Non-Fungible Tokens (NFT). The Analysis of Risk and Return.

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Abstract

This study examines the risk and return characteristics of the NFT-based startups listed on the cryptocurrency exchange. Our investigation is motivated by the recent surge in the NFT activity on the part of creators, investors, and traders. We begin by proposing novel classification of the existing NFTs that range from NFT blockchains through NFT metaverse to NFT DeFi. Next, we establish that NFTs: 1) earn 130% on the first-listing-day; 2) yield an average investment multiple of 40 (roughly 4,000%) over long-term, which is four times higher than bitcoin during the same period; 3) deliver positive and significant alpha and exhibit above-average beta. We also show that the NFT segment of the cryptocurrency market leads market recovery following the mid-2021 crash and generate a return of close to 350%. In the final analysis of the paper, we find that NFT infrastructure integrated within the existing blockchains increase market valuations of these networks.

[1]This paper was minted as an NFT (ERC-1155) on OpenSea under the contract address 0x2953399124F0cBB46d2CbACD8A89cF0599974963

1 Introduction

Non-fungible token (NFT) is a way to record, verify, and track the ownership of a unique asset, either physical or digital. Consequently, NFTs can be utilized to represent a work of art, futures contract, music score, book, real estate, etc. – any type of object that could be considered unique or rare. NFTs are minted, stored and transferred on a blockchain, and therefore cannot be seized or tampered with by bad actors. On the other hand, NFTs can provide an instant proof of authenticity and provenance, thus eliminating the problem of counterfeiting. In the first half of 2021, NFT sales rose to a record $2.5 billion[2].

Just like the ERC-20 token revolutionized fundraising through Initial Coin Offerings (ICO) in 2017, the ERC-721 token has been transforming the way investors interact with nonfungible assets, whose elasticity of supply is close to zero - or in some instances - absolutely zero. Both types of tokes were first minted on the Ethereum blockchain, however, recently they are also created on other types of blockchains, some of them fully dedicated to NFTs (e.g., Flow, Ethernity, Efinity).

In this paper, we look at the investability of the NFT startups traded in the cryptocurrency markets. First, we propose the novel classification of the NFT firms driven by the advancements in the NFT technology[3]. Most of these projects are linked to the NFT gaming, NFT decentralized finance (DeFi), and NFT-dedicated blockchains – networks built solely for the purpose of serving the NFT primary and secondary markets, as well as other NFT applications. Next, by analogy to the IPO, we move on to the analysis of the first-day trading characteristics. We find that, at the time of listing, the average NFT has roughly a unicorn status with 977 ($mil) of market capitalization. The average first trading day return is an astounding 130% on a raw basis, and the first trading day volume is about 333% of the average daily volume. To put these numbers into context, first day returns to IPO are an order of magnitude lower. For example, Loughran and McDonald (2013) report the first-day return of 35% at the mean (they consider it high), whereas Aggarwal et al. (2002) find the first-day post-IPO volume of about 130%.

Further, we examine long-run price behavior of the NFTs. We calculate raw buy-and-hold returns starting one day after the listing day – an approach that eliminates the impact of large

[2]https://www.reuters.com/technology/nft-sales-volume-surges-25-bln-2021-first-half-2021-07-05/

[3]Throughout the paper we refer to the NFT startups as NFT-based projects or simply NFTs. These are young organizations that incorporate NFT technology into their main product line(s). In some instances, the NFT startups are represented solely by open-source protocols. In lieu of the initial share offering, as in the standard entrepreneurship model (e.g., Shleifer and Wolfenzon, 2002), NFT startups issue cryptocurrencies or tokens (in our analysis, we make no distinction between the two).

returns observed on the first day of trading. We find that NFTs yield spectacularly high returns in the long-run. Because the returns are abnormally high, we adopt the approach used in the venture capital (VC) industry and present the results as investment multiples, defined as the net proceeds from selling the cryptocurrency divided by the net cost of buying the cryptocurrency. The average value of the multiple in our sample is 6 (600% in percentage terms). It implies that the typical NFT generates the return six times greater than the cost of investment.

Among the best performing NFTs are Axie Infinity Shards (AXS) that delivers an investment multiple of 535, Theta (THETA) with 60, and four other startups that obtain a multiple of 10 or higher. To put these numbers into perspective, a renowned venture capitalist Peter Thiel, realized an investment multiple of 20 when selling Facebook shares in 2012 after an eight-year holding period[4]. In contrast to cumbersome and exclusive venture investments, available only for the certain types of investment vehicles, NFTs are also available for retail clientele. Remarkably, compared to typical winners firm in a VC portfolio (see e.g., Harris, Jenkinson, and Kaplan, 2014), NFTs appear to yield much higher returns in a much shorter time frame. It is worth emphasizing that our analysis is based on the publicly available cryptocurrency trading data. Knowing that the prices at which tokens are sold to institutional investors in a private pre-sales are significantly lower than the prices on the first-listing day, the true magnitude of the NFT investment multiples must be substantially higher. Finally, our sample includes only about 23% NFTs that generate long-term losses.

The levels of volatility observed for the NFTs in our sample may seem excessive with the standard deviation of daily returns of 11% (175% annualized). By comparison, the annualized volatility of natural gas is 51%, oil 30%, and S&P 500 index 15% (Huang, Li, Wang, and Zhou, 2020). We also find that most volatile NFTs, yield the lowest returns. A similar pattern is observed for public equities (Campbell and Hentschel, 1992), whereby volatility tends to rise after the prices fall. However, in the context of cryptocurrencies, this finding cannot be in any way explained by the leverage effect, as the NFT startups are debt-free.

In the tests that follow, we examine the returns on the risk-adjusted basis by using Sharpe ratios and market-adjusted returns. A closer look at the Sharpe ratios reveal a sample average of 0.32. Interestingly, this figure compares with the historical average of 0.3 reported for publicly traded stocks (Fama and French, 2002; Ferreira and Santa-Clara, 2011). Nevertheless, over 25% of the NFTs in our sample have Sharpe ratios greater than 1 (e.g., AXS, THETA, MANA, ERN). Sharpe ratio,

[4]https://www.wsj.com/articles/SB10000872396390443713704577601832028619176

however, does not reflect the magnitude of the return. An asset with a low return and a low volatility can have a relatively high Sharpe ratio. As an alternative, we also examine market-adjusted returns. The performance of the NFTs on the market-adjusted basis is remarkable, with the average return of 83% for the holding period of about 300 days. Roughly 60% of NFTs in our sample deliver positive returns and over half of these earn market-adjusted returns greater than 200%.

Next, we estimate the NFT alphas and betas. We follow Aggarwal, Green and Ren (2018) and use capital asset pricing model (CAPM), as a single-factor model seems to work better for alternative investments. We find that several NFTs deliver positive and significant alphas, whereas most NFTs have betas greater than 1. At the NFT portfolio level, alpha is positive and highly significant and the portfolio beta is roughly 1.1. Beta greater than 1 reflects greater volatility of NFTs with respect to bitcoin price movements. This finding makes sense, since if bitcoin were to fail as a technology then most likely other networks would fail as well – they are less resilient to common risk factors (lower security) and have significantly shorter history. Positive and significant alpha implies higher than expected returns due to additional risks to which NFTs might be exposed. These risks may arise from new and untested technology used by NFT-driven startups, prototype nature of their products and business models, regulatory uncertainty, and many others.

In the subsequent analysis, we construct the equal-weighted NFT price index. The objective is to indicate visually the performance of the NFT portfolio against the backdrop of the return to bitcoin – the oldest, most valuable, and trusted cryptocurrency. We are particularly interested in gauging how NFTs respond to the bitcoin drawdown that occurred in the mid 2021, when bitcoin lost about 55% of its market value (based on the intraday minimums and maximums). The magnitude of the drawdown compares in percentage terms with the bitcoin price drop in March 2020 triggered by COVID-19. First, we find that the portfolio of NFTs outperforms bitcoin in the long-run within the time-window starting on the initial listing day and ending on the last day of the sample period. The NFT investment multiple is close to 40 (4000%), compared to 10 (1000%) earned by bitcoin over the same time span. Second and equally important, the NFT portfolio outperforms bitcoin following the crash of mid-2021. The realized multiples are much smaller (3.5 vs. 1.5), however, what is perhaps more interesting is that NFT segment leads the crypto market recovery after the market bottoms out in the summer of 2021.

In the final test, we perform an event study to measure the valuation effect on the blockchains

due to the integration of the NFT technology within their ecosystems. We identify earliest press announcements of various NFT applications and NFT partnerships formed between the blockchain developers and NFT startups. To this end, we use Internet sources specialized in the crypto news coverage. We follow the standard event study methodology to estimate daily cumulative abnormal returns around NFT announcements and report the valuation effects based on a two day window (-1 to 0). We find that the integration of the NFT studios and NFT marketplaces within the existing blockchain architecture generates billions of the combined dollar gains. For example, the announcement of the two innovative NFT endeavors to be built on Solana blockchain increases Solana's market capitalization by 22% or $3 billion in dollar terms.

The remainder of the paper is organized as follows. Section 2 discusses the NFT financialization processes. Section 3 describes the data and the sample used in the paper. Section 4 presents the empirical results, and Section 5 concludes.

2 Financialization of the NFT

In this section, we provide a brief overview of the NFT financialization processes as well as profit opportunities NFTs generate for institutions, retail investors, creators, and network end-users. The section concludes with a discussion of the proposed extensions to the existing NFT usability and the NFT wealth management.

2.1 NFT transformation of the existing asset classes

Arguably, most of the investable assets available in private and public markets are non-fungible. For instance, the estimated value of real-estate - which by nature is non-fungible - far exceeds the capitalizations of both the global bond and equity markets[5]. Perhaps more important, the derivatives, which are the largest asset class with the notional value of $580 trillion[6], are non-fungible as well [7]. They cannot be transferred between different exchanges and trading systems. Obviously, art and collectibles are another group of non-fungible assets, albeit with significantly lower value (about $2

[5]https://europhoenix.com/blog/part\%2Dii\%2Don\%2Dasset\%2Dclasses\%2Dsize\%2Dof\%2Dmarkets\%2Dand\%2Dtrading\%2Dvolumesby\%2Dles\%2Dnemethy\%2Dand\%2Dsergey\%2Dglekov/

[6]https://www.bis.org/statistics/about_derivatives_stats.htm?m=6\%7C32\%7C639

[7]https://www.ft.com/content/f6474a8a-76f0-11de-b23c-00144feabdc0

trillion[8]). Interestingly, ADRs are not fungible either. Non-US investors cannot trade ADRs in their home markets on par with domestic stocks (Bacidore and Sofianos, 2002).

The above discussion and advances in existing technology imply that all non-fungible assets can be represented as NFTs. Exploring this possibility is critically important for a number of reasons. First, NFTs improve market liquidity and price discovery. It is more efficient to trade assets, if the ownership can be instantaneously proven and transferred quickly and securely for a near-zero fee. That way, NFTs increase openness, transparency, and financial globalization of the assets. In and of itself, this leads to higher trading volumes and market expansion. Second, NFTs eliminate delayed clearance and settlement functions. At present, settlement lag can be counted in days (Duffie, Garleanu, and Pedersen, 2002). NFTs shorten settlement process from days to seconds. Moreover, Covitz and Downing (2007) report that some market participants still use physical clearance. In stark contrast, NFTs use fraud-proof blockchains, where information can be verified and recorded instantaneously. Third, collateral management requires transparency, which in the existing financial system can be seriously compromised as in the recent case of e.g., Archegos[9]. Here again, the NFT provides a clear-cut solution, where market participants have no opportunity to camouflage self-serving behaviors.

2.2 NFT minting, trading, and auctioning

Presently, the most prevalent use case for NFT is artwork and in-game items (see Figure 1 and 2). One might expect this to be so because NFT architecture allows for the removal of the intermediary between the creator and the public, thus increasing the product outreach, profit margin, and sales potential. It is well known that in the artworld, there still exist gatekeepers that limit creators' access to the marketplace. These include exclusive venues, elite groups, and rent-extracting middlemen. The NFTs allow for circumventing the traditional gatekeepers in the art world. Notably, the creators are able to generate (mint) the NFT of their art piece or the entire art collection on the blockchain using either the existing on-line marketplaces (e.g., OpenSea, Rarible) or decentralized applications that directly connect them to the desired network. One need not be expert to be able to mint an NFT, a process that removes entry barriers to the primary and secondary art markets. Going

[8]https://www2.deloitte.com/content/dam/Deloitte/lu/Documents/financial-services/artandfinance/lu-art-and-finance-report-2019.pdf

[9]https://www.wsj.com/articles/inside-credit-suisses-5-5-billion-breakdown-archegos-11623072713

further, minting an NFT appears to be synonymous with marketing an NFT, either at an arbitrary fixed-price or through various auction mechanisms.

[Place Figure 1 and 2 about here]

A related issue concerns the rights sold together with the NFT. The existing standards remain flexible. For example, the current owner of the most expensive NFT to date, "Everydays: The First 500 Days" by Beeple, which sold for 69.3 ($mil), acquired the right to display the NFT but not the copyrights. On the other hand, owners of the Hashmasks NFTs (there are 16,384 unique ones) acquire unlimited rights to use, copy, and display the NFT. Awkwardly, the NFT of the tungsten cube sold on OpenSea grants its holder the right to "one visit to see/photograph/touch the cube per calendar year."

2.3 NFT liquidity mining and NFT farming

NFT liquidity mining and NFT farming are closely related concepts. NFT liquidity mining is an investment activity that involves locking an NFT in a smart contract with two main objectives, depending on the market side: 1) creating NFT deposits (providing liquidity) on the NFT platform, and 2) generating a profit for the NFT investor for making the NFT deposit. Similar to a simple buy-and-hold strategy, NFT liquidity mining requires creating or purchasing an NFT and sending it to a smart contract (akin to staking activity in the PoS blockchain). In return for providing NFT liquidity, investor receives interest. Interest payment is typically denominated in a native currency of the network that relies on NFT liquidity mining for survival. It should be emphasized, that mining programs could arguably amass greater liquidity, if NFTs are fractionalized and therefore directly interchangeable.

For example, Dego Finance (DEGO) is the NFT-related project that focuses on NFT minitng, auctioning, trading, farming, and other diverse NFT applications[10]. Dego pays NFT owners for depositing their NFTs in the native Dego token with voting and dividend rights attached. The yield on staking is determined by the mining efficiency and power value attributed to a given NFT[11].

NFT farming, on the other hand, involves staking blockchain native token with the aim of receiving a native NFT as a reward, which then could be held, sold or used as collateral. NFT farming

[10]https://dego.finance
[11]https://docs.dego.finance

is currently operational on some of the NFT-dedicated blockchains (e.g., Ethernity, SuperFarm). It is worth noting that the locked native token can be un-farmed at any time.

2.4 NFT collateral-based loans

NFT holders may wish to unlock liquidity using collateralized loans against the value of their NFTs. The freed-up resources could then be used for investment, charity, consumption and more. Similar to existing lending protocols in DeFi, NFTs market valuation can be determined algorithmically in a smart contract. Conversely, investors may wish to borrow an NFT with the objective to generate yield. Paribus (PBX) is one of the protocols at the forefront of the NFT borrowing and lending. Another startup, Yield Guild Games (YGG) operates as an NFT holding firm and lends out NFTs to blockchain-based game players for a fee.

2.5 Fractional NFT

Unlike accredited investors and investment funds, retail clientele has limited access to capital, which narrows their investment opportunity set. On the other hand, certain asset classes experience low liquidity and unbalanced markets due to their prohibitive price levels. Blockchain technology solves the above problems by allowing for fractionalization of assets, that is, breaking up the asset into a number of smaller pieces. This possibility has already been discussed in the literature in the context of artwork under the name of securitization (Mei and Moses, 2002).

NFT fractionalization enables investors to purchase a piece of the NFT. It therefore represents the opportunity to get exposure to expensive and renowned NFT with high absolute price levels. For example, in a recent auction at Christie's, an NFT by a contemporary artist Mike Winkelmann (aka Beeple) sold for 69($mil) – an auction price out of reach for retail investors, fans, and small collectors. Fractionalization also ensures greater diversification potential. A piece of NFT can thus improve portfolio efficiency i.e., its alpha for a given level of risk.

The work of art can be minted as NFT, however, once it is split into multiple parts, each of these parts might be represented by a fungible token, that is a token which is perfectly interchangeable with other parts of the same NFT. Conversely, an NFT can be fractionalized into multiple NFT of different distinctive features and thus distinct valuations, and remain non-fungible. For example, a collector may be willing to pay more for Mona Lisa's shard of lips than for a shard of background

landscape from the same painting. In any case, many different collectors can now own pieces of exactly the same artwork, a possibility that never existed before in history.

Fractional NFT can be further endowed. It can be envisaged that owners of the fractional NFTs pool them together to create a decentralized autonomous organization (DAO) and issue shares against that endowment. The example suggests endless possibilities opened up by tokenization of unique assets.

3 Data and sample

Our data are drawn from Binance API as of August 31, 2021. We select Binance because it is the largest crypto-exchange in the world with the daily volume an order of magnitude higher than the second largest crypto-exchange in the ranking. Binance is also known for being retail-oriented, offering the largest number of cryptocurrency trading pairs, and being available in more geographic locations than any other exchange. Likewise, Binance caters to a larger public by listing assets relatively quickly following the launch of the crypto project. For example, only in August 2021, Binance listed 12 new cryptocurrencies and many more trading pairs against different sovereign currencies and stablecoins.

We begin by downloading all USDT trading pairs from the Binance spot market on August 31, 2021[12]. We extract 296 pairs, which correspond to roughly 296 different cryptocurrencies including Binance leveraged tokens. From these, we select only the projects that embed NFT technology as the central element of the business model. We classify the project as an NFT-driven if the white paper (or website) mentions an NFT product or service. It can be either an already existing product or the product in the making, yet close to the implementation. We exclude fairly established well-known blockchains that have their own native NFT studios, however, their NFT activity is both nascent and not dominant vis-à-vis other lines of business (e.g., Tezos, Solana, Avalanche). Notwithstanding, we provide a separate analysis of these NFT friendly blockchains in the later sections.

[Place Table 1 about here]

We find 20 NFT-based projects that list 22 different tokens (see Table 1). We classify them into six groups: NFT purpose-built blockchains, NFT gaming, NFT music, NFT media, NFT DeFi,

[12]https://www.binance.com/en/markets

and NFT "other". As can be seen in the Table 1, the dominant group belongs to the class of NFT gaming (7 projects), followed by NFT DeFi (6), and the NFT-dedicated blockchian architecture (5). Most of these projects issue tokens that intend to facilitate the governance of the network. About half of them intend to converge gradually into the decentralized autonomous organizations (DAO). Most of the networks are run either on their native blockchains or recently have switched from Ethereum into much cheaper and faster Proof-of-Stake (PoS) layer 1 or layer 2 systems.

To be included in the main analysis, the NFT token must be listed on Binance for at least 1 month, therefore we exclude from most tests 3 projects, as they begin trading in August 2021 and do not accumulate enough data (ERN, MBOX, and GHST). Thus, our final sample includes 17 projects with 19 different tokens. Among them, there are two projects that issue two different tokens each: Axie Infinity (AXS, SLP) and Theta (THETA, TFUEL). Arguably, the cross-section of 19 cryptocurrencies constitute broad enough sample. Existing studies use very few cryptocurrencies in the analysis, mostly bitcoin, ethereum, and ripple, as in Makarov and Schoar (2020). Equally important, ours is the first study that investigates NFT-based startups listed on cryptocurrency exchange. It is also the first paper to seriously consider risk and return characteristics of the NFTs.

4 Results

In this section we report the results of our main analyses. We begin by presenting NFT initial-listing-day characteristics. Then, we move to estimating NFT volatilities, raw-returns, Sharpe ratios, and returns on the market-adjusted basis. In the next step, we analyze NFT alphas and betas. Subsequently, we construct NFT price index that tracks NFT price movement over the long-run. We conclude by carrying out an event study to measure NFT-induced blockchain valuation effects.

4.1 NFT listing characteristics, risk, and raw return

Table 2 displays some key listing characteristics of the NFT cryptocurrencies as well as their riskiness and raw return performance. Column 1 reports the name of the NFT with the exception of Axie Infinity Shards (AXS) and Smooth Love Potion (SLP), which are token names that belong to the same network, as well as Theta Fuel (TFUEL) and Theta (THETA), which are the integral part of another network. As shown in Column 3, NFTs have been listed on the exchange for the duration ranging from 9 to 867 days, the sample average being 314 days. The number of trading days is

to some degree correlated with market capitalization, although there are some large outliers. For example, Cocos-BCX has been listed on the cryptocurrency exchange for over two years, whereas its market valuation stands at only $31 million.

[Place Table 2 about here]

Our sample includes 7 NFT "unicorns" that is companies with a token-based market capitalization of at least $1 billion (Column 4). These are Theta ($8.4bn), PancakeSwap ($5bn), Axie Infinity Shards ($4.4bn), Decentrland ($1.7bn), Enjin ($1.7bn), Flow ($1.4bn), and Audius ($1bn). Some of them are newly listed, for example, the NFT-dedicated blockchain architecture Flow has been traded on the Binance exchange for only 33 days. When we exclude unicorns, the average market capitalization drops to $354mil, indicating that our sample displays some heterogeneity in size. This figure compares with the average pre-money valuation of successful startups that exited through US-based IPO (see e.g., Nanda and Rhodes-Kropf, 2013).

Column 6 shows an astounding average first-day return of 130%, even after excluding the outlying observation of My Neighbor Alice (ALICE) that earns on the first listing day 24,640%. Unfortunately, we do not have information on the offer price (price at which tokens are sold directly to investors in private undisclosed deals). Nevertheless, typically, just like in the IPO, the offer price is significantly lower than the open price on the initial listing day. We draw on the IPO study of Aggarwal, Krigman, and Womack (2002) and estimate the first day return as the difference between the close and open prices scaled by the price at market open. The average return is 130% (median 31%). These values are substantially higher than 35% (13%) for IPO reported in Loughran and McDonald (2013) or 24% (18%) in Liu and Ritter (2011) although, during the 1999-2000 dot-com bubble the first day IPO return averaged 71%. First-day trading volume is enormous, indicating the increased market activity on day one. It is about 400% percent higher than the average volume recorded over a 30-day period following the listing. Even if we exclude the outlier (ALICE), the first-day volume remains as high as 333%. For comparison, Aggarwal et al. (2002) report first-day volume scaled by the number of shares offered in IPO to be 129% at the mean.

[Place Figure 3 about here]

Figure 3 reports first-listing-day NFT winners and losers. The average total return since listing is over 3,000% (Column 6) driven primarily by one outlying observation that belongs to

AXS (53,535%). If we remove AXS from the calculation, the return remains equally impressive and amounts to over 600% (median 65%). The total return is estimated as the close price on 31 August 2021 divided by the close price on the second listing day minus one. Effectively, it is a raw buy-and-hold return. Note that this is the crude measure of return, as it does not account for the holding period, which varies from NFT to NFT, neither it controls for the timing of the investment. Recall that the average longevity of the NFT enterprise on the crypto exchange is slightly less than one year. For purposes of comparison, long-term IPO performance has been documented to be persistently negative starting from the first month following the initial listing date (see e.g., Fan, Wong, and Zhang 2007; Ritter, 1991). In contrast, the average long-term return to the portfolio of NFTs is positive and spectacularly high (above 600%).

Alternatively, we could present the returns as investment multiples, which is a widely used metric in the venture capital (VC) industry. Investment multiple is defined as the sum of all cash distributions, net of fees and carry, divided by all cash contributions. If we suppose that all investments are made on the second listing day and are liquidated on 31 August 2021 (end of sample period), then the average investment multiple is 6 (assuming the only contribution is the money spent on buying the NFT and the only distributions are the proceeds from the sale of this NFT). For comparison, the study by Brown, Harris, Hu, Jenkinson, Kaplan, and Robinson (2021), reports investment multiples between 1.56 and 3.49 for their sample of venture capital funds between 1987 and 2013.

[Place Figure 4 about here]

Looking into investment multiples in more detail (Figure 4, Panel A), we find that the first five winning projects exhibit extraordinary returns, even if grossly underestimated. Typically, startup founders mint tokens prior to the initial listing and sell them to investors in private undisclosed deals at a considerable discount. Unfortunately, we do not have data on the terms of these private token sales. Despite the fact that we are forced to omit considerable pre-listing price appreciations from our analysis, the NFT multiples are staggering. For example, THETA returns roughly 60 times the money invested. Together with TFUEL the multiple rises to over 73 (both are part of the same crypto-network). The second highest is SAND with a multiple of 18 and MANA returning 12 times the capital invested. On the other hand, the losses are very limited with only 5 tokens out of 19 experiencing negative returns (26% of the sample). The largest loser is SUPER with the multiple of -0.7 or -71% return. To conclude, NFTs appear to behave much like venture investments with the

exception that they exhibit reduced downside risk and greater upside potential as compared to the average VC portfolio firm (see e.g., Harris, Jenkinson, and Kaplan, 2014). More specifically, about 23% of the NFTs in our sample give a return greater than 1,000% compared with 15% for the VC (Cochrane, 2005).

Next, we turn to the preliminary analysis of risk. By looking at the daily volatilities (Table 2, Column 11) we infer that the average volatility of the NFT-based projects is very high (11% daily) and that the volatility distribution (unlike return) is symmetric with the mean and median being equal. The least volatile NFT token is GHST (2% daily), whereas the most volatile one is MBOX (27% daily), even though they have been listed on the crypto exchange during the same calendar time. The annualized volatility is explosive 174% (median 176%), an order of magnitude higher than the volatility of the US listed equity.

[Place Figure 5 about here]

Figure 5 plots the relationship between daily values of return and volatility. As depicted in Panel A, the volatility clusters around the 11% level with the exception of the three outliers MBOX, WAX, and GHST, all of which began trading in August 2021. When we remove the outliers, the relationship between risk and return becomes parabolic (Panel B). It appears that, top performers are most volatile but so are the worst performers – among the riskiest NFTs there are either big winners or losers. The alternative explanation may be that the failing projects increase return volatility, due to extreme downside moves. Because the returns are scaled (per unit of time), the identity of the winners are different than those depicted in Figure 4, Panel A. The identity of losers remains the same, because these are the only projects in the sample that generate negative returns.

4.2 NFT risk-adjusted performance

In this section, we analyze returns to NFTs on the risk-adjusted basis. To this end, we select two standard measures: Sharpe ratio and market-adjusted return. We use ex-post Sharpe ratio defined as historic average differential return per unit of historic variability of the differential return as in Sharpe (1994). Then, for purposes of standardization we annualize both nominator and denominator (daily returns and daily volatilities). As seen in Table 3, the average Sharpe ratio for the entire sample of NFTs - after excluding an extreme outlier - is 0.32 (median 0.37). Interestingly, this figure compares

with the historical average of 0.3 for publicly traded equities (see e.g., Fama and French, 2002; Ferreira and Santa-Clara, 2011).

[Place Table 3 about here]

A closer look at the results reveal that several observations stand out (Column 2). ERN, MANA, AUDIO, THETA, and SAND have Sharpe ratios of at least 1. This subset overlaps to some degree with the top performers reported in Figure 4 and 5. However, the Sharpe ratio does not reveal the magnitude of the risk-adjusted returns. Small return (in absolute terms) with low volatility may translate into a high Sharpe ratio. Column 3 of Table 3 reports the results for the sample subperiod characterized by the strong crypto market recovery. Due to significantly higher returns during this time and approximately similar level of volatility, Sharpe ratios are significantly higher with a mean of 1.7. It is important to note that the Sharpe ratio distribution is skewed to the left with a median equal to 2.1.

In the following test, we consider market-adjusted returns. In contrast to Sharpe ratio, market-adjusted returns account for risk and at the same time convey information about the magnitude of the return. We proxy for the market return using return to bitcoin. Our motivation comes from the vast finance literature that uses S&P500 as a benchmark for different types of asset classes and investment vehicles, even those that include foreign holdings (see e.g., Becker, Ferson, Myers, and Schill, 1999; Mei and Moses, 2002; Kaplan and Schoar, 2005; Dichev and Yu, 2011). Moreover, crypto financial institutions tend to use bitcoin as the crypto market benchmark[13]. The results are displayed in Table 3 Column 3. They are closely in line with Sharp ratios at least for the subset of top and bottom performers. Among the NFTs that generate the highest returns are THETA, MANA, SAND, and AUDIO (as before, we exclude AXS). For example, both MANA and SAND, which have been trading on the crypto exchange for approximately the same amount of time (13 months) offer an impressive performance to investors of respectively 340% and 255%, above the return on bitcoin. It is worth highlighting that the price of bitcoin appreciated about 4.5 times (or 450%) during the same time interval.

Returns estimated since the market low on June 22, 2021 are equally stunning. SAND and ALICE generate, on the market-adjusted basis, at least 236% each, whereas TLM and AUDIO over 125%. Further, DEGO and SUPER earn 73% each. There are only four NFTs which underperform

[13]https://cryptofundresearch.com/q2-2021-crypto-fund-report/

bitcoin (TFUEL, SLP, THETA, and BAKE), TFUEL being the most extreme losing NFT (-52%), ahead of SLP (-34). It is important to stress that TFUEL and THETA are one of the best performers long-term (Figure 4, Panel A). Both have been listed on the crypto exchange for over two years and together with ENJ are the most senior NFTs traded on the crypto market. On the other hand, TLM is one of the best short-term performers but in the long-term it loses about 50% of its value against bitcoin (Figure 4, Panel B).

4.3 NFT alphas and betas

In this section, we estimate NFT alpha and beta from the capital asset pricing model (CAPM). We select a simple CAPM, because in the context of alternative investments "investor's flow preferences are best explained by performance when the returns from other risk factors are subsumed in the CAPM alpha." (Agarwal, Green, and Ren, 2018). We begin by estimating both parameters for each single NFT in the sample using hourly frequency data and the time series of returns from the initial listing day until the end of the sample period. We proxy for the market return using the return on bitcoin and assume the risk-free rate is zero. The latter is a reasonable assumption under the current economic circumstances.

[Place Table 5 about here]

Looking at Table 5, we notice that the vast majority of NFTs have positive alphas among which AXS, AUDIO, MANA, and THETA produce alphas, which are statistically significant at least at the 10% level. This result corresponds closely to our previous findings discussed above. AXS, AUDIO, MANA, and THETA are among the best-performing NFTs on both absolute and risk-adjusted basis. Moreover, and perhaps more important, when we estimate the parameters for the entire sample, alpha is positive and highly statistically significant at the 1% level. According to the standard interpretation, alpha captures returns unrelated to the market that may reflect additional risks unaccounted for in the existing model. From a different angle, alpha indicates how well the assets perform relative to the given benchmark. In our context, NFTs generate significantly higher returns than the average cryptocurrency in the crypto market.

When we turn to betas, we find that 12 out of 19 NFTs (63%) have betas significantly greater than one, with the average being 1.1. The highest beta estimate is 2 (TLM) and the lowest is 0.8 (FLOW). There are four other NFTs with betas ranging from 1.5 to 1.7 (ALICE, BAKE, CAKE,

and SUPER). It is interesting to note that almost all best performing NFTs on both the absolute and the risk-adjusted basis have betas that remain lower than one (AXS, THETA, TFUEL, SAND, MANA, AUDIO).

4.4 NFT price index

We construct the equal-weighted NFT index by scaling the NFT price series by their first-listing-day prices at market close. Then we average them out using the simple average. We do the same with the price of bitcoin and use it as a backdrop. The plots are depicted in Figure 6, Panel A. The series runs from 10 April 2019, which is the initial trading day for the oldest NFT in the sample Theta (THETA). The plot has a cut-off point on 1 July 2020, as prior to that date, NFT price index and bitcoin move in very close parallel. Therefore, for the sake of visual clarity, we do not to report it. As seen on Panel A, the portfolio of NFTs outperforms bitcoin by a factor of 4. Investing in NFTs in the bear market of 2019 would have generated after 2.5 years roughly $3800 for each $100. On the other hand, in the same period, bitcoin would have yielded $940. These returns are simple buy-and-hold returns that do not use compounding.

[Place Figure 6 about here]

If we exclude the superior performing NFT of Axie Infinity Shards (AXS), the NFT portfolio underperforms bitcoin (Figure 6 Panel B). The NFT investment multiple drops to 7 and bitcoin's remains at 9.4. However, excluding the outliers from the analysis may not be the right approach. In the VC industry large positive outliers are the norm. Venture capitalist actively search for outliers, as the few positive outliers determine the ultimate VC returns and the likelihood of VC success.

4.5 NFT at the forefront of the crypto market recovery

Panel C in Figure 6 shows the NFT price index during the roughly ten-week period following the bitcoin 55% price drawdown that bottomed out on June 22, 2021. As in the prior subsection, we construct the equal-weighted NFT price index by scaling NFT cryptocurrency prices by the close price on June 22 (by construction, 1 is the first index value). We proceed the same with the price of bitcoin. As seen in Figure 6 Panel C, the NFT index outperforms bitcoin by the factor of 7. More specifically, investing in the portfolio of NFTs around June 22, 2021 would have yielded a whopping

250% return in absolute terms and 200% in excess of bitcoin. It is worth pointing out that during the same period bitcoin generates a non-trivial 50% return. Also, note that NFT and bitcoin move in concert for some time before NFT begins outperforming bitcoin, meaning that investors had a great deal of flexibility in the timing of entry into the NFT positions.

In Panel B, we exclude superior performing cryptocurrency project Axie Infinity (AXS), even though AXS seems like a natural candidate for the NFT portfolio. It is probably the most successful and widely known NFT with total sales volume exceeding $2.3 billion[14], the bulk of which was generated during the first nine months of 2021. As seen in Panel B, excluding AXS from the index reduces the return on the NFT portfolio to 133% over a ten-week span (compared to 250% with AXS, see Panel A). On a bitcoin-adjusted basis, the return is over 80%. In any case, with or without the inclusion of AXS, the return to NFTs is staggering.

The above analysis shows, that the NFT cryptocurrency segment leads the recovery of the entire crypto market after the mid-year crash (May-June 2021). The reasons seem evident. Axie Infinity is perhaps the first successful use case for blockchain that adds additional functionality to the blockchain architecture apart from the being only the means of exchange and the store of value, as in the case of the Bitcoin-like networks. In the type of organization that underlies Axie Infinity (governance systems converging to DAO) the incentivized stakeholders include game players (or other direct users), developers, miners, advisors as well as other groups. Players benefit monetarily by engaging in the game, which in turn attracts new participants, leading to the improved aggregate value of the network, and the increased size of the treasury. Consequently, the treasury pays developers to improve the attractiveness of the product, which lures new players, further boosting network valuation, and the amount of resources stockpiled in the treasury. And the cycle repeats. It is worth noting that in e.g., Bitcoin, it is solely the miners who benefit directly from the systemic incentives.

Taken together, it is probably for the first time in the blockchain economic history that a cryptocurrency project generates billions in revenue from the actual users of the working product developed on top of the blockchain architecture[15]. It is the active users and the associated transaction fees that drive up the market capitalization of the NFT. From this perspective, it seems reasonable that the market expects abnormal gains on the venture that has a sellable product and a broad

[14]https://dappradar.com/nft/marketplaces

[15]https://fortune.com/2021/08/25/crypto-video-game-axie-infinity-crypto-traders-unemployed/

and fast-growing user base. The NFT technology in and of itself does not guarantee commercial success, however, it unlocks massive value by removing long-standing business frictions among various stakeholders in the traditional organization. From a somewhat different angle, NFT allows for financialization of all sorts of assets that could be easily and costlessly transferred, monetized, and liquidated in various ways by the users. This high value potential seems to be well understood by "smart money". According to the crypto analytics firm Messari Research, prominent venture and hedge funds are already invested in the NFTs (e.g., ALICE, AXS, BLZ, SAND)[16].

4.6 Does NFT infrastructure add value to blockchains?

The NFT boom of 2021 demonstrates convincingly that blockchains are able to: 1) solve real-life problems, 2) be deployed fast, and 3) create value both for the users and the underlying networks. Many existing blockchains that compete with Ethereum by adopting different consensus mechanisms and therefore increasing transaction speed and reducing fees, venture into NFT technology with the objective to broaden user base and boost market valuations. In August 2021, NFT sales volume on the OpenSea marketplace reached close to $4 billion compared with only $8 million in January 2021[17], which represents a 50,000% surge. This highlights the enormous revenue potential of the NFT economics built on top of the existing blockchains.

Driven by the excess demand curve, various existing blockchains began integrating NFT infrastructure that enables NFT minting, trading, auctioning, mining, staking etc. It seems sensible to say that NFT mania catalyzed significantly wider blockchain adoption – a significant step toward inevitable transformation of commerce and financial services by blockchain technology.

[Place Table 6 about here]

With this in mind, we run the next analysis to estimate how much value has been created for the existing blockchains due to their recent assimilation of the NFT architecture. To this end, we search for news stories about NFT in the context of the largest third generation blockchains by market capitalization. We select Algorand, Avalanche, Polkadot, Solana, Tezos, and Zilliqa. Then, we conduct a standard event study to determine whether the market reacts positively to the anticipated strategic implementations of the NFT. We use one factor market model to measure

[16]https://messari.io/article/messari-fund-analysis-h1-21-examining-liquid-portfolios-of-crypto-funds
[17]https://www.reuters.com/article/us-crypto-currency-nft-explainer-idUSKBN2B92MA

abnormal performance and a two-day event window (-1 to 0). Similar to previous tests, we proxy for the return on the market with the return on bitcoin. This approach is akin to using S&P500 as a benchmark for evaluating fund performance, including those with different investment styles and funds with foreign holdings (e.g., Becker, Ferson, Myers, and Schill, 1999).

The results are reported in Table 5. As seen in the table, a couple of NFT events concerning Solana blockchain are associated with the average unexpected 22% price increase of SOL (Solana's native cryptocurrency), a move which translates into the increase in the aggregate market capitalization of the Solana network on the order of $3 billion. Similarly, the transmission of news concerning the new NFT dedicated blockchain Efinity built on Polkadot, raises instantaneously the value of Polkadot network by over $1.5 billion or 4.6%, whereas the announcement of the Unifty launching NFT farming incentives on the Avalanche blockchain, boosts the value of the Avalanche network by over $1 billion (18%).

The above demonstrates massive value creation for blockchans that expand their functionality into the realm of NFT.

5 Conclusion

This study examines the risk and return characteristics of the NFT-based startups whose valuations are determined on a cryptocurrency exchange. Recent months have seen a surge in the use of NFTs, including primary NFT offerings and feverish NFT trading on the secondary markets. The NFT industry represents another important use case for blockchains, in addition to fundraising, remittance, store of value, borrowing, and lending.

A number of interesting results emerge from our dataset along the NFT risk and return attributes. First, we find that NFTs earn large first-day returns of 130% on average. This is an order of magnitude higher than returns on IPOs - startup firms going public on a traditional stock exchange. The first-day NFT volume is also abnormally high, pointing to a large value of assets changing hands on the first day of listing. Second, we show that NFTs provide superior long-term returns, both on the raw and the risk-adjusted basis. By way of comparison, the returns to NFTs are substantially higher than both long-term returns to IPO and returns from VC investments (about 23% NFTs in our sample give a return greater than 1,000%). Furthermore, volatility of NFTs remains excessively high (11% daily or 175% annually), implying that NFTs are for investors who are willing

to bear relatively high level of risk. On the other hand, knowing that the correlation between NFTs and S&P500 is nearly zero, NFTs can reduce portfolio variance, while maintaining portfolio expected return. This last attribute renders NFT an appealing diversifier. Third, we estimate NFT alphas and betas. We find that at the portfolio level, NFTs deliver positive and significant alpha and have an above-average beta. Finally, we run an event-study and estimate blockchain valuation effects that come about as a result of implementing the NFT technology. We show that incorporating NFTs into the existing blockchain networks can boosts their market valuations by over 20%.

A natural extension of our study would be to look into the on-chain activity of the NFT startups as potential predictors of their market performance. We leave this challenging question for future research.

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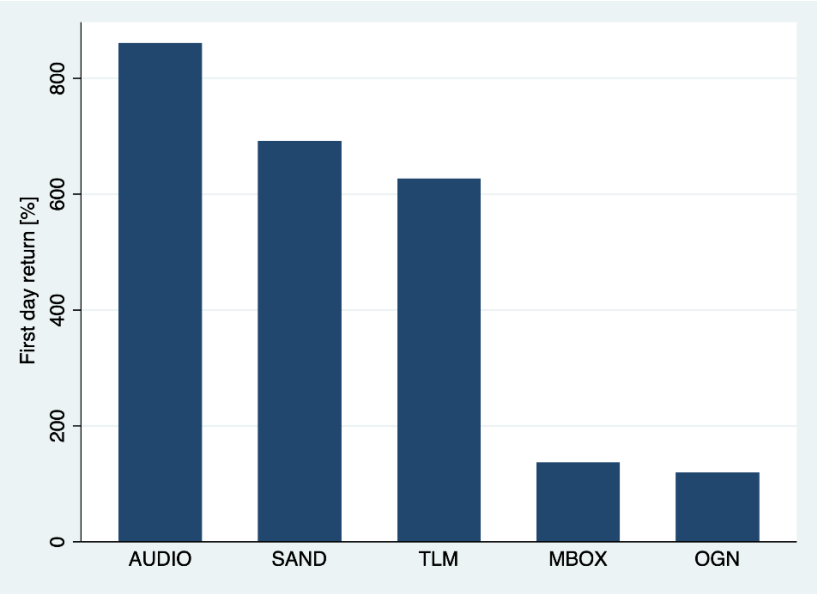
Figure 1
The visual arts NFT displayed below called "Bored Ape #8585" sold on October 20, 2021 on the OpenSea for $2.7 million (696.696 ETH). It belongs to the collection "Bored Ape Yacht Club" that features 10,000 unique visual arts NFTs at the current average price of $196,000, making the entire series worth close to $2 billion. The listing price of the Ape on the day of the project launch on April 30, 2021 was 0.08 ETH per single NFT (around $220 excluding gas fee).

Figure 2
The NFT shown below is the in-game asset from the metaverse Star Atlas built on Solana blockchain.

Figure 3
NFT first-listing-day returns
The bar charts displays winners and losers among the sample NFTs based on their first-listing-day returns. First-day return is calculated as the close price on the initial listing day divided by open price on the dame day minus one. The following NFTs classify as winners: Audius (AUDIO), Sandbox (SAND), Alien Worlds (TLM), Mobox (MBOX), Origin Protocol (OGN). Loser NFTs include: Theta (THETA), Bluzelle (BLZ), Ethernity (ERN), Theta Fuel (TFUEL), and Cocos-BCX (COCOS). The data are derived from Binance API as of August 31, 2021.

Panel A: Winners



Panel B: Losers

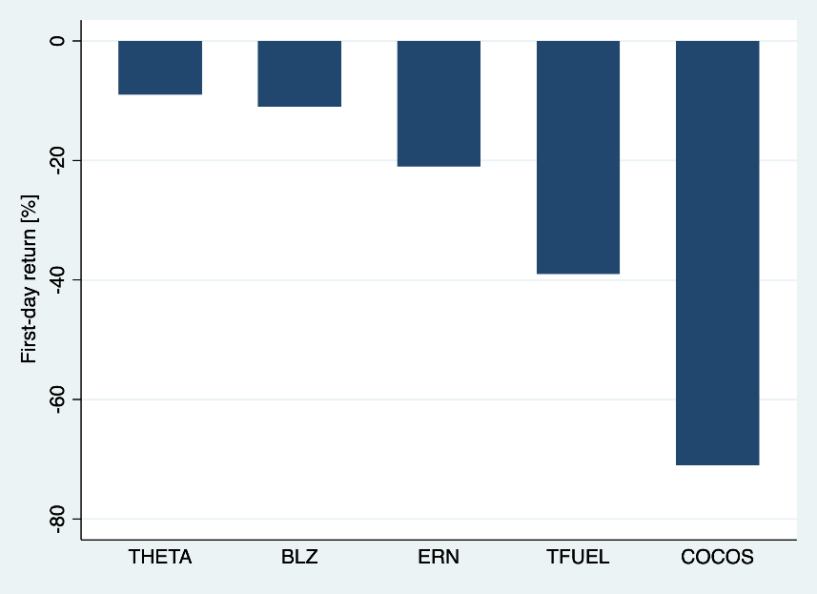
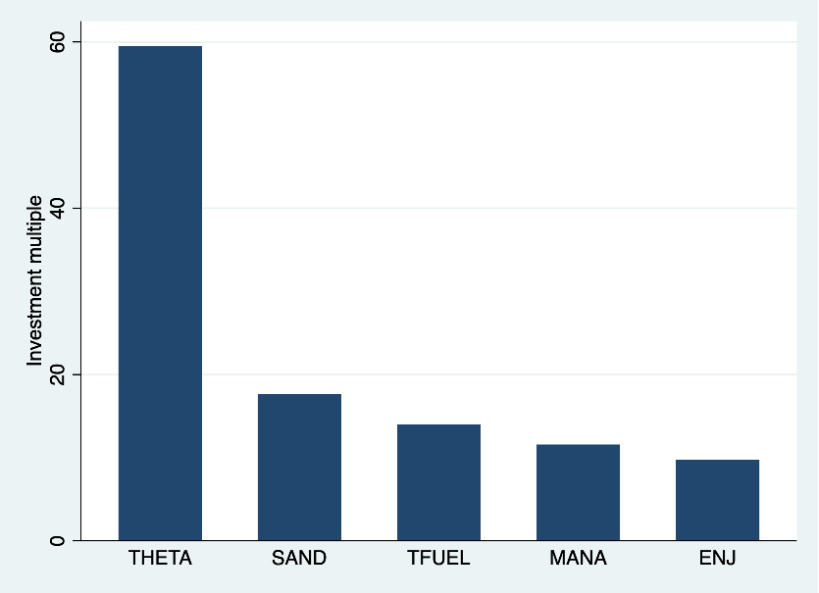


Figure 4
NFT long-term winners and losers
The bar charts displays winners and losers among the sample NFTs based on their long-term performance. Bars denote investment multiple, a widely used metric in the venture capital industry. In calculating the multiple, it is assumed that the only contributions are the money spent on buying the NFT on the second listing day (market close), and the only distributions are the proceeds from the sale of the NFT on 31 August 2021 (end of the sample period). Panel A reports the winners excluding Axie Infinity Shards (AXS), whose investment multiple is equal to 535 and is the order of magnitude higher than the second best performing NFT (THETA). The following NFTs classify as winners: Theta (THETA), Sandbox (SAND), Theta Fuel (TFUEL), Decentraland (MANA), and Enjin (ENJ). Loser NFTs include: SuperFarm (SUPER), Smooth Love Potion (SLP), Cocos-BCX (COCOS), BakerySwap (BAKE), and Alien Worlds (TLM). We consider only NFT-based projects with at least one month of available data. The data are derived from Binance API as of August 31, 2021.

Panel A: Winners



Panel B: Losers

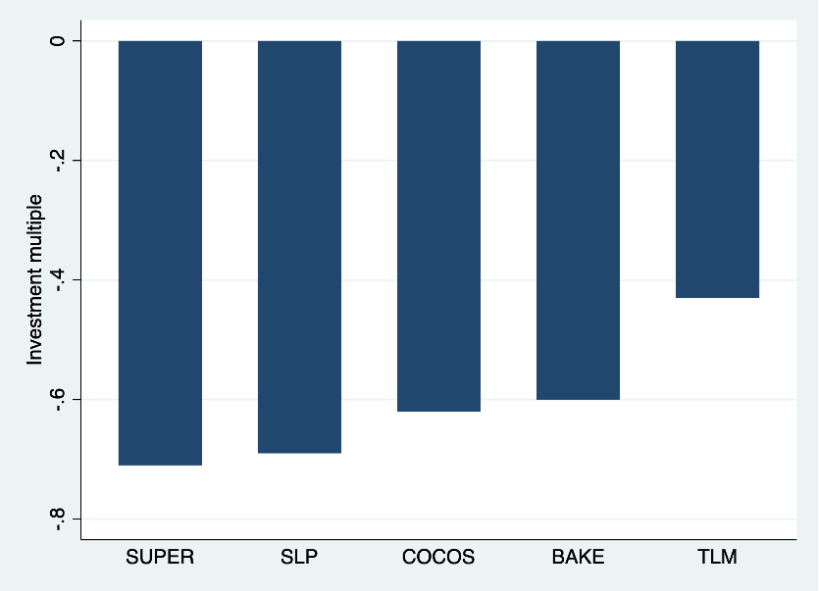
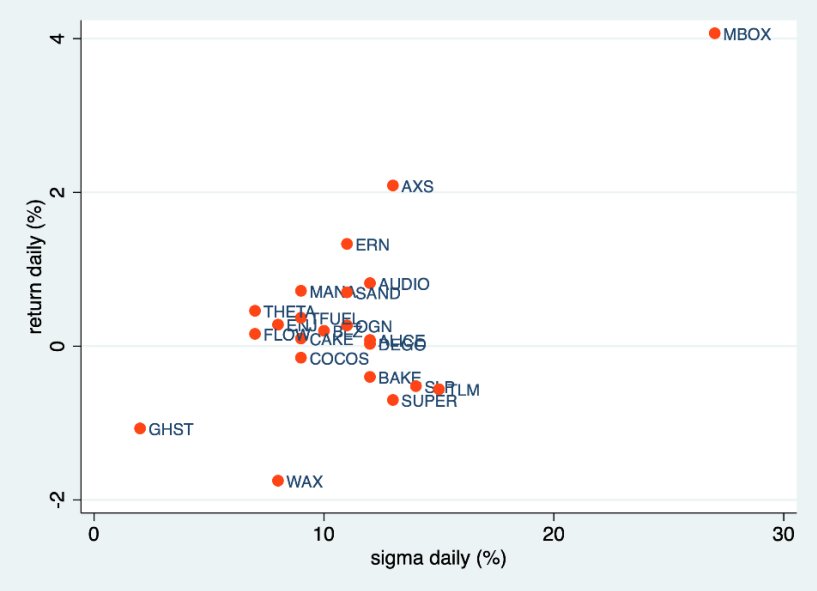


Figure 5
NFT daily return and volatility
The scatterplot displays the relationship between daily return and daily volatility for our sample of NFTs. Returns are daily compound returns estimated beginning on the second listing day to avoid the impact of unusually high returns, observed on the initial listing day. Volatility is measured as the standard deviation of daily returns beginning on the second listing day. Panel A includes the entire sample. Panel B excludes NFTs that begin trading in August 2021, as they do not accumulate enough data. The data are derived from Binance API as of August 31, 2021.

Panel A: Entire sample



Panel B: Excluding most recent listings

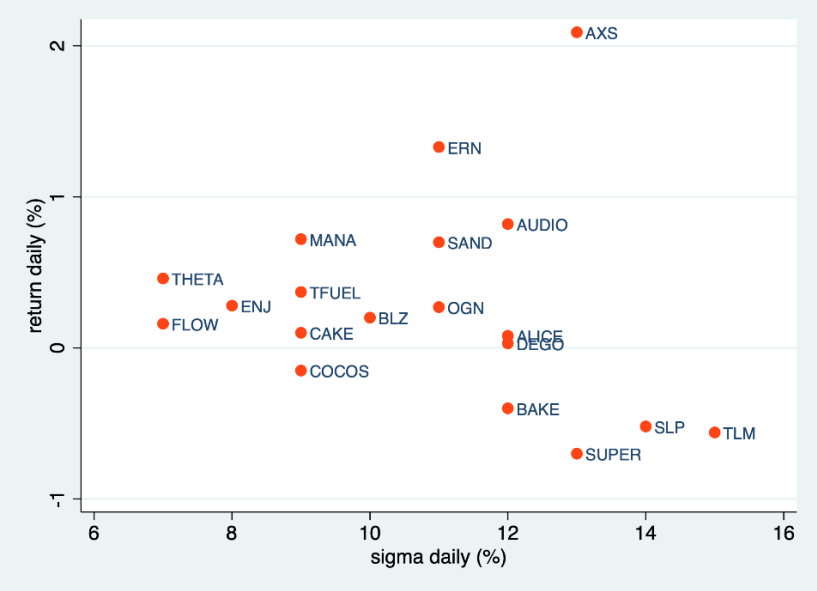
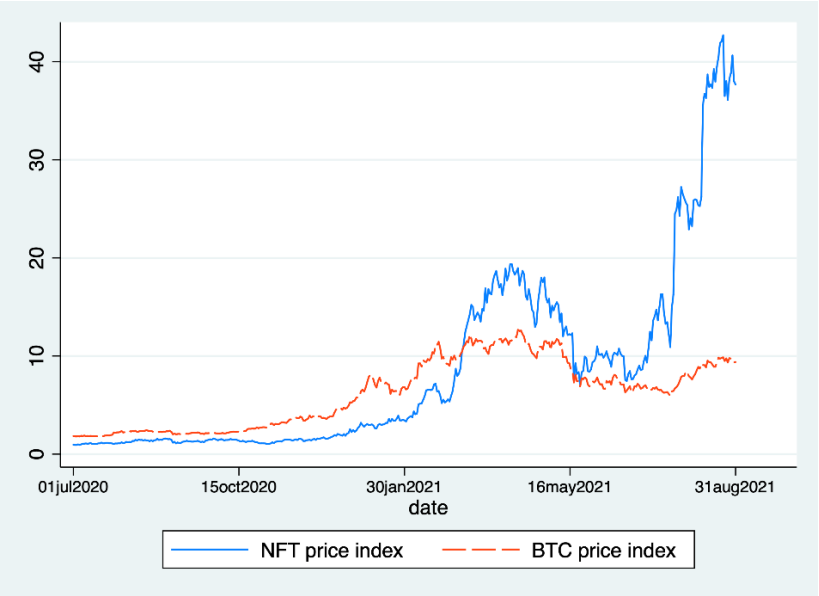


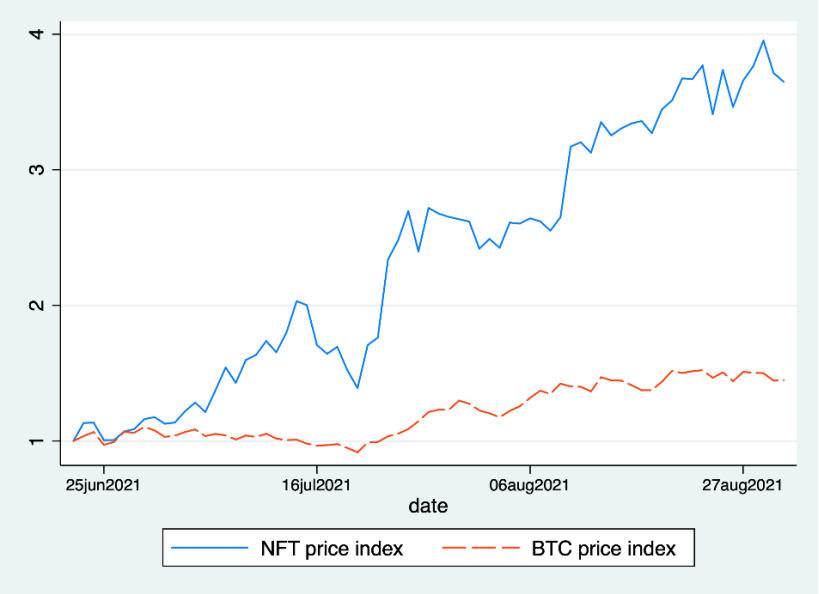
Figure 6
NFT price index
The plots depict the evolution of the equal-weighted NFT price index (solid line) and the price of bitcoin (broken line). In Panels A(B) the NFT price index is constructed as follows: the daily close price of each NFT is scaled to one on the second listing day. The prices are then averaged out using the simple average. Panel B excludes an outlying observation of Axie Infinity Shards (AXS). In both panels we choose 1 July 2020 as the cutoff point, because prior to that date, the NFT index and the price of bitcoin move in close parallel. In Panels C(D) the daily close price of each NFT is scaled to one on 22 June 2021 - the date when the intraday price of bitcoin reached its local minimum following a 55% price drawdown. The prices are then averaged out using the simple average. The value of the index minus one and multiplied by 100% can be interpreted as a passive buy-and-hold return. Panel B excludes the extreme outlier of Axie Infinity Shards (AXS). Data are derived from Binance API as of August 31, 2021.

Panel A: Entire series



Panel B: Excluding outliers

Panel C: Since mid-2021 crash



Panel D: Excluding outliers

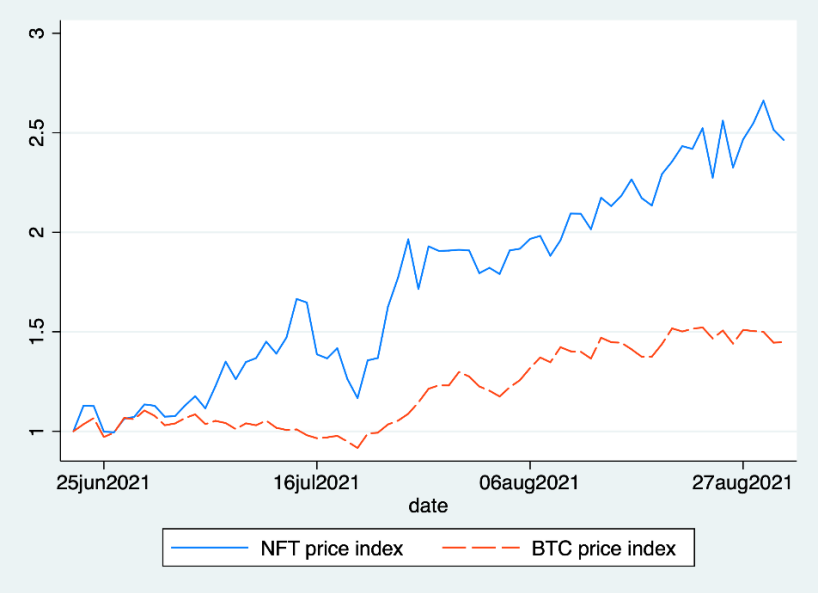


Table 1
Crypto exchange listed NFTs
This table presents the categorization of the startups that embed NFT technology as the main product line(s). Data are derived from Binance API as of 31 August 2021.

Project name	Ticker	Business model	Governance token	NFT dimension	Blockchain	DAO
Panel A: NFT purpose-built blockchains						
Cocos-BCX	COCOS	Blockchain gaming infrastructure	Yes	digital game economy	CocosChain	No
Ethernity	ERN	Produces authenticated NFTs and trading cards	Yes	exclusive NFT (notable figures)	Ethernity Chain	No
Flow	FLOW	Blockchain for creators developers and artists	Yes	apps, games, digital assets	Flow	No
WAX	WAXP	Blockchain for NFTs, dApps and video games	Yes	apps, games, digital assets	WAX	No
Panel B: NFT gaming						
Alien Worlds	TLM	Decentralized metaverse, gaming	Yes	game assets	WAX, BSC	Yes
Axie Infinity	AXS SLP	Gaming, play-to-earn	Yes	game assets	Ronin	Yes
Decentraland	MANA	Virtual reality, gaming, gambling	Yes	digital assets, art	Ethereum Polygon	Yes
Enjin	ENJ	Managing, distributing and trading virtual goods	Yes	gaming, NFT platform, NFT marketplace, NFT blockchain	Ethereum Efinity	No
Mobox	MBOX	Gaming, play-to-earn	Yes	NFT staking, mining, marketplace, NFT game creator	BSC	Yes
My Neighbor Alice	ALICE	Gaming, play-to-earn	Yes	game assets	Chromia	Yes
Sandbox	SAND	Gaming, play-to-earn	Yes	game assets	Ethereum	Yes
Panel C: NFT music						
Audius	AUDIO	music streaming	Yes	music, art gallery of music artists and fans	Solana	Yes
Panel D: NFT media						
Theta	THETA TFUEL	Decentralized video streaming and data delivery	Yes	Digital rights, NFT liquidity mining, NFT marketplace	Theta	No
Panel E: NFT DeFi						
Aavegotchi	GHST	DeFi-staked crypto collectibles powered by Aave	Yes	NFT staking, NFT mini games	Polygon	Yes
BakerySwap	BAKE	Automated market maker decentralized exchange	No	NFT marketplace NFT gamification	BSC	No
Dego Finance	DEGO	Decentralized cross-chain NFT ecosystem	Yes	NFT issuance, mining, marketplace, applications	BSC	Yes
Origin Protocol	OGN	DeFi NFT commerce	Yes	NFT launchpad	Ethereum	No
PancakeSwap	CAKE	Automated market maker decentralized exchange	Yes	NFT marketplace	BSC	No
SuperFarm	SUPER	Decentralized cross-chain NFT ecosystem	Yes	NFT issuance, mining, marketplace, gaming, launchpad	Ethereum	Yes
Panel F: NFT other						
Bluzelle	BLZ	Decentralized storage network for the creator economy	Yes	NFT decentralized storage	BluzelleNet	No

Table 2

NFT listing characteristics, risk, and raw return

The table reports listing characteristics as well as the risk and return profile of the NFTs in the sample. Market capitalization is reported as of 31 August 2021. Data are derived from Binance API as of 31 August 2021. Variable definitions are provided in the Appendix.

NFT	Ticker	Days since listing	Market cap ($mil)	First-day volume (%)	First-day return (%)	Total return since listing (%)	Total return since bottom (%)	Daily return since listing (%)	Daily return since bottom (%)	Daily volatility (%)	Annualized volatility (%)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
My Neighbor Alice	ALICE	170	416	1,947	20,640	6	381	0.08	2.23	12	194
Audius	AUDIO	313	999	145	861	932	231	0.82	1.17	12	188
Axie Infinity Shards	AXS	301	4,394	455	46	53,535	2,154	2.09	4.49	13	209
Bakery Swap	BAKE	124	509	21	-6	-60	27	-0.40	0.33	12	194
Bluzelle	BLZ	386	77	25	-11	87	88	0.20	0.89	10	161
Pancake Swap	CAKE	194	5,027	172	98	56	89	0.10	0.90	9	150
Cocos-BCX	COCOS	739	31	750	-71	-62	64	-0.15	0.70	9	144
Dego Finance	DEGO	175	96	311	47	13	153	0.03	1.31	12	196
Enjin	ENJ	867	1,685	100	-1	975	115	0.28	1.09	8	122
Ethernity	ERN	71	181	421	-20	129	n.a.	1.33	n.a.	11	175
Flow	FLOW	33	1,435	528	31	3	n.a.	0.16	n.a.	7	107
Avegotchi	GHST	12	105	257	8.5	-9	n.a.	-1.07	n.a.	2	33
Decentraland	MANA	391	1,695	51	9	1,158	103	0.72	1.00	9	141
Mobox	MBOX	13	420	460	137	74	n.a.	4.07	3.74	27	427
Origin Protocol	OGN	601	397	563	120	462	69	0.27	0.74	11	177
Sandbox	SAND	383	844	846	692	1,765	432	0.70	2.38	11	179
Smooth Love Potion	SLP	124	244	475	92	-69	1	-0.52	0.01	14	222
Super Farm	SUPER	160	91	342	1	-71	145	-0.70	1.27	13	199
Theta Fuel	TFUEL	831	1,752	292	-39	1,402	-28	0.37	-0.46	9	149
Theta	THETA	875	6,661	109	-9	5,948	2	0.46	0.03	7	113
Alien Worlds	TLM	141	303	343	627	-43	264	-0.56	1.84	15	235
Wax	WAX	9	600	328	113	4	n.a.	-1.75	-1.55	8	120
Mean (entire sample)		314	1,271	406	1,062	3011	252	0.30	1.16	11	174
Mean (excl. max)		288	977	333	130	605	134	0.21	0.98	10	162
Median		185	465	328	31	65	103	0.18	1.00	11	176
St. Dev.		289	1,790	409	258	1,346	507	1.16	1.39	4.6	73

Table 3

NFT risk-adjusted return

The table presents Sharpe ratios and market-adjusted returns for the sample of the crypto exchange listed NFTs sorted by market-adjusted returns (Column4). Sharpe ratios are defined as in Sharpe (1994) and are annualized based on the daily returns and volatilities. Market-adjusted returns are compounded daily returns computed as the difference between raw return and return on bitcoin. NFTs not listed on June 22, 2021 (local minimum) are excluded from the analysis whose results are displayed in Columns 3 and 5. Data are derived from Binance API as of 31 August 2021.

NFT	Ticker	Sharpe ratio since listing	Sharpe ratio since bottom	BTC-adjusted return since listing (%)	BTC-adjusted return since bottom (%)
	(1)	(2)	(3)	(4)	(5)
Axie Infinity Shards	AXS	2.52	4.73	15,952	1,483
Theta	THETA	1.02	0.08	464	-31
Decentraland	MANA	1.28	2.45	340	38
Sandbox	SAND	0.99	3.63	255	261
Audius	AUDIO	1.09	2.19	221	125
Theta Fuel	TFUEL	0.63	-1.29	210	-52
Ethernity	ERN	1.91	na	83	na
Pancake Swap	CAKE	0.16	2.93	77	28
Dego Finance	DEGO	0.04	1.99	48	73
My Neighbor Alice	ALICE	-0.11	2.76	26	236
Enjin	ENJ	0.58	2.58	16	47
Origin Protocol	OGN	0.39	1.68	-2	13
Flow	FLOW	0.37	na	-6	na
Bakery Swap	BAKE	-0.52	0.64	-10	-14
Alien Worlds	TLM	-0.6	2.12	-24	156
Smooth Love Potion	SLP	-0.59	0.13	-25	-34
Bluzelle	BLZ	0.31	2.61	-37	26
Super Farm	SUPER	-0.89	1.91	-53	73
Cocos-BCX	COCOS	-0.26	1.24	-93	12
Mean (entire sample)		0.44	1.90	918	144
Mean (excl. max)		0.32	1.73	83	60
Median		0.37	2.12	26	38
St. Dev.		0.89	1.43	3,644	357

Table 4

Correlation matrix

This table shows correlation coefficients between bitcoin, S&P500, and the crypto exchange listed NFTs. Bottom follows a 55% price drawdown of bitcoin and falls on June 22, 2021. Data are derived from Thomson Reuters EIKON and Binance API as of 31 August 2021.

Corr.	NFT	bitcoin	NFT	bitcoin
	entire time series		since bottom	
S&P500	15.4%	17.25%	2.2%	12.7%
bitcoin	60.2%	1	66.7%	1

Table 5
NFT alpha and beta

The table reports alpha and beta coefficients for each NFT in our sample estimated using the capital asset pricing model (CAPM). NFTs are sorted by Beta (Column 4). The frequency of data is hourly. The time series runs from the first listing day until the end of the sample period. NFTs listed in August 2021 are excluded from the sample due to an insufficient number of observations. Data are derived from Binance API as of 31 August 2021.

NFT	Ticker	Alpha x (103)	*p*-value	Beta	*p*-value
	(1)	(2)	(3)	(4)	(5)
Alien Worlds	TLM	0.500	0.545	1.955***	0.000
Pancake Swap	CAKE	0.521	0.216	1.706***	0.000
Super Farm	SUPER	0.037	0.954	1.568***	0.000
Bakery Swap	BAKE	-0.149	0.795	1.519***	0.000
My Neighbor Alice	ALICE	0.738	0.446	1.454 ***	0.000
Dego Finance	DEGO	0.273	0.638	1.312***	0.000
Ethernity	ERN	0.952	0.215	1.237***	0.000
Bluzelle	BLZ	0.149	0.682	1.220***	0.000
Origin Protocol	OGN	0.654	0.141	1.219***	0.000
Decentraland	MANA	0.684**	0.025	1.214***	0.000
Smooth Love Potion	SLP	0.312	0.756	1.134***	0.000
Sandbox	SAND	0.667	0.157	1.080***	0.000
Enjin	ENJ	0.482	0.208	0.981***	0.000
Theta	THETA	0.470**	0.022	0.963***	0.000
Axie Infinity Shards	AXS	1.963***	0.012	0.942***	0.000
Audius	AUDIO	0.982*	0.077	0.918***	0.000
Theta Fuel	TFUEL	0.959	0.176	0.802***	0.000
Flow	FLOW	-0.267	0.659	0.793***	0.000
Cocos-BCX	COCOS	-0.004	0.988	0.765***	0.000
Entire sample		0.559***	0.000	1.078***	0.000

Table 6

NFT event study

This table presents a selection of news announcements concerning the adoption of NFT architecture by the third generation blockchains. These blockchains have higher throughput, lower transaction costs, and faster finality as compared to Bitcoin or Ethereum. CAR is the average two-day (-1 to 0) cumulative abnormal return estimated using market model methodology, where the market return is proxied by the return on bitcoin. Valuation effect is calculated as the product of the circulating supply of the blockchain native cryptocurrency, its daily close price on day -1, and CAR.

Blockchain	Ticker	Date	NFT event	CAR	Valuation effect ($bn)
Algorand	ALGO	3 June 2021	Curate integrates Algo payments to mint NFT on Algorand	16.68%	0.60
Avalanche	AVAX	27 April 2021	Unifty launches NFT farming incentives on Avalanche	18.37%	1.07
Polkadot	DOT	31 March 2021	Enjin raises funding to build NFT blockchain Efinity on Polkadot	4.57%	1.53
Solana	SOL	18 May 2021	1) NFT art market and gallery VR-All-Art integrates with Solana; 2) Only1 first social NFT platform built on Solana	22.02%	3.00
Tezos	XTZ	17 June 2021	McLaren to build NFT platform on Tezos	7.83%	0.21
Zilliqa	ZIL	27 May 2021	Polaris Sports exclusive NFT collection on Zilliqa	14.38%	0.22

Appendix

Variable definitions

Variable	Definition
First-day return	Daily return on the first-listing-day calculated as the close price divided by the open price minus one.
Return since listing	Buy-and-hold return calculated as the close price on August 31, 2021 divided by the close price on the second listing day minus one. Due to the excessive volatility, the first-listing-day return is excluded from the calculation.
Return since bottom	Buy-and-hold return calculated as the close price on August 31, 2021 divided by the close price on June 22, 2021 minus one. June 22 marks intraday market low after the 55% drawdown of the price of bitcoin. The magnitude of the drawdown compares to bitcoin price drop in March 2020 triggered by COVID-19.
Daily return	Daily average return estimated based on the compound return.
First day volume	Volume on the initial listing day divided by the average volume estimated over the 30-day period following the first-listing-day.
Daily volatility	Standard deviation of daily return estimated over the life of the NFT. Due to excessive volatility, the first-listing-day is excluded from the calculation.
BTC-adjusted return	Raw return less the return on bitcoin, compounded daily.