Non-Fungible Token (NFT) in the academia and open access publishing environment: Considerations towards science-friendly scenarios

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Introduction

The following article is about possible science-friendly deployment scenarios of non-fungible tokens (NFTs) in the ecosystem of science-owned, -affiliated, or -friendly publishing infrastructures,[1] publication-relevant service and software licensing agreements,[2] archiving services,[3] and, of course, the scientific authors themselves (Fig. 1). The article aims to initiate a discussion in the scientific community and among these publication infrastructure and service providers to what extent the integration of NFTs into existing scientific publication processes could create value for researchers. "Value," in the context of this article, can mean both monetary value[4] and non-monetary benefits such as unique ownership and proof of ownership as well as related legal, transfer, inheritance, and (re)sale benefits. These values based on unique manuscript ownership, restricted access to works, or their scarce availability (e.g., with regard to purely printed works) have deteriorated in recent decades due to digitization and the Open Science movement, as shown in the following.

Scientific authors currently find themselves in a field of advancing open science orientation of research, significantly influenced by politics and research funders. In

1. Examples are library-, university- or scholarly led open access university presses, repositories, Open Journal Systems (OJS), or Open Monograph Press (OMP) instances.
2. This includes agreements with Digital Object Identifier (DOI) Registration Agencies (such as Crossref or DataCite); with author identification systems (such as ORCID—for example, via ORCID organizational membership); with institution identification systems (such as the Research Organization Registry [ROR] or Ringgold Identifier); and with service providers that clarify funding criteria, funding cooperation, or conditions (such as OA Switchboard, ChronosHub, and Oable).
3. Archiving services include a corresponding commitment of university archives, university libraries and their repositories, national and other mandatory libraries, special collections libraries and their subject information services, and computer centers.
4. Monetary value is the retail value of the original manuscript or printed works.

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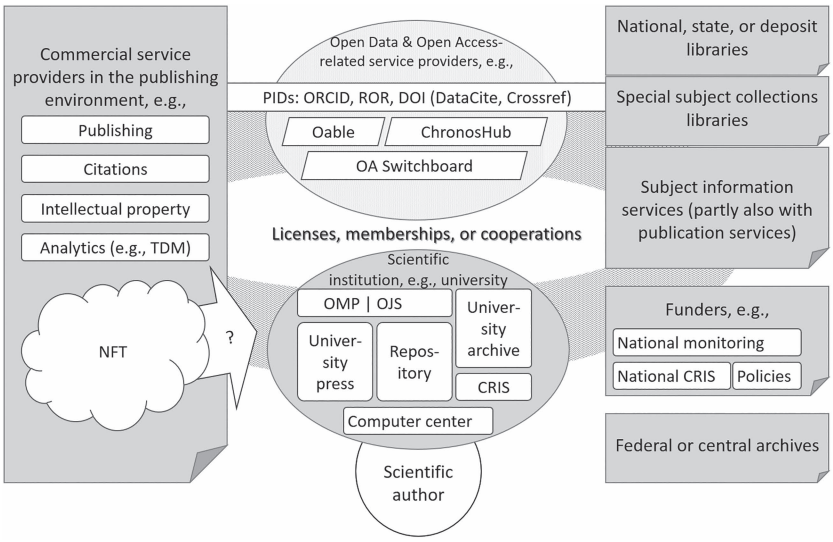

Figure 1. Scientific publication ecosystem (representation by the author)

addition to the general digitization of daily work, this includes making scientific findings freely accessible in the form of publications ("open access" [OA]), research data ("open data"), software ("open source"), and teaching materials ("open educational resources"), as well as in the documentation and reusability of working methods and processes ("open methodology")—for example, via electronic lab books or README files within data and code.

The commercial academic publishing and intellectual property (IP) environment has quickly adapted to the open science demands of politics and funders and is embracing the science-friendly transformation. However, the primary focus is on the company's own value creation, such as replacing previous revenues from print purchases, digital pay-per-view revenues, sales of e-book or e-journal packages, and other licensing revenues (e.g., for the use of images) with open access article processing charges (APCs) or book processing charges (BPCs).

Accordingly, researchers are now in an ecosystem with high costs and greater efforts (e.g., for method documentation) and requirements for reusability, which enables external value creation but only limited opportunities for value creation for the researcher.[5] The latter also deteriorates as the digitization of everyday scientific life progresses, both for the researchers and for their later "custodians of valuables," whether they are heirs or university archives.

As an illustrative example, in 2021, some Einstein paper manuscripts were auctioned for millions of euros (Specktor 2021). An Einstein of today would write manuscripts purely digitally and publish them open access. The modern Einstein, any heirs

5. An example is in the form of own resales, as their open access works have become a kind of common property.

after death, or a university archive or museum would then only be able to offer a digital representation of the work. This file would have no intrinsic, unique value. For example, it would not be a unique feature in a collection, could not fetch any amount in an auction, and could not be resold. Its value would only exist if the modern Einstein printed out the work and signed it. In that case, this paper copy would again be unique. With NFTs, however, this uniqueness can be transferred to digital objects.

This leads to the following considerations regarding NFTs and which science-friendly, value-creating scenarios would be possible in the ecosystem.

Non-Fungible Token (NFT)

Valeonti et al. (2021) have established the following definition for a NFT after reviewing various articles: "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."

Pinto-Gutiérrez et al. (2022) specify the latter further:

> Non-fungible tokens (NFTs) can be used to represent ownership of digital art or any other unique digital item where ownership is recorded in smart contracts on a blockchain. . . . NFTs are tokens stored on a blockchain that can be used to represent ownership of digital assets like artworks, recordings, virtual real estate and pets. NFTs are sold on specialized marketplaces, such as OpenSea, Axie Marketplace, and Rarible. On these platforms, investors can also exchange the property right to the asset underlying the NFT. And because NFTs use smart contract technology, they can be set up so that the original artist can earn a percentage of all subsequent sales.

The definition is better understandable with the help of comparisons. For example, on the home page of artists, galleries, or auction houses, one can look at pictures of the artworks and download them or print them out via the browser. However, these self-copied pictures have no monetary resale value. The situation is relatively similar when a third-party shop offers an unlimited number of posters of the artwork. These can be purchased cheaply, as they have little more than material and production value. Resale would be at flea market level.

A higher value can only be achieved if it is an "original," a series or a limited, signed print by the artist, and if this can be proven and verified (e.g., by a signature, a proof of origin, or a certificate from the artist or the gallery). Demand and a community's perception of value, such as that of collectors or experts, also determine success (Nadini et al. 2021).

NFTs transfer this sense of value or value creation to the digital world. Thus, anyone can copy and redistribute digital images, digital texts, and so forth, whether illegally or legally (e.g., in the case of open Creative Commons [CC] licenses). If there is no non-commercial license attached to the work (e.g., CC BY-NC 4.0), a third-party provider can even resell CC BY–licensed digital works commercially, but since they are available free of charge, presumably hardly any revenue can be generated.

The situation is different, however, if a NFT demonstrably originates from the author and the file itself is unique, cannot be copied, and *can* be sold, together with proofs of origin (in the case of multiple resales to different wallets, i.e., buyers) and corresponding certificates.

Depending on the blockchain and smart contracts, "semi-fungible" items, meaning multiple copies, are also possible in addition to or instead of the one-off original. These items would then correspond, for example, to a limited, signed print by the artist with several identical copies. Many NFT artists have also specialized in series. Series are digital motifs that are slightly modified (e.g., a digital character with different outfits) and are therefore still unique (this corresponds to serial art in the art world).

As Pinto-Gutiérrez et al. (2022) mention, depending on the blockchain and smart contract, the original NFT creators and owners can even secure revenue from subsequent sales, which are then sent to the creator's wallet; that is, NFTs offer a broad spectrum of value creation.

Limitations and Disadvantages of NFTs

Various limitations and disadvantages of NFTs are excerpted from the literature and embedded in the context of the following discussion.

Rosenblatt (2021) mentions that the potential value creation (in terms of, for example, salability or value enhancement) is based solely on the user's perception that the NFTs have value. In the context of scientific publications, this will often only be determined over the course of a career, such as when a certain level of fame is reached, or perhaps never. But even then, an author would then simply have an "original" again, as fifty years ago when an author still wrote on paper. Whether this original then seems valuable or worthwhile to the authors, whether they keep it, use it (e.g., in the sense of selling it or transferring it to friendly colleagues), or throw it away, is up to them.

In addition, Rosenblatt (2021) names possibilities for fraud: "there are many cases in which NFTs can be fraudulent or suspect. Leave aside the fact that DRM-free digital objects associated with NFTs can be copied perfectly at will. I could, for example, obtain an NFT for an object that I claim is mine but actually isn't, an object that already has an NFT, or an object that's out of copyright or licensed

under Creative Commons." The possibilities for fraud are real. It is possible to register on marketplaces such as OpenSea without any authentication, and ownership or originality of the digital objects does not have to be proven either. The only verification option for buyers is to match artists' appearances (e.g., home pages, social media profiles such as Twitter, and then the marketplace profiles) and cross-reference them to one another.[6] In scientific publication processes, however, authentication measures can be integrated into the usual submission process, such as via details of ORCID, the Research Organization Registry (ROR), and university email addresses, and this can consequently also be used for the authenticity of the person in NFT generation.

Valeonti et al. (2021) state a number of other problems in addition to those mentioned above, such as the so-called gas fees for NFT registrations or transactions (such as sales). These can be avoided by so-called gas-free marketplaces and blockchains, such as Polygon. This is desirable in terms of science friendliness, as otherwise there are new fee burdens for authors, similar to APCs in open access journals.

According to Valeonti et al. (2021), with certain blockchains there are high adverse effects on the environment due to their energy hunger. The European Environment Agency (2020) raises serious concerns in its briefing "Blockchain and the Environment." However, there are also more efficient or lower-energy blockchains. Unfortunately, one has to rely in part on the energy efficiency data in the white papers of the blockchains. Independent research raises doubts about this information in some cases (see, e.g., Digiconomist 2022).

In addition, there are risks at four levels—the remuneration level (i.e., the specific coin[s] with which NFTs can be paid), the blockchain level, the presentation level (i.e., the displayability of the media file linked to the code on the blockchain), and the money recipient or sender level (i.e., the wallets and their security levels)—and, finally, possible incompatibilities and complexities in combining the four levels:

- The NFT marketplaces usually only offer certain coins, partly also depending on the supported blockchain and the blockchain selected by the NFT creator. There are thus exchange rate risks[7] and differences to so-called fiat money (i.e., real money in euros or dollars), depending on the time difference and exchange rate change between registration, price setting, and sale or resale. In addition, depending on

6. For example, it is relatively likely that there is no fraud if the artist's NFT marketplace page mentions the official social media links and the artist's home page and, conversely, if the artworks are promoted via tweets and the official artist's home page including the NFT marketplace links.

7. In the context of exchange rate risks, the high dynamics of cryptocurrencies must be mentioned. In May 2022, there was a massive crash in almost all cryptocurrencies (Hern 2022). Even stablecoins were affected. Accordingly, the fiat money value of purchased NFTs could also drop via its documented coin payment price.

the wallet selected, additional financial applications or third-party providers may be required to exchange the coins into fiat money.
- If you bind the NFT to a blockchain that is not designed for it or is not supported by the marketplace, you may not be able to trade it afterwards.
- If the source or URL to the media file for which an NFT was purchased is suppressed or deleted from the marketplace, whether intentionally or unintentionally, or if this occurred due to a hack, it may no longer be possible to access it or have it displayed. This also affects tradability.
- In the case of hardware wallets, there is the risk of loss or technical defects in the hard disk, whereas cloud wallets from online custodians, such as Binance, harbor risks of compromise and insolvency of the operators. In both cases, the NFTs tied to the wallet would be lost. The risks can be reduced, for example, by hybrid solutions, such as cloud wallets with local hardware binding via browser extensions or equivalent couplings of hardware wallet and decentralized applications (e.g., via MetaMask).

The complexity described raises the question of the extent to which it is already possible to rely on a dedicated marketplace, on a specific blockchain, on representation formats, and on reliable wallet providers—in a future-proof manner. Here, too, one has to rely on the white papers and other information that exist to date.[8] In the scientific system, the advantage would be that data centers and experts from the research field of computer science can be consulted for corresponding assessments and checks.

Existing NFT Supporters in the Publishing and Intellectual Property (IP) Environment

Since the NFT provider field is very dynamic, the following selection from the publishing environment is certainly not complete. In addition, it should be noted that most of the providers currently focus on non-scientific publications, such as fiction, and books, not articles.

- Bookchain:
  The provider wants to focus on EPUB e-books as NFT books. There is a dedicated Bookchain Reader. At the marketplace, Bookchain's catalog, scientific books can

8. This may include to what extent the providers have a backup concept; are protected against natural disasters, fires, digital attacks, etc.; and could take a market leader position.

already be found at https://www.bookchain.ca/books/science. Payment is only possible in fiat money (Canadian dollars). Authors as well as publishers can upload books to the Bookchain Portal and use smart contracts to register the books in the blockchain. Ethereum seems to be the blockchain used.

- BooksGoSocial:
  BooksGoSocial is a service provider for self-publishing and marketing of books. For example, limited Special Edition NFT (with audiobooks, video book trailers, author interviews, etc.) can be created and sold; buyers and collectors also get exclusive access to the Private Members Only Area. A purchase is possible via the platform in fiat money (US dollars). Apparently, the WAX blockchain and WAX Cloud Wallet are used.
- BookVolts:
  BookVolts provides support for sophisticated editing and the creation of exclusive bonus materials and content (e.g., bonus chapters, prefaces, audio/video content, maps, illustrations, handwritten notes). A dedicated reader app is planned. OpenSea (the blockchain used for minting is Ethereum, and bids on the book are made in Wrapped ETH [WETH]) was used as the marketplace for the first book, but the BookVolts roadmap suggests that a dedicated marketplace will be created in the summer of 2022.
- Creatokia:
  The creator of Creatokia, the digital and publishing services provider Bookwire, wants to offer limited special editions of books, exclusive content, and "originals" for authors, content creators, and publishers via NFTs and support a more secure rights and license trade. The first Creatokia NFT collection is based on older, copyright-free literary classics, which are prepared and supplemented with art, audio files, etc., in addition to text. Ethereum is used as the blockchain. Books can be bought and sold on the Creatokia marketplace using fiat money (euros) or ETH. MetaMask is currently supported as a wallet; further connections are planned.
- Publica:
  Another provider for NFT books. At its marketplace, Publica's Ebook Catalog, one can buy the books via fiat money (US dollars) or its own cryptocurrency, the Publica (PBL, operates on Ethereum) coin. There is a dedicated Publica e-reader with importable wallet.
- WIP Publishing (WIPP):
  WIPP does not use its own marketplace for book trading but uses OpenSea (the blockchain used for minting is Polygon, and purchases are made via ETH). By using Polygon, the costs, such as gas fees, are significantly lower in contrast to the Ethereum-based models. The PDFs can be created and designed via a NFTBook Minter.

The listing shows several of the problems already mentioned, such as small proprietary or not exchangeable or combinable marketplaces; the use of energy-intensive blockchains such as Ethereum with "gas fees"; and a rather belletristic, aesthetic, and artistic approach that differs from the pragmatic approach of the scientific world. Some earlier providers or startups, mentioned in NetGalley (2019), have seemingly disappeared from the web (e.g., Wespr or Po:et).

In addition to the distribution and value creation, there would be various other possible uses of blockchain and smart contracts in the scientific publication and IP process, such as in the area of anti-plagiarism (Palmisano et al. 2022), peer review and usage figures (Wang and Zhao 2021), licensing and rights protection (license.rocks 2021), or record-keeping (Safdar et al. 2022). However, these are primarily areas of interest for publishers. This article focuses on possible scenarios of science-friendly value creation for authors.

Considerations Towards Science-Friendly Scenarios

First, it should be briefly outlined what is meant by science friendly: the NFT generation and the transfer to the scientific author should be done free of charge whenever possible and achievable, such as through choice of platform and blockchain. In addition, it should be possible to generate further resalable copies (i.e., semi-fungible items) and transfer them, for example, to the local university archive or to research colleagues, if the author wishes to do so. Any decision-making power over the NFT original(s) and copies should initially rest with the researchers or be transferred to them via university institutions or contracts. The complexity and workload should be low and the interoperability or further value creation high. That is, ideally, existing large and stable marketplaces (and their application programming interface [API] for automation steps) as well as blockchains should be used, whose continued operation and long-term support by the community is likely and future proof.

Based on these requirements, Figure 1 can be used for localization. In the publication process, NFT registration should happen as close as possible to the researcher and their institution. This would be the case with library- or university-operated open access presses as well as with institutional repositories.

The first possible scenario would be a location there and additionally (in the sense of holism) a technical integration of NFT support possibilities into the software development planning of the most common open source software for university presses and repositories, specifically, for example, Open Journal Systems (OJS) and Open Monograph Press (OMP) as well as DSpace and EPrints.

The disadvantage here would be that only a small proportion of publications are published via the local university press, and it is not always possible, either legally or

due to publisher requirements, to publish a preprint of publications in repositories. A significantly higher proportion of scientific publications would be covered if submissions were channeled at the respective scientific institution, specifically, for example, via ChronosHub. ChronosHub makes it possible to submit manuscripts and metadata directly to a wide variety of publishers (Büttner, Grubak, and Jägerhorn 2021).

The second possible scenario would be accordingly an extension of the ChronosHub function portfolio with NFT registration and publication services. In addition to ChronosHub, there are also similar providers such as OA Switchboard and Oable. However, in contrast to ChronosHub, these providers are designed for communication processes that happen after submission. To the author's knowledge, only ChronosHub currently allows direct university-centralized submissions to publishers.

ChronosHub currently cooperates with over 200 scientific publishers in terms of submissions directly via the platform, including the major ones such as Elsevier, Wiley, Springer Nature, and Taylor & Francis. However, not all publishers' journals could be integrated, since different imprints of the major publishers have different submission systems, making platform integration difficult. Accordingly, only a part of the university or scientific submissions can be reached and channeled.

Thus, the third possible scenario would be the most comprehensive solution: according to Liu (2021), Crossref is currently the world's largest Digital Object Identifier (DOI) Registration Agency, followed by DataCite, for providing scientific content with DOIs and making it persistently retrievable. Accordingly, NFT registration with Crossref and DataCite would be highly attractive.

However, it would be important that the legal coupling and transfer of NFTs happen as directly as possible with the scientific authors or their institutions and not with the publishers. Otherwise, as with open access business models (APCs, subscribe-to-open, publish-and-read fees, etc.), vast numbers of different, non-transparent, and heterogeneously priced NFT business models will emerge. For example, a global publisher with a prestigious name might charge significantly higher fees for NFT registration than a small, national publisher.

Instead, Crossref and DataCite should set up a uniform business and fee model and use the largely existing contractual ties to universities, such as via university libraries, for billing: "Presently, lots of libraries have been involved in DOI services and they may play the role of either a registrant or a client (a data center) or a user in the DOI community or simultaneously" (Liu 2021).

Due to the triangular situation with publishers, matters would nevertheless be complex. The simplest conceivable procedure possible would be for open access publications with Creative Commons licenses (specifically CC BY Attribution; all others would be difficult without further legal relationships), in which publishers have been granted simple rights of use. This would allow the DOI Registration Agencies to access the full

texts, whose persistent retrieval they guarantee, and to process them for the benefit of researchers in terms of NFT mining.

The possibilities of fraud by unauthorized third parties described in the section "Limitations and Disadvantages of NFTs" could be eliminated with unique author and institution identifiers such as ORCID and ROR. For example, the university could contractually request that NFTs be registered for all articles with the institutional ROR and/or ORCIDs of their own researchers. Afterwards, they are transferred centrally—that is, to the university library or the university archive and then to the authors. The intermediate step could also be omitted if the author could deposit his wallet at the ORCID. Theoretically, this is already possible now (under "Websites & Social Links").

Conclusion and Outlook

This article describes three theoretically possible science-friendly NFT deployment scenarios. Registration would be possible, for example, directly on behalf of the scientific author, such as with university-operated open access presses and repositories. In this case, the NFT could be transferred directly to the author, and the rights relationship (e.g., the publication contract with the university press or repository) could specify various details of the NFT creation, such as whether a series of semi-fungible items should be generated.

Pending eventual NFT software support by OJS, OMP, or the repository softwares, university operators could also act manually here, including registering publications as a service with NFT marketplaces such as OpenSea and transferring them to the author's wallet.

A broader approach would be possible in terms of preprints from a wide range of publishers, including commercial ones, provided that the university submissions can be channeled and processed upstream of the publisher. This would be the case, for example, via ChronosHub. A direct transfer as described in the previous paragraph would be possible. However, legal clarification would still be necessary as to what extent this would conflict with submissions to publishers (especially if the publisher later claims exclusive rights of use). In addition, corresponding functionality enhancements of the ChronosHub platform would, of course, be necessary, such as the possibility of entering the wallet address.

The same applies to the most powerful variant, NFT registration via DOI Registration Agencies. Since DOI registration is only done by publishers, one would have to rely on their support. A certain workaround would only be possible for open access publications with CC BY, and the question of transfer to the wallet comes into play. This would be possible via PIDs such as ORCID, if this supports the wallet specification

and makes it evaluable for Crossref and DataCite. Or there could be an institutional intermediate layer: since many universities already have contractual relationships with Crossref and DataCite, this could also regulate the transfer to a central university wallet, which then distributes to the wallets of the authors and possibly to the university archive too.

For Crossref and DataCite as well as for ChronosHub (and ORCID) it depends, of course, to what extent NFT support is relevant for software development planning. This article is intended to start and stimulate the relevant discussion in communities and among the mentioned publication infrastructure and service providers. Similar considerations apply to corresponding future discussions among operators of open access university presses, repositories, and archives. Theoretically, a new, value-managing and value-transferring intermediate layer and/or a link to the universities' own stores, which currently tend to sell merchandise, scripts, and textbooks, or computing centers that deal with storage issues would also be conceivable.

Another open question is the future-proof combination of the marketplace, blockchain, representation layer, and value determination (in terms of currencies in fiat money or cryptocoins). If an open access university press simply wants to start with NFTs on a test basis, the use of marketplaces and blockchains that are as free as possible (e.g., OpenSea and Polygon) and dollar-linked currencies such as DAI or USDC is a good way to reduce risks such as high fluctuations in the value of coins.

Ideally, the science-related and science-friendly publication infrastructures and service providers should not wait too long with NFT developments; Vasan, Janosov, and Barabási (2022) diagnose that "first movers" will have a clear advantage, such as in value growth. Moreover, otherwise commercial providers could take over the field and drive up the cost of NFT creation similar to other modern services, such as open access publishing.

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