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Article

# Crypto Collectibles, Museum Funding and OpenGLAM: Challenges, Opportunities and the Potential of Non-Fungible Tokens (NFTs)

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**Abstract:** Non-fungible tokens (NFTs) make it technically possible for digital assets to be owned and traded, introducing the concept of scarcity in the digital realm for the first time. Resulting from this technical development, this paper asks the question, do they provide an opportunity for fundraising for galleries, libraries, archives and museums (GLAM), by selling ownership of digital copies of their collections? Although NFTs in their current format were first invented in 2017 as a means for game players to trade virtual goods, they reached the mainstream in 2021, when the auction house Christie's held their first-ever sale exclusively for an NFT of a digital image, that was eventually sold for a record 69 million USD. The potential of NFTs to generate significant revenue for artists and museums by selling effectively a cryptographically signed copy of a digital image (similar to real-world limited editions, which are signed and numbered copies of a given artwork), has sparked the interest of the financially deprived museum and heritage sector with world-renowned institutions such as the Uffizi Gallery and the Hermitage Museum, having already employed NFTs in order to raise funds. Concerns surrounding the environmental impact of blockchain technology and the rise of malicious projects, exploiting previously digitised heritage content made available through OpenGLAM licensing, have attracted criticism over the speculative use of the technology. In this paper, we present the current state of affairs in relation to NFTs and the cultural heritage sector, identifying challenges, whilst highlighting opportunities that they create for revenue generation, in order to help address the ever-increasing financial challenges of galleries and museums.

**Keywords:** non-fungible tokens; museum funding; OpenGLAM; digitised collections



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## 1. Introduction

Sustaining funding has always been one of the main challenges for museums and galleries [1] with the recent COVID-19 pandemic severely aggravating the financial health of cultural heritage organisations. In order to survive financially, museums and galleries have been forced to turn to solutions of last resort, such as redundancies [2,3] and even deaccessions [4,5]. However, recent advancements in technology have introduced new ways for revenue generation from museum images and digitised collections. *Non-fungible tokens (NFTs)*, which can be described as a new medium that enables the ownership and trading of digital assets of any kind, have been gaining an increasing amount of attention in recent months. Introducing scarcity for born-digital assets for the first time ever, NFTs,

or *crypto-* or *digital collectibles*, as they are also referred to, have already shown glimpses of their potential. Indicatively, the founder of Twitter, Jack Dorsey, sold his first ever tweet for 2.9 million USD as an NFT [6], whilst DJ Justin Blau auctioned the “world’s first tokenized album” for 11.6 million USD [7]. The current record for the most expensive NFT ever sold, is held by Christie’s for the auction of “5000 Everyday’s”. A digital image that is a mosaic of 5000 digital artworks by Mike Winkelmann, a digital artist also known as Beeple, was sold for 69 million USD, ranking as the third most expensive work sold at an auction by a living artist, surpassing auctions by Gerhard Richter, as well as most auctions for works by famous old masters, including Raphael and Titian [8].

The museum sector has already started exploring the potential of crypto collectibles. The Uffizi Gallery was the first major art museum to sell an NFT for an image of one of its Michelangelo masterpieces “Doni Tondo”, which sold for 170.000 USD [9], while the Hermitage Museum announced that it is planning to sell NFTs for famous pieces of its collection including works by Leonardo Da Vinci and Van Gogh [10]. However, NFTs have also attracted strong criticism. Firstly, the energy consumption associated with creating, which is commonly referred to as *minting* and trading NFTs is significant [11]. In addition, the anonymity that is ubiquitous in the crypto space provides fertile ground for bad actors seeking to exploit content that is freely available, such as the images made available through institutions that have adopted the OpenGLAM principles [12]. However, given the dire financial state of cultural heritage organisations, it is deemed necessary to explore this new medium and the opportunities it creates.

This paper asks if it is appropriate for the heritage sector to embrace non-fungible tokens (NFTs), selling ownership of digitised images of collections items, to raise much needed revenue. How might such an initiative sit alongside the OpenGLAM movement, where galleries, libraries, archives and museums have been openly licensing images of items in their collections for others to use as they will? In this paper, we problematise beyond the hype of digital collectibles, exploring the opportunities, risks and challenges they present to the GLAM sector, concluding with recommendations for the sector, as well as for the academic community and researchers interested in exploring NFTs in relation to museum funding and openly licenced content.

## 2. Background

### 2.1. Long-Standing Financial Challenges of Museums and Countermeasures

The ill financial health of institutions has long been one of the main challenges of the cultural heritage sector. The economic crisis of 2008 directly affected the sector [13], whilst the consecutive budget cuts that followed in the UK made securing funding one of the top challenges for British museums [14]. The extended and repeated closures due to COVID-19, caused a staggering 77% drop in attendance of art museums globally in 2020 [15], severely aggravating the situation, having a devastating impact on the financial health of cultural heritage institutions. Indicatively, two-thirds (i.e., 71%) of Scotland’s independent museums reported that they do not have funds to survive a year [16], whilst a report on the impact of COVID-19 on the museum sector revealed that 85% of museum directors were concerned about attracting audiences back [17].

To counter the sharp decline in revenue, museums turned to redundancies and deaccessions. Even in the UK, where a multi-million-pound emergency funding was offered to the cultural heritage sector [18,19] redundancies were widespread. Even large, well-funded institutions were forced to reduce their staff, including the Tate, which cut 120 jobs (i.e., 12% of its workforce) [2] and the V&A, which cut 103 roles (i.e., 10% of staff) [20], including one-fifth of its curatorial team [21]. One of the arguably lesser-known functions of museums, i.e., deaccessioning, was also employed by museums in order to generate much-needed revenue. In the UK, despite the fact that “financially-motivated disposal [is] subject to particularly close scrutiny” [22], the Royal Opera House sold David Hockney’s “Portrait of Sir David Webster”, who was the General Administrator of the Royal Opera House for several decades [4]. The portrait was auctioned by Christie’s and it was sold for

12.8 million GBP [23] in order “to raise vital funds for London’s Royal Opera House” [24]. In the US, the American Association of Art Museum Directors, in response to requests from museums, approved in April of 2020 a resolution offering more flexibility regarding deaccessioning, addressing in particular “how a museum might use the proceeds from deaccessioned art to pay for expenses associated with the direct care of collections” [25]. Following that resolution the Everson Museum auctioned Jackson Pollock’s “Red Composition” for 12 million USD, whilst Palm Springs Art Museum raised 3.9 million USD by auctioning Helen Frankenthaler’s “Carousel” [5]. Despite the devastating effects of the pandemic on the sector and the acknowledgement that more flexibility may be needed, all such financially motivated deaccessions came under scrutiny [5,26] with critics arguing that these institutions are “betraying the museum field” and that “patrons and artists would think twice about donating art, or money, if they believed that works in the collection could become a funding stream at a director’s whim” [26].

In exploring other avenues for revenue generation, we might begin by asking if there is an opportunity for organisations to raise much needed income by selling cryptographically signed copies of digital items derived from their collections, in the emerging NFT market without undermining current image licensing revenue streams and disrupting open content policies of institutions in the OpenGLAM movement. An article published on Artnet News in March 2021, states that NFTs and digital collectibles could present “a lifeline for cash-strapped museums” [27], because with the emergence of NFTs “historical issues that have long plagued the media market, like digital piracy and illegal reproduction, can be now all but forgotten” [27]. The article concludes that it is “worth exploring what can be done digitally before resorting to the painful and unpopular act of deaccessioning artworks” because NFTs “could have a big impact on museums’ bottom lines” [27]. With the cultural heritage sector struggling to address its ever-mounting financial challenges, employing even the least favourite of solutions and with the majority of museums having been left to choose between redundancies, deaccessions and even permanent closure, it is deemed necessary to exhaustively explore all possibilities that emerging technologies are presenting us with, whilst assessing the challenges and risks.

## 2.2. The Emergence of Blockchain

In 2008, a person named Satoshi Nakamoto, whose real identity has yet to be revealed, posted to “The Cryptography and Cryptography Policy Mailing List” [28] a message titled “Bitcoin P2P e-cash paper” [29], describing a “new electronic cash system that’s fully peer-to-peer, with no trusted third party” [29]. Nakamoto’s message linked to a paper titled “Bitcoin: A Peer-to-Peer Electronic Cash System” [30] and it sparked a vivid discussion. Some members of the mailing list acknowledged the technology’s potential stating “this does seem to be a very promising and original idea” [31], whilst others dismissed it completely, replying to Nakamoto saying “your proposal involves complications I do not think you have thought through” [32]. More than a decade later, Bitcoin has “managed to exist and operate in an autonomous way” with a “considerable capitalization” in excess of 2 trillion USD (as of May, 2021 according to CoinMarketCap [33]), having yet to be “seriously challenged by any attack” [34].

A blockchain can be described as “a distributed, immutable ledger that is maintained and verified among a network of peers” [35], or in simpler terms, a commonly shared database that is accessible by everyone and cannot be compromised by anyone. Although influences and forerunners of blockchain technology can be traced back to the 1950s [34,36], the most well-known blockchain “emerged from the development of Bitcoin” [35], the popular cryptocurrency presented in the aforementioned paper by Nakamoto [30]. Its significance is acknowledged in academia, being described as a “revolutionary technology” of “disruptive nature” [36], with researchers emphasising that “blockchain is much more than a foundation for crypto currency” [37], documenting the technology’s widespread adoption in a wide range of industries beyond the financial sector, ranging from healthcare

to law [37–39] and, more recently, to the cultural heritage sector, through the emergence of digital collectibles.

### 3. Understanding Non-Fungible Tokens

#### 3.1. Definition of NFTs and Emergence

Combining and extending the definitions of Bal and Ner [35], Regner et al. [40] and Leech [41], we define a non-fungible token (NFT) as a *cryptographically unique, indivisible, irreplaceable and verifiable token that represents a given asset, be it digital, or physical, on a blockchain*. At present the vast majority of NFTs are built on the Ethereum blockchain network [41] and are therefore Ethereum tokens; it is worth noting, however, that emerging blockchain platforms such as Flow [42], Tezos [43] and Algorand [44] have also been adding support for NFTs. According to Ethereum's founder Vitalik Buterin, his main motivation for developing Ethereum was to explore "the blockchain concept can be used for more than just money" [45]. As a result, the fundamental difference between Ethereum and the Bitcoin blockchain network is that an Ethereum token (i.e., a token stored and traded on the Ethereum blockchain) is created and managed by a so-called "smart contract", which allows for programmatic computation, notably supporting "all types of computations" [46]. Buterin describes smart contracts as "systems which automatically move digital assets according to arbitrary pre-specified rules" [46]. In other words, a smart contract can be described as a self-executing contract between two parties, whose terms of agreement are written into lines of code and whose execution and related transactions are trackable, irreversible and exclusively controlled by code [47].

The concept of NFTs was first introduced in 2012 with Bitcoin's "Colored Coins", which referred to tokens that represent any type of physical asset, such as real estate properties, cars and bonds [48]. In their current format, NFTs were implemented in 2017, when Dieter Shirley, a contributor to the Ethereum source code repository and founder of the digital collectibles game CryptoKitties, introduced the ERC-721 smart contract standard, which allowed for the creation of a new type of Ethereum tokens [49]. Shirley explained the standard would allow for the implementation of "non-fungible tokens", also "referred to as 'NFTs'", providing "basic functionality to track and transfer ownership of NFTs" [49] on the Ethereum blockchain. Up until then, for purposes of interoperability, the vast majority of Ethereum tokens were based on the ERC-20 protocol, whose defining feature is that they are fungible, i.e., replaceable and interchangeable [50]. For example, on Ethereum, all cryptocurrencies (except for Ether, which is Ethereum's so-called native cryptocurrency) are created using an ERC-20 contract for that very reason; similar to a real-world currency, where a bank note is fungible and interchangeable with every other bank note of the same value, each ERC-20 token is fungible and interchangeable with every other token of the same type. By introducing the ERC-721 token protocol, Shirley offered an alternative to that.

Other smart contract protocols for creating NFTs have also been proposed. Although ERC-721 is considered the "gold standard" [51], the ERC-1155 "multi-token standard" [52] offers greater flexibility in the creation and management of NFTs, by offering support for batch operations, reducing gas fees and subsequently carbon emissions by 90% [53]. Another standard worth noting is EIP-2981, which enables universal support for royalty payments in all NFT marketplaces and ecosystems [54]. EIP-2981 addresses the lack of standardisation and interoperability across ecosystems, when it comes to the enforcement of resale rights across different platforms. Finally, fractionalised NFTs (F-NFTs), which support the fractional ownership of NFTs, are expected to be increasingly adopted, especially for high-value collectibles [55]. It could be argued that Ethereum's edge over other blockchains is primarily due to market domination. Although other blockchains may be better suited for NFTs (e.g., due to substantially lower transaction fees) [56], a recent study showed that a staggering 97% of the NFT sales examined were generated on the Ethereum blockchain [57].

NFTs became popular within the crypto community through gaming and, in particular, through the virtual game CryptoKitties, which is a digital collectibles game, where every CryptoKitty is unique [58]. CryptoKitties have been described as a “digital version of Pokemon cards” [58] and the NFT for one of the most expensive CryptoKitties was sold for 170,000 USD [59]. Beyond gaming, NFTs have also been adopted by various industries, ranging from finance, obligations and loans [60] to supply chains [61]. In 2021, NFTs hit the mainstream emphatically, shaking up the art world, when the Christie’s auctioned Beeple’s “5000 Everyday” in March 2021 as the “first purely digital artwork (NFT)” [62] for 69.3 million USD [63]. Although this was not Beeple’s first multi-million dollar sale [62], “5000 Everyday” ranked as the third most expensive work sold at auction by a living artist, causing many in the art world to pause and evaluate the potential of NFTs [8,64]. In addition to the aforementioned sectors, the potential of crypto collectibles is continuously being highlighted for an expanding range of industries, spanning from music [65] and sports [66] to real estate [67].

### 3.2. Storage of NFTs

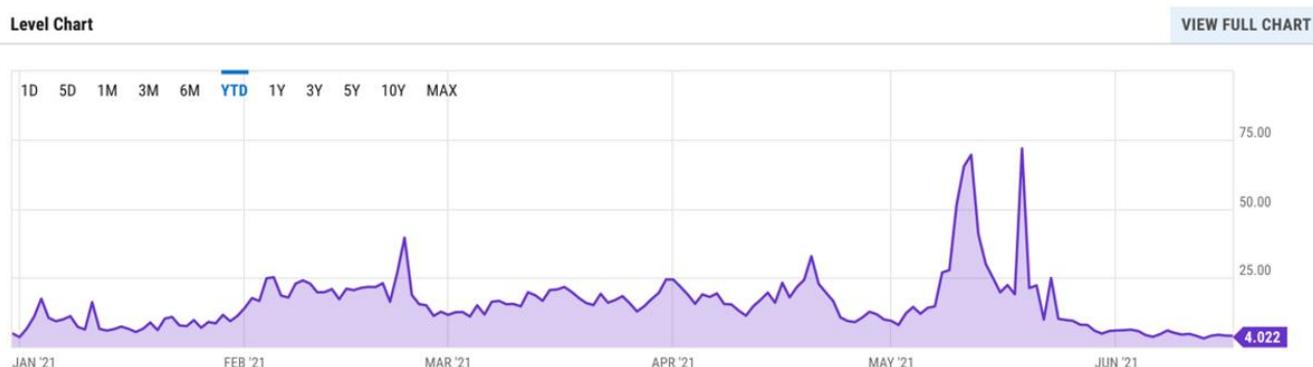
Given that digital collectibles by definition represent digital and physical assets, it is deemed necessary to examine where these assets that NFTs represent are stored. In the case of physical assets, the tangible artefact is usually shipped to the NFT collector, an indicative example of which is the NFT trading cards [68]. In the case of digital assets, however, storage is more complex. As a digital asset could be lost forever rather easily (e.g., being mistakenly erased due to human error, or by accident due to hardware damage), so systems have emerged for the persistent storage of assets represented by NFTs. In contrast to the actual tokens, which are stored on blockchains (e.g., on the Ethereum blockchain), the assets they represent (i.e., the digital files) are in most cases stored off-chain, as it would be prohibitively expensive otherwise. Indicatively, in July 2020, when gas fees were also significantly lower than in 2021, the fees to store (i.e., register) a 1 MegaByte image on the Ethereum blockchain cost more than 13,000 USD (i.e., 13.82 USD per KiloByte) [69]. To link the two, i.e., the blockchain-based tokens with the digital assets that they represent, which are stored in external storage systems, NFT platforms utilise different ways of associating the token with the asset; in the simplest of forms, one such reference can be a web link accompanying the token in its metadata.

There are mainly two types of storage systems for digital assets represented by NFTs, i.e., distributed storage infrastructures and centralised storage solutions. The most-widely used storage system at present, IPFS, is distributed; IPFS is where the assets of leading marketplaces of crypto collectibles such as Rarible.com and Foundation.app are stored by default [70,71]. On the other hand, an indicative example of a centralised storage solution is the Origin NFT Launchpad (originprotocol.com) platform. When an NFT is created and sold through the Origin NFT Launchpad, although the token transaction takes place on the Ethereum blockchain as normal (as if this NFT was created and sold through the aforementioned marketplaces), the asset represented by this NFT is stored on the company’s own centralised servers instead (information provided by Origin Protocol directly, as of June 2021).

### 3.3. Cost and Risks

Although the potential of NFTs is arguably undisputable, it must be noted that there are costs for creating and trading crypto collectibles, as well as potential risks, which should be addressed by any individual or organisation seeking to utilise this new medium. Regarding the former, to create and trade NFTs, or to perform any other blockchain-based transaction, one must pay the so called *gas fees*, i.e., fees that are paid to *node operators* to register new transactions on the respective blockchain [72]. Node operators play a vital role for a blockchain’s proper functioning; they lend their computer’s resources (e.g., RAM, disk space, bandwidth) to it, by running a software that “keeps a full copy of the blockchain” and also “broadcasts transactions across the [blockchain] network” [73]. Gas fees depend on

the volume of transactions taking place on the blockchain network at a given moment. As a result, for the Ethereum network in particular, where most NFTs are currently being traded, gas fees can get particularly high [74], ranging between 4 and 70 USD per transaction, as shown in Figure 1 [75]. Therefore, even if one was only interested in experimenting with NFTs, they would be required to have a budget to spend towards gas fees for any blockchain-related operation. However, some marketplaces have already started exploring solutions that eliminate gas fees by reducing the number of on-chain transactions [76].



**Figure 1.** Ethereum average transaction fee in USD (YTD).

Besides fees, there are also potential risks involved when creating and trading crypto collectibles. The main risk associated with NFTs is the same one that applies to any other token, or cryptocurrency, which relates to the security of crypto wallets and their cryptographic keys that allow their owners to access them. Some popular NFT platforms own and manage these keys on behalf of their users, serving as *custodial wallets*. An indicative example of a custodial wallet is the Binance NFT Marketplace ([www.binance.com/en/nft](https://www.binance.com/en/nft), accessed on 18 October 2021). Custodial wallets are simple to set up, require no familiarity with blockchain technologies and platforms and have all the conveniences one would expect, such as password recovery and account retrieval. On the downside, users of custodial wallets do not have true ownership of their NFTs, as these are not stored in their own crypto wallets on the blockchain. As a result, if the wallet provider's infrastructure gets compromised, or the firm declares bankruptcy, solvency issues would arise (similar to the MtGox case in Bitcoin wallets [77]). On the other hand, users who store their NFTs into crypto wallets that they manage themselves also face risks; if they happen to lose access to their wallet, or forget the wallet's cryptographic keys, then they immediately lose access to all of the wallet's contents [78], because a process for retrieving crypto wallets has yet to be established without compromising the integrity of the respective blockchain. Due to the importance of the key loss issue, hybrid solutions have been proposed, whereby the key is split between multiple entities [79]. More recently, a new smart contract method named KELP was introduced, which manages to regain access to a lost crypto wallet [80]; however, it has yet to be tested widely.

Another common risk for buyers of digital collectibles regards asset access and storage. Commonly known as the "pull the rug" risk [81], it concerns whether buyers of NFTs have guaranteed and continued access to the assets represented by their NFTs. As mentioned earlier, the most widely used storage solution at present is the decentralised storage system IPFS. In such decentralised solutions, node operators need incentives for the continuous maintenance of copies of all files. More importantly, there has yet to be some form of assurance that every asset will continue to be stored forever in the storage system and it is technically possible under certain circumstances for an asset to be deleted or to become inaccessible at some point in the future. The leading NFT marketplace Rarible.com states in its terms of service that they "cannot guarantee continued operation [ . . . ], or the integrity and persistence of data on IPFS" [70]. Similar risks also exist in centralised storage infrastructures. A user will lose access to their assets in various scenarios: if the firm

experiences a technical issue, if a natural disaster hits a data centre (and the company does not utilise geo-duplication, where the same asset is stored in multiple different geographical locations), or if the company dissolves without transferring data elsewhere proactively. The “pull the rug” problem has been highlighted by the crypto community as one of the key areas that need to be addressed and further developed in the future [81].

In addition to the aforementioned risks, there are also other critical issues that need to be acknowledged. Amongst them is the ubiquity of anonymity on any blockchain, which provides fertile ground for bad actors to sell unauthenticated NFTs to unsuspecting buyers (Section 5.1), the lack of a definitive copyright policy governing all NFT sales (Section 4.2), the volatility of the NFT market (Section 6.1) and last but not least, the reputation risk of embracing NFTs, which are severely criticised for their environmental impact (Section 6.2).

### 3.4. Importance of NFTs

It could be argued that the significance of NFTs is that they introduce scarcity in the digital realm, making the ownership and also the trading of digital assets technologically possible. With regards to the former (i.e., ownership) when one buys a NFT, the transaction is registered on the public database of transactions that is the blockchain and as a result no one can question, challenge, obfuscate, or compromise one’s ownership of a given asset. Regarding the latter (i.e., trading) NFTs are crypto tokens themselves and, therefore, they can be traded (e.g., bought, sold, transferred, repurchased) on the blockchain, similar to any other type of token. Whereas painters and sculptors could always produce unique physical artifacts, for photographers, when mechanical reproduction was invented “artists and collectors had to come to terms with the fact that [one could] produce an unlimited number of identical prints of any photograph” [82]. As a response, in order to achieve authenticity, scarcity and, therefore, collectability, signed editions were introduced [82]. Similarly, as a response to the “artificial abundance” [82] of the Internet, NFTs introduce and implement technologically the concept of signed editions in the digital realm [82]. More importantly, they do so in a way that is accepted by common consensus.

Long before the emergence of NFTs, one could claim and prove ownership of a given asset in a variety of different ways, ranging from image watermarks (in the simplest of forms) to solutions utilising the blockchain, such as Verisart, i.e., a company founded in 2015 before the emergence of NFTs for providing certificates of authenticity to artists, by utilising blockchain technology [83] (Verisart has since adopted NFTs). However, it could be argued that none of these methods were widely known and, as a result, there was no process people could refer to in order to look up the ownership of an asset or its authenticity. Thanks to the relative (i.e., in an anonymised manner) transparency of blockchains, where all transactions are publicly visible by everyone, NFTs make it possible for the first time for anyone with a basic understanding and knowledge of NFTs, to look up the provenance of an NFT, including its creator (i.e., the public blockchain address of the person, or entity, who minted it), the current owner, as well as all previous owners. As an example, given that the vast majority of NFTs are on the Ethereum blockchain, one could track the provenance of an NFT using platforms, such as Etherscan.io, which is a free tool for tracking transactions and looking up the content of smart contracts on the Ethereum network [84]. However, given the ubiquity of anonymity in the decentralised web, it must be noted that rigorous due diligence is required in order to match the creator of the NFT (i.e., the wallet address that minted the NFT) with its real-world counterpart. Towards that direction and in order to minimise fraud, NFT platforms have implemented a verification process for creators to prove their identity. However, not all NFTs are sold through such platforms and therefore it is deemed necessary for collectors to perform their own due diligence.

## 4. Monetising Museum Images: NFTs, Image Licensing and Copyright

### 4.1. NFTs and Revenue Generation from Museum Images

Despite the fact that NFTs are a nascent technology and cultural heritage institutions are not usually amongst the earliest adopters of bleeding-edge technologies (which can be attributed to the fact that museums traditionally have limited budgets to experiment with new technologies and only few and well-resourced museums have the privilege of in-house technology teams), museums have already started exploring the possibilities of crypto collectibles for revenue generation, as well as for sourcing funds for social impact projects. As early as March 2021, the Guggenheim advertised a job post for a candidate who would look into the potential of NFTs [85], whilst the Cultural Producer and Former Deputy Director of the San Jose Museum of Art, along with other museum delegates, participated in the webinar “Discussing & Debating the Potentials of NFTs in the Museum Sector” [86]. The first large-scale institution to embrace NFTs was, what is considered by some as the “world’s best art gallery” [87], i.e., the Uffizi Gallery in Florence, Italy. In an effort to recover some of the revenue lost due to the pandemic, the Uffizi Gallery took the decision to create and sell NFTs of digitised images of some of its iconic pieces [88]. On the 14 May 2021, the gallery sold its first NFT of Michelangelo’s “Doni Tondo”, for 170,000 USD [9]. Following in the Uffizi’s footsteps, in July 2021, the Hermitage Museum in Russia announced it would sell NFTs of digital copies of some of its masterpieces on the Binance NFT Marketplace, including works by Leonardo Da Vinci, Vincent Van Gogh and Wassily Kandinsky [10]. The museum’s general director, Mikhail Piotrovsky, stated that the Hermitage is “not looking at it as a way of making money” [10], but instead as an opportunity to experiment with this new medium [10]. However, at the same time, the Hermitage stated that they aim to utilise the funds raised to “provide better availability of the Hermitage collection” [89] and to undertake necessary restoration work [90]. The first British museum to embrace NFTs was the Whitworth Gallery in Manchester, UK. In July 2021, the gallery sold limited editions of its first NFT, featuring an image of William Blake’s “Ancient of Days”, through the Hic et Nunc platform ([www.hicetnunc.xyz/objkt/168856](http://www.hicetnunc.xyz/objkt/168856), accessed on 18 October 2021), which operates on the energy-efficient Tezos blockchain [91]. The gallery aims to raise funds for financing “social projects co-produced by the Whitworth and its constituents” instead of funding its own needs and collection [91]. The goal of this experiment, as they describe it, is to “explore the potential of directing new flows of private digitised capital into social capital” [91].

Although NFTs have already shown glimpses of their potential for monetising museum images, sceptics question whether they do so at the expense of an existing and long-utilised source of revenue for digitised collections—that of image licensing. Many museums and galleries have long relied on image licensing as a way to earn significant revenue from their images [92], either through their own in-house operations [93,94], or through image licensing firms such as The Bridgeman Art Library [95]. Using image licensing, museums have been claiming copyright even on images of artworks that are in the public domain, sparking controversy [96]. As a counter-argument, museums claim that revenue from image fees is vital for their collections [92,97]. An exception to this is the Open-GLAM movement, which has made digital images of collections’ items available with a variety of open licenses permitting reuse. There is some justifiable concern that third parties could mint openly licensed images of artworks as NFTs, taking potential revenue from institutions (discussed in Section 5.1) [96,98]. Therefore, it is deemed necessary to explore whether crypto collectibles impact image licensing operations by crystalising matters on NFTs in relation to copyright.

### 4.2. NFTs and Copyright

A common concern amongst sceptics is whether the intellectual property rights of the images featured in NFTs are also part of the trade and therefore museums would risk losing image licensing revenue by venturing in crypto collectibles. Although that is a field that is still being shaped, by general consensus, when it comes to intellectual property rights, the

trade of crypto collectibles largely mirrors real-world art trade unless otherwise specified. By copyright law, when one purchases a physical painting, they only buy ownership over the tangible asset; the copyright of the artwork, including any commercial rights, remains with the artist, unless that is specifically covered in writing and signed [99]. Tonya M. Evans, a law professor at Penn State university, in her study on digital collectibles in relation to copyright, concluded that copyright law “does not specifically identify digital or digitized works as copyrightable subject matter” [100], because it applies equally “to physical embodiments and those requiring the aid of a machine” and therefore, an NFT “contributed by an author that contains at least a minimum amount of creativity is capable of receiving copyright protection” [100]. Therefore, from a legal standpoint, it appears to be clear that NFTs would be treated like tangible paintings when it comes to copyright. It must be noted that legislation differs by country, however with regards to copyright law in particular, it could be argued that it shares great similarities across different countries and regions.

Examining how intellectual property rights of NFTs are enforced on the platforms where crypto collectibles are traded, different approaches can be identified. When the creators of CryptoKitties invented NFTs [49], they also published an accompanying license, i.e., the “Nifty License” (nftlicense.org, accessed on 18 October 2021), which allows collectors some commercial reuse of the asset associated with the NFT. However, that does not appear to be adopted elsewhere beyond CryptoKitties. Indicatively, the leading platform Foundation.app (where Edward Snowden sold his first NFT raising 5.5 million USD for the Freedom of the Press Foundation [101]), clarifies in its terms of service that collectors are able to trade the NFT, i.e., the token, but they do not obtain any commercial rights on the asset the NFT represents [102]. The “Nifty License” demonstrates an intent for crypto collectibles to push the boundaries and introduce new norms to the art trade in relation to artwork copyright ownership. However, at present, it is commonly accepted amongst creators, as well as buyers of NFTs, that, unless otherwise specified, the trade of crypto collectibles does not involve or impact the intellectual property rights of the asset NFTs are associated with in any way.

## 5. Digital Collectibles and OpenGLAM

### 5.1. *Malicious Uses the Case of Global Art Museum*

Despite the brief history of NFTs, malicious uses of crypto collectibles have already emerged. Amongst them is the case of the Global Art Museum (GAM). Launched in March 2021, GAM presented itself as an organisation that “transforms historic art into blockchain-secured NFTs [ . . . ] disrupting the Art Museum industry” [103]. Through the popular NFT marketplace OpenSea.com, GAM offered NFTs of masterpieces by Vermeer and Seurat for sale, claiming it would share 10% of profits with the institutions where these works belong [104]. All of the works that GAM utilised for its NFTs have been made available through OpenGLAM, an initiative that promotes free and open access to the digitised collections of galleries, libraries, archives and museums [96]. Pioneered by the Rijksmuseum in 2011 and later adopted by leading museums and galleries, such as the Metropolitan Museum of Art, the National Gallery of Denmark and the Getty, the core aim of OpenGLAM is to encourage cultural heritage organisations to refrain from adding new rights to images of artefacts, whose original work is in the public domain (i.e., free from any known copyright limitations) [96]. From a legal standpoint, GAM did not infringe copyright law, since images made available through OpenGLAM are available for unrestricted reuse. However, by naming its collections of NFTs after the respective institutions (e.g., “The Rijksmuseum Collection”) [105], whilst also promising revenue share with the museums, GAM created the false impression that it was in some form of partnership with the respective institutions, implying their endorsement.

Tina Rivers Ryan, the curator of modern and contemporary art at the Albright–Knox museum, uncovered GAM with an extensive thread on Twitter that went viral in museum circles, mounting strong criticism against it [12]. When the Rijksmuseum clarified that it

was not in partnership with GAM [106], the latter was forced to take down all of its NFTs and present the project as a “NFT social experiment” [107]. The trend GAM sought to exploit and be part of is that of unauthenticated NFTs selling for significant sums. One would expect that people prepared to give thousands, or tens of thousands of dollars for one NFT, would normally conduct due diligence regarding the authenticity of the collectibles they purchase; however, that is not always the case. An indicative case is crypto artist Pest Supply, who sold an NFT featuring an adaptation of one of Banksy’s works for 900,000 USD [108]. Even the name of the artist, “Pest Supply”, is misleading because it resembles “Pest Control”, which is Banksy’s authentication body [108]. The NFT itself had nothing to do with Banksy [108], but despite that, it was sold for nearly a million USD.

### 5.2. NFTs and OpenGLAM: Risk or Opportunity?

The case of GAM led many to believe that crypto collectibles “seem at odds” [27] with the open content initiatives of cultural heritage institutions and consequently with the OpenGLAM movement as a whole. Some hoped that GAM was “a wakeup call for the GLAM sector”, arguing that “NFTs could be harmful if we do not acknowledge them” [109]. However, when GAM was brought to Rijksmuseum’s attention, whose works and name were exploited by GAM, it clarified that the museum’s collection is “open to everyone”; the museum explained that the aim of their open data policy is “to connect [their] collection to as many and diverse people as possible” [106] and did not make any further comments. Similarly, other museums whose works were used by GAM did not openly criticise or oppose to GAM using their images [109].

One could argue that, to the contrary, OpenGLAM institutions are those best positioned to benefit from NFTs. Firstly, the case of GAM demonstrated that such scams, even small ones (as it was the case with GAM, which attracted little financial interest), will not go unnoticed in the museum sector. Additionally, as NFTs mature as a new medium over time, collectors will also be getting increasingly aware of such scams, becoming more cautious when it comes to verifying the authenticity of the collectibles they invest in. Secondly, as explained earlier, the opportunity that NFTs present cannot be underestimated. By bringing scarcity to the digital realm, NFTs have arguably increased the value of the digitised collections of cultural heritage institutions significantly. However, commonly, NFT collectors expect a high-quality image of the artwork associated with their NFT; therefore, museums seeking to experiment with crypto collectibles would need to come to terms with the fact that a collector could publicly share (e.g., on the Internet) the high-quality images they would obtain by purchasing their NFTs. In the case of institutions with open content policies, however, given the fact they are already sharing high-quality digitised images of their artefacts openly, they have one barrier less for adopting and taking advantage of NFTs (e.g., if not for fundraising, then for public engagement projects [110]), in comparison to institutions with more restrictive image licensing policies.

## 6. Criticism and Debates

### 6.1. The NFT Market: The “Silent Crash” and the Top One Percent

The false impression one may get by reading through the phenomenon’s media coverage is that all, or at least most, NFTs turn digital assets to gold. At a macro level, examining the NFT market as a whole, analysts were pointing out, as early as April 2021, that the market was already undergoing a “silent crash” [111]. Some credited the crash to crypto investors, who joined in February to “catch a ride on the money train” and did not hold their collectibles for more than a few days [112]. Irrespective of the causes of the market crash, the fall was steep. In a single day, i.e., on the 25 March, the average daily value of NFTs fell by more than 85%, from 19 to 3 million USD [112]. Some argued that the “silent crash” was a “healthy, relatively short-term correction”, given the fact the rise of the prices of NFTs in the first couple of months of 2021 “was unsustainable” [111], but nevertheless it was a steep fall of the market.

At a micro level, the examination of individual NFT sales reveals great similarities between the crypto art market and the traditional art world, despite the fundamental differences between the two (e.g., the transparency of transactions, the lack of middlepersons). A recent study led by Canadian concept artist Kimberly Parker revealed that nearly 80% (i.e., 79.6%) of NFTs sell for less than 500 USD, whilst one-third of all NFTs (i.e., 33.6%) sell for less than 100 USD [113]. The study, which analysed data from OpenSea.com, as well as sale information from other marketplaces, revealed that only a “whopping 1.8%” of primary sales (i.e., the first ever sale of an NFT) exceeded the price of 0.5 ether, approximately 894 USD, based on the exchange rate during the period of the study [113]. This greatly resembles the status quo of the “notoriously top heavy” [114], “winner takes all” [115] art market. In 2020, it was reported that 64% of total sales of the art market, estimated at 64.1 billion USD [116], went to the top 1% of artists [114], whilst in 2017, just 25 artists accounted for nearly 50% of total contemporary auction sales [115]. As Parker concluded in his study of the NFT market, “decentralization does not mean equality of opportunity” [113].

### 6.2. Environmental Considerations

The greatest controversy surrounding crypto collectibles is the energy consumption associated with the Ethereum blockchain, where most NFTs are being traded, which is indeed substantial. As of May 2021, Ethereum’s energy consumption is estimated at 48.7 Tera-Watt Hours (TWh) per annum, which equals to the annual energy consumption of Malta [117]. As a result, NFTs have attracted severe criticism from environmentalists [118]. “NFTs are helping to destroy our planet” [11], argues Art Newspaper’s columnist Anny Shaw, adding that Beeple’s record auction of “5000 Everyday’s” produced 79 kg of CO<sub>2</sub> emissions, equalling those of 13 homes in a year combined [11]. NFTs, however, are merely a smart contract protocol and one that can be implemented on any blockchain; hence, they are not exclusively tied to the Ethereum blockchain; Ethereum just happens to be the blockchain where NFTs were first introduced and is currently the most developed and widely adopted blockchain at present [119] in comparison to other more energy-efficient blockchains. Secondly, a systematic effort is being made for Ethereum itself to eliminate its carbon footprint [120]. Such indications make us hopeful for the future of NFTs.

Fierce critics of NFTs, however, argue that the energy consumption issues of NFTs will not be resolved anytime soon [121]. They consider Ethereum’s multi-year attempt to change its transaction validation method from the energy-consuming Proof-of-Work (PoW) method with the energy-efficient Proof-of-Stake (PoS) method as a “running joke” [121]. Making such a fundamental change on a blockchain, whose daily transactions exceed 1 million USD [122], would require a long and monumental effort and indeed, it may prove impossible eventually. However, as explained earlier, Ethereum has repeatedly pushed the boundaries of what is possible when it comes to decentralised technologies, so they may also succeed in moving to the PoS method, which would reduce the blockchain’s carbon emissions by 99% [120] and automatically reduce to the minimum the carbon footprint of all NFT-related trade.

Beyond Ethereum, energy-efficient NFTs already exist and are being traded as normal. The NFT of the Whitworth Gallery mentioned above is registered and traded on the energy-efficient Tezos blockchain. There are also numerous other blockchains that also utilise the Proof-of-Stake method for transaction verification, like Cardano [123] and Algorand [44], whose “electricity costs are comparable to using traditional servers in a centralized application” [124]. In addition, Cardano, a project driven by academic research, will fully launch at the end of summer 2021 [125]. Cardano claims to be “The Most Environmentally Sustainable Blockchain Protocol” [123] due to its pioneering, peer-reviewed Proof-of-Stake implementation, whilst its capabilities for scalability, interoperability and sustainability make it a contender for challenging Ethereum’s dominance [126].

Interestingly, the energy-efficient Proof-of-Stake method has also attracted criticism from environmentalists. PoS blockchains have been accused that they “grant power to the already powerful” (we note that according to the PoS method, the more coins a node

operator holds, the more transactions they are allowed to verify with their coins being held as collateral) and “that [this] is *also* a climate issue”, because “climate justice is social justice” [121]. At that point, it is deemed necessary to explore the broader context and the alternatives available. Museums and galleries are continuously looking for ways to raise funds [9,27]; if they were not fundraising with NFTs, they would be fundraising through current means, i.e., our financial system. The latter’s carbon footprint has yet to be estimated to allow for a direct comparison. What is staggering though, is that beyond the carbon footprint of banking operations itself, many of these institutions are actively investing in fossil fuels with “35 of the world’s major banks [having] provided \$2.7 Trillion (£2Tn) to fossil fuel companies since the Paris Agreement on climate change [in] 2015” [127]. Fossil fuels account for an astonishing “93% of total U.S. anthropogenic CO<sub>2</sub> emissions” [128], “driving global warming to dangerous levels” [129]. Notably, investment has been growing every year [127] instead of the opposite. In light of that, it is challenging to argue that transacting through PoS blockchains could be more harmful to the environment overall, in comparison to using current means [127]. Lastly, it is worth noting that, beyond the PoS adoption, there are also other measures being employed for reducing the carbon footprint of NFTs, albeit with lesser impact; such measures include the so-called *Layer 2* solutions (whereby the number of transactions that needs to be registered on the blockchain is reduced to the minimum) and the use of renewable sources of energy for mining [130,131].

### 6.3. Future Business Models for NFTs

NFTs are often described as an investment and beyond the scarcity value of owning something very rare, what that investment entails is still unclear and therefore speculative. It is also unclear what ownership and control GLAM institutions may surrender by selling digital assets such as NFTs; how they may lose out on potential future revenue streams, or other forms of value and inclusion that would only result from retaining full control and ownership of their digital assets. With the current move of media into transmedia universes (such as the Marvel Cinematic Universe [132]) and the emergence of blockchain-based metaverses, we may see a future generation of payments (e.g., for loaning artworks) to those who own digital assets as NFTs, when these are featured in digital spaces. Given that we are now “immortalizing our myths (art + memes) onto an immutable public ledger via NFTs” [133], in the shared digital experiences and universes that are now emerging the digital ownership of media may become profitable in these metaverses and multiverses [134]. NFTs are already widely exhibited in popular blockchain-based metaverses, such as CryptoVoxels.com and Decentraland.org, both of which are three-dimensional virtual worlds that anyone can access via their Internet browser, roam into, buy virtual land in, erect buildings and exhibit NFTs (as a different means of promotion) that other users may buy directly from them within the metaverse [135]. There are already countless art galleries in the aforementioned blockchain-based metaverses exhibiting NFT art collections [136]. The built-in resale rights of NFTs, whereby the original creator receives a percentage on every future resale, or the practice of minting multiple editions and retaining some for the institution, as it was the case with the Whitworth Art Gallery (which retained 2 of the 52 editions of the NFT they minted [91]), could potentially guard institutions against such risks. Nevertheless, this is a developing and speculative area; therefore, risk-averse GLAM institutions may not wish to relinquish any form of ownership or control until what is lost by selling NFTs based on collection items becomes clear. Indeed, a proactive move by institutions may be to mint their digital collections as NFTs, but carefully retain ownership themselves, thereby allowing their assets to be credited, whilst ensuring the opportunity for future returns on NFTs in the digital metaverse, which, at present, we can only begin to imagine.

## 7. Conclusions

NFTs, which can be described as cryptographically signed copies of digital or physical assets that are publicly registered on a blockchain, have made the ownership and trading of digital assets technologically possible. By bringing scarcity to the digital realm for the first time, crypto collectibles have increased the value of museum images and digitised collections of cultural heritage institutions significantly. The emergence of NFTs has been considered by some as a potential “lifeline” for museums, which have been turning to redundancies and deaccessions in order to survive financially. The museum sector, however, remains largely sceptical, as there are numerous risks involved, both for institutions (e.g., market implosion, or illicit exploitation of open content), as well as for buyers (e.g., key loss and storage issues). Uncertainty over artwork copyright also lingers; however, it appears to be accepted by common consensus that the trade of NFTs does not impact, or involve in any way, the intellectual property rights of the work or its image, unless otherwise specified. Although buyers do not expect to receive copyright when purchasing an NFT, they do expect a copy of the asset; for that reason, OpenGLAM institutions, which have already taken the decision to openly share their images for unrestricted reuse, have one barrier less for experimenting with digital collectibles. The greatest criticism over NFTs is the substantial energy consumption of the Ethereum blockchain, on which NFTs were first invented. Energy-efficient NFTs already exist; however, the majority of NFTs are still being traded on the Ethereum blockchain, whose energy consumption is substantial. Another criticism, which has not yet been fully expressed, concerns what institutions may lose by selling digital assets as NFTs, such as control, or revenue stream that is currently unknown, e.g., loaning NFTs for exhibition in future platforms or metaverses. For institutions, as well as potential buyers interested in exploring NFTs, it is advisable to explore the individual risks involved and individually address them in advance. Additionally, NFTs present a new medium that is still in its infancy and as such, it should be treated with caution, because there are still critical deficiencies (e.g., permanent loss of crypto wallets) and important unknowns (e.g., lack of a definitive copyright policy). However, the financial potential of crypto collectibles is substantial. Furthermore, for the research community, the dearth of literature and lack of data provide an opportunity for academics to bridge the gap between this new medium and the GLAM sector, exploring meaningful uses, as well as solutions and answers to the risks and issues that have already been identified. There are opportunities for future work for researchers working at the juncture of GLAM and digital technologies for the following: to explore new business models for revenue generation; to navigate emerging solutions for NFT deficiencies (or to explain unsurmountable deficiencies in ways that can be usefully communicated across the GLAM sector); to provide recommendations on digital preservation of NFT ownership and standards for making NFT data open and FAIR [137]; and to give clear guidance on the adoption of intellectual property laws and policies in regard to NFTs, which will safeguard GLAM institutions and respect their collections management procedures in the NFT space. Lastly, it is worth noting that blockchain technology is considered the technical foundation of Web 3.0, i.e., the decentralised web. When in 2006 Raj Jain presented his paper “Internet 3.0: Ten Problems with Current Internet Architecture and Solutions for the Next Generation” at IEEE’s Military Communications Conference, he was amongst the first to highlight the need for the future of the internet, “Internet 3.0”, to have “as little centralized control as possible” [138]. Fifteen years later, as we are now seeing this future unfolding, NFTs could serve as the springboard and an opportunity for the museum sector and the academic community alike, to explore, understand and embrace the decentralised future of the Internet.

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