COMPREHENSIVE ANALYSIS OF NON-FUNGIBLE TOKENS VALUATION AND ACCOUNTING UNDER IFRS: CHALLENGES AND ARTIFICIAL INTELLIGENCE IMPLICATIONS

Mfon Akpan [*], Henry Ugochukwu Ukwu [**]

* Corresponding author, Department of Accounting, Methodist University, Fayetteville, USA
Contact details: Department of Accounting, Methodist University, 5400 Ramsey St., Fayetteville, NC 28311, USA
** Department of Computer Engineering, Amsterdam Tech, Amsterdam, Netherlands

Abstract

The emergence of non-fungible tokens (NFTs) has created a new market with significant implications for stakeholders, particularly in industries such as art, fashion, gaming, and real-world assets, leading to challenges in finance, financial pricing, financial management, risk management, and cryptocurrency issues. This research paper adopts a quantitative approach to provide a comprehensive analysis of the challenges associated with NFTs, including their impact on the art market, risks related to ownership rights, and proper financial statement treatment. Additionally, the paper examines the challenges of accounting for NFTs under the International Financial Reporting Standards (IFRS), including valuation, tax treatment, and accounting considerations. The use of artificial intelligence (AI) in creating, verifying, and authenticating NFTs, as well as detecting potential fraud and valuing them in the market, is also discussed. Finally, the paper provides recommendations for companies and accounting professionals on addressing the challenges associated with NFTs under IFRS. The research contributes to the ongoing debate on the best practices for NFT accounting, the evolving nature of digital assets, and the role of AI in this emerging market.

Keywords: Non-Fungible Tokens (NFTs), Art Market, Artificial Intelligence (AI), Financial Reporting, Valuation, IFRS

Authors' individual contribution: Conceptualization — M.A. and H.U.U.; Methodology — M.A. and H.U.U.; Writing — Original Draft — M.A. and H.U.U.; Writing — Review & Editing — M.A. and H.U.U.; Visualization — H.U.U.

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1. INTRODUCTION

Intangible assets are non-physical assets with value but cannot be seen, touched, or measured. Examples of intangible assets include patents, trademarks, copyrights, and customer relationships (Ante, 2021). When valuing intangible assets under International Financial Reporting Standards (IFRS), it is essential to consider the asset's marketability, comparable assets or transactions, and the level of uncertainty or subjectivity involved in the valuation. It may also be making assumptions and estimates to arrive at a final valuation estimate may also be necessary to consult a qualified valuation professional for assistance with valuing intangible assets under IFRS.

The paper discusses potential solutions for valuing and accounting for non-fungible tokens (NFTs) under the IFRS. One solution is to utilize third-party valuation firms specializing in evaluating NFTs to provide reliable and independent valuations for accounting purposes (Van Roosmalen et al., 2022). Another solution involves developing industry-specific accounting standards and guidelines for NFTs, similar to the guidance provided for cryptocurrency transactions. Though IFRS offers some guidance, more is needed for valuing these unique digital assets, necessitating external resources and industry-specific standards (Wang et al., 2021). The study also suggests leveraging artificial intelligence (AI) to provide real-time valuations of NFTs by analyzing data from various sources, including the blockchain, social media, and online marketplaces (Arcenegui et al., 2020; Tsalavoutas et al., 2020).

The structure of this paper is as follows. Section 2 reviews the relevant literature. Section 3 analyses the methodology used to conduct empirical research. Section 4 is the results. Section 5 is a discussion of the findings. Section 6 is the conclusion and recommendations for further research.

2. LITERATURE REVIEW

In the world of blockchain technology, NFTs are digital representations of unique assets that individuals or organizations can own. Unlike fungible tokens, which are interchangeable like currency, NFTs are distinct and represent the authenticity of both physical and nonphysical assets (Barrington & Merrill, 2022; Chohan, 2021; Zhang et al., 2021). The value of NFTs is primarily derived from their scarcity and collectability, and they can encompass various types of digital assets (Ante, 2021; Dowling, 2022). However, there needs to be more research on how these digital tokens interact with other financial assets, as cryptocurrencies initially emerged as an alternative to traditional financial assets rather than representations of value (Kong et al., 2021).

Alternative assets, such as collectibles and creative works, including paintings, sculptures, coins, stamps, and wine, differ from financial assets like stocks and bonds. Their prices are driven by subjective values and external factors like taste and supply rather than generating income or being influenced by company performance. Traditionally, the market for these alternative assets has been illiquid, requiring investors to hold them for extended periods or sell them through dealers (Kong et al., 2021).

2.1. NFT components

The components are the fixtures needed to facilitate a primary NFT transaction. The components are the fundamental ingredients for an NFT transaction from buyer to seller (Wang et al., 2021). Cryptocurrencies are needed as a means of payment for an NFT. The blockchain, a distributed database secured by cryptographic protocols, plays a pivotal role in the world of NFTs. Utilizing the Ethereum blockchain network, NFT transactions benefit from its secure environment and enable the execution of smart contracts (Gupta & Malsa, 2023). Smart contracts eliminate the need for intermediaries and provide a unified method for conducting transactions across various industries. Users rely on blockchain addresses to send and receive NFT assets, which are unique identifiers generated from private and public key pairs. NFT transfers are accomplished through blockchain transactions, where owners prove their possession with private keys and digitally sign the transaction to send assets to another address. In the Ethereum blockchain, transaction elements, return values, parameter values, and function names are encoded using hex values, ensuring the authenticity and ownership of NFT assets (Wang et al., 2021; Wang, 2023).

The Ethereum network facilitates transactions using the cryptocurrency Ether (ETH) and decentralized applications (DAPPS). Ethereum operates on a public proof-of-work blockchain, including externally owned accounts controlled by private keys and contract accounts containing executable code (Das et al., 2021). NFTs for land acquisition in the metaverse can be obtained through fixed-price transactions or timed auctions, with ownership transferred over the Ethereum network (Mukhopadhyay & Ghosh, 2021). Crypto art galleries utilize smart contract technology on the blockchain. Artists can mint NFTs to represent their digital artwork, allowing internet users to view the art without owning it. NFTs can also be created with music or audio files, enabling fractional ownership of songs and potential royalty claims (Ante, 2021; Franceschet, 2021).

2.2. IAS 38 Intangible Assets

Under IFRS, the accounting for intangible assets is primarily governed by International Accounting Standard (IAS) 38. IAS 38 defines intangible assets as non-monetary assets without physical substance, which must be identifiable through separability or contractual/legal rights. Separable assets can be sold, transferred, or licensed. Initially, intangible assets are measured at cost and listed at cost less accumulated amortization or at a revalued amount based on fair value if an active market exists. Intangible assets with finite useful lives are subject to amortization and impairment testing, while those with indefinite useful lives are not amortized but are tested for impairment annually. However, IAS 38 does not cover intangible assets held for sale in the ordinary course of business. In such cases, the appropriate accounting treatment should be sought from *IAS 2 Inventories* (IFRS Foundation, 2023b).

2.3. IAS 2 Inventories

The International Accounting Standard 2 (IAS 2) provides a comprehensive framework for

the accounting treatment of inventories, with specific exclusions. The standard explicitly states that it does not apply to inventories held by commodity broker-traders who choose to value their inventories at fair value less cost to sell. In this case, changes in fair value less cost to sell are recognized as profit or loss during the relevant period. Broker traders, as defined in IAS 2, are entities involved in procuring or disposing of commodities on behalf of others or for their own accounts, with the aim of generating short-term sales profits from price fluctuations or margins. However, for other inventory classifications, IAS 2 requires a general measurement criterion based on the lower cost and net realizable value to ensure a prudent approach to inventory valuation (IFRS Foundation, 2023a).

2.4. Guidance

2.4.1. Scope

The accounting treatment of digital assets under IFRS has been addressed by the 2019 IFRS IC Agenda Decision. Companies must assess whether a digital asset meets the definitions of cash or cash equivalents, financial instruments, inventory, or intangible assets.

Though exceptions exist, digital assets are frequently considered indefinite-lived intangible assets under IFRS Standards. For example, companies holding digital assets for sale during business may classify them as inventory. It is crucial for companies to carefully evaluate the applicability of various accounting standards and classifications when accounting for digital assets under IFRS (Van Roosmalen et al., 2022).

2.4.2. Measurement at cost or fair value

Under IFRS Standards, there are two possible approaches for fair value measurement of digital assets that may not be present under US Generally Accepted Accounting Principles (GAAP):
- The revaluation model in IAS 38 can be applied to digital assets classified as intangible assets if an active market exists. However, determining whether an active market exists can be challenging.
- Under IFRS Standards, broker-traders measure their digital assets classified as inventory at fair value less cost to sell.

In other cases, under both IFRS Standards and US GAAP, digital assets classified as intangible assets are typically indefinite-lived and measured at costless impairment losses. This raises several practical issues, such as:
- Determining cost when the asset is obtained in exchange for goods or services.
- Impairment testing (and reversals of impairment losses under IFRS Standards), including fair value measurement. Recoverable amounts are subject to the volatility of digital asset values.

When digital assets are classified as inventory under IFRS Standards, and the entity is not a broker-trader, they are measured at the lower cost and net realizable value under IAS 2 (Van Roosmalen et al., 2022).

2.4.3. Fair value measurement

Although some digital assets are actively traded, determining their fair value may not be straightforward. The converged fair value accounting guidance in IFRS Standards and US GAAP requires an entity to identify its principal (or most advantageous) market for the digital asset.

Judgment is often required when determining an entity's principal market for a digital asset; common complexities include identifying which markets can be accessed by the holder and assessing whether information about/from various markets (e.g., volume of trading, prices) is reliable. Determining whether an active market exists can also be challenging (Van Roosmalen et al., 2022; Saifullah et al., 2022).

2.4.4. Revenue recognition

Under the IFRS framework, companies may receive digital assets as consideration for goods or services transferred and for participating in a blockchain's consensus protocol, such as mining or staking activities. IFRS Standards require noncash consideration to be generally measured at the fair value of that consideration. However, an exception arises when the fair value cannot be reasonably estimated, in which case the fair value of the goods or services transferred takes precedence.

Under IFRS 15, the transaction price is typically determined at contract inception, which implies that the fair value of noncash consideration should also be measured at that point. Therefore, any subsequent changes in the fair value of noncash consideration should be recognized outside of revenue under IFRS Standards (Van Roosmalen et al., 2022).

2.4.5. Future guidance

The International Accounting Standards Board (IASB) decided in April 2022 not to add a project on cryptocurrencies and related transactions to its 2022–2026 work plan. IASB Board Chair, Andreas Barckow, stated there was appropriate accounting for holdings of cryptocurrencies under the existing literature, and more importantly, the evidence from many of the respondents to the agenda consultation does not show that holdings of cryptocurrency are either significant or prevalent for IFRS Standards reporters in their respective jurisdictions at this stage. Instead, issues may be addressed indirectly through a more comprehensive project on intangible assets, though that is yet to kick off (Van Roosmalen et al., 2022).

3. METHODOLOGY

Developing a comprehensive review paper for emerging fields such as NFT and AI presents challenges due to the limited literature in these areas. To overcome this, we employed a diverse range of search strategies to ensure the inclusiveness and thoroughness of our review. In addition to the conventional approach of utilizing electronic databases like Google Scholar, we

recognized the interdisciplinary nature of NFT and AI and expanded our search beyond traditional academic sources. We explored interdisciplinary platforms, technology forums, art industry publications, and relevant business or financial platforms to capture insights on the intersection of NFTs and AI. To complement electronic database searches, we conducted manual searches across various sources. These included relevant journals, conference proceedings, working papers, preprints, industry reports, and the websites of pertinent organizations or institutions. This deliberate effort enabled us to access unpublished or less widely available information, thereby enriching the comprehensiveness of our review.

A comprehensive and rigorous examination of numerical data was undertaken to substantiate our assertions with empirical evidence and enhance their credibility. By incorporating these data-driven insights, we aimed to reinforce the relevance and practical implications of our review. By combining a wide-ranging literature search, careful exclusion criteria, and the inclusion of hypothetical data and numerical analysis, our comprehensive review paper thoroughly examines the challenges and implications of NFTs and their intersection with AI. This approach ensures that our findings are grounded in both theoretical foundations and empirical evidence, contributing to a robust and insightful analysis of the topic.

4. RESULTS

The comprehensive analysis conducted in this study sheds light on the implications of the review findings for the field of AI, particularly concerning the valuation and accounting challenges associated with NFTs. The following key results emerged from the analysis: valuation challenges of NFTs, accounting challenges of NFTs, implications for AI, adaptation of AI for NFT accounting, etc. NFTs have become increasingly popular for buying and selling digital creative content such as art, music, videos, and games. However, because NFTs have unique features, accounting, and valuation can take time and effort. The IFRS currently need to provide clear guidance on handling NFTs and other crypto assets. A potential approach for accounting NFTs is to classify them as intangible assets, with *IAS 38 Intangible Assets* (Ienciu & Ienciu, 2016). NFTs fulfill the requirements for an intangible asset since they are non-monetary assets that are identifiable and lack physical substance. As a result, organizations that deal with NFTs must apply existing IFRS requirements based on their specific circumstances. The initial assessment of intangible assets is generally based on their acquisition cost. However, determining the cost of an NFT can be difficult due to the absence of a market for comparable or identical assets. Consequently, organizations may have to use alternative methods such as relative valuation approaches or discounted cash flows to estimate the fair value of an NFT at the time of acquisition.

In accordance with *IAS 38 Intangible Assets*, the method for measuring an intangible asset after

the initial acquisition is determined by its useful life. If an intangible asset has an indefinite useful life, it should not be amortized, but assessed for impairment regularly or when there are signs that it may be impaired. An impairment loss occurs when the carrying amount of the asset is higher than its recoverable amount. On the other hand, if an intangible asset has a finite useful life, it should be amortized over its estimated useful life using a method that reflects how the organization will utilize the asset's future economic benefits. It should also be assessed for impairment if there is any indication that it may be impaired.

Organizations must disclose various details about their intangible assets in their financial statements, such as the carrying amount, useful lives, methods of amortization, impairment losses, reversals, and fair values if they were assessed using revaluation models. Additionally, they should reveal any significant assumptions and estimates used to identify, measure, and assess impairments in their intangible assets.

The IAS 38's disclosure guidelines provide a practical framework for organizations to report their intangible assets, including NFTs. However, entities need to exercise their professional judgment and seek guidance from auditors to ensure that their NFT accounting policies are appropriate and in compliance with the relevant accounting standards. Since subjective elements can influence NFT valuation, organizations should take into account the distinctive characteristics of NFTs and their business operations.

4.1. Adhering to existing IFRS guidelines for reporting NFTs

Following IFRS guidelines is crucial because the absence of clear guidance from IFRS regarding the handling of NFTs and other crypto-assets results in clarity and consistency in financial reporting by organizations. Failure to do so may lead to challenges in comparing financial performance across different entities, impacting the decision-making process of investors, creditors, and other stakeholders. Inconsistent reporting practices can also weaken financial statements' credibility and undermine financial markets' overall integrity. The flowchart depicted in Figure 1a provides a comprehensive overview of the NFT transaction process, from the creation of NFTs to their transfer of ownership and financial reporting in compliance with IFRS guidelines. Additionally, the diagram includes the role of AI verification at the end of the process.

Figure 1b specifically highlights the significance of IFRS and precise reporting. It centers IFRS in the NFT transaction process, emphasizing the importance of adhering to IFRS guidelines to achieve reliable and transparent reporting of crypto assets. Additionally, it incorporates AI's function in the verification process, which contributes to the accuracy and trustworthiness of financial reporting.

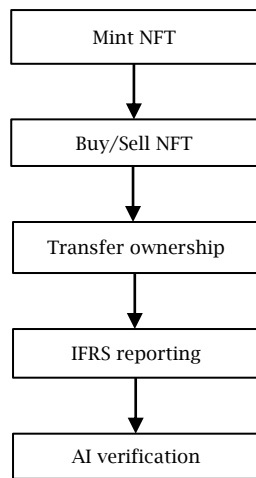**Figure 1a.** IFRS in the middle of the NFT transaction process and the role of AI

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┌─────────────────────┐
│      Mint NFT       │
└─────────────────────┘
          │
          ▼
┌─────────────────────┐
│     Buy/Sell NFT    │
└─────────────────────┘
          │
          ▼
┌─────────────────────┐
│  Transfer ownership │
└─────────────────────┘
          │
          ▼
┌─────────────────────┐
│    IFRS reporting   │
└─────────────────────┘
          │
          ▼
┌─────────────────────┐
│    AI verification  │
└─────────────────────┘
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Figure 1b. Integration of IFRS and AI in NFT transactions for reliable and transparent reporting of crypto-assets: A process diagram

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┌─────────────┐          ┌─────────────┐
│  NFT asset  │          │  NFT buyer  │
└─────────────┘          └─────────────┘
      │                        │
      ▼                        ▼
┌─────────────┐          ┌─────────────┐
│NFT transaction│        │NFT transaction│
└─────────────┘          └─────────────┘
      │                        │
      ▼                        ▼
┌─────────────┐          ┌─────────────┐
│ NFT seller  │          │ NFT exchange│
└─────────────┘          └─────────────┘
      │                        │
      ▼                        ▼
┌─────────────┐          ┌─────────────┐
│  Financial  │          │AI solution for│
│  reporting  │          │    NFTs     │
└─────────────┘          └─────────────┘
      │                        │
      ▼                        ▼
┌─────────────┐          ┌─────────────┐
│IFRS guidelines│        │AI-based fraud│
│             │          │  detection  │
└─────────────┘          └─────────────┘
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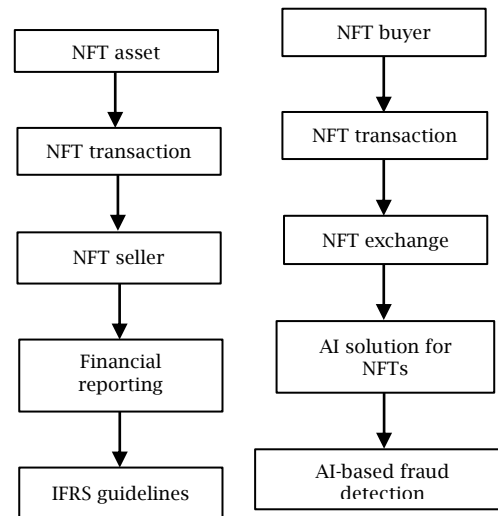
Figure 1b shows the NFT transaction process, starting from the NFT asset and ending with financial reporting. The flowchart includes two paths for the NFT transaction, one between the NFT asset and the NFT buyer and the other between the NFT seller and the NFT exchange. The financial reporting process is at the center of the diagram, indicating its importance in the NFT transaction process. The diagram also highlights the role of IFRS guidelines in ensuring accurate and transparent reporting of NFTs and other crypto assets. Additionally, it includes a section for AI solutions for NFTs, such as AI-based fraud detection, demonstrating the potential of AI to enhance the transparency and precision of financial reporting for NFT transactions.

4.2. Data analytics and AI for NFT valuation and decision-making

Organizations can leverage the expertise of AI professionals to facilitate compliance with the existing IFRS requirements of NFTs. These professionals can help organizations create and implement machine learning algorithms to analyze data relevant to NFTs, such as pricing trends and sales history. This analysis can provide valuable insights into the valuation of NFTs and their potential associated risks. Additionally, AI professionals can assist with developing automated processes for financial reporting and disclosures, enhancing efficiency and minimizing errors. However, organizations must ensure that their use of AI is compliant with relevant regulations and standards.

Technology can be used, but its effectiveness relies on access to sufficient data and well-trained algorithms, which may only sometimes be readily available for unique or "one-of-a-kind" NFTs (Darshan et al., 2022). Moreover, the subjective nature of NFT valuation and the absence of a standardized market for them can create obstacles to the effective use of such technology. Regarding "one-of-a-kind" NFTs, they are exclusive and singular, with only a single copy of that particular digital asset. This is due to the fundamental principle of non-fungibility, which implies that every NFT is distinct and cannot be interchanged with another NFT on a one-for-one basis. Consequently, although there may be several digital replicas of a specific artwork or media, only one NFT signifies ownership of the original digital asset.

The field of asset valuation, particularly regarding NFTs, is constantly evolving and requires further research. While there is currently no standardized method for determining the value of NFTs, a variety of factors can be explored. These factors include market sentiment, financial and economic policy uncertainty (EPU), pure volatility indices, etc. It is also crucial to understand the connection between NFTs and other cryptocurrencies, as well as the driving forces behind both markets, such as the Consumer Sentiment Index (CSI), the Consumer Confidence Index (CCI), EPU, and the Volatility Index (VIX).

The valuation of NFTs and their linkages with other assets is an area of research that may benefit from the use of AI. Leveraging AI technology for data analysis can facilitate the identification of patterns that may not be apparent to human analysts, thus resulting in more accurate valuations and predictions (Kräussl & Tugnetti, 2023). However, incorporating AI ultimately depends on the research approach and methodology being developed. One promising strategy involves training machine learning algorithms on large datasets of NFT transactions, user behavior, and market trends to identify patterns and correlations between these factors and NFT valuation (Gumelar et al., 2023). Additionally, natural language processing (NLP) techniques can be employed to analyze social media and other online platforms for discussions on specific NFTs, creators, and related topics, providing valuable insights into market sentiment and demand.

4.3. AI-assisted NFT-value prediction

Valuing an NFT can be complex, as personal preferences, cultural significance, and historical context can influence it. Capturing or accounting for these subjective factors is a challenge, making it difficult to predict the exact value of NFTs with complete certainty. However, technological advancements and the use of AI have shown

encouraging results in providing insights and more precise predictions. As machine learning algorithms improve and data access expands, we can expect AI to become more critical in analyzing market trends and offering more accurate valuations of NFTs (Tann et al., 2022). Ultimately, more specific accounting guidelines for NFTs could increase confidence in the market for NFTs and promote their wider adoption as a legitimate asset class. Figure 2 depicts a flowchart that includes AI at different levels and side-by-side with IFRS reporting. Figure 2 shows that AI is used for data analysis to predict the value of NFTs. NFT transactions are then monitored for IFRS compliance, and an IFRS compliance report is generated. The use of AI is also shown in compliance monitoring. While AI can provide valuable insights and assist with compliance monitoring, it should not be relied on as the sole source of decision-making. Human oversight and expertise are still necessary to ensure accuracy and ethical decision-making.

Figure 2. AI and IFRS reporting for NFT transactions
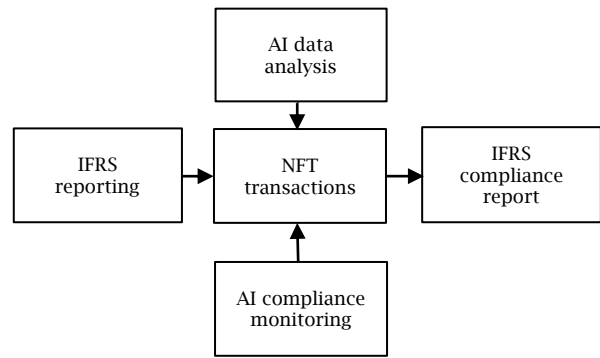
In this paper, we also highlight the entire NFT process from creation to transaction finalization and this is depicted in the process flow diagram in Figure 3.

Figure 3. The process flow of NFT transactions with IFRS reporting and AI compliance
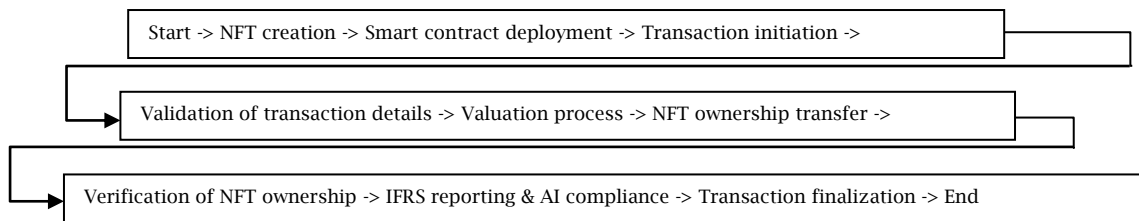
The process of creation is included because it is an important step leading to the issuance of a document known as the NFT creation certificate, which provides crucial information about the NFT, such as its ownership, authenticity, and creation details in the rapidly evolving and sometimes opaque NFT market. The NFT creation certificate benefits investors in several ways and serves as a record of the creation and authenticity of the NFT, which can help ensure compliance with IFRS guidelines for financial reporting. First, it provides proof of ownership and authenticity, which can reduce the risk of fraud and increase investor confidence in the NFT. Second, it provides information about the creator of the NFT, such as the date and time of creation, the creator's identity, reputation, and track record, and any relevant metadata, which can help investors to make more informed decisions about whether to invest in the NFT. Finally, the creation certificate can also provide information about the underlying asset or intellectual property associated with the NFT, which can help investors evaluate the potential value and prospects of the NFT (Barrington, 2022).

Figure 3 outlines the various steps involved in the creation and transfer of NFTs, as well as the necessary compliance and reporting requirements under the IFRS and the role of AI in the process. The process starts with creating an NFT, which involves the generation of a unique digital asset using specialized software. This can be done by an individual artist or a group of creators who want to monetize their digital content. Once the NFT is created, it needs to be deployed on a blockchain platform using a smart contract. This contract specifies the terms and conditions for the NFT's

ownership and usage, including any royalties or fees associated with its transfer or use.

Once the smart contract is deployed, the NFT can be sold or transferred to a new owner. This process involves initiating a transaction, which is validated by the blockchain network to ensure that the transfer of ownership is legitimate and that the transaction details are accurate. At this stage, AI can be used to analyze market trends and provide insights into the current and future value of the NFT. The valuation process involves assessing the value of the NFT based on various factors, including its uniqueness, rarity, historical context, and cultural significance. This process can be complex and subjective, but AI can help provide more accurate predictions by analyzing market data and historical trends. Once the NFT ownership is transferred, the new owner needs to be verified to ensure that they are the legitimate owner of the asset. This verification process can be done using blockchain technology and other digital identity verification methods.

As part of the IFRS reporting and compliance requirements, companies that hold NFTs as assets must report their value and usage in their financial statements. AI can monitor compliance with these reporting requirements by analyzing financial data and ensuring that the company meets all necessary regulatory and accounting standards. Finally, the transaction is finalized, and the process ends. The flowchart in Figure 3 provides an overview of the steps involved in the creation, transfer, and reporting of NFTs and highlights the critical role of AI in providing insights and ensuring compliance with regulatory requirements. However, Figure 4 outlines creating and transacting NFTs in sequential order.

Figure 4. A broad outline of the NFT creation, valuation, and transaction process and the necessary compliance and reporting obligations
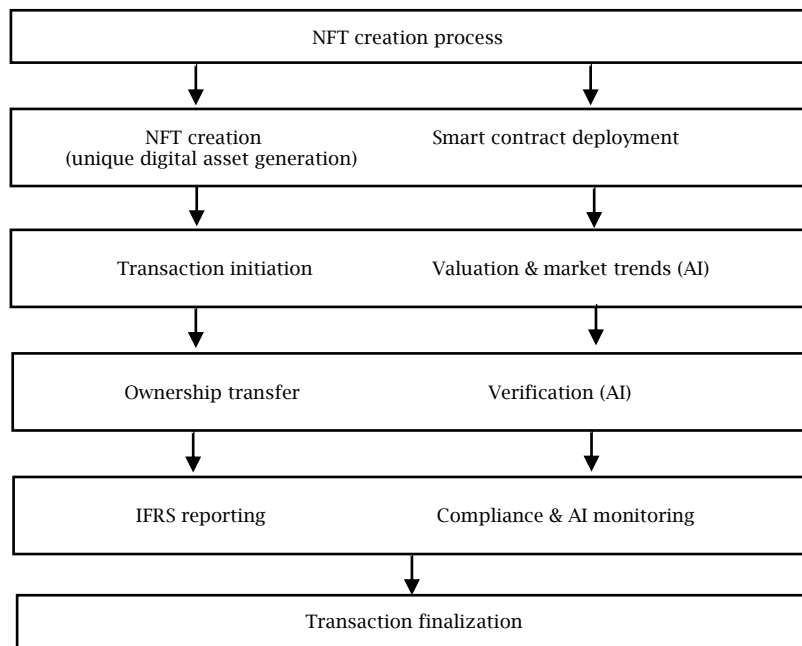

Figure 4 shows that the NFT process is a complex and multi-step process that involves various stakeholders, including creators, buyers, sellers, and regulators. It highlights the importance of transparency, compliance, and accurate reporting to ensure the legitimacy and trustworthiness of NFT transactions. The diagram can help accountants and investors to understand the different steps involved in the process and the role of AI in providing insights and ensuring compliance with regulatory requirements.

In the real world, the actual process of creating and transacting NFTs can vary depending on the specific use case and the parties involved. For example, a musician may create an NFT to sell a unique digital album and may follow a similar process to the one described in the diagram. However, a visual artist may create an NFT to sell a unique digital artwork and may follow a slightly different process. Similarly, the process for NFTs related to real estate or other physical assets may involve additional steps, such as conducting due diligence on the underlying asset or coordinating with various stakeholders. The technology and processes for NFTs are still evolving, and there may be different approaches or best practices depending on the context. As such, the diagram represents a possible ideal process for creating and transacting NFTs, but there may be other or the most optimal processes in every scenario. The flowchart shows the different stages involved in managing assets, from asset acquisition to transfer and reporting, and how AI-assisted valuation and risk assessment can be used at different stages to provide more accurate and timely information for decision-making. The flowchart also helps to identify potential areas where human judgment and oversight are still required despite the use of AI. Figure 5 illustrates AI-assisted asset management: from acquisition to reporting.

Figure 5. AI assistance at all levels
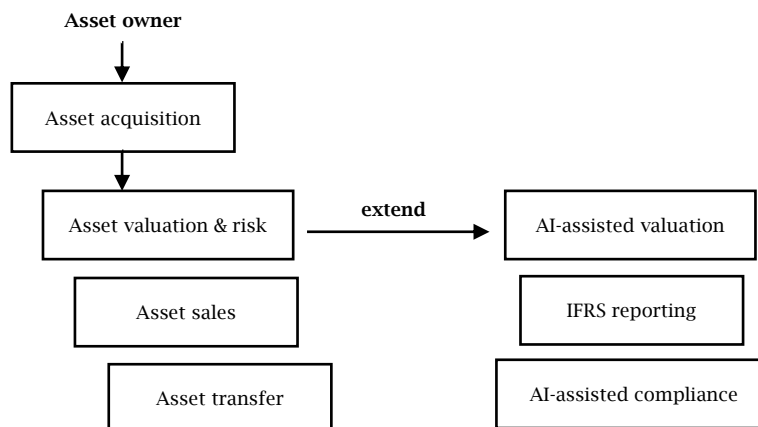
The block before the end in the updated flowchart that includes AI assistance at all levels is the "Valuation" block. It represents determining the value of the NFTs being transacted using various valuation methods, such as market comparables or income-based approaches. AI may be used at this stage to assist in the valuation process, such as using machine learning algorithms to analyze historical sales data and predict future trends in the market.

Figure 5 also shows the flow of activities involved in the management of assets, from acquisition to transfer and reporting, with the use of AI assistance at different stages. The activities are carried out by the asset owner or their designated personnel. Once the asset is acquired and subjected to valuation and risk assessment. This involves determining the asset' and the potential risks associated with its ownership and management.

AI-assisted valuation and risk assessment could involve machine learning algorithms to analyze data such as pricing trends and sales history.

Once the asset is valued and assessed for risk, it can be sold or transferred to another party. This is done through asset sales and transfer activities. AI-assisted valuation and risk assessment could also be used during this stage to inform the sale price and identify potential risks associated with the sale or transfer. IFRS reporting refers to complying with accounting standards for the financial reporting of assets. This involves disclosing information about the asset in financial statements, such as the value of the asset and any associated risks. AI-assisted compliance could involve the use of technology to automate the process of complying with accounting standards and analyzing data relevant to asset valuation and reporting.

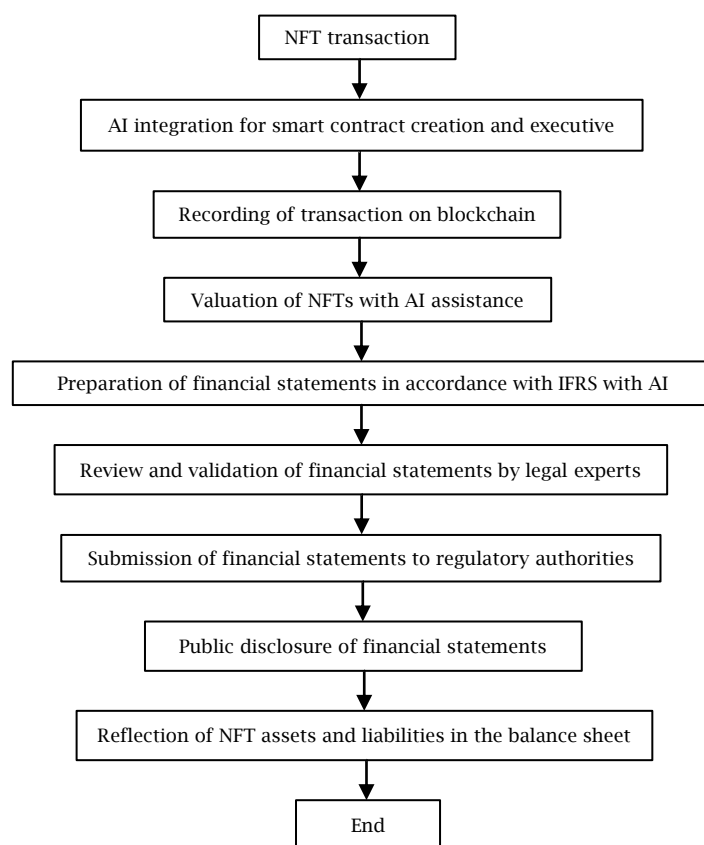**Figure 6.** The NFT transaction process with AI incorporation and legal aid provision

Figure 6 illustrates the process of NFT transactions with AI integration and legal assistance. The process involves NFT transaction initiation, AI integration for smart contract creation and execution, recording of transactions on the blockchain, valuation of NFTs with AI assistance, preparation of financial statements under IFRS with AI assistance, review, and validation of financial statements by legal experts, submission of financial statements to regulatory authorities, public disclosure of financial statements, and reflection of NFT assets and liabilities in the balance sheet. Legal teams play a crucial role in this process by reviewing and validating the financial statements, ensuring compliance with regulatory requirements, and

providing legal assistance in ownership verification, copyright infringement, and tax implications (Ito et al., 2022; Multazam, 2022). This updated flowchart provides a more detailed and robust framework for conducting NFT transactions while minimizing the risk of errors or non-compliance.

4.4. Data sources and analysis techniques for NFT market research

Various sources, such as public blockchain networks, NFT marketplaces, and tracking websites, provide organizations and companies with NFT data. This information includes NFT sales, transactions, ownership, and other relevant market data. The data

can be retrieved and analyzed using AI, machine learning, and data science techniques to identify market patterns and trends. The analysis can then inform the valuation and prediction of NFT prices and worth (Gumelar et al., 2023). Market research can also collect data directly from NFT creators and collectors through surveys and other means. Ethical and legal data acquisition is a common practice achieved through partnerships, application programming interfaces (APIs), and third-party providers. For example, OpenSea offers APIs for accessing and utilizing platform data, while Nansen analyzes blockchain data for NFT transaction insights (White et al., 2022). NFT sales and trend analytics are also available from DappRadar and NonFungible.com. Some companies partner with NFT creators or platforms to obtain data directly from the source, such as Dapper Labs' collaboration with the National Basketball Association (NBA) and National Basketball Players Association (NBPA) for creating licensed NBA Top Shot NFTs. It is essential to note that companies must ensure the legal and ethical acquisition of data to avoid potential legal or reputational risks.

Employing data science and machine learning techniques to analyze large amounts of NFT sales and transaction data can help organizations identify market patterns and trends. This information can be used to make more informed decisions about buying or selling NFTs and inform their valuation. NonFungible.com, a French-based website, is a platform that leverages these tools to track and analyze NFT sales and transactions across various blockchain networks. NonFungible.com data revealed a surge in NFT sales volume in early 2021, with total sales reaching $2 billion in the first quarter. The top-selling NFT categories were art, collectibles, and virtual real estate, providing useful insights for investors and collectors. Another company that utilizes AI for NFT analysis is Nansen, headquartered in Singapore. Nansen uses machine learning algorithms to analyze data from multiple blockchain networks and provide valuable insights into market trends and user behavior, helping to inform investment decisions and asset valuations for NFTs and other crypto-assets (Shahriar & Hayawi, 2022).

Moreover, data science and machine learning techniques can potentially enhance fraud prevention in NFT transactions. By detecting anomalous transaction patterns and identifying potential fraudsters, these tools can help organizations safeguard their investments in NFTs. For instance, in a recent study, researchers utilized machine learning algorithms to detect fraudulent activities in the NFT market by analyzing blockchain transaction data (Song et al., 2023; Leppla et al., 2022). Furthermore, data science can improve the accounting for NFTs by developing more accurate models for valuing and testing the impairment of NFTs based on their historical performance and market trends (Murphy, 2021).

4.5. NFT impairment

The IFRS guidance on NFTs is still developing, and companies should consult with accounting professionals while exercising their judgment to apply these principles to specific situations.

Determining NFT impairment under IFRS involves identifying the NFT asset, testing it for impairment, and comparing its carrying amount to its recoverable amount. The recoverable amount is the higher value of NFT's fair value less costs to sell and its value in use. Companies should consider market-based indications while determining the fair value less costs to sell and estimate the future cash flows for value in use, applying a discount rate that reflects the current market assessments of the time value of money and the risks specific to the asset. If the carrying amount of the NFT exceeds its recoverable amount, the NFT is considered impaired, and any impairment loss is recognized in the income statement. Testing NFT for impairment should be done at every reporting date, and any impairment losses or recoveries should be recognized in the income statement.

Included is a practical example of how to determine NFT impairment under IFRS. This section illustrates the steps involved in determining whether an NFT has been impaired in value and how to calculate the recoverable amount using the fair value less costs to sell and value in use. It also highlights the importance of estimating future cash flows and applying an appropriate discount rate to calculate the present value of the cash flows. This serves as a useful reference for researchers and professionals in the accounting and finance fields who may be interested in NFTs and their accounting treatment.

A company estimated the future cash flows expected to be generated by the NFT and compared the result to the carrying value of the NFT on its balance sheet. They also assumed a discount rate of 10% to calculate the present value of the estimated cash flows. Since the present value of the estimated cash flows exceeded the carrying value of the NFT, the NFT has not been impaired in value as of the balance sheet date. Assume that a company purchased an NFT for $10,000 on January 1, 2022. The NFT represents digital artwork created by a popular artist. The company intends to hold the NFT for the long term and believes that it will generate significant revenue from licensing the artwork for use in marketing campaigns. To determine whether the NFT has been impaired in value, the company estimates the future cash flows expected to be generated by the NFT and compares the result to the carrying value of the NFT on its balance sheet. For the purpose of illustration, we highlight the estimated cash flows as follows:

Table 1. Estimated cash flows

Serial No.	Year	Cash flow ($)
1	2022	2,000
2	2023	4,000
3	2024	5,000
4	2025	3,000
5	2026	1,000

Assuming a discount rate of 10%, the present value of the estimated cash flows is $12,932. This amount exceeds the carrying value of the NFT on the balance sheet ($10,000), so the NFT has not been impaired in value as of the balance sheet date.

Given that we are monitoring any potential decrease in the value of an NFT asset below its initial recorded cost, it is crucial to acknowledge that such decline can be attributed to a range of factors like

shifts in market trends, changes in user preferences, the emergence of competing assets, and even the consideration of the cost of capital. Delve into a more comprehensive example to better understand the implications of NFT impairment. Imagine a company that purchases a digital artwork NFT for $50,000, anticipating future returns from its ownership. The company assesses the value of the NFT based on projected cash flows, expected demand, and market trends. Suppose the interest rate used to discount the expected cash flows is smaller than 10%, indicating a lower cost of capital. This suggests that the company believes the NFT's future cash flows are relatively secure and less susceptible to impairment risk. However, over time, factors such as changes in market dynamics or a decline in the artist's popularity may lead to a decline in demand for the artwork.

Considering a longer time horizon beyond the initial 5-year period is also essential in assessing

potential impairment. For instance, suppose that after the first five years, the NFT's market value decreases to $30,000 due to shifting trends and the emergence of new artistic styles. In this case, the NFT has suffered an impairment of 40% compared to its initial recorded cost. This significant decline in value underscores the importance of considering longer-term projections and potential market developments when evaluating NFT investments. Furthermore, it is essential to factor in the cost of capital when assessing NFT impairment. If the company used a higher interest rate or cost of capital, let us say 15%, the discounted value of the NFT's projected cash flows would be lower. Consequently, any decline in market value would have a more substantial impact on the asset's overall valuation and potentially result in a higher impairment loss for the company.

Table 2. Comparative analysis of NFT impairment scenarios

Scenario	Initial NFT cost ($)	Discount rate (%)	Projected cash flows (years)	Market value after years ($)	Impairment (%)
1	50,000	10	5	30,000	40
2	50,000	10	10	40,000	20
3	50,000	15	5	25,000	50
4	50,000	15	10	35,000	30

This hypothetical table presents a few (four) different scenarios, each with varying initial NFT costs, discount rates, projected cash flows, market values after five years, and impairment percentages. Scenario 1 and Scenario 3 represent cases where the NFT suffers higher impairment due to a decline in market value, while Scenario 2 and Scenario 4 exhibit relatively lower impairment. These numerical examples can help illustrate the potential impact of different factors, such as discount rates and time horizons, on NFT impairment. By considering a range of scenarios and including corresponding data in a table format, researchers and readers can visually grasp the variations and outcomes associated with NFT investments in different contexts. Considering cash flows in the next five years is a common approach in financial analysis when assessing asset impairments. This time frame is often chosen as it allows for a reasonable projection of future cash flows based on available information and market trends. By focusing on the near-term cash flows, we can better estimate the immediate impact on the value of the NFT and evaluate its impairment in a relatively shorter time horizon. However, the choice of the time horizon may vary depending on the specific circumstances and the nature of the NFT investment. In some cases, a longer projection period may be warranted, especially if reliable data and reasonable assumptions support it.

AI can provide assumptions and predictions about factors that may affect the value of an NFT, such as useful life, revenue potential, market demand, and other relevant factors. Training machine learning models on relevant data, such as past sales of similar NFTs, market trends, and other relevant information, is typically done. The output of these models can then be used to inform estimates of the NFT's future cash flows and, ultimately, its recoverable amount. However, it

should be highlighted that these assumptions and predictions are only as reasonable as the data and models used to generate them and should be considered alongside other relevant information and professional judgment.

4.6. Challenges of NFT ownership and accounting

This research focuses on two examples: ownership disputes and financial statement challenges. Seeking legal advice and gaining new perspectives can help avoid copyright and intellectual property infringement. Ownership disputes arise when the original artwork's ownership is contested after an artist sells an NFT of their work, affecting its value and financial treatment. Proper accounting treatment of NFTs is also difficult due to their intangible nature and lack of clear market value. AI can address these risks by verifying ownership, evaluating NFT value, and detecting transaction fraud. AI offers efficient and accurate solutions for NFT ownership and financial statement treatment.

The legal disputes and regulatory issues surrounding NFTs are caused by the novelty and complexity of the technology, resulting in uncertainty regarding ownership and financial treatment (Sopamena, 2022). For instance, Beeple's "*Everydays: The First 5000 Days*" NFT raised concerns about the artwork's authenticity, ownership, and tax implications. To address these issues, clear guidelines and regulations must be established to ensure transparency and accountability in NFT ownership and sales. NFT marketplaces and creators can also provide more information and documentation about digital assets to enhance transparency and build trust with buyers. AI has the potential to assist in resolving these legal and regulatory challenges by analyzing large amounts of data, identifying patterns, and aiding in the development of guidelines and regulations.

AI can also automate the NFT authenticity and ownership verification process, monitor regulation compliance, and facilitate secure transactions through smart contracts.

5. DISCUSSION

This paper thoroughly explores various aspects of conducting market research in the NFT industry. It underscores the significance of comprehending the unique characteristics of NFTs and their challenges in valuation, market analysis, and fraud prevention. The researchers utilize different data sources and analysis techniques to gather and analyze NFT market data, including public blockchain networks, NFT marketplaces, tracking websites, and direct data partnerships with creators and platforms. Leveraging data science and machine learning techniques emerges as valuable for analyzing large volumes of NFT data and identifying market patterns and trends. Companies like NonFungible.com and Nansen effectively utilize these technologies to provide insights into NFT sales volume, top-selling categories, and user behavior, empowering investors and collectors to make informed decisions regarding NFT transactions. Additionally, the study highlights the potential of data science in addressing fraud prevention challenges and accounting for NFTs. Machine learning algorithms can detect anomalous transaction patterns and identify potential fraudsters, safeguarding NFT investments. Furthermore, data science contributes to developing more accurate models for valuing and testing the impairment of NFTs based on historical performance and market trends.

Examining NFT impairment in this study provides valuable insights into the potential financial risks of investing in digital artwork. An analysis of various numerical examples gives a deeper understanding of the factors influencing the impairment of NFT assets. It is important to note that considering different interest rates when discounting the expected cash flows is significant. While a discount rate of 10% was used in the initial analysis, it is essential to acknowledge that companies or individuals may adopt varying discount rates based on their cost of capital or risk preferences. Altering the interest rate can significantly impact the present value of cash flows and subsequently affect the determination of impairment. Future research should explore the implications of different interest rates on NFT impairment calculations.

Future research should include additional numeric examples or test cases to capture the full range of situations companies may encounter when purchasing digital artwork. The analysis of NFT impairment emphasizes the need for a nuanced understanding of this emerging asset class. Considering different interest rates, longer-term cash flows, and a wider range of scenarios would contribute to a more comprehensive analysis of NFT impairment risks, enabling stakeholders to navigate the challenges and opportunities presented by NFT investments more effectively.

6. CONCLUSION

In this paper, a thorough analysis of NFTs has been conducted, focusing on their applications in the financial market and exploring the challenges and opportunities they present. The literature review section of this paper has critically examined previous research on NFTs, highlighting key findings and gaps in knowledge. The studies by Taherdoost (2023), Roberts and Godement (2023), and Ghosh et al. (2023) have laid the foundation for understanding the unique characteristics and complexities of NFTs. In the context of these studies, our work builds upon this foundation and offers valuable contributions in several areas. Key findings have been uncovered by examining various aspects, including valuation, market analysis, fraud prevention, and accounting. The study has highlighted the significance of understanding the unique characteristics of NFTs and the complexities they pose in terms of valuation. The analysis of numerical examples, as presented in Tables 2 and well as Tables A.1 and A.2 in the Appendix, has deepened our understanding of the factors influencing the impairment of NFT assets. These additional numerical examples have provided valuable insights into the implications of different interest rates and longer-term cash flows, expanding the scope of analysis beyond the initial examination. It is evident that considering these factors is crucial in accurately assessing the impairment risks associated with NFT investments. These findings provide a more comprehensive understanding of NFT valuation and risk management.

Additionally, this paper has emphasized the significance of compliance, accurate reporting of NFTs in financial statements, and the value of data science and machine learning techniques in gathering and analyzing NFT market data and also AI verification in achieving reliable reporting of crypto assets as guided by the IFRS. By incorporating Figures 1, 4, 5, and 6, we have visually depicted the NFT creation, transfer, and reporting process, highlighting the role of AI verification and legal expertise. This contribution enhances the understanding of the practical implications of reporting requirements and strengthens the credibility of financial statements (Marwala & Xing, 2018; Governatori et al., 2018; Murphy, 2022).

The paper has also highlighted the challenges and risks associated with NFTs, including concerns related to fraud, theft, and illicit activities. It has been underscored that the accurate reporting of NFTs, in adherence to IFRS guidelines, is crucial for the integrity of financial markets. The study recommends that organizations leverage AI and legal expertise, as indicated in Figures 5 and 6, to ensure compliance with reporting requirements and enhance efficiency. Moreover, the research has emphasized the need for ongoing research and collaboration to address the evolving nature of NFTs in the financial market. Future studies should explore specific incidents, tax implications, and risks associated with custody and management. The potential for NFTs to facilitate cross-border transactions and their application in the gaming industry should also be examined.

Lastly, this paper has shed light on the challenges and opportunities presented by NFTs in the financial market. It has provided insights into valuation methodologies, fraud prevention, and the importance of accurate reporting in compliance with IFRS guidelines. The findings of this study highlight the potential of data science and AI, as well as the need for continued research and collaboration to unlock the full potential of NFTs in transforming the way we value and transact digital assets. In conclusion, the study by Marwala and Xing (2018) serves as a valuable resource for researchers, industry stakeholders, and regulators in navigating the complexities of NFTs in the financial market. The advancements made in this paper provide a solid foundation for further research and collaboration in this rapidly evolving field. By integrating insights from the literature review and showcasing our work as a significant contribution, this paper, authored by Marwala and Xing (2018) contributes to the ongoing dialogue on the transformative potential of NFTs in the digital economy.

It is vital to recognize the limitations of these technologies. The availability of high-quality data is crucial for accurate analysis, and addressing algorithmic bias is necessary. The evolving nature of the NFT market and the absence of established accounting standards pose additional challenges that demand continuous monitoring and adaptation.

Moreover, the study acknowledges the limitation of only considering cash flows within the next five years in the numerical examples. While this time frame allows for a comprehensive analysis of short-term implications, it is essential to acknowledge that NFT assets may hold longer-term value and generate cash flows beyond this period.

Incorporating an extended time horizon in future studies would provide a more comprehensive understanding of NFT impairment dynamics. Furthermore, it is crucial to recognize that the provided numerical examples offer a simplified representation of potential scenarios. Many factors, including specific artwork characteristics, market conditions, and regulatory changes can influence the valuation and impairment of NFT assets.

Based on the objectives and contributions of this study, several recommendations emerge. First, it is crucial to encourage ongoing research and collaboration among researchers, industry stakeholders, and regulators to keep pace with the rapidly evolving nature of NFTs. This collaboration can facilitate the development of standardized valuation methodologies, enhancing the credibility and comparability of NFT valuations. Efforts should also be directed toward addressing data scarcity and algorithmic bias by improving data quality and accessibility and implementing monitoring mechanisms. Furthermore, future studies should consider an extended time horizon for impairment analysis to provide a more comprehensive understanding of NFT dynamics. Exploring the tax implications of NFT transactions and focusing on custody and management practices are also important areas for further research. Finally, promoting education and awareness about NFTs can empower individuals to make informed decisions and navigate this asset class's unique characteristics and risks. By implementing these recommendations, stakeholders can effectively navigate the challenges and opportunities presented by NFTs, fostering transparency, trust, and the realization of the full potential of this emerging digital asset class.

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APPENDIX

Table A.1. Multifaceted factors influencing NFT valuation

Test case	NFT artwork	Market demand	Comparable sales	Intellectual property rights	Technological considerations	Artist/creator reputation	Revenue generation potential	Economic and market conditions	Cash flow	Legal compliance	Fair value measurement	Impairment assessment	Presentation & disclosure	IFRS adherence	GAAP adherence
1	CryptoPunk #7804	High	$10,000	Yes	Advanced Blockchain Tech	Established	High	Stable	$2,000	Compliant	Market approach	Not impaired	Adequate	Yes	Yes
2	Bored Ape Yacht Club	Low	$2,000	No	Traditional Digital Format	Unknown	Moderate	Fluctuating	$500	Non-compliant	Income approach	Impaired	Insufficient	Yes	Yes
3	Art Blocks Curated	Moderate	$5,000	Yes	Emerging Tech	Emerging	Limited	Stable	$1,000	Compliant	Market approach	Not impaired	Adequate	Yes	No
4	Rarible	High	$15,000	Yes	AR Integration	Established	High	Fluctuating	$3,000	Compliant	Income approach	Not impaired	Adequate	Yes	Yes
5	Pudgy Penguins	Low	$1,000	No	Traditional Digital Format	Unknown	High	Stable	$300	Non-compliant	Market approach	Impaired	Insufficient	Yes	Yes
6	Mutant Ape Yacht Club	Moderate	$3,500	Yes	AI-Generated Art	Emerging	Moderate	Fluctuating	$800	Compliant	Income approach	Not impaired	Adequate	Yes	No
7	Cryptokitties	High	$20,000	Yes	Advanced Blockchain Tech	Established	Moderate	Stable	$4,500	Compliant	Market approach	Not impaired	Adequate	Yes	Yes
8	Art Blocks Playground	Low	$500	No	Traditional Digital Format	Unknown	Limited	Fluctuating	$100	Non-compliant	Income approach	Impaired	Insufficient	Yes	Yes
9	NBA Top Shot	Moderate	$8,000	Yes	Emerging Tech	Emerging	High	Stable	$1,800	Compliant	Market approach	Not impaired	Adequate	Yes	No
10	CryptoKittens	High	$25,000	Yes	AR Integration	Established	Limited	Fluctuating	$5,500	Compliant	Income approach	Not impaired	Adequate	Yes	Yes
11	CryptoArt.io	Low	$800	No	Traditional Digital Format	Unknown	High	Stable	$200	Non-compliant	Market approach	Impaired	Insufficient	Yes	Yes
12	The Sandbox	Moderate	$4,000	Yes	Virtual Reality Integration	Emerging	Moderate	Fluctuating	$900	Compliant	Income approach	Not impaired	Adequate	Yes	No
13	Decentraland	High	$18,000	Yes	Virtual Land Marketplace	Established	High	Stable	$4,000	Compliant	Market approach	Not impaired	Adequate	Yes	Yes
14	Meebits	Low	$700	No	3D Character Assets	Unknown	Limited	Fluctuating	$150	Non-compliant	Income approach	Impaired	Insufficient	Yes	Yes
15	SuperRare	Moderate	$6,500	Yes	Curated Art Marketplace	Emerging	High	Stable	$1,500	Compliant	Market approach	Not impaired	Adequate	Yes	No

Note: This table is still a simplified representation and should not be considered a comprehensive or exhaustive IFRS compliance checklist. Companies ought to consult with accounting professionals and refer to the latest IFRS guidance to ensure full compliance with the accounting requirements for NFTs.

Table A.2. Additional factors that can impact NFT values

Scenario	Rarity	Utility	Celebrity endorsements	Partnerships	Technological advancements	Regulatory changes	Market trends
1	High	High	Present	Present	Present	Absent	Positive
2	Low	Moderate	Absent	Absent	Present	Present	Negative
3	Moderate	Low	Present	Absent	Absent	Absent	Positive
4	High	High	Absent	Present	Present	Present	Negative
5	Low	High	Present	Absent	Present	Absent	Positive
6	Moderate	Moderate	Absent	Present	Absent	Present	Negative
7	High	Low	Present	Absent	Present	Present	Positive
8	Low	Low	Absent	Present	Absent	Absent	Negative
9	Moderate	High	Present	Present	Absent	Present	Positive
10	High	Moderate	Absent	Absent	Present	Absent	Negative
11	Low	High	Present	Present	Present	Present	Positive
12	Moderate	Low	Absent	Present	Present	Absent	Negative
13	High	Low	Present	Absent	Absent	Present	Positive
14	Low	Moderate	Absent	Present	Present	Absent	Negative
15	Moderate	High	Present	Present	Present	Present	Positive

Note: This table provides a framework to capture different combinations of factors that can impact NFT values. However, the specific impact of each factor may vary depending on the context and industry dynamics. It's recommended to conduct a thorough analysis and assessment of each scenario to determine the potential implications on NFT valuation, fair value measurement, and impairment assessments.