

# **The Effect of Ethereum Gas Fees on Non-Fungible Token Demand**

Junior Independent Work

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This paper represents my own work in accordance with  
University Regulations

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# I. Introduction:

From the onset of 2021, blockchain technologies, consisting of digitalized ledgers recording all sorts of transactional data, have exploded in popularity and mainstream adoption. Leading this innovation has been the industry of cryptocurrencies which use the blockchain framework to facilitate the transfer of digital currency between agents on a decentralized network. While Bitcoin holds the highest cryptocurrency market capitalization due to its first-mover status, the second most popular coin, Ether, retains popularity because of its connection to the overall Ethereum network. Whereas the Bitcoin blockchain exists solely for the secure and decentralized transactions of its cryptocurrency, the Ethereum network is a fully programmable blockchain allowing for the creation of all sorts of financial services and decentralized apps (Dapps) (*Home / Ethereum.Org*, n.d.). These projects range anywhere from tower defense games to sophisticated lending platforms offering interest on cryptocurrency collateral. Ethereum founder, Vitalik Buterin, gives the following analogy in explaining the relationship: “Ethereum is the oil. Because Ethereum will be the energy source on the internet for the technology world. For this reason, we call Ether crypto-fuel. The energy needed by the Ethereum platform will be provided \by Ether (ETH)” (*Is Ethereum the New Oil?*, n.d.). Thus, with this elaborate framework, the possibilities for ingenuity and creation have led to entirely new asset classes that depend on the Ethereum network and token.

The most transformative of these new submarkets have been Non-Fungible Tokens or NFTs. Deemed as the word of 2021 by the Collins Dictionary, an NFT, in a fundamental sense, is a digital asset that represents some entity such as music, video game items, art, or collectibles, each with unique properties (Conti, 2022). Thus, while cryptocurrencies boomed in 2021, NFT total trading volume surged from \$63 million in 2020 to an astonishing \$23 billion by this year’s

end (Herrera, 2021). As a result, because NFTs rely on the functionality of blockchain networks and are typically paid for by cryptocurrency instead of fiat, this increase in demand has been followed by a simultaneous rise in corresponding blockchain network congestion. Most notably has been the effect on the Ethereum network, which accounts for 78% of the overall NFT market (Herrera, 2021).

Because Ethereum is a programmable blockchain, all its operations require a fee to compensate those providing the necessary computing power. These actions include basic tasks like sending ETH across crypto wallets to more computationally intensive activities like swapping one Ethereum-based coin for another (ERC20 Token Swap) or acquiring an NFT from a seller on a marketplace. Because Ethereum is decentralized, these fees, known as ‘Gas,’ provide the necessary compensation to incentive miners to carry out all the demanded operations on the Ethereum network (Hake, 2021). Thus, in times of congestion, the demand curve moves outward, causing Gas fees to increase naturally. With NFT demand surging in 2021, these Gas fees have been steadily rising following more activity on the network, with spikes often resulting in transaction costs in the hundreds of dollars. This increase in gas can often be a deal-breaker barrier to entry for small-scale market participants, as acquiring an NFT often results in a few independent operations requiring a fee (Hake, 2021). For example, it is not uncommon to pay hundreds of dollars in gas to acquire an asset whose market worth may only be \$50. With these variable transaction costs, influencers and market participants have increasingly vocalized their concerns on popular news and social media outlets. Despite such criticisms, it remains unclear what the actual effect of Ethereum’s gas fees has had on the demand for NFTs. This paper then looks to address this issue by studying the effect of Ethereum Gas Fees on Non-Fungible Token demand. I plan to use a Two-Stage Least Square Regression, with the Price of Ether as my

instrumental variable. I will prove the assumptions needed for this instrumental variable later in the methodology section. Nevertheless, I will have my first stage regression fit Ethereum Gas Fees on Ether Price under these expectations. Then in my second stage, I will fit NFT Demand on the predicted values of Ethereum Gas Fees. Under this methodology, I found a significant negative relationship between the Fees and NFT Sales, demonstrating the potential importance developers need to consider when onboarding more users. Finally, I computed the Price Elasticity of Demand for NFT Sales with respect to the Ethereum Transaction Fee.

The results from this regression will help build a narrative regarding the potential impacts that growing fees have on network growth and usage. Some Ethereum critics argue that high gas fees are a significant deterrent and have helped contribute to developing alternative blockchains. These competitors include the Solana, Ronin, and Avalanche blockchains that currently offer users lower transaction costs (Hake, 2021). Despite the current traction these platforms have found, Ethereum has maintained the lion's share of the NFT industry. This continuation of market dominance suggests that the effect of the fee may have a more negligible impact than common sense would offer. Reasons might include the NFT space being primarily dominated by "whales," individuals, or institutions with deep pockets and an overwhelming amount of digital assets. Hence for these agents, the high gas fees are nonexistent compared to the yield on the overall investments. Thus, examining the effect of transaction cost on the NFT demand regarding the price elasticity of demand will be crucial to understanding the future of blockchain development. A significant negative relationship would suggest that Ethereum needs to quickly find a solution to its fees to keep its market share from competitors. At the same time, a weak connection might demonstrate inelastic demand where market participants are willing to ignore the fees to acquire these digital assets. Despite immense growth, both cryptocurrencies and Non-

Fungible Tokens are adolescent compared to historical bonds, equities, and real estate; thus, understanding the effect of gas fees will give significant insights into this evolving sector.

Because of the novelty of these assets, I will flesh out a more detailed breakdown of NFTs to provide more perspective before reviewing the sparse literature. The most significant piece of this analysis begins with an examination of what precisely the term fungible refers to in both the digital and real world. Fungible simple means mutually interchangeable (*Fungible / Definition of Fungible by Merriam-Webster*, n.d.). U.S. dollars are fungible because exchanging \$1 for \$1 or two \$5 for one \$10 are legal processes that leave the exchanger with the same initial value. The cryptocurrency Ether acts in the same way, in that all Ether tokens store the same value in terms of ETH (*Home / Ethereum.Org*, n.d.) In contrast, non-fungible refers to items that cannot be exchanged with one another due to unique properties. Take one of the most well-known NFT projects, Cryptopunks, a collection of 10,000 similar but diverse digital artworks that look like pixelated men with various traits and accessories (Figure 1, Appendix). Here, you cannot simply swap one character for another because they have attributes with different rarities, resulting in contrasting valuations based on exclusivity and opinions of participating market agents.

Furthermore, the tokens are indivisible. Unlike Ether or any other cryptocurrency token, which can be split into minimal amounts and transferred through various crypto wallets, NFTs will always remain a whole entity connected to a specific asset. Lastly, due to their innate relationship with smart contracts, all NFTs have a clear, distinguishable owner certified by the blockchain (Finematics, 2020). This allows for the secure transfer of the NFT's rights from buyers and sellers on an easily accessible marketplace and thus refutes the belief that NFTs can be screenshotted and hold the same value as the original token. Thus, with such a diverse

offering of features, it is no wonder why the asset class has found increasingly more use cases across a diverse set of industries. Mason Nystrom, a senior analyst at crypto firm Messari, which this paper will collect data from, summarizes this utility, “NFTs are a significantly broad category that can include music, art, collectibles, gaming assets, fantasy sports, financial assets, and more,” (Hum, 2022). Hence, research and analysis on NFTs can potentially provide meaningful data and opportunities to analyze how these various categories may evolve.

Even though NFTs offered this technology back in 2015, they existed exclusively in the wallets of select crypto enthusiasts and blockchain ultra-believers through the first quarter of 2021. One of the catalysts that prompted widespread news coverage and began to spur intrigue on the asset was when in March of 2021, the artist Beetle sold a digital NFT representing a collection of 5000 joined works for \$69.3 million (Kramer, 2021). This remains the third-highest sale price for a current living artist at *any* auction, digital or real (Ante, 2021b). Although the sale indeed represents a data outlier for most NFT transactions, there would be numerous other multi-million-dollar NFT sales at the world-renowned Christie’s and Sotheby’s auctions throughout the year. In addition to these auctions, Herrera (2021) also attributes the surge in NFT volume to the increasing adoption by celebrities and reputable brands. Whether it be the celebrities Shaquille O’Neil or Steve Aoki promoting NFT communities, Visa’s six-figure purchase of a Cryptopunk, or collaboration from brands Gucci and Burberry, NFTs are no longer solely traded by small networks of blockchain computer enthusiasts (Herrera, 2021).

## **II. Literature Review:**

Due to the novelty of NFTs and their adoption in only the past year, the present scholarly work is quite limited. A few researchers have published work on specific components of the sector, albeit with warnings that conclusions are subject to change due to the rapidly evolving

nature of this asset class. One of the first comprehensive works, led by Nadini and a series of researchers (2021), sought to examine the overall market after NFT growth exploded in the first two quarters of 2021. By grouping NFTs into various categories such as art, collectibles, and games, the researchers were able to analyze the main properties of the NFT market and conclude that most of the market participants specialized in various sub-categories instead of the entire NFT space. Finally, the paper attempted to develop an algorithm to predict NFT prices for multiple projects. While variable, the article did conclude that price history tended to have the most substantial ability to anticipate price and that the features of the specific NFT were secondary in factoring price (Nadini et al., 2021). The paper then provides an excellent starting foundation for other researchers to familiarize themselves with the asset class and build upon their initial findings regarding NFT collections, traders, and prices.

Furthermore, Michael Dowling (2021) took on a more specialized lens by looking at the relationship between Cryptocurrency and NFT prices for three NFT markets. Dowling (2021) focused on the bluechip NFT collections of Cryptopunks, Decentraland tokens, and Axie Infinity characters, along with the cryptocurrency leaders Bitcoin and Ethereum. By choosing these specific projects, Dowling (2021) ensured that he gathered data on the most prominent and diverse NFT collections. Cryptopunks is a collection of profile images, Decentraland tokens represent a parcel of Metaverse land, and Axie Infinity Characters are NFTs validating ownership for game pieces. The study then examines the volatility spillover effects and wavelet coherence between the markets. Interestingly, the volatility spillover analysis suggests virtually no relationship between the pricing of Cryptocurrencies and NFTs and that the pricing between one NFT collection to the next was uncorrelated. However, the wavelet coherence analysis offered a slightly contradicting opinion as some co-movement between markets was present in

the chart. Instead of disappointment in the findings, Dowling expresses optimism. This contradiction illuminates the relative lack of knowledge and opportunity for upcoming research on a unique asset class (Dowling, 2021). However, this is important for my study, as I will use the contradicting findings on the relationship between Cryptocurrency and NFT prices to help build the exogeneity assumption in the IV regression.

Lennart Ante, a leader in ongoing NFT research and scholarly work, continued to build on Dowling's research between Cryptocurrency and NFT markets. Unlike Dowling (2021), who focused on three top NFT collections, Ante (2021b) sought to examine the entire NFT market's relationship with the two leading cryptocurrencies, Bitcoin and Ethereum. Thus, this work used the total volume of NFT sales on the Ethereum blockchain, the number of wallets related to these NFTs, and ETH and BTC prices. The article gathered data from 2018 to May of 2021 on each category and ran a regression using the VAR framework. Upon examining the dependencies across these categories, the study concluded that some price shocks in the cryptocurrencies led to changes in the NFT market, but not the other way around. Specifically, Ante discovered that Bitcoin shocks significantly caused changes in overall NFT sales, while Ether shocks did not considerably cause changes. Thus, while the article demonstrated some spillover effects from the larger cryptocurrency market into the NFT sector, Ante (2021b) emphasizes the study's novelty and the need for more research as the market matures. Again, it is essential to note that Ante's investigation did not find Granger causality between the price of Ether and NFT sales. This finding builds upon the literature on the increasing independence between cryptocurrency pricing and NFT demand, thus allowing my study to use the price of Ether as an instrumental variable on Ethereum Gas Prices.



The other main contribution from Lennart Ante (2021a) followed a few months later in August, looking at the relationship between the top NFT submarkets on the Ethereum blockchain network. The study gathered data from fourteen projects on each NFT's number of sales, daily NFT Sales Volume, and unique wallets for these days' trades. The study then examined each project's relationship by implementing a cointegrated VAR model, i.e., the VECM. This regression enables short-term effects to be looked at under an increasingly accurate scope alongside the overall long-run equilibrium. Although the study finishes with data showing the influence of specific projects on each other, Ante's (2021a) general conclusion is that "Other NFT submarkets drive most NFT submarkets." While the author demonstrates clear findings on the correspondence between the various markets, they highlight certain limitations in the study due to the novelty of the overall market and its unknown long-term equilibrium in the modern financial world (Ante, 2021). It is still important to incorporate this into the literature because the study highlights how NFT demand is affected by other NFT projects and not necessarily cryptocurrency prices. Both of Ante's papers will allow me to make better assumptions about the variables used in the regression as some of the conclusions directly apply to principles of correlation between variables.

These projects have been instrumental in beginning the research on NFT markets and highlighting some early conclusions regarding the broad NFT market and the sector's relationship with leading cryptocurrencies. Interestingly, Ante's (Ante, 2021b, 2021a) articles focused on NFT projects and sales on the Ethereum network. This enabled the author to isolate some of the variations in the NFT space and gather more concise and accurate data for their methodology. While studies will eventually examine NFTs from a cross-blockchain perspective, more data is needed before accurate and meaningful results can be found for these alternate

networks. Thus, while my paper intends to focus only on Ethereum transactions for these reasons, I believe that the results will begin to build upon the literature for examining the cross-blockchain space. By focusing on the function between transaction costs and demand for NFTs, the paper hopes to offer insight into how the market may develop with various blockchains offering lower transaction fees while maintaining fast and efficient processes. In addition, Ethereum is planning a significant update called the Merge in 2022 to improve transactions costs. Thus, this study will be critical in predicting how its proposed improvements to the network may affect NFT demand in the future, which will also factor into the underlying cryptocurrency flows.

### **III. Data**

One strength of obtaining data on cryptocurrencies and NFTs is that blockchain technologies automatically upload all transactions to a public digital ledger for anyone to view. Because it is decentralized, one does not have to worry about a central party altering, controlling, or hiding subsections of the data (Hussey, 2019). Thus, to gather data for the entire Ethereum network, this paper will use *Messari.io*, a leader in data collection research in the cryptocurrency markets. Founded by longtime crypto entrepreneur Ryan Selkis, Messari provides professional data analysis tools, research, and industry reports for individual investors and blockchain-focused firms. They are widely trusted by the blockchain community and have data on all facets of the Ethereum network going back multiple years. This paper gathers daily observations on the Price of Ether, and the Ethereum Network's Average Transaction Fee in USD, from January 1<sup>st</sup>, 2018, to March 31<sup>st</sup>, 2022. It is important to note that this paper can better account for recent market evolutions and trends by using more current data than previous studies. For example, according to the Dapp Radar 2021 Industry report, NFT trading was tallied at twenty-three

billion, yet only 2.5 billion of this is accounted for in the first six months (Herrera, 2021, Figure 2). Thus, an exciting component of this work concerning the others previously mentioned is purely due to our ability to gather and examine data following this surge in trading activity.

For collecting data on the NFT market, the paper will use, *Non-Fungible*, the same resource that Ante's studies called upon. *Non-Fungible.com* is the current leader in tracking all NFT transactions and submarkets on the Ethereum Network. The company scans the public blockchain and leading NFT marketplace, *OpenSea*, to aggregate historical data and charts for multiple NFT market categories. They are highly trusted in the community and used by many third-party outlets to gather data for news, valuations, and reports. I compiled their daily observations on the Number of NFT Transactions, NFT Sales Volume, and the Number of Active NFT Wallets from January 1<sup>st</sup>, 2018, to March 31<sup>st</sup>, 2022. Note again that I am only examining these NFT statistics regarding the Ethereum network for this paper.

Rising alternative networks either do not have sufficient data collection services or lack long enough exposure to the broad market. The inclusion of this data in the study would not warrant confidence. As firms develop and release future services, a follow-up study including other networks' transaction fees and NFT sales would offer an excellent opportunity for further research that may help solidify this paper's findings on a larger scale. Along these lines, it is essential to note that this site only includes on-chain sales, which appear on the public ledger, and does not factor in private off-chain activity. Off-Chain transactions are carried out by third-party actors such as PayPal and avoid interacting with the blockchain (Pinto, 2019). With benefits including added security, faster processing time as network confirmations are not needed, and nonexistent fees, I suspect this sector will draw more investment in the upcoming years. However, as these transactions are not visible to the public ledger, estimates of the size

and quantities of these sales vary wildly. Any attempt of adding the off-chain data would create an inconsistency with the Ethereum data from Messari, which is entirely on-chain. Thus, to maintain accuracy, I chose to limit the study to on-chain data, just as the earlier scholars did in their research. Table 1 gives the summary statistics for the paper's collected variables under these assumptions.

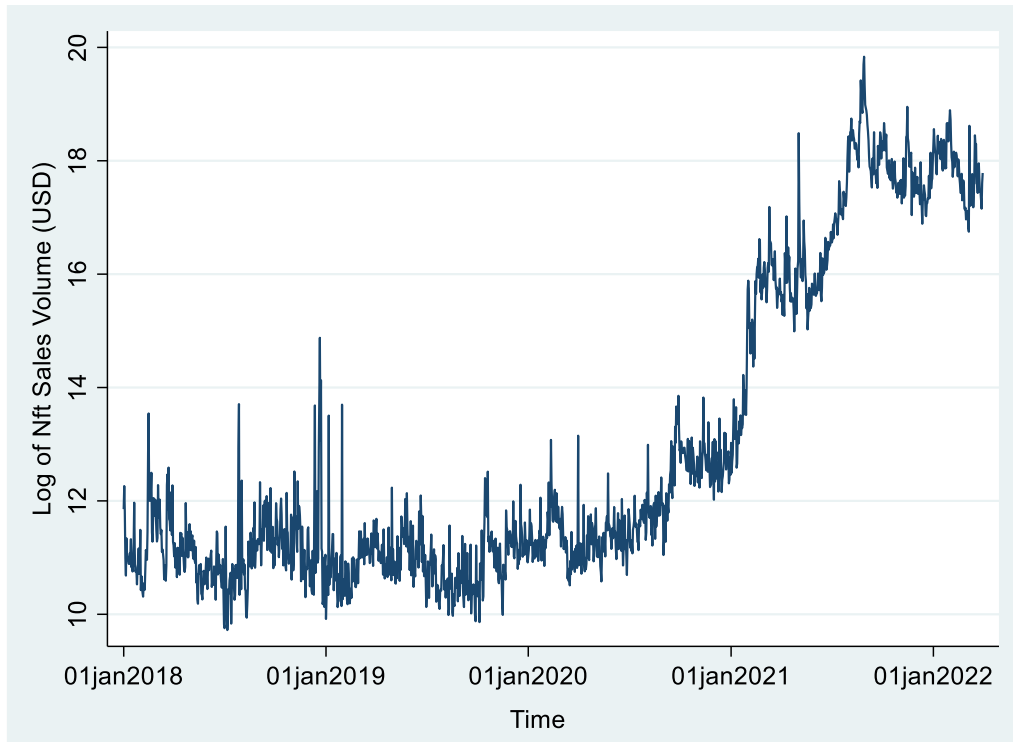
Table 1: Summary Statistics					
VARIABLES	(1) Obs	(2) Mean	(3) Std. Dev.	(4) Min	(5) Max
ETH Price	1,550	1,053	1,255	83.52	4,811
Transaction Fee	1,550	6.816	12.19	0.0501	68.30
NFT Transactions	1,550	14,038	31,932	242	220,450
NFT Sales	1,550	1.278e+07	3.234e+07	16,679	4.116e+08
NFT Wallets	1,550	6,314	12,446	239	79,922
Datevar	1,551	21,960	447.9	21,185	22,735
Log ETH Return	1,548	-0.00101	0.0530	-0.234	0.582
Log NFT Sales	1,550	12.95	2.728	9.722	19.84

In examining the data given in Table 1, it is essential to note that there is one extra entry for datevar, which represents the date. This is because there was a missing entry for NFT Wallets on October 10th, 2021. In referencing the source *Non-Fungible.com* to check for user error, the entry is missing from the site. Thus, as this is a collection of multiple time series data, I used the command *tsfill* to cover this gap with a blank value, hence why  $N = 1550$  for all collected variables. Lastly, note that all the unadjusted variables in Table 1 have standard deviations that exceed the mean values. This demonstrates the nature of these two growing markets, especially when considering the heightened media attention and investment over the past year and a half. NFTs are volatile assets subject to many market variables and changing conditions; hence this paper will keep the scope of the data analysis compact to avoid unwarranted conclusions.

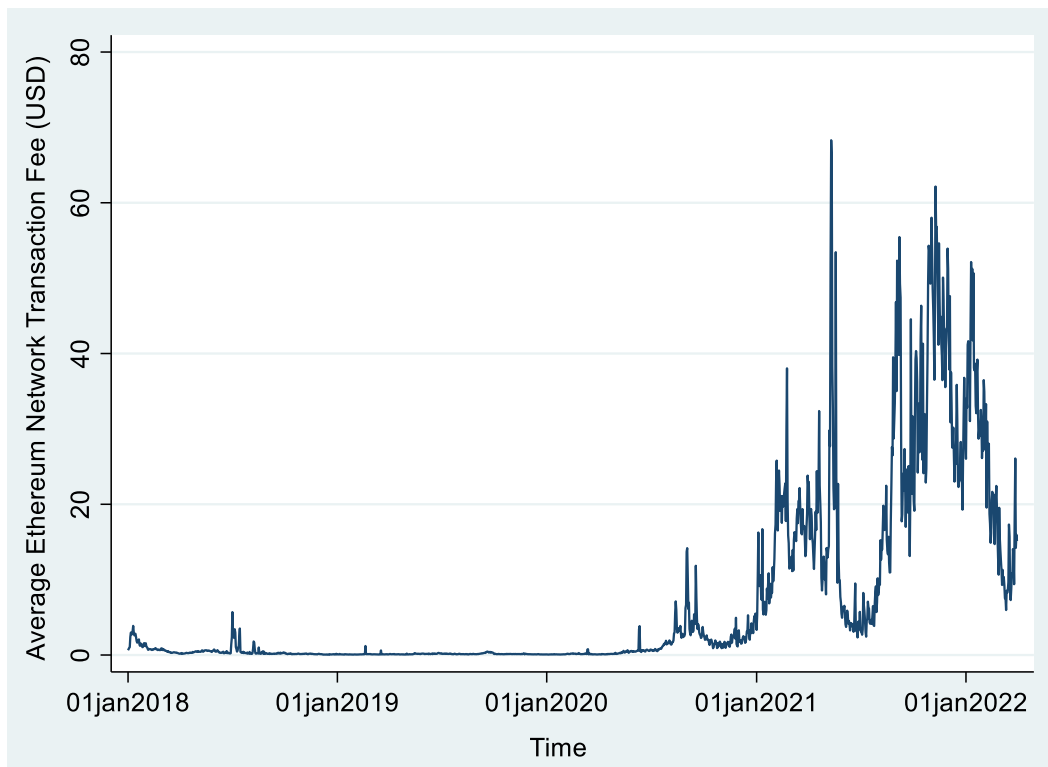
I then added the log values of NFT Sales growth, *Log NFT Sales*, to lower the magnitude of the variable so that Graph 1, given below, provides a more thorough picture than Graph 9 in Appendix B. We can see in Graph 1 that even when using log values, the NFT Daily Sales Volume expanded across several multiples throughout 2021.

Interestingly, in Graph 2: Average Transaction Fee data, you can see the same rapid growth as Graph 1 starting in 2021. However, Graph 2 exhibits evident volatility despite trending upwards. To better understand the factors causing this volatility, we will break down the pricing components of the transaction fees. Because these fees are on the Ethereum network, they are directly connected to the price of Ether, in that an appreciation in ETH results in greater gas fees in terms of USD (Mcshane, 2022). Hence, this part of the fee equation provides some initial motivation for choosing the price of Ether as our instrumental variable. In addition, the transaction fee depends on the supply and demand relationship between miners who provide the computational resources and agents who seek out these services (Mcshane, 2022). Thus, as there is a fixed amount of computational power available on the Ethereum network, these Gas fees can increase rapidly as agents outbid each other for the chance to gain access to exclusive NFT reveals and sales. When you combine these market interactions with the appreciation of ETH depicted in Graph 4, we see the overall rise trend in USD transaction fees pictured in Graph 2. Thus, I hope to look at this phenomenon further in the methodology and results sections to determine whether this overall increase in the price and volatility of transaction fees has any meaningful effect on NFT Sales.

Graph 1: Daily Log Value of NFT Sales Volume



Graph 2: Average Daily Transaction Fee on the Ethereum Network

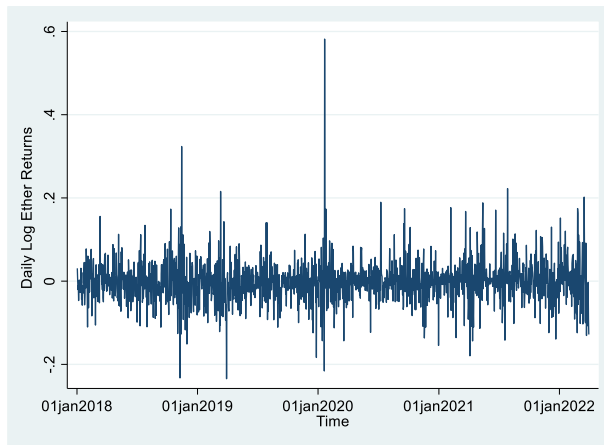


Furthermore, in gathering data on the Ether cryptocurrency, I chose the daily close value. Doing so provides a constant collection time and thus ensures accuracy when finding the daily log return on the cryptocurrency. I create the variable *Log Eth Return* according to the equation below, with  $R_t$  = Log Return at  $t$ ;  $P_t$  = Price of ETH at  $t$ ; and  $P_{t-1}$  = Price of ETH at  $t-1$ .

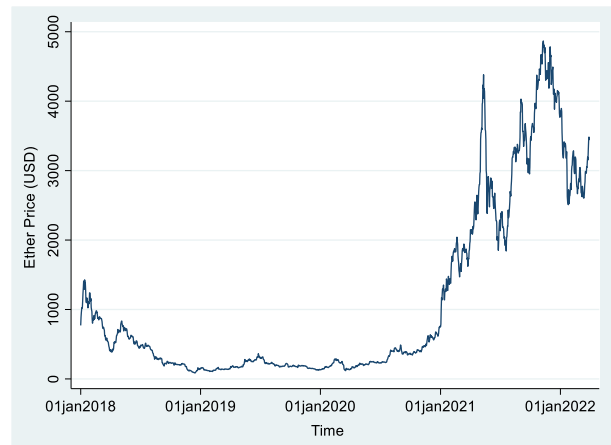
$$R_t = \ln (P_t / P_{t-1})$$

In the graphs below, we see that when comparing the Daily Log Returns alongside the Daily Price of Ether, although the price of Ether generally appreciates across this period, the returns appear centered at 0. Table 1 confirms this suspicion as Log ETH Return shows a mean value of -.001 or -.1%. A roughly zero-centered mean should not come as a surprise and even confirms the accuracy of the data as cryptocurrencies are known to experience more volatility than most traditional financial assets.

Graph 3: Daily Log Ether Returns



Graph 4: Daily Ether Price (Close)



## IV. Methodology:

To perform the analysis, I will run a Two-Stage Least Square Regression to examine the relationship between the Gas/Transaction Fees and NFT Demand, with the Price of Ether as my

instrumental variable. Here I chose the Daily Sales Volume to model our NFT Demand as it represents best the fluctuates in market activity and sentiment across the entire asset class. In addition, I use the Total Daily Number of NFT transactions and Daily Active NFT wallets, the number of unique addresses associated with any NFT transfer, as control variables. These controls are included in the regression to increase confidence that the instrument is uncorrelated with the error term, thus strengthening the accuracy of our findings.

To motivate the need to perform an Instrumental Regression, I ran a simple OLS regression of NFT Sales on the Gas Fees, including the given control variables. The output for this test is shown in Table 6 of the Appendix. The regression here gives a statistically significant coefficient of 382115.2 for the Transaction Fees. Thus, the initial analysis would appear to claim that a dollar increase in Ethereum Gas Fees would cause an increase of \$382,115.2 in the daily NFT Sales Volume. Assuming that these results were accurate, it would suggest that increases in fees led to more NFT sales, which contradicts popular consumer sentiment. One inference may be that simultaneous causality bias is present in this regression. This would make intuitive sense when considering the supply and demand mechanism that affects the pricing of fees explained in the Data section. As NFT Sales Volume increases, there is more congestion on the Ethereum network, resulting in rising gas fees to process the transactions. Despite this, we know that the cryptocurrency market is much larger than the NFT market, and thus this effect would be small if not negligible.

More importantly, the omitted variable bias of neglecting the price of Ethereum, which is directly connected with pricing transaction fees, poses a significant threat to this regression's validity. Given that all other variables remain constant, we know that an appreciation in ETH causes the transaction fees to increase as they depend on the ETH/USD conversion rate. Thus,



while providing statistically significant results, this OLS regression demonstrates bias that prompts the need for an instrumental regression to eliminate the correlation with the error term. Therefore, the instrumental variable chosen will be the Price of Ether. To ensure that my instrument is uncorrelated with the error term and thus provides meaningful regression results, I will have to motivate the instrument's validity. Using the variables presented in Table 1 from the data section, the setup for the instrumental regression is expressed in the following formulas:

$$(1) \text{ Linear Regression: } Y_i = \beta_0 + \beta_1 X_i + \beta_2 W_{1i} + \beta_3 W_{2i} + u_i,$$

$$(2) \text{ First Stage Regression: } \hat{X}_i = y_0 + y_1 Z_i + y_2 W_{1i} + y_3 W_{2i} + v_i$$

$$(3) \text{ Complete Regression: } Y_i = \beta_0 + \beta_1 \hat{X}_i + \beta_2 W_{1i} + \beta_3 W_{2i} + \varepsilon$$

With the variables  $Y_i = \text{NFT Sales}$ ,  $X_i = \text{Transaction Fee}$ , Control variables  $W_1 = \text{NFT Transactions}$ ,  $W_2 = \text{NFT Wallets}$ , and the Instrumental variable  $Z_i = \text{ETH Price}$ . In addition, we have the constant terms  $\beta_0$ ,  $y_0$ , and error terms  $u_i$ ,  $v_i$ . Hence, implementing this regression on equation (3) will enable the paper to answer the following hypotheses:

$$\text{Null Hypothesis (H}_0\text{): } \beta_1 = 0$$

$$\text{Alternative Hypothesis (H}_A\text{): } \beta_1 \neq 0$$

Thus, if the null hypothesis is rejected according to the results of the regression, then we accept the alternative hypothesis and claim that Transaction Fees do significantly affect NFT Sales.

Having provided the basic structure of the regression, it is essential to motivate the assumption that the instrument, ETH Price, is valid. First, I would like to examine the exogeneity assumption for the price of Ether. Because the model is exactly identified, in that the number of instruments ( $m$ ) equals the number of endogenous regressors ( $k$ ), I cannot test for this assumption directly. However, I can provide sufficient intuition to motivate that  $\text{corr}(Z_{1i}, u_i) = 0$ . As mentioned in our literature review, Ante's (2021b) and Dowling's (2021) studies presented

mixed findings on the relationship between cryptocurrencies and NFTs. Dowling's (2021) paper suggested little to no correlation between the markets in terms of volatility spillover effects. At the same time, Ante's (2021b) research could not conclude that price shocks in Ether caused statistically significant changes in the Daily NFT Sales Volume. Thus, in terms of scholarly work, we have seen two recent well-conducted studies that would suggest that the price of Ether is not significantly correlated with the error term in our regression.

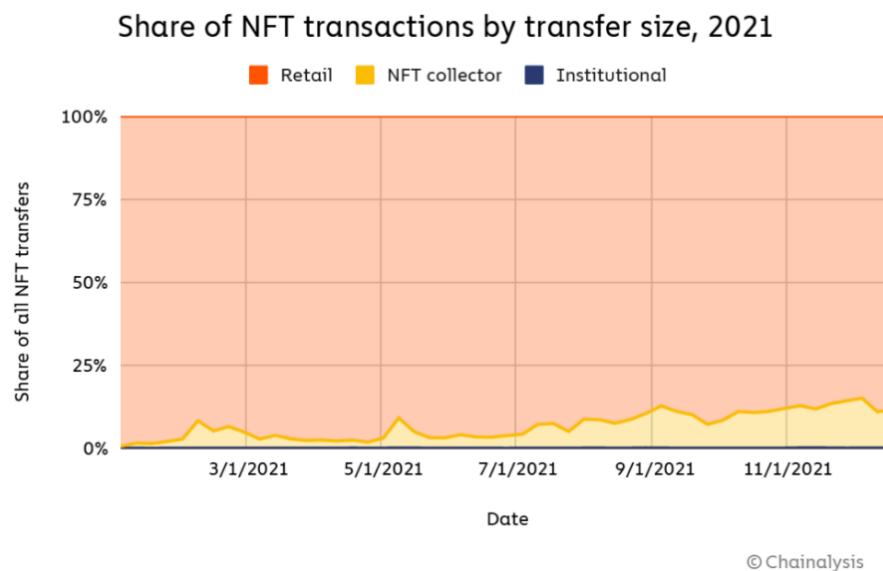
However, a weakness that may need to be addressed, which Ante (2021b) and Dowling (2021) mention, was that they did not isolate for NFT wash trading. Wash trading occurs when a single market agent will use multiple anonymous wallets and pretend to buy one of their assets at inflated prices to artificially raise the market floor, hoping to entice others to purchase above the asset's worth (Ante, 2021). According to a report from Chainalysis (*NFT Money Laundering and Wash Trading*, 2022), a well-respected crypto and web3 research firm, wash traders made approximately 8 million in profit over 2021. The article also mentions that one individual accounted for \$35,642 purely in Ethereum gas fees. While meaningful amounts, these sums represent tiny fractions for the broad NFT market, and thus we can reasonably ignore this activity in our study. It is clear though, that more studies addressing wash trading and other illegal activities associated with blockchain technology would be highly illuminating on how to regulate this new market sector better.

In addition to scholarly studies, I can draw on market sentiment to bolster the exogeneity assumption. Gauthier Zuppinger, the founder of *Nonfungible.com*, discussed above, mentioned: "that the NFT market (is) increasingly de-correlated with the crypto market" (Howcraft, 2021). Meanwhile, famous crypto influencer and collector, known by the pseudonym Pranksy, also commented, "The people who spend many thousands on NFTS aren't going to sell them for 50%

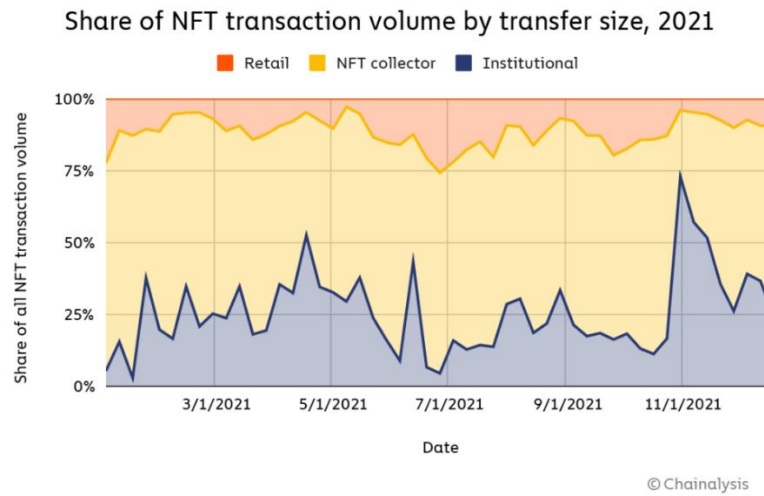
off tomorrow....Much like traditional art markets bucking Wall Street trends, I believe many see certain NFTs as a store of value” (Anand, 2022). Thus, while a modest snapshot, these comments illuminate the developing narrative that the cryptocurrency and NFT markets are independent and uncorrelated.

Finally, let us examine the 2021 Chainalysis NFT market report. Unlike crypto markets, which are mainly dominated by institutional investor flows, the NFT space has a much more significant retail presence (Grauer et al., 2022). Graph 5 demonstrates that nearly all transactions occur from retail accounts and collectors. Graph 6 shows that while institutions account for a more significant portion of the overall Transaction Volume, collectors and retail still maintain a majority, unlike the crypto market. Thus, we infer again that these two markets act independently and that we can motivate the exogeneity assumption for the model’s instrument.

Graph 5: Share of NFT transactions



Graph 6: Share of NFT Transaction Volume



Meanwhile, the relevance assumption is much easier to prove in that a change in cryptocurrency price will undoubtedly result in a shift in gas fees. This is the basic functionality of transaction costs within the Ethereum network discussed earlier. Thus, when  $Z$  (ETH Price) varies, so will  $X$  (Transaction Fee), i.e.,  $\text{cov}(X_i, Z_i) \neq 0$ . Furthermore, we can explicitly test for relevance using the F-test following the results of the First Stage regression. We know that if the coefficient on our instrument  $Z$  follows the First Stage regression is equal to 0, then we have a completely irrelevant instrument as no change in  $Z$  affects our regressor  $X$ . For even more confidence in the assumption, we can compute the first stage F-test value and compare it to the value of 10. The relevance assumption will always hold when this F-test value is larger. In the results sections below, Table 2 demonstrates that our regression's F value is greater than ten, and thus the relevance assumption passes. Thus, having motivated both the exogeneity and relevance assumptions, the paper will conclude the price of Ether to be a valid instrument uncorrelated with the error term.

## V. Results:

Using the Price of Ether as the instrumental variable, I run the First Stage regression according to equation 2. The results are depicted in the table below with both tests.

Table 2: First Stage (2SLS) Output	
VARIABLES	Model 1 Transaction Fee
ETH Price	-0.000920*** (8.89e-05)
NFT Transactions	-0.000491*** (2.96e-05)
NFT Wallets	0.00173*** (8.00e-05)
Constant	3.761*** (0.270)
Observations	1,550
R-squared	0.569
F-Test	107.07
Robust standard errors in parentheses	
*** p<0.01, ** p<0.05, * p<0.1	

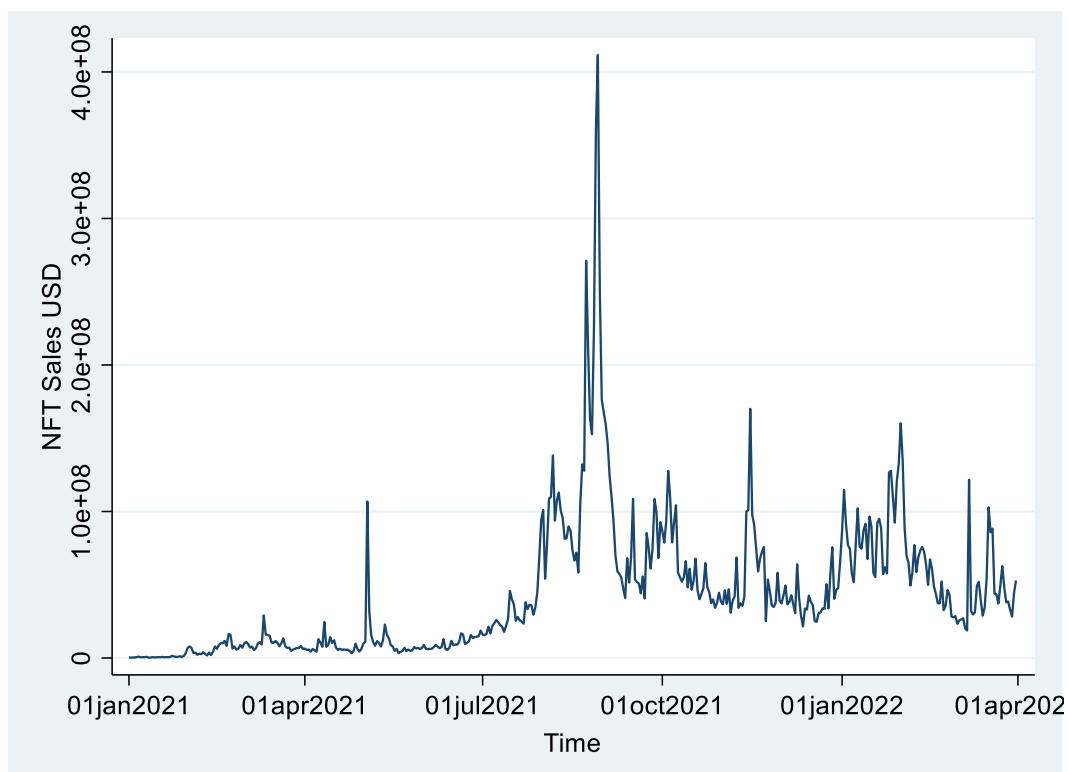
Here, Table 2 shows a significant relationship with the Transaction Fee, with a coefficient of -.000920. Although the value is small, this makes intuitive sense since the price action of Ether is quite volatile and subject to daily swings in the hundreds of dollars. Table 1 supports this notion as the standard deviation for the daily Log ETH Returns is .0530, demonstrating volatility. Also, consider that this is a negative relationship between our regressor Transaction Fee and the instrumental variable ETH Price. This may be an early indicator that when the price of crypto rises, there is less desire to perform complex transactions; thus, the overall average fee drops slightly. Lastly, the F-Test value of 107.07 is given, demonstrating relevance, as mentioned earlier.

Then given the fitted values for X using the price of Ether as a valid instrument, I implement the regression according to equation (3) and find the Second Stage results provided in the table below:

Table 3: Second Stage (2SLS) Output	
VARIABLES	Model 1 NFT Sales
Transaction Fee Hat	-730,374*** (143,229)
NFT Transactions	-923.1*** (91.50)
NFT Wallets	4,841*** (353.2)
Constant	151,865 (224,047)
Observations	1,550
R-squared	0.765
Robust standard errors in parentheses	
*** p<0.01, ** p<0.05, * p<0.1	

Table 3 demonstrates that there is a significant relationship between our predicted X, Transaction Fee Hat, and NFT Sales such that a \$1 increase in the Transaction Fee results in a \$730,374 drop in the daily NFT Sales Volume. When examining Graph 7 below, which zooms in on the NFT Sales data starting in January of 2021, we can conclude that the coefficient makes sense in terms of the magnitude of the data. As the daily NFT Sales bounce around fifty million with occasional peaks over one hundred million, a decrease of roughly 1 million in NFT Sales for a dollar increase in the average Transaction Fee is significant without being illogical. Note that because transaction fees were much lower from 2018 to 2021, I did not include the full NFT Sales graph as a dollar change in the Transaction Fee in this period was quite rare, as seen in Graph 2 earlier.

Graph 7: Daily NFT Sales (USD) from 2021 to Present



It is also interesting to examine the coefficients for both control variables. Table 4 shows that the controls, NFT Transactions, and NFT wallets, have statistically significant coefficients values of -923.1 and 4,841, respectively. The NFT Transaction coefficient is interesting as one would consider an increase in interest in the number of transactions to result in more overall Sales Volume. Thus, a negative value here potentially suggests that more NFT transactions result in higher fees, thus causing cheaper average sales, which drops NFT sales volume as predicted in the regression. In this case, agents would be reacting to a loss of purchasing power due to increased transaction costs, which raises the overall price required to purchase the asset. Meanwhile, a positive relationship between the number of active NFT Wallets and Transaction Fee is easier to understand, as more users would imply more overall sales.

Finally, because the standard errors in Table 3 do not account for the estimation on our regressor X in the first stage regression, I need to run a complete IV regression. Using the single command in Stata, I obtain the final regression results with the same coefficients but updated standard errors given in Table 4 below.

Table 4: IV Regression Output

VARIABLES	Model 1 NFT Sales
Transaction Fee	-730,374*** (167,161)
NFT Transactions	-923.1*** (109.1)
NFT Wallets	4,841*** (399.3)
Constant	151,866 (259,302)
Observations	1,550
R-squared	0.697
Robust standard errors in parentheses	
*** p<0.01, ** p<0.05, * p<0.1	

Thus, based on these findings, our model suggests that rising Transaction Fees on the Ethereum network significantly affect NFT sales volume. These findings make logical sense and demonstrate rising transaction costs' pricing out effect. Using these results, I compute the elasticity Price Elasticity of Demand of NFT Sales with respect to the Transaction Fee with the *eyex* Stata command, centered on the mean of the covariates. This gives the output shown in Table 5 below. Here we have that the Price Elasticity of Demand is -.389, or more specifically, a .389% decrease in NFT Sales given a percentage increase in the Transaction Fee. As this absolute value is less than one, the Price Elasticity of Demand for NFTs is inelastic. Thus, for a change in the price of the Transaction Fee, there is less of a change in the quantity of NFTs demanded. The following section will address how these findings might influence innovative



technologies and policies as the crypto and NFT markets evolve. Furthermore, we will address limitations and possibilities for follow-up research that may provide more general and influential conclusions.

Table 5: Price Demand of Elasticity

VARIABLES	(1) Elasticity
Transaction Fee	-0.389*** (0.0866)
Observations	1,550
Standard errors in parentheses	
*** p<0.01, ** p<0.05, * p<0.1	

## VI. Discussion:

Given the results, the paper most importantly accomplished its goal to determine if there was a significant relationship between the Ethereum Network's Gas Fees and the NFT Sales on Ethereum. Having found a negative causality between the fees and NFT demand on Ethereum, I believe that much of the growth of Ethereum competitors in the last six months can in part be attributed to these findings. As popular games and applications that required multiple transactions became unusable for most retail participants, many of these L1 networks saw rapid increases in users and activity, resulting in widespread token adoption. Hence while Ethereum's coin Ether appreciated roughly four times in value from January 2021 to its high of \$4,500, alternative network tokens, such as Binance Coin (BNB), Solana (SOL), or Avalanche (AVAX), saw returns in the thousands of percent. Thus, in going back to our findings, if Ethereum gas fees remain high and continue to exhibit this negative causality with NFT Sales, a potential

implication may be that holding ETH as an asset presents more risk for less upside than these alternative tokens.

Furthermore, the Ethereum developers themselves understand the importance of cheap long-term transaction costs. In response to high fees, the Ethereum team has been working on a series of upgrades for years to switch Ethereum from Proof of Work to Proof of Stake. The technical differences between these two methods can be complex, but Proof of Stake is much more energy-efficient to simplify. Thus, it will allow for more scalability enabling more transactions at cheaper fees (Stevens, 2022). Why has Ethereum lost market share if it has a well-thought-out roadmap to address its issues? The answer lies in a slew of development delays of the “Merge” update. However, the fact that the Ethereum developers understand the importance of cutting down on fees and improving efficiency demonstrates that the findings of this paper are incredibly relevant. The motivation for the vast resources and time required to implement these upgrades compliments this study’s conclusion that failure to address rising fees is associated with a decrease in platform NFT activity. The future of cryptocurrency and web3 technologies will be inherently tied to transaction costs. The long-run winners will be the networks that can deliver solid applications, security, and speed while also keeping transaction costs to a minimum.

However, the finding of inelasticity for NFT Sales adds further complexity to this narrative. In many ways, this highlights the rising sentiment by many that NFTs are becoming increasingly independent from cryptocurrencies. This inelastic demand builds off Dowling’s (2021) earlier conclusions that there was no volatility spillover between the crypto and NFT markets, hence the possibility for diversification benefits by holding the two assets together in the same portfolio. In addition, a new study from Coin Metrics looking at OpenSea Sales Volume against the Price of Ether (Graph 10 provided in Appendix) arrived at a similar

conclusion: “Although it’s still early, it appears that NFTs are a relatively independent market and may, for the most part, move separately from the rest of the crypto market,” (Maddrey, 2022). Thus, this consensus gives even more credibility to my findings for two reasons. First, it confirms the exogeneity assumption needed for the instrument in the regression. Secondly, although my study was the first to isolate transaction costs, the potential implications of both works remain highly correlated. Hence, the biggest takeaway from the inelasticity result is that NFTs, which were once a footnote in the larger crypto world, are increasingly differentiating themselves as a separate asset class subject to different market conditions. However, do not expect the effect of transaction costs to go away anytime soon. Gas fees on Ethereum are just like physical Gas Pump prices in that they routinely trump credit cards despite perpetual wishes for prices to lower.

Limitations regarding these results and policy implications center on the newness of the NFT market. While blockchain offers fascinating technology that is rapidly evolving from month to month, an overall lack of long-term data makes any prediction difficult to assert fully. For this reason, and all the potential evolution that will continue in the following days, months, and years, I chose to keep the scope of this study small to condense the focus and potentially limit drastic assumptions from being made that could affect the results. Thus, future research will look at the relationship between Transaction Fees and NFT Sales when incorporating other networks data into the analysis. A cross-blockchain experiment will be vital in seeing how agents act on smaller networks with negligible fees and may explain why some agents bridge funds to alternative Layer 1 chains while others continue to pay Ethereum’s fees. Furthermore, this subject regarding the relationship between Transaction Fee and NFT Sales should be reexamined following the new Ethereum Merge update. This event will reduce Ethereum Gas fees and is

much anticipated by the entire blockchain community. Thus, examining the event using a Difference-in-Difference regression may provide exciting results once there is pertinent data. Overall, this study, despite its limitations, built upon the small existing literature surrounding these two developing asset classes and presents a potential starting point for future follow-up analysis as the markets mature.

## **VII. Conclusions:**

This paper examined the effect of Ethereum Gas Fees on NFT Demand by looking at the Average Transaction Fee and overall NFT Sales Volume. The rapid growth of both the crypto and NFT markets in the past year motivated this paper's attempt to analyze a small facet of the two industries' relationship. While Ethereum currently dominates much of the literature between the two worlds and remains the go-to destination for new investment and innovation, the increasing backlash against its transaction fees has resulted in significant but relatively small competitor growth. These competitors are known as Layer 1 networks and include Binance Chain, Solana, Avalanche, and many others. By implementing new transaction authentication methods, these new networks have fees magnitudes lower than Ethereum, albeit sacrificing some security and decentralization to compensate for these improvements. Thus, this relationship between transaction costs and the various NFT networks will continue to play a dominant role in discussing future investment and user acquisition regarding NFTs. Hence, I sought to examine this relationship on the Ethereum Network to find significant causality that would offer a starting point for further research and analysis.

I implemented an Instrumental Variable regression of the Daily NFT Sales Volume on the Daily Average Transaction Fee using the Price of Ether as my instrument to accomplish this

goal. In motivating the exogeneity and relevance assumptions, the instrument was valid. Significant causality was determined between the Transaction Costs and the daily NFT Sales Volume such that increases in Gas Fees appear to result in drops in demand for NFTs. However, the test for elasticity also determined the price elasticity of demand for NFT Sales to be inelastic, potentially suggesting increasing independence between the broad cryptocurrency and NFT markets. While this paper was limited in scope by focusing on the Ethereum network, the implications of such findings are nevertheless relevant considering the evolving nature of NFTs. As seen with the resources devoted to the Ethereum Merge update, developers are already highly aware of fees' importance in maintaining user interaction and network. Hence, future investment and innovation will inherently be connected with those best equipped to provide high-quality services at low transaction costs. Furthermore, the inelasticity of NFT Sales builds upon this narrative that the NFT asset class is very much a complex and independent market. The effects of this are certainly hard to predict, but there will be plenty of opportunities for further research to build on this work and help define more characteristics of this new asset class. Overall, in beginning the research on NFTs concerning Transaction Costs, this paper found interesting and meaningful results that help build a narrative regarding this new and exciting market.

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## IX. Appendix:

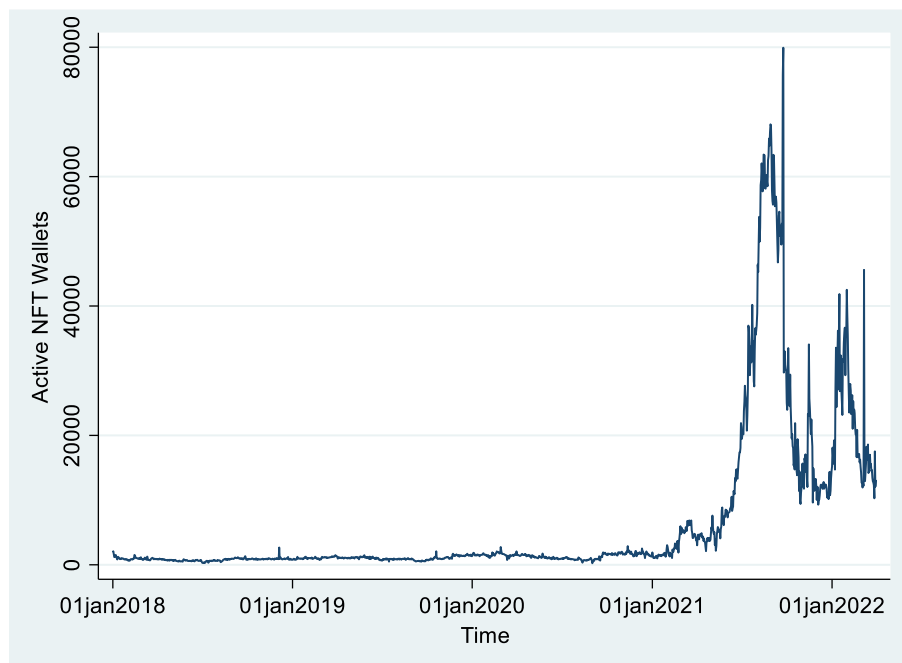
Table 6: OLS Regression

VARIABLES	Model 1 NFT Sales
Transaction Fee	382,115*** (78,367)
NFT Transactions	-368.7*** (77.23)
NFT Wallets	2,877*** (239.6)
Constant	-2.813e+06*** (391,876)
Observations	1,550
R-squared	0.774

Robust standard errors in parentheses

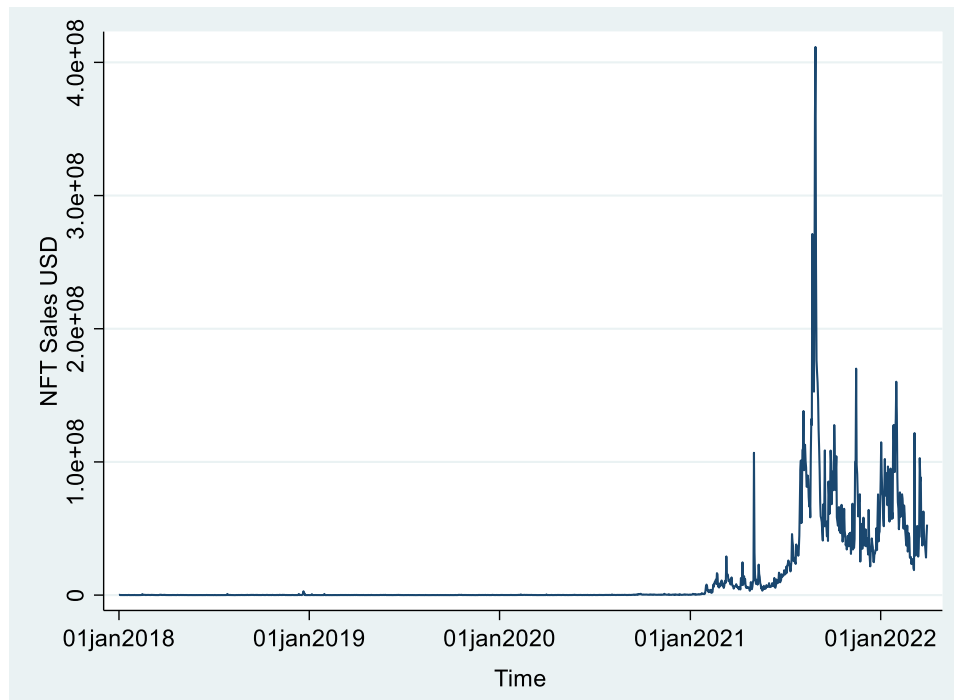
\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

Graph 8: Daily Active NFT Wallets





Graph 9: Daily NFT Sales Volume (USD)



Graph 10: Coin Metrics State of the Network

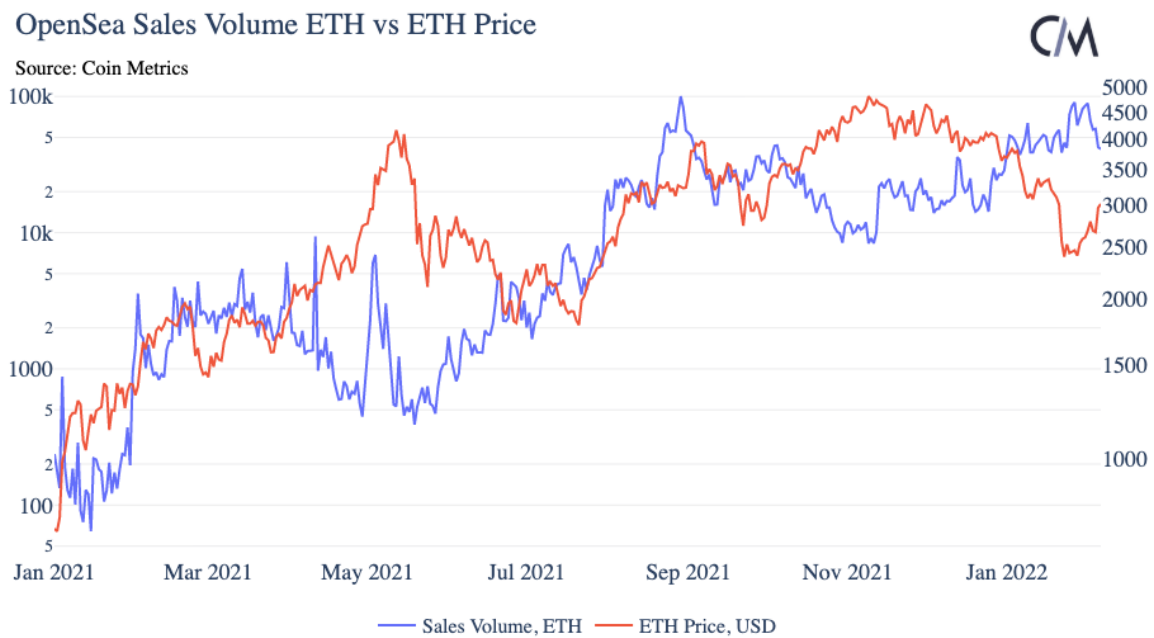


Figure 1: One Example of an NFT from the Cryptopunks Collection



Figure 2: Dapp Radar 2021 NFT Report

