Guest editorial: Non-fungible token (NFT) and alternative finance: digitalization, decentralization and tokenization

1. Introduction

Non-fungible tokens (NFTs) represent unique cryptocurrency tokens created on a chain of digital credentials and can be used for distribution, purchase and collection. Blockchain technology is a prominent feature of NFTs, which ensures tamper resistance and traceability. NFTs have revitalized digital media such as images, audio, video and land. According to 2024 Statista statistics, it is estimated that by 2028, the revenue and the user number of the NFT market are expected to reach 3.37 billion US dollars and 19.71 million persons, respectively. This situation demonstrates the NFT market's positive growth momentum and potential. The key companies include OpenSea, CryptoPunks – Larva Labs Studio, Funko Inc., Dapper Labs, Inc., Nifty Gateway, etc. They cover multiple aspects of the NFT market, including decentralized trading platforms, auctions of artworks and collectibles, digital entertainment, ticketing solutions and providing technical support and market channels for artists and creators (Grandview Research, 2024).

Although NFTs have gained significant attention after the 2021 exponential growth, their history can be traced back to the 1993 encryption transaction card. The concept of cryptographic trading cards comes from cryptography and mathematics, and the cards are presented as a mix of one-way functions, digital signatures and random blinding. The idea of cryptographic trading cards could be considered the original NFTs. In 2020, the NBA top shot digital basketball star card marked the beginning of the rapid growth in the popularity of NFTs.

As NFTs can be traded, discussing them as assets for digital investment is inevitable, leading to a call to examine their financial characteristics. The significant return on investment space demonstrated by NFTs has attracted investors. NFTs have also shown hedging attributes under all market conditions, including the COVID-19 pandemic, providing a new way to diversify portfolios (Abakah *et al.*, 2023). Meanwhile, speculators exist, resulting in abnormal behaviors such as wash trading and price manipulation. Given the importance of financial aspects in NFTs, this research aims to review the literature on NFT research from a financial perspective.

Previous NFT reviews have focused primarily on examining the changes in NFT research over time, as well as the most significant countries, organizations and published journals (Nobanee and Ellili, 2023). Ali *et al.* (2023) identified the absence of current NFT systems and conclusive research work, provided a detailed summary of the NFT ecosystem, described the most advanced NFT technology and then discussed the key challenges faced by NFT. However, the process and outcome of employing NFTs as a form of digital investment have not yet been systematically summarized. Bao and Roubaud (2022) conducted a systematic review of NFT research and reported that asset pricing is more concentrated in specific journals. They provided possible research topics on asset pricing, risk and supervision. Kräussl and Alessandro (2022) investigated the determinants of NFT prices and developed a framework for understanding investor behavior on the blockchain. However, a comprehensive study of the financial attributes of NFTs remains a current research gap. Therefore, we organized a special issue and systematically screened and summarized studies on NFTs relevant to digital investment in recent years.

2. Special issue and accepted papers

The present special issue of "Non-Fungible Token (NFT) and Alternative Finance: Digitalization, Decentralization, and Tokenization" seeks to explore the implications of NFTs as digital investments. It also aims to provide insights into the economic theories and practices related to NFTs and identify areas that require further exploration. Moreover, we hope it can guide businesses, investors and policy-makers on the risks and opportunities within the burgeoning NFT market.

We received numerous contributions in response to our call for papers, indicating the growing interest in the financial and economic ramifications of NFTs. Following a stringent peer-review process, eight papers were selected for publication in this special issue. These papers, both theoretical and empirical, significantly contribute to our understanding of NFTs from a finance and economics perspective.

The first group of studies explored the interrelationships between NFTs and other investment assets. Polat (2024) examined the time-varying return and volatility interlinkages among major cryptocurrencies, NFT tokens and decentralized finance (DeFi) assets to determine optimal portfolio allocations and hedging effectiveness under different portfolio construction techniques. The dynamic interlinkages identified can inform optimal portfolio decisions, with DeFi assets and NFTs demonstrating potential as safe havens during financial and geopolitical turmoil. Moreover, the marked increase in total connectedness indices during crisis periods provides a valuable tool for policy-makers to monitor risk. The study focuses on the dynamic time interlinkages among major cryptocurrencies, NFTs and DeFi assets during recent financial and geopolitical incidents; it also estimates and compares the network topologies of dynamic connectedness around these bursts and calculates time-varying optimal portfolio allocations and hedging effectiveness under different portfolio construction techniques. Ghosh et al. (2024) explored the interrelationships among NFTs, DeFi and carbon allowance (CA) markets from 2021 to 2023. The investigation is set against the backdrop of a shift in crypto and DeFi miners from China's green hydro energy to dirtier fuel energies elsewhere, prompting investments in carbon offsetting instruments. The originality of this research lies in addressing the direct nexus between NFTs, DeFi and CA, a connection previously unexplored in the literature. The results provide valuable insights for portfolio managers, demonstrating that market connectedness intensifies under extreme conditions in both bull and bear markets. This study contributes to understanding how shifts in energy consumption drive the environmental impact of digital asset mining. Chopra et al. (2024) examine how crypto traders can use Bitcoin as a hedge or safe haven asset to reduce their losses from cryptocurrency. Among the first to demonstrate how Bitcoin can act as a true matriarch/patriarch for crypto assets, the study employs the cross-quantilogram (CQ) approach to examine Bitcoin's safe-haven properties against other selected crypto assets. The findings indicate that Bitcoin acts as a weak safe haven asset for most new crypto assets throughout the entire study period. Bitcoin has the ability to protect crypto assets from sharp downturns in the crypto market, providing some respite for crypto traders in a highly volatile asset class. The relationship is clearly and concisely represented via heatmaps constructed from CQ analysis, depicting the quantile dependence association between Bitcoin and other crypto assets. The uniqueness of this study lies in assessing Bitcoin's protective properties not only for the entire sample period but also specifically during periods of greed and fear in the cryptocurrency market.

Another stream of accepted papers examines the success drivers of NFTs and other cryptocurrency projects. Baklanova et al. (2024) aimed to precisely interpret a machine learning model and produce definitive summaries that evaluate the influence of investor sentiment on the overall sales of NFT assets. The study proposed a sentiment index called the NFT hype index to measure the influence of market actors within the NFT industry. This index was developed by analyzing Twitter content posted by 62 high-profile individuals and opinion

leaders via the gradient-boosting regressor model and explainable AI techniques. It can potentially serve as an innovative, sentiment-based indicator for investment decision-making in the NFT market; it could also provide investors with unique insights into market sentiment, which can be used alongside conventional financial analysis techniques to enhance risk management, portfolio optimization and overall investment outcomes within the rapidly evolving NFT ecosystem. Ling and Sun (2024) developed a robust initial coin offering (ICO) financing model to address demand uncertainty, allowing entrepreneurs to be ambiguity-averse to this uncertainty. The potential market demand significantly impacts the probability of ICO success for blockchain-based platforms. However, accurately estimating market demand is challenging because of the intangible nature of these platforms' goods or services. To address these gaps, this study investigates how an entrepreneur's preference for robustness influences the optimal token financing ratio and other key factors, such as optimal output, effort and equilibrium token prices. The findings indicate that an entrepreneur with a high degree of ambiguity aversion will transfer more demand uncertainties to investors by increasing the token financing ratio and will exert less effort on the product, thereby reducing the venture's total value and the equilibrium token price. This insight helps us understand how ambiguity aversion shapes financing strategies and impacts the success and valuation of blockchain-based ventures.

Finally, we have accepted three papers examining NFT investor behaviors. Silva *et al.* (2024) explored the applicability of herding behavior in the NFT market. Indeed, the NFT market experienced a price surge in late 2021 and early 2022, with NFTs being sold at inflated prices. By April 2022, the market underwent a correction, and NFT prices returned to more reasonable levels. The study employs cross-sectional absolute deviation of returns to test for herding behavior, using moving time windows of 10, 20 and 30 days on the basis of sales data collected from OpenSea between July 1, 2021 and June 30, 2022. Additionally, the study includes an analysis of NFT-related keyword usage during identified herding periods. The results revealed that this behavior was present and aligned with the overall behavior of the market. The study uncovered the roots of herding behavior and assessed the time windows during which it occurs, considering the plausible socioeconomic contexts influencing these trends. Lee (2024) empirically examined consumer adoption attitudes and behaviors toward NFTs. The findings indicate that perceived usefulness, reliability and profit expectancy influence consumer attitudes toward NFTs and that strong attitudes are associated with purchase intentions. Additionally, the relationship between attitudes and purchase intentions is moderated by technology optimism. These findings offer valuable insights for NFT owners, content providers and trading firms. For the NFT market to expand, it must meet consumers' expectations for desired content features and asset investment attributes. Additionally, customer-targeting strategies should aim to attract and appeal to technology enthusiasts with an optimistic outlook on technology. On the basis of the extended unified theory of acceptance and use of technology (UTAUT) framework, Ramly and Mohd (2024) identified the determinants influencing investors' intentions toward NFT investments. This research marks a significant departure from existing studies by tailoring the UTAUT model to Malaysia's NFT investment context. This study reveals the nuanced dynamics influencing NFT investment intentions, emphasizing the unique contributions of performance expectancy and social support. This underscores the crucial role of perceived benefits and community support in shaping Malaysian investors' engagement with NFTs.

3. Literature review on the financial perspective of NFTs
To go beyond the special issue papers, we first look into the literature to answer a fundamental question: Is NFT a new asset class? Some scholars argue that NFTs constitute a

new asset category distinct from traditional assets (Corbet *et al.*, 2023; Ko *et al.*, 2022; Urom *et al.*, 2022). Other scholars hold the opposite view, arguing that NFTs cannot be regarded as a separate asset class but rather as a traditional asset (Gunay and Kerem, 2022; Ghosh *et al.*, 2023a; Schwiderowski *et al.*, 2023). The classification of NFTs as either new assets or traditional assets has not yet been definitively resolved in academia. The perspective one adopts may depend on the specific financial characteristics and behaviors being analyzed. Some see NFTs as groundbreaking asset classes with unique properties and potential for portfolio diversification, whereas others find their financial behaviors more aligned with those of traditional assets. As the market evolves and more research is conducted, a clearer consensus may eventually emerge. However, NFTs have unique characteristics that distinguish them from other financial markets. These characteristics include limited marketability and their appraisal as digital artwork, which segregates them from other financial assets (Wang, 2022b).

The second question relates to the trading dynamics of the NFT market. As a barometer of market activity, the trading volume of NFT reflects the enthusiasm of market participants and reveals the breadth and depth of digital asset trading. Emotion and search on social media are closely related to NFT sales and trading volume (Horky *et al.*, 2023; Chen *et al.*, 2023). In addition, the performances of established markets and emerging markets influence each other regarding trading activities (Ante, 2023). NFT pricing is a decision-making process involving multiple factors, including user adoption, platform productivity, network effects (Cong *et al.*, 2021), bidding costs (Kireyev, 2022), transaction frequency (Lin *et al.*, 2022), token rarity (Kong and Lin, 2021), cryptocurrency market volatility (Dowling, 2022) and marketplace design (Kireyev and Lin, 2021). The current study suggests a number of tools and methods to help sellers price more accurately and reduce the risk of mispricing. In summary, academics and market analysts are working to develop more refined pricing models that more accurately reflect the intrinsic value of NFT and the performance of the market.

Our third concern is about investors, who play essential roles in trading NFT assets in the market. They differ from traditional market participants in at least two aspects. One is the emotional factor, as reflected by their psychological factors (Ante *et al.*, 2023). The literature extensively discusses the differences in herding behavior between the NFT and traditional cryptocurrency markets (Yousaf and Yarovaya, 2022b; Mamidala and Kumari, 2023; Bao *et al.*, 2023; Chowdhury *et al.*, 2023). Fridgen *et al.* (2023) examined fluctuations in the NFT market, explicitly investigating the subsequent influences on NFT price patterns. Wang (2022a) identified the presence of behavioral biases, such as the anchoring effect and loss aversion, in the NFT market. Gunay *et al.* (2022) researched investor sentiment and its impact on the NFT market. Siev (2023) investigated the market response to corporate disclosure information, with a specific focus on the market reaction to NFT information. The study also explored the factors that may distinguish firms with positive or negative market reactions.

The other difference is investors' rational attitude toward the return-risk tradeoffs. The rapid expansion of the NFT market is unprecedented because of its potential for high returns. Investors are attracted to the NFT market for similar returns, leading to increased prosperity for NFT products (Zhang *et al.*, 2022). The academic community has focused primarily on investigating the factors influencing NFTs' short- and long-term returns. These factors include participant involvement, trading volume and external indicators such as social media and web search activity (Yousaf and Yarovaya, 2022a; Wang *et al.*, 2023; Oh *et al.*, 2022). Borri *et al.* (2022) conducted a comprehensive study on NFT transactions, examining their characteristics in relation to market returns. Their findings indicate that, in time series analysis, NFT market returns are strongly predicted by both volatility and the NFT valuation ratio. In cross-sectional analysis, NFT returns exhibit size and return reversal effects. Umar *et al.* (2022b) examined the relationship between the return and volatility of

NFT segments and media coverage during the outbreak of the pandemic. The findings suggest that COVID-19 had a significant effect on returns and the transmission of volatility effects. During times of crisis, both the hedging and diversification benefits of the NFT segments decrease. Additionally, discernible disparities in the long- and short-term interconnections were observed.

How can the returns of NFT investment portfolios be improved? Menvouta et al. (2023) developed a practical portfolio optimization technique for NFTs via machine learning, specifically robust hierarchical risk parity. The technique incorporates NFTs into a portfolio that includes both traditional and cryptocurrency assets, resulting in an enhanced adjusted Sharpe ratio; greater skewness, mean return, kurtosis and less concentrated portfolios. The study shows that adding high-value NFT collections to a portfolio can increase the overall portfolio return. The analysis indicates that this approach effectively optimizes portfolios that include NFTs, conventional assets and cryptocurrencies.

As for risks, NFTs exhibit considerable volatility and limited liquidity (Jiang and Xia, 2023), exposing investors to significant price changes and potential risks. Therefore, NFTs are more suitable for investors willing to take substantial risks (Mazur, 2021). Umar et al. (2022c) explored the transmission of risk and return between different sectors of the NFT market via the time-varying parameter vector autoregressive connectivity approach. The results indicate that each section of the NFT market has distinct risk and return attributes, exhibiting different average returns and standard deviations of return. According to research by Umar et al. (2022a), NFTs may carry a greater risk during the COVID-19 outbreak. However, this finding only applies in the short term for periods of less than two weeks. However, according to existing research, NFT also has a good hedging risk attribute, which provides more opportunities and possibilities for investors to diversify their portfolios (Akkus and Dogan, 2023; Karim et al., 2022; Kumar and Steven, 2023; Umar et al., 2022d, 2023). How can the risk of investing in NFT be reduced by predicting bubbles? Barbon and Ranaldo (2023) created a comprehensive dataset of the entire NFT market by obtaining transaction-level data for the top 1,000 most traded NFT sets on OpenSea, the largest NFT marketplace. They used this dataset to analyze the behavior of retail investors during asset bubbles. The study used principal component analysis to identify important financial characteristics, including nonfinancial funds, encompassing liquidity, volatility and returns. The study revealed that these financial indicators can significantly predict the emergence of bubbles and price crashes.

The last question we ask about NFTs is related to regulatory issues, as NFTs carry external risks such as potential fraud, market manipulation and cybersecurity threats (Teng et al., 2023). NFT wash trading refers to activities undertaken to artificially inflate asset prices and trading volume, which significantly distorts the fair value of tokens within the collection. Serneels (2023) suggested three tactics that can be employed in the NFT market to identify suspicious trading activities: closed-loop woken trades, closed-loop value trades and large transaction volumes. Oh (2023) discussed the prevalence and impact of insider trading and wash trading in the NFT market. Sifat et al. (2024) conducted a comprehensive analysis of NFT markets, revealing the presence of wash trading and price manipulation. To reduce irregularities, Fang et al. (2023) suggested that blockchain technology can reduce information asymmetry by promoting transparency. However, inadequate awareness of blockchain information among users has led to speculation in NFT marketplaces.

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427

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