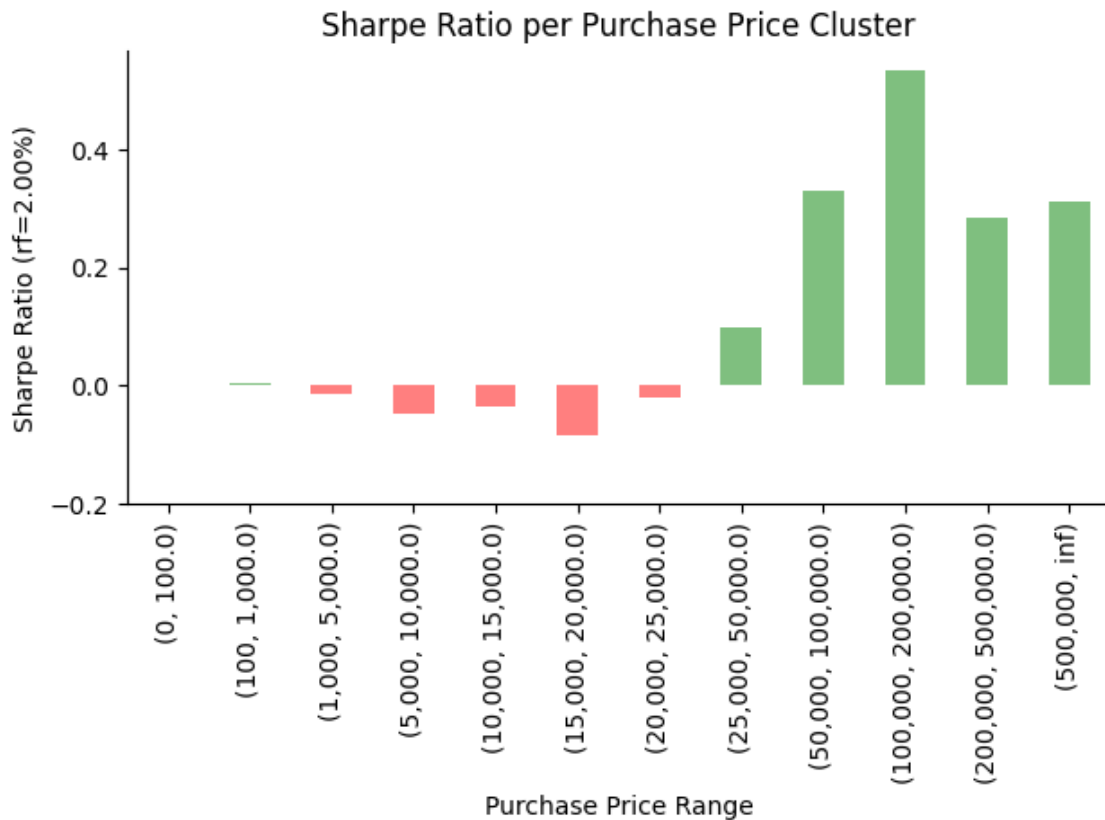
Figure 13   Sharpe Ratio per Purchase Price Range

Source: Own calculation

investment amount, lets take these numbers from the federal reserve. Assuming the increase in financial assets only consists of the new investment amount, excluding any market movement, the investment amount was $\frac{3\% \times \$25,700}{103\%}$ = \$748.54 in 2019. This number can be taken as a rough reference for retail investment budgets for further profit breakdown. Figure 12 compares the different median log-returns of trades clustered by their initial purchase price measured in USD. One will notice the bucket on the left, which includes art pieces that initially cost less than \$100, performed relatively well. The median log-return is almost 120%, by far the best-performing bucket. The mid-price buckets ranging between \$1,000 and \$25,000 all have a negative median return. The more expensive NFTs, on the other hand, achieve positive returns on the median. A possible explanation for that pattern is that unpopular and relatively cheap collections go through phases of hype after their release. NFTs in the mid-price range possibly do not get much attention. This might reflect the more significant phenomenon of wealth inequality. As explained by Keister (2000), there is a gap between the top one percent of the wealth of people and the rest in America. Whereas the lower income segment inside the historic NFT art investors mostly invests in NFTs costing \$1,000 or less, the comparably wealthy inside that

24

space primarily invest in assets costing at least $25,000. As a result, the mid-price segment gets excluded from phases of hypes.

These results might look promising and in favor of the affordable NFT art, initially costing less than $1,000. Figure 13 goes one step further and includes the above-explained performance metric, the Sharpe ratio. Now, taking the volatility of the log-returns into account, the lower price segment disappears entirely from the graph. Trades of initially higher-priced NFT art remain visually profitable, whereas the mid-price segment still seems unattractive and demonstrates negative Sharpe ratios. By subtracting the risk-free rate from the asset profit and dividing the standard deviation, the uncertainty of achieving the above-displayed returns is also considered. Historic investors of lower-priced NFT art had achieved a median log-return of almost 120%, but the fluctuations among all log-returns had been so large, making it difficult to calculate with such a median log-return for the future. The higher priced NFT art initially costing more than $100,000 achieved a positive Sharpe ratio of more than .5. These results match with the ones of Rennebog and Spaenjers (2012), where expensive art turned out as profitable. For comparison, the S&P 500 achieved a Sharpe ratio of 1.77 in the same time frame. The comparison of those two Sharpe ratios should not be taken too seriously since the NFT art returns in the used data set are no time series like the S&P 500. For the calculation of the S&P 500 Sharpe ratio, the total profit from the time frame mid-2019 till October 2022 was used. For the NFT art, the median profit of each price bucket was used.

3.2.5 NFT Art and Other Asset Classes

For better comparability, this work constructed an NFT art index. Unlike traditional historic art prices, the returns of NFT art contain extreme outliers of partially millions of percent in profit. To avoid bias by rare outliers, the monthly rolling median profit was used when creating the index visualized in figure 14. For plotting the comparison assets ETH price and S&P 500 were taken and the same rolling and median procedure was applied. In order to compare all three time series, the graph shows the accumulated returns adding on the base of 100%.

Since there was almost no trade activity in 2019 within the data set, the time series for the NFT art index starts in early 2020. As expected by previous insights from this analysis, the NFT art index demonstrates large up and down movements. The ETH price represented by the dashed line shows the rise and fall of this cryptocurrency, which is already known from figure 5. Comparing the NFT art index with the S&P 500, the differences in volatility stand out. While the stock market index S&P 500 steadily increased up to 25% until the beginning of 2022, the NFT art index already
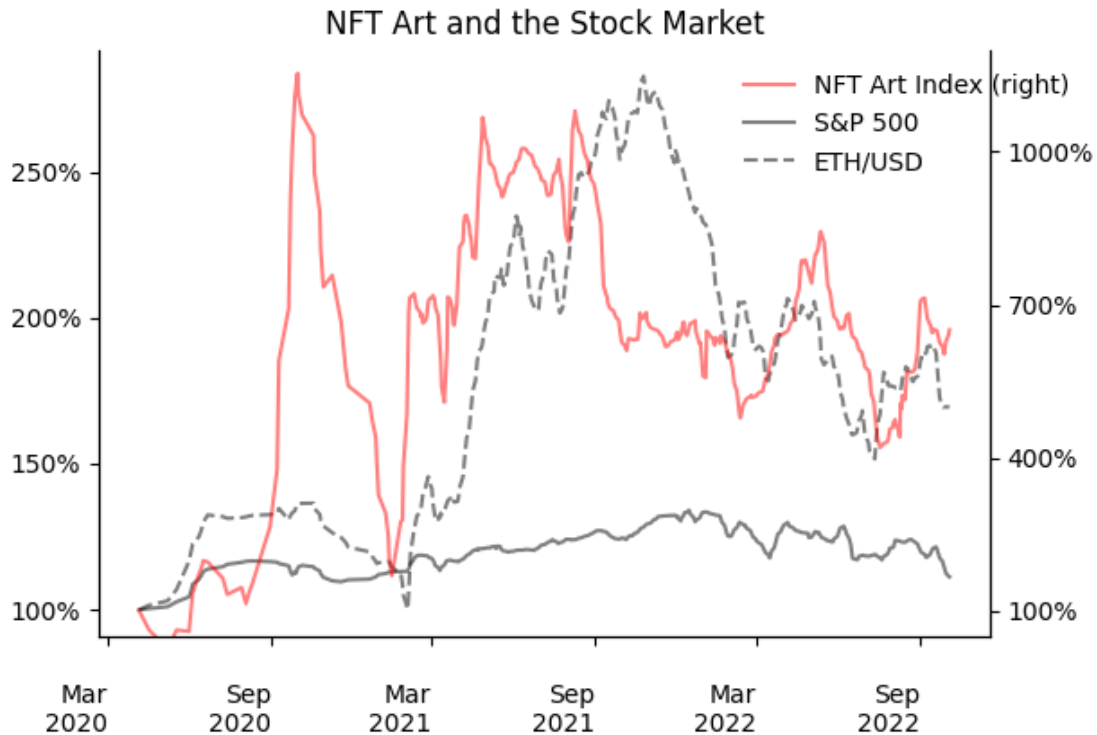
25

Figure 14   NFT Art Market and the Stock Market Equity Curves

Source: Historic price data from yahoo.finance.com; NFT Art Index: own calculation

had a roller coaster drive behind it. The NFT art index increased tenfold within a few months and dropped almost entirely right before multiplying by ten again. At the end of the sample period, the ETH price, as well as the NFT art index, increased by several hundreds of percent, whereat the stock market index gained less than 20%.

The following figure 15 substantiates these relationships, together with some more different asset classes and their monthly median returns. It appears that the NFT art index has a slightly positive correlation with the native cryptocurrency ether of the Ethereum blockchain and also with oil. Altogether the NFT art index shows little correlation with different asset classes, which is one desirable aspect of alternative investments because it can help with diversification. Looking at this correlation heat map in figure 15, a 3×3 cube in the top left attracts attention. The correlations among the S&P 500, ether, and bitcoin appear to be higher than most of the other correlation coefficients. As a conclusion from this heat map, one can say that cryptocurrencies may be positively correlated with the stock market and other assets, but NFT art, on the other hand, shows little market correlation.
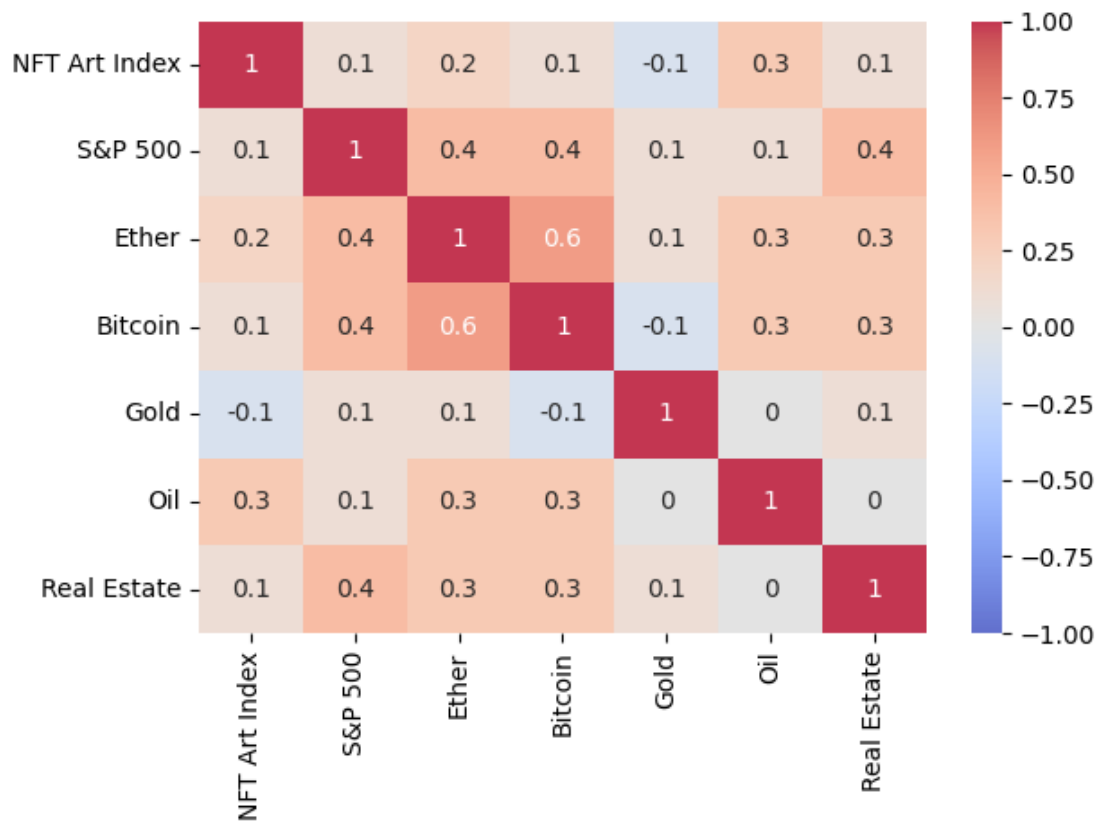
Figure 15   Correlation between NFT Art and Other Asset Classes

Source: Historic price data from yahoo.finance.com; Real estate is reflected by VanEck Global Real Estate UCITS ETF; NFT Art Index: own calculation.

3.3   Discussion on Profitability

The previous section analyzed the historical behavior of the NFT art market, with a focus on giving an objective overview of this new asset class to potential investors. In this last part of the analysis, both possible advantages and disadvantages of NFT art investments will be discussed, utilizing the previous findings.

3.3.1   Advantages

Looking at the scales of all graphs, including NFT art investment returns, it is eye-catching that 10x returns appear that often. Such large returns do exist in other asset classes but are comparably rare. NFT art pieces bought on the primary market for more than \$100,000 were able to double in price or achieve even larger returns. Most of the higher returns were achieved by, the lower price segment. The initial costs for such NFTs were \$1,000 or less, which makes these NFTs affordable for many investors with relatively small investment budgets. The above results also show that it is not necessary to place a lot of trades within the NFT art space to

become a profitable investor. It might even be unprofitable to trade a lot. Another benefit is the diversification aspect. NFT art is almost uncorrelated with other asset classes. This could be one of the biggest reasons to buy NFT art, right next to the possible large returns. There are not many alternative investments possible for retail investors with small budgets. Compared to traditional art, NFT art is easier to access. No transportation costs are required to get to the auctions by quickly accessing the primary market, just requiring a WiFi connection. But also reselling the art pieces on the secondary is possible in a minimalist fashion. Everything happens at the same location, for example, OpenSea. There is no KYC, Know-Your-Customer verification process required, which makes discrimination not possible within the NFT space. NFT art investors can profit from the decentralization and the ERC-721 standard. Compared to traditional art, historical transactions of NFT art are entirely transparent and visible on the blockchain. Additionally, many decentralized applications are open source, which allows users like NFT art investors to evaluate the marketplace they are using in terms of safety and reliability.

3.3.2 Disadvantages

One of the most significant disadvantages of NFT art investments is the short period of available data. Traditional art, other alternative investments, and common stocks provide a history in data of sometimes more than several centuries. The fact that NFT art has been existing for only a few years makes it difficult to compare with other investment types. Nevertheless, this work tries to bring some light into this new world of investments. Besides the short period of available data, the short median holding period attracts attention and might concern some potential investors. Intraday trades reflect most holding periods across the whole data set of NFT art trades. Many investors want to buy and hold long-term. Long-term investments of one year or more demonstrate an "all-or-nothing" pattern. This means investors can earn thousands of percent in return or lose their entire stake. Another drawdown from NFT art investments is cryptocurrency's relatively high exchange rate risk against fiat currency. As long as cryptocurrencies like ether are not commonly used in everyday life, chances are high that an investor wants to convert their NFT art profits back to fiat currency like USD. Not only volatility in cryptocurrency prices but also the relatively high volatility in the investment returns represent a disadvantage of NFT art investments. The commonly used metric Sharpe ratio makes affordable NFT art investments look unattractive. Thousands of percent in returns do not compensate for the high volatility. At the time of writing, lack of liquidity represents another risk. The total turnover across the data set summed up to only $8 million in September 2022. Comparing this number with almost half a billion USD in the total turnover

beginning of 2022, the liquidity fluctuation represents a severe risk. There may be simply not enough buyers when trying to sell the art piece. This might even lead to a kind of survivorship bias as explained by Goetzmann, Brown, et al. (1992). If NFT art cannot be sold, it will not appear in the data set since there is no return to measure. In addition to the total liquidity, there is also a cluster risk of liquidity. 51.30% of all trades happen within the first ten days of trading of each collection. This kind of risk may put pressure on investors to sell their NFT art pieces already after a short period of time. Another downside of NFT art investments is the uncertainty about transaction fees. While transaction fees are directly referred to the marketplace like OpenSea, the gas fees can fluctuate and may lead to eliminating profits, especially in the lower price segment. Finally, many countries still need to clarify the tax situation which depends on the individual investor. Common stock investments, on the opposite, are typically well-regulated, and many brokers carry the tax part for an investor.

4   Conclusion

The results of this work have shown that NFT art investments can provide returns of several thousand percent. Mainly lower priced art performed well. When looking at the Sharpe ratio, the lower-priced art loses that attractiveness. The risk-return relationship is similar to that of traditional art investments. The gap between extraordinarily high returns and significant losses reminds one of the pay-off structures of venture capital investments as described by Cochrane (2005). This indicates that NFT art can act as a severe alternative investment. Besides the high volatility in trade returns, the NFT art market is subject to cluster risk due to most trades happening within the first days of trading each collection. This makes it desirable to buy on the primary market and sell the art piece already after a short period of time instead of holding long-term. Additionally, liquidity depicts a risk because the total turnover dropped from half a billion to only eight million USD in September 2022. Another effect of investing in NFT art is the implied investment in cryptocurrency. This comes with additional exchange rate risk. NFT investors should either want to invest in cryptocurrencies or use financial instruments to hedge against this risk. Besides the risks, the high returns come with costs. The analysis has taken the fixed market price fee on OpenSea of 2.5% into account. But the volatile gas fees incurring for every transaction on the blockchain and the variable creator fees, ranging from zero to ten percent, also need to be considered before investing. A common point of criticism of blockchain in general often is environmental concerns. This can be opposed by the transition from proof-of-work to proof-of-stake, called the merge. As described by Ethereum.org (2022), the energy consumption of the Ethereum blockchain could be reduced by 99,95%.

Concluding it can be said that, yes, NFT art can represent an investment alternative. In the past, investors with all budget sizes had access to this new technology. Potential new investors need to make themself aware of the risks of NFT investing.

The future of NFTs continues to be interesting. NFT art prices and trade activity have dropped in the first quarter of 2022. The decrease might be due to the multiple crises around the world in 2022. In the meantime, prices of almost every other asset class have decreased, indicating that the problem might not be with NFT art itself. More and more mainstream companies are using NFTs in their business, like Meta (2022) with their social media app Instagram. In times of bots using artificial intelligence to auto-generate high-quality art, like DALL·E 2 by OpenAI (n.d.), and bots automatically buying and selling digital assets, the risk of an NFT bot bubble potentially emerges.

Bibliography

Alharby, M. and A. van Moorsel (2017). "Blockchain-based Smart Contracts: A Systematic Mapping Study". In: *CoRR* abs/1710.06372. arXiv: `1710.06372`.

Anderson, R. C. (Mar. 1974). "Paintings as an Investment". In: *Economic inquiry* 12.1. Last updated - 2013-02-23, p. 13.

Anson, M., F. Fabozzi, and F. Jones (2011). "The Handbook of Traditional and Alternative Investment Vehicles". In: John Wiley Sons, pp. 9–13. ISBN: 978-0-470-60973-6.

Bogle, J. C. (2010). *Common Sense on Mutual Funds*. Chap. Chapter 1, pp. 33–37.

Buterin, V. (Aug. 2014). "Ethereum: A Next-Generation Smart Contract and Decentralized Application Platform". In.

Buterin, V. et al. (Apr. 2019). "EIP-1559: Fee market change for ETH 1.0 chain". In: *Ethereum Improvement Proposals* 1559.

Chen, L., L. W. Cong, and Y. Xiao (2021). "A Brief Introduction to Blockchain Economics". In: *Information for Efficient Decision Making*. Chap. Chapter 1, pp. 1–40. DOI: `10.1142/9789811220470_0001`.

Cochrane, J. H. (2005). "The risk and return of venture capital". In: *Journal of Financial Economics* 75.1, pp. 3–52. ISSN: 0304-405X. DOI: `https://doi.org/10.1016/j.jfineco.2004.03.006`.

Entriken, W. et al. (Jan. 2018). "EIP-721: Non-Fungible Token Standard". In: *Ethereum Improvement Proposals* 721.

Ethereum.org (Nov. 2022). *The Merge*. URL: `https://ethereum.org/en/upgrades/merge/`. (accessed: 04.11.2022).

Goetzmann, W., S. J. Brown, et al. (Oct. 1992). "Survivorship bias in performance studies". In: *The Review of Financial Studies* 5.

Goetzmann, W., L. Renneboog, and C. Spaenjers (May 2011). "Art and Money". In: *American Economic Review* 101.3, pp. 222–26. DOI: `10.1257/aer.101.3.222`.

Gomber, P. et al. (June 2017). "Blockchain". In: *Business and Information Systems Engineering* 59. DOI: `10.1007/s12599-017-0467-3`.

Governors of the Federal Reserve System, '. of (September 2020). "Changes in U.S. Family Finances from 2016 to 2019: Evidence from the Survey of Consumer Finances". In: *Federeal Reserve Bulletin* 106.5.

Hughes, R. (Dec. 1984). "On art and money". In: *Art Monthly* 82.

Keim, D. B. (2003). "The Cost of Trend Chasing and The Illusion of Momentum Profits". In: *Wharton University of Pennsylvania: Finance Papers*.

Keister, L. A. (2000). *Wealth in America: Trends in Wealth Inequality*. Chap. Wealth Distribution, pp. 66–70.

Kong, D.-R. and T.-C. Lin (Aug. 2021). "Alternative Investments in the Fintech Era: The Risk and Return of Non-fungible Token (NFT)". In.

Meta (Nov. 2022). *Introducing New Tools for Creators to Build Businesses on Facebook and Instagram.* URL: `https://about.fb.com/news/2022/11/new-creators-tools-facebook-and-instagram/`. (accessed: 04.11.2022).

Nakamoto, S. (2008). "Bitcoin: A Peer-to-Peer Electronic Cash System". In: *bitcoin.org/bitcoin.pdf*.

OpenAI (n.d.). *DALL·E 2.* URL: `https://openai.com/dall-e-2/`. (accessed: 07.11.2022).

OpenSea (Oct. 2022a). *How to buy an NFT.* URL: `https://opensea.io/learn/how-to-buy-nft`. (accessed: 04.11.2022).

— (Oct. 2022b). *How to create an NFT on OpenSea.* URL: `https://opensea.io/learn/how-to-create-an-nft`. (accessed: 04.11.2022).

— (Oct. 2022c). *How to sell an NFT using OpenSea.* URL: `https://opensea.io/learn/how-to-sell-nfts`. (accessed: 04.11.2022).

— (Sept. 2022d). *What is a crypto wallet?* URL: `https://opensea.io/learn/what-is-crypto-wallet`. (accessed: 04.11.2022).

Rennebog, L. and C. Spaenjers (Apr. 2012). "Buying Beauty: On Prices and Returns in the Art Market". In: *Management Science* 59.1. DOI: `10.2139/ssrn.1352363`.

Rosenfeld, M. (2012). "Overview of Colored Coins". In: *bitcoil.co.il/BitcoinX.pdf*.

Seabold, S. and J. Perktold (2010). "statsmodels: Econometric and statistical modeling with python". In: *9th Python in Science Conference*.

Sharpe, W. F. (1998). "The sharpe ratio". In: *Streetwise–the Best of the Journal of Portfolio Management*, pp. 169–185.

Taulli, T. (2022). "Taxes and Regulations". In: *How to Create a Web3 Startup: A Guide for Tomorrow's Breakout Companies*. Berkeley, CA: Apress, pp. 151–163. ISBN: 978-1-4842-8683-8. DOI: `10.1007/978-1-4842-8683-8_9`.

Vogelsteller, F. and V. Buterin (Nov. 2015). "EIP-20: Token Standard". In: *Ethereum Improvement Proposals* 20.

Wang, Q. et al. (2021). *Non-Fungible Token (NFT): Overview, Evaluation, Opportunities and Challenges.* DOI: `10.48550/ARXIV.2105.07447`.

Winheller, S. and J. Schwendemann (n.d.). *Taxation of Non-Fungible Tokens in Germany.* URL: `https://www.winheller.com/bankrecht-finanzrecht/non-fungible-tokens/besteuerung-nft.html`. (accessed: 05.11.2022).

Wood, G. (Aug. 2022). "Ethereum: A secure decentralised generalised transaction ledger. Berlin Version". In.

A Appendix

A.1 Collections

0xmons.xyz	Killer GF
10KTF	Kitty Crypto Gang
3Landers	KnownOriginDigitalAsset
8SIAN	Lil Heroes
AIMoonbirds	Lives of Asuna
AVASTAR Token	Lost Poets
Anatomy Science Ape Club	MAX PAIN AND FRENS OPEN EDITION BY XCOPY
ArtAI	MOAR by Joan Cornella
Async Art	Meta Eagle Club
Autoglyphs	MidnightBreeze
Avid Lines	Mindblowon
Beeings	Murakami.Flowers
Beeple Round 2 Open Edition	Mutant Garden Seeder
Black Box	NFTBoxes
Bloot	Noodles
Boki	OGCR
Boonji Project	PeopleInThePlaceTheyLove
BoredApeYachtClub	Phanta Bear
C-01 Official Collection	Pop Art Cats
Cold Blooded Creepz	QQL Mint Pass
Corruptions	RareApepeYachtClub
Crypto Coven	Rarible
CryptoArte	Rektguy
CryptoJanky	Reptile Armoury
Cypher	SUPERPLASTIC: SUPERGUCCI
Deafbeef	Sneaky Vampire Syndicate
Desperate ApeWives	Squishiverse
Dippies	Super Cool World
Divine Anarchy	SuperRare
Elemental	TRAITORS by XCOPY
Fat Ape Club	Terraforms
Feline Fiendz	The Art of Seasons
First	The Surreals
Fishy Fam	TheCurrency
ForgottenRunesWizardsCult	Tubby Cats
Fragments By James Jean	Voxies
GODA Mint Pass	Waifus
Generativemasks	Weirdo Ghost Gang
Gh0stlyGh0sts	Women Rise
God Hates NFTees	Women and Weapons
Hashmasks	WonderPals
Hello, i'm Victor FEWOCiOUS And This is My Life!	YOLO
Incognito	inbetweeners
Karafuru Gachapon	merge.
Karafuru	

A.2 Regression on NFT Art Investment Returns

OLS Regression Results

Dep. Variable:	Log-Return	R-squared:	0.000
Model:	OLS	**Adj. R-squared:**	0.000
Method:	Least Squares	**F-statistic:**	13.70
Df Model:	3	**Prob (F-statistic):**	6.22e-09
Covariance Type:	nonrobust	**Log-Likelihood:**	-2.2017e+06
No. Observations:	272978	**AIC:**	4.403e+06
Df Residuals:	272974	**BIC:**	4.404e+06

	coef	std err	t	P>|t|	[0.025	0.975]
Intercept	12.9377	4.932	2.623	0.009	3.272	22.604
Holding Period	0.1487	0.024	6.130	0.000	0.101	0.196
Purchase Price	-0.0001	9.63e-05	-1.204	0.229	-0.000	7.28e-05
ETH/USD Price	-0.0034	0.002	-2.035	0.042	-0.007	-0.000

Table 5   Regression on NFT Art Profits

Statutory Declaration

"I herewith declare that I have composed the present thesis myself and without use of any other than the cited sources and aids. Sentences or parts of sentences quoted literally are marked as such; other references with regard to the statement and scope are indicated by full details of the publications concerned. The thesis in the same or similar form has not been submitted to any examination body and has not been published. This thesis was not yet, even in part, used in another examination or as a course performance."

Frankfurt am Main, 10.11.2022

_____

Viktor Fendesak