How do you price a Punk? An analysis of the first NFT market.

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Abstract

The year of 2021 will be remembered as the year the NFT markets exploded, yet due to its young age little is known on the underlying mechanics behind how this markets work. Thus, purpose of this thesis is to analyze to which extent do the different visual attributes of an NFT impact their valuation. To answer this question, we will be performing the first ever application of the Hedonic model to analyze the valuation of the NFT project Crypto Punks. Due to the novelty of the market, we developed a web scraper to recollect the necessary data and create the unique data set that comprises the different attributes of each Crypto Punk. Through our analysis we found that the valuation of these digital artworks did not solely rely on their scarcity but that there potentially was some cultural biases at play.

Keywords: Non fungible tokens, Blockchain, Art market, Digital markets, Hedonic regression, The extended self.

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1. Introduction

As if Covid was not enough of a surprise, on the 11th of March 2021, the world witnessed how and non-Fungible token from a publicly available Jpeg file was sold in a Christie's auction for 69.3 million USD (fees included) (Reyburn, 2021). Detractors of NFTs, called this absolute madness, claiming that the NFTs are no more than hot air, and labelled it as the new digital tulip fever (Wertheim, 2021). Proponents of the technology say that the NFTs is here to stay and that it will change forever the way we perceive and value digital assets (Shirley & Harley, 2021), revolutionizing the digital art market by introducing digital scarcity to world, and allowing artists to commercialize their digital art which had for long been ignored by most of the world, as reflected by the scarce academic literature about digital art and its low historical sales volume (Watkins et al., 2015). Whether you may side with one opinion or the other, one thing remains true: people are spending real money, sometimes millions, for these digital artworks.

There already exist a large body of academic literature that studied art markets, and how you can create price indexes for heterogeneous traded artworks (Ginsburgh et al., 2006). Most of these studies use the Hedonic Model to assess how the physical heterogeneity of each artwork may impact their valuation. Often looking at factors such as size, name of the artist, quality and method of production used. In the case of NFTs we cannot use any of these commonly used variables to create a price index as digital artworks are by nature immaterial. Thus, to analyze how these artworks are valued, we most solely rely on their visual attributes and characteristics.

In this thesis, we will investigate what is considered as the first-ever NFT market, Crypto Punks. A set of ten thousand computer-generated unique avatars with a retro video game aesthetic. With the entire market currently valued at almost 2 billion dollars, these unique avatars have attracted the attention of major auction houses, Christie's, and Sotheby's, where some of the punks have been auctioned for millions (Howcroft, 2021; Kiderlin, 2021). But while some of them are sold for astronomical sums (millions), while others are sold for tens of thousands.

As the NFT market is very novel, to obtain the necessary data to conduct such analysis, we coded a web scrapper whose mission was to create a data set that comprised all the ten thousand punks, their attributes, and the last sale price. The data will then be used to conduct a hedonic regression which may help us illuminate some pending questions about the market. Due to their inherent immaterial digital nature, rather than looking at the different physical attributes this thesis will analyze how different aesthetic attributes impact the valuation of the Crypto Punks. Some of these attributes, include the skin

color of a punk, the gender or type and the number of accessories that a Punk may have. Seeking to answer the question: *How do the different visual characteristics of the Crypto Punks may impact their valuation?*

To answer the questions, this thesis is structured as follows. Section two will include the theoretical framework where the topics of digital Art, blockchain technology, non-fungible tokens, and digital art markets will be presented. Section three of the thesis will explain the history of the Crypto Punks, their unique attributes, and their market. Section four will introduce to the reader Belk's concept of the extended digital self and attachment to digital possessions. Section five will discuss the methods used to create the web crawler used for the obtention of the original data set while also providing summary statistics on the Crypto Punks. Section six will explain the methodology used together with the sampling method, the chosen empirical methods, and this thesis hypotheses. Section seven will present the results of the model and robustness tests. Section eight will discuss the results and some aspects of the NFT market. Section nine will conclude the thesis with some final comments.

2. Theoretical Framework

2.1 Digital Art

We refer to digital art as art that incorporates digital technology as part of its creative or presentation process. Believed to originate in the 1960s, digital art creation began incorporating mechanical and analogue devices into artists' creative processes (Victoria & albert museum, 2021) At its source, digital art fomented relationships between artists, scientists, and engineers, whose aim was to explore the connections between technology and art. As the technology evolved, so did digital art, and while new digital techniques were developing, new digital art movements accompanied them. From pixel art to 3D computer models, we can find artists adopting artificial intelligence and neural networks within their creative processes (Cetinic & She, 2021). Some of the currently popular digital art movements include Vapor Wave, Cyberpunk, Pixel Art, Outrun, and Generative, to name a few. However, during the time where the production of digital artworks was evolving, very few of them were commercialized and sold (McConaghy et al., 2017).

The lack of sales can be attributed to three main factors linked to the digital nature of digitally born art, which prevented it from being commercialized in the same manner as physical art. The first factor, being digital art and digital goods, could be considered public goods. Like public goods, digital goods are characterized by non-rival and non-excludable consumption (Rayna, 2008). These digital goods can easily be copied and distributed freely across the internet or p2p networks without any costs or loss of quality. While restrictions and regulations exist to combat digital piracy, these have little to no power to prevent it, effectively providing an unlimited free supply of these goods on the internet (Sudler, 2013). Secondly, it is near impossible to verify the authenticity and "originality" of any file and consequently any digitally based artworks (Zeilinger, 2018). This aspect negatively affects the price and commercialization of digital pieces of art, as the absence of verifiable provenance information is known to negatively impact the cost of an artwork (Danchev, 2006; Radermecker, 2019). Finally, the lack of cultural and collecting norms for digital art further difficulted their commercialization (Watkins et al., 2015). While some digital artworks are sold within physical objects (USBs, C.D.s, etc.), their digital and not physical nature may still be valued less than their purely physical counterparts (Atasoy & Morewedge, 2018; Duan, 2014). The overall lack of interest and low valuation for digital artworks can also be noticed in the academic literature, where very few papers have been written about digital art, artistic currents, and commercialization. This is where non-fungible tokens come into play, introducing digital scarcity through smart contracts powered

by blockchain technology, providing solutions to the problems mentioned above, coming to the rescue of digitally born art.

2.2 A Brief Introduction to Blockchain

To understand smart contracts and NFTs we must first become acquainted with blockchain technology. Contrary to popular belief, although popularized, the technology was not invented by Satoshi Sakamoto in 2007 when he created the Bitcoin cryptocurrency, but rather by a mathematician and a physicist almost 30 years ago (Whitaker, 2019). Their objective was to develop a system that would improve digital information integrity and overall reliability, which is vulnerable to manipulation (Bayer et al., 1993). To address the problem, they proposed a database architecture that would use one-way cryptographic hash functions to ensure the trustworthiness of the digitally stored data. These functions served as unique digital timestamps for data packages referred to as blocks, chained together via one-way hash functions. Generated through the unique content of each block, these cryptographic functions would ensure the integrity of the chain. If there were to be any change into a previous block, it would automatically invalidate all the subsequent blocks, thus, breaking the chain. To further increase the ledger's security, compressed copies of the register would then be distributed among peer-to-peer networks (P2P). Each node must verify and accept each data transaction's validity before adding a new block to the ledger (Nofer et al., 2017). According to Tapscott & Tapscott (2017), the complex architecture of blockchain databases can provide three notable advantages compared to traditional ones. Firstly, it uses heavy encryption, which provides overall security to the network. Secondly, it has a distributed nature, meaning there is no single database to hack but a multitude across the web. Finally, its public ledgers grant any individual access to verify the stored information. These factors render Blockchains into quasi-immutable records, independent from any centralized authority to validate the authenticity and integrity of the stored data.

It is essential to underline that not a single but rather a multitude of blockchain protocols exist. While most share the attributes mentioned above, each protocol may significantly differ from blockchain to blockchain. Some have been designed to serve particular purposes; a famous example of this, the Bitcoin blockchain, was created to provide the infrastructure for a purely peer-to-peer version of decentralized electronic cash (Nakamoto, 2008). Attempting to use this blockchain for any other application than monetary transactions can prove to be a complicated endeavor (Crosby et al., 2016). In contrast, other protocols such as Ethereum aim to be more multifunctional, achieved through the support of a Turing-complete code in the blockchain architecture (Singh & Kim, 2019). Being Turing complete

means that it can handle more complex code than the bitcoin protocol, facilitating the integration of decentralized applications (dApps) and the deployment of smart contracts within its blockchain (Liu-Thorrold et al., 2017). The term smart contract refers to pieces of code (programs) that self-execute once the predefined conditions and clauses of a contract are met. Although this technology may seem trivial, these contracts, when secured through a blockchain, have had critical financial implications for digital world actors, especially for digital artists and digitally born art (Bershidsky, 2021; Fisher, 2018; Whitaker, 2019; Whitaker & Kräussl, 2020).

2.3 Non-Fungible Tokens

To better understand non-fungible tokens, we first have to address the concept of fungibility. At its core, fungibility stands for the extent to which a good is interchangeable by another good of the same class. An example of a highly fungible good is cash, and if you were to lend five euros to a friend for a week, you probably would not mind being given a different five-euro bill as a repayment for the debt. However, imagine you lend your car for a week to the same friend, and after the week, he gives you back a different car from the same brand and model. Aside from questioning your friendship choices, cars are considered non-fungible concerning ownership certificates.

Similarly, in the blockchain world, smart contract standards allow the creation of both fungible and non-fungible tokens to represent digital assets. For example, one of the most popular standards on the Ethereum blockchain is the Ethereum request for comments #20, commonly referred to as ERC-20. This standard facilitates the creation of new crypto tokens and currencies that can behave much like cash (Fenu et al., 2018). On the other hand, non-fungible tokens standards are used to track unique and distinct digital goods. Since its creation, Multiple Ethereum standards have been developed, as well as smart contracts from competing blockchains to serve this purpose (di Angelo & Salzer, 2020).

One of the most popular smart contract standards for creating non-fungible tokens is the Ethereum ERC-721. The standard facilitates the creation of digital proofs of ownership that enable artificial scarcity for digital goods (O'Dwyer, 2020; Serada et al., 2020). Constituting the backbone of the Crypto kitty's game, its creators used it to ensure the uniqueness and ownership of each Crypto Kitten (Evans, 2019). Beyond digital cats, the standard has also been used to create certificates for many different digital assets. Some examples include the ownership certificates of digital land from various online virtual worlds, the registration of web domains, or its use to secure event ticketing applications (Lau, 2020; Regner et al., 2019). It is essential to point that the ERC-721 token does not store the image or digital good within the blockchain but rather what the creator deems as the "original" location of the

artwork file. Thus, allowing individuals to verify the authenticity of a piece of digital Art by accessing Ethereum's public ledger.

2.3.1 Legality of NFTs

A common misconception that people may have when buying an NFT is that all NFTs grant you the same exploitation rights when acquired. As with regular contracts, one must note that the devil is in the details. In fact, some NFTs may allow the buyer to utilize the digital art content however they may please (i.e., print t-shirts and posters from the digital asset). Other NFTs, especially those from established artists or institutions such as the NBA, may have complex terms of use and license contracts which may restrict the commercial exploitation of the NFT aside from any potential gains from its resale(B. Martin, 2021). Think of NFTs like digital contract paper; while most sheets of paper have the same characteristics, each specific contract clauses may vastly differ from one another. A better way to think of NFTs is to compare them as the support on which the contract of sale and use will be put; think of them as digital paper for ownership contracts.

Furthermore, NFTs do not prevent copying unless the creators restrict access to the original location of the files the NFT represents. Most NFT trading platforms allow you to see the original artwork; without buying it, you may download the image via a simple right-click on the image and then click *save image*. The copy of the original artwork will be completely identical to the original, as it will be composed of the same combination of 1's and 0's. You may be wondering then what is the trick then behind these NFTs? In simple terms, although you may have access to the original file, you do not own it and may not legally use it in any way. Thus, although NFTs do not prevent the digital copying of a file, NFTs do help to solve the problem of provenance and traceability of digital artworks as the "real" ownership can be traced (Bershidsky, 2021). In turn, providing the infrastructure for creating an ecosystem with a set of rules for the trade of digital art while also allowing for the creation of a wide range of digital art markets.

2.4 Digital Art Markets

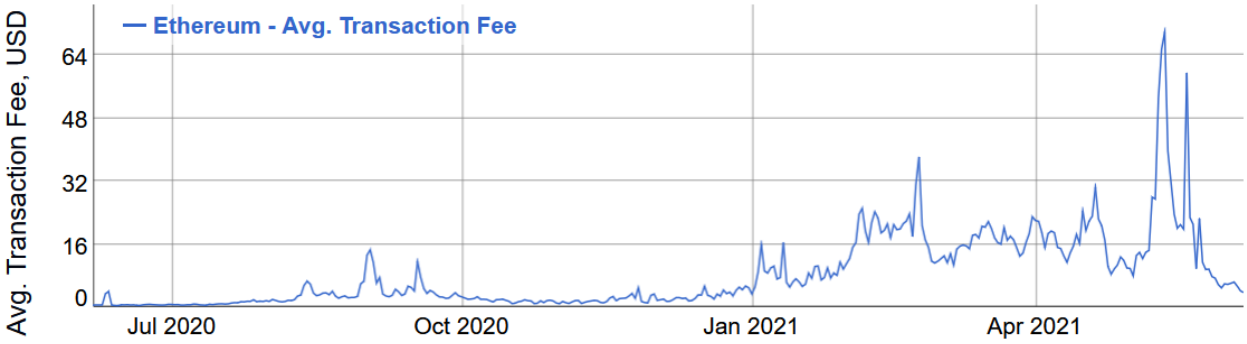
The end of 2020 and the beginning of 2021 witnessed the wide popularization of NFT art. Extensively covered by the media, the sale of an NFT by the digital Artist Beeple titled "everyday" for 69 million USD at a Christie's auction brought the NFT world into the mainstream (Pickford, 2021). Auction houses rejoiced themselves from selling some of these digital art pieces, going to the lengths of accepting cryptocurrencies as payment for them (Tarmy, 2021). And while these sales at traditional auction houses may be impressive, they remain an exception as most NFTs are traded through two-sided digital markets. These platforms are accessible to anyone worldwide with an internet connection, but you must possess a

crypto wallet to become an active participant. These are pieces of software that store the private cryptographic keys associated with a blockchain address controlled by the wallet user (Mercanti et al., 2018). You may think of them as a blend between a digital I.D. card and a wallet, providing you with a unique address (identifier) from which you can receive, send, or store digital assets such as cryptocurrencies, tokens, and NFTs. Wallets are a must-have for the acquisition of NFTs as the principal medium of exchange are cryptocurrencies and they also serve as vaults to keep the smart contracts/tokens used to represent digital assets.

2.4.1. NFT Market Fees

Alike traditional art markets, the trade of NFTs through these digital platforms is also subject to fees. We can distinguish three main types of fees, the first being the blockchain network fee. Commonly referred to as Gas fees, these are used to assess the cost of computational power used to validate a transaction within the blockchain. These fees are retributed to the nodes that maintain the decentralized network up and running by updating the blockchain transaction ledger and performing the necessary cryptographic calculations to maintain its security. These fees are determined by the complexity of the smart contract logic and the supply and demand of computational power to execute the transactions/contracts (Werner et al., 2020). Recently there was outrage regarding the price of Ethereum gas fees, which reached up to a couple of hundred dollars (Rozen, 2021), as the network became congested due to the high demand for NFT related transactions. This meant that if artists wanted to mint (create) an NFT, sell it or transfer it, the fees could be higher than the artwork sale price.

Figure 1: Average Ethereum transaction fee



Retrieved from bitinfocharts.com.

The second type of fee comes directly from the trading platform itself. Alike auction houses and art galleries, a percentage fee derived from the sale price is imposed onto the buyer of the NFT. Finally, a

fee is applied by the creator of the NFT themselves on the resale of their digital asset. Akin to a *droit de suite*, NFTs as smart contracts can automate that a percentage from the resale of digital artworks in the secondary market must go directly to the wallet of the artist/creator. We should notice that there is no standardization of fees yet and may differ across trading platforms, blockchain networks, or NFTs. And while each market may be unique and each fee system may vary from one another, we can note four broad categories of platforms that are specialized in the NFT trade.

Table 1

NFT platform Fees

Markets	Transaction Fee	Special Fee	Royalties	Gas (Blockchain)
Super Rare	2.5%	First sale 15%	10% (fixed)	Ethereum
NBA Top Shot	5%	-	-	Flow
Open sea	2.5%	-	Variable (10% recommended	Ethereum
Crypto Punks	0%	-	-	Ethereum
Rarible	2.5%	-	Variable (10% recommended	Ethereum/Rarible

Data collected by the author from each platform.

2.4.2. Market Types

In the first category of markets we can include the open markets, best illustrated by platforms such as *Rarible* and *Open Sea*; for lack of a better comparison, you may think of them as eBay for NFTs, a market for the trade of any crypto digital assets. From digital land plots to Art, even passing by website domains, if it is digital and has an NFT, they will sell it. Today, *Open Sea* currently ranks second among the largest markets in the overall volume of trade, at 494 million $ since its creation in January 2018. Like most NFT markets, the platform also allows users to mint new NFTs, but contrary to other platforms, it offers the unique service of creating an NFT with no upfront gas costs. It does so by only minting the NFT if a transaction is recorded, saving the creator the cost of minting if the NFT is never sold. Aside from having direct benefits for the NFT creators, it also reduces congestion in the blockchain network the market uses, namely Ethereum. Open Sea has also initiated the integration of a new blockchain protocol, named Tezos, to its platform; this is excellent news for gas prices since, in different chains, they can be substantially lower than Ethereum's (Finzer, 2021).

The second category of NFT markets is purely dedicated to the sale of NFT digital artworks. Within this category, we can further find two subcategories, Curated markets and non-curated markets. The latter allows anyone to mint NFTs and become a seller within the platform. On the other hand, curated markets filter the creatives who can access a seller role via submitting an artist profile and portfolio. Acting as gatekeepers in the digital art world, the content from these curated platforms tends to be artistically better, as a lot of the noise is filtered. One of the most widely recognized curated platforms is *SuperRare*; similar to a gallery but in a digital format, being accepted or invited as an artist in the platform is no easy task. To apply as an artist in the platform, you must go through a competitive selection process where you must present your portfolio and write a short essay on why you think your work aligns with the platform's curated aesthetics. Above all, artists need to have a defined unique style. If accepted into the platform, artists can sell their art at premium prices, as *SuperRare's* average sale price for an artwork tends to be higher than in other similar but non-curated platforms (Zafar, 2021). This is because the platform only allows for creating and selling unique NFTs for the artworks. Rather than creating ten versions, artists can only mint one NFT at a time, keeping the supply low, as the platform's name indicates.

Finally, the last category of the market is also the first type to have appeared for the trade of NFTs digital collectibles markets. Some notable examples also considered classics in the NFT community are Crypto Punks, Crypto Kitties, or Rare Pepes. Originally derived from the internet and digital culture, these collectible markets have also expanded to other areas, such as sports and games. Institutions such as the NBA have also started their line of collectible digital assets called NBA Top Shot. The project became a sensation when their creation of NBA trading cards of the league's most iconic moments reached a total trading volume of 573 million USD, ranking, at that time, as the largest NFT market by trading volume globally (DappRadar, 2021). While these trading platforms are undoubtedly popular, they do not allow their users to create or mint NFTs. Usually linked to institutions or established creators, these markets and their NFTs tend to have the highest levels of terms and conditions, which can dilute the ownership of the good itself. When acquiring the NFT, you may just be getting a license rather than the digital good itself; thus, limiting what its owners may or not do with them while also potentially restricting their trade-in non-proprietary platforms. Collectible markets, also tend to be ommit resale fees and *droit de suite*, although the NBA top shot as an exception charges 2.5% of the sale price both to the seller and buyer.

3. Crypto Punks

3.1 The history behind the first NFTs

Created in 2017 by co-founders of Larva Labs, Matt Hall, and John Watkinson, Crypto Punks are a limited series of 10.000 uniquely generated 24x24 pixel characters with an aesthetic of early computer games. The creators kept the first 1000 punks while the remaining 9000 were given away for free to anybody who owned an Ethereum wallet. It did not take long after their release for all of them to be claimed by crypto enthusiasts. Launched before the existence of Ethereum NFT standards, Punk's collectors claim Crypto Punks were the first NFT project to have ever existed on the Ethereum blockchain. Although recently, evidence of earlier NFT projects have begun to emerge, contesting their primacy (Matney, 2021). Whether first or not, their impact on the NFT scene was considerable, as they are widely regarded as the source of inspiration for the development of the first NFT standards on the Ethereum blockchain (Kane, 2021; Lau, 2020). Their certificates of ownership were uploaded into the blockchain using a modified version of the ERC-20 standard serving as an inspiration for one of the most widely popular Ethereum standards, ERC-721 (Entriken et al., 2018).

Figure 2: Crypto Punks

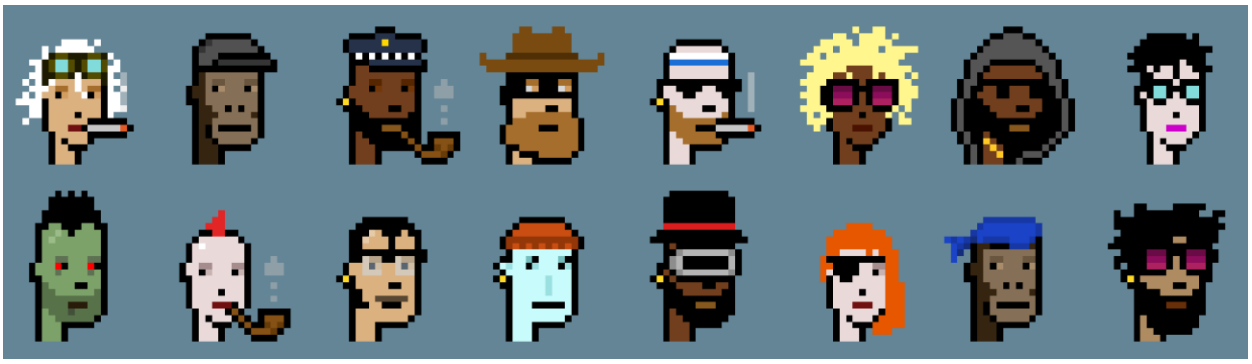


image retrieved from Larvalabs.

Matt Hall and John Watkinson further explained their creative process within the context of a podcast titled *Modern Finance* hosted by Kevin Rose (Rose et al., 2021). In there, the creators of crypto punks explained their long-time interest in collectibles, being themselves collectors, of Canadian Hockey cards and the game Magic the Gathering. They had flirted for quite a while with the idea of creating a digital collectible. Inspired by the current developments in online videogames where in-game collectibles sales played an increasing role, they first thought of developing a digital collectibles mobile app. However, after reconsidering the idea, they felt like an app would not provide an optimal collecting experience. Its

users would not know how many collectibles would exist as they had experienced themselves while collecting trading cards. In the meantime, while exploring solutions to ensure the digital scarcity of the collectibles, they were also refining the generative code that would create the crypto punks. With an emphasis on scarcity, they decided that each crypto punks should be unique, with some being more unique (scarce) than others. After coming across the Ethereum blockchain and modifying the ERC-20, they ran the generative code one last time and proceeded to upload the certificates of ownership on the blockchain. Their idea behind uploading the punks online was that they could potentially serve as online avatars for the collector's social media accounts and online identities.

3.2 The different types of Crypto Punks

With each crypto punk being unique, they can still be categorized according to some specificities inherent to their generative code. To illustrate these categories, I have created an infographic (see *Figure 3)* to help the reader visualize the different levels of complexity that each crypto punk may have. The first level of the infographic shows the core types of Crypto Punks that exist, presented from in the left, the rarest to the right, the most abundant. We can refer to the first three types, namely Alien, Ape, and Zombie, as the special types as they only make 121 of the 10000 punks. If the punks are male or female, there is a further subdivision by skin colour. Although the official website omits any labels on the Punk's skin colour, I have labelled them for the sake of their study. Finally, the last main category that defines the type of Punk is the number of attributes/accessories one may have. Punks can have zero to seven of these accessories, some are exclusive to males others to females, and finally, other attributes are not dependent on the type. We must also point those special types are considered by the generative code as males to be attributed male or mixed accessories. There are 87 different attributes, and each Punk can have from zero to seven of them.

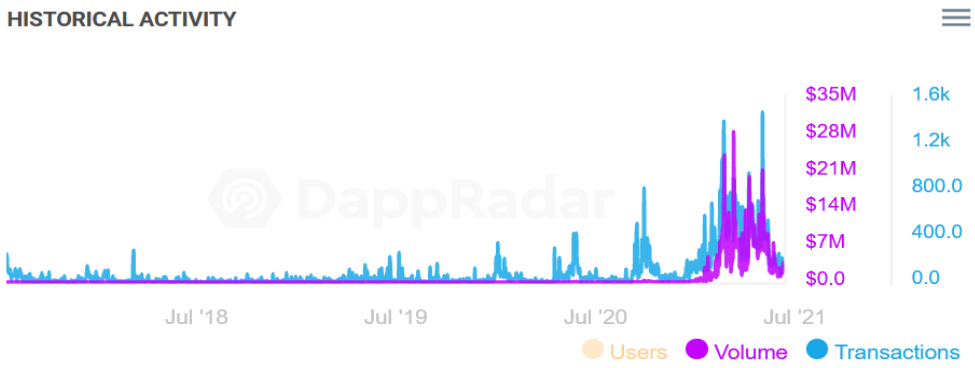
Figure 3: Crypto Punks main categories

images retrieved from Larvalabs

3.3 Market history of the Crypto Punks

Since their launch, punks have been traded on their proprietary website with no fees other than the Ethereum gas required by the platform. For most of their history, the crypto punk number of transactions and trade volume remained low and stable. As seen in *Figure 4*, this changed when Roberto Ceresia's Ark.Gallery deployed a smart contract that allowed collectors of crypto punks to convert their punk ERC-20 tokens into ERC-721 tokens. The purpose for the creation of the smart contract was to improve the liquidity of the punks. The contract would allow for them to be traded in markets such as Rarible and OpenSea to increase their liquidity in exchange of a 2.5% transaction fee from Ark.Gallery (Kalra, 2020). The second spike in their trade can be seen at the beginning of 2021; in March, the market's entirety reached a valuation close to 2 billion dollars.

Figure 4: Volume and number of Crypto Punk transactions



retrieved from www.dappradar.com

Today there is a strong community of collectors found in the official CryptoPunks Discord's server (Matney, 2021). Today, we can see the 10 thousand punks scattered across 2260 different wallets (collectors) with the price of an average sale price of 66 thousand dollars during last year, with some rarer Crypto Punks having been sold for millions. Thus far, the most expensive sale of a unique alien type punk #7804 punk for the staggering amount of 7.57 million USD. And more recently, the creators of the punks also decided to auction a bundle of nine punks through Christie's, selling for 16.9 million USD and scoring the second ever recorded sale of NFTs at 16.9 million USD (Kastrenakes, 2021). These record prices raise the question of how these digital assets are valued, the drivers of value, and how some of them are sold millions while others for thousands. This paper aims to provide the first analysis of the influence that specific attributes of Crypto Punks have on their price and to see if we can detect cultural biases in their valuation.

4. Possessions and Identity extension in the digital realm

To better understand the complexity of the reasons for collectors to buy art, and in digital art in particular, beyond the simple observation of its financial return assets can tell us more about digital art collectors than their simple valuation method, it is helpful to recall Belk's (1988) idea of the extended self. This concept refers to the notion that certain people and possessions are seen to be a part of us. We extend our identity beyond our mind and body; when lost or damaged, we may experience the loss as a wound to ourselves. For example, visualize the intricate relationship a musician may have with her instrument while performing: it is common for musicians to report becoming one with the instrument while perceiving the instrument as an extension of the self (Nijs et al., 2009). Similar occurrences have been reported by chefs with their cooking utensils, professional athletes and the object of their sport, and artists with their paint and brushes. This also happens with automobiles, representative clothing, wedding rings, and even the movies we watch; the music we listen to and the places we frequent end up shaping the way we perceive ourselves. Similarly, our digital life and possessions also impact the perception of ourselves and affect the way we present and express ourselves (Polito & Hitchens, 2020).

Aside from expanding the realm of how we as individuals can present ourselves to other fellow humans, digital technology has also drastically changed how we communicate, consume, learn, date, travel, and play (Harari, 2016). And while these changes are part of the unstoppable forces of evolution, the primary matter arises with the increased levels of self-awareness when representing ourselves online. An example of this heightened self-awareness is online self-censorship (Das & Kramer, 2013). A more recent example is zoom fatigue, partly caused by increased self-awareness from constantly facing ourselves with the camera (Morris, 2020). As the world we experience becomes less analogue and digital, it is crucial to explore how these changes affect us and our extended selves. We will be referring to Belk's (2016) framework, which focuses on three essential areas: dematerialization, re-embodiment, and the co-construction of the self.

4.1 Dematerialization

It has been widely documented those digital goods with the equivalent content tend to be valued less than their analogue counterparts (i.e., Vinyl vs mp3, Ebook vs book, etc.) (Atasoy & Morewedge, 2018). Because of their high fungibility and abundance, we do not perceive them anymore as unique goods also because they can be flawlessly copied at a negligible cost. Humans tend to be more attracted to value scarcer goods, making the unlimited supply of digital goods renders less attractive (Lynn & Bogert, 1996). And while we may appreciate them less, by no means this implies that we do not get attached to these

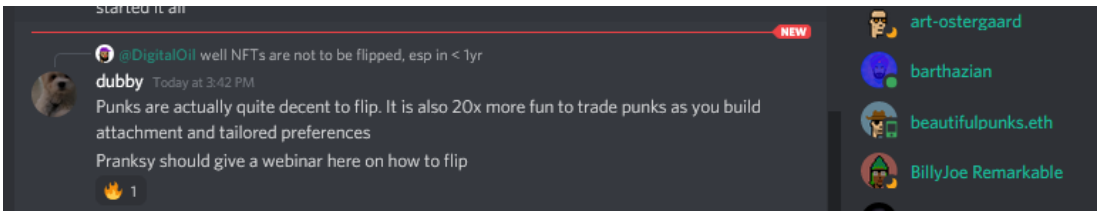
digital possessions. Often referred to as the Tamagotchi effect (Lawton, 2017) this attachment can be reported in the realm of video games (Watkins & Molesworth, 2012), social media profiles (Altuwairiqi et al., 2019), Spotify playlists (Sinclair & Tinson, 2017) and internet memes (Glitsos & Hall, 2019) among many others. This is particularly true for younger individuals who tend to have a stronger attachment to their digital possessions than older people (Cushing, 2013, 2011). Extrapolating this research to NFTs and digital art collectors would infer that the average collector would tend to be younger than your usual art collector.

4.2 Re-embodiment

Belk (2016) explains that humans are disembodied when using digital tools such as emails or social media compared to physical interactions. Still, nevertheless, we are re-embodied through our online profiles, avatars, and personal pages. These self-representations can be far from reality as we tend to curate and share idealized versions of ourselves, emphasizing aspects that we perceive as more likeable and signalling social value (Kim & Sundar, 2012; Manago et al., 2008; Vasalou & Joinson, 2009). This is also true for online communities and video games, through personalized avatars, for which users its owners develop emotional attachment towards (Kim & Sundar, 2012; Vasalou & Joinson, 2009). While we lack the necessary data to prove how digital art collectors are emotionally attached to their digital possessions, we still notice that many collectors feel an attachment towards their digital possessions.

Furthermore, we can also notice that many of the collectors use their punks as their online avatars in social media (SEE Appendix.). Rather than buying expensive cars, fashion brand clothes, or other luxury items, Crypto Punk collectors display their status within the community with their crypto punks. As Matney (2021) explains in his article on the punk phenomena, many collectors perceive them as a "digital flex", primarily when used in social media, serving as a status signaling symbol among NFT and crypto traders. The rarer the Punk, the higher the price specific accessories deemed cool and valuable by the community and can provide its owner with respect and credibility.

Figure 5: Crypto Punk Collector Forum



Retrieved from the official Crypto Punks Discord server

4.3 Co-construction of the self

In his paper, Belker (2016) references the American sociologist Charles Cooley who proposed that we humans get to know ourselves through the lenses of other reactions to ourselves. As Yuval Noah Harrari (2016) wrote in his book *HomoDeus, p.88* "the lives of most people have meaning only within the network of stories they tell one another". The same can be said from our online identities, which are under constant scrutiny from other's likes, followers, friendship requests, comments, etc. (Belk, 2014), serving as input for our online self-representation, in turn shaping our and others' online image and identities. In the case of Crypto Punks, while the scarcity of their attributes and accessories may work as a driver of their price, there are a few attributes, although common, that may be more sought after than other rarer ones. This reasoning, lead us to think that some attributes and types are deemed cooler or more desirable by the community resulting in premium prices even if more common than other attributes. This may be purely driven by their more appealing aesthetic goods or negative associations with some of these attributes. By analyzing this, we may gain valuable insights into which aesthetics and attributes the collectors of Crypto Punks appreciate and possibly gain further understanding of the participants of these new NFT markets.

5. Crypto Punks Data

5.1 Data Gathering

For this thesis, we favored the recollection of quantitative data as we wished to provide an unbiased price analysis of the Crypto Punks market. For the obtention of simple descriptive statistics, we used Excel's data web extractor, which allowed me to copy a few descriptive Tables from the proprietary website of the Crypto Punks (See Appendix A2). The data Tables provided statistics of the market as a whole, but there was no complete data set on individual Punks. For this thesis, we aimed at collecting data from each of the Crypto punks, their type, and their specific attributes they have. In the case of being human, we also wanted to obtain their skin colors and their last sale price, if sold at all. Most of this information could be extracted from the official website, but rather than providing it easy to use and access Table, the data would have to be extracted from the individual page of each Crypto Punk (See Appendix A3). Although Excel allows you to extract simple Tables from websites directly, it, unfortunately, does not yet provide the possibility to automate the extraction from a multitude of web pages. Now confronted with the colossal task of manually accessing each of the 10000 punk pages on my own to extract the data, we researched how to automate this task. After some exploration realized that the best option was to build a web scraper that would access the ten thousand pages and extract the data on our behalf. Aside from sparing me from what could be considered as cyber repetitive and tedious work, the intent of the web scrapper was also to prevent any human errors that could happen during data recollection.

5.2 The web scraper.

It could be worth to illustrate how web scrapers work. They are pieces of software whose mission is to extract data from websites to then export it into a valuable format for analysis by its users. To create such a program, we used the open-source coding language Python. Aside from being recognized as a relatively approachable and versatile language, its popularity also meant that the search for educational content, modules, and community surrounding it would make the process of building the scraper easier. Furthermore, its popularity also meant that it could easily be integrated with other open-source web scraping specialized software. Using modules such as Beautiful Soup, whose purpose is to "clean" coding errors from the website's HTML source code, and the Pandas module, which allows for the recollection and organization of data, we were able to begin the development of the web scraper.

The first task was to inspect if the website's content structure was consistently organized from page to page. Fortunately, since two informaticians created the original project of Crypto Punks, the

website was well structured. The scraper begins by opening the first Crypto punk page, which starts with the following URL: https://www.larvalabs.com/cryptopunks/details/0 up to: */details/9999.* Unfortunately, when testing the code during its development, the website would automatically block the web crawler out after getting data on 20 punks. This is a common occurrence when web crawling and scraping as the hosting server perceives the multiple connection demands as an attack to the web page. To solve this issue, we used a series of nine proxies which provided us with additional I.P. addresses, which we cycled so that the page would receive only a request from each proxy every 30 seconds. Once ensured that the program would adequately work without any crashes, we decided to run the crawler at midnight UTC-4 to avoid congesting the server and creating any nuisances to its creators.

Figure 6 : Web Scrapper Code Sample

```
for punk_id in range(0,10000):
    results = {}
    proxy = next(proxy_pool)
    proxies = {
      "http": proxy,
      "https":proxy
    }
    response = requests.get(f'https://www.larvalabs.com/cryptopunks/details/{punk_id}', headers=headers,proxies=proxies)
    soup = BeautifulSoup(response.text,'lxml')
    data = soup.find('div',{'id':"punkDetails"}).text
    if 'Female' in data:
        gender = 1
    elif 'Male' in data:
        gender = 0
    elif 'Zombie' in data or 'Ape' in data or 'Alien' in data:
        gender = 3
    attributes = [i.text for i in soup.find('h3',string="Accessories").findNext('div').findAll('a')]
    no_of_attributes = len(attributes)
    owner = soup.find('h3',string="Current Market Status").findNext('div').find('a').text.strip()
    rows = soup.find('div',{'id':"punkHistory"}).findAll('tr')
    for row in rows:
        if row.find('td') is not None and row.find('td').text.strip() == 'Sold':
            sold_row = row
            break
        else:
            sold_row = None
```

The program was structured to recollect the following variables: nature of the Punk (i.e. male, zombie), number of accessories the Punk has, which of the 87 accessories does the Punk has followed by the last sale price of the Punk (if sold at all), the date of sale, and current owner. I must also disclaim that the data set does not include sale price and time from the 279 Crypto Punks wrapped (turned into an ERC-721 standard) by Ark Gallery smart contracts (Kalra, 2020). Regarding the skin color of the crypto punks, unfortunately, the official website does not provide this data. Instead, we had to find an alternative source for it. After a long exploration across multiple dedicated collector forums, while asking members for guidance on where these data, could be obtained we were kindly directed by Gerald Bauer, the moderator of the Reddit page r/devcryptopunks, who pointed me towards a website that classified every Crypto Punk by skin color. For simplicity, the color of skin in this paper has been ranked as (Dark, Mid, Light and Albino).

5.3 Descriptive Statistics

5.3.1 Distribution of types and attributes

The full dataset comprises 10000 data entry points, and as we can see in Table 2, most punks are males (60.39%) and females (38.40%), with males having almost 20 more points. Furthermore, we can also note the distribution of skin color among the human types, with the Mid color being the most common, followed by Light, Dark and Albino, the scarcest. We can also notice that the skin color is very similarly distributed among males and females. Table 3, shows the distribution of the number of attributes, which is slightly skewed to the right, with three accessories being the most common and seven being the rarest with only one Punk. The reader may Also Find in Appendix B, a table comprising all of the different 87 accessories/attributes that Punk can have. Accessories are divided by whether they are only for males, females, or any two genders. We must also note that the special types (alien Ape and Zombie) are considered by the generative algorithm as Males, thus receiving male attributes. Finally, Table 4 provides us with the summary statistics on the sold punks; we can note that only 4213 of the punks have ever been traded, meaning that more than half have never moved from the wallets of their original collectors. Many of those are probably lost forever as they may have belonged to collectors who lost access to their wallet, thus losing the proof of ownership of their digital assets. Furthermore, we should also note the high Skewness and kurtosis of the dataset, attributable to the rise in average price and sales of Crypto Punks in 2021.

Table 2
Distribution of type and skin color

Type	Skin Color							
	Albino	Alien	Ape	Dark	Light	Mid	Zombie	Total
Alien	0	9	0	0	0	0	0	9
	0.00	100.00	0.00	0.00	0.00	0.00	0.00	0.09
Ape	0	0	24	0	0	0	0	24
	0.00	0.00	100.00	0.00	0.00	0.00	0.00	0.24
Female	420	0	0	1101	1145	1174	0	3840
	41.26	0.00	0.00	38.99	38.09	38.73	0.00	38.40
Male	598	0	0	1723	1861	1857	0	6039
	58.74	0.00	0.00	61.01	61.91	61.27	0.00	60.39
Zombie	0	0	0	0	0	0	88	88
	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.88
Total	1018	9	24	2824	3006	3031	88	10000
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

The first row has *frequencies,* and the second row has *column percentages.*

Table 3
Distribution Number accessories

Number of Accessories	Freq.	Percent	Cum.
0	8	0.08	0.08
1	333	3.33	3.41
2	3559	35.59	39.00
3	4502	45.02	84.02
4	1420	14.20	98.22
5	166	1.66	99.88
6	11	0.11	99.99
7	1	0.01	100.00
Total	10000	100.00	

Table 4
Summary Statistics of the Dollar variable (representing sale price)

Variables	Obs	Mean	Std. Dev.	Min	Max	p1	p99	Skew.	Kurt.
Dollar	4142	43756.298	177000	0	7580000	19	242131	37.437	1576

5.3.2 Price distribution of different attributes

As we can note in Table 5, there is quite some disparity in the prices of each type of crypto punks, with aliens being the most expensive on average, followed by the Apes and then Zombies. These high prices can be attributed to their relative scarcity when compared to others. We can also note that those Females punks are on average 11% more expensive than males, while the supply of actively traded females is 45% lower than males. Table 6 provides us with the average prices per skin colours, with albino being the scarcest and most expensive. The second most valued skin colour is Light, followed by Dark and Mid. Surprisingly Dark, while being the second scarcest skin colour, it only ranks fourth in skin colour valuation. Finally, Table 7, provides us with the average price for the different distribution of accessories. While the category with 0 attributes has one of the lowest mean prices, this does not reflect their current valuation as an early sale since the market was created pulls it down. Finally, a graph with the average price of each of the 87 accessories is provided in Appendix B.

Table 5
Crypto Punk type distribution and mean price

type	N	mean	SD	min	max
Alien	3	5050870	4371924	2610	7580000
Ape	10	398719	644358	587	1540000
Female	1452	41678	51780	13	547845
Male	2660	37256	47659	0	653814
Zombie	17	145816	303926	205	954650

Table 6
Skin color distribution and mean prices

Skin color	N	mean	SD	min	max
Albino	369	42783	53682	0	419362
Dark	1161	37935	48260	13	653814
Light	1288	40415	52684	4	495197
Mid	1294	36888	44835	3	394972

Table 7

Number of accessories distribution and mean prices

# Accessories	N	mean	SD	min	max
0	3	46921	78473	304	137522
1	80	177281	868083	34	7580000
2	1419	40743	63840	0	1180000
3	1960	40453	176391	4	7570000
4	622	39653	48032	13	361208
5	55	81700	96902	3	324764
6	3	218195	377257	13	653814
7	0	.	.	.	.

6. Methodology

6.1 Empirical framework: The hedonic regression

The hedonic regression method (HRM) has been used to estimate how a specific characteristic of a good or service impacts its price. First developed by Andrew Court in 1939, his purpose was to study how the different features from different car models affected consumers' willingness to pay for a vehicle. The HRM was later popularized by Zvi Griliches, who also used it to create a Car price index in the early 1960s (Goodman, 1998). Since then, the HRM method has been used due to its versatility to create price indices of a wide variety of goods and services, such as comic books (Wyburn & Roach, 2012), vinyl records (Cameron & Sonnabend, 2020), agricultural externalities (le Goffe, 2000), hotel rooms (Chen & Rothschild, 2010) and even restaurant meals (Yim et al., 2014). Although now widely associated with real estate and housing market academic literature (Chau & Chin, 2003; de Haan & Diewert, 2013; Nicholls, 2019). The HRM has also been widely used in a variety of studies on art markets and art valutation (Candela et al., 2004; Clement et al., 2006; Fedderke & Li, 2020; Lazzaro, 2006; Locatelli-Biey & Zanola, 2002; Renneboog & Spaenjers, 2013; Scorcu & Zanola, 2011; Worthington & Higgs, 2006).

One of the main advantages of using this technique is its ability to estimate the values of specific attributes providing further understanding of how each feature may impact the price of the good or service. However, this powerful method also comes with drawbacks, such as the need for extensive datasets, coupled with issues of multicollinearity and heteroskedasticity (Ginsburgh et al., 2006). Even though it may come with its disadvantages, the technique is widely used in the academic study of heterogeneous markets. Thus, we apply the HRM the method to understand how the different attributes of the Crypto Punks affect their final price. Thus far, the only instance of an application of the HRM to a blockchain-based asset can be found in Shorish (2019), where it is used to analyze how the characteristics of different cryptocurrency tokens affected their valuation. Moreover, to the best of our knowledge, the only paper on the pricing of NFTs is Downling's (2021) paper on the price of digital land. This study, however, focuses on market's efficiency rather than on hedonic pricing.

Our study aims to further our understanding of one of the NFT markets, investigating the pricing of specific digital collectibles and exploring whether we can identify also cultural or social biases by the NFT consumers. The Crypto Punks market seemed like the perfect study case to do so. As one of the first-ever markets, if not the first, owning a crypto punk is considered a must and status symbol within the NFT community. Providing its collectors access to the exclusive club of high-end NFT collectors (Delaney, 2021).

Personal preferences can come from culturally established interpretations, but they can also come from other sources based on personal experience. To put it another way, a personal preference is when a person's feelings regarding a person, culture, service, or good affect their understanding of that person or thing (Haddad et al., 2019). Depending on the cultural background of the collectors, they may find specific attributes more valuable than others. This is particularly interesting in the case of Crypto Punks as these characters emulate human traits and accessories. With the purpose of serving as online avatars for their collectors, these NFTs may serve as a mirror into the anonymous world of NFT collectors. As analyzing their valuation data may provide us with a blurry picture of the current collectors.

6.2 The Hypotheses

Crypto Punks, NFTs, cryptocurrencies, and blockchain fall primarily within the realm of computer science, meaning that one must have an intermediate understanding of technology to access those markets. It has been extensively documented and acknowledged that there is a significant disparity between males and females in the world of computer science (Luxton, 2016). Furthermore, it has also been documented that the computer science and tech world, aside from being male dominated, tends to be populated mainly by white males (Marchant, 2021). A reason for this, white dominance within the tech sector, is that on average white people have a background (social capital) and the means to study in this sector (del Río & Alonso-Villar, 2019; N. D. Martin, 2009). Aside from this, 2021 witnessed a rally in the price of cryptocurrencies which may have increased the amount of disposable income that actors from the crypto market may have had. Furthermore, we also believe that the market is partially driven by scarcity. These factors, coupled with the idea of identity extension, led to the development of the four-following hypothesis.

H1) The variable Time Sold, will be positively correlated with the dependent variable Dollar.

H2) The variable Female will be negatively correlated to the dependent variable Dollar.

H3) The scarcest dummies from the variable Number of Accessories will be positively correlated with the dependent variable Dollar.

H4) Lighter skin-colored punks will be positively correlated to the dependent variable Dollar.

6.3 Sample Selection

The original dataset collected is a Cross-Sectional data set, as it includes price and date of the last sale only of each Crypto Punk. The market was created in 2017, but as shown in *Figure 4*, it only took off in early 2021. As one of the purposes of this thesis is to understand the current state of the market, the

sample is restricted to sales only incurred in the first five months of 2021, starting from January 1st . Furthermore, I also decided to exclude the special types of punks that represent outliers as they constitute a meagre 1.21% of the entire crypto punk population, but are some of the most expensive punks, selling for substantially higher prices than others. In a similar fashion, I have only selected the dummies from the variable number of accessories, which are at one standard deviation from the dummy variable mean picking only punks with two, three or four attributes (See Table 5). Like the special types, punks with a scarcer number of attributes represent only 4.79% of the punk e population. Because of their relative scarcity, they can also be considered outliers, as their valuations are far from the average (see Table 7). After applying the restrictions just discussed, a scatter plot of observations is drawn in Figure 8. It is evident from the scatter plot the presence of heteroskedasticity, which is handled by applying a final filter that only considers sales that are less than 150 thousand USD. The reason for selecting this number, is that it was close to 2.5 standard deviations from the sample's mean. Finally, after all these restrictions have been applied, we are left with a selection of 2495 Crypto Punks to analyze, which when compared to Table 8 (the summary statistics for the variable Dollar of the entire data set) getting the SD closer to the mean and reducing the kurtosis level from 1576 to 4.446.

Figure 7 Crypto Punk scatter plot

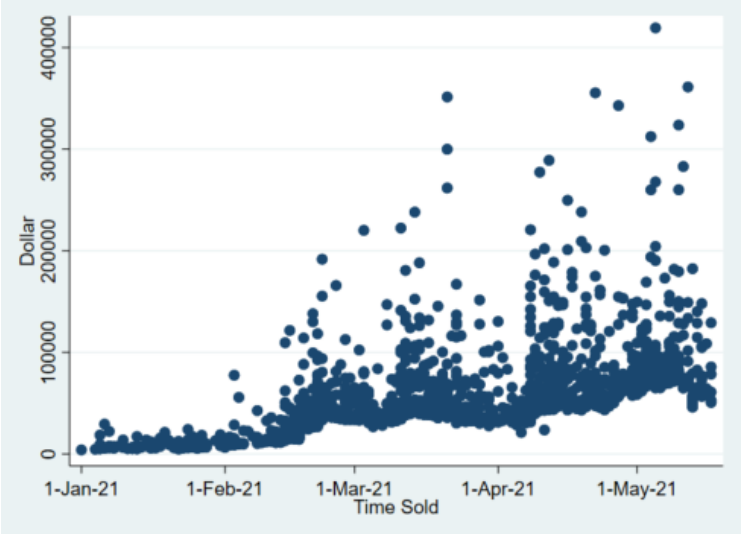


Table 8
Descriptive Statistics Dollar

Variables	Obs	Mean	Std. Dev.	Min	Max	p1	p99	Skew.	Kurt.
Dollar	2495	53474.104	29563.	373	149948	5758	142877	.984	4.446

6.4 The Variables

As it is often the case with hedonic regression, the dependent variables in this analysis will be the price of sale of each Crypto Punks in US dollars. For the independent variables, the gender, skin color and number of attributes were considered. Furthermore, I decided to merge some of the accessory's variables together, the rationale behind this was to be able to obtain variables with stronger significance while also reducing possible problems of multicollinearity. The new variables and their composition of accessories can be seen in Table 9. The variables were merged through common themes, such as hair, if these were glasses or hats, etc. The reason behind this merging is that if a punk happens to have a variable within one of the categories, the other variables could not appear as they exclude each other. Resulting in 15 new variables which account for the 87 accessories, with Earing being the only variable that escaped merging as it is the most common and the only variable that interacts with the Punks Ears. The merging of the variables was conducted through Python with the help of the module Panda, where a copy of the data set was provided and then merged into a new CSV file. Likewise, the recollection of the dataset, technology was favored for this task, primarily to avoid any human errors that could alter the set's integrity. A sample of the code has been provided in *Figure 7* for the reader to visualize the process.

TABLE 9
Independent Variables

Variable name	Short explanation of the variable
Number of accessories	Either two, three or four accessories. Using as base three accessories.
Type	Whether the Punk is a male or a female using male as base
Skin Color	Whether the Punk is either Dark, Mid, Light or Albino. The model will be using as base Light.
Time Sold	The date that the Punk was last sold, accounted in days, starting from 1/1/21-

TABLE 10
Independent Variables for accessories.

Variable Name	accessories
Skin & Teeth	Buck Teeth, Spots, Mole, Rosy Cheeks, Clown Nose.
Mouth	Cigarette, Pipe, Vape, Medical Mask.
Hats	Headband, Bandana, Cap, Knitted Cap.
Male Hats	Cowboy Hat, Police Cap, Cap Forward, Fedora, Top Hat, Beanie, Hoodie.
Female Hats	Pilot Helmet, Tiara, Tassle Hat, Pink with Hat.
Hair	Clown Hair Green, Frumpy Hair, Wild Hair, Stringy Hair, Crazy Hair, Messy Hair, Mohawk, Mohawk Thin, Mohawk Dark.
Female Hair	Wild Blonde, Straight Hair Blonde, Blonde Short, Red Mohawk, Wild White Hair, Half Shaved, Pigtails, Orange Side, Dark Hair, Blonde Bob, Straight Hair Dark.
Male Hair	Vampire Hair, Peak Spike, Shaved Head, Purple Hair, Do-rag
Facial Hair	Front Beard Dark, Normal Beard, Normal Beard Black, Front Beard, Shadow Beard, Luxurious Beard, Big Beard, Chinstrap, Mustache, Muttonchops, Handlebars, Goat
Eyes	Blue Eye Shadow, Purple Eye Shadow, Green Eye Shadow, Clown Eyes Blue, Clown Eyes Green.
Glasses	Nerd Glasses, Horned Rim Glasses, Small Shades, Regular Shades, Big Shades, 3D Glasses, VR, Welding Goggles, Classic Shades, Eye Mask, Eye Patch
Lip stick	Purple Lipstick, Hot Lipstick, Black Lipstick
Emotion	Smile, Frown
Neck	Choker, Silver Chain, Gold Chain
Earring	Earing

Figure 8: Python code for merging variables

```python
import pandas as pd


crypto = pd.read_csv("Attributos.csv", header=0)


# Skin
crypto['Skin_teeth'] = crypto['Buck Teeth'] + crypto['Spots'] + crypto['Mole'] + crypto['Rosy Cheeks'] + crypto['Clown Nose']
crypto = crypto.drop(['Buck Teeth','Spots','Mole','Rosy Cheeks', 'Clown Nose'], axis=1)
crypto['Skin_teeth'] = crypto['Skin_teeth'].apply(lambda w: 1 if w >= 1 else 0)

# Mouth
crypto['Mouth'] = crypto['Cigarette'] + crypto['Pipe'] + crypto['Vape'] + crypto['Medical Mask']
crypto = crypto.drop(['Cigarette','Pipe','Vape','Medical Mask'], axis=1)

# Hats
crypto['Hats'] = crypto['Headband'] + crypto['Bandana'] + crypto['Cap'] + crypto['Knitted Cap']
crypto = crypto.drop([ 'Headband', 'Bandana', 'Cap', 'Knitted Cap'], axis = 1 )

```

7. Results

7.1 Model Results

To perform the empirical analysis, we used Stata. The results of this model were estimated using robust standard errors to account for the possible heteroskedasticity problems that the sample could be subject to. Furthermore, the variable Hair from the accessories group was eliminated from the model as it was will it was highly correlated to the multiple other variables (see Table 13 and 14). Now taking a deep look into the results, we can note that the variable Time Sold is highly significant and positive (618***). We can interpret this result as an average appreciation of 618 dollars for any punk per day. Confirming the first hypothesis that the market did greatly appreciate during the 2021 period.

Table 11
Model results

VARIABLES	(1) model-robust	(2) model-robust-filtered
Time Sold	617.910***	618.017***
	(11.932)	(11.932)
Albino	-1,451.002	-1,443.854
	(1,487.731)	(1,487.307)
Dark	-4,239.216***	-4,236.957***
	(1,051.352)	(1,051.324)
Mid	-1,867.873*	-1,855.875*
	(1,094.919)	(1,093.973)
Female	2,389.373	2,370.318
	(1,513.622)	(1,511.456)
Neck	-21,359.730***	-21,346.235***
	(3,713.892)	(3,713.156)
Emotion	-8,086.553***	-8,118.824***
	(2,176.833)	(2,179.152)
Lips	512.867	489.037
	(1,609.788)	(1,610.265)
Glasses	-5,462.909***	-5,478.451***
	(991.992)	(990.328)
Eyes	560.315	560.557
	(1,143.131)	(1,143.453)
Facial Hair	-234.248	-242.777
	(1,068.940)	(1,069.260)
Male Hair	3,019.048	1,191.332
	(3,538.275)	(1,031.020)
Hair	1,885.243	
	(3,506.500)	
Female Hair	-13,838.864***	-15,682.197***
	(3,870.480)	(1,721.204)
Female Hats	-24,593.168***	-26,434.470***
	(5,580.834)	(4,361.169)

Male Hats	-16,968.138***	-18,793.938***
	(3,843.407)	(1,832.225)
Hats	1,441.546	-388.773
	(3,531.892)	(932.559)
Mouth	-3,854.259***	-3,875.218***
	(1,145.436)	(1,144.847)
Skin teeth	-2,876.631**	-2,892.025**
	(1,393.960)	(1,391.295)
Earring	62.369	40.893
	(980.729)	(979.670)
Constant	-1.359e+07***	-1.357e+07***
	(270,268.156)	(267,742.082)
Observations	2,431	2,431
R-squared	0.537	0.537

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Although, at first glance, we could also reject that Punk males should be more expensive than the female's punks as in this model, being female increases the price by 2370$. The result from the model does not have a strong significance, thus we shall argue in the discussion section why the original assumption may still hold true. The following variables we will be looking at are skin color which is composed of 4 dummy variables. We chose Light as a base variable for skin tone, as we wanted to understand better if having a light skin color would provide any benefits compared to other tones. While albino and Mid provide negative results with little significance, Dark's skin color, aside from being the largest negative coefficient, is also the most significant. The model tells us that all else equal, Dark Crypto Punks are worth 4236$*** less than their light (white counterparts, on average). Confirming the theory that there is a cultural bias of the collectors towards the darker skin feature. The effect is even stronger if we consider that the Dark skin color is the second in scarcity to Albinos.

The next variable we will be discussing is the number of accessories, I chose to use three as the base as it was the most abundant category. Contrary to expectations, we can see mixed effects in this category, having four accessories when compared to three can increase the value of a Punk by (18336$***) whereas having two when compared to three decreases the average price by (-14109$***). Although we expected scarcer Punks with two accessories, we could interpret that the model is telling us, the more accessories, the merrier, confirming further that the market does not value punks solely by their scarcity. Finally, when it comes to the list of accessories, most of them are valued negatively except for male hats, female hats, and hair. A possible explanation for this may be that these attributes tend to take

a bigger space in the picture making them more recognizable than other more discreet attributes such as Earing.

7.2 Diagnostics

In this section, we will present the three methods used to check the validity of the presented model. After testing multiples combinations of the presented models, we found that they had high levels of heteroskedasticity. Thus, presented models use robust standard errors to account for errors derived from a possible heteroskedasticity from the sample. Furthermore, as we also merged and excluded some related variables, we decided to run a RESET test to check whether the model was still Valid. RESET stands for Regression Specification-Error test, introduced by Ramsey (1969). The model is commonly used to check for the occurrence of omitted variables (Whiting, 2020). Finally, the test can also tell us if the model is missing any critical variable. The results presented in Table 12, the test uses a significance p-value of 0.05, as we may appreciate below, the test indicates that there are omitted variables within the model.

Table 12 Ramsey RESET omitted variables.

Ramsey RESET test using powers of the fitted values of Dollar
Ho: model has no omitted variables
F (3, 2408) = 0.53
Prob > F = 0.6585

The second robustness check I made use of is the Variance Inflation Factor or (VIF). Serving as a measure of the amount of multicollinearity between the variables of multiple regression. The test values start a one and have no upper limit, as a rule of thumb, if the value is between one and five, it indicates that there is a moderate correlation among the explanatory variables, if the value exceeds five, then there is a severe correlation. As we can appreciate in Table 13, the model suffered more severe multicollinearity. exempt from severed multicollinearity. The most problematic variable being Hair which was highly correlated with a multitude of the model variables. After removing the variable Hair, and rerunning the test, we obtained an overall mean of the VIF model at 1.394 which can be considered as low. Further providing confirming that the model predictions are correct. As we can conclude, we may dive further into may interpret these results in the next section.

Table 13
Variance inflation factor first model

	VIF	1/VIF
Time Sold	1.009	.991
Albino	1.185	.844
Dark	1.385	.722
Mid	1.387	.721
female	3.202	.312
Neck	1.045	.957
Emotion	1.079	.927
Lips	1.782	.561
Glasses	1.471	.68
Eyes	1.488	.672
Facial Hair	1.746	.573
Male Hair	11.496	.087
Hair	21.611	.046
Female Hair	11.475	.087
Female Hats	3.152	.317
Male Hats	9.616	.104
Hats	13.616	.073
Mouth	1.127	.888
Skin teeth	1.143	.875
Earring	1.068	.937
Mean VIF	4.554	.

Table 14
Variance inflation factor second model

	VIF	1/VIF
Time Sold	1.009	.991
Albino	1.184	.844
Dark	1.385	.722
Mid	1.386	.721
Female	3.2	.312
Neck	1.044	.957
Emotion	1.077	.928
Lips	1.78	.562
Glasses	1.47	.68
Eyes	1.488	.672
Facial Hair	1.745	.573
Male Hair	1.27	.788
Female Hair	1.562	.64
Female Hats	1.119	.894
Male Hats	1.228	.814
Hats	1.197	.835
Mouth	1.125	.889
Skin teeth	1.142	.876
Earring	1.066	.939
Mean VIF	1.394	.

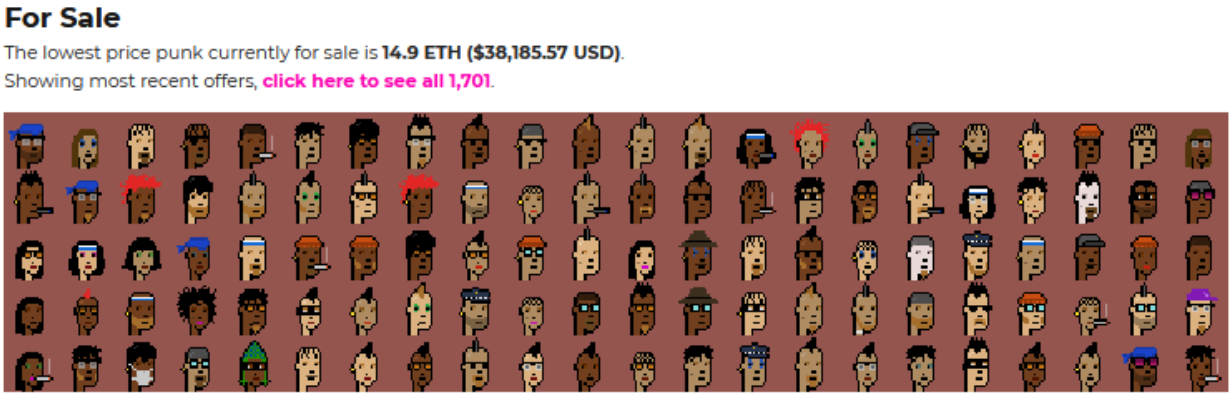
8. Discussion

8.1 A racist market?

In the era of Cultural wars and political correctness, the word racist is being used a bit too lightly. While some readers may be inclined to think that the regression results show that the market has a bias towards

darker punks, we must interpret these results with caution before labelling the market as racist. If we refer to Belk's theory of the extension of the self, rather than assuming that the market is racist per se, we may also interpret this figure to indicate that most of the collectors may be white. As potential buyers may prefer to acquire even at the cost of a bonus, a punk resembles themselves and their idealized physical appearance. Furthermore, we must also note that in the United stated, where the Crypto Punks project was launched, white individuals are more numerous and tend to be richer than Afro-Americans and thus possess more significant amounts of disposable income (Shaikh et al., 2014)

Figure 9: First hundred Punks currently for sale



from cheapest (top left) to more expensive (bottom right) retrieved from Larva labs 14 of June 2021

8.2 NFT market, yet another boys club.

Aside from the overall bias towards darker skin-colored crypto punks, we could also claim that there is a general bias towards females within the Crypto Punk project and market. There are two primary sources of this bias, the first can be attributed to the creators and the second towards the market valuation. Concerning the creator's bias, we must note that the entire project was done by two males, who designed and coded the generative code used to create the punks. The design of the code consciously or unconsciously provided preference to Male punks and their attributes, as can be seen in the overall distribution of punks, 38.4% are females while 60.39% are males. We must also consider that the generative code also considers the special types (Alien, Ape and Zombie) as males, thus they also receive mixed or male-only attributes. Finally, male punks have five more uniquely male attributes than females., The code was likely to be designed from a male centric perspective, as is often the case in the design and tech world. Famous examples of this male centrism include seat belts, primarily designed for men, women are 47% more likely to be critically injured in a car crash than males (Ely, 2015). Another more recent

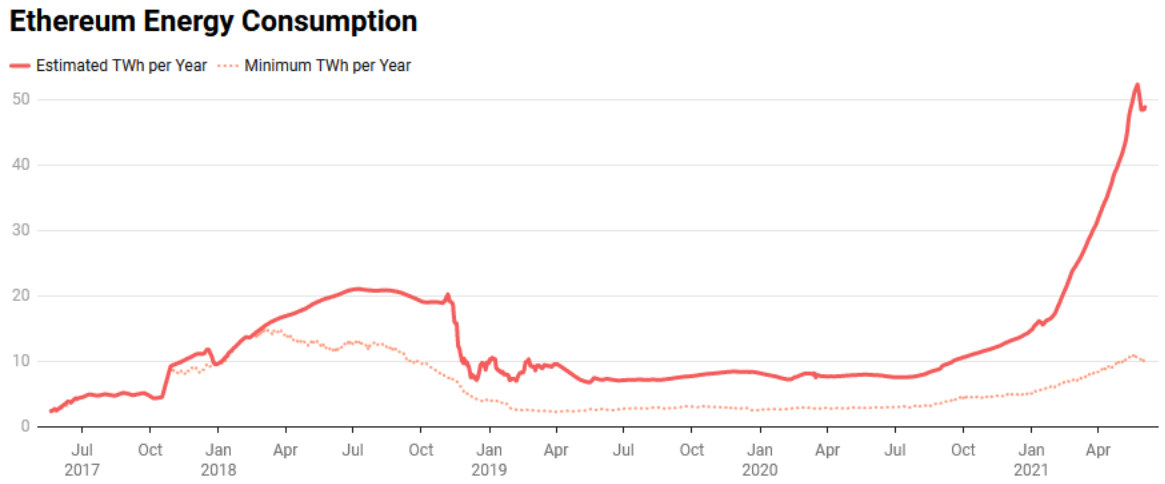
example are the Virtual reality headsets, designed for the center of gravity of males. Thus, females are twice as likely to get dizzy and sick when using them than their male counterparts (The Economist, 2019)

The second source of bias comes from the market itself, although we lack the necessary data to claim that it is male dominated. We may still dare to extrapolate the data we have on the average participation of women within the blockchain ecosystem. Women represent only 14% of individuals who participate in the blockchain environment (Frizzo-Barker, 2020). Thus, we may assume that the market is largely male-dominated. Furthermore, we may also have a look at the data, while there are approximately 40% fewer female punks, their average price is just 11% higher than their male counterparts, further confirming a bias towards female punks. Furthermore, as in the traditional art world, the biggest names in the NFT scene are from males, further perpetuating the disparity among male and female artists (Geyser, 2021). Aside from Race and gender issues and male dominance of the market, NFTs and Crypto Punks have also sparked the fury of environmentalists, which we will discuss further in the next section.

8.3 The Elephant in the server.

The Ethereum Blockchain consumes as much electricity as the entire country of Iraq, with an average of 48.81 TWh in a year, producing an estimated 23.18 Mt of Co2 comparable to the carbon footprint of the Dominican Republic (Digiconomist, 2021). As we can see in *figure 9,* in January of 2021, when the NFT gold rush took off, there was a sharp rise in the overall power consumption of the chain. The more complex a transaction or smart contract is, the more processing power is required to handle it. As NFTs are more complex products than cryptocurrencies, they need more significant amounts of electricity. This does not consider the electricity used by the websites, servers, and computers of the collectors.

Figure 10: Ethereum Electricity Consumption



retrieved from: https://digiconomist.net/ethereum-energy-consumption

Drawing criticism from multiple public actors, the energy consumption of Ethereum and Blockchains can be considered as the technology Achilles heel (Lewis, 2021). While there is no denying that the environmental cost is too large, we must also note that digital-born art impact can be more easily calculated when compared to traditional physical Art. Thanks to tools such as the website Carbon.fyi developed by Offsetra, we can easily calculate the CO2 impact that our personal wallet or any Ethereum bases wallet or smart contract has emitted since existing. Thanks to its ledgers being public, through websites such as Etherscan, we can easily find the address of the crypto punk's project. Once we know the address code, we can just copy and paste it into the carbon.fyi website tells us that the crypto punk's smart contract has created 969 kg of co2 since its creation, comparable to a flight from London to Seoul (939 Kg of Co2). This may seem like a lot, but if factor the fact that this Co2 amount includes every one of the 13750 sales of the punks, the Co2 count per transaction becomes less impressive. Non digital art requires the use of toxic chemicals and overall waste from materials that artists produce in their practice. This is without factoring in the shipping and transport of the completed art pieces, further complicating tracking the environmental impact that artwork may have.

This does not excuse the fact that the amount of electricity used by this specific blockchain is excessive but rather contextualize that digital art is not forcibly worse than physical art. Although Ethereum currently the most popular, many other blockchains allow for the creation of NFTs with much lower environmental costs than Ethereum (Wintermeyer, 2021). An example of such a blockchain is Tezos, which utilizes a more energy-efficient verification system than Ethereum while providing the same

functionalities. The problem remains that blockchains are also subject to network effects, and as these blockchains are younger and less popular, they have a more challenging time competing against older established ones. Thought, there is still some hope for the Ethereum networks as it has been planning to embrace newer and more efficient ledger verification methods. The question remains if they will ever change them, as the community of Ethereum miners is largely opposed to this change (Leissing, 2021). In addition to the excessive energy use of the Ethereum Blockchain, there also is the issue of the over-centralization of the network, which leaves the control of it in a few hands (Barton, 2020). This over-centralization of the network is a product of the economies of scale, from which miners can benefit by pooling together and gaining control over the network. Aside from the energy problem, critics of the technology have also pointed to another problem faced by digital Art NFTs hyper commodification.

8.4 Hyper Commodification and financialization of digital Art.

Up until recently, digital Art escaped from hyper-commodification and financialization, this changed with the arrival of NFTs (Zeilinger, 2018). In the past, as with many other digital goods, digitally born Art was valued less than its physical counterpart, as lack of probable authenticity and ease of copying prevented it from becoming an attractive investment. NFTs solve some of these issues, and as we have witnessed in 2021, digital art valuations can reach hefty sums. The question remains, do collectors really appreciate the Art, or do they just see NFTs to diversify their crypto portfolios? While I cannot provide an empirically backed answer to this question, multiple actors from the digital art market have noted that some artworks are sometimes bought and resold within the same day. Making you wonder if the buyer cared at all for the Art. This is not to say that all collectors perceive their acquisitions as mere investments and criticize those who just see Art as another investment, deprived of any emotional value or meaning. Furthermore, NFTs came with the promise of providing artists with a new source of income, but as is the case in the physical world, most of that revenue went to the top dogs, while the rest of artists fought for the leftover crumbles, perpetuating the status quo within the digital realm. The last concern with NFT markets is their decentralized and anonymous nature, which, likewise traditional art markets, may also serve as a platform for individuals to perform tax evasion. A reason we may have witnessed such a rally in the prices of NFTs is that as the cryptocurrency market exploded in the months before(Szalay, 2021). Rather than cashing in their benefits and turning them into fiat currency, crypto investors may have looked at NFTs to diversify their portfolios and avoid taxation of their benefits.

8.5 Policy Recommendations

Cryptocurrencies, blockchains and NFTs have become one of the worst nightmares for regulators, which lack the necessary legal frameworks to create fair and sound legislation in the field (Lee, 2019). Many believe that the market needs more regulation and control to prevent individuals from realizing large profits without contributing their fair share to our tax systems. Furthermore, as we noted from the Regression, we must also improve our education systems, reduce current disparities of race and gender. As our world becomes ever more digital, all sectors of society must get involved in creating and designing tomorrow's tools, technologies, and algorithms to avoid perpetuating the current status quo.

8.6 Research limitations and suggestions for further analysis

As a first of its kind, this study on the valuation of digital works of art, tries to pave the way for the further study of what we believe to be the art markets of tomorrow. As a novel attempt to use the Hedonic regressor to estimate how purely aesthetic immaterial features of an image impact their valuation, we must interpret the results with caution. Further research and more robust statistics will be required if we truly wish to understand the underlying mechanics behind these novel markets. One main thing we should note, is that for the average reader to understand the worth and value of these NFTs we converted the price of every Punk into Dollars. This may have distorted their valuation as their increase in price may well have been correlated with the recent rally on cryptocurrencies. Furthermore, we would also like to indicate that further studying on the punks and NFT market should be conducted, especially time-series studies which may provide valuable insights in the evolution of these markets while also providing an understanding of its movements and its causes.

9. Conclusion

The purpose of this thesis has been to investigate one of the first markets of NFTs. The starting point for the research, was the recent uptake and popularization of the digital art market, with exclusive pieces and rare punks being sold for millions. After having spent most of this year studying the subject, I realized that the literature on the subject was extremely scarce, and thus decided to add my little grain of sand to the temple of Academic knowledge. The thesis started by introducing digital art and its digital characteristics that made it hard to commercialize. This section was followed by an introduction to the blockchain technology, an introduction to NFTs and a clarification on their legal value. After which I presented some of the currently most popular markets for NFTs. Providing an explanation of how the fees of these work while I also took the liberty to classify them into three broad categories of markets.

This section was then followed by a brief history to the Crypto Punks, their history, attributes, and market. Followed by an in-depth explanation of Beck's concept of possessions and identity in the digital realm, further diving into the concept of dematerialization, re-embodiment, and co-construction of the self in the digital realm. Providing the reader with the theoretical background to understand how we may interpret the results obtained in this thesis. Following this section, I proceed to explain the challenges behind recollecting the data set used for this thesis. A concise explanation of the methodology used for the creation of the web scraper accompanied by the respective summary statistics. Leading us into the methodology section, where the Hedonic Regression was introduced, further in the section the five hypotheses were presented, followed by the sample selection method. Within the same section I also introduced the method and rationale behind the variable merging of the accessories.

Proceeding to the presentation of the findings confirming the cultural biases towards specific attributes of the punks. Such as female punks being more expensive on average than punks, and Darker skin punks being valued less all things equal than their lighter counterparts. The results were also backed by two additional robustness tests, namely the variation inflation factor, and the regression specification-error test for omitted variables. Both test providing positive results confirming the validity of the hedonic model. To finally conclude with a discussion not only centered on the results but also the implications that NFTs markets and blockchain may have on the environment and society.

This thesis aim is to provide a steppingstone for the future study of the NFT and digital art markets. I cautiously do not claim any causality from the results but rather seek to provide a picture to the reader of how the assets of these infant markets are valued and who the participants may be. The thesis also

seeks to clarify certain concepts surrounding NFTs and possible pitfalls, shortcomings, and biases that the market may be subject to. While the NFT bubble may be currently deflating, I am confident that the technology is going to stick around for quite a while, thus pointing the importance of continuing the study of these novel markets.

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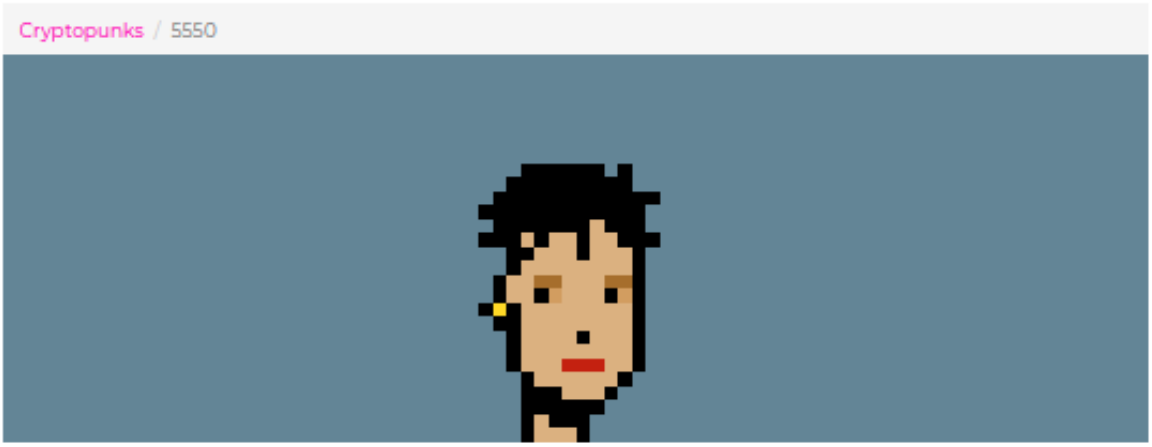
APPENDIX A

A1. Social Media Avatars (Retrieved from twitter)

A2. Crypto Punk website tables

Attribute	#	Avail	Sale	Cheapest	More Examples
0 Attributes	8	1	0	115,590,668,673,405,831,693,358,289,707,374,067.53Ξ	
1 Attributes	333	31	93.65Ξ	39Ξ	
2 Attributes	3560	575	28.35Ξ	15.40Ξ	
3 Attributes	4501	796	27.42Ξ	14.94Ξ	
4 Attributes	1420	252	31.42Ξ	16.50Ξ	
5 Attributes	166	41	61.87Ξ	55.55Ξ	
6 Attributes	11	3	667Ξ	999Ξ	
7 Attributes	1	0	0		

A.3 Individual Crypto Punk Page



CryptoPunk 5550

One of 3840 Female punks.

Accessories

Messy Hair
460 punks have this.

Choker
48 punks have this.

Hot Lipstick
696 punks have this.

Earring
2459 punks have this.

Current Market Status

This punk is currently owned by address **0xbb1ec7**.
This punk has not been listed for sale by its owner.
There are currently no bids on this punk.

Transaction History

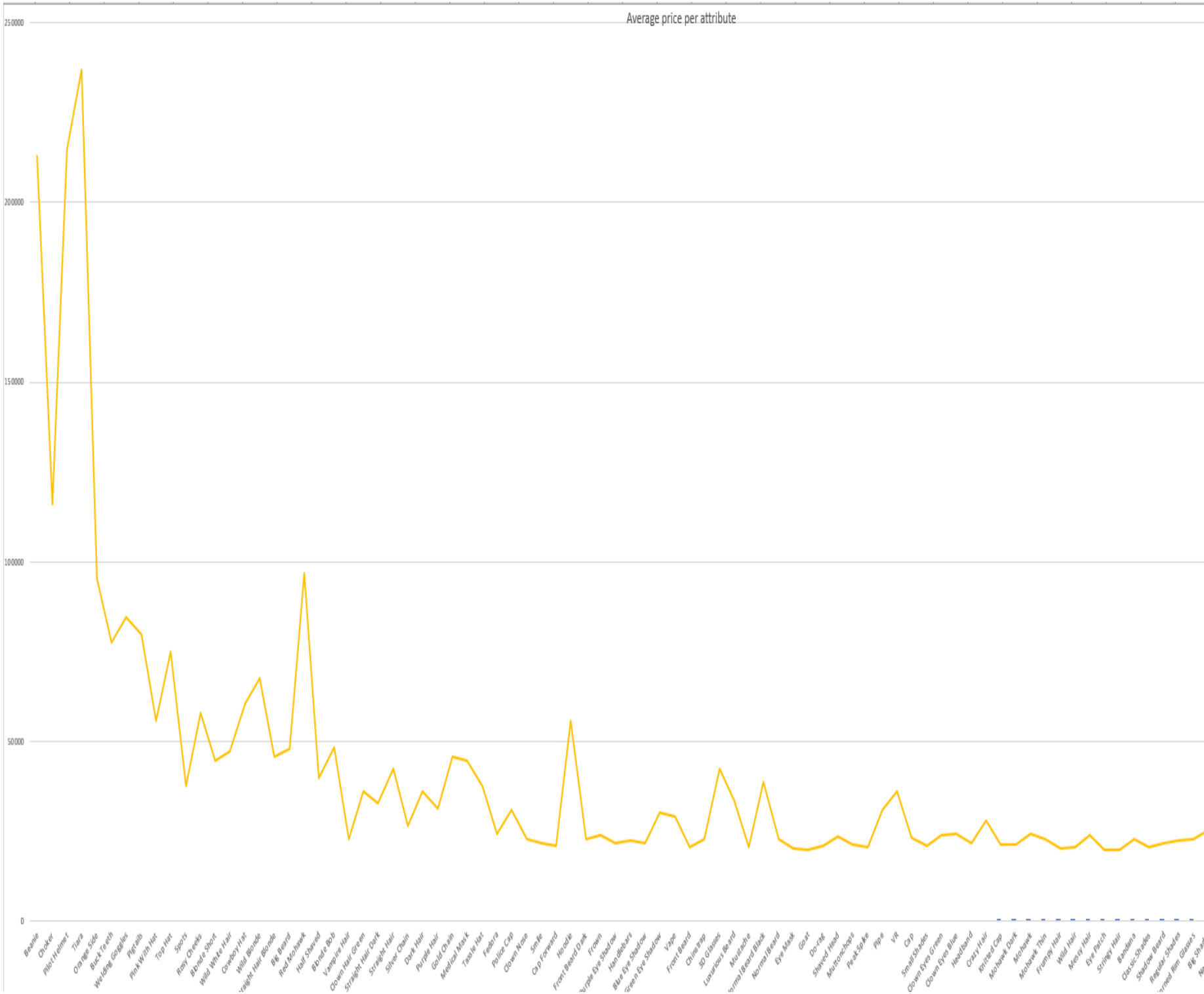
Type	From	To	Amount	Txn
Sold	0x3e17fa	0xbb1ec7	69Ξ ($133,957)	May 23, 2021
Offered			69Ξ ($133,401)	May 23, 2021
Sold	0x167e00	0x3e17fa	60Ξ ($118,375)	Feb 21, 2021
Offered			60Ξ ($116,737)	Feb 19, 2021
Offer Withdrawn				Jan 19, 2021

APPENDIX B

List of all accessories

Male & Special Only		Female only		Mixed Attributes	
Attribute	Quantity	Attribute	Quantity	Attribute	Quantity
Beanie	44	Choker	48	Spots	124
Buck Teeth	78	Pilot Helmet	54	Rosy Cheeks	128
Top Hat	115	Tiara	55	Clown Hair Green	148
Cowboy Hat	142	Orange Side	68	Silver Chain	156
Big Beard	146	Welding Goggles	86	Gold Chain	169
Vampire Hair	147	Pigtails	94	Medical mask	175
Purple Hair	165	Pink with Hat	95	Clown Nose	212
Fedora	186	Blonde Short	129	Vape	272
Police Cap	203	Wild White Hair	136	3D Glasses	286
Smile	238	Straight Hair Blonde	144	Eye Mask	293
Cap Forward	254	Wild Blonde	144	Pipe	303
Hoodie	259	Red Mohawk	147	VR	332
Front Beard Dark	260	Blonde Bob	147	Cap	351
Frown	261	Half Shaved	147	Clown Eyes Green	382
Handlebars	263	Straight Hair Dark	148	Clown Eyes Blue	384
Front Beard	273	Dark Hair	157	Headband	406
Chinstrap	282	Tassle Hat	178	Crazy Hair	414
Luxurious Beard	286	Purple Eye Shadow	262	Knitted cap	419
Mustache	288	Blue Eye Shadow	266	Mohawk Dark	429
Normal Beard Black	289	Green Eye Shadow	271	Mohawk	441
Normal Beard	292	Black Lipstick	617	Mohawk Thin	441
Goat	295	Purple Lipstick	655	Frumpy Hair	442
Do-Rag	300	Hot Lipstick	696	Wild Hair	447
Shaved Head	300			Messy Hair	460

Peak Spike	303	Eye Patch	461
Muttonchops	303	Stringy Hair	463
Small Shades	378	Bandana	481
Shadow Beard	526	Classic Shades	502
		Regular Shades	527
		Big Shades	535
		Horned Rim Glasses	535
		Nerd Glasses	572
		Mole	696
		Cigarette	961
		Earring	2459


Average price per attribute
250000
200000
150000
100000
50000
0
Beanie
Choker
Pilot Helmet
Tiara
Orange Side
Black Teeth
Welding Goggles
Pigtails
Pink With Hat
Top Hat
Spots
Rosy Cheeks
Blonde Short
Wild White Hair
Cowboy Hat
Wild Blonde
Straight Hair Blonde
Big Beard
Red Mohawk
Half Shaved
Bronde Bob
Vampire Hair
Clown Hair Green
Straight Hair Dark
Straight Hair
Silver Chain
Dark Hair
Purple Hair
Gold Chain
Medical Mask
Tassle Hat
Fedora
Police Cap
Clown Nose
Smile
Cap Forward
Hoodie
Front Beard Dark
Frown
Purple Eye Shadow
Handlebars
Blue Eye Shadow
Green Eye Shadow
Vape
Front Beard
Chinstrap
3D Glasses
Luxurious Beard
Mustache
Normal Beard Black
Normal Beard
Eye Mask
Goat
Do-rag
Shaved Head
Muttonchops
Peak Spike
Pipe
VR
Cap
Small Shades
Clown Eyes Green
Clown Eyes Blue
Headband
Crazy Hair
Knitted Cap
Mohawk Dark
Mohawk
Mohawk Thin
Frumpy Hair
Wild Hair
Messy Hair
Eye Patch
Stringy Hair
Bandana
Classic Shades
Shadow Beard
Regular Shades
Normal Rim Glasses